APPENDIX 1A:

Mr. D Japp: Fish and Fisheries

Capricorn Fisheries Monitoring cc
PO Box 50035,
Waterfront, 8002, RSA.

DRAFT REPORT
SPECIALIST STUDY NO. 1A:

Marine Benthic Specialist Study for a Proposed Development of Phosphate Deposits in the Sandpiper Phosphate Licence Area off the Coast of Central Namibia

Capricorn Fisheries Monitoring

Project:
The Dredging of marine phosphate enriched sediments from Mining Licence Area No. 170

Date:
December 2011

Prepared for:
Namibian Marine Phosphate (Pty) Ltd.

Prepared by:
M. J. Smith (CapFish)
D.W. Japp (CapFish)
Dr T. Robinson (Stellenbosch University)

Declaration:
I, D.W. Japp of Capricorn Fisheries Monitoring, 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 the South African Environmental Impact Assessment Regulations, 2010
A broad overview of Namibia’s marine resources and commercial fisheries is presented. Five primary impacts of the proposed Sandpiper phosphate mining are suggested. These are: the likely impact of mining on commercial fisheries; the likely impact of mining on the main commercial fish species; the likely impact of mining on the recruitment of commercially important species; the likely impact of mining on fish biodiversity and the likely impact of mining on seabirds and marine mammals.

We conclude that the impact on Namibian fisheries will vary depending on the sector. Overall the significance of impact on the fishery sector is considered to be negative and of medium to low significance. Of the main commercial fisheries, the monk-directed trawl fishery will be most impacted. The dredging will potentially cover a significant portion of the historical monk trawling grounds (13.8 % of the Mining Licence Area) with a displacement and mortality of the resource in the target mining sites.

The hake trawl and longline fisheries will also lose fishing grounds although this is unlikely to happen in the first phase of dredging in the SP-1 mining area. Of the other main fisheries, which include horse mackerel and other small pelagic species, the mining area does not overlap significantly with the grounds fished. Further, the nature of the gear deployed (mid-water and purse seine) is such that less impact with the mining is expected.

The impact of the proposed mining on the broader ecosystem, in particular the fish fauna, will on average be moderate. The mining will displace fish resources and essential habitat occupied by these resources (such as monk, gobies, hake and others). In particular, gobies have been identified as a key forage feeder in the mining area and is also a key trophic species. Significant alteration of the ecosystem characteristics only in the immediate target mining sites is expected. Any expansion of the proposed dredging will significantly alter the potential to impact on the broader ecosystem.

There is an obvious impact in the immediate area of the mining which is serious and likely to be permanent (or at least > 20 years) – that is the physical removal and destruction of substrate. In particular monk recruitment is likely to be impacted although the significance and extent is difficult to state conclusively. Otherwise we could find no major impacts on fish recruitment. Factors such as sediment plumes are not expected to significantly affect recruitment as the mining operation is small and the plumes will disperse quickly over a short distance. Analysis of the available data also suggest that spawning and egg and larval abundance is not concentrated in or near the mining lease area. Hake juveniles are abundant in the depth range of the Mining Licence Area, however their mobility will mitigate impacts (unlike for monk that are less mobile).

With regard to biodiversity, the impact in the immediate mining area will be severe and will result in loss of flora and fauna. 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. In this regard a precautionary approach is recommended since little is known of the biodiversity in the Mining Licence Area.

With regard to seabirds and mammals, the proposed mining, although localised, will result in modification of behaviour of mammals and seabirds. 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. 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.

There are no realistic options to mitigate these impacts (apart from no directed mining). The accommodation of the needs of the monk fishery through a mutually agreed access operational plan should be given consideration.

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 an appropriate monitoring system should be established in the Mining Licence Area 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 an ecosystem study of the potential impacts of dredging.
Benthic | Occurring on the seafloor
---|---
**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.
**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
**MFMR** | Ministry of Fisheries and Marine Resources (Namibia)
**MLA** | Mining Licence Area
**NatMirc** | National Marine Research Center
**Pelagic** | Occurring in the middle or surface layers of the ocean
**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

**Acknowledgements**

CapFish would like to acknowledge the support of the Ministry of Fisheries in Namibia, especially the scientists and staff who provided the necessary data. The Namibian fishing industry have also been extremely proactive while undertaking this assessment and are thanked for supporting Dr Kirchner to facilitate the acquisition of data for this assessment. Lastly, the persistence and support of Jeremy Midgley who coordinated this work was much appreciated.
Fonticepiece: Location of the Mining Licence Area MLA 170, indicating the initial target mining areas of the Sandpiper deposit (SP-1, SP-2 and SP-3) of the mineral resource area.
INTRODUCTION

1.1 ASSUMPTIONS AND LIMITATIONS

OVERVIEW OF Ichthyofauna OF Namibia

2.1 PELAGIC FISH SPECIES
  2.1.1 Horse mackerel
  2.1.2 Sardine
  2.1.3 Anchovy
  2.1.4 Red-eye round herring
  2.1.5 Snoek

2.2 DEMERSAL FISH SPECIES
  2.2.1 Hake
  2.2.2 Monkfish
  2.2.3 Sole
  2.2.4 Orange roughy

2.3 OTHER FISH SPECIES
  2.3.1 West coast steenbras
  2.3.2 Silver kob
  2.3.3 Bearded goby

2.4 WEST COAST ROCK LOBSTER IN Namibia

COMMERCIAL FISHERIES IN Namibia

3.1 DEMERSAL TRAWL FISHERY

3.2 DEEP-WATER TRAWL FISHERY

3.3 MID-WATER TRAWL FISHERY

3.4 SMALL PELAGIC PURSE-SEINE FISHERY

3.5 DEMERSAL LONG-LINE FISHERY

3.6 WEST COAST ROCK LOBSTER FISHERY

COMMONLY OCCURRING MARINE MAMMALS AND SEABIRDS IN Namibian Waters

4.1 SEABIRDS

4.2 MARINE MAMMALS IN Namibia
  4.2.1 Mysticete (baleen) whales (Appendix 2)
  4.2.2 Odontocetes (toothed whales and dolphins)(Appendix 3)
  4.2.3 Seals
5 LEGISLATION

5.1 THE MARINE RESOURCES ACT 27 OF 2000

6 IDENTIFICATION OF IMPACTS AND RISK ASSESSMENT

6.1 DATA AND METHODOLOGY OF IMPACT ASSESSMENT
   6.1.1 Commercial fisheries data
   6.1.2 Survey data

6.2 IDENTIFICATION OF IMPACTS FOR ASSESSMENT

6.3 RESULTS
   6.3.1 Impact 1: The impact of the mining operations on commercial fisheries.
   6.3.2 Impact 2: The impact of the mining operations on the ecosystem (trophic interactions)
   6.3.3 Impact 3: The impact of phosphate mining on fish recruitment
   6.3.4 Impact 4: The impact on biodiversity
   6.3.5 Impact 5: Impact on seabirds and marine mammals

7 CONCLUSIONS

8 RECOMMENDATIONS

8.1 MITIGATION
8.2 MONITORING
8.3 REFERENCES

Appendix 1. Seabirds of southern Namibia
Appendix 2. Distribution and seasonal abundance of Mysticete (baleen) whales in southern Namibian waters
Appendix 3. Distribution and seasonal abundance of odontocetes (toothed whales and dolphins) in southern Namibian waters
Appendix 4. Datasets provided by the Namibian Ministry of Fisheries and Marine Resources (MFMR) for this impact assessment.
Appendix 5. List of species included in the biodiversity assessment
Tables and Figures

Table 1. Commercial fisheries data showing percentage catches per impact zone

Table 2. Impact assessment table summarizing the impact of phosphate mining on the main Namibian fisheries

Table 3. Visually assessment of the potential impacts of phosphate mining on ecologically important fish species

Table 4. Impact assessment table of phosphate mining on the ecosystem

Table 5. Data (surveys) used in the assessment of the potential impacts of phosphate mining on fish recruitment

Table 6. Impact Assessment of phosphate mining on fish recruitment

Table 7. Impact assessment table of phosphate mining on fish biodiversity

Table 8. Table of assessment of Impact 5 summarizing the likely impact of phosphate mining on the seabirds and mammals around the MLA.

Fonticepiece: Location of the Mining Licence Area MLA 170, indicating the initial target mining areas of the Sandpiper deposit (SP-1, SP-2 and SP-3) of the mineral resource area.

Figure 1. Distribution of horse mackerel in the Benguela region

Figure 2. Distribution of sardine stocks in the Benguela region

Figure 3. Distribution of anchovy in the Benguela Region

Figure 4. Distribution of M. paradoxus (top) and M. capensis (below)

Figure 5. Distribution of monkfish in the Benguela region

Figure 6. Total Allowable Catches set for hake and monkfish from 1991 to 2010

Figure 7. Distribution of fishing effort by the hake-directed demersal trawl fishery with respect to phosphate Mining Licence Area for the years 2005 to 2009

Figure 8. Schematic diagram of trawl gear typically used by deep-sea demersal trawl vessels

Figure 9. Commercial fishing grounds for Namibian Orange Roughy in relation to phosphate Mining Licence Area

Figure 10. Catches (mid water and purse seine) and TACs set for the Namibian stock of Cape horse mackerel from 1961 to 2009 (Kirchner et al 2010)

Figure 11. Typical gear configuration used during mid-water trawling operations

Figure 12. Distribution of fishing effort by the mid-water trawl fishery targeting horse mackerel in relation phosphate Mining Licence Area for the years 2008 to 2009

Figure 13. Total allowable catches of sardine for the years 1991 to 2010

Figure 14. Typical gear configuration of a pelagic purse seine vessel targeting small pelagic species

Figure 15. Typical configuration of demersal (bottom-set) hake longline gear used in Namibian waters

Figure 16. Location of commercial fishing grounds within the Namibian rock lobster fishery

Figure 17. Hake commercial data (2004-2009). Each dot represents the position per trawl relative to the MLA. n=63351

Figure 18. Hake commercial longline data. Each dot represents the position per throw relative to the MLA. n = 4553

Figure 19. Monk commercial data (2005-2010). Each dot represents the position per trawl. n=36798

Draft Report
Namibian Marine Phosphate (Pty) Ltd.
Figure 20. Horse mackerel commercial data (1997-2011). Dots are the position of the last trawl per day. n=39697
Figure 21. Small pelagic commercial data (anchovy, sardine and round herring) 2000 – 2011. n=2260
Figure 22. Location of anchovy catches from commercial data (2000 – 2011). n=552
Figure 23. Location of sardine catches from commercial data (2000 – 2011). n=1099
Figure 24. Location of round herring catches from commercial data (2000-2011). n=83
Figure 25. Distribution of hake from hake-survey data (1995-2010). Dots show the cumulative weights per station. n=678
Figure 26. Horse mackerel from hake-survey data (1995-2010). Dots show cumulative weight per station. n=78
Figure 27. Monk from hake-survey data (1995 – 2010). Dots show cumulative weight station. n=134
Figure 28. Monk from monk-survey data (2007-2010). Dots show cumulative weight per station. n=100
Figure 29. Pelagic (anchovy, sardine and round herring) weights from pelagic-survey data (2002 – 2011). n=2557
Figure 30. Total catch per station for snoek from hake-survey data (1997-2010). n=8
Figure 31. Distribution of goby from hake-survey data (1995 – 2010). n=93
Figure 32. Distribution of goby from monk-survey data (2007 – 2010). n=24
Figure 33. Total catch per station for west coast sole from hake-survey data (1997 – 2010). n=48
Figure 34. Total catch per station for west coast sole from monk-survey data (1997-2010). n=42
Figure 35. Distribution of orange roughy from hake-survey data (1995 – 2010). n=4
Figure 36. Distribution of orange roughy from monk-survey data (2007-2010). n=29
Figure 37. Hake juvenile numbers (<21cm) from length frequency hake-survey data (1995-2010). n=6649
Figure 38. Hake stage 4 represented as a percentage of the total number of all stages per station form hake-survey data (1995-2010). n=8769
Figure 39. Horse mackerel juvenile numbers (<21cm) from hake-survey data (1995-2010). n = 1368
Figure 40. Juvenile monk (<21 cm) from hake-survey data (1995-2010) represented as numbers per station. n=263
Figure 41. Pelagic (anchovy, sardine, and herring) juveniles numbers (< 8cm) from pelagic-surveys 2002-2011. n=10714
Figure 42. Distribution of anchovy eggs (grey) and Larvae (black) from Spanish survey data. n=333
Figure 43. Distribution of sardine eggs (grey) and larvae (black) from Spanish survey data. n=333
Figure 44. Horse mackerel eggs and larvae from Nansen survey data (1999-2005). n=2811
Figure 45. Distribution of sardine (grey) and anchovy (black) eggs from SWAPELS survey data (1978-1985). n=265
Figure 46. Distribution of sardine eggs (grey) and larvae (black) from Nansen survey data (1999 – 2005). n=2811
Figure 47. Dots represent number of species counted per coordinate (lat/long) from the hake-survey data, monk-survey data, & small pelagic-survey n=9116
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, subject to the completion of an Environmental Management Plan (EMPR) 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.

This specialist study was 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.

The information included in this report includes the available scientific and other literature available in the region as well as with direct information gained from scientists specialising in particular areas of marine and fisheries interest. 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 created in ArcGIS 9 and show the position of the MLA with target mining areas (SP-1, SP-2 and SP-3) overlaid.

The mining licence (granted for 20 years) covers an area of 2233 km². The company proposes to recovery 5.5 Mt of phosphate enriched sediments from an area of approximately 3 km² annually, this is an area of 60 km² over the granted period of the mining licence. These sediments are to be recovered from the target mine areas of the mineral resource which are described by SP-1 (Sandpiper-1), SP-2 (Sandpiper-2) and SP-3 (Sandpiper-3), (Frontispiece). SP-1 and SP-2 are each of 22 x 8 km (176 km²) and are the initial focus areas for sediment recovery using Trailing Suction Dredge Technology.

To quantify the extent of the impacts resulting from phosphate mining on fish, fisheries, marine mammals and seabirds we used four impact zones viz.

1. Zone 1 – MLA: the actual designated prospect area including SP-1, SP-2 and SP-3,
2. Zone 2 – Mine site: <25 km from the boundary of the MLA,
3. Zone 3 – Local: 25 -50km from the boundary of the MLA
4. Zone 4 – Regional: 50 -100km from the boundary of the MLA and
5. Zone 5 – National: > 100km

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. The analysis and report preparation was undertaken by CapFish consultants (M. Smith, S. Wilkinson and D. Japp). In addition to the expertise within CapFish, specialists in different fields were also consulted. These included:
1.1 ASSUMPTIONS AND LIMITATIONS

This analysis and environmental risk assessment is based on the available literature 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 assumptions may need to be made based on a broad understanding of the Benguela Ecosystem. Data provided are often limited in extent and may 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.

2 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 on demersal species, small pelagic species, large migratory pelagic fish, linefish (caught both commercially and recreationally) and crustacean resources (e.g. lobster and crabs). The following chapter is a review of the ecologically important species that may be affected on by mining of marine phosphate in Namibia. For each species the spatial distribution, recruitment (spawning behaviour) and dietary habits are considered.

2.1 PELAGIC FISH SPECIES

2.1.1 Horse mackerel

Off Namibia horse mackerel *Trachurus trachurus capensis* generally occur in waters between 200 – 1000 m depth (Crawford *et al*. 1987) (Fig. 1). 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). 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) and the bearded goby has
become an increasingly important food source for predators (Crawford et al. 1987, Boyer & Hampton 2001a), there may have been a shift in diet of some species (including horse mackerel) to focus on \textit{S. bibartus}.

### 2.1.2 Sardine

Traditionally, spawning of sardine \textit{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) (Fig. 2). 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).

### 2.1.3 Anchovy

The distribution and movement patterns of anchovy \textit{Engraulis encrasicolus} in Namibian waters were similar to those described for sardine (Fig. 3). 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).

\textit{Figure 3. Distribution of anchovy in the Benguela Region}
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).

2.1.4 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).

2.1.5 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). Spawning patterns have not been established for the Namibian stock, but it is likely that these fish move offshore to spawn along the shelf break during winter and spring, as has been recorded for snoek off the South African west coast (Griffiths, 2002). The diet of snoek consists mainly of fish. Inshore (>150 m) there is a focus on small pelagic species (e.g. sardines and anchovy) while offshore snoek also feed on demersal fish (e.g. hake) (Griffiths, 2002).

2.2 DEMERSAL FISH SPECIES

2.2.1 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) (Fig. 4). 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 intermediate 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)

While temporal and spatial patterns in hake spawning are yet to be fully resolved (Smith & Japp 2009), 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. It is, however, not clear if *M. paradoxus* spawns along the Namibian coast at all (Kainge et al. 2007). It has been suggested that both hake species are serial spawners with females spawning numerous times a year (Osbourne et al. 1999). Spawning appears to occur year round with peak spawning periods in Namibian waters occurring from mid-July to mid-September (Roux pers comm.). During this time *M. capensis* appear to move to waters <200m to spawn (Gordoa et al. 2006). For their first year 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. There is a general northward movement of hake along the Benguela coast as they age (Smith & Japp, 2009). This is reflected in recent work which has recorded evidence of older hake off Cape Frio compared to Lüderitz in the south (Roux pers comm.).

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 day as light intensity increases, the risk of predation is thought to increase, causing hake to remain close to the bottom.
Figure 4. Distribution of *M. paradoxus* (top) and *M. capensis* (below)
2.2.2 Monkfish

Two species of monkfish are common in Namibian waters. *Lophius vomerinus* (Fig. 5) 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).

2.2.3 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.

2.2.4 Orange roughy

Orange roughy *Hoplostethus atlanticus* is a deep sea 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 km² in extent (Boyer and Hampton 2001b).

2.3 OTHER FISH SPECIES

2.3.1 West coast steenbras

Two stocks of west coast steenbras Lithognathus aureti 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).

2.3.2 Silver kob

Silver kob Argyrosomus inodorus 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).

2.3.3 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 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). Presently, 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 migratory behaviour makes the goby available to a wide variety of predators, including pelagic seabirds, seals and a variety of fish. Indeed, 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).

2.4 WEST COAST ROCK LOBSTER IN NAMIBIA

While the west coast rock lobster Jasus lalandii 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). Cannibalism is known to occur in crowded conditions (Boyer & Hampton, 2001a).

3 Commercial Fisheries in Namibia

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.
3.1 DEMERSAL TRAWL FISHERY

A fleet of about 100 Namibian-registered trawlers operates within Namibian waters primarily targeting hake (*Merluccius paradoxus* and *M. capensis*). Main by-catch species include monkfish (*Lophius* spp.), kingklip (*Genypterus capensis*) and snoek (*Thyrsites atun*). The directed hake trawl fishery is Namibia’s most valuable fishery with a current annual hake TAC of 131,780 tonnes (2011). Recent TACs for hake and monkfish are shown in Figure 6.

![Graph showing Total Allowable Catches set for hake and monkfish from 1991 to 2010](image)

*Figure 6. Total Allowable Catches set for hake and monkfish from 1991 to 2010*

The fishery is active year-round except for a closed period during October each year. Trawlers are based predominantly in Walvis Bay, but also operate from Lüderitz and fishing grounds extend along the entire coastline between a depth of 200 m and 850 m. Trawlers are prohibited from operating inshore of the 200 m isobath. The past five years (2005 – 2009) have shown an average annual effort of ~170,000 hake-directed trawling hours per year (Fig. 7).
Figure 7. Distribution of fishing effort by the hake-directed demersal trawl fishery with respect to phosphate Mining Licence Area for the years 2005 to 2009
The deep-sea fleet is segregated into wet fish and freezer vessels which differ in terms of the capacity for the processing of fish offshore (at sea) and in terms of vessel size and capacity (shaft power of 750 – 3000 kW). There are currently 13 licensed freezer trawlers and 59 licensed wetfish trawlers. Wet fish vessels (which hold fish on ice – mostly whole or headed and gutted) have an average length of 45 m, are generally smaller than freezer vessels (which freeze the fish at sea, usually after a degree of processing) which may be up to 90 m in length. While freezer vessels may work in an area for up to a month at a time, wet fish vessels may only remain in an area for about a week before returning to port. 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 (see Figure 7). 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. All bottom trawls must have a cod-end with a mesh size of at least 110 mm however the smaller, older trawlers are still permitted a mesh of size of 75mm in the cod-end. Traditionally trawling was restricted to soft sediments but the development of trawl gear that is able access rocky grounds has meant that trawling now takes place on a variety of substrata

Typical demersal trawl gear configuration (Fig. 8) consists of:

- Steel warps up to 32 mm diameter - in pairs up to 2 km long when towed
- A pair of trawl doors (500 kg to 3 tonnes each);
- Net footropes which may have heavy steel bobbins attached (up to 24” diameter) as well as large rubber rollers (“rock-hoppers”); and
- 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 130 mm stretched mesh.

The environmental impacts associated with bottom trawling have been widely considered in the scientific literature, and it is accepted that trawling significantly alters benthic communities (Collie et al. 2000, Kaiser et al. 2006). A recent 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).
3.2 DEEP-WATER TRAWL FISHERY

These species are extremely 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).

In Namibia the orange roughy fishery is split into four Quota Management Areas (QMA’s) referred to as “Hotspot”, “Rix”, “Frankies” and “Johnies” (Fig. 9) and TACs are set for each specific QMA. Almost no fishing for this species takes place outside of the designated QMAs. Fishing grounds were discovered in 1995/1996 and total catches reached 15,500 tonnes in 1997. At this point catch limits were set and effort was limited to five vessels. Following a drop in the biomass levels, TACs were decreased from 12,000 tonnes in 1998 to 1,875 tonnes in 2000. General aggregations of the stock occur between June and August. The fishery uses a similar gear configuration to that used by the demersal hake-directed trawl fishery (Fig. 7).

While certain groups of biota inhabiting soft sediments show resilience to the impacts of trawling (Kenchington et al. 2001), the biota of hard grounds are known to be particularly vulnerable to the physical disturbance associated with trawling (Turner et al. 1999). Typically trawling on and around hard grounds and seamounts (such as that associated with the orange roughy fishery) causes damage to the structure-forming biota associated with these habitats (Ragnarsson & Steingrimsson, 1999).
2003). This in turn causes reduced habitat complexity, affecting community structure and diversity (Kaiser et al. 2000). No studies specific to the impacts of trawling on Namibian hard grounds have been conducted.

3.3 MID-WATER TRAWL FISHERY

The Cape horse mackerel has the highest volume and catch of all Namibian fish stocks; however by economic value is second highest contributor to the fishing industry behind the Cape hake fisheries. The fish are either converted to fishmeal or sold as frozen, whole product with landings for the year 2006 valued at N$800 million (MFMR unpublished data in Kirchner et al., 2010). The stock is caught by the mid-water trawl fishery (targeting adult horse mackerel) and pelagic purse-seine fishery (smaller quantities of juvenile horse mackerel). Maximum historical catches were reported during the 1980s but catch rates and have since declined and averaged at 252,680 tonnes since 1990 in 2008 (see Figure 10 for annual set TACs and catches). TACs were decreased from 360,000 tonnes to 230,000 tonnes following a decline in estimated stock biomass, but the TAC has since been increased following improvements in stock biomass.

![Figure 10. Catches (mid water and purse seine) and TACs set for the Namibian stock of Cape horse mackerel from 1961 to 2009 (Kirchner et al 2010)](image-url)
The target catch species is meso-pelagic (i.e. found at depths between 200 – 1000 m above the sea floor) and shoals migrate vertically upwards through the water column between dusk and dawn. Mid-water trawlers exploit this behaviour (diurnal vertical migration) by adjusting the depth at which the net is towed (this typically varies from 400 m to just below the water surface). The net itself does not come into contact with the seafloor (unlike demersal trawl gear) and towing speed is greater than that of demersal trawlers (between 4.8 and 6.8 knots) – Figure 11 refers.

Once the gear is deployed the vessel is hampered in its ability to manoeuvre as the gear may extend up to 1 km astern of the vessel (depending on the depth being fished).

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 (Fig. 11). 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.

In 2006, 12 rights-holders and 12 vessels were registered within the mid-water trawl fishery. The fleet operates exclusively out of the port of Walvis Bay and fishing grounds extend north of 25ºS to the border with Angola and effort is highest in the north (Fig. 12). Juvenile Cape horse mackerel move into deeper water when mature and are fished mostly between the 200 m and 500 m isobaths towards the shelf break.

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).
Figure 12. Distribution of fishing effort by the mid-water trawl fishery targeting horse mackerel in relation to phosphate Mining Licence Area for the years 2008 to 2009.
3.4 SMALL PELAGIC PURSE-SEINE FISHERY

The small pelagic purse-seine fishery is based on the Namibian stock of sardine (*Sardinops sagax*) and small quantities of juvenile horse mackerel. Commencing in 1947, the fishery is the largest by volume of landings and is operated predominantly from the port of Walvis Bay. The fishery grew rapidly until 1968 at which time the stock collapsed. Fishing continued thereafter at a low level of effort, but the resource has not recovered and the fishery was closed in 2007. It has since been reopened with 25,000 tonnes of sardine allocated in 2010 (the TACs allocated for sardine in recent years are shown in Figure 13). Recent biomass surveys have shown small aggregations of the stock located inshore of the 100 m bathycontour.

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 (Fig. 14). 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, hauled in and the fish pumped on board into the hold of the vessel. It is important to note that after the net is deployed the vessel has no ability to manoeuvre until the net has been fully recovered on board and this may take up to 1.5 hours. Vessels usually operate overnight and return to offload their catch the following day.

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 foodwebs (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).

3.5 DEMERSAL LONG-LINE FISHERY

Like 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. The catch landed is predominantly prime quality hake for export to Europe.

The catch is packed unfrozen on ice and the value is approximately 50% higher than that of trawled hake. Longline vessels fish in similar areas targeted by the hake-directed trawling fleet, in a broad area extending from the 300 m to 600 m contour along the full length of the Namibian coastline. Approximately 18 boats are currently (2011) operating within the sector within three broad areas. Vessels based in Lüderitz 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. Operations are ad hoc and intermittent, subject to market demand. A total hake TAC of 131,780 tonnes was set for 2011 but less than 10,000 tonnes of this is caught by long-line vessels.

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 (Fig. 15). 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. 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 it is retrieved. A line hauler is used to retrieve gear (at a speed of approximately 1 knot) and can take six to ten hours to complete. During hauling operations the vessel’s manoeuvrability is severely restricted.
Figure 15. Typical configuration of demersal (bottom-set) hake longline gear used in Namibian waters
3.6 **WEST COAST ROCK LOBSTER FISHERY**

The small but valuable fishery of rock lobster (*Jasus lalandii*) is based exclusively in the port of Lüderitz. The lobster stock is commercially exploited in Namibian waters between 28°30’S and 25°S from the Orange River border in the south to Easter Cliffs/Sylvia Hill north of Mercury Island (see Figure 16 for the location of commercial fishing grounds). Catch is landed whole and is managed using a TAC. The current TAC approximates 350 tonnes although historically the fishery sustained relatively constant catches of up to 9,000 tonnes per year until the fishery collapsed in the late 1960s. Activity is greatest over January and February with up to 25 vessels active per day over this period with the number of vessels declining towards the end of the season in May.

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.

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).
4 Commonly occurring marine mammals and seabirds in Namibian waters

4.1 SEABIRDS

A total of 50 species of seabirds has been recorded in the waters of southern Namibia (Appendix 1a-1). Of these, 13 (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 (Ryan and Rose, 1989).

Of the 50 species, nine (18%) have been given a IUCN (World Conservation Union) category of threat, and five are considered Near Threatened (BirdLife International 2000, Table 1). Conservation concern has thus been expressed for nearly one third of the seabird species occurring in southern 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 is considered Endangered (Appendix 1).

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 Cape Gannet, a plunge diver feeding on epipelagic fish, is thought to have suffered as a result of the decline of the pilchard Sardinops sp. (Crawford, 1991). The rapid increase in the seal population has resulted in seals competing for island space to the detriment of the breeding success of both gannets and penguins (Crawford et al., 1989).

The African Penguin, Caspian and Damara terns are listed in the Red Data Book (Barnes (ed) 2000). The African Penguin is considered to be "Vulnerable" and the population along the west coast of southern Africa is in a severe decline. The Caspian Tern is considered to be "Near-threatened" and the population decreasing. The Damara Tern is rated as being "Endangered" with a stable population. Although the Red Data ratings in Barnes (ed) (2000) are specifically for the South African situation they apply equally to the Namibian populations of these three species.

The Damara Tern is endemic to the west and south coasts of southern Africa i.e. Angola, Namibia and South Africa. The population size of the Damara Tern is being reassessed as a result of the...
recent observation of a flock of some 5 000 individuals about 180 km south of the Cunene River (Braby et al., 1992). It appears that the total population may be nearer 7 000 individuals than the ca. 2 500 cited by Crawford et al., (1990).

4.2 MARINE MAMMALS IN NAMIBIA

Information on cetaceans for the Namibian coastal area was obtained from a number of sources, including scientific and incidental sighting records, historical whaling catches and sightings and stranding records. These data sources are briefly described below.

The available published literature was reviewed for records of sightings or strandings from the southern Namibian region or the greater southern African region (in the case of further species, which are expected to be found in the southern Namibian region). Ross (1984) reviewed cetacean distribution patterns and biology from the south eastern coast of southern Africa. Findlay (1989 unpublished) reviewed the distribution patterns of all 37 species of cetaceans then found in southern Africa, from which Findlay et al. (1992) published the distribution patterns of smaller odontocete cetaceans from the region. Peddemors (1999) reviewed the distribution of the 18 delphinid species from southern African waters. Best (2007) provides the most recent comprehensive overview of cetaceans in southern African waters.

Between 22 and 25 species of cetacean have been recorded from southern Namibia, or 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.

4.2.1 Mysticete (baleen) whales (Appendix 2)

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 Waerebeek (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 Pasquier 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 marginata*): 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.

### 4.2.2 Odontocetes (toothed whales and dolphins)(Appendix 3)

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° 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-whale 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.

4.2.3 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 that 10% of measured dive profiles) (David 1989). The mining area falls within feeding range of South African fur seals.

5 Legislation

5.1 THE MARINE RESOURCES ACT 27 OF 2000

Namibia regulates every facet of their fishing sector. The principle legislation under which all marine living resources are managed in Namibia is the Marine Resources Act 27 of 2000. (with the associated regulations). The act is administered by the Ministry of Fisheries and Marine Resources (MFMR). MFMR’s 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).

This Act provides for the conservation of the marine ecosystem; for the responsible utilization, conservation, protection and promotion of marine resources on a sustainable basis. Section 52 states: “Any person who discharges in or allows to enter or permits to be discharged in Namibian waters anything which is or may be injurious to marine resources or which may disturb or change the ecological balance in – any area of the sea, or which may detrimentally affect the
marketability of marine resources, or may hinder their harvesting, shall be guilty of an offence and liable on conviction to a fine not exceeding N$500 000.”

Section 52 (3) (f) states: “Any person who kills or disables any marine animal by means of any explosive, poison or noxious substance, or by means of a firearm except as may be prescribed, shall be guilty of an offence and liable on conviction to a fine not exceeding N$ 500 000.”

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 and fishing areas.

From an International perspective, Namibia’s regional and International legal and policy documents, instruments and declarations require the protection of 20 – 30 per cent of all marine habitats (under the jurisdiction of individual Governments) by 2012. These legal instruments include the Convention on Biodiversity (CBD), the 2003 World Parks Congress (WPC) recommendations V.22, policy declarations, 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), the Ramsar Convention and the Algiers Convention. Namibia also signed the revised African Convention on Nature and Natural Resources on 9 December 2003. This revolutionary regional treaty was adopted by the African Union in the same year, as a replacement treaty of the former Algiers Convention. One of the objectives was to ‘.....take into account recent developments in the African environment and natural resources scenes, while bringing the Convention to the level and standard of current multilateral environmental agreements (MEAs).’

The broad objectives of this African Convention apply to all environmental media excepting the atmosphere. They include the declaration of marine protected areas, the fostering and sustainable use and conservation of natural resources, the protection and utilization of fauna and flora, and the harmonization and co-ordination of policies in these fields.

6 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 3 m (and possibly in some instances, to 6m) 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 275m 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 (see Figures 17 to 47). The area of the mining lease area covers 2233 km². There are three areas of phosphate enrichment identified for exploitation. These areas are referred to as; Sandpiper-1 (SP-1), Sandpiper-2 (SP-2) and Sandpiper-3 (SP-3) and
these serve as the primary mining targets of the deposit within the MLA. It is proposed to exploit each area systematically over time staring in SP-1.

6.1 DATA AND METHODOLOGY OF IMPACT ASSESSMENT

The data used in this specialist study to assess the impact of mining on fish, fisheries mammals and seabirds are listed in Appendix 4. These 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). These data were used primarily in a spatial context to identify areas of overlap between fisheries and the Mining Licence Area (ML-170).

The distribution maps were created in ArcGIS 9 (refer to Figure 17 and onwards) 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. To quantify the extent of the impacts due to phosphate mining, five impact zones were considered:

- Within the MLA (including target mining areas SP-1, SP-2 & SP-3),
- Mine site (< 25 km from the MLA),
- Local (25-50 km),
- Regional (50-100 km) and
- National (>100 km)

The following methods have been used to determine the significance rating of impacts identified in this benthic specialist study:

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 will it be affected.

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

- **Extent**;
- **Duration**;
- **Probability**; and
- **Intensity**.

These impact criteria are to be applied as prescribed in the table below:

<table>
<thead>
<tr>
<th>Impact Criteria:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Extent</strong></td>
</tr>
<tr>
<td><strong>Dredge Area</strong></td>
</tr>
<tr>
<td>Per vessel cycle</td>
</tr>
<tr>
<td>i.e. ~66,000m² or</td>
</tr>
<tr>
<td>6.6 ha</td>
</tr>
<tr>
<td><strong>Annual Mining</strong></td>
</tr>
<tr>
<td>Area</td>
</tr>
<tr>
<td>Up to 3 km²</td>
</tr>
<tr>
<td><strong>Specific Mine</strong></td>
</tr>
<tr>
<td>Site (SP1 or SP2)</td>
</tr>
<tr>
<td>each is 22x8 km</td>
</tr>
<tr>
<td>or 176km²</td>
</tr>
<tr>
<td><strong>Local</strong></td>
</tr>
<tr>
<td>25-50 km or</td>
</tr>
<tr>
<td>2,000km² - 8,000km²</td>
</tr>
<tr>
<td><strong>Regional</strong></td>
</tr>
<tr>
<td>50-100 km or</td>
</tr>
<tr>
<td>8,000km² - 30,000km²</td>
</tr>
<tr>
<td><strong>National</strong></td>
</tr>
<tr>
<td>100 km to EEZ</td>
</tr>
<tr>
<td>(200 nautical</td>
</tr>
<tr>
<td>miles)¹</td>
</tr>
<tr>
<td>100 to 370 km,</td>
</tr>
<tr>
<td>or &gt;30,000km²</td>
</tr>
</tbody>
</table>

¹ 1 nautical mile = 1,85 kilometres

Draft Report
Namibian Marine Phosphate (Pty) Ltd.
The status of the impacts and degree of confidence with respect to the assessment of the significance are stated 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**: The degree of confidence in the predictions, based on the availability of information and specialist knowledge. This had been assessed as high, medium or low.

Based on the above considerations, the specialist provides an overall evaluation of the significance of the potential impact, which is described as follows:

- **None**: A concern or potential impact that, upon evaluation, is found to have no significant impact at all.
- **Low**: Any magnitude, impacts will be localised and temporary. Accordingly the impact is not expected to require amendment to the project design.
- **Medium**: Impacts of moderate magnitude locally to regionally in the short term. Accordingly the impact is expected to require modification of the project design or alternative mitigation.
- **High**: Impacts of high magnitude locally and in the long term and/or regionally and beyond. Accordingly the impact could have a ‘no go’ implication for the project unless mitigation or re-design is practically achievable.

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;

---

*Draft Report*

*Namibian Marine Phosphate (Pty) Ltd.*

*Page 39*
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.

6.1.1 Commercial fisheries data

The percentage catch in the main fisheries within zones around the MLA was calculated and used
to inform the assessment of the significance of the impacts. In cases where spatial data on catch
and effort was not provided for the whole Namibian coast for all fisheries, the percentage (per
impact zone) of the cumulative catch to the 100 km boundary (from the MLA) was calculated
(Equation 1).

\[
\text{Mine site: Local:Regional catches (t)} \times 100 \quad \text{...Equation 1}
\]

In fisheries for which data for the whole Namibian EEZ was provided (hake, monk and horse
mackerel) the percentage catch taken within the <25 km zone as a proportion of the EEZ catch
was calculated (Equation 2).

\[
\frac{\text{Mine site catches (t)}}{\text{Total EEZ catches (t)}} \times 100 \quad \text{...Equation 2}
\]

For the hake longline and small pelagics sectors the data only incorporated catches from the area
between 23°S and 26°S. For these sectors the percentage catch within the MLA in relation to the
EEZ could not be calculated.

6.1.2 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 4). In many
instances samples are taken from the same stations on successive annual surveys – interpretation
using these data for the respective impact zones had, therefore, to consider any bias this may
have given. For example, the distribution of biological data used to help interpret impacts on
recruitment (e.g. spawning, juveniles fish, eggs and larvae) were visually assessed by declaring
“Yes or No” if the data overlapped with the MLA (Tables 1-8). Note, an analysis is only declared
“Yes” if there is an overlap of catches in one of the three target areas (SP-1, SP-2 and SP-3).

6.2 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 influenced by
the mining of phosphate in several direct ways. For example:

- **Exclusion of fishing to avoid mining, and the destruction of potential fishing grounds**
  Fishing activities will cease to occur in the MLA 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 full term of the mining in the immediate vicinity of the MLA and around the designated exclusion zones required for the safe operations of the dredger and maritime traffic in the vicinity.

- **The removal of habitats (or disturbance of bacterial mats, if present) utilised by marine fauna.**
  Demersal fish species live on the sea bottom and will 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 (but not considered directly in this report).

- **The creation of sediment plumes (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.

- **Loss of biodiversity through direct physical removal of fauna;**
  This is a difficult impact to assess – however it is an important consideration if unique species occur in the MLA that may result in the permanent loss of biodiversity (refer to Appendix 1c). Note that this specialist assessment only considers biodiversity in the context of ichthyofauna.

  **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);**
  Underwater sound 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.

- **Disturbance of normal trophic interactions and the general ecosystem functioning;**

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:

1. **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 MLA 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;

2. **Impact 2**: The likely impact of mining **ON** the main commercial fish species (hake, monk, horse mackerel, small pelagics, sole, orange roughy, snoek and bearded goby). 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 c) sediment plumes (turbidity);

3. **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);

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

5. **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 in the ecosystem interactions between trophic levels.

### 6.3 RESULTS

#### 6.3.1 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 the MLA and other zones. Refer to Figures 17 - 24 for the specific fisheries. Refer also to Table 1 for our estimates of the likely proportion of catch that will be impacted by each zone adjacent to the mining operations. The significance of the impact is summarised in Table 2.
### Table 1. Commercial fisheries data showing percentage catches per impact zone

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Dates</th>
<th>Species (percentage of 100km buffer zone)</th>
<th>MLA (SP-1, SP-2 &amp; SP-3)</th>
<th>Mine site &lt; 25 km</th>
<th>Local 25 - 50 km</th>
<th>Regional 50 - 100 km</th>
<th>National &gt;100 km Zone 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hake commercial trawl data</td>
<td>2004-2009</td>
<td>Hake (<em>Merluccius paradoxus</em> &amp; <em>M. capensis</em>)</td>
<td>Yes</td>
<td>28.69</td>
<td>20.21</td>
<td>51.10</td>
<td>5.03*</td>
</tr>
<tr>
<td>Hake commercial longline data</td>
<td>2006-2010</td>
<td>Hake (<em>Merluccius paradoxus</em> &amp; <em>M. capensis</em>)</td>
<td>No</td>
<td>31.49</td>
<td>21.11</td>
<td>47.4</td>
<td>No data</td>
</tr>
<tr>
<td>Horse mackerel commercial mid-water trawl data</td>
<td>1997 - 2011</td>
<td>Horse mackerel (<em>Trachurus trachurus</em>)</td>
<td>Yes</td>
<td>18.15</td>
<td>24.50</td>
<td>57.36</td>
<td>1.08*</td>
</tr>
<tr>
<td>Monk commercial trawl data</td>
<td>2005-2010</td>
<td>Monk (<em>Lophius vomerinus</em> &amp; <em>L. vaillanti</em>)</td>
<td>Yes</td>
<td>46.17</td>
<td>18.57</td>
<td>35.26</td>
<td>13.08*</td>
</tr>
<tr>
<td>Small pelagics commercial data</td>
<td>2000-2011</td>
<td>Anchovy (<em>Engraulis encrasicolus</em>)</td>
<td>No</td>
<td>1.67</td>
<td>42.28</td>
<td>56.06</td>
<td>No data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sardine (<em>Sardinops sagax</em>)</td>
<td>No</td>
<td>17.44</td>
<td>29.17</td>
<td>53.39</td>
<td>No data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Round herring (<em>Etrumeus whiteheadi</em>)</td>
<td>No</td>
<td>1.82</td>
<td>23.67</td>
<td>74.52</td>
<td>No data</td>
</tr>
</tbody>
</table>

Explanation of Table 1: The percentages reflect the following:

Column MLA: Will mining result in fishing excluded – yes / no

Zone 1. <25 km: % of fishing from MLA to 25 km boundary within the total area of the 100 km boundary that may be affected (equation 1 – see section 6.1.1).

Zone 2. >25 to 50 km: % of fishing from >25 km to 50 km boundary within the total area of the 100 km boundary that may be affected (equation 1 – see section 6.1.1.).

Zone 3. >50 to 100 km: % of fishing from >50 km to 100 km boundary within the total 100 km boundary that may be affected (equation 1 – see section 6.1.1.).

Zone 4. % of fishing potentially affected as a proportion of the total fishing activity estimated within the Namibian EEZ (equation 2 – see section 6.1.1.)
Specifically for each fishing sector we summarise as follows:

The hake trawl fishery

Figure 17 shows the position of hake trawls carried out during the period 2004 – 2009. Trawling intensity is expected to be moderate as the preferred trawl depth for the fishery is greater than 300 m. Catches taken from the mine site area (25 km from the MLA) is a small proportion of the entire Namibian EEZ and only constitutes 5.03% of the total catches (Table 1). There are minimal records of fishing in SP-1 and SP-3. Fishing has been reported mostly in SP-2. Hake trawling however is likely to be impacted within the whole MLA, in particular on the seaward (deeper) areas (western fringes of the MLA). Trawling for hake, although it occurs significantly beyond the MLA, is highly unlikely to be affected. The only caveat in this regard is the extent of any exclusion zone around the mining operation (which is not likely to be beyond the MLA).

The hake longline fishery

Hake is also targeted by the demersal longline fishery and the position of the throws relative to the MLA is represented in Figure 18. The catch distribution of longline is similar to the trawl in that in the MLA the fishery only overlaps on the fringes of their catch distribution profile. The demersal longline fishery will only be impacted in the south western portion of the MLA.

The monk trawl fishery

This fishery deploys similar bottom-trawl gear but target monk using gear with some modifications (such as tickler chains). The mining operation is expected to significantly impact monk-directed trawling as the data show that historically about 13.08% (Table 1) of monk are taken in the MLA (Fig. 19). Catches are taken from more than 50% of the MLA and in particular monk trawling will be excluded from the SP-2 and SP-3 areas. The proximity of SP-1 to monk grounds is also likely to exclude monk trawling. We conclude therefore that Monk trawling will be largely excluded from the MLA, at least in parts as mining will only occur initially in SP-1.

Horse mackerel

The bulk of the mid-water fleet catches of horse mackerel are usually made north of 20°00’S. Only a small percentage (1.08% Table 1) of the fishing activity occurs in the MLA (Fig. 20), however the frequency (intensity) of midwater trawling is low in the MLA. Historically the data suggest that fishing has occurred in nearly the whole of the MLA. This implies that the mid-water trawl fishery will lose the option of fishing in the MLA but that due to the low frequency of fishing in the area, the overall impact on the fishery will be moderate to low.

Small pelagics

Though the MLA is not situated in the main small pelagic fishing grounds (sardine – Figure 23; round herring – Figure 24), the MLA is an area of occasional high abundance of adult fish (Fig. 21). The northern extent of the MLA overlaps marginally with purse seine grounds and to a greater extent northwards of the MLA into the zones more distant from the mining area. This has significance depending on the extent of the plume generated by the actual mining operation and the discharge of water once settled in the dredger. As the extent of the plume is understood to be localised (and not extend much further than 500 to 1500 m, Appendix 1b) (Smith et al. 2006) it is highly unlikely that mining will impact the small pelagic fishery.
In general for all fisheries the likely impacts on are summarized in Table 2\(^2\).

**Note:**
- only hake trawl, horse mackerel midwater trawl, and monk trawl will be directly impacted by mining through at the actual mining location within the MLA.
- In all other zones 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 contained within 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 might be transported into the main distribution areas for hake, horse mackerel, sardine and monk.

Depending on the concentration of the dredge overspill particles in the water column, the effects can vary. Small pelagic fish as filter feeders are expected to be disturbed by dredging activity, either directly by gill clogging or indirectly through the food web. There is a remote possibility that dredging would alter the plankton abundance and community and disturb normal 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 are considered low.

\(^2\) Our assessment does not consider the impact of the removal or disturbance of naturally occurring bacteria in the MLA (refer to Appendix 1c).
Table 2. Impact assessment table summarizing the impact of phosphate mining on the main Namibian fisheries

<table>
<thead>
<tr>
<th>Nature of the impact</th>
<th>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.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extent</td>
<td>MLA - 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.</td>
</tr>
<tr>
<td>Duration</td>
<td>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)</td>
</tr>
<tr>
<td>Intensity</td>
<td>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).</td>
</tr>
<tr>
<td>Probability</td>
<td>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.</td>
</tr>
<tr>
<td>Status (+ or -)</td>
<td>Negative - the impact will result in a direct loss in fishing operations in MLA</td>
</tr>
<tr>
<td>Significance (no mitigation)</td>
<td>Medium - the project design might require modification to accommodate certain fishing operations</td>
</tr>
<tr>
<td>Mitigation</td>
<td>Consider options to minimise impact on fishing operations for example options with respect to spatial and temporal area closures.</td>
</tr>
<tr>
<td>Significance (with mitigation)</td>
<td>Medium to low</td>
</tr>
<tr>
<td>Confidence level</td>
<td>High - the evaluation is based on good qualitative and quantitative, historical and current fisheries related data.</td>
</tr>
</tbody>
</table>
Figure 17. Hake commercial data (2004-2009). Each dot represents the position per trawl relative to the MLA. \(n=63351\)

Figure 18. Hake commercial longline data. Each dot represents the position per throw relative to the MLA. \(n=4553\)

Figure 19. Monk commercial data (2005-2010). Each dot represents the position per trawl. \(n=36798\)

Figure 20. Horse mackerel commercial data (1997-2011). Dots are the position of the last trawl per day. \(n=39697\)
Figure 21. Small pelagic commercial data (anchovy, sardine and round herring) 2000 – 2011. n=2260

Figure 22. Location of anchovy catches from commercial data (2000 – 2011). n=552

Figure 23. Location of sardine catches from commercial data (2000 – 2011). n=1099

Figure 24. Location of round herring catches from commercial data (2000-2011). n=83
6.3.2 Impact 2: The impact of the mining operations on the ecosystem (trophic interactions)

As commercial data are not “independent”, we used survey data as the basis for estimating the approximate spatial distribution of the main commercial fish species. These species are used as biological indicators of the main fish components of the ecosystem, in particular their distribution reflects the likely trophic structure of the ecosystem in the vicinity of the MLA. Note that trophic modelling of the Benguela ecosystem has been done although the specific application to Namibia and the MLA in particular can only be inferred from these broad studies (Shannon, 1986).

The survey data (see Table 3) were analysed by visually examining the maps (Fig. 21 – 36). To determine the likely impact of mining we used as an indicator for the distribution and abundance of each species relative to their proximity to the MLA. (the unit or index applied is simply the cumulative catch of a particular species in the different surveys).

This crude assessment is summarized in Table 3 - i.e. the likelihood of the species listed being found (and impacted) in the actual mining locations within the MLA. The significance of the impact is summarised in Table 4.

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Dates</th>
<th>Species</th>
<th>MLA (SP-1, SP-2 &amp; SP-3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hake survey data</td>
<td>1995-2010</td>
<td>Horse mackerel</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Snoek (<em>Thrysites atun</em>)</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Goby (<em>Sufflogobius bibarbatis</em>)</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Monk</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hake</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sole (<em>Austroglossus microlepis</em>)</td>
<td>Yes</td>
</tr>
<tr>
<td>Monk survey data</td>
<td>2007-2010</td>
<td>Monk</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Goby</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Orange roughy (<em>Hoplostethus atlanticus</em>)</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sole</td>
<td>No</td>
</tr>
<tr>
<td>Small pelagic survey data</td>
<td>2002-2011</td>
<td>Horse mackerel, anchovy, sardine and round herring</td>
<td>No</td>
</tr>
<tr>
<td>Hake, monk and small pelagics survey data combined</td>
<td>1995-2011</td>
<td>All species counted per sample station</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Figure 25. Distribution of hake from hake-survey data (1995-2010). Dots show the cumulative weights per station. n=678

Figure 26. Horse mackerel from hake-survey data (1995-2010). Dots show cumulative weight per station. n=78

Figure 27. Monk from hake-survey data (1995 – 2010). Dots show cumulative weight station. n=134

Figure 28. Monk from monk-survey data (2007-2010). Dots show cumulative weight per station. n=100
Figure 29. Pelagic (anchovy, sardine and round herring) weights from pelagic-survey data (2002 – 2011). n=2557

Figure 30. Total catch per station for snoek from hake-survey data (1997-2010). n=8

Figure 31. Distribution of goby from hake-survey data (1995 – 2010). n=93

Figure 32. Distribution of goby from monk-survey data (2007 – 2010). n=24
Figure 33. Total catch per station for west coast sole from hake-survey data (1997 – 2010). n=48

Figure 34. Total catch per station for west coast sole from monk-survey data (1997 – 2010). n=42

Figure 35. Distribution of orange roughy from hake-survey data (1995 – 2010). n=4

Figure 36. Distribution of orange roughy from monk-survey data (2007 – 2010). n=29
Based on the survey data we conclude the following with respect to the impact of the mining on the abundance and distribution of the main commercial fish species:

**Hake**: Hake (*M. capensis*) are found throughout the mining lease area (Fig 25). One station in the MLA and just south of SP1 has a high frequency of occurrence of hake. Otherwise we assume the abundance of hake in the MLA and surrounding areas is fairly uniform with higher levels of hake abundance in deeper water. Mining at the specific sites 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).

**Horse mackerel**: In the MLA horse mackerel abundance is low although high incidence of this species is expected north and westwards of the MLA. 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.

**Monk**: (Figures 27 and 28) – 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 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 15 years) impact on the availability of monk in and around the mining sites (starting with SP1).

**Pelagic Species**: (Figure 29) - Abundance of small pelagic species is low in the MLA – availability of this species group is higher in the >25 km zone. One survey station indicates that small pelagic species are found in the MLA. We assume therefore that small pelagic species are highly likely to be found throughout the MLA but that the impact of mining and the resulting plumes is unlikely to have a significant detrimental impact on the resource and the ecosystem associated with these species as a whole.

**Snoek**: (Figure 30) - 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.

**Pelagic Goby**: (Figures 31 & 32) - Two surveys suggest that goby are distributed throughout the MLA and will occur inside the mining sites (SP1-3). 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.
Sole: (Figures 33 & 34) - As for monk, sole are a sedentary species preferring muddy substrate. They feed on polychaetes and other worms and fauna in the substrate. Their distribution is throughout the MLA and extending into the adjacent zone. Dredging operations will have a significant impact on sole abundance due to localise mortality. Some displacement of sole to adjacent areas away from the mining is expected. This localised impact will be long-term (at least 15 years) due to the removal of the preferred substrate of sole.

Orange Roughy: (Figures 25 & 36) – Orange roughy are only found in deeper waters and well outside of the MLA. No impact on the ecosystem is expected.

Table 4. Impact assessment table of phosphate mining on the ecosystem

<table>
<thead>
<tr>
<th>Nature of the impact</th>
<th>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, orange roughy, goby populations and small pelagics because of 1) actual mining activities 2) habitat disturbances and 3) sediment plumes (turbidity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extent</td>
<td>MLA - demersal and pelagic fish species will be displaced or redistributed from inside the MLA and possibly from the surrounding areas up to the 25 km buffer zone</td>
</tr>
<tr>
<td>Duration</td>
<td>Permanent (&gt;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</td>
</tr>
<tr>
<td>Intensity</td>
<td>Moderate effects - only a small fraction (compared to the regional extent) of fish inhabit the MLA and fish populations will recovery or settle in areas after mining operations ceases however habitat destruction may cause a longer period of recovery.</td>
</tr>
<tr>
<td>Probability</td>
<td>Highly probable - fish (and in particular demersal fish) are expected to move away from the dredging activity (and therefore MLA) in most instances</td>
</tr>
<tr>
<td>Status (+ or -)</td>
<td>Negative</td>
</tr>
<tr>
<td>Significance (no mitigation)</td>
<td>Medium - the duration of the impact is permanent but recovery of fish populations in the area may occur sooner. The intensity is minor to moderate and the extent is confined to the MLA impact zone</td>
</tr>
<tr>
<td>Mitigation</td>
<td>In terms of the ecosystem as a whole there are no particular mitigation measure that can be implemented.</td>
</tr>
<tr>
<td>Significance (with mitigation)</td>
<td>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</td>
</tr>
<tr>
<td>Confidence level</td>
<td>Low to medium - assumptions based on fish ecology is limited by the data available</td>
</tr>
</tbody>
</table>
6.3.3 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 data used to this assessment are given in Table 5. The significance of the impact is summarised in Table 6.

Table 5. Data (surveys) used in the assessment of the potential impacts of phosphate mining on fish recruitment

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

Hake: (Figures 37 & 38) – The distribution of juvenile hake (< 25 cm) occurs throughout and mostly shallower than the 200 m bathycontour. 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.

Horse Mackerel: (Figure 39 & 44) – Horse mackerel juveniles are not in high abundance in the and around the MLA. They occur mostly northwards of the MLA. 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 40) – 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) – the data given however suggest that the extent of the mining area is small compared to the overall distribution of monk. Recruitment effects on monk are therefore expected to be low.

Small Pelagic: (Figures 41, 42, 43, 45 & 46) – The known distribution patterns of small pelagic juveniles (species combined) suggests that they are predominantly found landwards (shallower) than the MLA. Further, egg and larval surveys suggest spawning occurs well north of the MLA.

Draft Report
Namibian Marine Phosphate (Pty) Ltd.

Page 55
Historical data suggests also that spawning occurred north of Walvis Bay and well away from the MLA. There is however some evidence that historically sardine and anchovy eggs were found in small numbers south of Walvis Bay and across the MLA. We conclude however that the mining is unlikely to 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 unlikely to have a significant impact on the recruitment of all commercially and ecological important fish species. However Cape hake spawn in deep water (100 and 400 m) between Cape Cross and Conception Bay (22-24°30’S) and depending on environmental conditions (cross-shelf circulation, low oxygen layers, meso-scale gyres, the dredging activities could impact on the hake spawning throughout the water column (Sundby et al. 2001).

The potential impacts of increased turbidity around the mining area is likely to impact most species and it should be noted that on the shelf between Cape Cross and Conception Bay (i.e. in the area of proposed mining and north of it) where turbidity plumes possibly might be expected to extend, is an important area for Cape hake (M. capensis) and monk juveniles. There is, therefore, a concern that the mining operation might have an effect on recruitment of these species.

The distribution of sardine and anchovy ichthyoplankton (eggs and larvae) (Fig. 42 – 46) are found further north and do not overlap with the MLA. It should be noted that this could purely be a result of the lack of survey stations in the southern areas of Namibia.

Similar to the ecosystem analysis, the spatial maps (Fig. 37 - 46) were visually examined and the intensity of potential impacts on recruitment was interpreted.
Figure 37. Hake juvenile numbers (<21cm) from length frequency hake-survey data (1995-2010). n=6649

Figure 38. 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 39. Horse mackerel juvenile numbers (<21cm) from hake-survey data (1995-2010). n = 1368

Figure 40. Juvenile monk (<21 cm) from hake-survey data (1995-2010) represented as numbers per station. n=263
Figure 41. Pelagic (anchovy, sardine, and herring) juveniles numbers (< 8cm) from pelagic-surveys 2002-2011. n=10714

Figure 42. Distribution of anchovy eggs (grey) and Larvae (black) from Spanish survey data. n=333

Figure 43. Distribution of sardine eggs (grey) and larvae (black) from Spanish survey data. n=333

Figure 44. Horse mackerel eggs and larvae from Nansen survey data (1999-2005). n=2811
Figure 45. Distribution of sardine (grey) and anchovy (black) eggs from SWAPELS survey data (1978-1985). n=265

Figure 46. Distribution of sardine eggs (grey) and larvae (black) from Nansen survey data (1999 – 2005). n=2811

Table 6. Impact Assessment of phosphate mining on fish recruitment

<table>
<thead>
<tr>
<th>Nature of the impact</th>
<th>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 are effected by 1) physical disturbance of the fishing grounds and 2) sediment plumes (turbidity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extent</td>
<td>MLA - impacts on recruitment is restricted to areas inside the mining licence area and possibly the surrounding areas up to the 25 km impact zone</td>
</tr>
<tr>
<td>Duration</td>
<td>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)</td>
</tr>
<tr>
<td>Intensity</td>
<td>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</td>
</tr>
<tr>
<td>Probability</td>
<td>Improbable - mass mortality of juveniles and eggs and larvae may occur under extreme circumstances but is highly unlikely</td>
</tr>
<tr>
<td>Status (+ or -)</td>
<td>Neutral</td>
</tr>
<tr>
<td>Significance (no mitigation)</td>
<td>Low</td>
</tr>
<tr>
<td>Mitigation</td>
<td>No practical mitigation measures are possible.</td>
</tr>
<tr>
<td>Significance (with mitigation)</td>
<td>Low - if fish abundance levels remain the same or increase then impact is not expected to have an influence on the project design</td>
</tr>
<tr>
<td>Confidence level</td>
<td>Low to medium - assumptions based on fish ecology is limited by the data available</td>
</tr>
</tbody>
</table>
6.3.4 Impact 4: The impact on biodiversity

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). 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 MLA. 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 Table in Appendix 5 and spatially in Figure 47.

The survey data from the hake, monk and small pelagic research cruises are shown spatially disaggregated by survey type and station (Fig. 47). Specifically within the MLA the number of stations sampled is relatively low 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 MLA is comparatively low. This crude assessment does however indicate that approximately 40 different species have been

Figure 47. Dots represent number of species counted per coordinate (lat/long) from the hake-survey data, monk-survey data, & small pelagic-survey n=9116
recorded in or adjacent to the MLA 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. The precautionary approach would be to permit mining under strict monitoring conditions once a biodiversity baseline for the MLA has been established. The significance of the impact is summarised in Table 7.

**Table 7. Impact assessment table of phosphate mining on fish biodiversity**

<table>
<thead>
<tr>
<th>Nature of the impact</th>
<th>The impact of phosphate mining on species diversity. Mining operations will result a reduction or loss in biodiversity because of the 1) actual mining operations, 2) the habitat destruction and 3) sediment plumes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extent</td>
<td>MLA – impact on species diversity is restricted to areas inside the mining licence area (ML 170) and possibly the surrounding areas up to the 25 km buffer zone</td>
</tr>
<tr>
<td>Duration</td>
<td>Permanent (&gt;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 should persist for an indefinite period thereafter. If biodiversity is lost, the impact is permanent.</td>
</tr>
<tr>
<td>Intensity</td>
<td>Minor effect – biodiversity in the MLA is expected to be comparatively low. Loss of biodiversity in the MLA 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 recovery of the substrate.</td>
</tr>
<tr>
<td>Probability</td>
<td>Improbable – consequence of diversity loss may occur under extreme conditions but are highly unlikely</td>
</tr>
<tr>
<td>Status (+ or -)</td>
<td>Negative</td>
</tr>
<tr>
<td>Significance (no mitigation)</td>
<td>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.</td>
</tr>
<tr>
<td>Mitigation</td>
<td>No practical mitigation measures are possible.</td>
</tr>
<tr>
<td>Significance (with mitigation)</td>
<td>Low</td>
</tr>
<tr>
<td>Confidence level</td>
<td>Low to medium - assumptions based on marine biodiversity in the MLA is limited to the nature of the data available.</td>
</tr>
</tbody>
</table>

### 6.3.5 Impact 5: Impact 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, Williams & 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 marginal component of the broad southern Atlantic marine mammal community and includes three species of pinnipeds (seals) and roughly 40 species of cetaceans (whales and dolphin) (Griffin, 1998). There has been a northerly shift
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 acutostrata*, 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 long-finned 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).

The MLA is located in a critical area offshore – that is mid-shelf along the 200 m bathycontour. Its location is therefore close enough to the shore line to expect coastal and oceanic sea birds as well as the large migrating whales and the more localised distributions of the smaller mammals (such as 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 MLA. 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 significance of the impact is summarised in Table 8.
Table 8. Table of assessment of Impact 5 summarizing the likely impact of phosphate mining on the seabirds and mammals around the MLA.

<table>
<thead>
<tr>
<th>Nature of the impact</th>
<th>The impact of phosphate mining on seabirds 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</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extent</td>
<td>MLA - impact on seabirds and mammals is restricted to areas inside the mining licence area (ML 170) and possibly the surrounding areas up to the 25 km buffer zone</td>
</tr>
<tr>
<td>Duration</td>
<td>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.</td>
</tr>
<tr>
<td>Intensity</td>
<td>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.</td>
</tr>
<tr>
<td>Probability</td>
<td>Probable - consequences of trophic interaction disturbances and noise pollution is highly likely.</td>
</tr>
<tr>
<td>Status (+ or -)</td>
<td>Negative</td>
</tr>
<tr>
<td>Significance (no mitigation)</td>
<td>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.</td>
</tr>
<tr>
<td>Mitigation</td>
<td>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.</td>
</tr>
<tr>
<td>Significance (with mitigation)</td>
<td>Low</td>
</tr>
<tr>
<td>Confidence level</td>
<td>Medium - information based on seabirds and mammals was provided by scientific specialists, however spatial data is limited</td>
</tr>
</tbody>
</table>

7 Conclusions

Five critical impacts have been identified.

The impact on Namibian fisheries will vary depending on the 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 most impacted. The species exploited (monk) prefers muddy substrate of which the dredging operation is likely to remove a substantial portion. 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.
The hake trawl and longline fisheries will also lose fishing grounds although this is unlikely to happen in the first phase as our assessment suggests hake effort is not directed in the SP-1 mining area.

Of the other main fisheries, which include horse mackerel and other small pelagic species, the mining area does not overlap significantly with the grounds fished. Further the nature of the gear deployed (mid-water and purse seine) is such that less impact with the mining is expected. Considering the impact of the proposed mining on the broader ecosystem, in particular the fish fauna, the impact will on average be moderate. The mining will displace fish resources and essential habitat occupied by these resources (such as monk, gobies, hake and others). In particular, gobies have been identified as a key forage feeder in the mining area and is also a key trophic species. There is therefore expected to be significant alteration of the ecosystem characteristics in the immediate mining area. 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 areas, which are small compared to the full extent of the fishing grounds.

Any expansion of the dredging will significantly alter the potential to impact on the broader ecosystem.

With regard to the third impact identified, that is the impact of fish recruitment, we could find no major impacts. There is an obvious impact in the immediate area of the mining which is serious and likely to be permanent (or at least > 15 years) – that is the physical removal and destruction of substrate. In particular monk recruitment is likely to be impacted although the significance and extent is difficult to state conclusively. Other factors such as sediment plumes are not expected to significantly affect recruitment as again, the mining operation is small and the plumes will disperse quickly over a short distance. Most data suggest that spawning and egg and larval abundance is not concentrated in or near the mining lease area. Hake juveniles are abundant in the depth range of the MLA, however their mobility will mitigate impacts (unlike for monk that are less mobile).

With regard to the fourth impact identified, biodiversity – the impact in the immediate mining area will be severe and will result in loss of flora and fauna. However we have 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 approach here however should be precautionary since little is known of the biodiversity in the MLA.

The final impact relates to seabirds and marine mammals. Mining, although localised, will result in modification of behaviour of mammals and seabirds. 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.
8 Recommendations

8.1 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.

8.2 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 an appropriate monitoring line (s) through the Mining Licence Area 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.
8.3 REFERENCES


Bianchi G, Carpenter KE, Roux JP, Molloy FJ, Boyer D, Boyer HJ. 1999 Field guide to the living marine resources of Namibia. FAO Rome 265p

FISHERIES, MAMMALS AND SEABIRDS SPECIALIST STUDY


Currie H, Grobler C. 2007 Concept note, background document and management proposal for the declaration of marine protected areas on and around the Namibian Offshore Islands and adjacent coastal areas. Ministry of Fisheries and Marine Resources, NACOMA & WWF.


Cury P, Shannon L. 2004 Regime shifts in upwelling ecosystems: observed changes and possible mechanism in the northern and southern Benguela. Progress in oceanography, 60: 223 - 243


Department of environmental affairs and of water affairs. 1990 Report of the subcommittee of the Sea Fisheries Advisory Committee appointed at the request of the Minister of Environment Affairs and of Water Affairs, to advise the Minister on scientific aspects of sealing. Pretoria. 112 pp.


Gordoa A, Macpherson E. 1990 Food selection by the sit-and-wait predator, the monkfish, Lophius upsicephalus, off Namibia (South West Africa). Environmental Biology of Fishes 27: 71-76.


Kemper J, Underhill LG, Crawford RMJ, Kirkman SP. 2007 Revision of the conservation status of seabirds and seals breeding in the Benguela Ecosystem. In: SP Kirkman (ed.) Final Report of the BCLME (Benguela Current Large Marine Ecosystem) Project on Top Predators as Biological Indicators of Ecosystem Change in the BCLME. Avian Demography Unit, Cape Town. 325-342.


Kirkman SP (ed) 2007 Final Report of the BCLME (Benguela Current Large Marine Ecosystem) Project on Top Predators as Biological Indicators of Ecosystem Change in the BCLME. Avian Demography Unit, Cape Town.


Nel DC. 2004 Bycatch of threatened sea birds, sharks and turtles in longline fisheries in the Benguela Large Marine Ecosystem (BCLME): an integrated approach. Preliminary Report prepared by the WWF for the BCLME.


APPENDICES

Appendix 1a-1. Seabirds of southern Namibia

Appendix 1a-2. Distribution and seasonal abundance of Mysticete (baleen) whales in southern Namibian waters

Appendix 1a-3. Distribution and seasonal abundance of odontocetes (toothed whales and dolphins) in southern Namibian waters

Appendix 1a-4. Datasets provided by the Namibian Ministry of Fisheries and Marine Resources (MFMR) for this impact assessment.

Appendix 1a-5. List of species included in the biodiversity assessment
## Appendix 1a-1  Seabirds of southern Namibia

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>STATUS*</th>
<th>RELATIVE ABUNDANCE</th>
<th>SEASONALITY</th>
<th>CONSERVATION STATUS (IUCN)</th>
</tr>
</thead>
<tbody>
<tr>
<td>African Penguin <em>Spheniscus demersus</em></td>
<td>B, inshore</td>
<td>Common</td>
<td>All year</td>
<td>Vulnerable</td>
</tr>
<tr>
<td>Black-necked Grebe <em>Podiceps nigricollis</em></td>
<td>AM, inshore</td>
<td>Locally common</td>
<td>Winter, summer</td>
<td></td>
</tr>
<tr>
<td>Wandering Albatross <em>Diomedea exulans</em></td>
<td>SM, offshore</td>
<td>Rare</td>
<td>Winter, summer</td>
<td>Vulnerable</td>
</tr>
<tr>
<td>Shy Albatross <em>Thalassarche cauta</em></td>
<td>SM, offshore</td>
<td>Uncommon</td>
<td>All year</td>
<td>Vulnerable</td>
</tr>
<tr>
<td>Black-browed Albatross <em>T. melanophris</em></td>
<td>SM, offshore</td>
<td>Common</td>
<td>Winter, summer</td>
<td></td>
</tr>
<tr>
<td>Grey-headed Albatross <em>T. chrysostoma</em></td>
<td>SM, offshore</td>
<td>Rare</td>
<td>Vagrant</td>
<td>Vulnerable</td>
</tr>
<tr>
<td>Yellow-nosed Albatross <em>T. chlororhynchos</em></td>
<td>SM, offshore</td>
<td>Common</td>
<td>Winter, summer</td>
<td>Near threatened</td>
</tr>
<tr>
<td>Northern Giant Petrel <em>Macronectes halli</em></td>
<td>SM, In/offshore</td>
<td>Common</td>
<td>All year</td>
<td>Near threatened</td>
</tr>
<tr>
<td>Southern Giant Petrel <em>M. giganteus</em></td>
<td>SM, In/offshore</td>
<td>Uncommon</td>
<td>All year?</td>
<td></td>
</tr>
<tr>
<td>Pintado Petrel <em>Daption capense</em></td>
<td>SM, offshore</td>
<td>Common</td>
<td>Winter</td>
<td></td>
</tr>
<tr>
<td>Antarctic Fulmar <em>Fulmarus glacialis</em></td>
<td>SM, offshore</td>
<td>Rare</td>
<td>Winter</td>
<td></td>
</tr>
<tr>
<td>Antarctic Prion <em>Pachyptila desolata</em></td>
<td>SM, offshore</td>
<td>Common</td>
<td>All year</td>
<td></td>
</tr>
<tr>
<td>Great-winged Petrel <em>Pterodroma macroptera</em></td>
<td>SM, offshore</td>
<td>Uncommon</td>
<td>All year?</td>
<td></td>
</tr>
<tr>
<td>Atlantic Petrel <em>P. incerta</em></td>
<td>SM, offshore</td>
<td>Rare</td>
<td>Summer</td>
<td></td>
</tr>
<tr>
<td>Soft-plumaged Petrel <em>P. mollis</em></td>
<td>SM, offshore</td>
<td>Uncommon</td>
<td>Winter, summer</td>
<td></td>
</tr>
<tr>
<td>White-chinned Petrel <em>Procellaria aequinoctialis</em></td>
<td>SM, offshore</td>
<td>Common</td>
<td>Winter, summer</td>
<td>Vulnerable</td>
</tr>
<tr>
<td>Grey Petrel <em>P. cinerea</em></td>
<td>SM, offshore</td>
<td>Rare</td>
<td>Winter</td>
<td>Near threatened</td>
</tr>
<tr>
<td>Spectacled Petrel <em>P. conspicillata</em></td>
<td>SM, offshore</td>
<td>Rare</td>
<td>Winter, summer</td>
<td>Critical</td>
</tr>
<tr>
<td>Manx Shearwater <em>Puffinus puffinus</em></td>
<td>NM, offshore</td>
<td>Rare</td>
<td>Summer, winter</td>
<td></td>
</tr>
<tr>
<td>Great Shearwater <em>P. gravis</em></td>
<td>SM, offshore</td>
<td>Uncommon</td>
<td>Summer passage</td>
<td></td>
</tr>
<tr>
<td>Sooty Shearwater <em>P. griseus</em></td>
<td>SM, offshore</td>
<td>Common</td>
<td>Winter, summer</td>
<td></td>
</tr>
<tr>
<td>Cory’s Shearwater <em>Calonectris diomedea</em></td>
<td>NM, offshore</td>
<td>Common</td>
<td>Summer</td>
<td></td>
</tr>
<tr>
<td>European Storm Petrel <em>Hydrobates pelagicus</em></td>
<td>NM, offshore</td>
<td>Common?</td>
<td>Summer, winter</td>
<td></td>
</tr>
<tr>
<td>Wilson’s Storm Petrel <em>Oceanites oceanicus</em></td>
<td>SM, offshore</td>
<td>Common</td>
<td>Winter, summer</td>
<td></td>
</tr>
<tr>
<td>Leach’s Storm Petrel <em>Oceanodroma leucorhoa</em></td>
<td>NM, offshore</td>
<td>Uncommon</td>
<td>Summer</td>
<td></td>
</tr>
<tr>
<td>SPECIES</td>
<td>STATUS*</td>
<td>RELATIVE ABUNDANCE</td>
<td>SEASONALITY</td>
<td>CONSERVATION STATUS (IUCN)</td>
</tr>
<tr>
<td>--------------------------------------------------</td>
<td>--------------------</td>
<td>--------------------</td>
<td>-------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>Black-bellied Storm Petrel <em>Fregetta tropica</em></td>
<td>SM, offshore</td>
<td>Rare</td>
<td>Winter</td>
<td></td>
</tr>
<tr>
<td>White-bellied Storm Petrel <em>P. grallaria</em></td>
<td>SM, offshore</td>
<td>Rare</td>
<td>Winter</td>
<td></td>
</tr>
<tr>
<td>White-faced Storm Petrel <em>Pelagodroma marina</em></td>
<td>SM, offshore</td>
<td>Rare</td>
<td>Winter</td>
<td></td>
</tr>
<tr>
<td>Great White Pelican <em>Pelecanus onocrotalus</em></td>
<td>B, inshore</td>
<td>Rare</td>
<td>All year</td>
<td>Vulnerable</td>
</tr>
<tr>
<td>Cape Gannet <em>Morus capensis</em></td>
<td>B, In/offshore</td>
<td>Common</td>
<td>All year</td>
<td>Near threatened</td>
</tr>
<tr>
<td>Cape Cormorant <em>Phalacrocorax capensis</em></td>
<td>B, inshore</td>
<td>Common</td>
<td>All year</td>
<td>Vulnerable</td>
</tr>
<tr>
<td>Bank Cormorant <em>P. neglectus</em></td>
<td>B, inshore</td>
<td>Rare</td>
<td>All year</td>
<td>Near threatened</td>
</tr>
<tr>
<td>Crowned Cormorant <em>P. coronatus</em></td>
<td>B, inshore</td>
<td>Uncommon</td>
<td>All year</td>
<td>Near threatened</td>
</tr>
<tr>
<td>White-breasted Cormorant <em>P. carbo</em></td>
<td>B, inshore</td>
<td>Uncommon</td>
<td>All year</td>
<td></td>
</tr>
<tr>
<td>Grey Phalarope <em>Phalaropus fulicarius</em></td>
<td>NM, offshore</td>
<td>Uncommon</td>
<td>Summer</td>
<td></td>
</tr>
<tr>
<td>Arctic Skua <em>Stercorarius parasiticus</em></td>
<td>NM, In/offshore</td>
<td>Common</td>
<td>Summer, winter</td>
<td></td>
</tr>
<tr>
<td>Pomarine Skua <em>S. pomarinus</em></td>
<td>NM, offshore</td>
<td>Common</td>
<td>Summer, winter</td>
<td></td>
</tr>
<tr>
<td>Long-tailed Skua <em>S. longicaudus</em></td>
<td>NM, offshore</td>
<td>Common</td>
<td>Summer</td>
<td></td>
</tr>
<tr>
<td>Subantarctic Skua <em>Catharacta antarctica</em></td>
<td>SM, offshore</td>
<td>Common</td>
<td>Winter, summer</td>
<td></td>
</tr>
<tr>
<td>Sabine’s Gull <em>Larus sabini</em></td>
<td>NM, In/offshore</td>
<td>Common</td>
<td>Summer</td>
<td></td>
</tr>
<tr>
<td>Kelp Gull <em>L. dominicanus</em></td>
<td></td>
<td></td>
<td>Common</td>
<td>All year</td>
</tr>
<tr>
<td>Hartlaub’s Gull <em>L. hartlaubii</em></td>
<td>B, inshore</td>
<td>Common</td>
<td>All year</td>
<td></td>
</tr>
<tr>
<td>Grey-headed Gull <em>L. cirrocephalus</em></td>
<td>B, inshore</td>
<td>Rare</td>
<td>All year</td>
<td></td>
</tr>
<tr>
<td>Common Tern <em>Sterna hirundo</em></td>
<td>NM, inshore</td>
<td>Common</td>
<td>Summer</td>
<td></td>
</tr>
<tr>
<td>Arctic Tern <em>S. paradisaea</em></td>
<td>NM, offshore</td>
<td>Uncommon</td>
<td>Summer passage</td>
<td></td>
</tr>
<tr>
<td>Sandwich Tern <em>S. sandvicensis</em></td>
<td>NM, inshore</td>
<td>Common</td>
<td>Summer</td>
<td></td>
</tr>
<tr>
<td>Swift Tern <em>S. bergii</em></td>
<td>B, inshore</td>
<td>Common</td>
<td>All year</td>
<td></td>
</tr>
<tr>
<td>Damara Tern <em>S. balaenarum</em></td>
<td>B, inshore</td>
<td>Uncommon</td>
<td>All year</td>
<td>Near threatened</td>
</tr>
<tr>
<td>Caspian Tern <em>S. caspia</em></td>
<td>B, inshore</td>
<td>Rare</td>
<td>All year</td>
<td></td>
</tr>
<tr>
<td>Black Tern <em>Chlidonias niger</em></td>
<td>NM, inshore</td>
<td>Rare</td>
<td>Summer</td>
<td></td>
</tr>
</tbody>
</table>

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

* Recent taxonomic divisions not taken into account.

Draft Report
Namibian Marine Phosphate (Pty) Ltd.
### Appendix 1a-2. Distribution and seasonal abundance of Mysticete (baleen) whales in southern Namibian waters

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>SEASONALITY</th>
<th>DISTRIBUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue whales</td>
<td>Migratory</td>
<td>Pelagic</td>
</tr>
<tr>
<td><em>(Balaenoptera musculus)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fin whales</td>
<td>Migratory</td>
<td>Pelagic – some association with the shelf edge</td>
</tr>
<tr>
<td><em>(B. physalus)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sei whales</td>
<td>Migratory</td>
<td>Pelagic</td>
</tr>
<tr>
<td><em>(B. borealis)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minke whales</td>
<td>Migratory / year round</td>
<td>Pelagic / Neritic</td>
</tr>
<tr>
<td><em>(B. acutorostrata)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bryde’s whales</td>
<td>Migratory</td>
<td>Probable pelagic</td>
</tr>
<tr>
<td><em>(B. edeni)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Humpback whales</td>
<td>Migratory / year round</td>
<td>Pelagic / Neritic (uses coastal waters as</td>
</tr>
<tr>
<td><em>(Megaptera novaeangliae)</em></td>
<td>(some summer residency)</td>
<td>migratory corridors)</td>
</tr>
<tr>
<td>Southern right whales</td>
<td>Migratory</td>
<td>Neritic – extreme inshore</td>
</tr>
<tr>
<td><em>(Eubalaena australis)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pygmy right whales</td>
<td>Migratory</td>
<td>unknown</td>
</tr>
<tr>
<td><em>(Caperea marginata)</em></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix 1a-3. Distribution and seasonal abundance of odontocetes (toothed whales and dolphins) in southern Namibian waters

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>SEASONALITY</th>
<th>DISTRIBUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sperm whales</td>
<td>Some migration</td>
<td>Pelagic</td>
</tr>
<tr>
<td><em>(Physeter macrocephalus)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pygmy Sperm whales</td>
<td>Unknown</td>
<td>Pelagic</td>
</tr>
<tr>
<td><em>(Kogia breviceps)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cuvier’s beaked whale</td>
<td>Unknown possibly year round</td>
<td>Pelagic</td>
</tr>
<tr>
<td><em>(Ziphius cavirostris)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Layard’s beaked whale</td>
<td>Unknown though stranding data</td>
<td>Pelagic</td>
</tr>
<tr>
<td><em>(Mesoplodon layardii)</em></td>
<td>suggest a strong autumn</td>
<td></td>
</tr>
<tr>
<td></td>
<td>seasonality</td>
<td></td>
</tr>
<tr>
<td>Gray’s beaked whale</td>
<td>Unknown</td>
<td>Pelagic</td>
</tr>
<tr>
<td><em>(M. grayii)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Killer whale</td>
<td>Year round</td>
<td>Cosmopolitan</td>
</tr>
<tr>
<td><em>(Orcinus orca)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>False killer whale</td>
<td>Year round</td>
<td>Pelagic</td>
</tr>
<tr>
<td><em>(Pseudorca crassidens)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pygmy killer whale</td>
<td>Unknown</td>
<td>Pelagic</td>
</tr>
<tr>
<td><em>(Feresa attenuata)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long finned pilot whale</td>
<td>Unknown</td>
<td>Pelagic</td>
</tr>
<tr>
<td><em>(Globicephala melas)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Risso’s dolphin</td>
<td>Unknown</td>
<td>Pelagic – some association with the shelf edge</td>
</tr>
<tr>
<td><em>(Grampus griseus)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common dolphin</td>
<td>Unknown</td>
<td>Pelagic</td>
</tr>
<tr>
<td><em>(Delphinus delphis / capensis?)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dusky dolphin</td>
<td>Year round</td>
<td>Neritic</td>
</tr>
<tr>
<td><em>(Lagenorhynchus obscurus)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heaviside’s dolphin</td>
<td>Year round</td>
<td>Neritic</td>
</tr>
<tr>
<td><em>(Cephalorhynchus heavisidii)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Southern right-whale dolphin</td>
<td>Year round</td>
<td>Pelagic / Neritic (localised)</td>
</tr>
<tr>
<td><em>(Lissodelphis peronii)</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bottlenose dolphin</td>
<td>Year round</td>
<td>Pelagic</td>
</tr>
<tr>
<td><em>(Tursiops truncatus)</em></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix 1a-4. Datasets provided by the Namibian Ministry of Fisheries and Marine Resources (MFMR) for this impact assessment.

<table>
<thead>
<tr>
<th>DATASET</th>
<th>DATES</th>
<th>SPECIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hake commercial trawl data</td>
<td>2004-2009</td>
<td>Hake (Merlucius paradoxus &amp; M. capensis)</td>
</tr>
<tr>
<td>Hake commercial longline data</td>
<td>2006-2010</td>
<td>Hake (Merlucius paradoxus &amp; M. capensis)</td>
</tr>
<tr>
<td>Horse mackerel commercial mid-water</td>
<td>1997-2011</td>
<td>Horse mackerel (Trachurus trachurus)</td>
</tr>
<tr>
<td>trawl data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monk commercial trawl data</td>
<td>2005-2010</td>
<td>Monk (Lophius vomerinus &amp; L. vaillanti)</td>
</tr>
<tr>
<td>Small pelagics commercial data</td>
<td>2000-2011</td>
<td>Anchovy (Engraulis encrasicolus)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sardine (Sardinops sagax)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Round herring (Etrumeus whiteheadi)</td>
</tr>
<tr>
<td>Hake survey data</td>
<td>1995-2010</td>
<td>Horse mackerel</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Snoek (Thyrsites atun)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Goby (Sufflogobius bibarbatis)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Monk</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hake</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sole (Austroglossus microlepis)</td>
</tr>
<tr>
<td>Monk survey data</td>
<td>2007-2010</td>
<td>Monk</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Goby</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Orange roughy (Hoplostethus atlanticus)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sole</td>
</tr>
<tr>
<td>Small pelagic survey data</td>
<td>2002-2011</td>
<td>Horse mackerel, anchovy, sardine and round herring</td>
</tr>
<tr>
<td>Hake length-frequency survey data</td>
<td>1995-2010</td>
<td>Horse mackerel juveniles (&lt;21cm)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hake juveniles (&lt;21cm)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Monk juveniles (&lt;21cm)</td>
</tr>
<tr>
<td>Pelagic length-frequency survey data</td>
<td>2002-2011</td>
<td>Horse mackerel, anchovy, sardine and round herring juveniles (&lt;8cm)</td>
</tr>
<tr>
<td>Hake maturity survey data</td>
<td>1995-2010</td>
<td>Hake stage 4 (spawning stage)</td>
</tr>
<tr>
<td>Hake, monk and small pelagics survey</td>
<td>1995-2011</td>
<td>All species counted per sample station</td>
</tr>
<tr>
<td>data combined</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pelagic egg and Larvae from Spanish</td>
<td></td>
<td>Anchovy eggs and larvae</td>
</tr>
<tr>
<td>survey data</td>
<td></td>
<td>Sardine eggs and larvae</td>
</tr>
<tr>
<td>Pelagic egg and Larvae from Nansen</td>
<td>1999-2005</td>
<td>Sardine eggs</td>
</tr>
<tr>
<td>survey data</td>
<td></td>
<td>Horse mackerel eggs and larvae</td>
</tr>
<tr>
<td>Pelagic egg from SWAPELS survey data</td>
<td>1978-1985</td>
<td>Sardine</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Anchovy eggs</td>
</tr>
</tbody>
</table>
### Appendix 1a-5. List of species included in the biodiversity assessment

<table>
<thead>
<tr>
<th>SPECIES INCLUDED IN THE BIODIVERSITY ASSESSMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Acanthurus monroviae</strong></td>
</tr>
<tr>
<td><strong>Aequorea sp.</strong></td>
</tr>
<tr>
<td><strong>Aleppechus (family)</strong></td>
</tr>
<tr>
<td><strong>Aleppechus australis</strong></td>
</tr>
<tr>
<td><strong>Alloctytus verrucosus</strong></td>
</tr>
<tr>
<td><strong>Aphrodite pol</strong></td>
</tr>
<tr>
<td><strong>Aquorea aquarea</strong></td>
</tr>
<tr>
<td><strong>Aristeus varidens</strong></td>
</tr>
<tr>
<td><strong>Arnochlossus imperialis</strong></td>
</tr>
<tr>
<td><strong>Astronuces sp.</strong></td>
</tr>
<tr>
<td><strong>Austroglossus microlepis</strong></td>
</tr>
<tr>
<td><strong>Bivalves</strong></td>
</tr>
<tr>
<td><strong>Bajacalifornia megalops</strong></td>
</tr>
<tr>
<td><strong>Bassanago albuscence</strong></td>
</tr>
<tr>
<td><strong>Bathynectes piperinus</strong></td>
</tr>
<tr>
<td><strong>Bathyraja smithii</strong></td>
</tr>
<tr>
<td><strong>Bathyuroconger vicinus</strong></td>
</tr>
<tr>
<td><strong>Bentheodesmus tenuis</strong></td>
</tr>
<tr>
<td><strong>Bothus sp.</strong></td>
</tr>
<tr>
<td><strong>Brachiotethys picta</strong></td>
</tr>
<tr>
<td><strong>Brama brama</strong></td>
</tr>
<tr>
<td><strong>Caelorinchus braueri</strong></td>
</tr>
<tr>
<td><strong>Caelorinchus simornychus</strong></td>
</tr>
<tr>
<td><strong>Callanthias (family)</strong></td>
</tr>
<tr>
<td><strong>Callionymidae</strong></td>
</tr>
<tr>
<td><strong>Callorynchus capensis</strong></td>
</tr>
<tr>
<td><strong>Caristiunus groenlandicus</strong></td>
</tr>
<tr>
<td><strong>Centrophorus granulosus</strong></td>
</tr>
<tr>
<td><strong>Centroscyllium fabricii</strong></td>
</tr>
<tr>
<td><strong>Centroscymnus crepidater</strong></td>
</tr>
<tr>
<td><strong>Chaceon maritae</strong></td>
</tr>
</tbody>
</table>
## Fisheries, Mammals and Seabirds Specialist Study

<table>
<thead>
<tr>
<th>Fish Species</th>
<th>Fish Species</th>
<th>Fish Species</th>
<th>Fish Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chatrabus melanurus</td>
<td>Lepidopus caudatus</td>
<td>Perulibatrachus rossignoli</td>
<td>Trachipteridae</td>
</tr>
<tr>
<td>Chelidonichthys capensis</td>
<td>Lithodes ferox</td>
<td>Photonectes braueri</td>
<td>Trachurus capensis</td>
</tr>
<tr>
<td>Chlamydoselachus anguineus</td>
<td>Lithognathus mormyrus</td>
<td>Plesionika martia</td>
<td>Trachurus trachurus capensis</td>
</tr>
<tr>
<td>Chlorophthalmus agassizi</td>
<td>Lobotes surinamensis</td>
<td>Plesiopenaeus edwardsianus</td>
<td>Trachyrincus acanthiger</td>
</tr>
<tr>
<td>Chlorophthalmus atlanticus</td>
<td>Lophius vaillanti</td>
<td>Polychaelidae (family)</td>
<td>Trachyrincus scabrus</td>
</tr>
<tr>
<td>Chloroscombrus chrysurus</td>
<td>Lophius vomerinus</td>
<td>Pontinus leda</td>
<td>Trachyscopia capensis</td>
</tr>
<tr>
<td>Chlorothalmus punctatus</td>
<td>Lophius vomerinus (juvenile)</td>
<td>Psychrolutes macrocephalus</td>
<td>Trachyscorpia eschmeyeri</td>
</tr>
<tr>
<td>Chrysaora spp</td>
<td>Lycodes agulhensis</td>
<td>Psychronyiidae spp</td>
<td>Trigla lyra</td>
</tr>
<tr>
<td>Coelorinchus acanthiger</td>
<td>Lycoteuthis lorigera</td>
<td>Pterothrissus belloci</td>
<td>Tripterophycis gilchristi</td>
</tr>
<tr>
<td>Coelorinchus coelorhinchus polli</td>
<td>Macrouridae (family)</td>
<td>Raja caudaspinosa</td>
<td>Turbo sp. Gastropods</td>
</tr>
<tr>
<td>Coelorinchus matamua</td>
<td>Malacolephalus laevis</td>
<td>Raja clavata</td>
<td>Unidentified mix</td>
</tr>
<tr>
<td>Coloconger scholesi</td>
<td>Malacosteidae</td>
<td>Raja confundens</td>
<td>Vitreledonella richardi</td>
</tr>
<tr>
<td>Coryphaenoides macrolophus</td>
<td>Malecocephalus occidentalis</td>
<td>Raja leopardus</td>
<td>Yarrella blackfordi</td>
</tr>
<tr>
<td>Cranchia scabra</td>
<td>Maurolicus muelleri</td>
<td>Raja pullopunctate</td>
<td>Yarrella sp.</td>
</tr>
<tr>
<td></td>
<td>Megalocranchia sp.</td>
<td>Raja spinacidermis</td>
<td>Zeidae</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Raja straeleni</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Zeus capensis</td>
</tr>
</tbody>
</table>