ENVIRONMENTAL IMPACT ASSESSMENT REPORT

Proposed Development of Phosphate Deposits in the Sandpiper Phosphate Licence Area ML 170 off the Coast of Central Namibia

Specialist Report

FISHERIES, MAMMALS AND SEABIRDS

Prepared for:

Namibian Marine Phosphate (Pty) Ltd.

By

Fisheries and Oceanographic Support Services cc

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Updated Assessment : May 2022

Initial Assessment : December 2011

Assumptions and limitations

This EIA review was undertaken by FOSS cc and has used the original report framework followed by the consultants who first undertook the assessment in 2011.This analysis and environmental risk assessment is based on the available literature, 2014 EIA Verification data and specialist studies and the data supplied mostly by the Namibian Ministry of Fisheries and Marine Resources (MFMR), in particular scientific staff of the research branch of MFMR the National Marine Research Centre (NatMirc), based in Swakopmund. Because of the extent of the environment under consideration informed assumptions may need to be made based on a broad understanding of the Benguela Ecosystem. Data provided may be limited in extent and could have spatial and temporal bias due to the sampling methods used. The information provided by the fishing industry as well as Interested and Affected Parties is also acknowledged.

EXPERTISE AND DECLARATION OF INDEPENDENCE

I, *D.W. Japp* of *Fisheries and Oceanographic Support Services cc*, do not have and will not have any vested interest (either business, financial, personal or other) in the proposed activity proceeding other than remuneration for work performed in terms of Namibian legislative framework. I am an independent professional marine and fisheries scientist, registered with the South African Council for Natural Scientific Professionals (SACNASP). This assessment is undertaken without bias and in an entirely neutral capacity.

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David Japp

Fisheries and Oceanographic Support Services cc

Rationale for this Report

Following conclusion of the High Court proceedings in Namibia in June 2021, Namibian Marine Phosphate (Pty) Ltd (NMP) is required to re-submit an application for an environmental licence certificate. The new application needs to include updates to the Environmental Impact assessment (EIA) and Environmental Management Plan (EMP) submitted in 2014 and updated 2016, based on new additional studies conducted by NMP in 2019/2020 and recent relevant research. The author of this report provided input to the EIA and EMP previously completed for NMP. This report updates the original EIA on fisheries, marine mammals and seabirds compiled and submitted in December 2011. It is not intended to significantly revise the original report but aims to review the assessment based on new information available. Further, this assessment is focused on ore recovery by dredging in the SP-1 area in Mining License ML170 shown in Figure 1a. Figure 1b (BCC, 2022) also shows the known phosphate resource in Namibian waters.

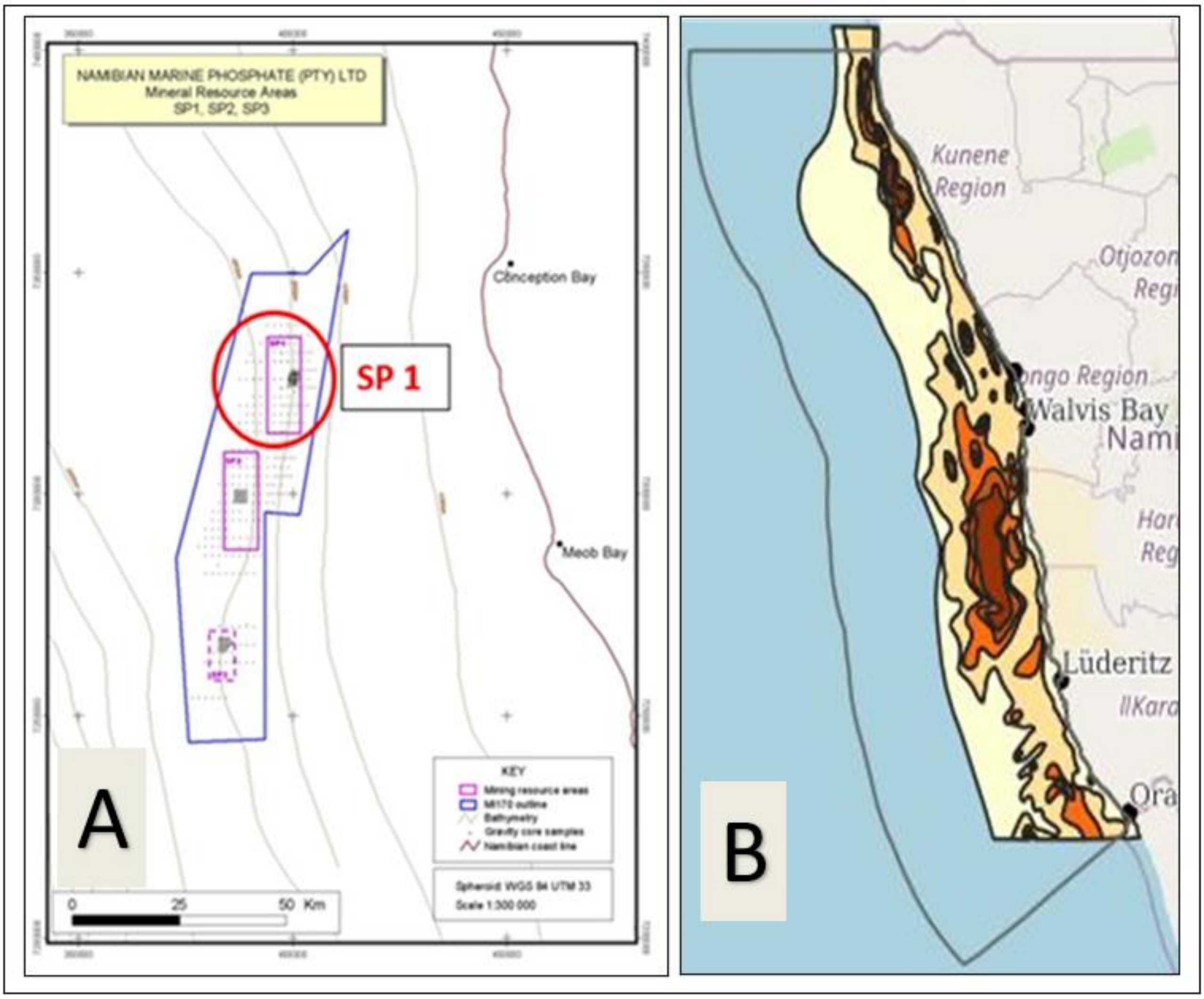

Figure 1. Namibian Marine Phosphate Mining Lease Area showing Sand Piper 1 focus area for this EIA review (A) and the known marine phosphate deposits in Namibian waters (B) (after BCC, 2022)

Glossary of Terms and Abbreviations

BCLME	Benguela Current Large Marine Ecosystem
BCC	Benguela Current Convention
Benguela Ecosystem	The region along the South African, Namibian and Angolan coasts influenced by the cold Benguela Current. The system is typified by coastal upwelling and high productivity and is broadly split into northern and southern Benguela
CPUE	Catch Per Unit Effort
Demersal	Occurring near the seafloor.
Ichthyofauna	The assemblage of fish species occurring in a certain area
Ichthyoplankton	Eggs and larvae of fish, floating new born fish before they can adequately swim by themselves
JNCC	Joint Nature Conservation Committee
MARISMA	Marine Spatial Management and Governance Project (of the BCC)
MFMR	Ministry of Fisheries and Marine Resources (Namibia)
MLA	Mining Licence Area
MSP	Marine Spatial Planning
NatMirc	National Marine Research Centre
Pelagic	Occurring in the middle or surface layers of the ocean
QMA	Quota Management Area
Upwelling	The process where by wind-driven surface waters are replaced by cool nutrient rich waters
SP-1	Sandpiper Mining area No. 1 (as well as SP-2 & SP-3)
TAC	Total allowable catch

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1 Introduction

Namibian Marine Phosphate (PTY) Ltd has identified the existence of a high-grade phosphate deposit on the Namibian continental shelf. This deposit lies approximately 40-60 km offshore from Conception Bay in water depths of 190 to 300m. Within the context of increasing international demand for phosphates, the company has been granted a mining licence (ML170) and is required to obtain a valid Environmental Clearance Certificate in order to undertake the proposed operations in ML170. to develop this resource. It is currently estimated that a total resource of 1951 Mt at 10 % P_2O_5 (1877 Mt at 10 % P_2O_5 & 74 Mt at 10 % P_2O_5) exists. This places Namibia as the country holding the seventh largest phosphate resource. The mining licence (granted for 20 years) covers an area of 2233 km^2 (Figure 1). The company proposes to recover 5.5 Mt of phosphate enriched sediments annually to produce 3.0 Mt of phosphate concentrate. These sediments are to be recovered from the initial target mine area of the mineral resource SP-1 (Sandpiper-1) using Trailing Suction Dredge Technology. The scale of the Sandpiper Project within the SP1 target area will involve mining a total area of 34 km^2 over a period of 20 years at an average of 1.7 km^2 annually. The annual mining area equates to 0.08% of ML170. The total 20 year mining area equates to less than 2 % of ML170 and less than 0. 0003% of the seabed within Namibia's exclusive economic zone. The other target mine areas, SP-2 (Sandpiper-2) and SP-3 (Sandpiper-3), also contain phosphate resources and may be considered for development at a later stage (Figure 1).

The initial specialist studies in 2011 and 2013/2014 were undertaken to assess the possible impacts of the proposed mining of the phosphate resource on fish, fisheries, seabirds and marine mammals. Impacts are expected to occur during the development, actual operation and decommissioning stages. This updated report includes any new information that may be material to the original impact assessment. It includes mainly updated fisheries catch and effort information aimed at verifying the assessment undertaken some 10 years ago. While the characteristics of Namibian fisheries are not expected to have changed significantly, it is prudent that the best available spatial data is used that might reflect any recent changes in the fisheries assessed. The information also includes any new publicly-available scientific and other literature.

To evaluate the potential environmental impacts, fish survey data and commercial fishing data, from the Namibian Ministry of Fisheries and Marine Resources (MFMR) were used to show the distributions of fish and fishing effort in relation to the Mining Licence Area (MLA) or ML-170. The distribution maps were originally created in ArcGIS 9 and show the position of the MLA with target mining areas (SP-1, SP-2 and SP-3) overlaid. The updated maps have used R-Script to create new maps, but still based on the original designated areas of risk. To quantify the extent of the impacts resulting from phosphate mining on fish, fisheries, marine mammals and seabirds we originally assumed four broad impact zones. This review now also incorporates a much smaller area pertinent to the actual site of operations which do not occur in the whole of ML170 at any one time. The actual 20 year mine plan and original zonation used is provided in Figure 32)[1]. The Zone are therefore :

Zone 1: 20 year Mine Plan Direct Impacts (the 5 km area used only as reference distance)

Zone 2 : Area extending from Zone 1 outwards to 25km (Indirect Impacts)

Zone 3 : Area extending from Zone 2 to 50 km (Indirect Impacts)

Zone 4 : Area extending from Zone 3 to the EEZ (Indirect Impacts)

[1] The actual area mined will approximate < 0.08% of ML 170 at any one time and the planned area to be mined over 20 years is 34km^2 or < 2% of ML170.

For each impact zone the percentage of fish and fishing effort was calculated and used to help assess the significance of the impacts. This report follows a pre-designated format that first provides an overview of the species and fisheries in the affected marine system followed by a technical analysis of the zones, analysis and results and conclusions. Since the last assessment, Namibia, through the MARISMA programme of the Benguela Current Commission has undertaken a comprehensive Marine Spatial Planning (MSP) project[2]. This review therefore also draws on the information available through the MARISMA META-data portal[3] and also fisheries surveys undertaken by NORAD/FAO[4] as well as the most recent available fishery biomass surveys under taken by MFMR[567].

2 Legislative Framework Applicable to this Assessment

This environmental assessment falls under the broad legislative framework applicable to the preparation environmental impact assessments in Namibia. This section does not cover in detail all of the legislation applicable to the EIA as that can be found in the overall report, of which this specialist report on fisheries, seabirds and mammals is only one part. Applicable mainly to this assessment is the following :

- Marine Resources Policy of 2004
- The Marine Resources Act 27 of 2000 (as amended)
- Environmental Management and Assessment Act of 2007 (with Regulations No.30 of 2012)
- Aquaculture Act (No. 18 of 2002)
- Convention on Biological Diversity (1992)

To further implementation of the 2015 amendment to the Resource Management Act, an updated draft Namibia Fisheries Policy was developed. This policy, based on complementing Namibia's Vision 2030 and NDP development goals, focuses on ensuring stocks sustainability, while at the same time promoting value addition and socio-economic contribution of fisheries and marine resources to Namibia's economy, particularly creation of additional employment for Namibians, resource rent capture for wealth distribution, and contribution to food security for poverty eradication (Ministry of Fisheries and Marine Resources, 2015).

From an International perspective, Namibia's regional and International legal and policy documents, instruments and declarations required the protection of 20 – 30 per cent of all marine habitats (under the jurisdiction of individual Governments) by 2012. These legal instruments include amongst others the Convention on Biodiversity (CBD), targets and goals issued and proclaimed at the World Summit on Sustainable Development (WSSD) held in Johannesburg in 2002, the Reykjavik Declaration on Responsible Fisheries in the Marine Ecosystem, the SADC Fisheries Protocol (encapsulating the Ecosystem Approach to fisheries management – EAF) and the Ramsar Convention.

Marine Resources Policy of 2004 : Namibia regulates every facet of their fishing sector primarily through policy (Marine Resources Policy of 2004) and the Marine Resources Act 27 of 2000. The Ministry of Fisheries and Marine Resources emphasises conservation of stocks through Namibia's Marine Resources Policy of 2004. This policy includes, broadly an ecosystem-wide approach to fisheries management, including multi-stock management where stock inter-dependence includes

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[2] Ministry of Fisheries and Marine Resources (MFMR), 2018. Current Status Report: National Overview for Marine Spatial Planning & Knowledge Baseline for Namibia's 1st Marine Spatial Plan. MFMR, Windhoek: Namibia.
[3] https://cmr.mandela.ac.za/Research-Projects/EBSA-Portal/MARISMA-Spatial-Data-Portal
[4] Boyer et al. 2019. Cruise report Dr Fridtjof Nansen – Transboundary demersal survey, SE Atlantic Leg 2.2, April 2019.
[5] Uanivi et al. 2019. Cruise Report – Horse mackerel & small pelagics survey of the Northern Benguela. MFMR.
[6] Nangola et al. 2017. Cruise Report – Monk biomass survey. *Ministry of Fisheries and Marine Resources, Namibia.*
[7] Paulus et al, 2020. Surveys of the Hake Stocks. Survey No. 2020901. *Ministry of Fisheries and Marine Resources, Namibia*

shared and straddling stocks with countries sharing borders. Further, it also includes the maintenance and/or rebuilding measures for each resource to long-term sustainable levels, management plans based on reference points, management strategies and research priorities. The policy also promotes protection measures for marine fish stocks and fisheries from possible negative effects of other activities impacting on the sea or seabed. With respect to fisheries, this policy is implemented mainly through the Marine Living Resources Act of 2000.

The Marine Resources Act 27 of 2000 : Namibia's Marine Resources Act of 2000 is almost 20 years old. It was amended in 2015, primarily to cover redefining MFMR's mandate. The Act is administered by the Ministry of Fisheries and Marine Resources (MFMR) whose primary mandate is couched as the sustainable utilization and long-term protection of marine resources, and the conservation of the marine ecosystem. No fishing may take place without authorization in the form of a fishing licence or permit. Rights allocation processes have taken place within stated policy frameworks. Importantly, as in South Africa, this has included and incorporated the Ecosystems Approach to Fisheries Management (EAF). The Act provides for, amongst others, the conservation of the marine ecosystem and the responsible utilization, conservation, protection and promotion of marine resources on a sustainable basis. Part 10 of the Marine Resources Act empowers the Minister to prescribe specific conditions and restrictions regarding closed areas and exclusion zones, applicable to commercial fishing rights, quotas and licenses granted under the Act. In this regard, trawling and longlining is prohibited in waters shallower than 200 m. The Act also provides for the declaration of Marine Protected Areas (MPAs) and Fishery Management Areas (FMAs). The Act also incorporates management, conservation and utilisation of marine mammals and seabirds.

Environmental Management and Assessment Act of 2007 : Drafting of the Environmental Management and Assessment Bill started in 1996, with a highly consultative approach. The Act provides a set of principles for environmental management that guide the interpretation, implementation and administration of the Act and any other law that relates to the protection of the environment. Further it serves as the general framework within which environmental plans must be formulated and provides "*guidelines for any organ of state when making any decision in terms of the Act or any other law that relates to the protection of the environment*". The Act promotes public participation, and makes provision for external review by the Environmental Commissioner, where required, at the proponent's expense.

Aquaculture Act (No. 18 of 2002) : The Aquaculture Act of 2002, provides for the regulation and control of aquaculture activities in Namibia; for the sustainable development of aquaculture resources and for related matters. Associated with this act are the Aquaculture (Licensing) Regulations (2003) and the Regulations relating to Import and Export of Aquatic Organisms and Aquaculture Products (2010).

Convention on Biological Diversity (1992) : Namibia signed the Convention on Biological Diversity (CBD) on 12 June 1992 in Rio de Janeiro, at the United Nations Conference on Environment and Development, and ratified it on 18 March 1997. Namibia is accordingly now obliged under international law to ensure that its domestic legislation conforms to the CBD's objectives and obligations. Its Constitution explicitly refers to biodiversity (Article 95(I) providing that "*in the interests of the welfare of the people, the State shall adopt policies aimed at maintaining ecosystems, ecological processes and biodiversity for the benefit of present and future generations*". Article 6 (a) also requires the "development of national strategies, plans or programmes for the conservation and sustainable use of biological diversity, or adapting existing strategies, plans or programmes for this purpose". Article 14 requires each contracting party to carry out EIAs for projects that are likely to adversely affect biological diversity. It further requires that the EIA be aimed at avoiding or minimising such effects and, where appropriate, allow for public participation in the assessment.

3 Overview of Ichthyofauna of Namibia

Supported by the high productivity of the Benguela upwelling ecosystem, abundant fish stocks typify Namibian waters. Fish resources in upwelling systems are typically high in biomass and relatively low in diversity (relative to non-upwelling environments). These stocks have traditionally supported intensive fishing activities. Although varying in importance at different times in history, fisheries have focused broadly on demersal species, small pelagic species, large migratory pelagic fish, linefish (caught both commercially and recreationally) and crustacean resources (e.g. lobster and crabs). In recent years, aquaculture has also become an important consideration in the nearshore area.

The following section is a broad review of the ecologically important species that may occur in or near the proposed mining for marine phosphate in Namibia. For each species the spatial distribution, recruitment (spawning behaviour) and dietary habits are considered. The maps used were prepared by CapMarine in the first State of Stocks Report undertaken for the Benguela Current Large Marine Ecosystem (BCLME) programme (now the BCC). The impacts assessment of the commercial fisheries themselves is provided in para 6.0.

3.1 Small Pelagic fish species

3.1.1 Horse mackerel

Off Namibia horse mackerel *Trachurus trachurus capensis* generally occur in waters between 200 – 1000 m depth (Crawford *et al*. 1987) (Figure 2). Adults are found mostly north of 21°S. Here spawning is highest between October and March in the mixing zone between warm oceanic water and cool coastal waters (O'Toole, 1977).

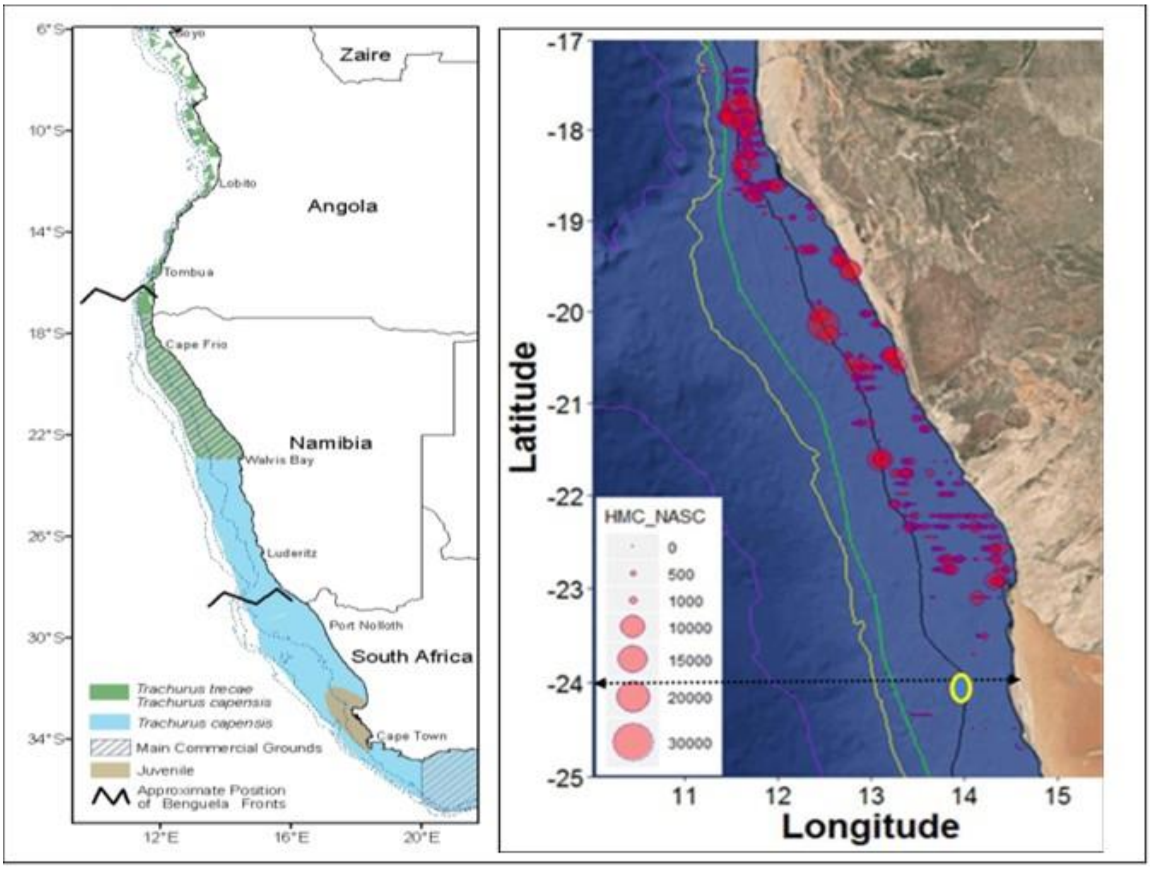

Figure 2. Broad distribution of the two horse mackerel species in the northern and southern Benguela (left) and recent survey biomass estimates (Uanivi et al. 2019). The dotted line approximates the northern-most location of the MLA and the circle SP-1)

Nursery grounds exist adjacent to these spawning grounds but closer to shore. Juveniles migrate south to Walvis Bay especially in winter. Maturing fish then move offshore and migrate north to spawn (Boyer & Hampton 2001a). Horse mackerel of up to two years of age feed predominantly on zooplankton that they consume near the sea surface. Research in the 1980s found that off Namibia 95% of the diet of adult horse mackerel comprised euphausiid shrimps (Konchina, 1986 cited in Boyer & Hampton 2001a). This is in contrast to horse mackerel occurring off South Africa which feed opportunistically on euphausiids, polychaete worms, squid, crustaceans and fish such as bearded goby *Sufflogobius bibartus* (Konchina, 1986 cited in Boyer & Hampton 2001a). Since the trophic structure of the northern Benguela system off Namibia has altered substantially in the last two decades (Kirkman, 2007, Utne-Palm *et al*. 2010) primarily as a result of anthropogenic effects including fishing and also climate change. For example, there may also have been a shift in diet of some species (including horse mackerel) to focus on the bearded goby *S. bibartus* which has become an increasingly important food source for predators (Crawford *et al*. 1987, Boyer & Hampton 2001a).

3.1.2 Sardine and Anchovy

Traditionally, spawning of sardine *Sardinops sagax* took place at two locations roughly 60 km off the Namibian coast: off Walvis Bay and further north at the meeting of the Benguela and Angola Current systems (O'Toole, 1977) (Figure 3).

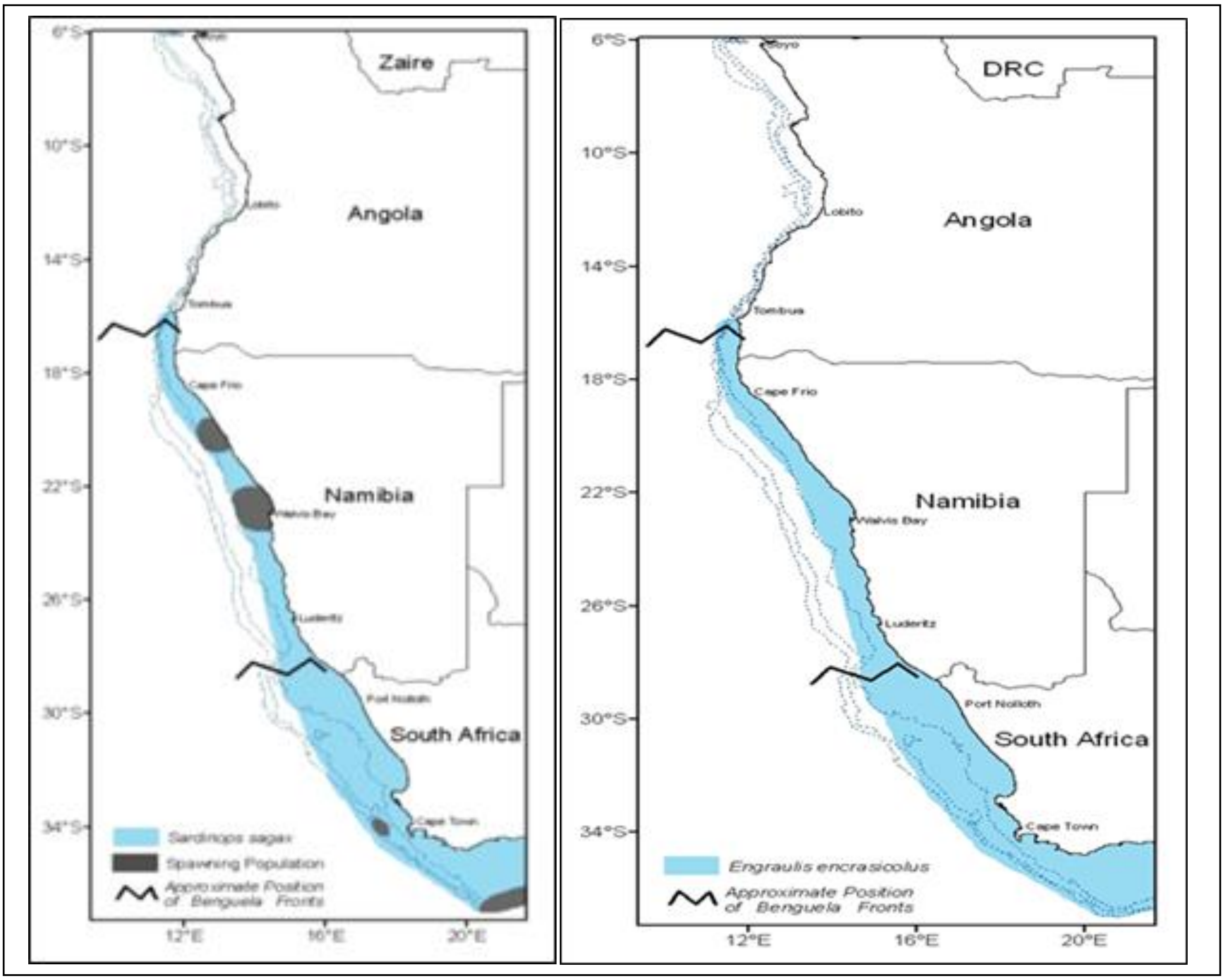

Figure 3. Distribution of Sardine (left) and anchovy (right) stocks in the northern and southern Benguela ecosystem

Spawning in the north was predominantly by young adults and peaked in late summer / autumn around the 200 m isobath (Crawford *et al*. 1987). In contrast, older fish spawned further south in summer, in cooler waters close to upwelling zones. Following spawning, larvae drifted southward along the coast. Sardine would then migrate northwards where juveniles and young adults would spawn for the first time. Adult fish would subsequently return to south to spawn off Walvis Bay (Boyer & Hampton, 2001a). Following the collapse of the sardine stock in the 1970s, spawning in the south is thought to have weakened (Crawford *et al*. 1987) as the migration of adult sardine has contracted (Boyer & Hampton, 2001a). While the diet of juvenile sardine is focused primarily on zooplankton, phytoplankton is also utilised by adults in areas where it is consistently available in high abundance (James, 1988).

The distribution (Figure 3) and movement patterns of anchovy *Engraulis encrasicolus* in Namibian waters were similar to those described for sardine. The only exceptions were that significant spawning by anchovy took place only north of Walvis Bay (Shannon & Pillar, 1986) and larvae occurred in high density further than 100 km offshore (O'Toole, 1977). Due to the very small size of current stocks, the present distribution and movement of anchovy off Namibia is unclear, but the life history of this species is likely to have changed from that previously recorded (Boyer & Hampton, 2001a). Anchovy feed predominantly on zooplankton (James, 1988). Differing size selectivity between sardine and anchovy is thought to minimise competition for food between these two co-existing species (Louw *et al*. 1998).

3.1.3 Red-eye round herring

Similar to other small pelagic species the round herring *Etrumeus whiteheadi* is widely distributed along the Namibian coast (Boyer & Hampton, 2001a). Spawning has not been explicitly studied in Namibian waters but is thought to occur throughout the year reaching a peak in late winter and early summer (Boyer & Hampton, 2001a). This species feeds almost entirely on zooplankton (James, 1988).

3.1.4 Snoek

An important predatory fish, snoek *Thyrsites atun* occur along the entire length of the Namibian coast (Boyer and Hampton 2001). The Lüderitz upwelling cell thought to separate the species into two separate stocks, although a certain amount of mixing does occur between the two (Griffiths, 2003). This species occurs mainly in cool upwelled waters where it is an important predator of small pelagic species (Crawford & de Villiers, 1985). There is no definitive description of snoek migrations in the Benguela system with regard to their exact spatial and temporal movements. Crawford et al. (1987)[8] do provide a schematic that is consistent with our understanding (Crawford et al. 1987). In the southern Benguela snoek availability coincides with peaks in the availability of other small pelagic species, notably anchovy and sardine (see Nepgen, 1979). The diet of snoek consists mainly of fish.

3.1.5 Bearded goby

The bearded goby *Sufflogobius bibarbatus* occurs from the Kunene River to the east coast of South Africa (Cruickshank *et al*. 1980). Juveniles of this species usually inhabit inshore waters shallower than 200m, with the greatest concentrations occurring within 10 km to 30 km of the coast (Cruickshank *et al*. 1980, Cruickshank, 1982 in Melo & Le Clus, 2005). In contrast adults occur across the shelf (Melo & Le Clus, 2005, Utne-Palm *et al*. 2010). Following the collapse of the Namibian sardine stocks, bearded gobies became an important food source for commercial fish such as hake and horse mackerel as well as seabirds and seals (Crawford *et al*. 1985, Crawford *et al*. 1987, Boyer & Hampton, 2001b). Recent research has shown that gobies have been able to sustain these levels of predation due to unique physiological and behavioural adaptions which enables them to inhabit environments which are inhospitable to their predators (Utne-Palm *et al*. 2010).

During the day bearded gobies rest on or hide in muddy sediments on the seafloor and feed on polychaete worms and diatoms which constitute an estimated 15% of their diet (Utne-Palm *et al*. 2010). While at the

[8] The Benguela ecosystem: Part IV. pg 438 and Nepgen (1979) in Fish. Bull. S Afr. 12:35-43.

sea bottom these fish are exposed to extremely low levels of oxygen and high levels sulphide, conditions which are fatal to most other organisms (including their predators). At night the gobies ascend into the water column where they reoxygenate and digest the food they consumed earlier (Utne-Palm *et al*. 2010). While in the water column bearded gobies tend to associate with jellyfish (which are avoided by their predators). Jellyfish account for up to 70% of the diet of bearded gobies (Utne-Palm *et al*. 2010) although it is unclear if this constitutes live jellyfish taken at night, or dead jellyfish which are consumed in the benthic environment during the day. This consumption of jellyfish is of significant ecological importance, as gobies make nutrients and energy available to their predators that would otherwise essentially be lost to the food chain (Utne-Palm *et al*. 2010).).

The diurnal migratory behaviour makes the goby available to a wide variety of predators, including pelagic seabirds, seals and a variety of fish. Since the collapse of the pelagic fishery off Namibia during the 1970s, the bearded goby has replaced sardine *Sardinops sagax* in the diets of many of the higher trophic levels within the system and it is now playing a key role within the regional food webs (Cury &Shannon, 2004). Despite the high level of predation pressure, the regional biomass of the bearded goby is increasing (Staby & Krakstad, 2006). Its success within the altered ecosystem off Namibia is likely to be a result of its physiological adaptions to hypoxic conditions as well as its ability to utilise the increasing jellyfish biomass and the bacteria-rich sediments for nourishment (van der Bank *et al*. 2011).

3.1.6 Meso-pelagic species

This is a broad group of species known a myctophids (lantern and lightfishes) that are important prey for many species (such as hake). Typically they have a strong diurnal variation commonly seen as a "feed" layer that migrates upwards at night and towards the seafloor during the day. Species such as the deep-water hake are known to follow these movements as they are primary prey. Historically, the meso-pelagic were best known in the southern Benguela through the work of Hulley[9] [10]. More recently the study of Duncan et. al. (2022) has focused on the northern Benguela [11] and has identified seven distinct assemblages characterized by water mass, oxygen concentration in the surface layer, and chlorophyll concentrations between 50 and 100 m. In the northern Benguela shelf area ("nBUS" as referred to by Duncan et. al. 2022) characterised by low oxygen concentrations, abundance was dominated by *Diaphus dumerilii (*Figure 4). In the southern Benguela shelf assemblage *Maurolicus walvisensis* dominated (see also Table 15 in Boyer et al. 2019). For the purposes of this assessment it is stressed that while meso-pelagic feed layers can be found on the shelf (being <500 m water depth), myctophids are mainly found in deep water and are not expected to be abundant shallower than 200 m water depth.

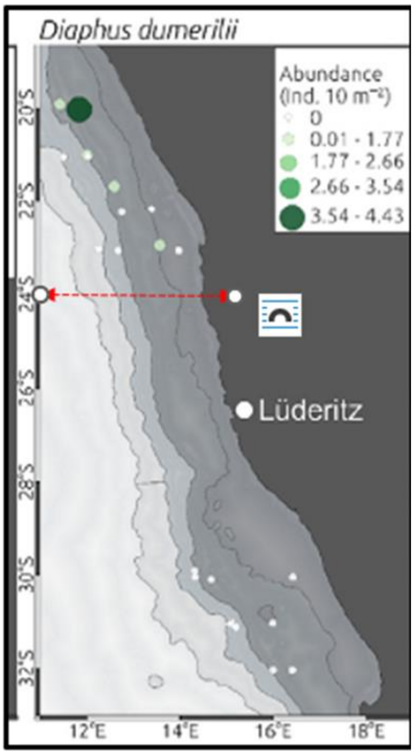

Figure 4. Abundance of the dominant mesopelagic species *Diaphus demerilii (*extracted from Duncan et. al. 2022). Note the highest abundance is in the northern Benguela on the shelf edge (about 500 m water depth). The line is the northern-most border of the MLA.

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[9] Hulley PA (1992) Upper-slope distributions of oceanic lanternfishes (Family: Myctophidae). Mar Biol 114: 365−383

[10] Hulley PA, Lutjeharms JRE (1989) Lanternfishes of Southern Benguela region. Part 3: the pseudoceanic−oceanic interface. Ann S Afr Mus 98: 409−435

[11] Duncan et. al (2022). Environmental drivers of upper mesopelagic fish assemblages in the Benguela Upwelling System Vol. 688: 133–152, 2022 https://doi.org/10.3354/meps14017

3.2 Demersal fish species

3.2.1 Hake

Two species of hake commonly occur in Namibian waters. These are deep-water hake *Merluccius paradoxus* and the shallower water species *M. capensis*. Both species occur along the entire length of the Namibian coast, although *M. paradoxus* occurs mainly off southern Namibia while *M. capensis* occurs predominantly north of 27°S (Burmeister, 2001) (Figure 5). There is some overlap of the Namibian and South African populations of both these species (Van der Westhuizen, 2001). The two species show some spatial separation with *M. capensis* occurring from the near-shore to depths of 400 m – 500 m and *M. paradoxus* focused at depths greater than 400m (Gordoa *et al*. 1995 cited in Sundby *et al*. 2001). A zone of overlap does, however, exist at inter-mediate depths where both species co-occur.

Hake are opportunistic feeders and as a result their diets vary both seasonally and spatially (Roel & Macpherson, 1988). Prior to reaching sexual maturity, juveniles of both species feed largely on planktonic crustaceans, pelagic gobies and lanternfish, with their diet becoming increasingly focussed on fish as they age (Punt *et al*. 1992). Squid and pelagic fish (e.g. lanternfish and lightfish) constitute a significant proportion of the diet of adult hake. However, the principal food items of larger fish are juvenile hake and other demersal fish (Punt *et al*. 1992). Diurnal vertical migration is known from both hake species, with individuals moving from the mid-water column at night to the sea floor during the day. This vertical migration pattern has been linked to nightly feeding in the water column (Punt et al. 1992). During the

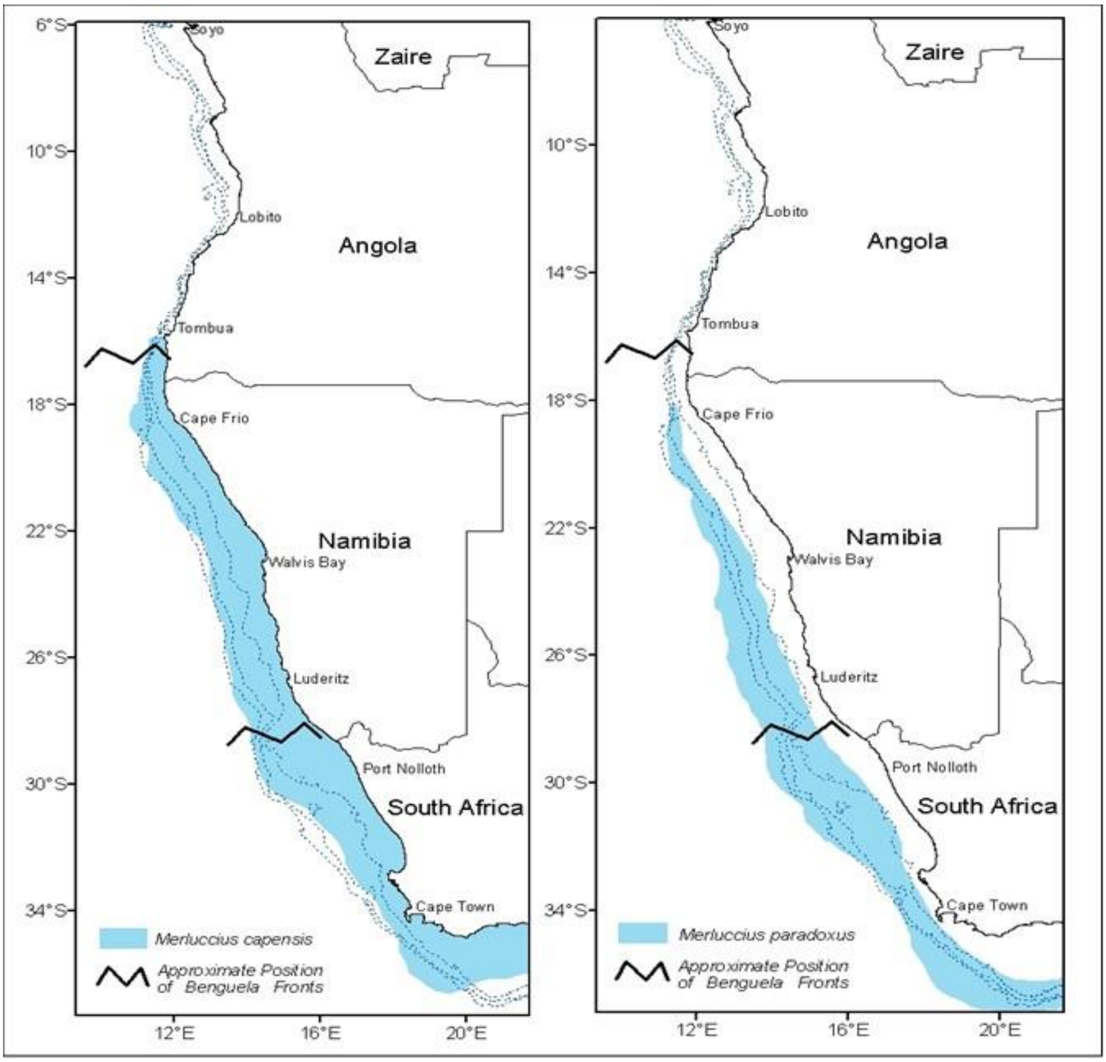

Figure 5. Distribution of M. paradoxus (right) and M. capensis (left) in the northern and southern Benguela ecosystem

day as light intensity increases, the risk of predation is thought to increase, causing hake to remain close to the bottom.

Spawning by *M. capensis* has been recorded along most of the Namibian coast from about 27°S to 18°S (Olivar & Shelton, 1993). While spawning occurs across a wide range, areas of localised spawning appear to be focused off central Namibia (25°S to 20°S), although the exact location varies between years (Assorov & Berenbeim, 1983 cited in Sundby *et al*. 2001, Olivar *et al*. 1988, Sundby *et al*. 2001) but these areas appear not to be permanent. For their first year of growth hake remain in a pelagic phase and aggregate inshore in nursery grounds. In their second year juveniles become demersal and systematically move offshore into deeper waters as they age. Recent genetic studies have suggested that the deep-water hake are transboundary between Namibia and South Africa, while the stocks of shallow water hake are likely separate stocks between the two countries (Henriques et al. 2016)[12].

The abundance of hake in Namibian waters specifically is also estimated annually through depth-stratified biomass surveys undertaken by MFMR (Boyer et al. 2019 & Paulus et al. 2020). These surveys provide valuable information on stock status of the two hake species including stock size structure, annual recruitment and important biological parameters of the most important commercial species (Paulus et al, 2020) and define density of both species base across the Namibian shelf (Figure 6).

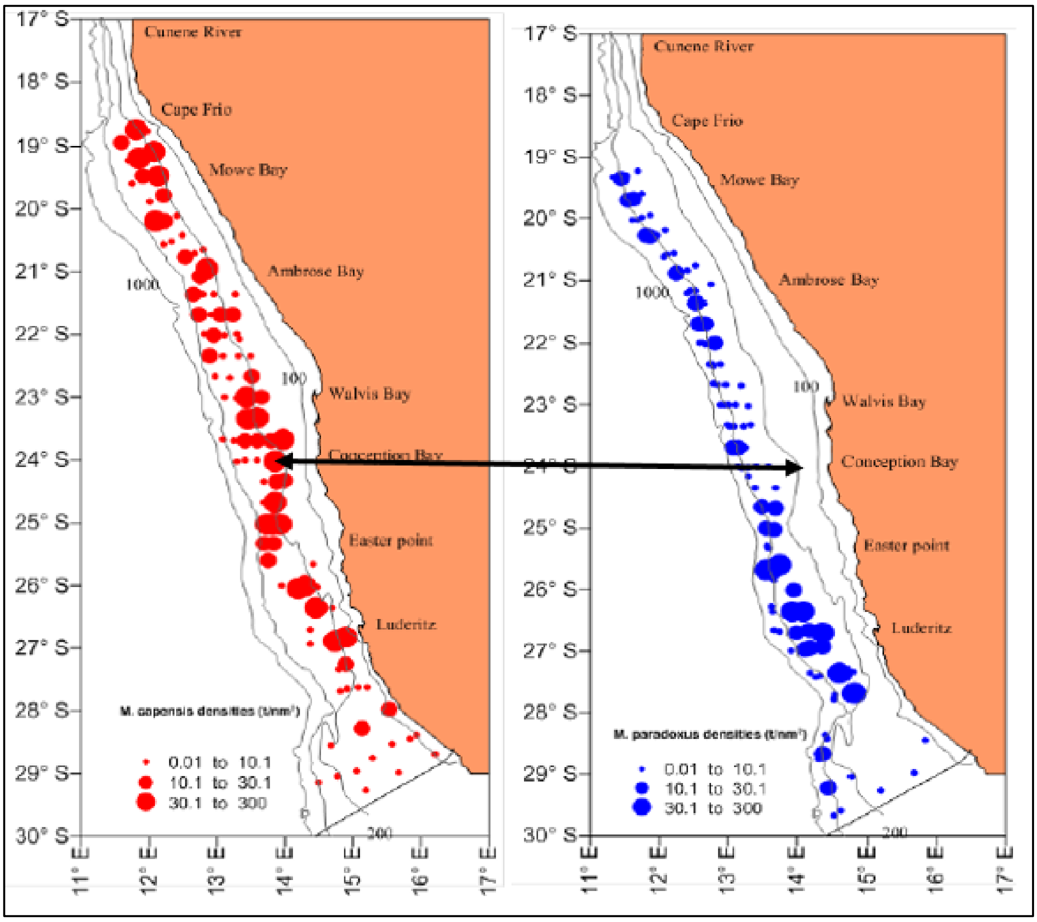

Figure 6. Density distributions (t/nm²) for the two species of hake: M. capensis (left) and M. paradoxus (right) from the Jan/Feb 2020 swept-area survey. Depth contours represent 100, 200,500 and 1000m respectively. The key reference for this assessment is the transect line along 24⁰ S west of Conception Bay.

[12] Henriques et. al. 2016. Spatio-temporal genetic structure and the effects of longterm fishing in two partially sympatric offshore demersal fishes (Molecular Ecology (2016).

3.2.2 Monkfish

Two species of monkfish are common in Namibian waters. *Lophius vomerinus* (Figure 7) occurs from northern Namibia to the east coast of South Africa (Boyer & Hampton, 2001a) and *L. vaillanti* occurs north of Walvis Bay (Maartens & Booth, 2001). While *L. vomerinus* inhabits the sea bottom from the tidal zone to depths of more than 600 m (Maartens *et al*. 1999), highest densities occur between 300 and 400 m off central Namibia (Maartens, 1999). This species spawns throughout the year with a peak in spawning taking place in late winter and summer (Maartens & Booth, 2005). Monkfish are known to recruit off Walvis Bay at depths of 150m and 300m, and near the Orange River at depths of 100 m to 300 m (Maartens & Booth, 2005). Monkfish are non-selective predators which lure their prey by moving their illicium (Gordoa & Macpherson, 1990). These fish feed during the day (Macpherson, 1985) with their most important prey being shallow water hake (*M. capensis*) (Maartens *et al.* 1999).

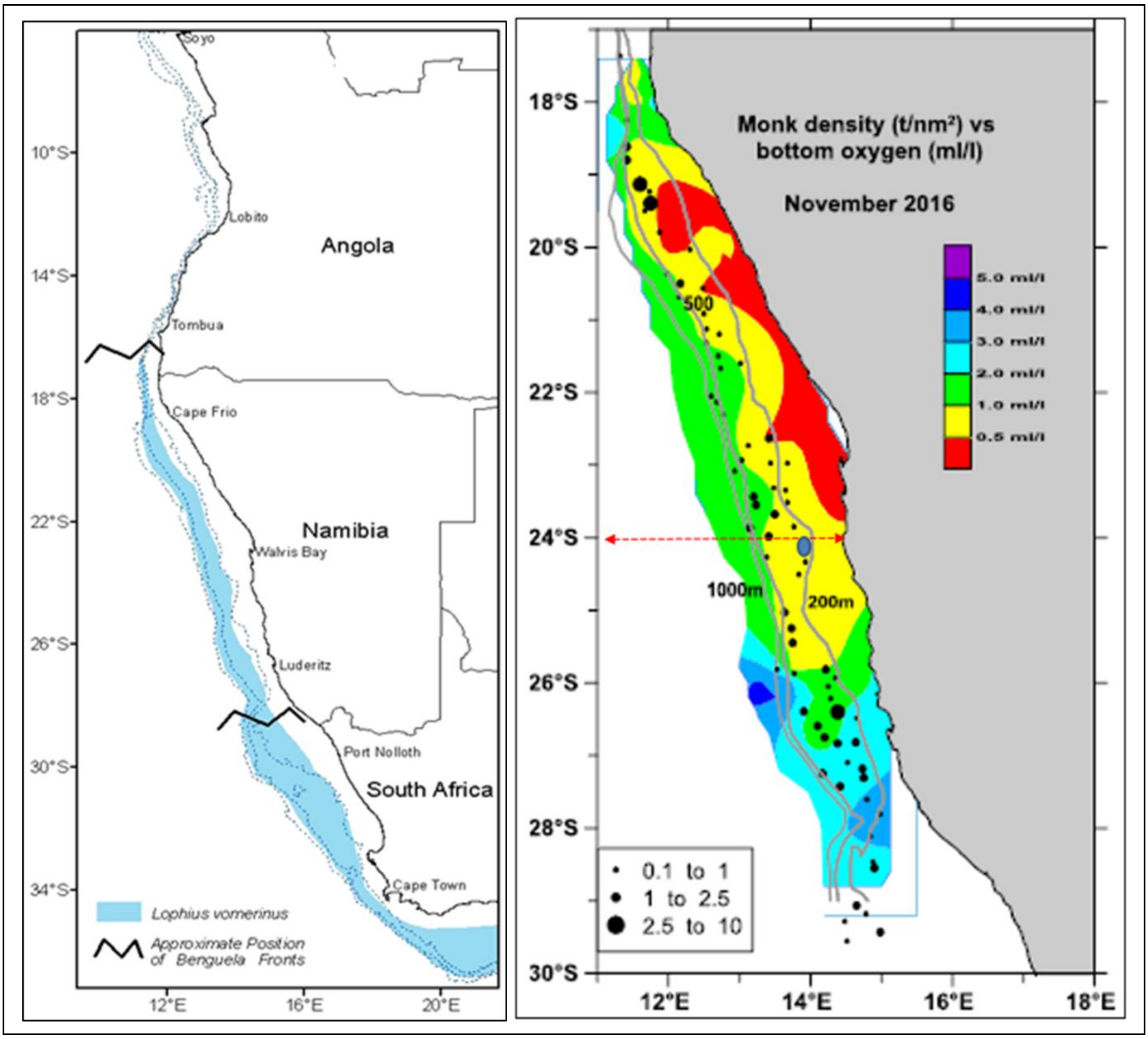

Figure 7. Distribution of monkfish in the northern and southern Benguela ecosystem (left). Monk densities from the most recent monk survey done by MFMR is shown on the right (Nangola et al. 2017). The dotted line and circle approximate the location of SP-1)

3.2.3 Sole

The west coast sole *Austroglossus microlepis* occurs from northern Namibia to False Bay in South Africa (Diaz de Atarloa 2002). *A. microlepis* inhabits muddy substrata at depths of 100-300m (Heemstra & Gon, 1995), where adults prey on polychaete worms, crustaceans, molluscs, and fish (e.g. gobies) (Bianchi *et al*. 1999). No information exists in the published literature regarding spawning and recruitment of west coast sole along the Namibian coast.

3.2.4 Orange roughy

Orange roughy *Hoplostethus atlanticus* is a deepsea species occurring at depths of 400 – 1400 m (Branch 2001). These fish are unusual in that they are very long-lived (> 100 years) and slow growing (reaching sexual maturity at around 25 years), have low fecundity and show low natural mortality (Boyer and Hampton 2001a, Boyer *et al*. 2001b, Branch 2001). Off Namibia this species has a restricted spawning period of less than a month in late July, when spawning takes place in dense aggregations close to the bottom in small areas typically between 10 and 100 km^2 in extent (Boyer and Hampton 2001b).

3.3 Large Pelagic fish species

There are numerous highly migratory large pelagic species found in the southern Atlantic waters, all of which are under international management (ICCAT). Two tropical tuna species (yellowfin and bigeye tuna) are fished in the Benguela system and third temperate water species (longfin tuna) comprises a sub-stock found in the south Atlantic. There are also small fisheries for swordfish and shark (mainly mako and blue shark). All are discussed briefly below.

3.3.1 Albacore Thunnus alalunga

Albacore *(longfin tuna)* is a temperate tuna widely distributed throughout the Atlantic Ocean and Mediterranean Sea. It is found throughout the BCLME region. It is a pelagic shoaling species occurring predominantly in temperate waters of all oceans. Juveniles smaller than 90 cm typically form large schools near the surface, while the adults occur much lower down in the water column and do not form large schools. The adults (over 90 cm) appear in subtropical and tropical waters while immature albacore are found in temperate waters. In the Atlantic, the larger size classes (80 to 125 cm) are associated with cooler water bodies while smaller individuals tend to occur in warmer strata. Albacore migrate seasonally and move from the southern Benguela (South African waters) into Namibia in late summer and autumn. Albacore are top carnivores and they opportunistically prey on schooling stocks of sardine, anchovy, mackerel and squid.

3.3.2 Yellowfin Tuna (Thunnus albacares)

Yellowfin tuna has a worldwide distribution and occurs widely throughout the BCLME region and forms part of an Atlantic population. The main spawning ground of this population is off Brazil and the equatorial zone of the Gulf of Guinea, with spawning primarily occurring from January to April. Juveniles are generally found in coastal waters off Africa. Larger fish are found further offshore, along the edge of the continental shelf. A single stock for the entire Atlantic is assumed.

3.3.3 Bigeye Tuna

Bigeye tuna are distributed throughout the Atlantic Ocean between 50º N and 45º S and occurs throughout the BCLME region. This species swims at deeper depths than other tropical tunas and exhibits extensive vertical movements. Similar to the pattern found in other oceans they exhibit clear diurnal patterns and are found much deeper during daytime than at night. Spawning takes place in tropical waters when the environment is favourable. From nursery areas in tropical waters, juvenile fish tend to diffuse into temperate waters, as they grow larger. Catch information from surface gears indicate that the Gulf of Guinea is a major nursery ground for this species. The dietary habits of bigeye tuna are varied and prey organisms include fish, molluscs and crustaceans.

3.3.4 Swordfish (Xiphias gladius)

Swordfish are found in the colder temperate waters during the summer and autumn months and can reach a maximum size in excess of 500 kg. They are distributed widely in the Atlantic Ocean and Mediterranean Sea. The results of recent genetic studies suggest the presence of three main populations, namely in the Mediterranean, Atlantic and Indo-Pacific. However, the precise boundaries between stocks remains uncertain, and mixing is expected to be highest at the boundary in tropical waters. Swordfish are however widely distributed in the BCLME region and form part of the "South Atlantic stock". They feed on a wide variety of prey including groundfish, pelagic fish, deep-water fish, and invertebrates and are believed to feed throughout the water column, and undertake extensive diel vertical migrations. Swordfish spawn in the warm tropical and subtropical waters throughout the year, although seasonality has been reported in some areas.

3.2.5 Pelagic Shark

3.3.5.1 Shortfin mako (*Isurus oxyrinchus*)

The shortfin mako shark is a coastal and oceanic species, with a circum-global distribution in all temperate and tropical seas. It is found throughout the BCLME region. It is a common, extremely active, offshore littoral and epipelagic species found in tropical and warm-temperate seas. This shark occurs from the surface down to at least 500 m, mostly in waters well offshore, but penetrates the inshore littoral just off the surf zone in places such as parts of KwaZulu-Natal, South Africa, where the continental shelves are very narrow. Shark meshing data off South Africa suggests that this species prefers clear water to turbid water and is caught at a range of water temperatures from 17 to 22°C. They feed primarily on other fishes, with a wide variety of prey recorded.

3.2.5.2 Blue shark (*Prionace glauca*)

The blue shark is a highly migratory species in the Atlantic and is the most commonly occurring pelagic shark species in the Benguela ecosystem. Their migratory patterns are complex and encompass great distances, but are not well known. Blue shark movements are strongly influenced by water temperature and this species undergoes seasonal latitudinal migrations on both sides of the North and South Atlantic. The blue shark feeds heavily on relatively small prey, especially bony fishes and squid. Much of the prey of the blue shark is pelagic, though bottom fishes and invertebrates are also part of their diet.

3.4 Other Important Exploited Species

3.4.1 West Coast Rock Lobster (Jasus lalandii)

The west coast rock lobster occurs from Cape Cross to the east coast of South Africa, significant densities only occur south of Meob Bay (Cockcroft, 2001). The spawning cycle of this species is strongly related to the annual moulting cycle. Males moult in spring and mating takes place after the females have moulted in late autumn and early winter (Boyer & Hampton, 2001a). Females carry their eggs until they hatch in October and November, releasing planktonic larvae (Pollock, 1986). These larvae remain in the plankton for a period of months before becoming free-swimming (Crawford et al. 1987) and settling in near-shore rocky areas. Adults generally occur further offshore than juveniles, except in central Namibia where the whole population is forced close to the shore by low-oxygen conditions

(Pollock & Beyers, 1981). Seasonal variability in dissolved oxygen near the seabed also drives seasonal changes in the depth distribution of adult lobsters (especially males) (Grobler & Noli-peard, 1997). The diet of west coast rock lobster is dominated by mussels (especially *Aulacomya ater*), except in areas where mussel abundance is low and lobsters feed on a variety of invertebrates such as sea urchins, starfish, gastropods and seaweeds (Pollock & Beyers, 1981).

3.4.2 Deepsea Crab (Chaceon maritae)

There are several deepwater crab species in the BCLME, though only one is targeted commercially (Chaceon spp). There are thought to be at least three Chaceon species in the region, *C. macphearsoni* off the South African southeast coast, *C. chuni* off the South African west coast and *C. maritae* off Namibia. Only *C. maritae* is however the only commercially exploited species and is distributed along the West African coast from South Africa northwards to roughly 5° S between depths of 300-1000 m. The stock is therefore "shared" between Namibia and Angola where there are viable commercial fisheries. The stock could also extend further south into South African waters where their abundance is much reduced and considered in non-commercial quantities. The stock is therefore transboundary in the BCLME area, extending beyond the economic zones of the coastal states (high seas) and falls also within the mandate of the South East Atlantic Fisheries Organization (SEAFO).

3.4.3 West coast steenbras (Lithognathus aureti)

Two stocks of west coast steenbras occur in Namibian waters, a southern population around Meob Bay and a northern population in central and northern Namibia (Holtzhausen & Kirchner, 2001a). The southern population falls within the restricted area of the Namib-Naukluft Park. No spawning migration is known for this species, although males of the northern population appear to disperse south in search of gravid females (Holtzhausen et al. 2001). The diet of this species is focused on the mussels *Choromytilus meridionalus* and *Perna perna* (Holtzhausen & Kirchner, 2001b).

3.4.4 Silver kob (Argyrosomus inodorus)

Silver kob occurs along the entire length of the Namibian coast but are most abundant from Meob Bay to Cape Frio (Kirchner & Voges, 1999). Namibian stocks are distinct from those occurring off South Africa (Van der Bank & Kirchner, 1997). Spawning adults move southwards from the northern end of their distributional range in early summer. Spawning occurs at Meob Bay and Sandwich Harbour (Holtzhausen *et al*. 2001). From here larvae drift northward to the nursery area between Sandwich Harbour and the Ugab River mouth. Two years after spawning juveniles reach the area north of the Ugab River. It is to this same area that adults return after spawning (Kirchner & Holtzhausen, 2001). In northern Namibia silver kob feed mainly on pelagic fish, shrimps and squid, whereas in the central and southern Namibia shrimps dominate the diet of these fish (Kirchner, 1999).

4 Receiving Environment Baseline - Commercial Fisheries

A review of the Namibian fisheries is provided in the following section. Note although all the fishing sectors were examined only the sectors that could potentially be impacted on by the phosphate mining project are included in this report. For each fishing sector the geographic extent of the fishery, fishing methods, gear, catches and environmental impacts of the fishing are considered. Namibia's 200 nautical mile Exclusive Economic Zone (EEZ) supports some 20 different commercially exploited marine species with most stocks considered to be sustainably utilized. Namibia is Africa's fourth largest capture fisheries nation behind Morocco, South Africa and Mauritania, and 36th worldwide.[13] The fishing industry is therefore an important part of the Namibian economy (behind mining and tourism) and is estimated to provide some 16 800 direct jobs (Ministry of Fisheries and Marine Resources, 17 February 2017) - 70% of which are in the hake sector. Mariculture production is a developing industry based predominantly in Walvis Bay and Lüderitz Bay and surrounds.

The two main Namibian commercial species are hake and horse mackerel with some other species of lesser commercial importance. These included orange roughy (fishery closed), the deepwater crab trap fishery, monk, rock lobster and the large pelagic fisheries for tuna. Note also that sardine stocks in Namibia collapsed prior to independence in 1990 and have not recovered (there is a moratorium on fishing for sardine in Namibian waters currently). The main commercial fisheries, targeted species and gear types are shown in Table 1 and recent TACs are presented in Table 2. The allocation of TACs and management of each fishing sector is the responsibility of MFMR.

Table 1. List of fisheries that operate within Namibian waters, targeted species and gear types.

Sector	Gear Type	Target Species
Small pelagic	Purse-seine	Sardine (*Sardinops sagax*), Horse mackerel (*Trachurus capensis*)
Mid-water trawl	Mid-water trawl	Horse mackerel (*Trachurus capensis)*
Demersal trawl	Demersal trawl	Cape hakes (*Merluccius paradoxus, M. capensis*), Monkfish (*Lophius vomerinus)*
Demersal long-line	Demersal long-line	Cape hakes (*Merluccius paradoxus, M. capensis*)
Large pelagic long-line	Pelagic long-line	Albacore tuna (*Thunnus alalunga*), Yellowfin tuna (*T. albacares*), Bigeye tuna (*T. obesus*), Swordfish (*Xiphias gladius*), shark spp.
Tuna pole	Pole and line	Albacore tuna
Deep-sea crab	Demersal long-line trap	Red crab (*Chaceon maritae*)
Deep-water trawl	Demersal trawl	Orange roughy (*Hoplostethus atlanticus),* Alfonsino (*Beryx splendens*)
Rock Lobster	Demersal trap	Rock lobster (*Jasus lalandii*)
Line-fish	Hand line	Silver kob (*Argyrosomus inodorus*), Dusky kob (*A. coronus*)
Mariculture	Long-lines, rafts	Pacific oysters, European oysters, Black mussel, Seaweed (Gracilaria sp.)

[13] Wikipedia, February 2017. https://en.wikipedia.org/wiki/Fishing_industry_by_country

Table 2: Total Allowable Catches (tons) from 2010/11 to 2021/22 (supplied by Ministry of Fisheries and Marine Resources, Namibia).

Year	Sardine (Pilchard)	Hake	Horse Mackerel	Crab	Rock Lobster	Monk
2010/11	25 000	140 000	247 000	2700	275	9 000
2011/12	25 000	180 000	310 000	2850	350	13 000
2012/13	31 000	170 000	310 000	3100	350	14 000
2013/14	25 000	140 000	350 000	3100	350	10 000
2014/15	25 000	210 000	350 000	3150	300	12 000
2015/16	15 000	140 000	335 000	3446	250	10 000
2016/17	14 000	154 000	340 000	3400	240	9800
2017/18	0	154 000	340 000	3400	230	9600
2018/19	0	154 000	349 000	3900	200	9600
2020/21	0	154 000	349 000	3900	180	9600
2021/22		154 000	330 000	4200	180	

Note 1: Deepwater trawl TAC is currently not applied for Alfonsino and Orange Roughy. There is no TAC (output control) for albacore tuna – this is an effort (input) controlled sector with no restriction on catch.
Note 2: Namibian fisheries statistics data can also be found on the Namibian Profiles on the FAO websites : www.fao.org

Namibia has only two major fishing ports from which all the main commercial fishing operations are based namely, Walvis Bay and Lüderitz. In central Namibia, the major port is Walvis Bay and it is from this port that the majority of fishing vessels operate. Most of the fishing conducted from this port is, for economic and logistical reasons, directed at fishing grounds in the central and northern part of Namibia and to a lesser extent the southerly fishing grounds towards the South African border. A significant amount of fishing activity also takes place from Lüderitz, from where hake trawlers and longliners operate, as well as a small rock lobster fishery based in southern Namibian waters.

There are currently 116 Namibian-registered commercial fishing boats. The dominant fleet comprises demersal trawlers that include both large freezer vessels (up to 70 m in length), as well as a smaller fleet of monk trawlers. These vessels fish year-round the entire length of the Namibian EEZ from the northern border with Angola to the southern border with South Africa. (with the exception of a one month closed season for hake in October). The only other fleets of significance are the mid-water trawlers that target horse mackerel and the large pelagic tuna long-line vessels. Currently these large midwater trawl vessels (mostly >100 m in length) operate in the northern waters of Namibia and are restricted to fewer than 20 vessels. There is a 200 m fishing depth restriction for all forms of trawling (midwater and bottom). The main reason for this is not articulated anywhere though it is understood to have its foundation in protecting "recruitment" aimed at stock rebuilding and recovery of hake and other commercial stocks that had been heavily over-exploited prior to independence.

The large pelagic (tunas and shark) long-line vessels operate broadly in Namibian waters, but unlike the mid-water vessels, concentrate in the south near the South African border targeting the migrations of albacore and yellowfin tuna. The numbers of these vessels varies and is dependent on the seasonal availability of tuna and tuna-like species. The tuna pole (baitboat) vessels are a small fleet[14]. The tuna long-liners are also variable with the number of licenses issued to both Namibian flags and others (mostly Asian) fluctuating annually. The extent and number of these vessels is difficult to ascertain (as they are unpublished), although the actual numbers are limited and are less than the numbers of licensed Namibian boats.

There are few known foreign fishing vessels licensed to fish in Namibian waters, although the majority of the current mid-water fleet have permits to fish under foreign flag registration, but as a rule all licensed fishers must reflag under Namibia.

4.1 Hake Fisheries and Other Bottom-Trawl Sectors

4.1.1 Hake Demersal Trawl

The most economically important species in Namibia is hake. A fleet of 71 demersal trawlers are currently licensed to operate within the fishery and their principal target species are the hakes Merluccius capensis and M. paradoxus with the latter caught mainly in deeper waters towards the South African border. Trawl gear configurations are similar for both freezer and wet-fish vessels, the main elements of which are trawl warps, bridles and doors, a footrope, headrope, net and codend (Figure 8). Typical demersal trawl gear configuration consists of i) steel warps up to 32 mm diameter - in pairs up to 3 km long when towed; ii) a pair of trawl doors (500 kg to 3 tons each); iii) Net footropes which may have heavy steel bobbins attached (up to 24" diameter) as well as large rubber rollers ("rock-hoppers"); and; iv) net mesh (diamond or square shape) is normally wide at the net opening whereas the bottom end of the net (or cod-end) has a 110 – 130 mm stretched mesh.

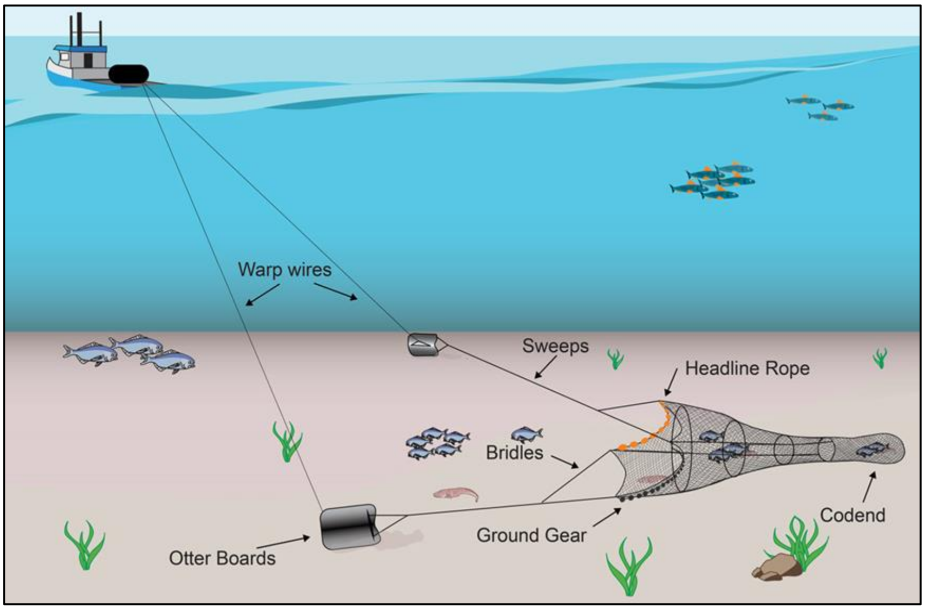

Figure 8. Typical bottom trawl configuration as deployed by Namibian hake and monk vessels. Source: http://www.afma.gov.au/portfolio-item/trawling)

[14] The baitboat fleet consists of up to 20 Namibian vessels. This is a small number of vessels compared to South Africa. However, because of the variable and migratory nature of tuna, the number of vessels participating in the fishery varies depending on the seasonal and inter-annual availability of tuna.

The opening of the net is maintained by the vertical spread of the trawl doors, which are in contact with the seafloor. Generally, trawlers tow their gear at 3.5 knots for up to four hours per drag. When towing gear, the distance of the trawl net from the vessel is usually between two and three times the depth of the water. The horizontal net opening may be up to 50 m in width and 10 m in height. The swept area on the seabed between the doors may be up to 150 m.

Catches of hake in Namibian waters (Figure 9) reached almost 1 million tons in the mid-1970s at the peak of their exploitation (some believe this was a gross underestimated) and was fished by many nations including eastern-block countries, South Africa and Spain. The fishery is currently managed by a TAC, which varies from year to year but approximates 154 000 tons (2020/2021). TACs for hake and monkfish over the period 1991 to 2018 are shown in Figure 10 . The fishery is active year-round except for a closed period during October each year (Figure 11).

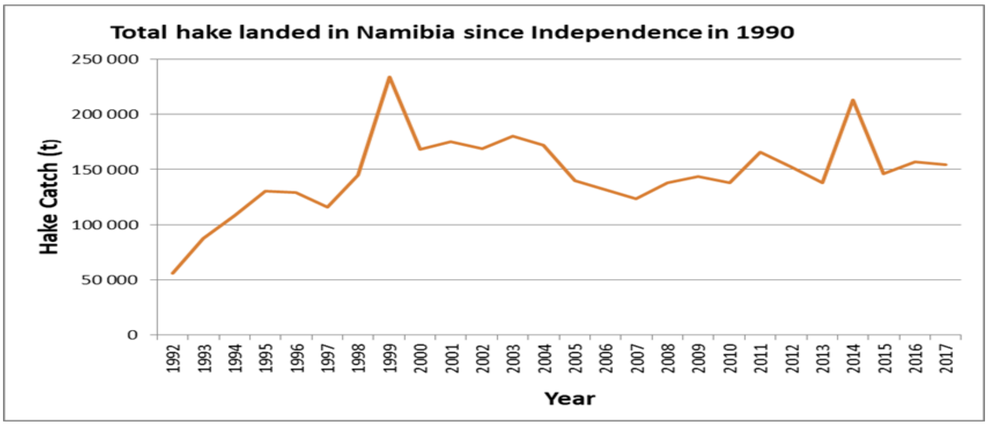

Figure 9. Time series of catches of hake in Namibian waters. Catches in recent years have stabilised at 154 000 t.

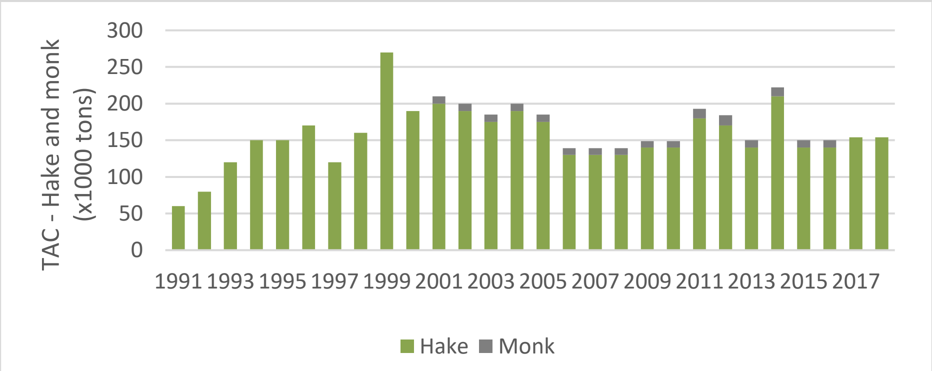

Figure 10. Total Allowable Catch set for Hake and Monkfish from 1991 to 2018.

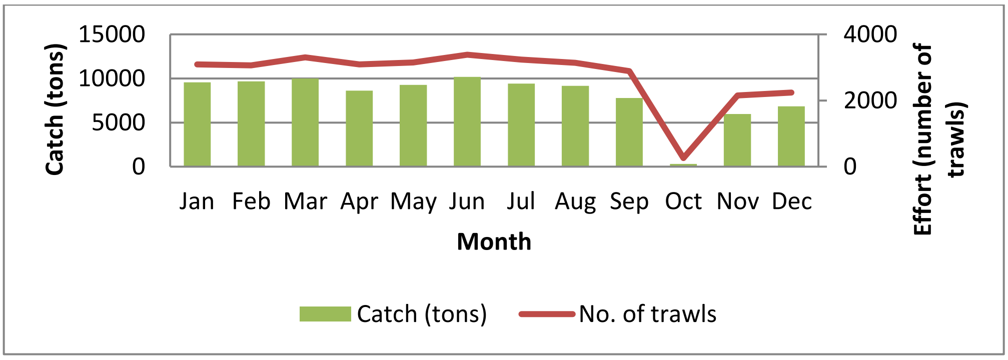

Figure 11. Average landings by month reported for wetfish trawlers from 2005 to 2017.

Fishing grounds extend along the entire coastline following the distribution of hake and monkfish along the continental shelf at a depth range of 200 m to 850 m. The total extent of fishing grounds used by the demersal trawl fleet is approximately 78,895 km^2. The spatial distribution of hake trawl effort has not changed noticeably since last assessment, which is also confirmed by the MARISMA marine spatial assessment (Figure 12) with BCC data inset for comparison) and hake surveys undertaken by MFMR (Figure 6). The most recent fines scale data are provided in (Figure 35) for the assessment of impacts.

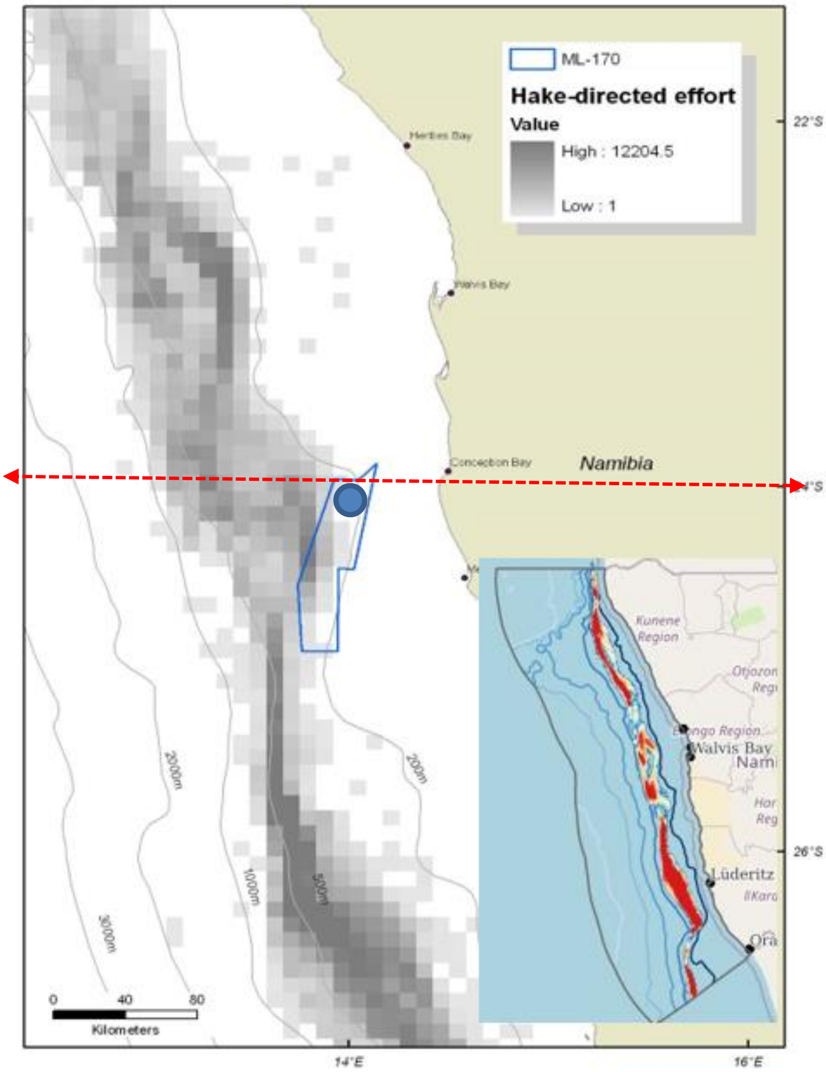

Figure 12. ***Distribution of fishing effort by the hake-directed demersal trawl fishery with respect to phosphate Mining Licence Area from 2005 to 2009 with recent marine spatial information (MFMR, 2018). The location of SP-1 and location of the 20-year mining area within the MLA is circled. The dotted line approximates the latitude of the transect line used by MFMR in demersal surveys***

4.1.2 Hake Demersal Longline

Similar to the demersal trawl fishery the target species of this fishery is the Cape hakes, with a small non-targeted commercial by-catch that includes kingklip. Typical gear used is shown in Figure 13 though this may vary slightly between operators. A demersal long-line vessel may deploy either a double or single line which is weighted along its length to keep it close to the seafloor. Steel anchors, of 40 to 60 kg are placed at the ends of each line to anchor it. These anchor positions are marked with an array of floats. If a double line system is used, top and bottom lines are connected by means of dropper lines. Since the top-line (polyethylene, 10 – 16 mm diameter) is more buoyant than the bottom line, it is raised off the seafloor and minimizes the risk of snagging or fouling. The purpose of the top-line is to aid in gear retrieval if the bottom-line breaks at any point along the length of the line. Lines are typically 20 – 30 nautical miles in length. Baited hooks are attached to the bottom line at regular intervals (1 to 1.5 m) by means of a snood. Gear is usually set at night at a speed of 5 – 9 knots.

Once deployed the line is left to soak for up to eight hours before retrieval commences. A line hauler is used to retrieve gear (at a speed of approximately 1 knot) and can take six to ten hours to complete. Long-line vessels are similar in size and power to wet-fish trawlers and may vary in length from 18 m to 50 m and remain at sea for four to seven days at a time. The catch packed unfrozen, on ice, and is landed as either prime quality (PQ) or headed and gutted. A total hake TAC of 154 000 tons was set for 2020/21 (Figure 14) but less than 10 000 tons of this is caught by longline vessels. Annual landings recorded by the sector from 2005 to 2018 is shown in Figure 14. Vessels operate year-round but operations are particularly low in October (see Figure 15). Long-line vessels fish in similar areas targeted by the hake-directed trawling fleet, in a broad area extending from the 200 m to 650 m contour along the full length of the Namibian coastline.

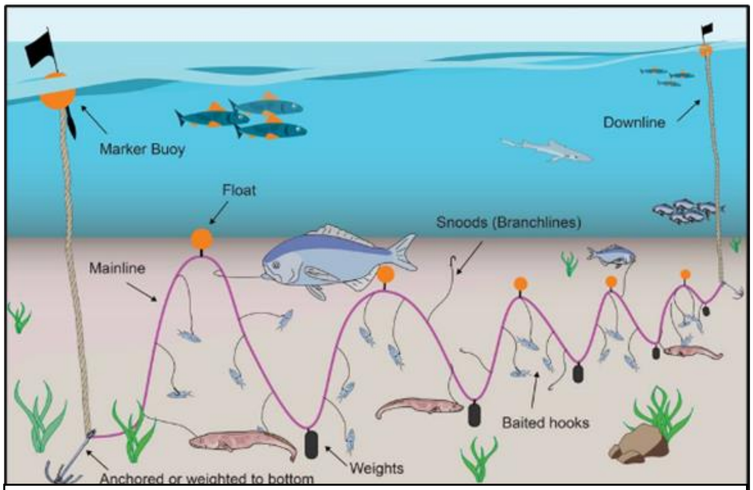

Figure 13. Schematic diagram of gear typically used by the demersal long-line fishery (Source: http://www.afma.gov.au/portfolio-item/longlining).

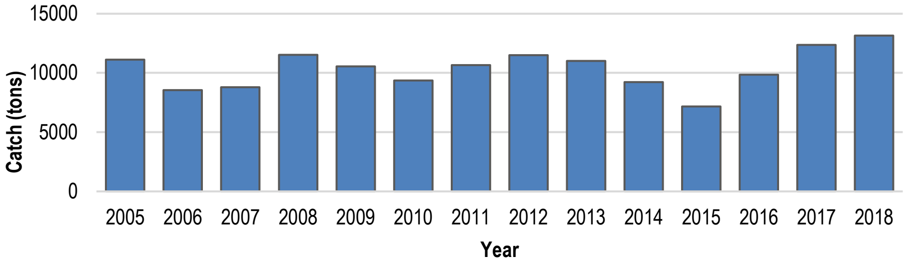

Figure 14. Annual Landings of hake by demersal longliners in Namibian waters

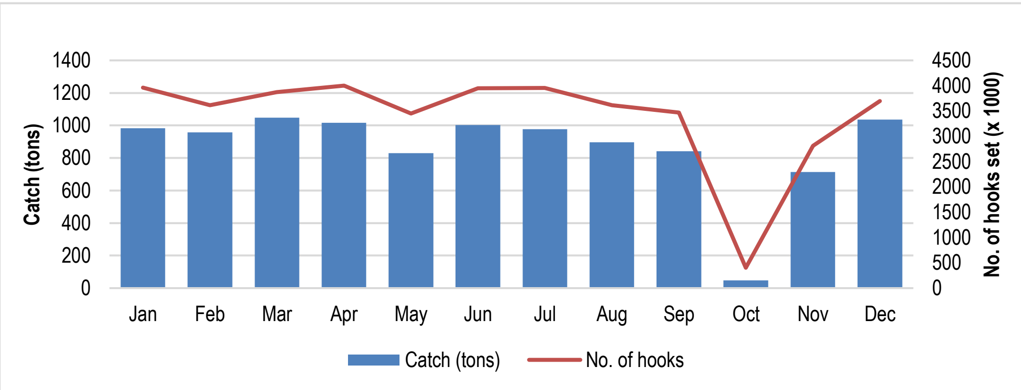

Figure 15. Average monthly catch (tons) recorded by the Namibian demersal long-line sector between 2005 and 2018.

Some 18 vessels may operate within the sector. Those based in Lüderitz mostly work South of 26°S towards the South Africa border while those based in Walvis Bay operate between 23°S and 26°S and North of 23°S.

The catch distribution of the fleet is similar to that shown for the hake-directed trawl fleet in Figure 12 and the recent effort in area of the MLA provided Figure 35

4.1.3 Monk-Directed Demersal Trawl

Smaller trawlers fish inshore for monkfish (Lophius spp.) and sole. Monkfish is found along the entire extent of the Namibian coast, with the fishery concentrated between 17°15'S and 29°30'S at depths of 200 m to 500 m (Figure 7). Spawning is irregular and variable and is thought to occur throughout the year (Macpherson 1985) with two separate areas of recruitment recorded between the 100 m and 300 m isobaths off Walvis Bay and Lüderitz (Leslie and Grant 1990). The directed fishery includes a small portion of sole. The spatial extent of the fishery is similar to the hake wetfish fleet(Figure 12), although the habitat preference of monk and sole for soft muddy substrate means a higher level of effort in these areas. The broad distribution of Monk is shown in the MARISMA data (BCC, 2022) in Figure 16 and the most recent fishing effort in Figure 36.

Figure 16. Spatial extent of the monk & sole-directed bottom trawl fishery in Namibia (BCC, 2022). Approximate location of SP-1 relative to monk fishery locations is shown by the circle

4.1.4 Deep-water Trawl Fishery

Aggregations of the deep-water species Orange Roughy (*Hoplostethus atlanticus)* are a much sort after deepwater commercial species found in Namibian waters in the mid-1990s. Deepwater species are normally long-lived and aggregate densely, leading to high catch rates. Fishable aggregations are usually found on hard grounds on features such as seamounts, drop-off features or canyons (Branch, 2001). The fishery however had a relatively short lifespan and catches declined over a period of 10 years (Figure 17) and is now reduced to a small research allocation aimed at annually determining the stock biomass.

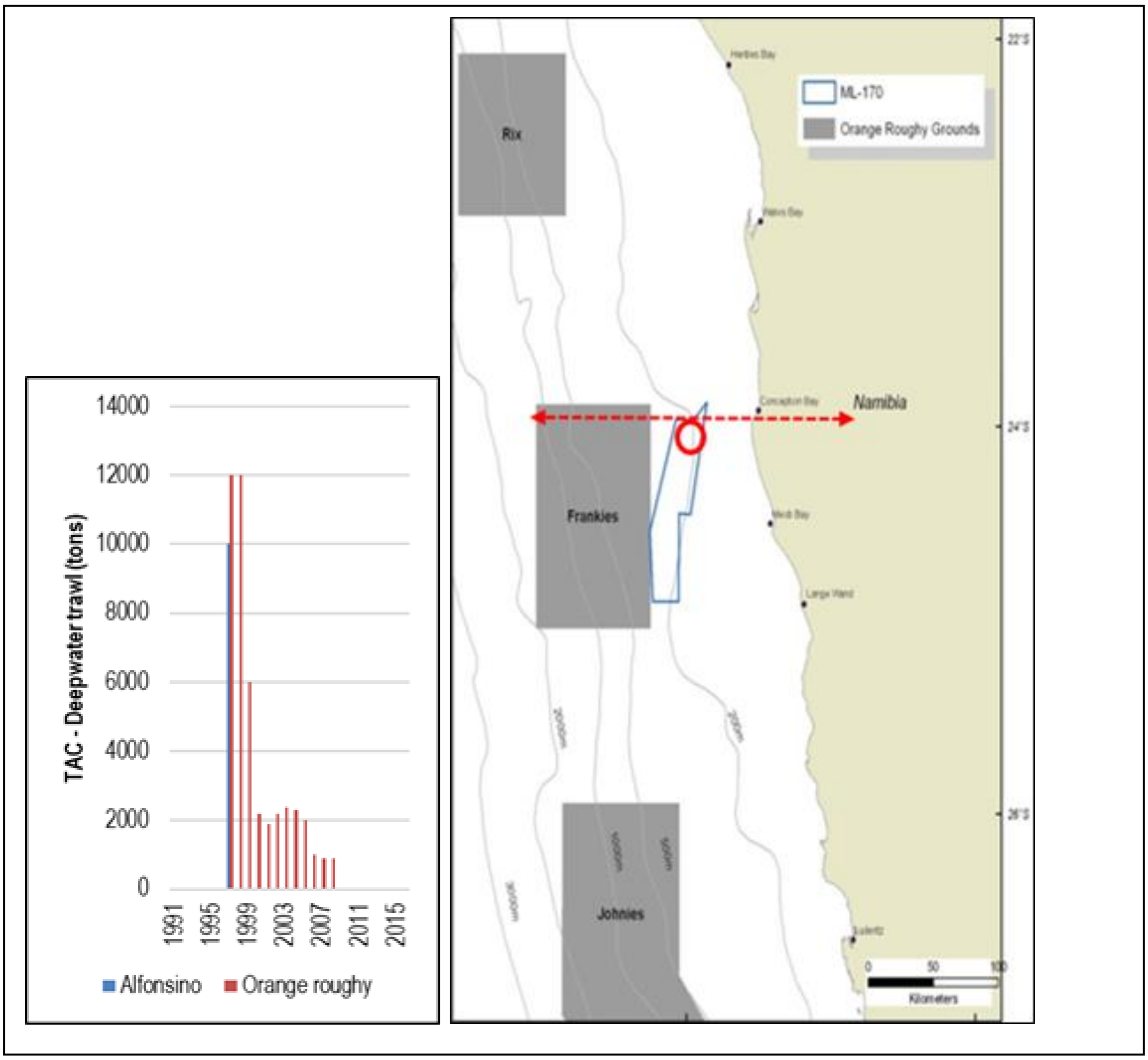

Figure 17. Catches (left) and main commercial fishing grounds in the Namibian deep-water trawl fishery comprising of the two main species, Orange roughy and Alfonsino.

Orange roughy has a discontinuous pattern of distribution along the continental slope with concentrations of fish within four known spawning grounds (within designated Quota Management Areas (QMAs) within the Namibian EEZ. The species has a short, intense spawning period of about a month from July to August (Boyer and Hampton 2001) during which period individuals aggregate. The fishery uses a similar gear configuration to that used by the demersal hake-directed trawl fishery though specific areas fished do not overlap.

4.2 Small pelagic fisheries

4.2.1 Mid-water Trawl Fishery for Horse Mackerel

The fishery for Cape horse mackerel (*Trachurus capensis*) is the largest contributor by volume and second highest contributor by value to the Namibian fishing industry. The stock is caught mainly by the mid-water trawl (Figure 18) fishery (targeting adult horse mackerel) and more recently by a directed pelagic purse-seine fishery. The midwater fishery operates using trawls within the water column above the sea floor to catch large schools of adult horse mackerel.

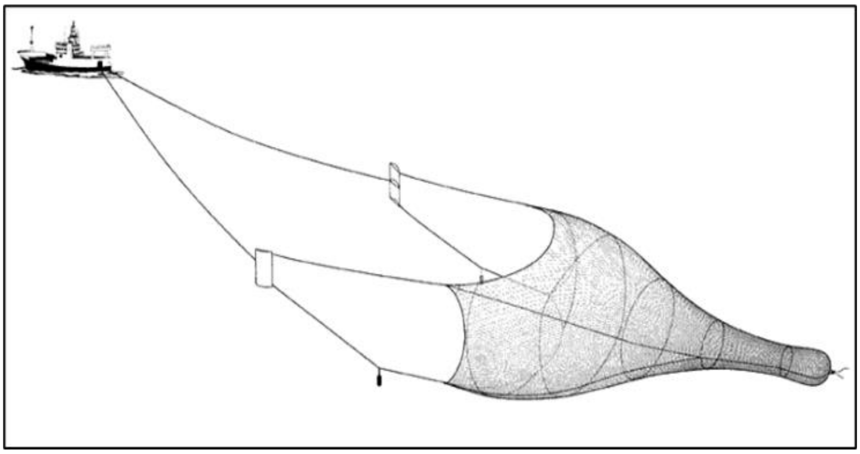

Figure 18. Typical midwater trawl configuration used by Namibian vessels targeting horse mackerel

Trawl warps are heavy, ranging from 32 mm to 38 mm in diameter. Net openings range from 40 m to 80 m in height and up to 120 m in width. Weights in front of, and along the ground-rope assist in maintaining the vertical opening of the trawl. To reduce the resistance of the gear and achieve a large opening, the front part of the trawl net is usually made from very large rhombic or hexagonal meshes. The use of nearly parallel ropes instead of meshes in the front part is also a common design. On modern, large mid-water trawls, approximately three quarters of the length of the trawl is made with mesh sizes above 400 mm.

The history of the sector in Namibian waters shows initial low catches reported in the early 1960s and a fluctuating but overall increase to a maximum of 600 000 tons in the early 1980s. Since the 1990s landings were on average 300 000 tons per year and the current TAC for horse mackerel is 349 000 tons (2018/19). Figure 19 shows the TACs set from 1997 to 2018 for the pelagic and mid-water fisheries targeting the Namibian stock of horse mackerel.

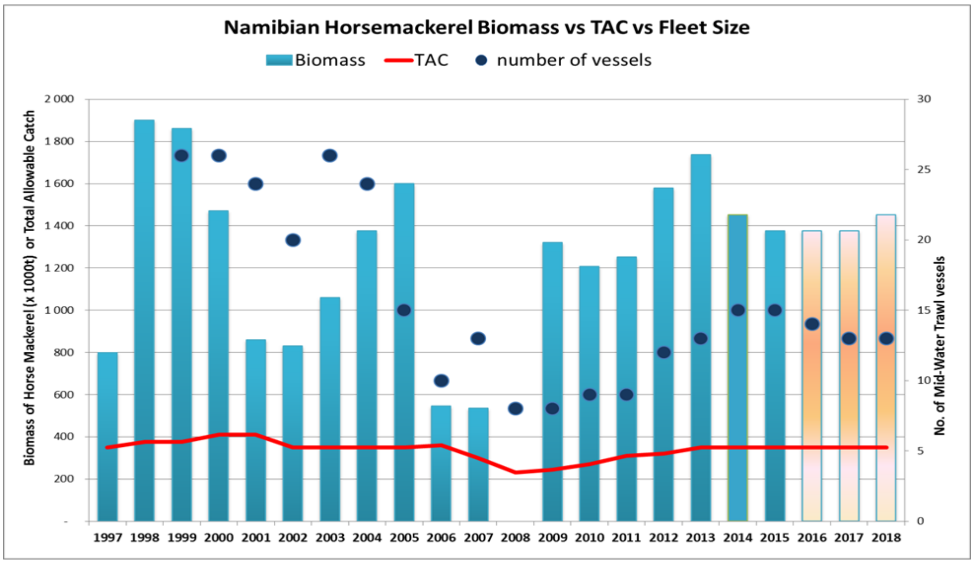

Figure 19. Catches (mid water and purse seine) and TACs set for the Namibian stock of Cape horse mackerel from 1997 to 2009 (Kirchner et al 2010)

Mid-water trawl fisheries are not usually considered to have significant impacts on benthic biodiversity (Atkinson & Sink, 2008). Nonetheless, as they tow their nets at a relatively high speed they regularly entangle sea birds, sharks, dolphin and seals (Nel, 2004). The catch is either converted to fishmeal or sold as frozen, whole product with landings for the year 2006 valued at N$800 million and job creation under Government's National Development Plan, NDP 5, together with development of mariculture (National Planning Commission, 2016)[15]. The spatial distribution of the fishery is shown in Figure 20 with the MARISMA data (inset). The most recent data for the fishery is shown in the assessment (Figure 37). The fishery is operational mainly north of 24^0 S (see also Figure 2).

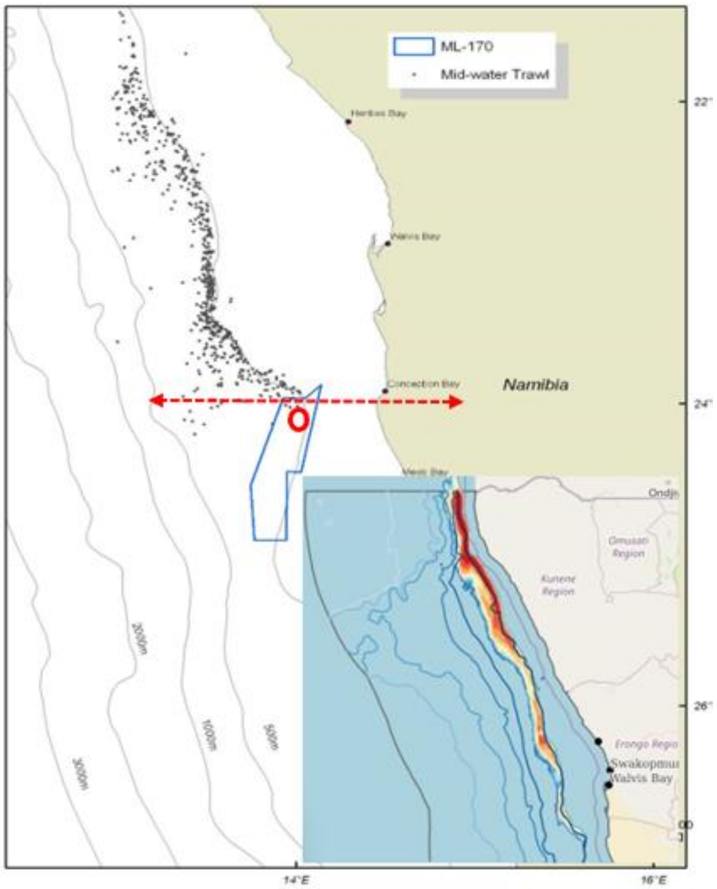

Figure 20. Distribution of fishing effort by the mid-water trawl fishery targeting horse mackerel in relation phosphate Mining Licence Area (SP-1 in circle) for the years 2008 to 2009 with MARISMA data inset MFMR, 2018).

4.2.2 Sardine and horse mackerel purse seine fisheries

The pelagic purse-seine fishery is based on the Namibian stock of Benguela sardine (*Sardinops sagax*) (also regionally referred to as pilchard), and small quantities of juvenile horse mackerel. The purse-seine fishery in Namibia commenced in 1947 following World War II and an increased demand for canned fish. The fleet consists of approximately 30 wooden, glass-reinforced plastic and steel-hulled vessels ranging in length from 21 m to 48 m. The targeted species are surface-shoaling and once a shoal has been located the vessel will steam around it and encircle it with a large net, extending to a depth of 60 to 90 m (Figure 21). Netting walls surround the aggregated fish, preventing them from escaping by diving downwards. These are surface nets framed by lines: a float line on top and lead line at the bottom. Once the shoal has been encircled the net is pursed and the fish pumped on board.

[15] It is understood this in part prompted the directed purse seine sector that started in 2019.

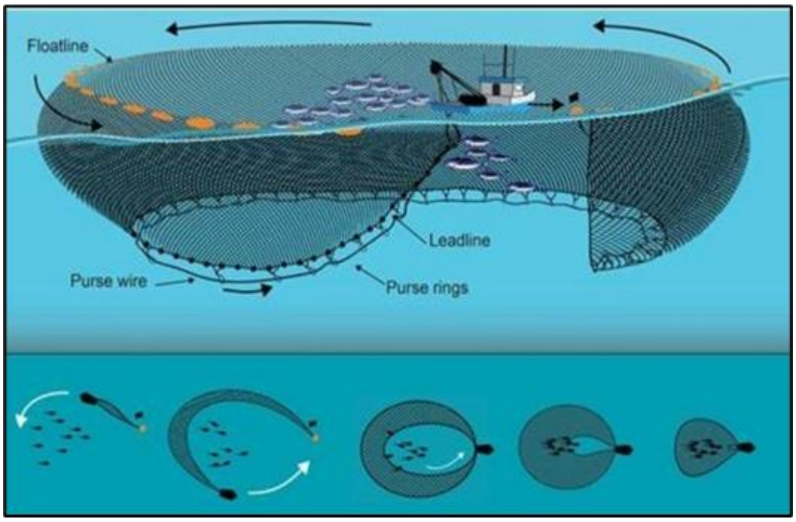

Figure 21. Schematic diagram of purse-seine gear deployed in the small pelagic fishery (http://www.afma.gov.au/ portfolio-item/purse-seine).

The fishery was the largest by volume of fish landings in the Benguela ecosystem and grew rapidly until 1968, at which time the stock collapsed. Over the period 1960 to 1977, landings of pilchard averaged 580 000 tons per year and fell to a mere 46 000 tons in 1978. Since independence, Namibia has issued a small TAC of pilchard to sustain the small pelagic sector and to allow land-based factory turnover and in addition, they allow part of this catch to target juvenile horse mackerel (Kirchner et al., 2014). In recent years the resource base has been unable to sustain even these minimal TACs and the fishery has been closed and reopened on an ad hoc basis depending on resource availability. A three-year moratorium was implemented on 01 January 2018 due to a significant population reduction, and extensive scientific studies are underway to ascertain the causes (MFMR 2015 and 15 February 2019). The moratorium currently (2022) remains in place. The most recent landings (2005 to 2017) are shown in Figure 22 (source MFMR, 2019).

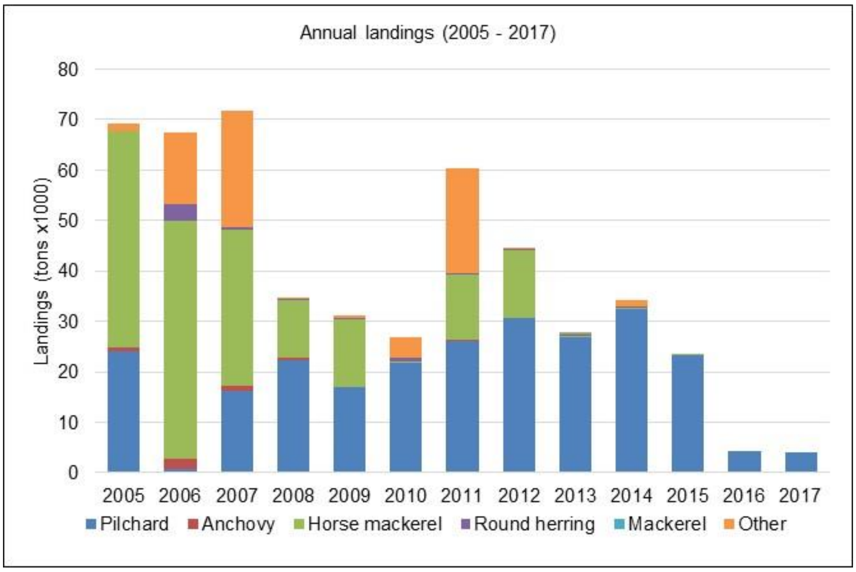

Figure 22. Landings of small pelagic species in the Namibian purse seine sector between 2005-2017.

The environmental concerns associated with these fisheries are centred on the impacts of reduced abundance of the target species. Purse-seine fishing operations are very selective and this sector tends to have low discard rates (Atkinson & Sink 2008). As such direct impacts on non-target species are not significant. Instead, concerns relating to this fishing sector are linked to the reduction in levels of the target species. These small fish are an important link in marine food webs (Cury *et al*. 2000) and reductions in their abundance can have negative impacts on ecosystem structure and functioning (Crawford *et al*. 1985, Crawford *et al*. 1987, Boyer & Hampton 2001b).

4.2.3 Horse mackerel purse seine

Historically as shown in Figure 22 horse mackerel have comprised a small portion of the small pelagic purse seine fishery. In 2019 a directed fishery for "wet" horse mackerel using purse seine fishery was initiated so there is no long-term historical performance records for the fishery. The fishery is assesed based on the most recent catch and effort data provided (Figure 38)sed on six vessels currently active in the fishery. Note this fishery was not previously assessed relative to the MLA[16]. Operational characteristics differs from the mid-water trawl in that it is required to land "fresh" product for onshore processing and as such, vessels must access fish in the proximity of Walvis Bay.

4.3 Crustacean Fisheries

There are two commercial crustacean fisheries in Namibian waters, both of which operate in areas well beyond the MLA. These are described briefly below.

4.3.1 West Coast Rock Lobster

The small but valuable fishery of rock lobster (*Jasus lalandii*) is based exclusively in the port of Lüderitz. Within Namibian waters, the lobster stock is commercially exploited between 28°30'S and 25°S from the Orange River border in the south to Easter Cliffs/Sylvia Hill north of Mercury Island (Figure 23). Catch is landed whole and is managed using a TAC. The sector operates in water depths of up to 80 m. Baited traps consisting of rectangular metal frames covered by netting, are deployed from small dinghy's and delivered to larger catcher reefers (refrigerated vessels) to take to shore for processing. The rock lobster fishing fleet consists of vessels that range in length from 7 m to 21 m. Traps are set at dusk and retrieved during the early morning using a powerful winch for hauling. Historically, the fishery sustained relatively constant catches of up to 9 000 t per year until a decline in the late 1960s. Figure 24 shows the commercial rock lobster catches from 1986 to 2019. The TAC for the 2020/21 was set at 180 tonnes, remaining unchanged from the previous season and a reduction from 200 tonnes TAC set during 2018/19. The TACs have not been filled in recent years with between 50% and 80% of the total TAC each season being caught.

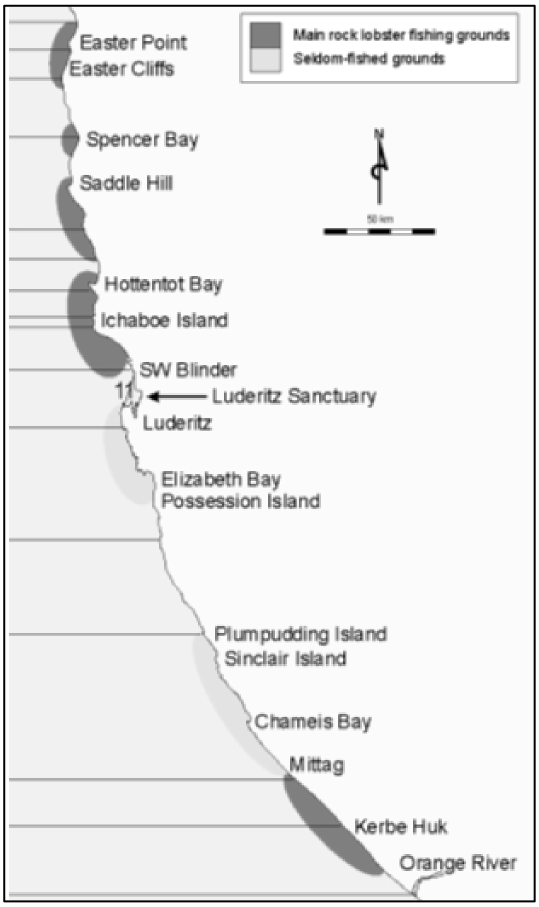

Figure 23. Main rock lobster fishing areas in southern Namibia

[16] Note : The fishery is restricted as with other fisheries, to fishing deeper than the 200 m bathy-contour although it is understood that the fishery has motivated to be allowed to fish shallower

As fishing for west coast rock lobster takes place mainly on or adjacent to rocky reefs. The use of traps has the potential to disrupt these habitats by damaging the associated fauna and flora (Atkinson & Sink, 2008). In addition, the consistent removal of large rock lobsters from an area may impact on the structure of the benthic community (Atkinson & Sink, 2008).

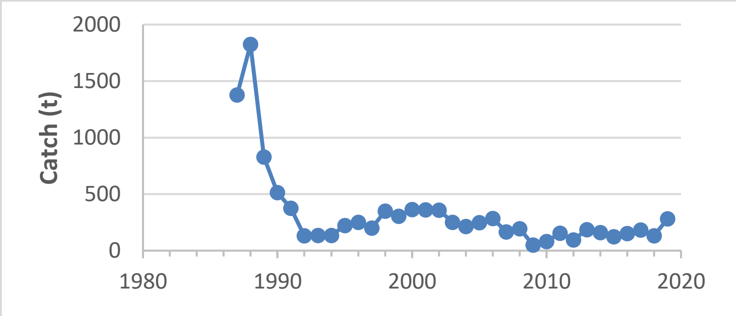

Figure 24. Historical catches of rock lobster in Namibia from 1986 to 2019 (Source: FAO catch statistics).

4.3.2 Deep Sea Red Crab

The Namibian deep-sea crab fishery is based on two species of crab namely spider crab (*Lithodes ferox*) and red crab (*Chaceon maritae*). Method of capture involves the setting of a demersal long-line with a string of approximately 400 Japanese-style traps (otherwise known as "pots") attached to each line. Traps are made of plastic and dimensions are approximately 1.5 m width at the base and 0.7 m in height. They are spaced 15 m apart and typically baited with horse mackerel or skipjack. The line is typically 6000 m in length and weighted at each end by a steel anchor. A surface buoy and radar reflector mark each end of the line via a connecting dropper line that allows retrieval of the gear. Up to 1200 traps may be set each day (or two to three lines) and are left to soak for between 24 and 120 hours before being retrieved. The fishery commenced in 1973 with a peak in catches of 10 000 tons in 1983. Catches remained high during the 1980s between 5000 tons and 7000 tons. Following heavy exploitation by foreign fleets during this period, catch rates dropped significantly and have averaged at approximately 2000 tons in 1997 and have been steadily increasing since then. The TAC for 2020/21 has been set at 3900 tons.

The distribution of red crab extends from ~5°S to just South of Walvis Bay and the commercial fishery operates in grounds extending northwards of 23°S and into Angolan waters (Figure 25). There is a minimum operational depth of 400 m set for the fishery, which sets traps at depths of up to 1200 m. The fishery is small, with only two vessels currently operating from the port of Walvis Bay. Vessels are active year-round but with relatively low fishing effort from November to February. Fishing grounds are located at least 730 km to the north of the licence area and there is therefore no spatial overlap of the licence blocks with the sector.

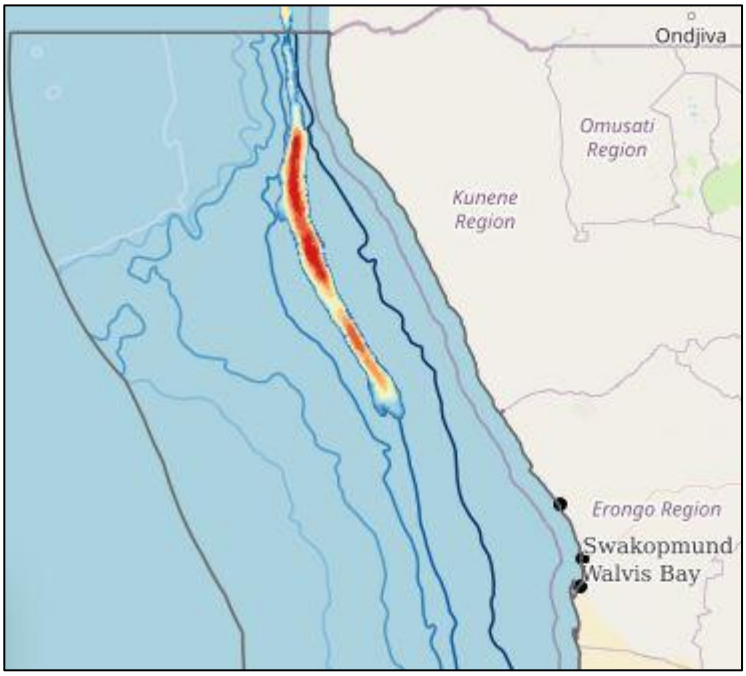

Figure 25. Know distribution of the deepsea red crab fishery (BCC, 2021) in Namibian waters. The MLA is located well south of the grounds fished.

The fishery as shown in Figure 25 is in deep water and no impact from phosphate mining is expected.

4.4 Line Fisheries

4.4.1 Traditional Line

The traditional line fishery primarily targets snoek (*Thyrsites atun*) with bycatch of yellowtail, silver kob (*Argyrosomus inodorus*), dusky kob (*A. coronus*), and shark, which are sold on the local market. Snoek availability to the fishery is seasonal. Catches peak in late summer where after the fish migrate south into South African waters. The other species caught, such as kob and shark occurs year round, but is in relatively small amounts. Operationally the fishery is limited in extent to Walvis Bay, Swakopmund and Henties Bay and also due to the small size of the boats does not operate much further than 12 nm offshore (i.e. 22 km). There is also a small component of the fishery operating out of Lüderitz in the South. The two commercial components of the linefish sector comprise a fleet of up to 26 small deck boats.

The monthly landings are shown in Figure 26 with catches dropping in the mid-winter period with catches increase from spring into summer. This trend is associated with both the availability of snoek and also with weather and sea conditions which make it difficult for the fishery to operate during this time due to the small size of the boats used. The distribution of linefish catch is therefore inshore and there is no spatial overlap with the MLA.

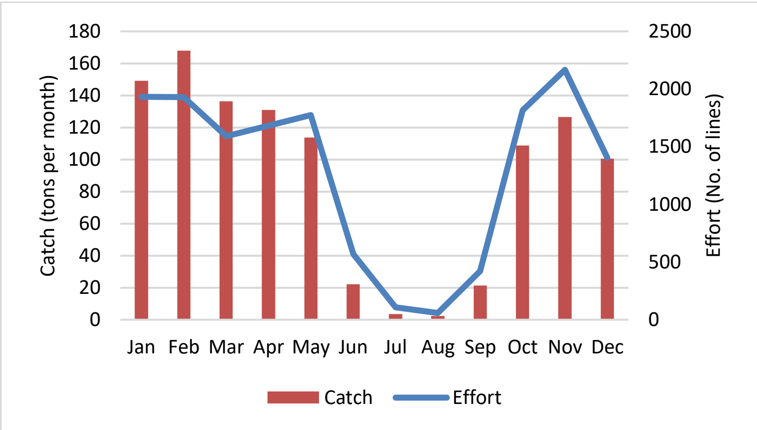

Figure 26. Average monthly catch and effort recorded by linefish vessels in Namibian waters (2000 – 2019). Source: MFMR, 2020.

4.4.2 Tuna Pole and Line and Longline

There are two "line" fisheries" that target highly migratory tuna species. Both fisheries are seasonal.

The **pelagic longline** fishery targets yellowfin tuna (*T. albacares*), bigeye tuna (*T. obesus*), swordfish (*Xiphias gladius*) and various pelagic shark species. Long-line vessels targeting pelagic tuna species and swordfish operate extensively around the entire coast along the shelf-break and into deeper waters. The spatial distribution of fishing effort is widespread and may be expected predominantly along the shelf break (approximately along the 500 m isobath) and into deeper waters (2 000 m). Effort occurs year-round with a slight peak over the period March to May (Figure 27).

Yellowfin tuna are distributed between 10°S and 40°S in the south Atlantic, and spawn in the central Atlantic off Brazil in the austral summer (Penney et al. 1992). According to Crawford et al. (1987) juvenile and immature yellowfin tuna occur throughout the year in the Benguela system. Bigeye tuna occurs in the Atlantic between 45°N and 45°S. Spawning takes place in the Gulf of Guinea and in the eastern central Atlantic north of 5°N and it is thought that bigeye tuna migrate to the Benguela system to feed. Swordfish spawn in warm tropical and subtropical waters and migrate to colder temperate waters during summer and autumn months. Tuna are targeted at thermocline fronts, predominantly along and offshore of the shelf break.

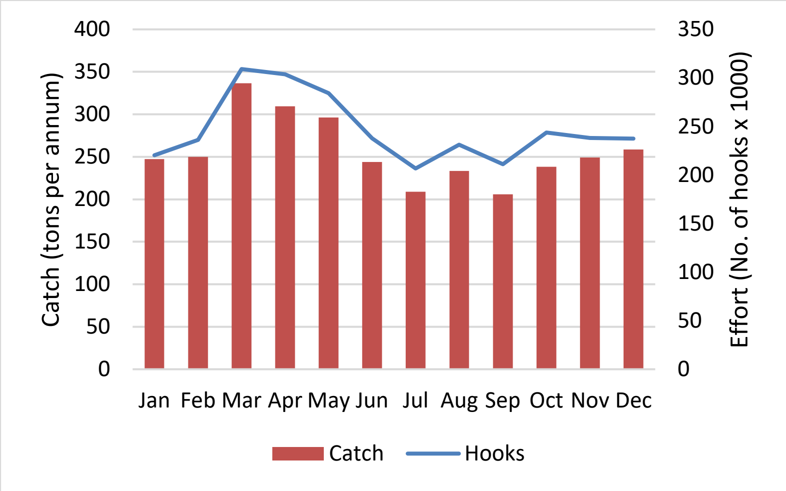

Figure 27. Seasonal trend in catch and effort of the Namibian longline fleet

Pelagic long-line vessels set a drifting mainline, up to 50-100 km in length, and are marked at intervals along its length with radio buoys (Dahn) and floats to facilitate later retrieval. Commercial landings of these species by the fishery are variable and Namibian-reported catch from 1994 to 2018 is reported to the Regional Fisheries Management Organisation (see ICCAT, 2020). There is provision for up to 26 fishing rights and 40 vessels (http://www.mfmr.gov.na/).

The Pole and Line fishery targets the southern Atlantic albacore (longfin tuna) stock (*T. alalunga*) and a very small amount of skipjack tuna (*Katsumonus pelamis*), yellowfin tuna and bigeye tuna. Albacore are a temperate species of tuna, favouring subtropical ocean waters of 16° – 20°C (Penney et al 1998). Spawning occurs in equatorial regions where water temperatures exceed 24°C (Schaefer 2001). Southern albacore migrate annually through their Atlantic distribution range between 10°S and 40°S. Nepgen (1971) noted that juvenile and sub-adult albacore are present in the Benguela region throughout the year. They migrate locally along the west coast feeding at upwelling and topographically induced fronts (Penney et al 1992). The pole-and-line (also referred to as bait boat) and longline fisheries target albacore that occur in four main areas of the Benguela region: the Vema Seamount off Namibia, Tripp Seamount south of Lüderitz, South Bank south of Hondeklip Bay and the Cape Canyon (Penney et al 1992).

Vessels operating within the fishery are typically small (< 25 m in length). Catch is stored on ice, chilled sea water or frozen and the storage method often determines the range of the vessel. Trip durations average between four and five days, depending on the distance of the fishing grounds from port. Catches peak in March (Figure 28).

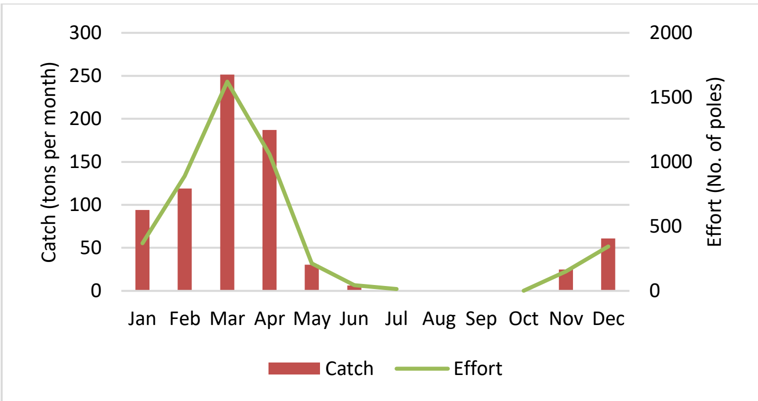

Figure 28. Average monthly catch and effort recorded by the tuna pole and line fleet in Namibian waters (2004 – 2019). Source: MFMR0.

Namibia's quota for tuna and swordfish is allocated by the International Commission for Conservation of Atlantic Tunas (ICCAT), of which Namibia is a member. Catches of albacore tuna for Namibia and South Africa apply to what is referred to as the Atlantic "southern stock" (ICCAT Statistical Bulletin 2012).

4.5 Mariculture

Namibia has a developing mariculture industry for Pacific and European oysters (*Crassostrea gigas* and *Ostrea edulis*), black and Mediterranean mussels (*Choromytilus meridionalis* and *MytilusGallo-provincialis*), abalone (*Haliotis midae*) and seaweed (*Gracilaria gracilis*) (Oellermann, 2007). The Namibian government has strongly promoted mariculture through the promulgation of the Aquaculture Act, Act 18 of 2002. One of the objectives of the Ministry of Fisheries and Marine Resources (MFMR) is to have a fully established aquaculture industry (freshwater and marine aquaculture) by 2030. There are 67 aquaculture licence holders in Namibia at present; at least 30 are involved in mariculture. Not all have secured access to a mariculture site, and less than half are currently producing. The Namibian mariculture industry is an export industry developing foreign trade with South Africa, and European countries. For 2008, the volume of marine aquaculture production in Namibia was approximately 450 tons (MFMR, 2012). Mariculture methods vary but include rafts, suspended long-lines, racks in ponds and onshore flow-through tanks. Mariculture locations are distributed in clusters along the Namibian coastline and concentrate around Oranjemund, Lüderitz, Walvis Bay, and Swakopmund (Figure 29). Apart from Oranjemund (where oysters and marine finfish are farmed), all current mariculture production areas are located in Lüderitz and Walvis Bay falling within the port limits under NAMPORT's authority. Currently, four farms operate within the Aquaculture Production Area of Walvis Bay and five farms operate within the aquaculture production area of Lüderitz. Pacific oysters are the predominant species cultivated in Namibia and grow rapidly compared to other parts of the world due to the warm temperatures and highly productive coastal waters of the Benguela Current (Walvis Bay Salt Refineries, 2005).

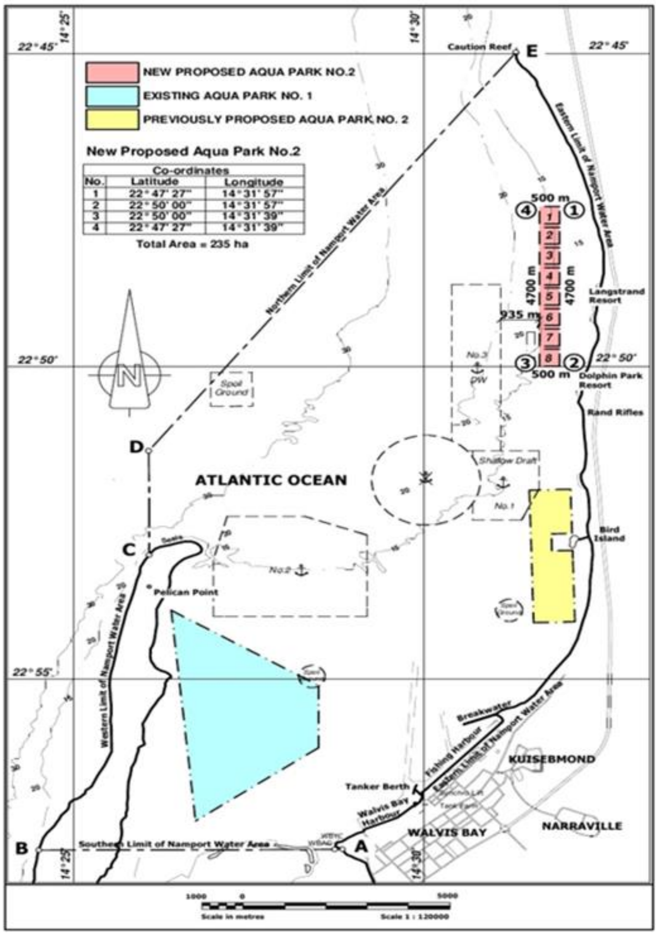

Figure 29. Location and planned areas for aquaculture farms in the Walvis Bay area (as provided by the Namibian Ports Authority

The Walvis Bay farms are the closest mariculture facilities to the mine site. Aquaculture production is mainly aimed at Pacific oysters, with one farm producing mussels (*Mytilus galloprovincialis*) for the local market. There are 27 licensed aquaculture sites in Aqua Park 1, located east of Walvis Peninsula (Figure 29). In addition, there are two open water sites located within the waters of Walvis Bay, one is located west of the Walvis Peninsula (known as Donkiesbaai) and the second is located approximately 12.8 km northeast of Pelican Point (known as Patrysberg). The aquaculture sites range in size from 3.65 ha to 243.9 ha and cover a total area of 1 340.83 ha. Pacific oysters and mussels are cultivated in Walvis Bay using the longline method.

4.6 Seabirds[17]

There are 16 species of seabird that breed within the BCLME[18] (Azwianewi et al. 2021.) as well as 66 other species (excluding rare vagrants) that are known to migrate through the BCLME. Non-breeding migrants may remain within the BCLME year round. In the northern Benguela, the Namibian coastline sustains large populations of both breeding and foraging seabird species, which require suitable roosting, foraging and breeding habitats for their survival. Some 50 species of seabirds has been recorded in Namibia waters (Pisces, 2017) (reproduced in Table 3). These consist of a number of albatrosses, petrels, giant petrels, storm-petrels, shearwaters skuas and prions, and include several globally and/or nationally threatened species (Simmons et al. 2015; IUCN 2020). Information on their exact seasonal distributions and abundances in Namibian waters is generally limited (Roux 2007; Simmons et al. 2015).

Table 3. Pelagic seabirds common in the southern Benguela region (Crawford et al. 1991 in Pisces, 2017).

Common Name	*Species name*	*Global IUCN*
Shy albatross	*Thalassarche cauta*	Near Threatened
Black browed albatross	*Thalassarche melanophrys*	Endangered[1]
Yellow nosed albatross	*Thalassarche chlororhynchos*	Endangered
Giant petrel sp.	*Macronectes halli/giganteus*	Near Threatened
Pintado petrel	*Daption capense*	Least concern
Greatwinged petrel	*Pterodroma macroptera*	Least concern
Soft plumaged petrel	*Pterodroma mollis*	Least concern
Prion spp	*Pachyptila* spp.	Least concern
White chinned petrel	*Procellaria aequinoctialis*	Vulnerable
Cory's shearwater	*Calonectris diomedea*	Least concern
Great shearwater	*Puffinus gravis*	Least concern
Sooty shearwater	*Puffinus griseus*	Near Threatened
European Storm petrel	*Hydrobates pelagicus*	Least concern
Leach's storm petrel	*Oceanodroma leucorhoa*	Least concern
Wilson's storm petrel	*Oceanites oceanicus*	Least concern
Blackbellied storm petrel	*Fregetta tropica*	Least concern
Skua spp.	*Catharacta/Stercorarius* spp.	Least concern
Sabine's gull	*Larus sabini*	Least concern

[1]May move to Critically Endangered if mortality from long-lining does not decrease.

Highest densities of pelagic seabirds occur in winter on the shelf-break, but some species may venture closer inshore and some can even be observed occasionally from the shore, including giant petrels and White-Chinned Petrels (J-P Roux, J Kemper pers. obs.). These seabirds forage in open waters, covering vast distances, and feed on a range of fish, krill and squid. In the 2019 hake transboundary survey (Boyer et al. 2019) sightings of seabirds identified 19 different seabird species based on a count from 99 - 10 minute transects. White-chinned Petrels (*Procellaria aequinoctialis*) were the most abundant species encountered with 377 individuals recorded.

[17] Extracts from Pisces, 2017. Environmental Impact Assessment (EIA) for proposed deep-water exploration well drilling in petroleum exploration license 39 in Namibia.

[18]Azwianewi et al. 2021. Seabirds of the Benguela Ecosystem: Utilisation, Long-Term Changes and Challenges DOI: http://dx.doi.org/10.5772/intechopen.96326

Of the species reported in Ryan and Rose (1989) some 13 species (26%) are southern African breeding species, 13 (26%) are non-breeding migrants from the northern hemisphere, and 24 (48%) are non-breeding migrants from islands in the Southern Ocean. Nine species (18%) have been given an IUCN (World Conservation Union) category of threat, and five are considered near-threatened. Conservation concern has thus been expressed for nearly one third of the seabird species occurring in Namibian waters. Threatened species include both migrants (albatrosses and petrels) and southern African breeding species. Only one species is considered to be Critically Endangered (the Spectacled Petrel *Procellaria conspicillata*) and none are considered Endangered (see Appendix 1).

Most of the seabird species breeding in Namibia generally feed relatively close inshore (10-30 km) and also have a measure of protection in Namibia's declared MPAs (which are well to the south of the MLA) (Figure 30). Namibia's first Marine Protected Area (MPA), the Namibian Islands Marine Protected Area (NIMPA) was proclaimed in 2009 (Ludynia et al. 2011). The NIMPA runs for 400 km southwards from Hollamsbird Island along the southern coast of Namibia. It covers approximately 10 000 km^2 and averages 25 km in width. A major objective of the NIMPA is to protect the breeding sites as well as the main foraging areas of the Threatened African Penguin, Cape Gannet, and Bank Cormorant. Some species may forage further offshore, such as Cape Cormorants (Roux 2007), Cape Gannets, which may forage more than 100 km offshore (Dundee 2006; Grémillet et al. 2008; Ludynia et al.2012), and African Penguins, which have been recorded more than 60 km offshore in Namibia (Ludynia et al. 2012).

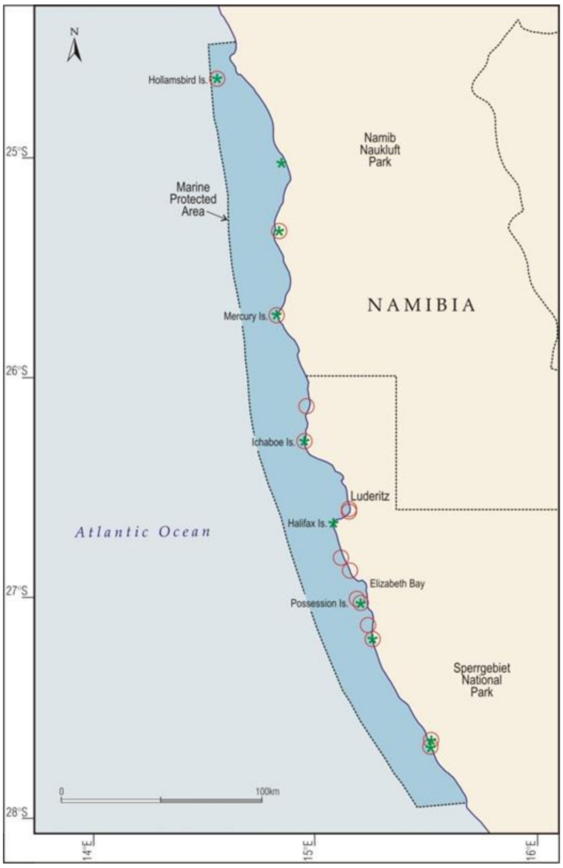

Figure 30. Namibian islands and MPAs (all well south of the mine site)

Birds reported from the 30 km stretch of coast between Walvis Bay and Swakopmund include African Black Oystercatcher, Kelp Gull, Cape cormorant, Turnstone (*Arenaria interpres*), Curlew Sandpiper (*Calidris ferruginea*), Grey plover (*Pluvialis squatarola*), Swift Tern, Damara tern and Common Tern *(Sterna hirundo*) (Simmons et al. 1999). This section of central Namibia has recorded the highest linear count of birds in southern Africa at ~450 birds/km with totals exceeding 13,000 shorebirds of 31 species, most of which are Palearctic migrants (Simmons et al. 1999; Molloy & Reinikainen 2003; http://www.ramsar.org/profile/profiles_namibia).

Small pelagic fish species, including sardine *Sardinops sagax*, anchovy *Engraulis encrasicolus* and round herring *Etrumeus whiteheadi* are the preferred food of African Penguins, Cape Gannets and Cape Cormorants. With the crash of stocks of small pelagic fish in Namibia in the 1970s, these birds have switched to generally less nutritious diets that include the widespread and relatively abundant bearded goby *Sufflogobius bibarbatus* (Roux et al. 2013) (see also 3.1.5). Crawford *et al* (1991) reviewed the role of seabirds as consumers in the Benguela and western Agulhas ecosystems. Four regions were recognized: northern Namibia, southern Namibia, western South Africa and southern South Africa. The southern Namibia region corresponds to the area encompassed by the present study. Populations of pelagic seabirds are highest during the austral winter when Southern Ocean species move north to temperate and subtropical regions. Large numbers of Prions *Pachyptila* spp. (17 500); Whitechinned Petrel *Procellaria aequinoctialis* (14 700); Sooty Shearwater *Puffinus griseus* (14 200) and Storm petrels mainly *Oceanites oceanicus* and *Hydrobates pelagicus* (7 000) are present in the southern Namibia region during the winter.

The breeding population of African Penguins on the islands along the southern Namibian coast has declined drastically from ca. 27% of the total breeding population in the 1950s to < 2%. Similarly, the Cape Gannet breeding population in the area has fallen from 9% of the total to about 2% (Crawford *et al*., 1991). Conversely the Cape Cormorant breeding population has risen from < 1% to nearly 15% of the total breeding population. The African Penguin is considered to be "Vulnerable" and the population along the west coast of southern Africa is in a severe decline. The pelagic seabirds that are considered likely to occur in the proximity of the MLA are provided in Appendix 1.

4.7 Turtles[19]

Five of the eight species of turtle worldwide occur off Namibia (Bianchi et al. 1999). The Leatherback (*Dermochelys coriacea*) is the only turtle likely to be encountered in the offshore waters of southern Namibia. The Benguela ecosystem, especially the northern Benguela where jelly fish numbers are high, is increasingly being recognized as a potentially important feeding area for leatherback turtles from several globally significant nesting populations in the south Atlantic (Gabon, Brazil) and south east Indian Ocean (South Africa) (Lambardi et al. 2008; Elwen and Leeney 2011; SASTN 2011). Leatherback turtles inhabit deeper waters and are considered a pelagic species, travelling the ocean currents in search of their prey (primarily jellyfish). While hunting they may dive to over 600 m and remain submerged for up to 54 minutes (Hays et al. 2004). Their abundance in Namibian waters is unknown but expected to be low. Although they tend to avoid nearshore areas, they may be encountered further offshore where seawater temperatures are higher.

During the past five years 200 to 300 dead turtles were found (www.nacoma.org.na). Leatherback Turtles are listed as ‘Critically Endangered’ worldwide by the IUCN and are in the highest categories in terms of need for conservation in CITES (Convention on International Trade in Endangered Species), and CMS (Convention on Migratory Species). Observations of Green (Chelonia mydas), Loggerhead (Caretta caretta), Hawksbill (*Eretmochelys imbricata*) and Olive Ridley (*Lepidochelys olivacea*) turtles in the area are rare. Loggerhead and green turtles are globally listed as ‘Endangered’ whereas Hawksbill and Olive Ridley turtles are globally listed as ‘Critically Endangered’ and ‘Vulnerable’, respectively. Although not a signatory of

[19] Extracts from Pisces, 2017. Environmental Impact Assessment (EIA) for proposed deep-water exploration well drilling in petroleum exploration license 39 in Namibia.

CMS, Namibia has endorsed and signed a CMS International Memorandum of Understanding specific to the conservation of marine turtles. Namibia is thus committed to conserve these species at an international level. All marine turtles outside their rookeries (breeding beaches) face various common threats which include boat strikes (J-P. Roux pers. obs.), incidental bycatch in fisheries (at least a few Olive ridley turtles have occasionally been recorded in trawl bycatch in Namibia), marine pollution, marine litter and entanglement (see below). Natural mortality (including predation by Killer whales) has also been noted in Namibia for Leatherback turtles.

4.8 Marine mammals in Namibia

Information on cetaceans for the Namibian coastal area was obtained from a number of sources (original report undertaken by CapMarine), including scientific and incidental sighting records, historical whaling catches and sightings and stranding records (see also the hake transboundary report in Boyer et al. 2019). The distribution of cetaceans in Namibia can largely be split into those associated with the continental shelf and those that occur in deep, oceanic water. Between 22 and 25 species of cetacean are expected to be found in the region based on their distributions elsewhere along the southern African west coast. Cetaceans can be divided into two major groups, the mysticetes or baleen whales which are largely migratory, and the toothed whales or odontocetes which may be resident or migratory. The range in the number of species reflects taxonomic uncertainty rather than a lack of information on distribution patterns. Importantly, species from both environments may be found in the shelf-edge area (200 - 2,000 m) making this the most species-rich area for cetaceans. Cetacean density (i.e. number of animals encountered) on the continental shelf is usually higher than in pelagic waters as species associated with the pelagic environment tend to be wide ranging across 1,000s of km.

Top predator observations on the 2019 hake transboundary survey (Boyer et al. 2019) covered mostly the southern portion of Namibian waters, extending to Walvis Bay and therefore included the Conception Bay transect in the proximity of SP-1 in the MLA. These observations are shown in Figure 31 and suggest that dusky dolphin is the most likely species to occur in the proximity of SP-1 (noting that seasonally migrating humpback and pilot whales may also be expected).

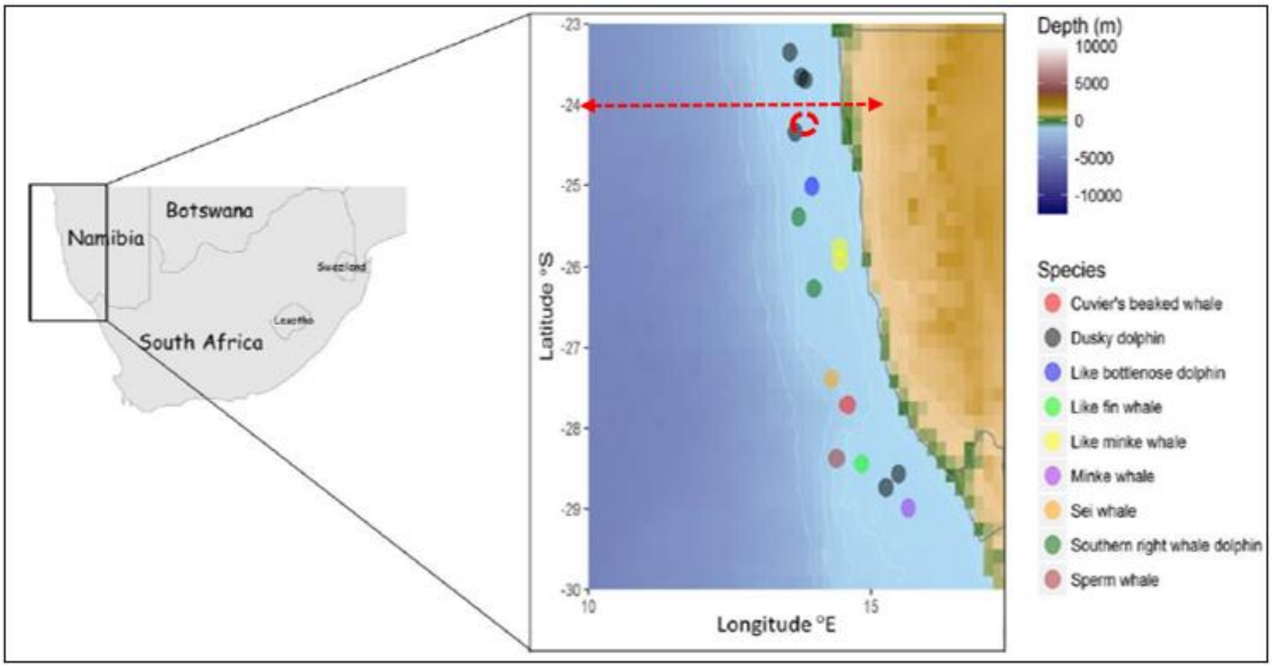

Figure 31. Sightings of top predators from the 2019 hake transboundary (Boyer, 2019) with reference line and mining area approximated.

The term 'whale' is used to describe cetaceans larger than approximately 4 m in length in both these groups and is taxonomically meaningless (e.g. the killer whale and pilot whale are members of the Odontoceti, family Delphinidae and are thus dolphins, not whales). Due to large differences in sociality, communication abilities, ranging behaviour and acoustic behaviour, these two groups are considered separately.

4.8.1 Mysticete (baleen) whales (Appendix 2a)

Blue whales : Two forms of blue whales are recorded from the Southern Hemisphere. Antarctic or true blue whales (*Balaenoptera musculus intermedia*) migrate from summer feeding grounds within the southern ocean (near the Antarctic ice edge) to winter calving grounds in temperate waters, although little is known of their definite destination in winter (Mackintosh 1966). Pygmy blue whales (*B. m. brevicauda*) are recorded from the southern Indian Ocean. Harmer (1931) noted on the basis of the peak of the catches being sharper off Moçamedes (now Namibe), Angola, than Walvis Bay, Namibia, that Angola was closer to the northern point of the blue whale migration than Walvis Bay. The seasonality of catches of blue whales from the southern African west coast suggests that the majority of blue whales migrate northwards through southern Namibian waters between May and July to Angolan waters (July and August) and return southwards after August.

Although no offshore distribution patterns were recorded off Namibia, catches of blue whales in waters 65 to 95 kilometres offshore of the South western Cape coast of South Africa suggest the migration to occur off the continental shelf slope (in waters of depths of between 2000 and 3500 metres). Furthermore, catches of blue whales off the southern Africa west coast generally occurred after catches of humpback whales which suggests that blue whales occurred in offshore, deeper waters than humpback whales. Olsen (1915) however noted that off the Western Cape, large schools moved inshore from the north between June and August.

Fin whales (*B. physalus*) : Like blue whales, little is known of the winter migration destinations of fin whales. Gambell (1985) noted that fin whale migrations occur after blue whale migrations, but precede those of sei whales. Harmer (1931) reported that catches off the Western Cape had a bimodal distribution (with maxima in May – July and October – November). Fin whales have been recorded in catches from Walvis Bay and Angola (Harmer 1929), and off Gabon in 1934 (Budker and Collignon 1952), and although no seasonal maxima are provided, these records show migrations to the north of the Western Cape. If the shelf edge is taken as 200 m, most of the fin whales should pass inshore of the mining area. Although the offshore distribution of fin whales in southern Namibia is unknown, there is some suggestion that the species migrates along the continental shelf edge (Macintosh 1966).

Sei whales (*B. borealis*) : Harmer (1929) found sei whales particularly numerous off the Cape Colony, although he suggests that some confusion between sei and Bryde's whales may have occurred. Best and Lockyer (unpublished, in Horwood, 1987) note that such confusion may have continued up until 1962. Best (1967) found catches of sei whales in the Saldanha Bay whaling grounds to show an annual peak over the period of August and October, and although a second peak was reported from sightings between March and April, Best (*op cit*.) suggests that these may have been Bryde's whales. Best (1967) suggested that sei whales off the southern African west coast are mainly found in waters of 16º-18º C, 60 to 100 nautical miles offshore. Sei whales, therefore, could be encountered in the Mining Licence Area.

Minke whales : There is little information on the distribution or seasonal abundance of minke whales off the west coast of southern Africa, although Stewart and Leatherwood (1985) note their presence in these waters. Possibly two forms of minke whales, the dwarf minke whale (*Balaenoptera acutorostrata*) and the larger Southern Hemisphere minke whale (possibly (*Balaenoptera bonaerensis)* may be found off the coast of southern Namibia. Findlay (1989) reports incidental sightings of minke whales inshore off Lüderitz, which may well correspond to the dwarf form.

Bryde's whales : There is little information on the distribution and seasonal occurrence of Bryde's whales in southern Namibia. Two forms of Bryde's whales are recorded from southern African waters (Best 1977, Best 2007, Rice 1999). The smaller resident form (of which the taxonomic status is uncertain) is found year-round along the southern Cape coast between Algoa Bay and Lamberts Bay. A larger offshore form (*B. edeni*) appears to migrate along the African west coast, being most abundant in the Saldanha Bay whaling grounds between March and May and in October, and possibly migrating northwards along the African west coast in winter.

No information on the distribution of Bryde's whales in southern Namibia could be located. As it is the larger migratory form that is found in these waters it is assumed that the distribution would be off the continental shelf.

Humpback whales (*Megaptera novaeangliae*) : Humpback whales utilise coastal waters of southern hemisphere continents as migratory corridors during annual migrations between summer Antarctic feeding grounds and breeding grounds in coastal tropical and subtropical waters. It appears that some humpback whales remain off the southern African west coast throughout summer (Findlay and Best, 1995), possibly taking advantage of upwelling productivity to feed within the Benguela System (as suggested for other upwelling areas by Papastavrou and van Waerebeeck (1997).

Southern Right whales (*Eubalaena australis*): Southern right whales were heavily exploited by open-boat whalers between Walvis Bay in Namibia and Delagoa Bay in Mozambique prior to 1835 (Richards and du Pasqier 1989, Best and Ross 1986). Right whales were protected from 1935 onwards (although such protection was only promulgated in South Africa in 1940). Annual surveys have shown the population utilising the coast between Muizenberg and Algoa Bay to now be recovering at approximately 7% per annum. IWC (in press) stated that few sightings are recorded off the coast of Namibia each year, although it noted that no surveys for right whales are being undertaken. Based on distributions elsewhere in southern African waters (Best 2000), southern right whales in southern Namibia would be expected in extreme coastal waters (within the 50 m isobath) i.e. inshore of the Mining Licence Area between the months of July and November.

Pygmy right whales (*Caperea marginanta*) : The pygmy right whale is a little known species, which has been recorded incidentally in the inshore waters around the South African coast between Algoa Bay and Walvis Bay and if it occurs at all, it will be inshore of the Mining Licence Area. The incidence within southern Namibia is expected to be extremely low. A summary of the distribution and seasonal abundance of baleen whales in southern Namibian waters is presented in Appendix 2.

4.8.2 Odontocetes (toothed whales and dolphins)(Appendix 2b)

The majority of toothed whales and dolphins have more resident than migratory distribution patterns. Findlay *et al.* (1992) investigated the distribution patterns of small odontocete cetaceans off the coast of Namibia and South Africa. The distribution and seasonal abundance of odontocetes (toothed whales and dolphins) in southern Namibian waters are summarized in Table 2.

Sperm whales (*Physeter macrocephalus*) : The major part of global sperm whale distributions lie within tropical oceanic waters, although females and small males occur as far south as 40° – 50°S, while mature males are found as far south as the Antarctic ice edge. Sperm whales are recorded throughout southern African pelagic waters. Their distribution would be expected to the west of the proposed mining area in deeper pelagic waters. Some migratory habits are suggested from historical catch records off Saldanha Bay, with Best (1969) suggesting northward movement in autumn and southward movement in spring.

Pygmy Sperm whales (*Kogia breviceps*) : The pygmy sperm whale appears to be confined to warm oceanic waters. A number of strandings have been recorded on the Namibian coast, which probably originate from warm offshore waters. It is, therefore, unlikely to occur in the mining area.

Cuvier's beaked whale (*Ziphius cavirostris*) : Cuvier's beaked whale appears to have a pelagic cosmopolitan distribution in southern African waters. Although strandings have been recorded from the Namibian coast, it is expected that these originated from further offshore than the mining area.

Layard's beaked whale (*Mesoplodon layardii*) : Layard's beaked whale is distributed in cold temperate waters in the Southern Hemisphere with strandings from Namibian waters resulting from the whales moving inshore into cold Benguela system on the southern African west coast. However this species has an offshore distribution elsewhere in the world and is expected to occur offshore of the mining area.

Gray's beaked whale (*M. grayii*) : As with Layard's beaked whale Gray's beaked whale appears to be restricted to cold temperate oceanic waters south of 30^{o} S, although there are a few records from within the Benguela system. It too has an expected offshore distribution outside of the mining area.

Killer whale (Orcinus orca) : Killer whales (*Orcinus orca*) have a cosmopolitan distribution in all major oceans of the world (Leatherwood and Reeves, 1983) and is found throughout southern African waters regardless of season or water depth (Findlay *et al.* 1992, Peddemors 1999). It may consequently be found within the mining area.

False killer whale (*Pseudorca crassidens*) : The false killer whale (*Pseudorca crassidens*) is an offshore species found in tropical and temperate waters of all oceans (Ross 1984). This species occurs offshore of the 1000 m isobath all along the southern African coast (Findlay *et al.* 1992, Peddemors 1999).

Pygmy killer whale (*Feresa attenuata*) : Pygmy killer whales appear to be confined to the tropical, subtropical and warm temperate oceanic waters of the world. Strandings within southern African waters are limited to the north of Cape Point and to the east of Algoa Bay, possibly as a result of the wider continental shelf over the Agulhas Bank. Stranding records within Namibian waters are surprising given the species preference for warm waters, and it is assumed that such animals originated from warmer offshore waters (Findlay *et al.* 1992).

Long finned pilot whale (*Globicephala melas*) : Long-finned pilot whales have been recorded from within southern Namibian waters, albeit in slightly deeper waters than the mining area (Findlay *et al.* 1992).

Risso's dolphin (*Grampus griseus*) :Risso's dolphins are found year round throughout southern African oceanic waters (Findlay *et al.* 1992).

Common dolphin : Although common dolphins are recorded from Namibian waters, an absence of sightings within coastal neritic waters, suggest that common dolphins avoid the cooler inshore waters of the Benguela Current region (Findlay *et al.* 1992). Consequently the species would not be expected to occur in the mining area, but may occur in warmer offshore waters.

Dusky dolphin (*Lagenorhynchus obscurus*): Dusky dolphins are a year round resident species within coastal waters of the southern African west coast between southern Angola (12°S) and Danger Point (19°20'E). Although generally occurring within the 50 m isobath, they may be found out to the 500 m isobath (Findlay *et al.* 1992, Peddemors, 1999).

Heaviside's (Benguela) dolphin *(Cephalorhynchus heavisidii*) : Heaviside's dolphin are a resident species endemic to the nearshore waters of the west coast of southern Africa between Cape Point (34°20'S) and northern Namibia (17°30'S). Although the species does occur out to the 200m isobath, the highest densities have been recorded inshore of the 100 m isobath (Findlay *et al.* 1992).

Southern right-whale dolphin (*Lissodelphis peronii*) : Southern right-whale dolphins are generally limited to the cooler waters of the Southern Hemisphere, between the Subtropical Convergence and the Antarctic Convergence, or within the "West Wind Drift, although they have been recorded as far north as 19ºS in the Humboldt Current. However, an apparent isolated distribution of southern right-wale dolphins occurs off the coast of southern Namibia between 24ºS and 30º30'S (Rose and Payne 1991, Findlay *et al.* 1992, Peddemors 1999). These animals have been recorded year round in water depths between the 100 - 200 and 1000 - 2000 m isobaths. This distribution is possibly associated with the Lüderitz upwelling cell.

Bottlenose dolphin (*Tursiops truncatus*) :Two forms of bottlenose dolphin occur in inshore waters around the southern African coast (a smaller form on the east coast and a larger form in the extreme inshore region of northern Namibia), while a larger form appears to occur throughout southern African offshore waters (Findlay *et al.* 1992, Peddemors 1999). The species is not expected to occur in the mining area but may occur offshore to the west in warmer offshore waters.

4.8.3 Seals

The South African (Cape) fur seal *Arctocephalus pusillus pusillus* is abundant throughout the region. Numbers around the southern African coast have increased rapidly over the past seven decades, from an estimated 150 000 in 1920 to close to two million at present (Department of Environment Affairs and of Water Affairs and Forestry, 1990).

South African (Cape) fur seals generally forage in shallow, shelf waters (David 1989). South African fur seals range to over 150 km from the coast, with bulls ranging further out to sea than females. Tracking of South African fur seal with time depth recorders has shown that two females from Kleinsee dived to 200 m (although dives to 150 m comprised less than 10% of measured dive profiles) (David 1989). The mining area falls within feeding range of South African fur seals.

5 Identification of impacts and risk assessment

Namibia Marine Phosphate (NMP) has been granted a 20-year Mining Licence (ML 170) by the Ministry of Mines and Energy, to recover phosphate-rich sediment from the Namibian seabed (subject to this Environmental Impact Assessment). A Trailing Suction Hopper Dredge (TSHD) will be used to remove up to 2.5 - 3 m of phosphate deposits from the seabed. A volume of 5.5 million tonnes will be removed annually. Dredging will occur in water depths of up to 225m in the mine plan area and the slurry will be transported to shore and transferred (pumped) from the vessel to the shore by a pipeline.

The Mining Licence Area (MLA) is located on the Namibian continental shelf approximately 40-60 km off the coast of Conception Bay (refer to the 24^0 S latitude line of reference in the figures). The area of the mining lease area covers 2 233 km^2. There are three areas of phosphate enrichment identified for exploitation. While the original assessment considered the whole MLA and applied zones for the assessment, this revision now focuses on the area exploited which is only SP-1 incorporating a 20-year mine plan covering an approximate annual dredge area of 1.7 km^2 and a cumulative planned total of 34 km^2 (Figure 32). The annual mining area equates to 0.08% of the MLA and the 20-year mining area to less than 2 % which is about 0. 0003% of the seabed within Namibia's exclusive economic zone.

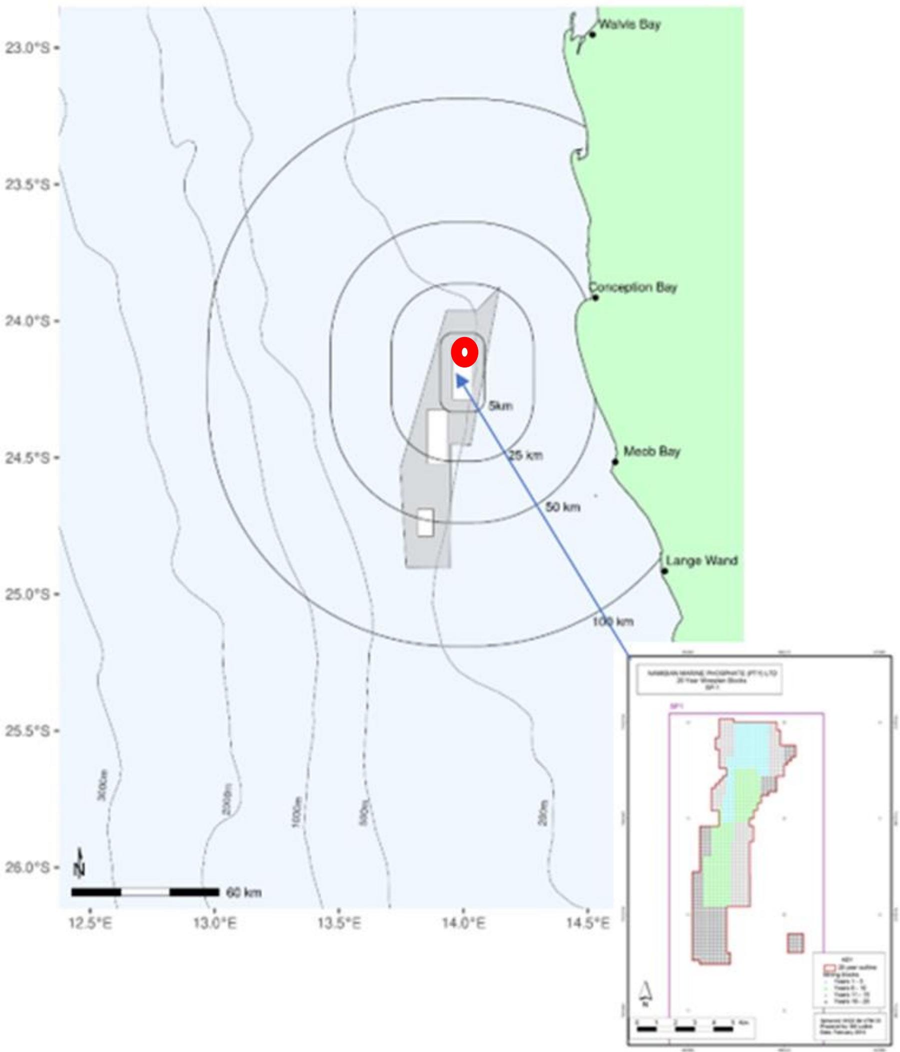

Figure 32. NMP 20-year mine plan for extracting phosphates in SP-1 within the MLA. Inset map shows the 20 year mine plan and is reflected approximately by the red dot which is the effective Zone 1 assessed. The MLA is the grey shaded area with the three Sandpiper blocks from north to south are SP1, SP2 & SP3 that were assessed originally. Only the impact of Zone 1 incorporating SP-1 is considered in this updated assessment.

5.1 Data and methodology of impact assessment

For this updated assessment some refinements have been made. The original comprehensive fisheries data (Table 4) have been used as well as now the most recent fisheries data provided by MFMR now integrated (spatially) for direct comparison as shown in (Table 4). These data include commercial catch and effort data of the main commercial fisheries sectors, fisheries survey data and numerous historical data sets provided by the Namibian Ministry of Fisheries and Marine Resources (MFMR) as well as the most recent transboundary survey undertaken through the FAO/NORAD programme (Boyer et al. 2019). This assessment and consideration of the data available (past and recent) therefore assume dredging will occur in a systematic way annually and in the area designated under the 20-year plan (Figure 32).

Table 4. Table showing old and updated data sets used in this updated assessment.

Sector	Date Range		Comment
	Catch	Effort	
Small pelagic purse-seine	2005 –	2005 – 2017	Fishery has been closed since 2018
Midwater trawl	2005 –	2005 – 2018	
H. mackerel purse seine	N/A	2019 - 2021	New fishery
Demersal longline	2005 –	2005 – 2018	
Large pelagic long-line	2004 –	2004 – 2019	
Tuna pole	2004 –	2004 – 2019	
Line-fish	2000 –	2000 – 2019	
Deep-sea crab	2013 –	2013 – 2018	
Deep-water trawl	1994 –	N/A	Fishery has been closed since 2007
Rock lobster	2005 –	2005 – 2016	
Hake Survey (MFMR)	2020	MFMR annual resource survey	
Monk Survey (MFMR)	2017	MFMR annual resource survey	
Small pelagic survey	2019	MFMR annual resource survey	
FAO / NORAD	2019 -	Independent Biomass transboundary survey	

The original distribution maps were created in ArcGIS 9 to show the position of the MLA and the target mining areas (SP-1, SP-2 and SP-3) relative to the different fishing sectors as well as numerous other data to help identify the impact of the proposed mining. The revised spatial assessment used R-Script and also ArcGIS and a modified zonation consistent with the proposed mining plan. The areas selected to assess impacts for this assessment have used as a rough guide the following broad characterizations as shown in Figure 33. The extent of the effect of a project activity on a particular physical, biological or social resource will vary and is termed the Area of Influence (AoI)[20].

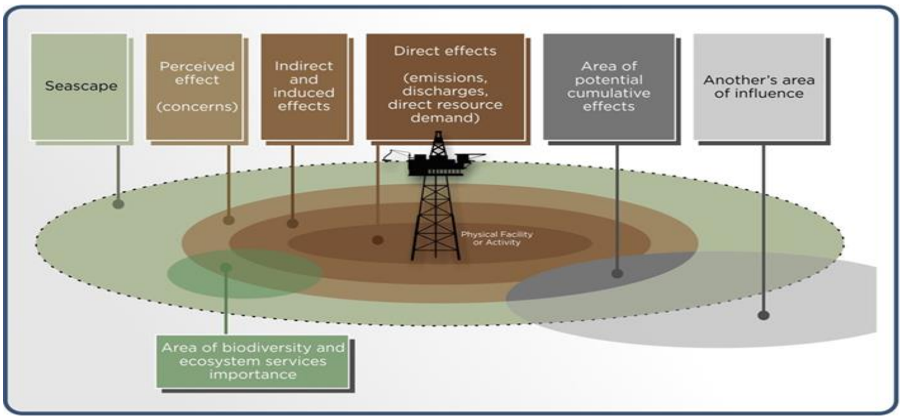

Figure 33. Broad areas of influence for assessments of impacts (IFC,

[20] Extracted from the IFC Performance Standard 1 in defining and illustrating the Area of Influence ref: IFC, 2012. IFC Performance Standards on Environmental and Social Sustainability. Performance Standard 1 - Assessment and Management of Environmental and Social Risks and Impacts.

The areas of influence broadly are :

- An area of assumed direct effects (a moving scale annually)
- An "local" area of Indirect and induced effects in the proximity of the mined area
- An area of perceived effects (Regional)
- An area extending beyond the regional scale or the seascape (we refer to this as "national")

To quantify the extent of the impacts due to phosphate mining therefore we apply these four zones as follows (Figure 32) :

Zone 1: 20-year Mine Plan [21] Direct Impacts (the 5 km area used only as reference distance)

Zone 2 : Area extending from Zone 1 outwards to 25km (Indirect Impacts)

Zone 3 : Area extending from Zone 2 to 50 km (Indirect Impacts)

Zone 4 : Area extending from Zone 3 to the EEZ (Indirect Impacts)

The data sets used and assessment methodology followed is provided in Appendix 3 and 4 respectively

5.1.1 Commercial fisheries data

The percentage catch or effort in the primary commercial fisheries (hake, monk and horse mackerel) in each zone was calculated and used to inform the assessment of the significance of the impacts relative to the total catch (National / EEZ). Note that this assessment considered all fisheries catch and effort data on an annual basis and also combined data for periods where aggregated or averages had no material effect to the outcomes. In some cases the fisheries data available for different fisheries differed in character. Catch and or effort were then selected that best represented each fishery sector. The previous assessment summary information is shown in Table 5 and the new consolidated information in Table 6 for comparison.

Table 5. Commercial fisheries data showing percentage catches per impact zone (original assessment)

Dataset	Dates	Species (percentage of 100km buffer zone)	MLA (SP-1, SP-2 & SP-3)	Mine site < 25 km	Local 25 - 50 km	Regional 50 - 100 km	National >100 km Zone 5
Hake commercial trawl data	2004-2009	Hakes	Yes	28.69	20.21	51.10	5.03*
Hake commercial longline data	2006-2010	Hakes	No	31.49	21.11	47.4	No data
Horse mackerel commercial mid-water trawl data	1997 - 2011	Horse mackerel	Yes	18.15	24.50	57.36	1.08*
Monk commercial trawl data	2005-2010	Monk	Yes	46.17	18.57	35.26	13.08*
Small pelagics commercial data	2000-2011	Anchovy	No	1.67	42.28	56.06	No data
		Sardine	No	17.44	29.17	53.39	No data
		Round herring	No	1.82	23.67	74.52	No data

[21] Note that this is an area within SP-1 and does not incorporate as previously done, the whole of the MLA or any of the other previously referenced locations of SP-2 and SP-3

Table 6. Summary table of recent primary commercial fishery data used in the assessment of fishery impacts (current assessment)

		Zone 1 : 20-yr mine site SP-1		Zone 2: Local < 25km		Zone 3: Regional < 50km		Zone 4: National >50km	
Year	Hake Wet	No.	%	No.	%	No.	%	No.	%
2016	12936	0	0,00	0	0,00	52	0,40	12884	99,60
2017	10754	0	0,00	3	0,03	47	0,44	10710	99,59
2018	3057	0	0,00	0	0,00	10	0,33	3047	99,67
3 yr avg	8916	0	0,00	1	0,01	36	0,39	8880	99,62
	Hake Freezer (t)	Catch	%	Catch	%	Catch	%	Catch	%
2016	104234	0	0,00	4005	3,84	7564	7,26	92665	88,90
2017	124179	0	0,00	1730	1,39	8125	6,54	114324	92,06
2018	107369	0	0,00	2285	2,13	6263	5,83	98821	92,04
3 yr avg	111927	0	0,00	2673	2,45	7317	6,54	101937	91,00
	Hake LL sets	No. Sets	%	No. Sets	%	No. Sets	%	No. Sets	%
2016	1242	0	0,00	5	0,40	55	4,43	1182	95,17
2017	1536	0	0,00	10	0,65	131	8,53	1395	90,82
2018	1787	0	0,00	12	0,67	99	5,54	1676	93,79
3 yr avg	1522	0	0,00	9	0,58	95	6,17	1418	93,26
	Monk Catch (t)	Catch	%	Catch	%	Catch	%	Catch	%
2016	16177	0	0,00	1646	10,17	2389	14,77	12142	75,06
2017	13930	0	0,00	2360	16,94	3492	25,07	8078	57,99
2018	14789	0	0,00	2016	13,63	3545	23,97	9228	62,40
2019	13993	0	0,00	2349	16,78	3364	24,04	8280	59,17
4 yr avg	14722	0	0,00	2093	14,38	3198	21,96	9432	63,65
	Midwater	No.	%	No.	%	No.	%	No.	%
2014	7664	0,00	0,00	0	0,00	0	0,00	7664	100,00
2015	8724	5,00	0,06	18	0,21	113	1,30	8588	98,44
2016	9019	2,00	0,02	2	0,02	24	0,27	8991	99,69
3 yr avg	8469	2	0,03	7	0,08	46	0,52	8414	99,38
	Small Pel (PS)	No. Shots	%	No. Shots	%	No. Shots	%	No. Shots	%
2014	450	0	0,00	1	0,22	1	0,22	448	99,56
2015	267	0	0,00	0	0,00	0	0,00	267	100,00
2016	43	0	0,00	1	2,33	2	4,65	40	93,02
2017	48	0	0,00	0	0,00	2	4,17	46	95,83
4 yr avg	202	0	0,00	1	0,64	1	2,26	200	97,10
	HM P Seine	No. Shots	%	No. Shots	%	No. Shots	%	No. Shots	%
2015	132	0	0,00	0	0,00	0	0,00	132	100,00
2016	109	0	0,00	0	0,00	1	0,92	108	99,08
2017	153	0	0,00	0	0,00	0	0,00	153	100,00
2018	102	0	0,00	0	0,00	0	0,00	102	100,00
2019	663	0	0,00	0	0,00	0	0,00	663	100,00
2020	697	11	1,58	18	2,58	28	4,02	640	91,82
2021	570	3	0,53	12	2,11	15	2,63	540	94,74
7 yr avg	347	2	0,30	4	0,67	6	1,08	334	97,95

5.1.2 *Survey data*

In addition to using commercial catch and effort data for spatial assessments, data from numerous fisheries surveys were provided by MFMR. This included data from the main annual biomass surveys for hake, monk, horse mackerel and small pelagic species (Annexure 6). The survey data, which are "independent" of the commercial data provide insights and comparisons with the NMP verification survey undertaken in 2014 and is used primarily to inform the relative abundance and biodiversity. The northern-most extent of the MLA approximates 24^0 S and 14^0 E and is a useful reference line. It was not possible to extract all historical survey trawls in the proximity of the SP-1 mining area, though six selected stations (Table 7 and Appendix 6) provided supportive information for this assessment and for comparison with the NMP verification survey undertaken in 2014 and the consolidated main species or groups in Table 8. Direct comparisons between the species lists collected by both the verification survey and the MFMR surveys is provided in Appendix 7: Table 17

Table 7. Selected stations in the proximity of the SP-1 Mining site used to verify independent abundance of fish and other species (see detail in Appendix 6).

Station	68	70	58		90	93	94
	R/V Dr. Fridtjof Nansen				Mirabilis	Mirabilis	Mirabilis
Lat	24°1.82	23°41.14	24°22.25		24°1.00	23°41.00	23°41.00
Long	13°50.74	13°48.27	14°0.24		13°51.00	13°48.00	13°35.00
Trawl time	30	21,1	25		24	30	30
Depth	246	192	199		237	192	228
Total fish catch	859,08	358,11	1394,34		1101,75	406,42	616,9

Table 8. Comparison of selected survey proportions (%) of main species and groups with the NMP verification survey (see also Appendix 6 and 7)

	MFMR/NORAD	Verification
Hake	59,000	19,432
Monk	1,754	17,035
Horse Mackerel	10,000	0,202
Sole	0,151	1,403
Jacopever	2,200	0,525
Gurnard	0,131	0,007
Shark	0,113	0,028
Goby	8,000	0,474
Myctophids and other deep	5,000	6,861
Cephalopods	3,300	1,685
Crustacea	3,800	1,196
Tunicate	0,251	47,046
Sponge	5,000	3,733
Sea Cucumber	0,010	0,000
Starfish	0,290	0,001
Gastropods	1,000	0,371
	100 %	100 %

Comparatively the species breakdowns are similar between the hake-directed MFMR surveys and the monk-directed[22] verification survey.

[22] The surveys differed fundamentally in that hake surveys use a different bottom-trawl configuration to the monk-trawl used for the verification survey. This is reflected in part by the difference in volumes caught of hake and monk. Both survey type catches were dominated by jellyfish and tunicates (Jellyfish proportion separated in the MFMR survey data)

5.2 Identification of impacts for assessment

The displacement of the mainly commercial fishing activities and the redistribution, survival and recruitment of ecological important fish species, seabirds and mammals could be impacted directly or indirectly by the mining of phosphate in several ways. These are outlined below.

5.2.1 Direct Impacts

Exclusion of fishing to avoid mining, and the destruction of potential fishing grounds **:** Fishing activities will cease to occur in the mined area during the phosphate mining operations because of the physical nature of phosphate mining (habitat removal) and increased levels of maritime traffic. Fishing effort will certainly be displaced for the mining period as the mining progresses over the 20-year period[23]. Fishing is possible in the proximity of the mining operations provided normal navigation safety conditions apply.

The removal of habitats (or disturbance of bacterial mats, if present) utilized by marine fauna : Demersal fish species are mostly associated with the sea bottom and may be displaced by loss of habitat through the direct removal of substrate. The removal of the "giant" bacteria *Thiomargarita* and *Beggiatoa* is also a consideration (and is assessed in the updated report by Carter and Steffani (2021)[24]).

Potential Loss of biodiversity through direct physical removal of fauna : It is an important consideration if unique species occur in the mining area that may result in the loss of or disturbance of biodiversity. Note that this specialist assessment only considers biodiversity in the context of ichthyofauna and that no unique species have been recorded in this or other reports undertaken to date. The creation of sediment plumes[25] (turbidity) that might affect species abundance (area avoidance, mortality, loss of feeding and spawning grounds etc) : Mining for marine phosphate deposits by dredging the seafloor may increase the amount of suspended nutrients in the surrounding sea water if soluble phosphate is present in the sediment pore water (Note: the phosphate ore to be mined is insoluble in sea water). When nutrients increase in the water column, the amount of phyto and zooplankton are likely to increase. See Figure 34 below showing modelling of the sediment plume relative to historical hake catches undertaken by HR Wallingford (2020).

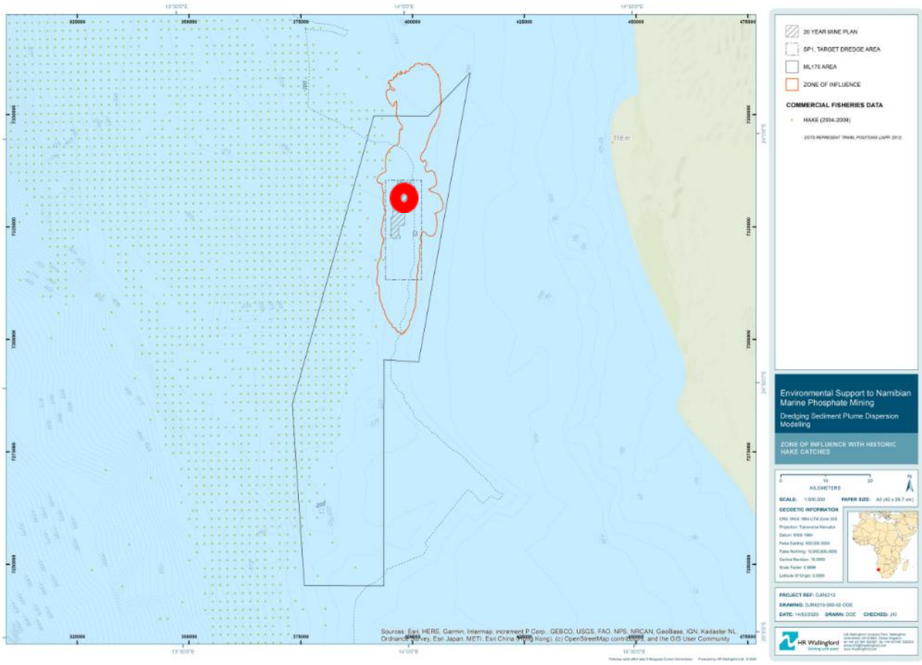

Figure 34. Example of sediment plume modelling showing "zone of influence" relative to the 20-year mine plan and historical hake catches in the proximity of the mining site (red dot marks approximate mine area).

[23] Note Mining is not continuous (3 cycles/week with average time on site in mining area of 16 hrs)

[24] Carter, R. & Steffani, N. 2021. NMP EIA & EMPR Amendments Revisions based on supplemental studies and scientific advances

[25] Note here that the annual mine area is 1.7km2 and that the cumulative zone of influence for plume dispersion & at any point in time is expected to be substantially smaller

5.2.2 Indirect impacts

Indirect effects may also occur such as :

- Displacing the normal behaviour of seabirds and mammals due to the physical disturbance of the mining activity (including noise from the dredging operation)
- Disturbance of normal trophic interactions and the general ecosystem functioning*:*

Underwater sound[26] can have a variety of effects on marine life, ranging from subtle to strong behavioural reactions such as startle response to complete avoidance of an area. In extreme instances it may create conditions that contribute to reduced productivity and effects on survival. Dredging sounds generally fall within the lower end of the frequency ranges although insufficient knowledge exists to confidently predict at what levels sound can cause injury, such as hearing damage or communication interference.

5.2.3 Impact Categorisation

We have categorised our assessment into the different types of impacts for ease of interpretation. These include the likely impact of the proposed phosphate mining on fishing, the ecosystem in general, on fish recruitment, biodiversity (predominantly fish) and the likely impact of the mining operations on seabirds and marine mammals. Our five primary impacts that have been assessed independently according to the significance rating and impact criteria provided are:

Impact 1 : The likely impact of mining **ON** commercial fisheries (hake and monk demersal trawl fishery, the hake longline fishery, the mid-water trawl fishery and the small pelagic purse seine fishery). The fishing sectors will not be able to operate properly in the mined area due to a) the disturbance from actual mining operations; b) associated sediment plumes; c) exclusion zones around the mining site; and d) increase levels of maritime traffic associated with the mining operation;

Impact 2 : The likely impact of mining **ON** the main commercial fish species (hake, monk, horse mackerel, small pelagics, sole, orange roughy, snoek and mariculture). The fish fauna is a critical component of the broader marine ecosystem and may be displaced and/or redistributed by the mining operation primarily because of the a) actual mining activities; b) habitat disturbance; and 3) sediment plumes (turbidity);

Impact 3 : The likely impact of mining **ON** the recruitment of commercially important species (hake, monk, horse mackerel and small pelagics). The dispersal and survival of juveniles, eggs and larvae will be affected by a) physical disturbance of the fishing grounds and b) sediment plumes (turbidity);

Impact 4 : The likely impact of mining **ON** the fish and other biodiversity. Mining operations will result in a reduction or loss in biodiversity because of the a) actual mining operations, b) the habitat destruction and c) sediment plumes; and

Impact 5 : The likely impact of mining **ON** seabirds and marine mammals. Mining operations will cause the displacement and/or redistribution of seabirds and mammals due to a) noise pollution and b) disturbance of the ecosystem.

5.3 Results

5.3.1 Impact 1: The impact of the mining operations on commercial fisheries.

We used spatial analysis to estimate the proportion of fished ground likely to fall within each defined zone. Refer also to Table 5 and Table 6 showing the estimates of the likely proportion of catch or fishing effort that may be impacted by each zone adjacent to the mining operations. The comparative spatial maps (between 1st assessment and current is shown in the figures below) and the impact ratings for each sector in Figures 35 to 38 (red dots mark approximate location of 20-year mining area)

[26] Noise impacts have been assessed in different studies by Wallingford (2020) and Carter & Steffani 2021) and has been based on quantitative measurements of sound profiles and impacts on marine life supported by known dredging operations.

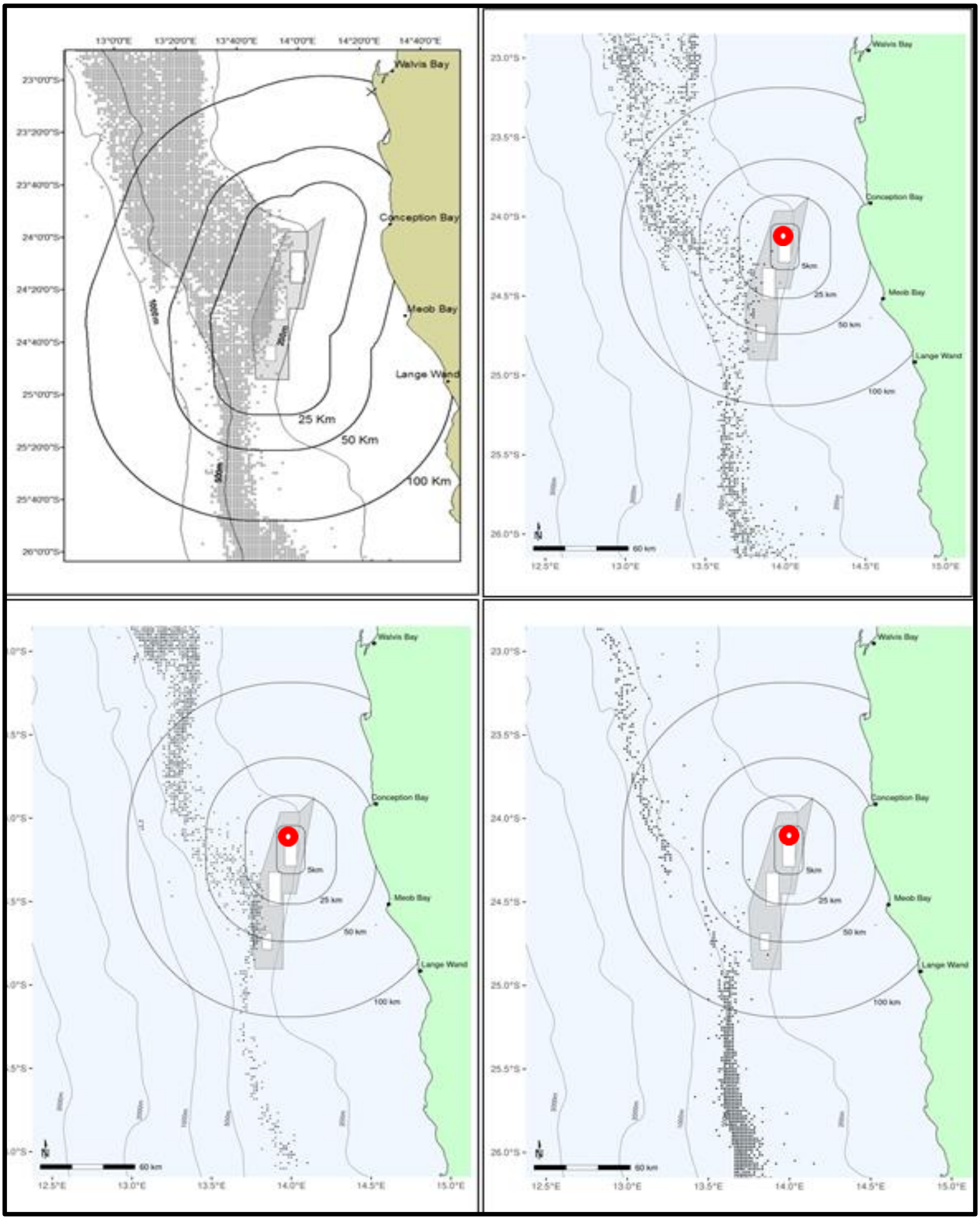

Figure 35. Hake commercial data (2004-2009) (top L) and 2016-2018 data for Wetfish (Top R), Freezer (bottom L) and longline (Bottom R). Each dot represents the position per trawl or set as in Table 6. (red dot marks approximate mining area)

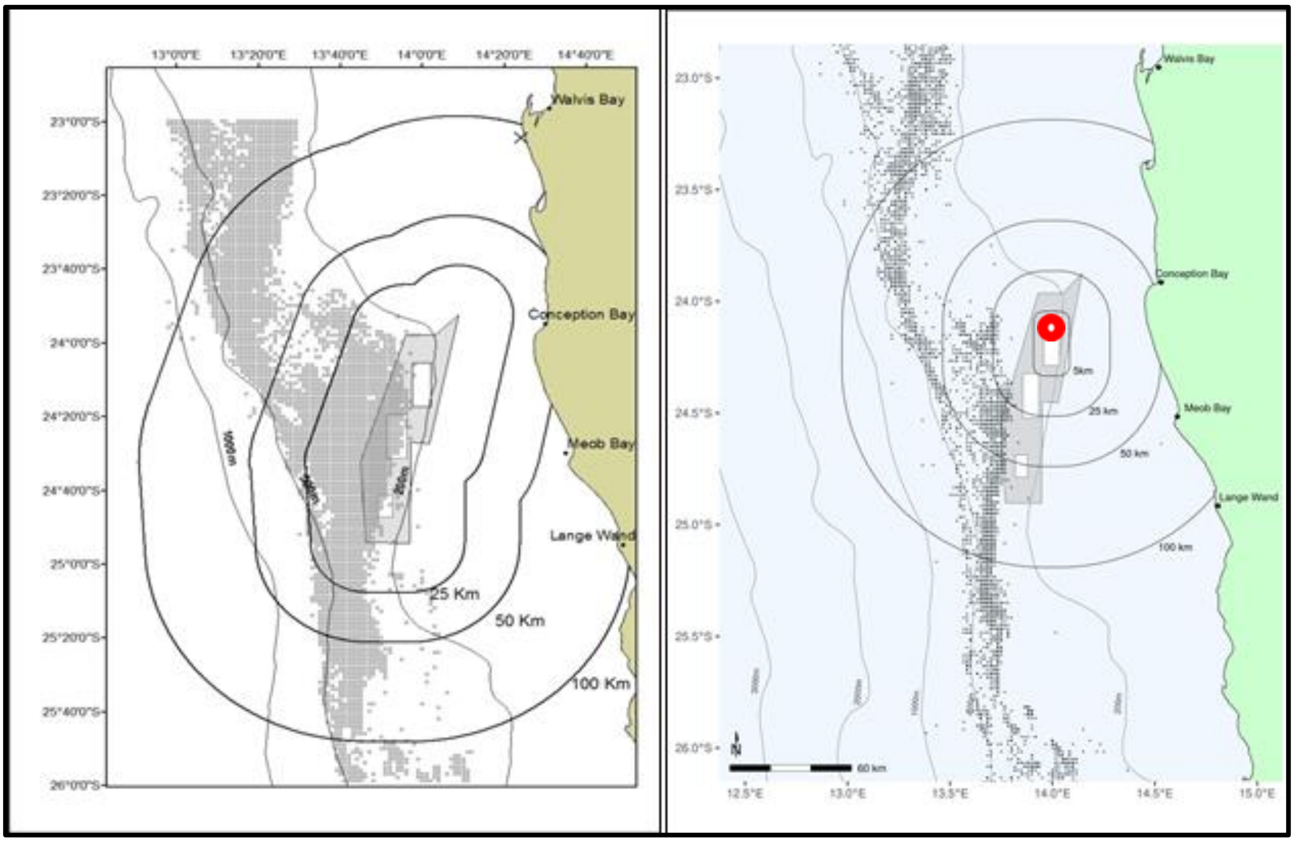

Figure 36. Monk commercial data (2005-2010) (left) and 2016 to 2019 (right). Each dot represents the position per trawl.

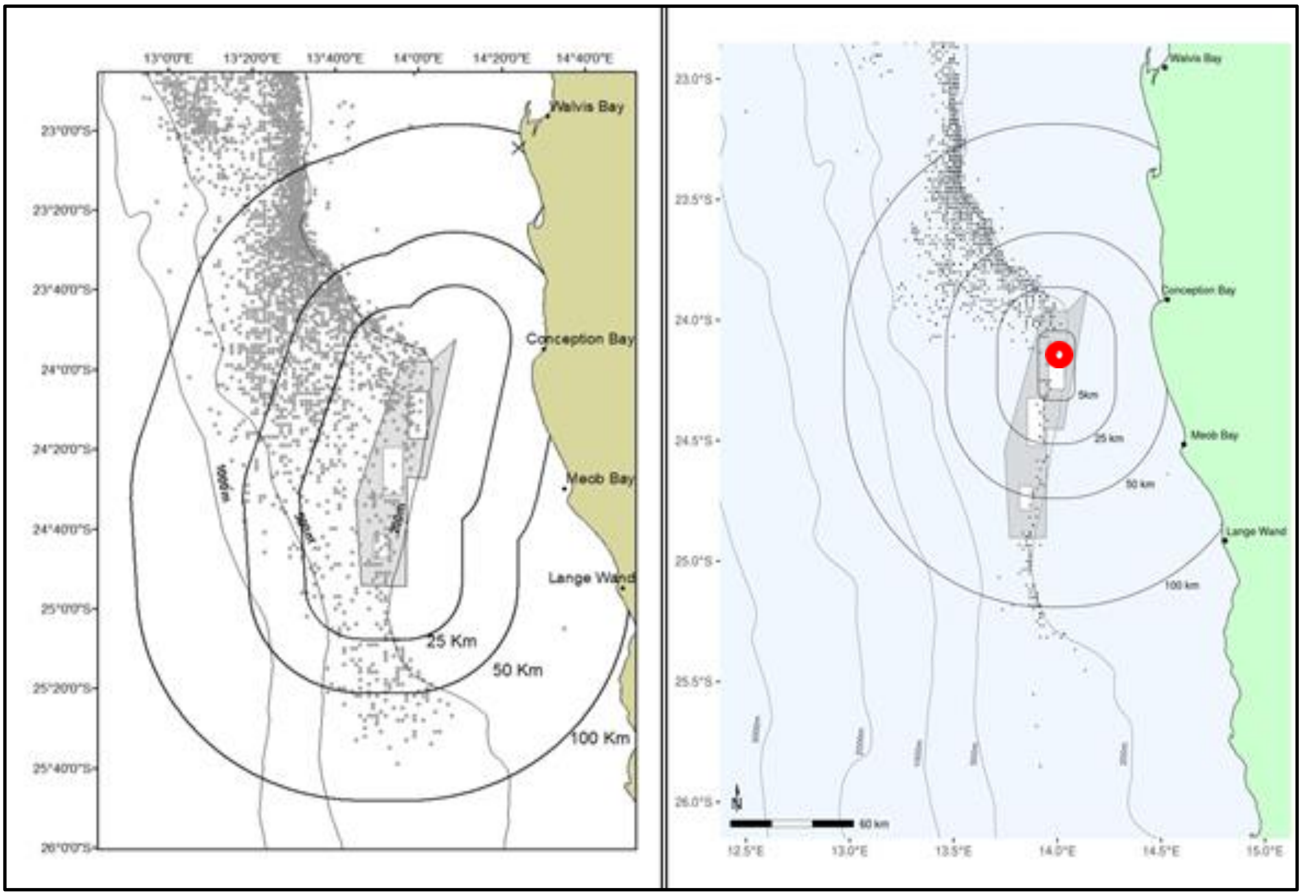

Figure 37. Horse mackerel commercial data (1997-2011) + 2016 – 2019. Dots are the position of the last trawl per day.

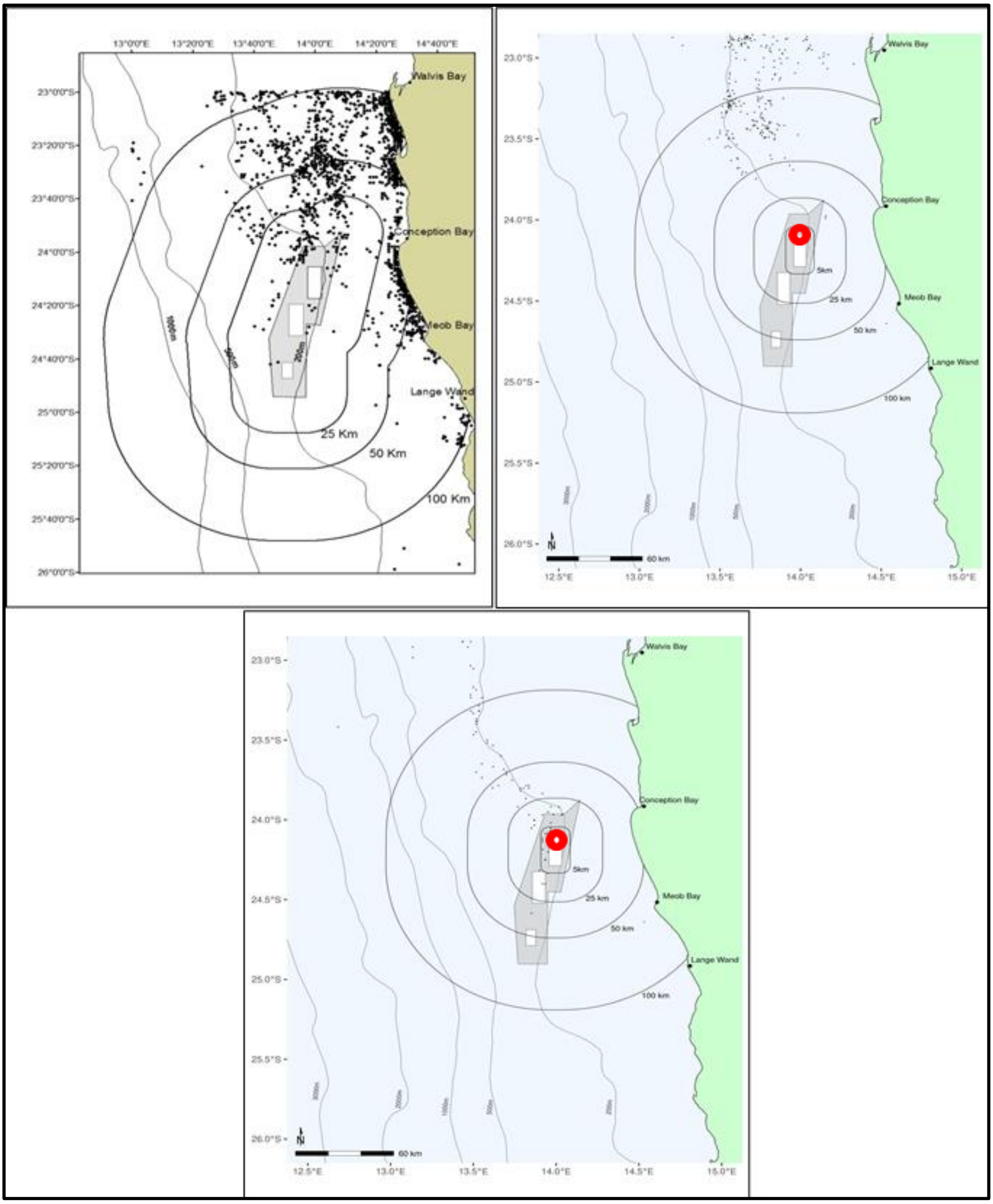

Figure 38. Small pelagic commercial data (anchovy, sardine and round herring) 2000 – 2011 + 2016-2019 + horse mackerel 2018-2021 (red dot marks approximate location of mining)

For all other fisheries as described for deepwater trawl (para 4.1.4); crustaceans (para 4.3); linefish (para 4.4) and Mariculture, direct effects are deemed not likely to occur. The assessment system provided (Appendix 8) was used to determine fishery-specific and in some cases, where deemed appropriate , scores aggregated. Table 9 is used as reference for the original EIA done in 2012.

Table 9. Impact assessment table done in 2012 summarizing the impact of phosphate mining on the main Namibian fisheries (provided for comparative purposes)

Nature of the impact	The impact on **fishing operations** of phosphate mining on the main Namibian fishing sectors; **a)** hake trawl and **b**) hake longline, **c)** monk trawl **d**) horse mackerel mid-water trawl, and **e)** small pelagic purse seine fisheries. The fishing sectors will not be able to operate in certain areas due to **1)** actual mining operations, **2)** associated sediment plumes **3)** exclusion zones around the mining site and **4)** increase levels of maritime traffic associated with the mining operation.
Extent	MLA[27] - fishing operations will be affected in the MLA and beyond to within a 25 km boundary of the actual target mining sites SP-1, SP-2 and SP-3.
Duration	Long term - the direct impact will cease once the mining activity ends after 20 years (the period for which the mining licence is issued). Thereafter the recovery of the fishing grounds and fish abundance to levels prior to the commencement of mining operations is expected to take up to 20 years (long term)
Intensity	Serious effects - significant impacts will occur for the duration of mining in the MLA, moderate effects are expected to occur in the long term once mining ceases (up to 20 years).
Probability	Definite- consequences will occur in all instances for the duration of mining. Once mining ceases consequences are expected to occur in some instances (moderate effects) within the MLA and persist at a reduced level in the long term within the 25 km boundary zone.
Status (+ or -)	Negative - the impact will result in a direct loss in fishing operations in MLA
Significance (no mitigation)	Medium - the project design might require modification to accommodate certain fishing operations
Mitigation	Consider options to minimise impact on fishing operations for example options with respect to spatial and temporal area closures.
Significance (with mitigation)	Medium to low
Confidence level	High - the evaluation is based on good qualitative and quantitative, historical and current fisheries related data.

5.3.1.1 Outcome 1: Hake Fisheries – The deemed impact on fishing industry operations based on the spatial assessment in Zone 1 is as follows :

Table 6 shows that there is no evidence of historical fishing in Zone 1, and only marginal hake effort in Zone 2. Most hake effort occurs in Zone 3 and beyond where effort increases systematically into deeper water.

Seabed dredging (direct impacts) will have minimal impact on hake fisheries operations, the impact is expected to be of long-term duration (20-year mine plan) and will be restricted to Zone 1 with minimal extent. The Impacts are improbable on freezer trawl and hake longline and possible on wetfish trawl. Impact status is neutral except for wetfish trawl where it will be minor. Confidence in the assessment is high (medium for wetfish trawl due to some data uncertainty). Overall the significance of impacts for all hake sectors is deemed low.

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[27] Note : in the previous EIA the whole MLA applied – this assessment considers only the area to be mined (Zone 1)

4.3.2.1 Outcome 2 : Monk Fishery The deemed impact on fishing industry operations based on the spatial assessment in Zone 1 is as follows :

Table 6 shows that there is no evidence of historical fishing in Zone 1, with an average of 14.38% of effort in Zone 2. Most monk effort occurs in Zone 3 and beyond where effort increases systematically into deeper water.

Seabed dredging (direct impacts) will have minimal direct impact on the monk fishery, the impact is expected to be of long-term duration (20 year mine plan) and will be restricted to Zone 1 with minimal extent to Zone 2. Dredging impacts will not impact fishing operations and the proximity to the mining site is not deemed to have any direct impacts (the cumulative plume as shown in Figure 34 is limited in extent and is not expected to be persistent as the operational plume will depend on the actual dredging operation (see also Carter and Steffani, 2021). Impact status is possible and negative with medium level of confidence. Overall the significance of impacts for the monk sectors is deemed low (minor).

4.3.2.2 Outcome 3 : Horse mackerel Midwater Trawl.

Table 6 shows that there is near zero effort of historical fishing in Zone 1 (0,03%) increasing to 0.08% in Zone 2. Over 99 % of midwater effort occurs in Zone 4 northwards of the mining site.

Seabed dredging (direct impacts) will therefore have minimal direct impact on the MW trawl fishery, the impact is expected to be of long-term duration (20-year plan) and minimal extent from Zone 2 and beyond. Dredging impacts will not impact fishing operations and the proximity to the mining site is not deemed to have any direct impacts. The plume effect is likely of limited effect though it is anticipated to move northwards towards areas fished for horse mackerel in waters deeper than 200m. The Impacts are possible and negative with high level of confidence. Overall the significance of impacts for the MW sector is deemed low.

4.3.2.3 Outcome 4 : Small pelagic purse seine horse mackerel-directed.

Table 6 shows that there is near zero effort of historical fishing in Zone 1 (0,3%) increasing to 0.67% in Zone 2. Over 98 % of horse mackerel purse seine effort occurs in Zone 4 and as with MW trawl is northwards of the mining site.

Seabed dredging (direct impacts) will therefore have minimal direct impact on the fishery, the impact is expected to be of long-term duration (20-year mine plan) and minimal extent from Zone 2 and beyond. Dredging impacts will not impact fishing operations and the proximity to the mining site is not deemed to have any direct impacts. The plume effect is localised and likely of limited effect though it is anticipated to move northwards towards areas fished for horse mackerel in waters deeper than 200m. The impacts are possible and negative with medium level of confidence. Overall the significance of impacts for the Horse mackerel purse seine sector is deemed low.

4.3.2.4 Outcome 5 : Small pelagic purse seine (fishery inactive)

Table 6 shows that there is zero historical effort of historical fishing in Zone 1 and 0.64 in Zone 2. Over 99 % of small pelagic effort occurred in Zone 4. Seabed dredging (direct impacts) will therefore have no direct impact on the small pelagic sector. This is determined with high confidence. Overall the significance of impacts is therefore deemed low.

4.3.2.5 Outcome 6 : Crustacean fisheries, deepwater trawl sector

There is zero historical effort of historical fishing in Zone 1 and Zone 2 for these sectors. Seabed dredging (direct impacts) will therefore have no direct impact. This is determined with high confidence. Overall the significance of impacts is therefore deemed low.

4.3.2.6 Outcome 7 : Meso-pelagic, snoek and other migratory (snoek)

There is zero historical fishing effort in Zone 1 for these sectors. Meso-pelagic species occurs mostly in deeper waters than 200 m though some seasonal effort directed at snoek is possible (though unlikely at the distance of the mining site offshore). Seabed dredging (direct impacts) is therefore of possible probability and with medium confidence and an overall neutral impact. Overall the significance of impacts is therefore deemed low.

4.3.2.7 Outcome 8 : Linefish and Mariculture

There is zero historical fishing effort or mariculture in Zone 1 for these sectors. The proximity of mariculture extends further than 100 km from the mine site and the operational distance from ports negates any likelihood of impacts on linefish operations. Plume dispersion modelling (Wallingford, 2020) shows the mariculture areas in Walvis Bay lie well beyond the defined cumulative Zone of influence from dredging operations. Overall the significance of impacts is therefore deemed low.

4.3.2.8 Summary of Impact 1

In general for all fisheries operations the likely direct impacts of seabed dredging is deemed low. This conclusion does not differ significantly from the EIA undertaken in 2011-2012. The full assessment table should be viewed in context (excel version) to fully understand the sensitivity of all receptors. Of these receptors the following should be noted :

- only hake trawl, horse mackerel midwater trawl, horse mackerel purse seine and monk trawl will be directly impacted by mining over the 20-year life of mine and only directly at the actual mining location during operations over the 20-year period.
- In all other zones (2 to 4) the proportion of fishing that may be indirectly impacted will vary with distance from the actual mining lease area.
- With respect to demersal and pelagic fish, the dredge overspill plume impacts will likely be low or minimal and localised, provided that plumes are limited to the mining or immediate operational area.
- Due to the northward-flowing current along the Namibian shelf it is possible, but unlikely, that the impact of the operations (plume effect) might be transported into part of the fishing areas for hake, horse mackerel, sardine and monk (for further reference see plume modelling undertaken by Wallingford, 2020).[28]

5.3.2 Impact 2: The impact of the mining operations on the on the main commercial fish species

The survey data (Table 10) were analysed by visually examining the maps (Figure 39 - Figure 53). To determine the likely impact of mining we used as the distribution and abundance of each species relative to their proximity to the 20-year mining location (SP-1). (the unit or index applied is simply the cumulative catch of a particular species in the different surveys). Note that the most recent surveys and MFMR survey maps have also been used (see Hake : Figure 6; Horse mackerel : Figure 2; Sardine : Figure 3; and Monk : Figure 7 : Monk).

[28] Note also that these areas are already disturbed by trawling and or other fishery gears.

Table 10. Visually assessment of the potential impacts of phosphate mining on ecologically important fish species

Dataset	Dates	Species	Occurrence in Zone 1	Likelihood of being impacted in Zone 1
Hake survey data	1995-2010 2019 & 2020	Horse mackerel	Yes	Unlikely
		Snoek (*Thyrsites atun*)	Unknown	Unlikely
		Goby (*Sufflogobius bibarbatus*)	Yes	Possible
		Monk	Yes	Probable
		Hake	Yes	Possible
		Sole (*Austroglossus microlepis*)	Yes	Probable
Monk survey data	2007-2010	Monk	Yes	Probable
		Goby	Yes	Unlikely
		Orange roughy (*Hoplostethus atlanticus*)	No	Unlikely
		Sole	Yes	Probable
Small pelagic survey data	2002-2011	Horse mackerel, anchovy, sardine and round herring	Yes	Unlikely
Hake, monk and small pelagics survey data combined	1995-2011	All species counted per sample station	Yes	Yes

Note : Context and scale are significant factors influencing determination of impacts.

In the original assessment the zoning was scaled around the whole MLA as at the time that was the terms of reference for the impact assessment as it was assumed dredging would be done in the three areas. This assessment makes reference to that assessment the MLA and the figures used. This revised assessment however considers only the actual mined site as Zones 1 (SP-1), though materially this change in scale makes no significant difference to the outcomes in most cases.

Depending on the concentration of the dredge overspill particles in the water column, the effects can vary. The effects of sedimentation from the dredger overspill plumes is discussed in more detail in Carter and Steffani (2021). Based on the acute effect threshold (The TSS SSD HC5 value of 7.6 mg/l, protective of 95% of the taxa tested) HR Wallingford defined a 20-year suspended sediment plume zone of influence (ZOI) that encompassed the SP-1 Mine area and extended 25 km north, 9 km east, 17 km south and 3 km west of its borders. The ZOI is the area within which a suspended sediment concentration above 7.6 mg/L may occur at any location within the water column at any time over the modelled period. For actual dredging events the modelling indicated more restricted plume dimensions in the range of 1-5km^2 compared to the ZOI 546 km^2. Carter and Steffani (2021) further noted that plume effects associated with deposition of particles/ fine material from the dredging operation is expected to be minimal, concluding that for an individual dredge cycle (58.5 hours being 16 hrs active dredging and remainder of time dredger is offsite), the impact is expected to be short term.

Benthic biota in the immediate vicinity of the dredge area may therefore be affected by smothering, elsewhere sedimentation rates are expected to be very low with low significance. In this regard, small pelagic fish such as filter feeders may be intermittently disturbed by dredging activity, either directly by gill clogging (potentially but not verified) or indirectly through the food web (if mortality occurs). Trophic cascade effects are possible (again not verifiable), for example affecting plankton abundance and disturbance of feeding behaviour of small pelagic species. As long as the effects of dredging are not transported inshore where most small pelagic spawning activity occurs, the effects of phosphate mining on small pelagic commercial fish is considered low.

The relative impacts (to commercial fisheries) is also considered using the recent independent trawl survey stations in Appendix 6 which shows that the species caught in these survey stations in the proximity of SP-1 do not differ significantly from those recorded in the 2014 verification survey undertaken by CapMarine (Smith and Japp, 2014 - see also the consolidated Table 8). Reference is also made to Gaylard (2013)[29] who estimated the contribution of the MLA and surrounding areas to biomass for three commercially exploited finfish in SP-1, namely shallow-water hake, *Merluccius capensis* (Cape Hake), deep-water hake *Merluccius paradoxus* and monkfish *Lophius vomerinus*. This quantitative assessment considered four size categories of each species (juveniles, recruits, maturing stock and mature stock) as well as the MFMR survey biomass estimates. The study concluded that " *less than 0.2 % of each species considered lies directly within the proposed SP-1 mining site. The SP-1 site also makes no significant contribution to recruitment or spawner stock biomass for any of the species considered in this assessment. Outside of SP-1 and within the larger MLA, the biomass of monk expected to contribute to the recruitment to the fishery is estimated to be 7%. This assessment makes no judgement on the possible impact on recruitment of mining only in SP-1 on the area outside of SP-1 and within the total MLA. It is emphasized that, as the proportion of the potential biomass in SP-1 and recruiting to the commercial fisheries in the adjacent areas is extremely small, the broader impact, if scaled outside of the mined area, is likely to be minimal."*

A further consideration is also the broader context of the cumulative impacts of other anthropogenic activities on the substrate, in particular those associated with bottom trawling which have been widely considered in the scientific literature. It is accepted that trawling significantly alters benthic communities (Collie et al. 2000, Kaiser et al. 2006). A study conducted in the southern Benguela (including a site to the south of Lüderitz) found that epifaunal abundances and species diversity decrease with increasing trawling intensity (Atkinson et al. 2011). Besides the impacts on benthic fauna, bottom trawls also pose a threat to seabirds that collide with the warp cables or become tangled in trawl nets (Watkins et al. 2008).

As indicated in the previous EIA the following is concluded regarding the impact of the proposed seabed dredging on the abundance and distribution of the main commercial fish species :

a) Hake (Figure 39 & 40) : Shallow-water is the dominant hake species found throughout the mining lease area (see also the MFMR recent survey density distributions in Figure 6). We assume the abundance of hake in the MLA and surrounding areas including the mine site is fairly uniform with higher levels of hake abundance in deeper water. Mining at the specific site (Zone 1) is therefore expected to impact on hake – due to their mobility hakes will avoid the mined area. This will result in displacement of hake biomass into adjacent areas, mortality is unlikely. From an ecosystem perspective this will have implications only in a localised context (we assume hake will avoid the mined area). Disturbance of the substrate will result in minor loss of food for hake (hake generally do not feed on substrate organisms and predate mostly on other fish species and squid).

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[29]Gaylard, J. 2013. Biomass and stock estimates of Hake and Monk in the mining lease areas of Namibian Phosphates

b) Horse mackerel (Figure 40) : In the MLA horse mackerel abundance is low although high incidence of this species is expected north and westwards of the mine site. Horse mackerel are highly mobile and as with hake, are expected to be displaced outside of the mined locations. Mortality is not expected and the impact on the ecosystem is expected to be low.

c) Monk and Sole : (Figure 41 & Figure 42) – Monk are found throughout the MLA and the adjacent areas. Distribution appears fairly uniform. Monk are aggressive ambush predators and are found mostly on flat muddy substrate. They are also not highly mobile fish and have mostly patchy localised distribution patterns. These characteristics are expected to make monk vulnerable to mortality from the direct physical nature of the dredging process. This will have a localised impact on the trophic ecology but due to the relatively small area of the mining sites, this impact is expected to be moderate. The removal of the preferred substrate type for monkfish will have a long-term (at least 20 years) impact on the availability of monk in and around the mining sites. As for monk, sole (Figure 47 & Figure 48) are a sedentary species preferring muddy substrate. They feed on polychaetes and other worms and fauna in the substrate. Their distribution is broad occurring at the mine site (Zone 1) and extending into Zone 2. Dredging operations could have a significant localised impact on sole abundance due to direct mortality associated with dredging. Some displacement of sole to adjacent areas away from the mining is expected. This localised impact will be long-term (at least 20 years) due to the removal of the preferred substrate of sole.

d) Pelagic Species : (Figure 38) - Abundance of small pelagic species is low in the MLA as a whole – availability of this species group is higher in Zone 2. Small pelagic species are nevertheless likely to be found throughout the MLA but the impact of mining and the resulting plumes is considered unlikely to have a significant detrimental impact on the resource and the ecosystem associated with these species as a whole. Pelagic Goby : (Figure 45 & Figure 46). Surveys suggest that goby are distributed throughout the MLA and will occur inside the mining sites including SP1. Goby also occurred in small amounts in the MFMR and Norad surveys (see Appendix 6). Goby have been identified as having a key trophic role in the ecosystem. As goby are a mobile species they will be displaced. Mortality is expected at the dredging location. Both the displacement and mortality of this species will have a moderate impact on the whole ecosystem in the MLA only.

e) Snoek : (Figure 44) - This species is found in and around the MLA. They are highly mobile and are only found seasonally and in aggregations with high abundance at these times. Snoek when occurring in the area of the MLA and mining operation are expected to avoid the area – i.e. will be displaced. This is not expected to have a significant impact on the ecology in the MLA and adjacent zones.

f) Orange Roughy : (Figure 49 & Figure 50) – Orange roughy are only found in deeper waters and well outside of the MLA. No impact on the ecosystem is expected.

NOTE : Figure 39 shows the approximate location of the Mine Site (20-year plan) by a red dot. This applies to each of the figures 40-50 included).

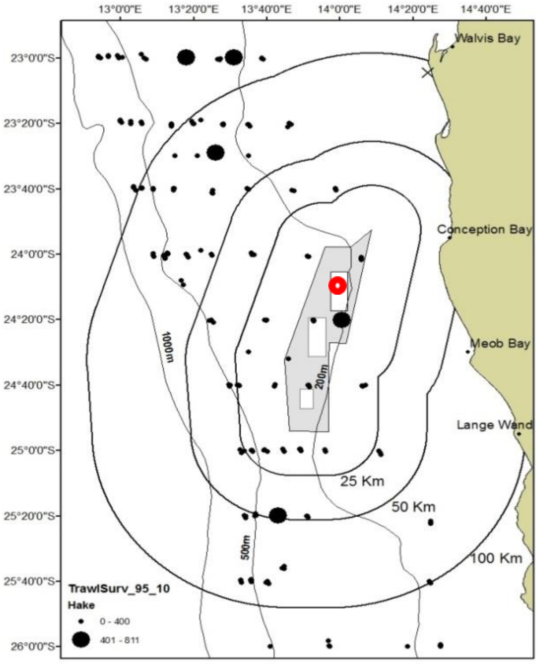

Figure 39. Distribution of hake from hake-survey data (1995-2010). Dots show the cumulative weights per station. n=678.

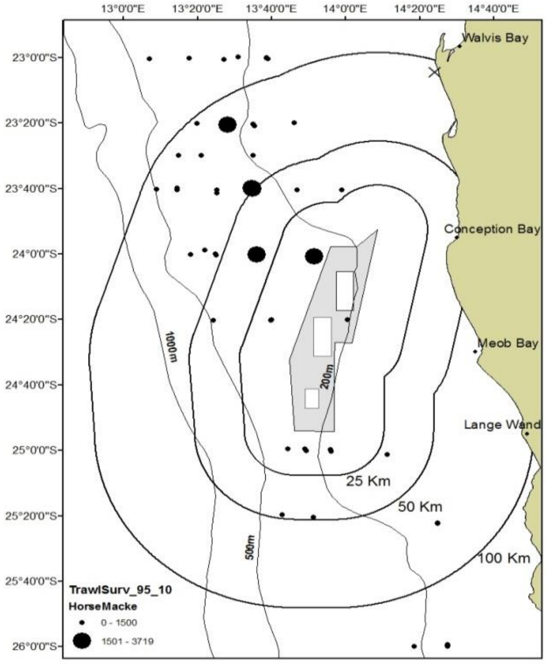

Figure 40. Horse mackerel from hake-survey data (1995-2010). Dots show cumulative weight per station. n=78

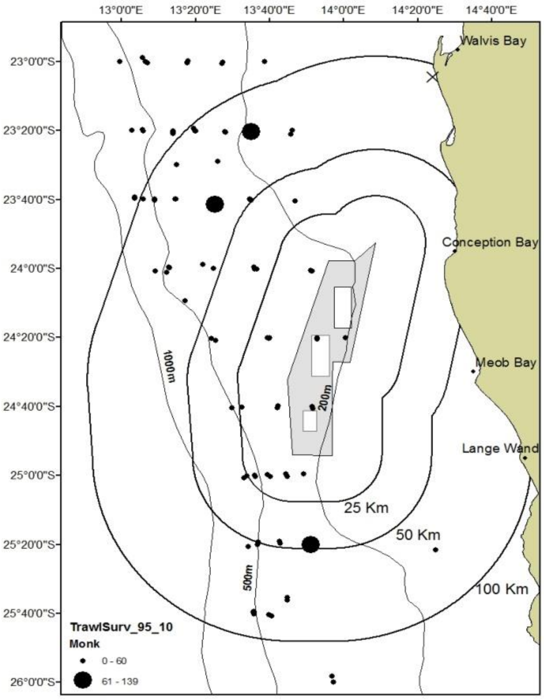

Figure 41. Monk from hake- survey data (1995 – 2010). Dots show cumulative weight station. n=134

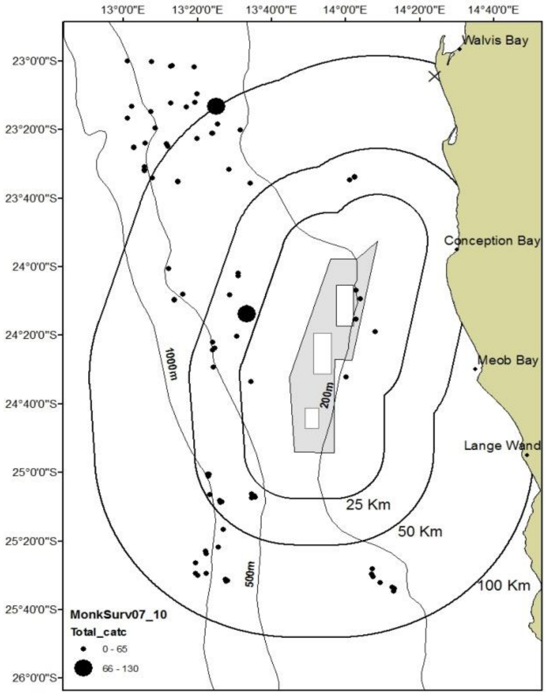

Figure 42. Monk from monk-survey data (2007-2010). Dots show cumulative weight per station. n=100

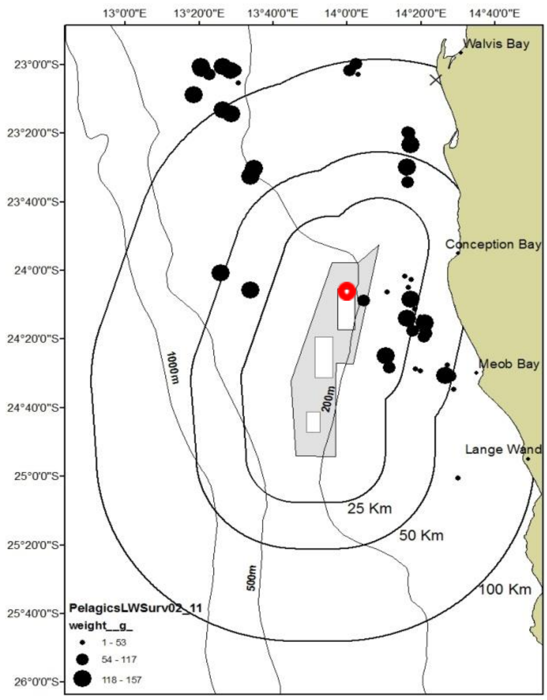

Figure 43. Pelagic (anchovy, sardine and round herring) weights from pelagic-survey data (2002 – 2011). n=2557

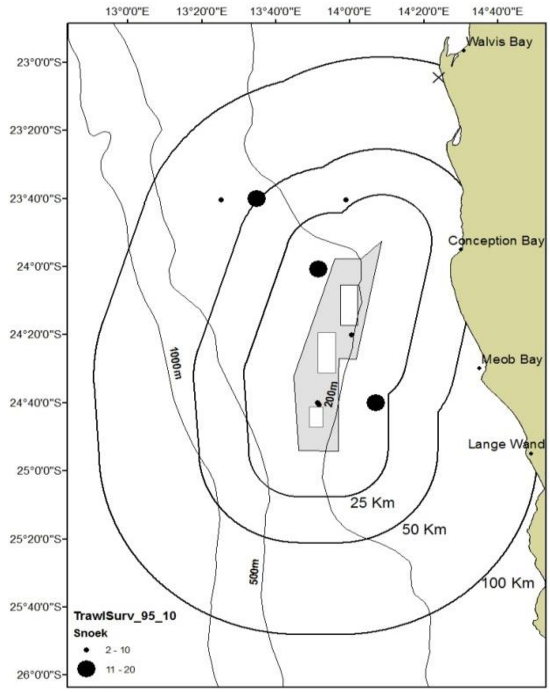

Figure 44. Total catch per station for snoek from hake-survey data (1997-2010). n=8

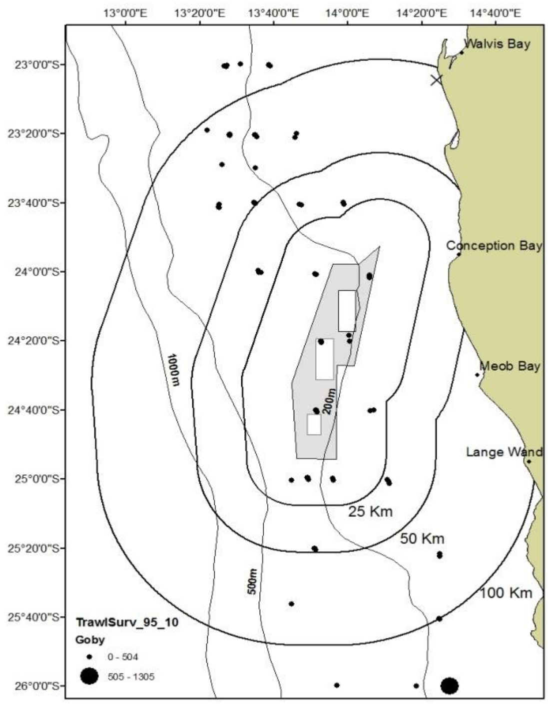

Figure 45. Distribution of goby from hake-survey data (1995 – 2010). n=93

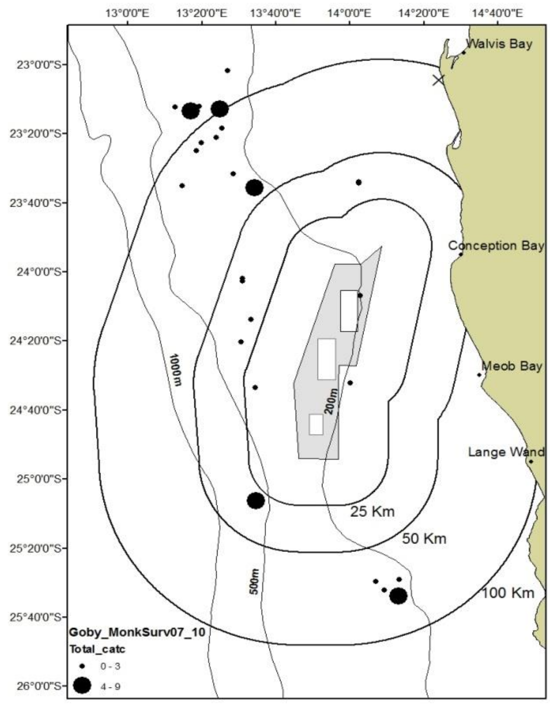

Figure 46. Distribution of goby from monk-survey data (2007 – 2010). n=24

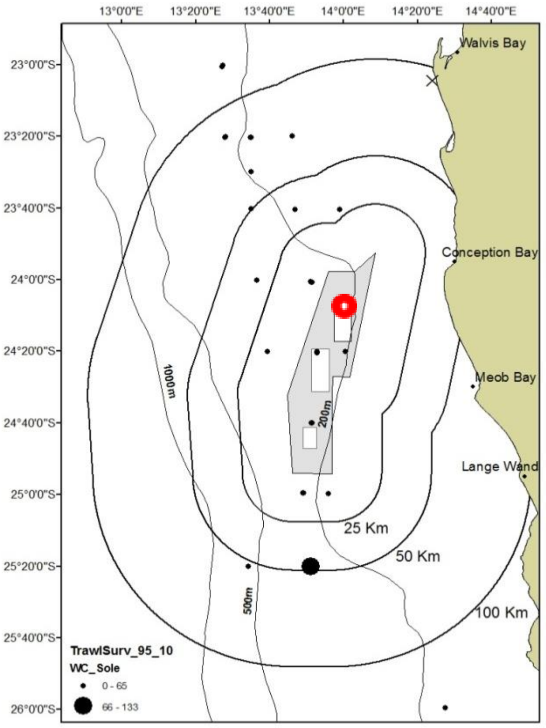

Figure 47. Total catch per station for west coast sole from hake-survey data (1997 – 2010). n=48

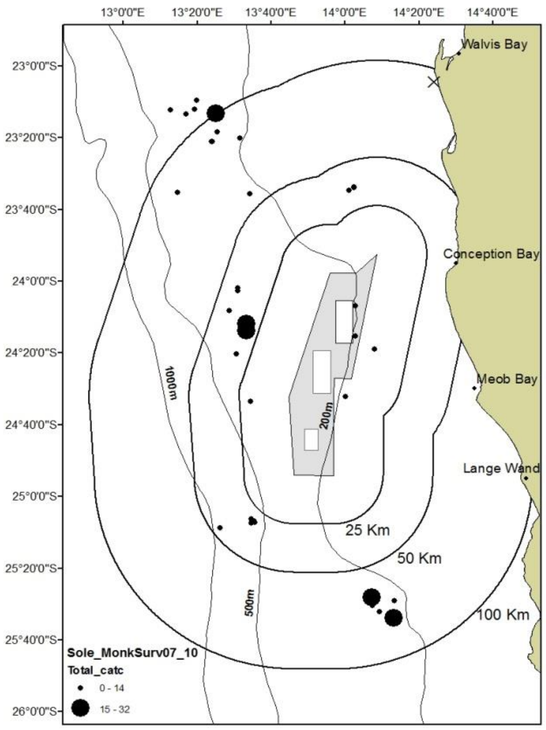

Figure 48. Total catch per station for west coast sole from monk- survey data (1997 – 2010). n=42

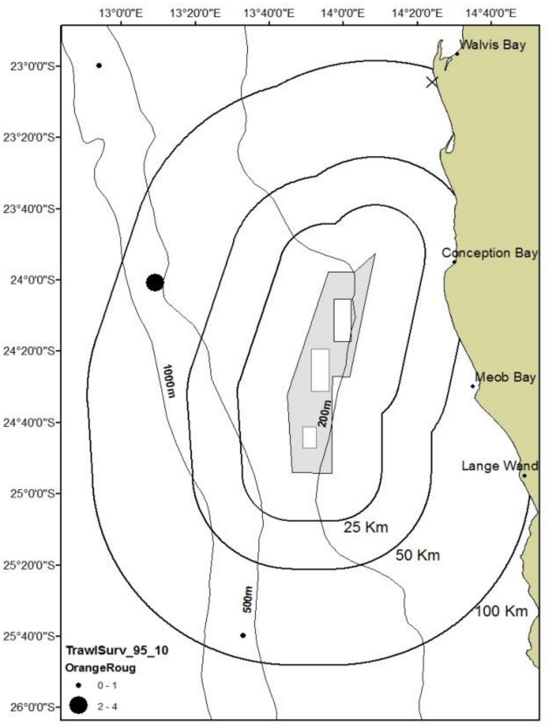

Figure 49. Distribution of orange roughy from hake-survey data (1995 – 2010). n=4

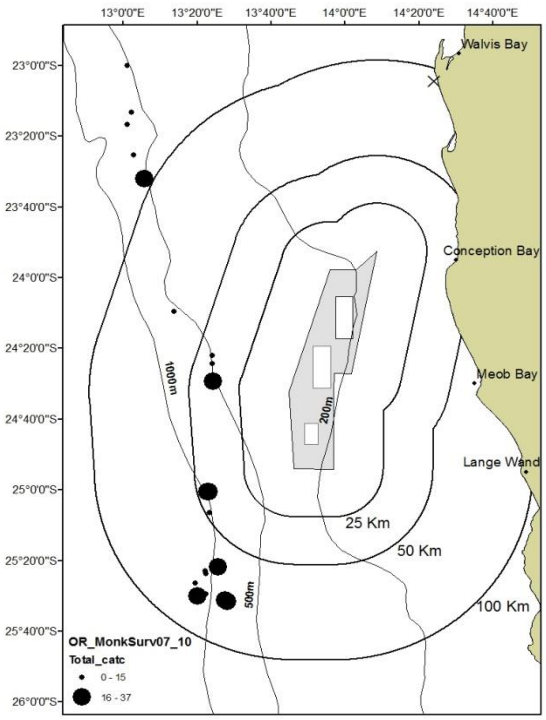

Figure 50. Distribution of orange roughy from monk-survey data (2007 – 2010). n=29

The overall assessment (aggregate) for this impact is provided in Table 11 which incorporates text from the 2012 assessment (refer also to Appendix 8).

Table 11. Impact assessment table of phosphate mining on the ecosystem (previous assessment)

Nature of the impact	**The impact of phosphate mining on the ecologically important demersal and pelagic fish species. The impact will result in the redistribution and/or displacement of hake, monk, horse mackerel, sole and small pelagic species because of 1) actual mining activities 2) habitat disturbances and 3) sediment plumes (turbidity)**
Extent	Zone 1 - demersal and pelagic fish species will be displaced or redistributed from the mine site and possibly from Zone 2 being the surrounding areas up to the 25 km from zone 1.
Duration	Permanent (>20 yrs) - the impact will cease once the mining activity ends after 20 years (the period for which the mining licence is issued) however fish recovery is expected to occur sooner
Intensity	Moderate effects - only a small fraction (compared to the regional extent) of fish inhabit the mine site and fish populations will recovery or settle in areas after mining operations ceases however habitat destruction may cause a longer period of recovery.
Probability	Highly probable - fish (and in particular demersal fish) are expected to move away from the dredging activity in most instances
Status (+ or -)	Negative
Significance (no mitigation)	Medium - the duration of the impact in Zone 1 is permanent but recovery of fish populations in the zones adjacent to Zone 1 may occur sooner. The intensity is minor to moderate and the extent is confined to the actual mine site (Zone 1).
Mitigation	In terms of the ecosystem as a whole there are no particular mitigation measure that can be implemented.
Significance (with mitigation)	Low to medium- if fish abundance estimates remain the same or increase then impacts are not expected to have an influence on the project design
Confidence level	High to medium - assumptions based on fish ecology is limited by the data available

The outcome of Impact 2 is summarised as follows :

5.3.1.2 Outcome 9: The deemed impact of phosphate mining on the ecologically important demersal and pelagic fish species is as follows :

The impact will result in the redistribution and/or displacement of hake, monk, horse mackerel, sole and small pelagic species because of 1) actual mining activities 2) habitat disturbances and 3) sediment plumes (turbidity). Impact as a result of mortality is expected to be proportionately minimal relative to total biomass of the main commercial species. Seabed dredging is therefore expected to be of long-term duration (20 year mine plan) and will be restricted to Zone 1 with minimal extent. The impacts are improbable (<5%) and status negative for monk, sole and hake and neutral for other commercial species. Confidence in the assessment is high for all species except for monk which is rated medium as the data availability and number of directed monk surveys is fewer than for the other main commercial species. The aggregate significance is low except for monk which is rated medium (minor negative).

5.3.3 Impact 3: The impact of phosphate mining on fish recruitment

We identify recruitment as the mechanism by which most fish species breed, spawn, migrate and ultimately become available for exploitation. The stakeholder response to this particular is noted (Appendix 9). For clarification we expand on our rationale for assessing Recruitment as an important impact.

5.3.3.1 Rationale for "Recruitment Impact" :

Strong focus in this assessment has been placed on the potential impact sea dredging may have on commercial fisheries – both in relation to commercial fishing operations (Impact 1) and Impact on the stocks exploited (Impact 2). A crucial aspect related to the biological status of stocks is "recruitment" which as described earlier can be broadly defined as "the mechanism by which most fish species breed, spawn, migrate and ultimately become available for exploitation". In the Namibian context, this impact is of particular concern. It is recognised that the main commercial fisheries, in particular hake and horse mackerel are of significant socio-economic importance. To this end, a specific independent study was undertaken by a Namibian fishery scientist aimed at supporting the original assessment (Ndajula. 2014)[30].

There are numerous key factors to consider, namely :

- Since independence in 1990, Namibia embarked on a stock rebuilding process – this has reflected positively in that resources have improved and stocks seemingly stabilised and management strengthened, In particular for the hake and horse mackerel fisheries;
- Part of the resource strategy was to maintain a 200 m depth restriction – although not clearly articulated anywhere, the objective was to protect juvenile fish and associated habitat.
- In the main fisheries, such as hake, there are management measures that also aim to minimise, for example, impacts on juvenile mortality. These include depth separation of fleets (wet and freezer fleets) as well as mesh size.
- Independent surveys, as referred to in the stakeholder response, do focus on "commercial sizes, being fish mainly > 32 cm total length in the case of hake.

In the verification survey (Smith and Japp, 2014), the MFMR survey vessels with standardised gear as requested by the proponent, could not be accessed. As a result, a monk-directed vessel was used, using monk fishing gear but with a cod-end liner – this ensures the best possible capture of benthic and other species to facilitate likely species breakdown.

Further, the survey was 24-7 – purposely to capture the different groups of species as well as those species, such as hake, and hake juveniles, that might migrate off the sea floor or may be only found in the water column. The comparative results of this exercise, with the recent NORAD and MFMR surveys is provided in Appendices 6 and 7. While not exhaustive, it does show that trawl and gear types can have material differences.

In addition, the stakeholder stresses that in the case of hake in particular, productivity of hake may be underestimated because of age interpretation. The work done by Namibian scientists in this regard is highly regarded but not particularly pertinent to the recruitment issue. However, what is more relevant is the issues pointed out that there is a seasonal movement of juvenile hake and that there is evidence

[30] Ndajula, H. 2014. Fish Recruitment and Stock Dynamics Study with respect to a Proposed Development of Phosphate Deposits in the Sandpiper Phosphate Licence Area off the Coast of Central Namibia

that the central Namibian shelf (we assume < 200m) is a key area for juvenile hake, in particular, those from 2-3 years that recruit to the fishery. This is an important finding.
It is further noted, that much of the above discussion related to Cape Hake (shallow water hake), but apparently not to deepwater hake, though as pointed out "juvenile hake" are notoriously difficult to identify. There is genetic evidence that separate shallow water hake stocks exist between Namibia and South Africa. The evidence for deepwater hake is less certain, and certainly the mixing and recruitment of juvenile hake of the two species is by no means clear (as alluded to by the stakeholder response).

In consideration of the assessment of this impact, the above is certainly significant and there is no doubt that recruitment impact is an important consideration. Namibian stock assessments of hake, for example do model and consider "recruitment", and as pointed out are reliant on annual survey data and may not effectively capture the full annual hake migratory cycle. The State of Stocks report (2020) for example shows clearly the significance of juvenile biomass of shallow water hake in the 100-200 m depth zone and a biomass that approximates somewhere between 10-30.1 tonnes per nm^2 (Figure 51).

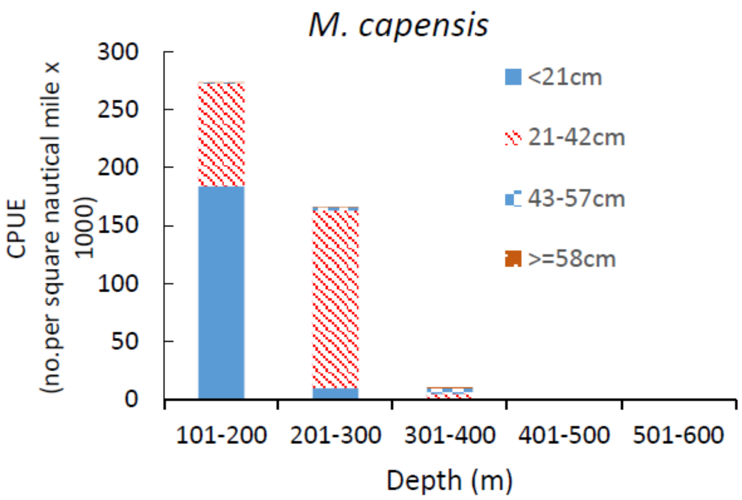

Figure 51. ref. Figure 3.10 Average catch rates of the two hake species by size groups in relation to depth during the 2020 survey (MFMR Hake SOS report, 2020).

Namibian scientist do nevertheless consider and apply recruitment indices when assessing stocks annually, such as shown below extracted from the 2020 State of stock report for hake.

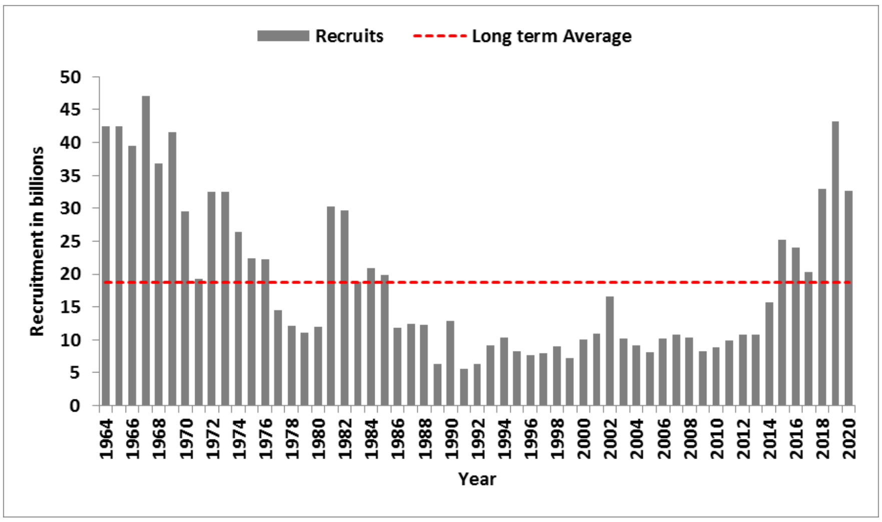

Figure 52. ref. Figure 3.29: Model estimated recruitment (numbers) from 1964-2020 (a), Beverton and Holt recruitment curve fit onto the estimated recruitment values

With regard therefore to the assessment of impacts of sea dredging, the broad understanding of recruitment is critical, not only for hake. However the assessment of **scale** is important. The hake recruitment work undertaken by Namibia, as with most assessment methodologies globally, may be influenced by high variability due to many influences, in particular environmental variability, and mortality associated with fishing itself.

The evidence used in the initial impact assessment (2012 and 2014 EIA Verification) considered many different data sets – egg and larval studies etc (Table 12) and was cognisant of this complexity. Using "zones" as done in this assessment, while not definitive, does help in understanding scale effects. The current 20-year Mining Plan (in 200m -225m water depth) focuses on a very small area of the Namibian waters, and is also largely constrained to the proximity of the 200 m depth contour, which is outside of the area deemed important for recruitment. While mortality may occur of different species through the dredging process, the relatively small area affected, and also the likely extent of the biomass impacted (see Gaylard report), demonstrably supports this assessment and the ratings given.

Table 12. Data (surveys) used in the assessment of the potential impacts of phosphate mining on fish recruitment

Dataset	Dates	Species (percentage of 100km buffer zone)	MLA (SP-1, SP-2 and SP-3)
Hake length-frequency survey data	1995-2010	Horse mackerel juveniles (<21cm)	No
		Hake juveniles (<21cm)	Yes
		Monk juveniles (<21cm)	Yes
Pelagic length-frequency survey data	2002-2011	Horse mackerel, anchovy, sardine and round herring juveniles (<8cm)	No
Hake maturity survey data	1995-2010	Hake stage 4 (spawning stage)	Yes
Pelagic egg and Larvae from Spanish survey data		Anchovy eggs and larvae	No
		Sardine eggs and larvae	No
Pelagic egg and Larvae from Nansen survey data	1999 - 2005	Sardine eggs	No
		Horse mackerel eggs and larvae	No
Pelagic egg from SWAPELS survey data	1978-1985	Sardine	No
		Anchovy eggs	No

With regard to recruitment impacts the master "impact" assessment methodology was followed and the scoring applied (Appendix 8) and summarised for each key species below and in Table 13 .

Hake : (Figure 53 & Figure 54) – The distribution of juvenile hake (< 25 cm) occurs throughout and mostly shallower than the 200 m bathy-contour. This is a typical distribution pattern for juvenile hake that recruit in shallow water and then migrate deeper as they age. Specifically juvenile hake are found in the MLA in the northern part near SP1. Juvenile hake are expected to be displaced from the dredging area, but their mobility should limit the likelihood of mortality. The distribution of stage 4 adult hake is an indicator that these fish are spawning. The data provided suggest that spawning hake are not commonly found in the MLA and are generally found in the areas north of the MLA well away from the mining site. Hake recruitment is therefore not expected to be significantly impacted (noting also the stakeholder comments and concerns in this regard).

Horse Mackerel : (Figure 55) – Horse mackerel juveniles are not in high abundance in and around the MLA (and less so in the 20-year mine area). They occur mostly northwards of Zone 1. Similarly horse mackerel eggs and larvae are found predominantly north of the MLA. The impact on the recruitment of Horse Mackerel is therefore expected to be low or negligible.

Monk : (Figure 56) – Juvenile monk (< 21 cm) are found throughout the MLA but are not in high abundance (note this is surmised from hake survey data only). The impact on juvenile monk as a direct result of the dredging operation will be high (mortality) but only localised in the mine site (Zone 1) – the data given however suggest that the extent of the mining area is small compared to the total biomass of Monk in Namibian waters. Recruitment effects on monk are therefore expected to be Low.

Small Pelagic : (Figure 57 -Figure 62) – The known distribution patterns of small pelagic juveniles (species combined) suggests that they are predominantly found landwards (shallower) than the mine site. Further, egg and larval surveys suggest spawning occurs well north of Zone 1. Historical data suggests also that spawning occurred north of Walvis Bay and well away from the mine site. There is however some evidence that historically sardine and anchovy eggs were found in small numbers south of Walvis Bay and broadly across the MLA. We conclude however that the mining in Zone 1 is unlikely to significantly impact recruitment of small pelagic species. In the context of attempts to rebuild the much depleted small pelagic stocks however, any minor disturbance or disruption of potential spawning by small pelagic species raises the impact implications to moderate.

In general the mining operations are deemed unlikely to have a significant impact on the recruitment of all commercially and ecological important fish species (Table 13).

Table 13. Impact Assessment of phosphate mining on fish recruitment

Nature of the impact	**The impact of phosphate mining on the recruitment of key commercial fish stocks a) hake b) horse mackerel c) monk and d) small pelagic species. The dispersal and survival of juveniles, eggs and larvae may be affected by 1) physical disturbance of the fishing grounds and 2) sediment plumes (turbidity)**
Extent	Zone 1 - impacts on recruitment is restricted to areas inside the mining licence area being Zone1 (20 year mine plan) and possibly Zone 2 the surrounding areas up to the 25 km from Zone 1 impact zone
Duration	Permanent (>20 yrs) - the impact will only cease once the mining activity ends after 20 years (the period for which the mining licence is issued)
Intensity	Minor effect - only a small fraction (compared to the regional extent) of juveniles and eggs and larvae occur in the MLA. Impacts will decrease in this area after mining operations cease
Probability	Improbable - mass mortality of juveniles and eggs and larvae may occur under extreme circumstances but is highly unlikely
Status (+ or -)	Neutral
Significance (no mitigation)	Low
Mitigation	Mitigation of the plume effects is addressed in Carter and Steffani (2021)
Significance (with mitigation)	Low - if fish abundance levels remain the same or increase then impact is not expected to have an influence on the project design
Confidence level	High to medium - assumptions based on fish ecology is limited by the data available

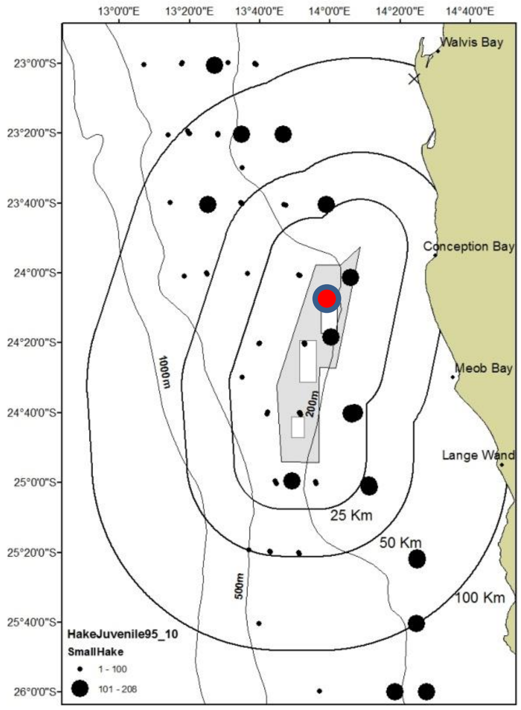

Figure 53. Hake juvenile numbers (<25cm) from length frequency hake- survey data (1995-2010). n=6649

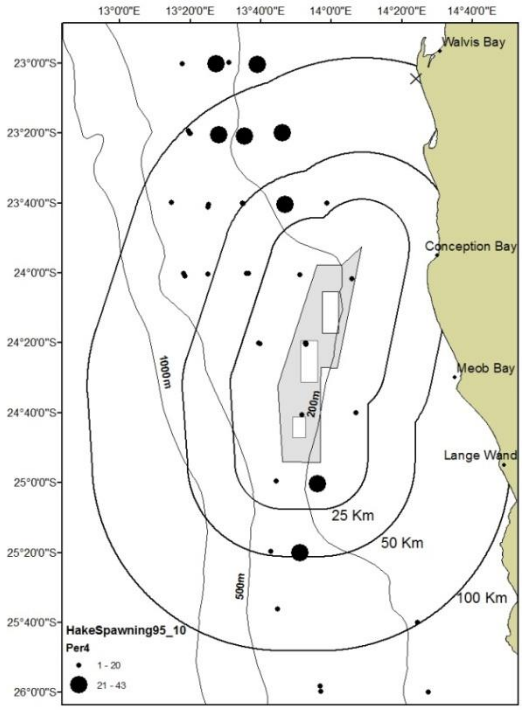

Figure 54. Hake stage 4 represented as a percentage of the total number of all stages per station from hake-survey data (1995-2010). n=8769

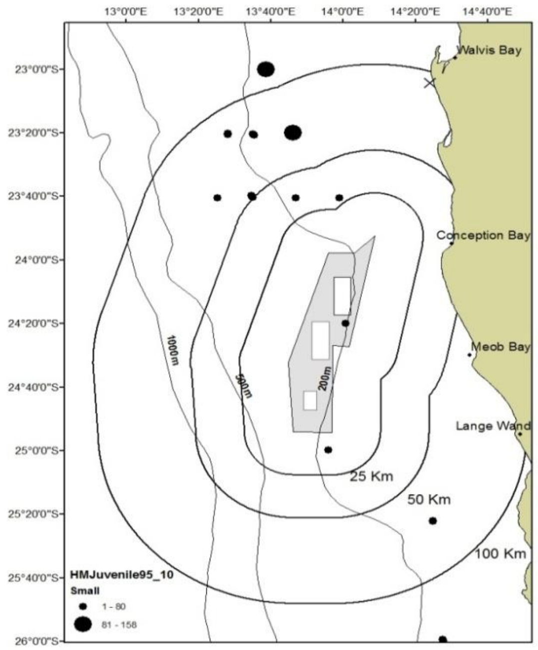

Figure 55. Horse mackerel juvenile numbers (<21cm) from hake- survey data (1995-2010). n = 1368

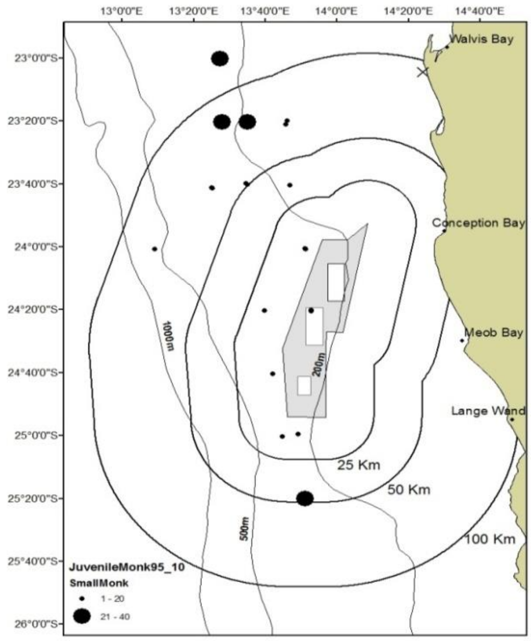

Figure 56. Juvenile monk (<21 cm) from hake- survey data (1995-2010) represented as numbers per station. n=263

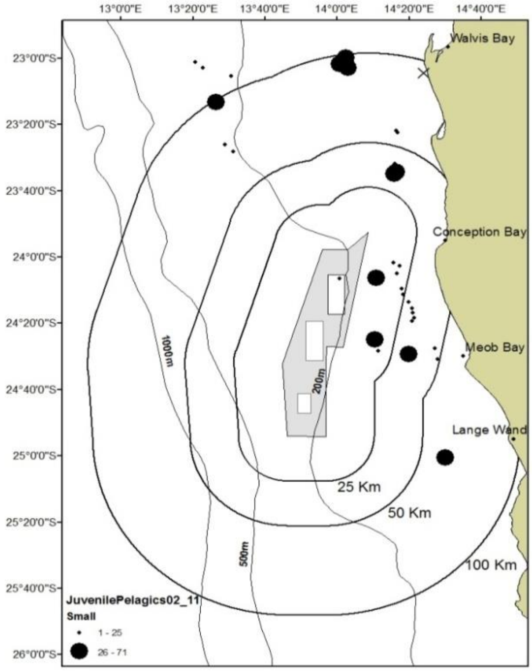

Figure 57. Pelagic (anchovy, sardine, and herring) juveniles numbers (< 8cm) from pelagic-surveys 2002-2011. n=10714

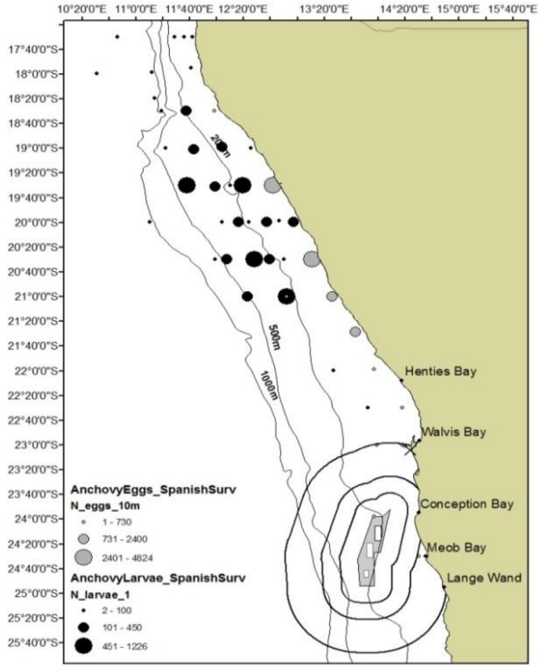

Figure 58. Distribution of anchovy eggs (grey) and Larvae (black) from Spanish survey data. n=333

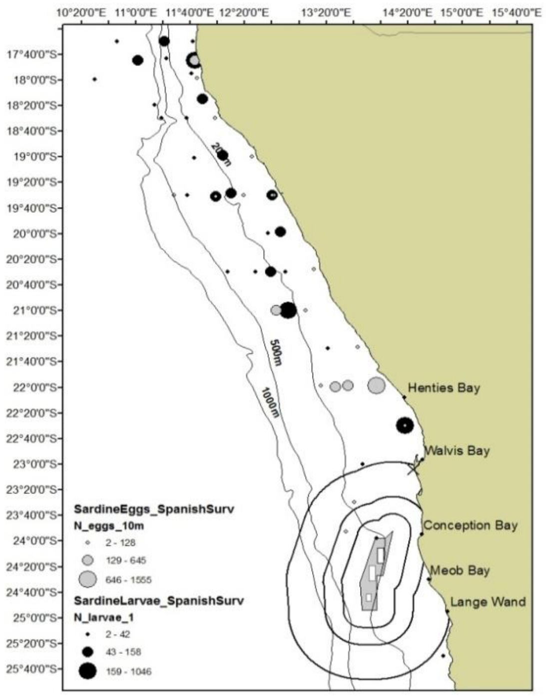

Figure 59. Distribution of sardine eggs (grey) and larvae (black) from Spanish survey data. n=333

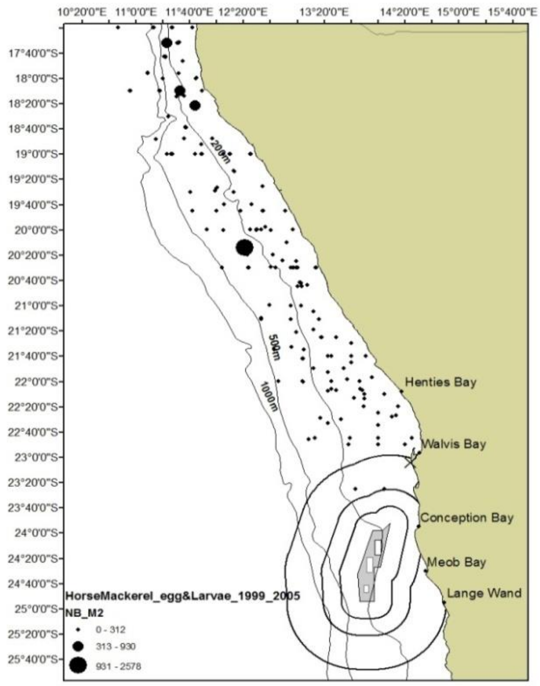

Figure 60. Horse mackerel eggs and larvae from Nansen survey data (1999-2005). n=2811

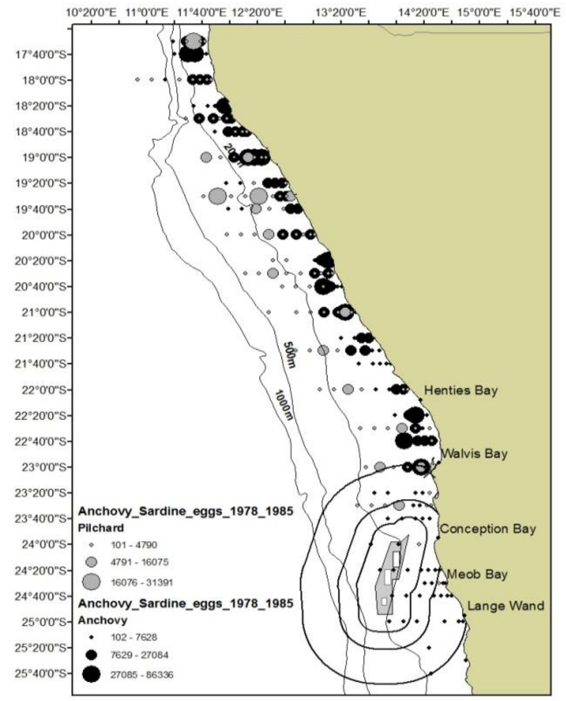

Figure 61. Distribution of sardine (grey) and anchovy (black) eggs from SWAPELS survey data (1978-1985). n=265

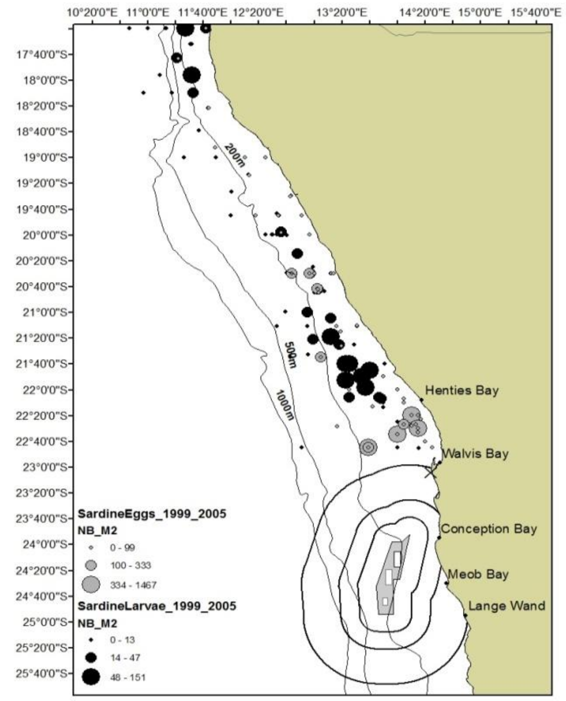

Figure 62. Distribution of sardine eggs (grey) and larvae (black) from Nansen survey data (1999 – 2005). n=2811

5.3.3.2 Outcome 10 : Impact on Recruitment to the main commercial fish species

The impact of dredging on hake, monk, horse mackerel and sardine, as long as maintained within the planned 20-year mining area is deemed to be of long-term duration as related to the term of the mining licence with no lasting effects except for monk which will have minor effects. The extent will be in Zone 1 only, though for monk impacts may extend into Zone 2. The probability of the impacts occurring is possible for hake and monk and improbable for horse mackerel and sardine and impact status deemed neutral for all species. For hake and horse mackerel there is high confidence in the assessment and for sardine and monk medium confidence. Overall significance and sensitivity rating is low for hake, horse mackerel and sardine and minor (medium) for monk.

5.3.4 Impact 4: The impact on biodiversity of sea dredging

The living marine resources of Namibia are relatively well-known. By definition marine biodiversity is the degree of variation of marine life forms within a given ecosystem. It is a measure of the health of the ecosystem and changes in marine biodiversity are directly caused by exploitation, pollution and habitat destruction or indirectly through climate change and related perturbations of ocean biogeochemistry (Worn *et al*. 2006). Broadly the environment affected can be illustrated in Figure 63.

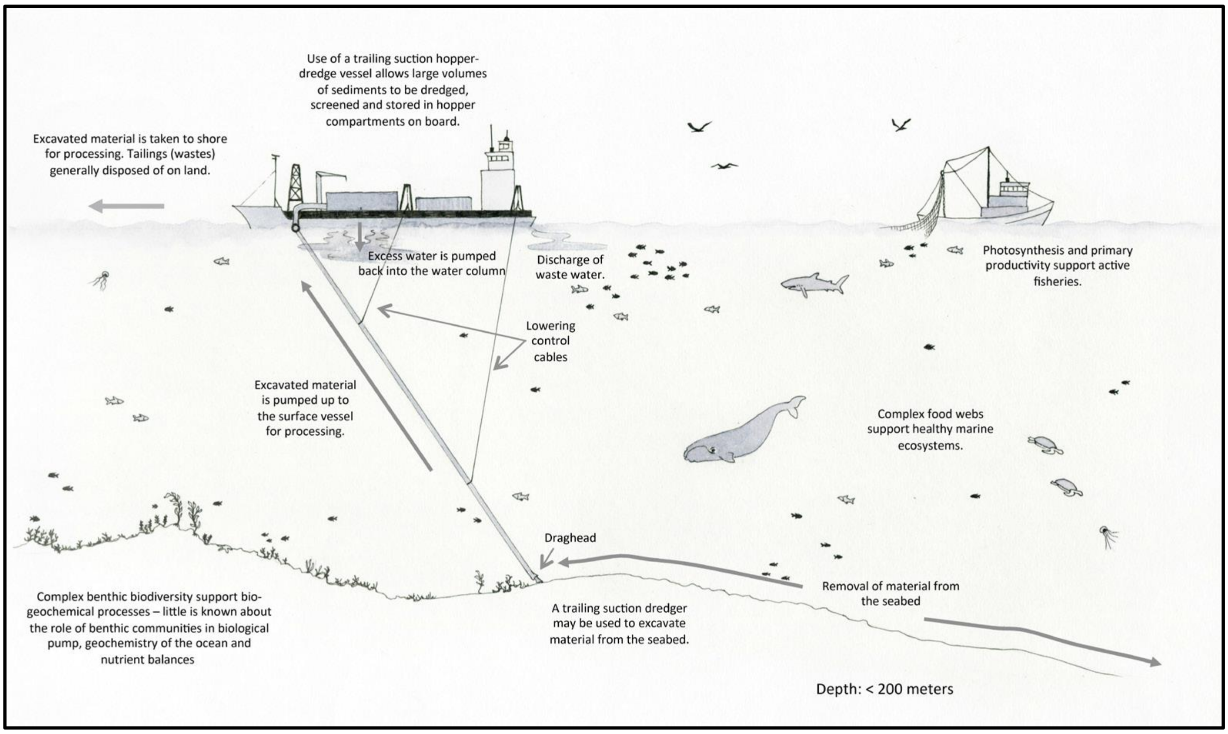

Figure 63. Schematic of the affected ecosystem impacted by sea dredging (Flora and Fauna International, 2020)

Data on biodiversity in Benguela ecosystem is not well documented although there are on-going initiatives to study biodiversity through the Benguela Current Commission. As a proxy for biodiversity we have used the number of species recorded in all independent surveys to gauge the relative number of species (predominantly fish) expected in and around the Zone 1[31]. This should form a baseline to monitor changes in the fauna diversity in the proximity of the mining area(s). Critical to biodiversity is the permanent loss of any unique species to the area. Note, the list is not intended to be exhaustive. Our data are presented in the Appendix 5 (Table 14) and spatially in Figure 64. A comparative species list between the recent NORAD and MFMR surveys and the 2014 NMP verification survey is provided in Appendix 7 (Table 17)

We have broadly separated biodiversity impacts into three groups, namely a) demersal fish and b) habitat flora and fauna (due to dredging itself) and c) pelagic species (due to overspill discharge / plume effects). These three impacts have been scored individually and aggregated in the master assessment table (Appendix 8). It is stressed this is a rough indicator only based on species recorded in surveys and is not intended as a comprehensive list (see also the assessment of Carter and Steffani, 2021 for detail on micro and macro fauna in the substrate itself) and the plume description in para5.2.1. The survey data from the hake, monk and small pelagic research cruises are shown spatially disaggregated by survey type and station (Figure 64). Specifically within the MLA the number of stations sampled is relatively low and zero in SP-1 specifically compared to stations in deeper water towards the shelf edge. Nevertheless we conclude that the diversity of primarily fish fauna in and immediately adjacent to the Zone 1 is comparatively low. This crude assessment does however indicate that approximately 40 different species have been recorded in or adjacent to the intended mining area and that these species i.e. fish biodiversity will in some way be impacted by the mining operation. The extent of this is difficult to judge, though the impact on benthic flora and fauna through the dredging process will be removed entirely and seriously impacted as the 20-yr mine plan is expedited. The significance of the impact is summarised in Table 14.

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[31] This was defined as the MLA in the previous assessment.

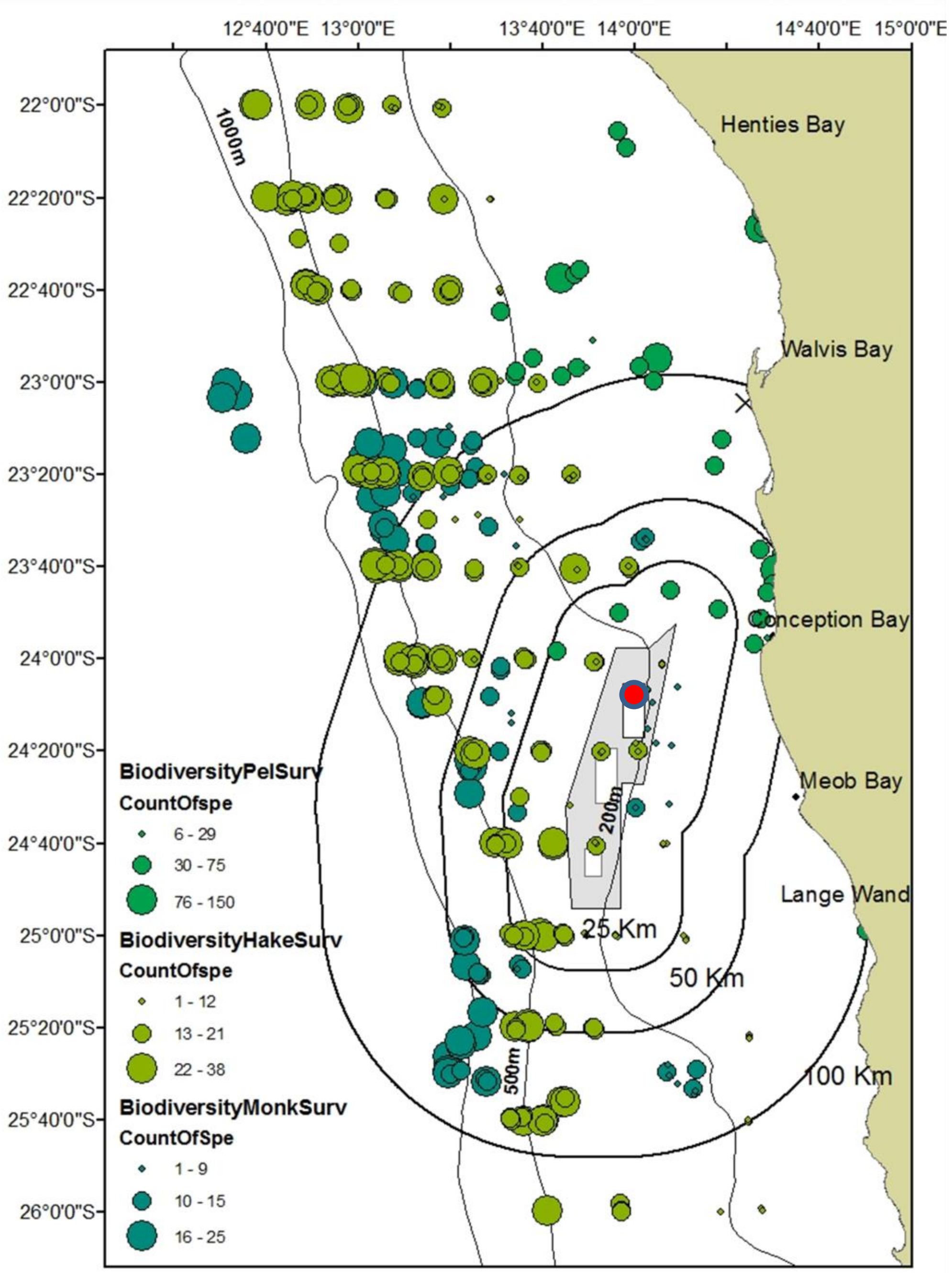

Figure 64. Dots represent number of species counted per coordinate (lat/long) from the hake-survey data, monk-survey data, & small pelagic-survey n=9116 (red dot approximates the 20-year mine area

5.3.4.1 Outcome 11: Potential impact on biodiversity of fish and other species

The impact of dredging on biodiversity of demersal fish species and species associated with the surface substrate is assessed as follows :

The aggregated assessment for all three groups, keeping in mind the relative scale of the operations, is that the impact will have no lasting effect on demersal species (i.e. over time repopulation is expected of the affected area). For surficial flora and fauna (habitat associated) the impact will be moderate and for pelagic species affected by the plume it is expected to have minor effects. For each group the impact will be of long duration, (20 years) though shorter in places as the dredging moves away from mined areas.

The impacts are deemed to be regional as although seabed dredging is expected to have localised effects, extending from Zone 1 into Zone 2. For demersal and pelagic species the impacts are deemed possible and for habitat-associated species the probability is high. For all groups the impacts status is negative and confidence is medium for fish species but high for the substrate element. Overall the aggregate significance/sensitivity rating for biodiversity is minor (medium), noting that for substrate impacts the significance/sensitivity rating is rated moderate (medium) (applies only to the specific mine site).

Table 14. Impact assessment table of phosphate mining on fish biodiversity in Zone 1

Nature of the impact	**The impact of phosphate mining on species diversity. Mining operations will result in a reduction or loss in biodiversity because of the 1) actual mining operations, 2) the habitat destruction and 3) sediment plumes**
Extent	Zone 1 – impact on species (fish mainly) diversity is restricted to areas inside the mining licence area (ML 170) being Zone 1 and possibly Zone 2 being the surrounding areas up to the 25 km from Zone 1.
Duration	Permanent (>20 yrs) - the impact will only cease once the mining activity ends after 20 years (the period for which the mining licence is issued) and could persist for an indefinite period thereafter. If biodiversity is lost, the impact is permanent.
Intensity	Minor effect – biodiversity in Zone 1 is expected to be comparatively low. Loss of biodiversity in the area and MLA broadly is likely although at the regional level the limited extent of the mining locations is unlikely to cause permanent loss of biodiversity. Recovery of biodiversity in the specific area of extraction within the MLA once mining has stopped is likely to be slow and will follow a natural process of ecological succession that is dependent upon the rate of recover of the substrate.
Probability	Improbable – consequence of diversity loss may occur under extreme conditions but are highly unlikely
Status (+ or -)	Negative
Significance (no mitigation)	Low – the impact on species diversity is not expected to influence project design provided the current area limitations are maintained. Expansion of dredging in the current or alternate lease areas without baseline monitoring of biodiversity and controls must be a prerequisite to the commencement of mining.
Mitigation	No practical mitigation measures are possible, noting that in the first assessment the possibility of dredge-free lanes withing the MLA was suggested. Current mine site scale is unlikely to be practical for this.
Significance (with mitigation)	Low
Confidence level	Medium to high - assumptions based on marine biodiversity in the MLA is limited to the nature of the data available.

5.3.5 Impact 5: The impact of phosphate mining on seabirds and marine mammals

The Namibian coast supports large populations of seabirds. Detailed scrutiny of the published literature has revealed that no important seabird breeding or foraging areas fall within the vicinity of Conception Bay (Cooper 1981, Wiliams & Cooper 1983, Cooper 1985, Berruti 1989, Hockey *et al*. 2005, Crawford *et al*. 2007, Kemper *et al*. 2007, Kemper 2007, Pichegru *et al*. 2007).

The Namibian marine mammal fauna is considered a marTheginal component of the broad southern Atlantic marine mammal community and includes three species of pinnepeds (seals) and roughly 40 species of cetaceans (whales and dolphin) (Griffin, 1998). There has been a northerly shift (away from the MLA in the south) in breeding seal populations in the last decade, which is thought to be linked to shifts in the geographical distribution of prey (Kirkman *et al*. 2007).

Baleen whales are thought to be primarily seasonal visitors to the Namibian coast although some species may support resident populations (Griffin, 1998). Today most species which were once exploited remain very rare (Bianchi *et al*. 1999) and whales are now fully protected by Namibian legislation. While the Namibian breeding population of southern right whales *Eubalaena australis* is thought to have been eradicated by over exploitation (Roux *et al*. 2001 in Currie & Grobler, 2007), the historical breeding range included Walvis Bay, Conception Bay, Spencer Bay, Lüderitz Bay, Elizabeth Bay and the Sperrgebiet coast. Since 1996 calves have been sighted between Conception Bay and the Orange River, indicating the presence of a breeding population. Mother and calf pairs being recorded within 1 nautical mile of the shore in the shelter of Conception Bay and six locations to the south (Currie & Grobler, 2007).

Other baleen whales that occur along the Namibian coast include, but are not limited to, pygmy right whales *Caperea marginata*, fin whale *Balanoptera physalus*, minke whale *Balaenoptera acutorostrata*, humpback whale *Megaptera novaeangliae* (Bianchi *et al*. 1999). All of these species are widely distributed on a global scale but detailed records of the distribution and habitat use of these animals along the Namibian coast are not available.

Toothed whales known from Namibia include sperm whale *Physeter catodon*, killer whales *Orcinus orca* and the longfinned pilot whale *Globicephala melas* (Bianchi *et al*. 1999). All of these species have wide global distributions and thought to be occasional visitors to Namibian coastal waters.

A number of dolphin species, most notably the dusky dolphin *Lagenorhynchus obscurus*, bottlenose dolphin *Tursiops truncatus* and Heavisides dolphin *Cephalorhynchus heavisidii* are year round residents along the Namibian coast (Griffin, 1998).

Zone 1 is located in a critical area offshore – that is mid-shelf along the 200 m bathy-contour. Its location is therefore close enough to the shoreline to expect coastal and oceanic sea birds as well as the large migrating whales and the more localised distributions of the smaller mammals (such a common dolphins and pilot whales).

As the actual dynamics of these species are difficult to gauge relative to the mining location, it must be assumed that most, if not all species are expected to be found in the proximity of the mine site. Most mammal species are naturally inquisitive and certainly, any dredging activity will attract most small mammals. Larger mammals are expected to avoid areas where maritime activity is high and also areas of poor water quality (such as may be created by sediment plumes). Impacts on birds and marine mammals will nevertheless be limited to the actual mining site and immediate areas (500 m around the dredging location). Disturbance of the substrate is also likely to result in higher levels of biological activity, increased particulate matter in the water column and at the surface. This will alter bird behaviour as they will be naturally attracted to these areas to feed on any edible floating matter. The effect of sound is also a consideration though this impact on mammals in particular, relatively to for example seismic airguns, is considered relatively benign. Lighting is also known to affect some bird species, in particular this species more active nocturnally. Standard mitigation and monitoring procedures can be implemented to reduce impacts associated with both sound and light [see also the report by Jan de Nul (2019)[32] - noise contour model to predict the contours of sound surrounding an operating Trailer Suction Hopper Dredger (TSHD)]

[32] De Nul, 2020. TSHD sound measurements (sound propagation associated with dredging operations)

Conclusions from that report are that sound frequencies and amplitudes generated from an operational TSHD are like those for other vessels of comparable size that are likely to be in transit through the area where dredging is to take place. The sound levels are in all cases far below those which would (or could) pose any threat to marine life. Noise from shipping is not to be confused with the well-known damaging effects of activities such as pile driving and most effects concern short, perhaps medium-term behavioural reactions and masking of low-frequency calls in baleen whales and seals (Todd, 2015).
The significance of the impact is summarised in Table 15.

Table 15. Table of assessment of Impact 5 summarizing the likely impact of phosphate mining on the seabirds and mammals in Zone 1.

Nature of the impact	**The impact of phosphate mining on seabirds, turtles and marine mammals. Mining operations might result in the displacement and/or redistribution of seabirds and mammals because of 1) disturbance of the ecosystem and availability of feed and 2) physical disturbance of the dredgers including noise pollution**
Extent	Zone 1 - impact on seabirds and mammals is restricted to areas in the proximity of the mining operations in the in the Mining licence area (SP-1) and possibly to Zone 2 being the surrounding areas up to the 25 km from zone 1
Duration	Very short term – The impact on sea birds and mammals will be for the term of the exploitation. These species will not be affected by the mining activities once mining ceases. Mammals and sea birds will return naturally to the area once the ecosystem and food availability recovers.
Intensity	Minor effects - Trophic disturbances could have a significant impact on the behaviour of seabirds and marine mammals. Noise pollution is a consideration for marine mammals whose acoustic communications may be affected resulting in avoidance of the area.
Probability	Probable - consequences of trophic interaction disturbances and noise pollution is highly likely.
Status (+ or -)	Negative
Significance (no mitigation)	Medium – Most sea birds and mammal species found in the area will be affected but at a low level due to the limited extent of the mining operations.
Mitigation	Maintain a bridge watch for large mammal species. Although the dredger will have limited manoeuvrability a protocol to limit interaction should be followed – in this regard JNCC guidelines are recommended.
Significance (with mitigation)	Low
Confidence level	Medium - information based on seabirds and mammals was provided by scientific specialists, however spatial data is limited

5.3.5.1 Outcome 12: The impact of phosphate mining on seabirds, turtles and marine mammals

The impact of dredging on seabirds, marine mammals (including seals) and turtles is assessed as follows :

The aggregated assessment for all four groups, is that the impact will have no lasting effect on marine mammals and seals). The impact will have minor effects on seabirds and turtles. For each group the impact will be of long duration (20 years for as long as the mining is active) though reduced in places as the dredging moves away from mined areas. The impacts are deemed to be regional. For mammals, seabirds and turtles the impact is deemed possible, whilst improbable for seals. For all groups the impacts status is negative, with a medium confidence except for seals, which is high. Overall the aggregate significance/sensitivity rating is minor (medium), noting that for impacts for mammals, seabirds and turtles significance/sensitivity rating is rated minor (medium) and low for seals.

6 Conclusions and Recommendations

6.1 Conclusions

This assessment has identified 12 Outcomes from five principle Impacts.

- The impact on Namibian fisheries will vary depending on the fishery sector. The operations of all fisheries will in some way, and at different levels be impacted. Overall however the significance is considered to be negative and medium to low. However, of the main commercial fisheries, the monk-directed trawl fishery will be relatively more impacted than the others. The species exploited (monk) prefers muddy substrate of which the dredging operation is likely to result in some localised loss of biomass. In the initial assessment completed in 2014, it was estimated that for the MLA some 13.8 % of the fishing ground for monk are likely to be impacted by the dredging operation and there is also likely to be displacement and mortality of the resource in the mining area. However, mining operations will not be over the whole of the MLA at one time and will in fact be active in only a very a small percentage (<1%) of the area on an annual basis. With the revised planning by NMP through the 20-year mine plan in SP-1 the area affected by sea dredging will be significantly reduced, as will the impacts attributed to the dredging. While no current monk or hake catch is recorded in the 20 year mine plan area (Zone 1) there is still a significant amount of monk operation in the zone adjacent to and up to 25 km from the 20 year mining area (14,38%), there is no evidence that dredging operations will impact the historically fished monk grounds.
- A similar conclusion can be drawn for the operational impacts of other trawl fisheries (horse mackerel as well) and for the other fishery sectors as their operations are too distant to be impacted i.e. deemed LOW.
- The impact on stocks (biomass) is also deem LOW as the relative scale to the total abundance of the main commercial species of dredging is considered LOW and unlikely to have any significant impact on these stocks.
- The impact on recruitment to the main fisheries, primarily because of the reduced scale of the dredging, is also considered to be neutral and of low significance.
- Considering the impact of the proposed mining on the broader ecosystem, in particular the fish fauna, the impact will on average be moderate. There is no evidence to suggest that the mining will result in a permanent loss of biodiversity, assuming there are no species unique to the area to be mined.
- The mining will displace fish resources and essential habitat occupied by these resources (such as monk, gobies, hake and others) in the immediate area of the mining (Zone 1). In particular, gobies have been identified as a key forage feeder in the mining area and is also a key trophic species. This may have localised trophic effects, but due the relative scale effect, only alteration of the ecosystem characteristics in the immediate mining area is expected. This alteration of the ecosystem will be very localised and is unlikely to impact the broader marine ecosystem assuming it is contained within the proposed area, which is small compared to the full extent of the grounds fished and the wider ecosystem of Namibian waters. Any expansion of the dredging will however likely alter the potential to impact on the broader ecosystem.

- Specifically the impact on biodiversity of demersal and pelagic fish species is considered to be of low significance.
- The impact on habitat is of moderate significance and is likely not reversible in the long-term (it has not been rated permanent as post the mining period, recovery is possible but the time this might take is unknown).
- With regard to the impact on seabirds, turtles and marine mammals, at a local level, modification of behaviour of mammals, turtles and seabirds is expected. Small mammals will be attracted to the mining area, although this behaviour is unlikely to persist and to be negative. Large mammals, most of which are transient, are likely to avoid the mining area. Noise levels from the dredging may also affect behaviour, but we have no firm conclusion on this impact which requires a specialist response. Seabirds will also interact with the mining and are expected to forage in the plumes and waste discharge for feed. This impact is rated neutral.

6.2 Recommendations

6.2.1 Mitigation

To mitigate loss of fishing grounds there are no realistic options in our view. The only possible exception is the accommodation of the needs of the monk fishery through a mutually agreed access operational plan.

6.2.2 Monitoring

- Due to the small scale of the proposed dredging operations in the context of the larger ecosystem and extent of the marine resources it is unlikely to be able to discriminate a clear signal relating to ecosystem change as a result of dredging (primarily due to variability within the ecosystem).
- In the short term MFMR should establish appropriate monitoring line (s) through SP-1 to monitor the effects of dredging on a real-time basis.
- Given the number of industrial mineral EPLs that have been granted in the area between Walvis Bay and Lüderitz consideration should be given to requesting that the Benguela Current Commission incorporate into their Strategic Environmental Assessment of the mineral sector of the Benguela ecosystem a study of the potential impacts of dredging.

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APPENDICES

Appendix 1. Seabirds of southern Namibia

SPECIES	STATUS*	RELATIVE ABUNDANCE	SEASONALITY	CONSERVATION STATUS (IUCN)
African Penguin *Spheniscus demersus*	B, inshore	Common	All year	Vulnerable
Black-necked Grebe *Podiceps nigricollis*	AM, inshore	Locally common	Winter, summer	
Wandering Albatross *Diomedea exulans*	SM, offshore	Rare	Winter, summer	Vulnerable
Shy Albatross[a] *Thalassarche cauta*	SM, offshore	Uncommon	All year	Vulnerable
Black-browed Albatross *T. melanophris*	SM, offshore	Common	Winter, summer	
Grey-headed Albatross *T. chrysostoma*	SM, offshore	Rare	Vagrant	Vulnerable
Yellow-nosed Albatross[a] *T. chlororhynchos*	SM, offshore	Common	Winter, summer	Near threatened
Northern Giant Petrel *Macronectes halli*	SM, In/offshore	Common	All year	Near threatened
Southern Giant Petrel *M. giganteus*	SM, In/offshore	Uncommon	All year	Vulnerable
Pintado Petrel *Daption capense*	SM, offshore	Common	Winter	
Antarctic Fulmar *Fulmarus glacialoides*	SM, offshore	Rare	Winter	
Antarctic Prion *Pachyptila desolata*	SM, offshore	Common	All year	
Great-winged Petrel *Pterodroma macroptera*	SM, offshore	Uncommon	All year?	
Atlantic Petrel *P. incerta*	SM, offshore	Rare	Summer	
Soft-plumaged Petrel *P. mollis*	SM, offshore	Uncommon	Winter, summer	
White-chinned Petrel *Procellaria aequinoctialis*	SM, offshore	Common	Winter, summer	Vulnerable
Grey Petrel *P. cinerea*	SM, offshore	Rare	Winter	Near threatened
Spectacled Petrel *P. conspicillata*	SM, offshore	Rare	Winter, summer	Critical
Manx Shearwater Puffinus puffinus	NM, offshore	Rare	Summer, winter	
Great Shearwater *P. gravis*	SM, offshore	Uncommon	Summer passage	
Sooty Shearwater *P. griseus*	SM, offshore	Common	Winter, summer	
Cory's Shearwater *Calonectris diomedea*	NM, offshore	Common	Summer	
European Storm Petrel *Hydrobates pelagicus*	NM, offshore	Common?	Summer, winter	
Wilson's Storm Petrel *Oceanites oceanicus*	SM, offshore	Common	Winter, summer	
Leach's Storm Petrel *Oceanodroma leucorhoa*	NM, offshore	Uncommon	Summer	

SPECIES	STATUS*	RELATIVE ABUNDANCE	SEASONALITY	CONSERVATION STATUS (IUCN)
Black-bellied Storm Petrel *Fregetta tropica*	SM, offshore	Rare	Winter	
White-bellied Storm Petrel *P. grallaria*	SM, offshore	Rare	Winter	
White-faced Storm Petrel *Pelagodroma marina*	SM, offshore	Rare	Winter	
Great White Pelican *Pelecanus onocrotalus*	B, inshore	Rare	All year	
Cape Gannet *Morus capensis*	B, In/offshore	Common	All year	Vulnerable
Cape Cormorant *Phalacrocorax capensis*	B, inshore	Common	All year	Near threatened
Bank Cormorant *P. neglectus*	B, inshore	Rare	All year	Vulnerable
Crowned Cormorant *P. coronatus*	B, inshore	Uncommon	All year	Near threatened
White-breasted Cormorant *P. carbo*	B, inshore	Uncommon	All year	
Grey Phalarope *Phalaropus fulicarius*	NM, offshore	Uncommon	Summer	
Arctic Skua *Stercorarius parasiticus*	NM, In/offshore	Common	Summer, winter	
Pomarine Skua *S. pomarinus*	NM, offshore	Common	Summer, winter	
Long-tailed Skua *S. longicaudus*	NM, offshore	Common	Summer	
Subantarctic Skua *Catharacta antarctica*	SM, offshore	Common	Winter, summer	
Sabine's Gull *Larus sabini*	NM, In/offshore	Common	Summer	
Kelp Gull *L. dominicanus*		Common	All year	
Hartlaub's Gull *L. hartlaubii*	B, inshore	Common	All year	
Grey-headed Gull *L. cirrocephalus*	B, inshore	Rare	All year	
Common Tern *Sterna hirundo*	NM, inshore	Common	Summer	
Arctic Tern *S. paradisaea*	NM, offshore	Uncommon	Summer passage	
Sandwich Tern *S. sandvicensis*	NM, inshore	Common	Summer	
Swift Tern *S. bergii*	B, inshore	Common	All year	
Damara Tern *S. balaenarum*	B, inshore	Uncommon	All year	Near threatened
Caspian Tern *S. caspia*	B, inshore	Rare	All year	
Black Tern *Chlidonias niger*	NM, inshore	Rare	Summer	

** B: breeding resident; AM: African migrant; SM: Southern Ocean migrant; NM: northern hemisphere migrant.*

[a] Recent taxonomic divisions not taken into account.

Appendix 2a. Distribution and seasonal abundance of Mysticete (baleen) whales in southern Namibian waters

SPECIES	SEASONALITY	DISTRIBUTION
Blue whales (*Balaenoptera musculus*)	Migratory	Pelagic
Fin whales (*B. physalus*)	Migratory	Pelagic – some association with the shelf edge
Sei whales (*B. borealis*)	Migratory	Pelagic
Minke whales (*B. acutorostrata*)	Migratory / year round	Pelagic / Neritic
Bryde's whales (*B. edeni*)	Migratory	Probable pelagic
Humpback whales (*Megaptera novaeangliae*)	Migratory / year round (some summer residency)	Pelagic / Neritic (uses coastal waters as migratory corridors)
Southern right whales (*Eubalaena australis*)	Migratory	Neritic – extreme inshore
Pygmy right whales (*Caperea marginata*)	Migratory	unknown

Appendix 2b. Distribution and seasonal abundance of odontocetes (toothed whales and dolphins) in southern Namibian waters

SPECIES	SEASONALITY	DISTRIBUTION
Sperm whales (*Physeter macrocephalus*)	Some migration	Pelagic
Pygmy Sperm whales (*Kogia breviceps*)	Unknown	Pelagic
Cuvier's beaked whale (*Ziphius cavirostris*)	Unknown possibly year round	Pelagic
Layard's beaked whale (*Mesoplodon layardii*)	Unknown though stranding data suggest a strong autumn seasonality	Pelagic
Gray's beaked whale (*M. grayii*)	Unknown	Pelagic
Killer whale (*Orcinus orca*)	Year round	Cosmopolitan
False killer whale (*Pseudorca crassidens*)	Year round	Pelagic
Pygmy killer whale (*Feresa attenuata*)	Unknown	Pelagic
Long finned pilot whale (*Globicephala melas*)	Unknown	Pelagic
Risso's dolphin (*Grampus griseus*)	Unknown	Pelagic – some association with the shelf edge
Common dolphin (*Delphinus delphis / capensis?*)	Unknown	Pelagic
Dusky dolphin (*Lagenorhynchus obscurus*)	Year round	Neritic
Heaviside's dolphin (*Cephalorhynchus heavisidii*)	Year round	Neritic
Southern right-whale dolphin (*Lissodelphis peronii*)	Year round	Pelagic / Neritic (localised)
Bottlenose dolphin (*Tursiops truncatus*)	Year round	Pelagic

Appendix 3. Datasets provided by the Namibian Ministry of Fisheries and Marine Resources (MFMR) for the impact assessment in 2011.

DATASET	DATES	SPECIES
Hake commercial trawl data	2004-2009	Hake (*Merlucius paradoxus* & *M. capensis*)
Hake commercial longline data	2006-2010	Hake (*Merlucius paradoxus* & *M. capensis*)
Horse mackerel commercial mid-water trawl data	1997-2011	Horse mackerel (*Trachurus trachurus*)
Monk commercial trawl data	2005-2010	Monk (*Lophius vomerinus* & *L. vaillanti*)
Small pelagics commercial data	2000-2011	Anchovy (*Engraulis encrasicolus*)
		Sardine (*Sardinops sagax*)
		Round herring (*Etrumeus whiteheadi*)
Hake survey data	1995-2010	Horse mackerel
		Snoek (*Thyrsites atun*)
		Goby (*Sufflogobius bibarbatus*)
		Monk
		Hake
		Sole (*Austroglossus microlepis*)
Monk survey data	2007-2010	Monk
		Goby
		Orange roughy (*Hoplostethus atlanticus*)
		Sole
Small pelagic survey data	2002-2011	Horse mackerel, anchovy, sardine and round herring
Hake length-frequency survey data	1995-2010	Horse mackerel juveniles (<21cm)
		Hake juveniles (<21cm)
		Monk juveniles (<21cm)
Pelagic length-frequency survey data	2002-2011	Horse mackerel, anchovy, sardine and round herring juveniles (<8cm)
Hake maturity survey data	1995-2010	Hake stage 4 (spawning stage)
Hake, monk and small pelagics survey data combined	1995-2011	All species counted per sample station
Pelagic egg and Larvae from Spanish survey data		Anchovy eggs and larvae
		Sardine eggs and larvae
Pelagic egg and Larvae from Nansen survey data	1999-2005	Sardine eggs
		Horse mackerel eggs and larvae
Pelagic egg from SWAPELS survey data	1978-1985	Sardine
		Anchovy eggs

Appendix 4. Impact Identification & Evaluation Methodology

Limitations, uncertainties and assumptions

The following limitations and uncertainties associated with the assessment methodology will be considered in the assessment phase:

- Topic specific assessment guidance has not been developed in Namibia. The definitions identified are in line with commonly applied impact criteria used in Southern Africa, recognised internationally and best practice.
- Guidance for cumulative impacts has not been developed in Namibia but a single accepted state of global practice has been applied.
- Determining the sensitivity of biological receptors to direct physical disturbance, e.g., seabed excavation, noise, and indirect effects from temporary modifications in the abiotic environment, e.g., increased water column turbidity, will be done per sub-discipline. Metrics employed can include proportions of known habitats for species and/or communities affected, their vulnerability to disturbance, and recovery potential from this. In cases where this is not feasible for either or both biodiversity attributes and ecosystem service(s) the receptor sensitivity will be excluded when scoring significance of the impact.

ASSESSMENT METHODOLOGY

In order to ensure consistency in the approach in the evaluation of impacts from the 2012 and 2014 specialist's studies, the same methodology will be utilised and will form the basis for this ESIA process of the biophysical environment. The aforementioned methodology was verified and approved by the CSIR for both the 2012 EIA and the 2014 verification studies. Independent reviews were undertaken by UNAM as well as an independent peer review panel. Additionally, the appointed external reviewers and SAEIA approved the methodology for both the 2012 and 2014 studies. To improve the robustness and confidence in the rating of significance of impacts, ECC will utilise best practice through application of a rating scale for probability to determine a score for significance of the impact to the receptor. IFC standards as modified by ECC will be utilised to rate the impacts for the social baseline.

The following describes the methods used to determine significance rating of impacts identified in the specialist's studies for the biophysical environment:

1. Description of impact – reviews the type of effect that a proposed activity will have on the environment;
2. What will be affected; and
3. How it will be affected.

Points 1 to 3 above are to be considered/evaluated in the context of the following impacts criteria:

- Extent;
- Duration;
- Probability; and
- Intensity/magnitude.

These impact criteria are to be applied as prescribed in the table below.
Furthermore, the following are being considered:

- Impacts are described both **before** and **after** the proposed **mitigation** and management measures have been implemented;
- Where possible the impact evaluation takes into consideration the **cumulative effects** associated with this project. Cumulative impacts can occur from the collective impacts of individual minor actions over a period of time and can include both direct and indirect impacts;
- **Mitigation / management actions:** Where negative impacts were identified, the specialists specified practical mitigation measures (i.e. ways of avoiding or reducing negative impacts); and
- **Monitoring (forms part of mitigation):** Specialists recommend monitoring requirements to assess the effectiveness of mitigation actions, indicating what actions are required, the timing and frequency thereof.

Table 16. Impact Criteria applied

Impact Criteria					
Extent	**Zone 1** Area of direct impact (20 year plan) within SP1	**Zone 2 : Local** Indirect and induced effects (within 25 km of mined area), (area of biodiversity / ecosystem effects)	**Zone 3 : Regional** Perceived effect (concerns) (within 50 km) (area of biodiversity / ecosystem effects) + cumulative effects	**Zone 4 : National** >50 km to EEZ includes + cumulative effects	
Duration	**Very Short Term** 3 days	**Short Term** 3 days – 1 year	**Medium Term** 1 – 5 years	**Long Term** 5 – 20 years	**Permanent** >20 years (life of mine)
Intensity/ Magnitude	**No lasting effect** No environmental functions and processes are affected	**Minor effects** The environment functions but in a modified manner	**Moderate effects** Environmental functions and processes are altered to such an extent that they temporarily cease	**Serious effects** Environmental functions and processes are altered to such an extent that they permanently cease	
Probability	**Improbable** <5%	**Possible** 5% - 50%	**Probable** 50% - 90%	**Highly probable/Definite** 90% - 100%	

The status of the impacts and degrees of confidence with respect to the assessment of the significance are stated below as follows:

- **Status of the impact**: a description as to whether the impact is positive (a benefit), negative (a cost) or neutral.
- **Degree of confidence in predictions**: based on the availability of information and specialist knowledge. This has been assessed as high, medium or low.

Based on the above considerations, a score is provided (1-100) that is linked to the significance of the impact. This score is tabled in a matrix (4x3) whereby the specialist provides an overall evaluation of the significance of the potential impact based on the sensitivity of the receptor, if applicable.

Mitigation

Mitigation comprises a hierarchy of measures ranging from preventing environmental impacts by avoidance, to measures that provide opportunities for environmental enhancement. The mitigation hierarchy is: avoidance; reduction at source; reduction at receptor level; repairing and correcting; compensation; remediation; and enhancement.

Mitigation measures can be split into three distinct categories, broadly defined as:

1. Actions undertaken by the ESIA process that influence the design process, through implementing design measures that would entirely avoid or eliminate an impact, or modifying the design through the inclusion of environmental features to reduce the magnitude of change. These are considered as embedded mitigation.
2. Standard practices and other best practice measures for avoiding and minimising environmental impacts. These are considered as good practice measures.
3. Specified additional measures or follow-up action to be implemented, to further reduce adverse impacts that remain after the incorporation of embedded mitigation. These are considered as additional mitigation.

Appendix 5. List of species included in the biodiversity assessment

SPECIES INCLUDED IN THE BIODIVERSITY ASSESSMENT			
Acanthurus monroviae	*Cruriraja parcomaculata*	*Melanocetus johnsoni*	*Raja wallacei*
Aequorea sp.	*Cynoglossus capensis*	*Melanostomias sp.*	*Riparidae (family)*
Alepocephalus (family)	*Cynoglossus zanzibarensis*	*Merluccius capensis*	*Salps*
Alepocephalus australis	*Deania calcea*	*Merluccius capensis (big)*	*Sardinops ocellatus*
Allocyttus verrucosus	*Dicrolene intronigra*	*Merluccius paradoxus*	*Schedophilus huttoni*
Aphrodite pol	*Diogenidae (family)*	*Miscellaneous fishes*	*Scorpaena stephanica*
Aquorea aquarea	*Ebanania costaecanari*	*Mola mola*	*Selachophidium guentheri*
Aristeus varidens	*Echinorhinidae*	*Molluscs*	*Sepia australis*
Arnoglossus imperialis	*Engraulis capensis*	*Monolene microstoma*	*Sepia elegans*
Astronesthes sp.	*Epigonus denticulatus*	*Moroteuthis robsoni*	*Sergestidae (family)*
Austroglossus microlepis	*Epigonus telescopus*	*Muraenidae (family)*	*Serrivomer beanii*
Bivalves	*Etmopterus branchyurus*	*Mustelus palumbes*	*Shark eggs*
Bajacalifornia megalops	*Etrumeus whiteheadi*	*Myxine sp.*	*Shrimp mix*
Bassanago albescense	*Galatheidae (family)*	*Naucrates ductor*	*Shrimps, small, non comm.*
Bathynectes piperitus	*Galeus polli*	*Neocyttus rhomboIdalis*	*Snapper shrimp (Alpheus sp.?)*
Bathyraja smithii	*Gastropods*	*Neoharriotta pinnata*	*Solenocera africana*
Bathyuroconger vicinus	*Gempylidae*	*Neolithodes capensis*	*Sponges*
Benthodesmus tenuis	*Genypterus capensis*	*Nephropsis atlantica*	*Sqaulus megalops*
Bothus sp.	*Glyphus marsupialis*	*Nezumia micronychodon*	*Squatina oculata*
Brachioteuthis picta	*Gobiidae*	*Nezumia milleii*	*Squilla acuelata calmani*
Brama brama	*Gonostoma elongatum*	*Nezumia sp.*	*Squilla sp.*
Caelorinchus braueri	*Gymnura sp.*	*Notacanthus sexspinis*	*Starfish, mixed*
Caelorinchus simorynchus	*Helicolenus dactylopterus*	*Octopus vulgaris*	*Stomias boa boa*
Callanthias (family)	*Heterocarpus grimaldii*	*Ommastrephes pteropus*	*Stromateus fiatola*
Callionymidae	*Hexanchus griseus*	*Ophistoteuthes agassizi*	*Sufflogobius bibarbatus*
Calloryhnchus capensis	*Hoplostethus cadenati*	*Ophiuroidea*	*Symbolophorus boops*
Caristius groenlandicus	*Hoplostethus melanopus*	*Opostomias micripnis*	*Synapturichthys kleini*
Centrophorus granulosus	*Hoplostetus atlanticus*	*Panulirus sp.*	*Todarodes angolensis*
Centroscyllium fabricii	*Jellyfish*	*Parapaguridae (family)*	*Todarodes sagittatus*
Centroscymnus crepidater	*Laemonema laureysi*	*Parapenaeus longirostus*	*Todaropsis eblanae*
Chaceon maritae	*Lamprogrammus exutus*	*Paronchelius stauchi*	*Torpedo nobiliana*
Chatrabus melanurus	*Lepidopus caudatus*	*Perulibatrachus rossignoli*	*Trachipteridae*
Chelidonichthys capensis	*Lithodes ferox*	*Photonectes braueri*	*Trachurus capensis*
Chlamydoselachus anguineus	*Lithognathus mormyrus*	*Plesionika martia*	*Trachurus trachurus capensis*
Chlorophthalmus agassizi	*Lobotes surinamensis*	*Plesiopenaeus edwardsianus*	*Trachyrincus acanthiger*
Chlorophthalmus atlanticus	*Lophius vaillanti*	*Polychaelidae (family)*	*Trachyrincus scabrus*
Chloroscombrus chrysurus	*Lophius vomerinus*	*Pontinus leda*	*Trachyscopia capensis*
Chlorothalmus punctatus	*Lophius vomerinus (juvenile)*	*Psychrolutes macrocephalus*	*Trachyscorpia eschmeyeri*
Chrysaora spp	*Lycodes agulhensis*	*Psychroniyidae spp*	*Trigla lyra*
Coelorinchus acanthiger	*Lycoteuthis lorigera*	*Pterothrissus belloci*	*Tripterophycis gilchristi*
Coelorinchus polli	*Macrouridae (family)*	*Raja caudaspinosa*	*Turbo sp. Gastropods*
Coelorinchus matamua	*Malacocephalus laevis*	*Raja clavata*	*Unidentified mix*
Coloconger scholesi	*Malacosteidae*	*Raja confundens*	*Vitreledonella richardi*
Coryphaenoides macrolophus	*Malecocephalus occidentalis*	*Raja leopardus*	*Yarrella blackfordi*
Cranchia scabra	*Maurolicus muelleri*	*Raja pullopunctate*	*Yarrella sp.*
	Megalocranchia sp.	*Raja spinacidermis*	*Zeidae*
		Raja straeleni	*Zeus capensis*

Appendix 6. MFMR and NORAD Trawl Station Data that best approximate the location and depths of SP-1

Transboundary Demersal Survey (2019) of the Dr Fridtjof Nansen[33]

Station 58:

```
R/V Dr. Fridtjof Nansen      SURVEY:2019403        STATION:   58
DATE  :19/04/19            GEAR TYPE: BT NO: 27  POSITION:Lat   S 24°22.25
         start     stop    duration                         Lon   E 14°0.24
TIME  :11:11:52 11:36:55  25.0 (min)           Purpose    : 3
LOG   :  395.61   396.82   1.2                 Region     : 5030
FDEPTH:     197      199                       Gear cond.: 0
BDEPTH:     197      199                       Validity   : 0
Towing dir:   0°     Wire out    : 475  m      Speed      : 2.9 kn
Sorted    :  41      Total catch: 1394.34      Catch/hour: 3341.07
```

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Chrysaora fulgida	2665.69	0	79.79	
Aequorea forskalea	311.21	0	9.31	
Sufflogobius bibarbatus	231.37	191693	6.93	
Merluccius capensis	68.43	98	2.05	267
G A S T R O P O D S	57.03	0	1.71	
Ascidiacea	3.26	0	0.10	
Starfish	1.63	244	0.05	
Squilla acuelata calmani	1.63	163	0.05	
Bathynectes piperitus	0.81	81	0.02	
Total	3341.07		100.00	

Station 68:

```
R/V Dr. Fridtjof Nansen      SURVEY:2019403        STATION:   68
DATE  :20/04/19            GEAR TYPE: BT NO: 27  POSITION:Lat   S 24°1.82
         start     stop    duration                         Lon   E 13°50.74
TIME  :16:58:45 17:28:54  30.1 (min)           Purpose    : 3
LOG   :  546.24   547.84   1.6                 Region     : 5030
FDEPTH:     246      242                       Gear cond.: 0
BDEPTH:     246      242                       Validity   : 0
Towing dir:   0°     Wire out    : 625  m      Speed      : 3.2 kn
Sorted    : 146      Total catch: 859.08       Catch/hour: 1710.18
```

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Merluccius capensis	1442.75	10437	84.36	304
PORIFERA (Sponges)	100.71	0	5.89	
Coelorinchus simorhynchus	44.13	1340	2.58	
Helicolenus dactylopterus ***	30.32	948	1.77	307
Todarodes sagittatus	30.02	74	1.76	
Myctophidae sp. small/mix	11.65	5821	0.68	
Sufflogobius bibarbatus	10.01	1204	0.59	
Merluccius capensis	8.00	10	0.47	305
Lophius vomerinus	7.01	24	0.41	306
Macropipus australis	5.95	378	0.35	
Chlorophthalmus agassizi	5.41	446	0.32	
Deepwater fish mixture	4.06	0	0.24	
Squilla acuelata calmani	3.78	257	0.22	
Ascidiacea	2.99	0	0.17	
Sepia elegans	1.07	68	0.06	
Solenocera africana	0.82	285	0.05	
Dead shells	0.82	0	0.05	
G A S T R O P O D S	0.54	0	0.03	
Snail	0.14	0	0.01	
Total	1710.18		100.00	

Station 70:

```
R/V Dr. Fridtjof Nansen      SURVEY:2019403        STATION:   70
DATE  :21/04/19            GEAR TYPE: BT NO: 27  POSITION:Lat   S 23°41.14
         start     stop    duration                         Lon   E 13°48.27
TIME  :06:45:40 07:06:49  21.1 (min)           Purpose    : 3
LOG   :  626.34   627.48   1.1                 Region     : 5030
FDEPTH:     192      192                       Gear cond.: 0
BDEPTH:     192      192                       Validity   : 0
Towing dir:   0°     Wire out    : 510  m      Speed      : 3.2 kn
Sorted    : 103      Total catch: 358.11       Catch/hour: 1015.91
```

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Trachurus capensis	519.57	3452	51.14	314
Merluccius capensis	319.52	3350	31.45	318
Sufflogobius bibarbatus	78.10	13016	7.69	
Chlorophthalmus agassizi	15.74	3938	1.55	
Helicolenus dactylopterus ***	13.84	3121	1.36	319
Macropipus australis	13.22	2562	1.30	
Dead shells	10.30	0	1.01	
Starfish	9.45	0	0.93	
Chelidonichthys capensis	7.66	14	0.75	317
Merluccius capensis	5.84	9	0.58	313
Lophius vomerinus	4.54	11	0.45	315
Todarodes sagittatus	4.14	28	0.41	
Aequorea sp.	2.95	0	0.29	
Austroglossus microlepis	2.38	3	0.23	316
Coelorinchus simorhynchus	2.30	74	0.23	
Deepwater fish mixture	1.90	0	0.19	
Ascidiacea	1.90	0	0.19	
Lepidopus caudatus	1.08	9	0.11	
G A S T R O P O D S	1.05	0	0.10	
Squilla acuelata calmani	0.43	31	0.04	
Total	1015.91		100.00	

[33] Boyer et al. 2019. Cruise report Dr Fridtjof Nansen – Transboundary demersal survey, SE Atlantic Leg 2.2, April 2019.

MFMR[34] Hake Survey (2021) FV Mirabilis

Station 90

RV Mirabilis SURVEY:2020901 STATION: 90
DATE :31/01/20 GEAR TYPE: BT NO: 3 POSITION:Lat S 24°1.00
start stop duration Lon E 13°51.00
TIME :08:45:00 09:09:00 24.0 (min) Purpose : 3
LOG : 0.00 1.20 1.2 Region : 5020
FDEPTH: 243 237 Gear cond.: 0
BDEPTH: 243 237 Validity : 1
Towing dir: 0° Wire out : 580 m Speed : 3.0 kn
Sorted : 215 Total catch: 1101.75 Catch/hour: 2754.38

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Merluccius capensis	703.13	3150	25.53	545
Merluccius capensis	506.25	2738	18.38	544
Merluccius capensis	243.12	178	8.83	542
PORIFERA (Sponges)	198.75	0	7.22	
Caelorinchus simorhynchus	183.75	15	6.67	
Todarodes sagittatus	183.75	262	6.67	550
Chrysaora sp.	163.13	0	5.92	
Macropipus australis	112.50	2812	4.08	
Helicolenus dactylopterus	108.75	4108	3.95	551
Sufflogobius bibarbatus	106.88	14250	3.88	
Lophius vomerinus	81.25	160	2.95	546
Merluccius capensis	34.75	25	1.26	543
Symbolophorus boops	33.75	6750	1.23	
Deepwater fish mixture	26.25	0	0.95	
GASTROPODS	13.13	0	0.48	
Brama brama	10.00	8	0.36	547
Thyrsites atun	8.38	2	0.30	548
Galeus polli	7.50	225	0.27	
Dead shells	5.63	0	0.20	
Aequorea sp.	5.63	0	0.20	
Todaropsis eblanae	5.63	112	0.20	
Lepidopus caudatus	3.75	38	0.14	
Austroglossus microlepis	2.38	10	0.09	549
Squilla acuelata calmani	1.88	112	0.07	
Starfish	1.88	0	0.07	
Not found	1.88	0	0.07	
Chlorophthalmus agassizi	0.37	112	0.01	
Merluccius capensis	0.37	75	0.01	552
Total	2754.38		100.00	

[34] Paulus et al, 2020. Surveys of the Hake Stocks. Survey No. 2020901. Ministry of Fisheries and Marine Resources, Namibia

Station 93

RV Mirabilis SURVEY:2020901 STATION: 93
DATE :15/02/20 GEAR TYPE: BT NO: 3 POSITION:Lat S 23°41.00
start stop duration Lon E 13°48.00
TIME :20:12:00 20:42:00 30.0 (min) Purpose : 3
LOG : 0.00 1.55 1.6 Region : 5020
FDEPTH: 192 192 Gear cond.: 0
BDEPTH: 192 192 Validity : 0
Towing dir: 0° Wire out : 450 m Speed : 3.1 kn
Sorted : 29 Total catch: 406.42 Catch/hour: 812.84

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Merluccius capensis	385.00	4452	47.36	567
Sufflogobius bibarbatus	119.00	23800	14.64	
Merluccius capensis	116.20	1036	14.30	566
Trachurus capensis	72.80	532	8.96	568
Chrysaora sp.	37.80	0	4.65	
Macropipus australis	35.00	1988	4.31	
Ascidiacea	11.20	0	1.38	
Starfish	11.20	0	1.38	
G A S T R O P O D S	5.60	0	0.69	
Deepwater fish mixture	5.60	0	0.69	
Aequorea sp.	4.20	0	0.52	
Austroglossus microlepis	2.80	28	0.34	570
Solenocera africana	2.80	812	0.34	
Dead shells	1.40	0	0.17	
Helicolenus dactylopterus	1.12	112	0.14	571
Squilla acuelata calmani	0.56	56	0.07	
Trachurus capensis	0.28	56	0.03	569
Sea cucumbers	0.28	0	0.03	
Total	812.84		100.00	

Station 94:

RV Mirabilis SURVEY:2020901 STATION: 94
DATE :15/02/20 GEAR TYPE: BT NO: 3 POSITION:Lat S 23°41.00
start stop duration Lon E 13°35.00
TIME :22:08:00 22:38:00 30.0 (min) Purpose : 3
LOG : 0.00 1.51 1.5 Region : 5020
FDEPTH: 228 228 Gear cond.: 0
BDEPTH: 228 228 Validity : 0
Towing dir: 0° Wire out : 550 m Speed : 3.0 kn
Sorted : 121 Total catch: 616.90 Catch/hour: 1233.80

SPECIES	CATCH/HOUR weight	numbers	% OF TOT. C	SAMP
Chrysaora sp.	372.60	0	30.20	
Merluccius capensis	339.30	1782	27.50	560
Merluccius capensis	126.00	648	10.21	561
PORIFERA (Sponges)	109.80	0	8.90	
Macropipus australis	102.60	3420	8.32	
Merluccius capensis	58.40	60	4.73	558
Lophius vomerinus	30.50	36	2.47	562
Merluccius capensis	24.50	28	1.99	559
Sufflogobius bibarbatus	21.60	2880	1.75	
Pterothrissus belloci	16.20	108	1.31	
Deepwater fish mixture	15.30	0	1.24	
Starfish	4.50	0	0.36	
G A S T R O P O D S	3.60	0	0.29	
Austroglossus microlepis	3.40	18	0.28	563
Squilla acuelata calmani	2.70	144	0.22	
Todarodes sagittatus	1.00	2	0.08	565
Todaropsis eblanae	0.90	18	0.07	
Trachurus capensis	0.90	4	0.07	564
Total	1233.80		100.00	

Monk Survey data[35]

Survey No	Station	Date	Position (Lon)	Position (Lat)	Start time	End time	Duration	Start depth	End depth	Sample weight
2016911	7	09-11-16	13.76666667	-23.85	11:29:00	11:53:00	24	227	227	1408.47
2016911	8	09-11-16	14.05	-23.93333333	14:34:00	15:04:00	30	184	182	566.75
2016911	9	09-11-16	14.06666667	-24.18333333	16:57:00	17:17:00	20	175	174	4183.01

[35] Nangola et al. 2017. Cruise Report – Monk biomass survey. Ministry of Fisheries and Marine Resources, Namibia.

Appendix 7. Comparative species list between MFMR/ NORAD Trawls and NMP Verification survey

Table 17. Comparative trawl samples and species proportions between MFMR recent trawl surveys and the NMP verification survey

MFMR Survey Data (sample in proximity to SP-1)		
No of Stations	**6**	
Mean Depth	**215,7 m**	
Total fish catch	**4736,6 kg**	
	Standardised	Proportion (%)
M. capensis	9808,8	59,12
L. vomerinus	291,1	1,75
Horse Mack	1625,5	9,80
Austroglossus microlepis	25,1	0,15
Jacopever	374,1	2,25
Gurnard capensis	21,8	0,13
Lepidopus caudatus	12,4	0,08
Brama brama	25,0	0,15
Thyrsites atun	21,0	0,13
Goby	1345,8	8,11
Galeus polli (sawtail catshark)	18,8	0,11
Chlorophthalmus agassizi (greeneye)	56,5	0,34
Pterothrissus belloci (longfin bonefish)	32,4	0,20
Symbolophorus boops (lantern)	84,4	0,51
Myctophidae sp.	23,3	0,14
Coelorinchus simorhynchus	554,2	3,34
Deepwater fish mix	120,9	0,73
Todarodes sagittatus	533,2	3,21
Todaropsis eblanae	15,9	0,10
Sepia elegans	2,1	0,01
Squilla	23,9	0,14
Macropipus australis (crab)	605,9	3,65
Solenocera africana (mud shrimp)	7,2	0,04
Bathynectes piperitus (crab)	1,9	0,01
Ascidiacea (tunicate)	41,6	0,25
Sponges	917,9	5,53
Sea Cucumber	0,6	0,00
Starfish	66,9	0,40
Gastropods	192,4	1,16
Shells dead	47,8	0,29
Other	4,7	0,03
Sample Mass (all sp incl. fish)	16591,2 kg	100 %
Species Count	31	31
Aequorea forskalea (jelly)% of trawls	777,8 kg	4,69 %
Chrysaora fulgida (jelly) % of trawls	7626,3 kg	45,97 %

Verification Survey	**Total**	
No of Stations	**24**	
Mean Depth	**223 m**	**% wt**
Species sampled in kg		
Hake	1926,0	19,43
Monk	1688,4	17,03
Maasbanker	20,0	0,20
West Coast Sole (female)	139,1	1,40
Jacopever	52,0	0,52
Cape Gurnard	0,7	0,01
Shark (bluntnose sixgill)	2,8	0,03
Pelagic Goby	47,0	0,47
Pomfret	3,1	0,03
Mackerel	8,0	0,08
Rat Tail (short nose rough)	668,0	6,74
Bonefish (long fin)	1,0	0,01
Squid (Angola flying)	167,0	1,68
Squid (flying)	0,0	0,00
Prawn	0,1	0,00
Swimming Crab	103,0	1,04
Hermit Crab	5,3	0,05
Mantis Shrimp	10,0	0,10
Prawn	0,2	0,00
Jellyfish (white)	405,0	4,09
Jellyfish (purple)	7059,1	71,22
Sea Squirt	4663,0	47,05
Whelk (tulip)	8,0	0,08
Whelk (dog)	0,0	0,00
Starfish (short armed)	0,1	0,00
Starfish (long armed)	0,0	0,00
Sponge (brown)	370,0	3,73
Sea Cucumber	0,0	0,00
Sea Pen	28,8	0,29
	9911,5 kg	100 %

Appendix 8. Assessment of impacts for each of the 5 identified impacts

Impact Description			Magnitude of Change/Intensity		How long will the impact occur?		Scale and Extent of impact?		What the probability the impact will occur?		Status of the Impact		Degree of Confidence		Significance of Impact	Significance of Impact	Sensitivity of receptor	Assessment Matrix Result
Environmental Impact Description (Hazard)	**Activity**	**Receptor**	**Magnitude Biophysical Environment**	**Score**	**Duration**	**Score**	**Extent**	**Score**	**Probability**	**Score**	**Impact Status**	**Score**	**Confidence**	**Score**	**Result**	**Term**	**High / Med / Low**	**Signific x Sensitivity**
Impact 1: The likely impact of mining **ON** commercial fisheries																		
Hake wetfish trawl impact	Seabed dredging	Fishing industry, operatio	No lasting effect	1	Long term	4	Zone 1	1	Possible	2	Negative (a c	3	Medium	2	22	Low (negativ	Low	Low (1)
Hake freezer trawl	Seabed dredging	Fishing industry, operatio	No lasting effect	1	Long term	4	Zone 1	1	Improbable	1	Negative (a c	3	High	1	10	Low (negativ	Low	Low (1)
Hake Longline	Seabed dredging	Fishing industry, operatio	No lasting effect	1	Long term	4	Zone 1	1	Improbable	1	Neutral	1	High	1	8	Low (negativ	Low	Low (1)
Monk and Sole Trawl	Seabed dredging	Fishing industry, operatio	Minor effects	3	Long term	4	Zone 2 : Local 1	3	Possible	2	Negative (a c	3	Medium	2	30	Minor (negat	Medium	Minor (4)
Horse mackerel Midwater trawl	Seabed dredging	Fishing industry, operatio	No lasting effect	1	Long term	4	Zone 1	1	Possible	2	Negative (a c	3	High	1	20	Low (negativ	Low	Low (1)
Horse mackerel purse seine	Seabed dredging	Fishing industry, operatio	Minor effects	3	Long term	4	Zone 1	1	Possible	2	Negative (a c	3	Medium	2	26	Minor (negat	Low	Low (2)
Small pelagic purse seine (sardine and anchovy)	Seabed dredging	Fishing industry, operatio	No lasting effect	1	Long term	4	Zone 1	1	Improbable	1	Neutral	1	High	1	8	Low (negativ	Low	Low (1)
Orange Roughy Trawl	Seabed dredging	Fishing industry, operatio	No lasting effect	1	Long term	4	Zone 1	1	Improbable	1	Neutral	1	High	1	8	Low (negativ	Low	Low (1)
Meso-pelagic, snoek and other migratory (snoek)	Seabed dredging	Fishing industry, operatio	No lasting effect	1	Long term	4	Zone 1	1	Possible	2	Neutral	1	Medium	2	18	Low (negativ	Low	Low (1)
Large pelagic Tunas	Seabed dredging	Fishing industry, operatio	No lasting effect	1	Long term	4	Zone 1	1	Improbable	1	Neutral	1	High	1	8	Low (negativ	Low	Low (1)
Crustaceans : rock lobster and deepwater crab	Seabed dredging	Fishing industry, operatio	No lasting effect	1	Long term	4	Zone 1	1	Improbable	1	Neutral	1	High	1	8	Low (negativ	Low	Low (1)
Linefish	Seabed dredging	Fishing industry, operatio	No lasting effect	1	Long term	4	Zone 1	1	Improbable	1	Neutral	1	High	1	8	Low (negativ	Low	Low (1)
Mariculture	Seabed dredging	Fishing industry, operatio	No lasting effect	1	Long term	4	Zone 1	1	Improbable	1	Neutral	1	High	1	8	Low (negativ	Low	Low (1)
Aggregate Score				1.31		4.00		1.15		1.38		1.77		1.31	12.57	Low (negativ	Low	Low (1)
Impact 2 : The likely impact of mining **ON** the main commercial fish species																		
Demersal : Hakes	Seabed dredging	Marine fish species	No lasting effect	1	Long term	4	Zone 1	1	Improbable	1	Negative (a c	3	High	1	10	Low (negativ	Low	Low (1)
Demersal : Monk	Seabed dredging	Marine fish species	Minor effects	3	Long term	4	Zone 2 : Local 1	3	Possible	2	Negative (a c	3	Medium	2	30	Minor (negat	Medium	Minor (4)
Demersal : Orange roughy	Seabed dredging	Marine fish species	No lasting effect	1	Long term	4	Zone 1	1	Improbable	1	Neutral	1	High	1	8	Low (negativ	Low	Low (1)
Small pelagic : Horse mackerel	Seabed dredging	Marine fish species	No lasting effect	1	Long term	4	Zone 1	1	Improbable	1	Neutral	1	High	1	8	Low (negativ	Low	Low (1)
Small Pelagic Sardine	Seabed dredging	Marine fish species	No lasting effect	1	Long term	4	Zone 1	1	Improbable	1	Neutral	1	High	1	8	Low (negativ	Low	Low (1)
Mariculture	Seabed dredging	Marine fish species	No lasting effect	1	Long term	4	Zone 1	1	Improbable	1	Neutral	1	High	1	8	Low (negativ	Low	Low (1)
Aggregate Score				1.33		4.00		1.33		1.17		1.67		1.17	11.08	Low (negativ	Low	Low (1)
Impact 3 :The likely impact of mining **ON** the recruitment of commercially important species																		
Hake	Seabed dredging	Marine fish species	No lasting effect	1	Long term	4	Zone 1	1	Possible	2	Neutral	1	High	1	16	Low (negativ	Low	Low (1)
Monk	Seabed dredging	Marine fish species	Minor effects	3	Long term	4	Zone 2 : Local 1	3	Possible	2	Neutral	1	Medium	2	26	Minor (negat	Medium	Minor (4)
Horse mackerel	Seabed dredging	Marine fish species	No lasting effect	1	Long term	4	Zone 1	1	Improbable	1	Neutral	1	High	1	8	Low (negativ	Low	Low (1)
Sardine	Seabed dredging	Marine fish species	No lasting effect	1	Long term	4	Zone 1	1	Improbable	1	Neutral	1	Medium	2	9	Low (negativ	Low	Low (1)
Aggregate Score				1.50		4.00		1.50		1.50		1.00		1.50	14.25	Low (negativ	Low	Low (1)
Impact 4 : The likely impact of mining **ON** biodiversity																		
Demersal Fish species	Seabed dredging	Marine fish species	No lasting effect	1	Long term	4	Zone 3 : Regional	5	Possible	2	Negative (a c	1	Medium	2	26	Minor (negat	Medium	Minor (4)
Substrate / habitat flora and fauna	Seabed dredging	Marine benthic communit	Moderate effects	5	Long term	4	Zone 3 : Regional	5	Highly probal	4	Negative (a c	3	High	1	72	Moderate (ne	Medium	Moderate (6)
Pelagic species	Overspill discharge	Marine fish species	Minor effects	3	Long term	4	Zone 3 : Regional	5	Possible	2	Negative (a c	3	Medium	2	34	Minor (negat	Low	Low (2)
Aggregate Score				2.63		4.00		4.13		2.38		2.00		1.63	34.14	Minor (negat	Medium	Minor (4)
Impact 5 : The likely impact of mining **ON** seabirds and marine mammals																		
Mammals (including seals)	Noise	Marine mammals	No lasting effect	1	Long term	4	Zone 3 : Regional	5	Possible	2	Negative (a c	3	Medium	2	30	Minor (negat	Medium	Minor (4)
Seabirds	Marine vessel operations	Marine avifauna	Minor effects	3	Long term	4	Zone 3 : Regional	5	Possible	2	Negative (a c	3	Medium	2	34	Minor (negat	Medium	Minor (4)
Turtles	Marine vessel operations	Marine ecology and biodi	Minor effects	3	Long term	4	Zone 3 : Regional	5	Possible	2	Negative (a c	3	Medium	2	34	Minor (negat	Medium	Minor (4)
Seals	Marine vessel operations	Marine mammals	No lasting effect	1	Long term	4	Zone 3 : Regional	5	Improbable	1	Negative (a c	3	High	1	14	Low (negativ	Low	Low (1)
Aggregate Score				2.00		4.00		4.83		1.88		2.80		1.73	26.74	Minor (negat	Medium	Minor (4)

Appendix 9. Responses to Scoping Report

Name	Comment received	Response
Dr Jean- Paul Roux Ministry of Fisheries and Marine Resources: Lüderitz	1. Please note that my concerns regarding the impact of mining in that region on hake recruitments have been submitted a few times (at meetings, comments on reports and again to the Environmental Commissioner office in 2017. It appears that despite these efforts, nothing seem to have been done about this most important issue. I have been a marine ecologist in the Ministry of Fisheries and Marine Resources for three decades and have worked extensively on several aspects of the ecology of the northern Benguela region. The results of my research have been communicated regularly in the form of internal reports, communications at meeting and symposia, as well as through numerous peer-reviewed scientific papers. I started addressing the subject of Cape hake recruitment 24 years ago and have put in place a monitoring programme which is continuing today. Some of the findings of my colleagues (including my students) and myself, that are relevant to the marine phosphate mining project but have been overlooked in the Verification Study, can be summarized as follows Some major concerns about the ecological effects of proposed marine phosphate mining on the most valuable fisheries resource: the hakes and the inadequacy of the Sand Piper Project Verification Programme by NMP to address those major issues 1. In Namibian waters, Cape hake (*Merluccius capensis*) spawns over a long season; however, the resulting juvenile cohorts were produced over a short winter period centred on the end of July (14 out of 15 consecutive cohorts had a mean birth date in July or August (the exception being the 1996 cohort on 31 May). 2. Every year the pre-recruits were found to appear inshore in the north central area (21° to 23° South) between September and December at sizes of 4 to 7 cm TL (total length). 3. These pre-recruits, upon reaching sizes of 8.5 to 9.5 cm TL, display a marked southward migration of several hundred km (possibly to exploit the northern frontal edge of the Lüderitz Upwelling Cell). 4. They will remain in this South-Central nursery area (from around Conception Bay to about 26° South) from late summer to early autumn at ~10 cm TL, throughout winter and early spring, during which time they grow in length to ~ 20 cm TL. During this period they spend extensive time in the water column in dense aggregations in autumn / early winter, while feeding on large zooplankton and later shifting their diet to small fish. 5. Upon reaching 21 cm to 23 cm TL in late spring to late summer, these pre-recruits disperse along the shelf edge and become more markedly demersal (in December to March) and, only then, become available to demersal trawl surveys.	Thank you for your email. The comments have been captured and forwarded to the Project Lead for consideration in the ESIA study that is currently being compiled. A response to Dr JP Roux's issue3s raised is included in the section on Impact 3 (recruitment).

	6. Cape hake has been found in our studies to grow at a much higher rate than previously assumed (including in the current hake assessment methodology for example) and that the ageing methodology needs to be revised as they deposit 2 rings in their otoliths per year until at least ~5 years of age. This means that the fishery (and fishable biomass) is mostly under the influence of the recruitment levels of the cohorts from 2.5 to 3 years before. 7. Hakes of less than 20 cm TL are notoriously difficult to sample with bottom trawls as they spend most of their time in the water column, and therefore bottom trawl surveys are not an adequate method to determine levels of recruitments (before the fish has grown to > 23 cm TL). 8. Our work indicates that it is possible to estimate cohort strength before the fish has grown to >23 cm TL (and be available to trawl surveys) by using samples from winter in the region of the nursery area (mostly North of Lüderitz), and we developed a yearly recruitment index since 1993/94. This recruitment time series correlates well with that obtained by trawl surveys 5 to 8 months later when the fish has become demersal. 9. From 1993/94 to present it was found that recruitment levels varied markedly between years, from high recruitment years (e.g. for the cohorts spawned in 1996, 2002, 2012) to near complete recruitment failures (like for the cohorts spawned in 1995, 2001 and 2013. Relevance to the SP-1 proposed phosphate mining project and discussion on the Verification Study and EIA: 1. Despite being available in numerous reports for many years and in part within already published peer-reviewed publications the importance of these results have been totally overlooked (e.g. in Section C 3.1 Vol 1). - The consultants claim to have analysed the NatMIRC survey data in terms of stock structure and spatial and temporal dynamics. Since the NatMIRC hake surveys are aimed at determining the biomass of the demersal portion of the hake stocks they are conducted by swept-area bottom trawls, and are therefore not adequate to sample young fish <19-22 cm TL which are not fully demersal at those sizes (Points 4 and 5 above). - Since almost all of the hake biomass surveys effected by NatMIRC in the last two decades have been conducted at the same time of the year (January-February), they are not adequate to study spatial and temporal dynamics of a portion of the stock which might be migratory in particular the 9 to 19 cm TL fish (Points 2, 3 and 4 above) even if the sampling gear was able to sample them adequately in the water column (which it is not). - Since the nursery area identified in our study is occupied by pre-recruits mostly between March and November each year (with a peak in June), the timing of the NatMIRC hake surveys would not having been adequate to identify this nursery area.	

	- Out of the 24 bottom trawls effected as part of the verification study within or around the Mining Licence Area (MLA) in June 2014, 12 were made during the night. As hakes at these depth have a marked diurnal cycle of depth distribution, night trawls are not adequate for hake biomass estimates at depths shallower than at least 400 m, leading to a large underestimate of the biomass compared to that determined from day trawls. - Despite these limitations and the expected biases, it is interesting to note that the most abundant species sampled in this survey of the MLA consisted of young Cape hakes with a mean length of 26 cm. With what we know of the growth rates and effective spawning seasonality of this species in Namibian waters (Points 1 and 6 above), these fishes were part of the strong cohort spawned in the winter of 2012 and were therefore just under two years of age at the time of the survey (Point 9 above and Fig. 1). This in itself shows that the MLA is a relatively important habitat for 2 year old Cape hakes about one year before they enter the fishery. - More importantly, while our study has identified this region as being the most important nursery area for hakes between 10 and 20 cm (Points 3 and 4 above), the few trawls of the June 2014 survey failed to find those fish (in June, at the time of the survey, they would have been expected to be around 15.5 cm TL). This is not surprising as those fish would have been ~11 months old at the time of the survey, and mostly in the water column and therefore mostly not available to the sampling gear used (Points 1, 4 and 7 above). In addition they would have belonged to the cohort spawned during the previous winter (2013) that our results have shown to have been a near recruitment failure (Points 8 and 9 above). Therefore, and unfortunately, that particular winter these fishes would have been scarce due to the poor recruitment of the 2013 cohort. The authors of the Verification Study claim that the area contains ~ 1.6 % of Cape hake biomass and recruits, based on NatMIRC survey data (effected at the wrong time of the year) and a few additional trawls done in June 2014 with an inadequate sampling gear for pre-recruits and during a year of near recruitment failure. 2. The findings by the consultants that the MLA “has no pronounced recruitment of small or young fish” (Section C 3.1, p 10), is totally invalidated and in total contradiction with our own long term work which has identified this area as being the most important nursery ground for young Cape hake. 3. The Namibian hake fishery relies on two species, the deep-water hake (*Merluccius paradoxus*) which is shared with South Africa and possibly do not spawn in our waters, and the Cape hake (*Merluccius capensis*). As the Namibian Cape hake stock seems to be distinct from the South African one and is spawning locally, it is essential to carefully manage all its life stages, their habitats and ecological requirements. Previous studies have indicated that young hakes of between 9 and 16 cm TL seem to aggregate in high densities, and are sensitive to sea water chemistry (for example oxygen levels, presence of hydrogen sulphide etc.). They are also visual predators and their foraging is expected to be greatly affected by increased turbidity. Any change of these parameters within the main nursery area caused by dredging has a high probability to have catastrophic consequences on recruitment levels. Underwater noise may also affect them considerably but the severity of this effect, given that their other ecological needs and habitat requirements are mostly unknown at present, is unclear.	

	4. The summary conclusions of the verification report (Vol 1, Table 3, page XXVi) found in Column 3 dealing with the recruitment of key commercial species that the intensity of the effect of the dredging is rated as Minor Effect, its probability as Improbable, its significance as Low, and that the confidence of the rating is High. However, as explained above, the Namibian hake fishery is by far the most important in terms of revenue, exports and employment, and it surely ranks as a key commercial species. In the light of the above these conclusions are unwarranted, based on wrong assumptions and inadequate data and methodology. Since most, if not all, the Cape hake pre-recruits in Namibia use this area as a nursery, the intensity of effect of the dredging is potentially Very High to Catastrophic (as it will affect the entire stock), while its probability is unknown it is potentially Extremely High (at least in years of good recruitment from which the fisheries is dependent), and therefore the significance should be rated as Major. The fact that the consultants have a High confidence in their own ratings is extremely disturbing in view of the fact they their study is based on inadequate data and methodology and has ignored or omitted extremely relevant information as evidenced above.	