SECTION C - SPECIALIST STUDIES

C3.3 Opinion on the Ecosystem Impacts related to Dredging of Phosphates offshore Namibia

NAMIBIAN MARINE PHOSPHATE

VERIFICATION SURVEY

OPINION ON THE ECOSYSTEM IMPACTS RELATED TO DREDGING OF PHOSPHATES OFFSHORE NAMIBIA

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SUMMARY

Ecosystem modelling is often a valuable tool for the investigation of indirect and ecosystem ramifications of natural or human impacts on a part of the ecosystem. Spatially disaggregated ecosystem models have been applied in a number of localities and ecosystems around the world and have been found to be useful. In this case, however, the combination of the high uncertainty typically associated with projections by ecosystem models and the small area that will be impacted by the proposed dredging mean that it is unlikely that ecosystem modelling would expose any unexpected, highly significant threats that have not already been considered in the specialist studies.

That conclusion might not apply, however, if the area to be impacted by the dredging was found to be of particular importance in the ecosystem or in the life cycle of one or more key species, and therefore that some ecological impacts could be disproportionately higher than would be expected from considering only the impacted area as a proportion of the total area of a species distribution or of the ecosystem as a whole. The results from the Verification Biodiversity Survey did not produce any results to suggest that the proposed impacted area has any unique or unusual features that would indicate such a disproportionate importance.

The expected ecosystem impacts of the dredging can be considered in the context of other actual or potential environmental impacts in the region, such as from trawling and other fishing impacts, diamond mining, and oil and gas exploration. At this stage, the only other anthropogenic activity taking place in the MLA is fishing with trawl nets, as reported in specialist report Appendix 1a (Japp, in Midgley 2012). The impacts of extraction in the specific area planned to be dredged can be expected to have considerably greater, and longer-lasting, direct impacts on the biota in that area than does bottom trawling. However, the limited area currently designated to be dredged means that, overall, these impacts will almost certainly be considerably less across the northern Benguela shelf and southern slope environments as a whole than have been the impacts of trawling on these environments, noting that the impacts of trawling are well-managed and considered to be sustainable.

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This review was commission by Namibian Marine Phosphate (Pty) Ltd (NMP). The objective was to provide an independent professional opinion on the ecosystem impacts of the proposed dredging.

Terms of Reference

1. Review the impact assessment undertaken by NMP for the offshore component of the proposed dredging, providing opinion on the EIA context relating particularly to the broader ecosystem. The reviewer should consider in particular the Benguela Ecosystem and the modelling done for the Benguela and or similar marine ecosystems;
2. The opinion should consider in particular the fisheries section of the EIA as well as the ecosystem issues in the other sections of the EIA report (substrate, plumes, oceanography, etc) or wherever ecosystem issues have been raised;
3. The reviewer is not required to undertake ecosystem modelling, but should review the current models (generic) and any models applicable to ecosystems in the Benguela and their potential application (if any) to the proposed dredging for phosphates.
4. Consider the ecosystem impacts of the proposed dredging and give an opinion on the broader impacts (scaling effects) – consider also the impacts of scaling up dredging beyond SP-1 or expansion into other areas on the Namibian shelf.
5. Review the EIA verification survey proposed and if in any way, data collected can support / provide information for possible use in the ecosystem models to better understand the impacts of the proposed dredging.
6. Consider the dredging impacts in the context of the other environmental impacts in the Benguela such as trawling extent, other fishing impacts, diamond mining, oil and gas exploration.

1 INTRODUCTION

The Mining Licence Area (MLA) is located on the Namibian continental shelf approximately 60 km off the coast of Conception Bay. The area of the mining lease area covers 2233 km^2 within which there are three areas identified for exploitation: Sandpiper-1 (SP-1), Sandpiper-2 (SP-2) and Sandpiper-3 (SP-3). It is proposed to exploit each area systematically over time starting in SP-1. A mining licence (covers an area of 2233 km^2) has been granted for 20 years, dredging may only commence once the company has been issued with an Environmental Contract from the authorities. The company proposes to mine an area of approximately 3 km^2 annually, which will lead to dredging an area of 60 km^2 over the period licenced.

2 SUMMARY OF KEY FINDINGS FROM INITIAL EIA ASSESSMENT

The specialist report Appendix 1a (Japp in Midgley 2012) on fish resources, fisheries, marine mammals and birds of the Environmental Impact Assessment (EIA) for the proposed phosphate dredging considered the following five primary impacts of dredging:

1) on commercial fisheries;
2) on the main commercial fish species;
3) on the recruitment of commercially important species;
4) on fish biodiversity and

5) on seabirds and marine mammals.

The details are available in that report. In summary, this report concluded that:

- The mining licence area covers a surface area in which an estimated 0.86% of the hake trawl catch, 0.32% of the midwater horse mackerel catch and 6.34 % of the monk trawl fisheries catch had been taken in the six most recent years for which suitable data were available;
- Impact on the commercial fisheries catch in the actual mined areas (SP-1) will be < 0.05% except for the monk trawl fishery where it is expected that about 1.08% of the historical catch will be directly impacted in SP-2 and SP-3 combined and 0.0% in SP-3.
- The dredging area does not overlap significantly with the fishing grounds for horse mackerel and other small pelagic species;
- The direct impact will be the physical removal and destruction of substrate. This will be serious and likely to last for at least 20 years. Significant alteration of the ecosystem is expected only in the immediate target dredging sites and will affect essential habitat occupied by some key fisheries resources including monk, gobies and hake. Gobies are considered a key trophic species in the ecosystem.
- Recruitment of monk fish is likely to be negatively affected but the extent of this impact could not be assessed. No other major impacts on fish recruitment were identified. Sediment plumes are not expected to significantly affect recruitment as the area of dredging operations will be small and plumes should disperse quickly within a short distance from the dredging operations.
- There are likely to be negative impacts on birds and mammals in the dredging areas but their likely intensity and significance could not be evaluated. Bird mortality caused by bird strikes could be expected and will require mitigation.

The specialist report on the water column (Appendix 1b – Carter, in Midgley 2012) considered a number of potential impacts on the water column from the dredging activities and concluded that, apart from the risk of ecosystem impacts from the introduction of alien species, all the others were of low significance or not of significance. Particularly relevant to this report on ecosystem modelling, the significance of negative impacts from the generation of a turbid plume was estimated as low. The study assumed that the dimensions of plumes generated by dredging would be 1 500 m long by 800 m wide and that the concentration of sediment in the plume would be between 20 mg/ℓ and 100 mg/ℓ. The study reported that at the lower limit of these concentrations, there could be chronic effects on marine biota after 3 days of exposure while acute effects could occur from concentrations above 100 mg/ℓ. The longevity of plumes was estimated to be about 16 hours.

The specialist report on benthos_(Appendix 1c – Steffani, in Midgley 2012) came to the following conclusions:

- ML 170 is located on the outer shelf beyond the inner shelf break and is characterised by a generally sandy environment where organic matter and nutrient concentrations in the sediments are likely to be relatively low.
- It occurs in the southern offshore fringe of the oxygen minimum zone (OMZ) and has low dissolved oxygen levels (<0.5 ml/ℓ) at the bottom throughout the year but is generally not anoxic. Hydrogen sulphide pore and bottom water concentrations are likely to very low but may be higher in deeper sediments.
- There is very little known about the benthic fauna of the Namibian OMZ but a macrofauna baseline survey across SP-1 (2010) showed relatively low species richness of the benthic

macrofauna assemblages which were dominated by polychaetes, especially the spionid polychaete *Paraprionospio pinnata*. Crustaceans were poorly represented.

- The dredging will result in the loss of benthic organisms through the removal of the substratum. It will also lead to the re-suspension of sediments into the water column and subsequent re-deposition of the suspended sediments. The impact of the removal of the upper layer of sediments was estimated to be of medium significance but it was noted that in the proposed development, the area actually dredged will be limited to a maximum of 60 km^2 after 20 years.

3 AVAILABLE MODELS AND POTENTIAL FOR APPLICATION

Many different types of model have been developed to simulate ecosystem processes in aquatic systems. Some of the more highly developed and widely used were described by Plaganyi (2007) and include, for example, Ecopath with Ecosim (EwE), the European Regional Seas Ecosystem Model (ERSEM), the Integrated Generic Bay Ecosystem Model (IGBEM), ATLANTIS, and the Spatial Ecosystem and Population Dynamics Model (SEAPODYM). EwE and Atlantis are generic models and could be adapted to include most ecosystem components (Plaganyi, 2007). In addition, multispecies models that incorporate size and spatial structure have been developed for the southern Benguela, based on an approach known as Object-oriented Simulator of Marine ecOSystems Exploitation (OSMOSE, Shin *et al*., 2004; Travers-Trolet *et al*., 2014).

Ecopath with Ecosim is the most widely used approach and, by October 2008, there were 5,649 registered users of EwE in 164 different countries and over 300 papers making use of the approach had been published, demonstrating its wide scientific credibility. It was developed by a group of researchers based at the University of British Columbia, Canada. EwE includes three main packages: Ecopath, which provides a static, mass-balanced framework for representing the trophic relationships within an ecosystem; Ecosim, which extends Ecopath into a time dynamic simulation model; and Ecospace which extends Ecopath and Ecosim into a framework that enables dynamic simulations across space and time. Ecospace was developed mainly to enable consideration of the design and impacts of marine protected areas but can be used for spatial simulations with different objectives[1].

EwE has been applied in the Benguela ecosystem in a number of studies including some focused on the northern Benguela such as Roux and Shannon (2004) and Heymans and Sumaila (2007).

3.1 ECOSPACE AS A POTENTIAL MODELLING FRAMEWORK IN THE CONTEXT OF THE MLA

Ecospace is based on the Ecopath with Ecosim modelling approach but allows for the division of the modelled system into a spatial grid with the Ecosim model replicated within each spatial cell. Movement between cells can be driven in the model by estimates of the dispersal rate for each species or taxonomic group in the model, constraints on movement caused by, for example, land-water boundaries, habitat preferences (which would be simulated by higher emigration rates, lower feeding rates and higher vulnerability to predation in non-favourable cells), and other fishing and ecological processes. This modelling application potentially could be applied to exploring the ecosystem impacts of dredging by developing a model that differentiates between cells which are rendered unfavourable or less favourable as a result of the dredging activities and those which are

[1] http://www.ecopath.org/about

unaffected. Running such a model over time would provide estimates of how the direct negative impacts on the ecosystem in the impacted areas spread, both within the affected areas and beyond, across the ecosystem as a whole.

Several studies have been undertaken using Ecospace, generally in relation to the size and placement of marine protected areas (MPAs). For example, an Ecospace model of the Northern Gulf of California was constructed in which the area was sub-sudivided into a 40 x 40 spatial grid with each cell being a square of 10 km x 10 km (Lecari *et al*. 2007). The effectiveness of MPAs in the central Pacific was examined using an Ecospace model covering the area from 0°N to 35°N and 150°W to 160°E, which was sub-divided into a grid made up of 34 rows and 50 columns, with each grid cell being approximately 100 km x 100 km.

Heymans and Sumaila developed an Ecospace model of the northern Benguela from 15°S to 29°S and 10°E to 17°E which encompasses the MLA. They divided the area into 140 rows and 70 columns, with each cell being a 10 km square. The whole area was then sub-divided into 11 different habitat types of differing areas ranging from less than 0.1% of the total area (Luderitz Harbour) to 57.9% (deep areas south of the Walvis Ridge). Should it be decided to undertake a modelling exercise to assess the likely impacts of the dredging across the ecosystem, it should be possible to use this model as a starting point and modify it to represent the desired spatial and ecosystem structure.

4 INDICATIONS OF LIKELY ECOSYSTEM IMPACTS BASED ON AVAILABLE MODELLING STUDIES

4.1 TAXONOMIC DETAIL

The existing ecosystem models of the northern Benguela give good indications of the current state of knowledge on the relative abundance, distribution and taxonomic resolution of the biodiversity of the Northern Benguela ecosystem. The MLA occurs within two of the 11 habitats included in the Heymans and Sumaila (2007) model:

- the Shelf (30 - 200 m depth) and
- Southern Slope (200 - 500 m) habitats.

The species and species groups included in each of them are listed in Annexure 1. This reflects a high degree of knowledge on the commercially-important fish species and those of conservation interest: i.e. sharks, seals, seabirds and marine mammals, but very limited knowledge of other fish and invertebrate species, including invertebrates that occupy the shelf and slope benthic habitats. Monkfish, hakes and pelagic gobies are explicitly included, with hakes and pelagic gobies split into juveniles and adults.

The northern Benguela model of Roux and Shannon (2004), while not spatially disaggregated, was constructed with a very similar taxonomic structure to that of Heymans and Sumaila (Annexure 1).

Judging by these two modelling exercises, in particular the species and groupings that were used, it is unlikely that there would be sufficient relevant information at greater taxonomic detail to be able to construct a realistic model with much greater taxonomic resolution and detail than they have included.

4.2 ECOSYSTEM CONSEQUENCES OF HUMAN INTERVENTIONS

Heymans and Sumaila did not use their model to investigate the consequences of human impacts on the system or parts of the system but Roux and Shannon used their model to estimate the likely ecosystem ramifications of a number of simulated changes in fishing harvest strategies. They examined the impacts of both reductions and increases in fishing or harvest mortality by simulating the trajectories over time of all other species and species groups. Some of their results are shown in Table 1, in particular those in which they simulated an increase in fishing mortality as this would lead directly to an increased in mortality of the target species and thereby a reduction in biomass. These effects would be similar in direction (but not necessarily scale) to the direct impacts of dredging, if it is assumed that habitat destruction by dredging would lead to a proportionate reduction in biomass of those fish species dependent on that habitat. It should be noted, though, that whereas the impacts of fishing mortality, as simulated in the model, cease as soon as fishing is stopped, the impacts of dredging have a longer-lasting impact because of habitat destruction. Potentially this could mean that dredging could lead to a longer-term reduction in the maximum population size (carrying-capacity) of a species strongly dependent on the benthic environment. In contrast, fishing mortality alone leads only to a reduction in the population size at the time.

The results in Table 1 demonstrate that changes in abundance and productivity of particular species do lead to changes in biomass and production of other species. For example, starting a serious fishery on pelagic goby was found to lead to an 87% decline in biomass of gobies which resulted in substantial increases in biomass of competitors, including anchovy and sardine, and a decline in biomass of *M. capensis* which preys on pelagic gobies. The decline of the shallow water hake, *M. capensis,* in turn led to an increase in the biomass of deep water hake *M. paradoxus* which is an important prey species for the larger individuals of *M. capensis.* In another trial, increasing the fishing mortality on *M. capensis* led to a reduction in biomass of that species, small changes in biomass of *M. paradoxus* and considerable increases in the biomass of dolphins and seabirds, presumably as a result of increases in availability of prey species previously kept at lower biomasses by *M. capensis* predation.

The specialist report on fish resources, fisheries, marine mammals and birds report (Appendix 1a – Japp, in Midgley 2012) found that monkfish would be the species most affected by the proposed dredging activities, as would the fishery targeting monkfish. It was reported that just over 1% of the monkfish catch would be affected. It also concluded that recruitment of monkfish could be affected but could not estimate the extent of that impact. Roux and Shannon (2004) included monkfish within one of the multi-species ‘demersals’ groups. They did not report on any simulations involving direct changes in fishing mortality on these demersal groups and therefore do not give any indication of the likely ecosystem ramifications of a reduction in monkfish biomass or production. However, Heymans and Sumaila (2007) did include a specific monkfish species in their model and reported that the simulated diet of monkfish in the model was: 36.7% hake, 29.4% demersals, 6.6% horse mackerel, 0.2% gobies, 1% cannibalism, 12.3% small pelagics, 3.9% anchovy, 0.4% mesopelagics, 8.4% cephalopods and 1.2% macrobenthos. Based on this diet, it could be assumed that a reduction in biomass of monkfish would lead to a reduction in predation mortality on those species in proportion to:

i) the reduction in monkfish biomass and
ii) the proportional representation of the species in the monkfish diet.

Therefore, for example, hakes and other demersals could be expected to show the biggest increases while for most other taxonomic groups the responses would be considerably smaller. This does not take into account interactions between the species preyed on by monkfish, which could affect these simple forecasts. For example, the increase in *M. capensis* caused by reduced predation by monkfish could be expected to lead to higher predation on juvenile *M. paradoxus* which could offset the effect of reduced predation by monkfish on that species.

An important feature of the results shown in Table 1 and other results reported in Roux and Shannon (2004) is that the indirect impacts on other species of a management intervention on a target species were invariably smaller, as a percentage change in biomass, than the magnitude of change in the directly impacted species. For example, a fourfold increase in fishing mortality of large horse mackerel led to an estimated 88% decline in horse mackerel biomass, while the largest percentage response amongst other groups was a 59% increase in seabirds. Similarly, a 50% reduction in the Cape fur seal population led to increases in biomass of anchovy and sardine of 16 and 10% respectively. These results suggest that the indirect impacts on other species of any reductions in e.g. hakes, monkfish or pelagic gobies will be lower, as percentage changes in biomass, than the direct impacts on those species. In other words, the Roux and Shannon (2004) results do not give evidence that direct impacts on the species and taxonomic groups examined in their study could lead to much bigger, non-linear, indirect responses in other elements of the ecosystem.

Table 1. Summarised results of the projected ecosystem consequences of selected management actions as simulated by the Roux and Shannon EwE model (Roux and Shannon 2004).

Management Action	**Changes in other groups as projected by model (% change in biomass)**
Opening fishery on pelagic goby (removing 50% of goby production).	Goby -87 Anchovy +51 Sardine +27 Small horse mackerel +21 *M. capensis – 25* *M. paradoxus* +16
Increasing fishing mortality on small and large horse mackerel (fourfold)	Sardine – negligible Seabirds +70 Large pelagics +35 *M. capensis – 30* *M. paradoxus* +17
Removal of 50% of gelatinous zooplankton production	Anchovy +22 Cephalopods and horse mackerel +33 Large pelagic fish and whales +42 *M. capensis* +20 *M. paradoxus* +33 Pelagic goby -8 Seabirds -6
50% reduction in Cape fur seal population	Anchovy +16 Sardine +10 Most other groups between -5 and +5
Increasing fishing mortality on large *M. capensis* (fourfold)	Large *M. capensis* – 36 Small *M. capensis* -27 *M. paradoxus* between -5 and +5 Dolphins +17 Seabirds +22

Examination of similar simulations undertaken on the southern Benguela are, however, not entirely consistent with the results from the northern Benguela suggesting that the indirect impacts on other species arising from a reduction in one species will be proportionately smaller than the initial reduction. That conclusion, therefore, may not always be applicable. Simulations undertaken using an EwE model of the southern Benguela estimated that heavy pulse fishing on hake reduced the biomass of hake substantially but, under one particular assumption on the nature of predator-prey relations known as wasp-waist control, indicated that the indirect impacts of the hake reduction led to larger reductions in the biomass (as a proportion of the original biomass) of chub mackerel and horse mackerel than had taken place with hake. Under the assumption of wasp–waist control, recovery from the change for some groups was slow and they had still not reverted to their biomasses 35 years after the perturbation (Shannon *et al*. 2000). Simulations using an OSMOSE model found that overfishing of hake led to reduction in biomass of adult *M paradoxus* to approximately 70% of its original biomass which in turn led to an increase in biomass of silver kob to about 1.3 times its initial biomass and of snoek to about 1.5 times its initial biomass (Travers *et al*, 2010). In these examples, the indirect impacts, as a proportion of the original biomass of the impacted stock, were as large or larger than the direct impacts on the targeted stock.

Ecosystem models inevitably include high levels of uncertainty that lead to equivalent uncertainty in the results. This is demonstrated in the study by Travers at al. (2010), which compared the forecasts of two models, an EwE model and an OSMOSE model. The authors concluded that the two models simulated similar trophic functioning in the southern Benguela but that there were differences in the results of the simulations in both the directions of change of species and other indicators (i.e. increases or decreases) and in their variability. They ascribed these differences to different assumptions made in constructing the models.

In a separate study to explore the combined effects of climate forcing and fishing on the southern Benguela, the authors constructed an end-to-end model in which the trophic interactions were simulated using an OSMOSE model with a simplified food-web structure. The results were that the simulations of these two drivers in combination generated changes in biomass that were less pronounced than, or dampened, compared to the changes that occurred when the impacts of only one driver were simulated (Travers-Trolet *et al*. 2014). The severely simplified representation of the composition and structure of the food web in that study would have influenced the results but they nevertheless illustrate the complexities of regulation and responses of species to perturbations.

The studies referred to in this assessment reveal the uncertainties associated with ecosystem models. At the current state of development of ecosystem understanding and simulation, it is not possible to forecast indirect impacts with any degree of certainty. However, overall the results referred to suggest that indirect impacts resulting from the direct impacts of a perturbation, such as fishing or dredging, on a species are likely to be of the same general order of magnitude as those direct impacts. The results further indicate that the indirect impacts are most likely to be smaller or, at most, slightly larger as a proportion of the original condition, than the direct impacts. There was no evidence to suggest that indirect impacts disseminated through the food web would be disproportionately larger than the original direct impacts and therefore that direct impacts on the scales simulated here could generate serious, unexpected consequences in all or some components of the ecosystem.

5 POTENTIAL FOR APPLICATION OF MODELLING TO EVALUATE THE ECOSYSTEM IMPACTS OF THE PROPOSED DREDGING

In principle, a spatially disaggregated ecosystem model could be used to assess the likely impacts of the proposed dredging on the ecosystem as a whole. However, the practical utility of this in this particular case is highly questionable.

The first factor to be taken into account is that the projections of ecosystem models typically have high uncertainty associated with them as a result of a combination of incomplete knowledge of the functional relationships within the ecosystem and similarly incomplete knowledge of the value of the parameters associated with those relationships. As model complexity is increased, which would include through the addition of spatial complexity, these uncertainties increase further (Plaganyi 2007).

Notwithstanding this uncertainty, ecosystem models can still give an indication of likely or possible trends. However, in this particular case, ecosystem modelling is unlikely to be useful for the following reasons:

- The area impacted by the proposed dredging, as a proportion of the distribution of most of the key ecological compartments (3km^2 per year to a maximum, assuming no recovery, of 60 km^2 over 20 years, as a proportion of more or less the whole northern Benguela), will be small. As a result, the uncertainties in the projections are likely to be much larger than the magnitude of the impacts and any true trends would probably be buried in the high uncertainty and resulting wide confidence intervals of the projections.
- A primary conclusion from this short report is that
    - i) direct impacts on specific species will lead to indirect impacts on predators, prey and competitors of the directly impacted species;
    - ii) the indirect impacts are most likely to be smaller or at most slightly larger in terms of percentage changes in biomass than the direct impacts;

This conclusion, coupled with the wide confidence intervals discussed in the previous point, suggest that it is very unlikely, based on available knowledge, that ecosystem modelling would uncover any surprising ecosystem impacts of greater significance than the impacts already assessed in the three specialist studies referred to in the Introduction. Nevertheless the uncertainty inherent in ecosystem understanding and knowledge must be recognized and this requires a precautionary approach in planning for any human activities that could impact on components of the ecosystem.

6 IMPACTS OF SCALING-UP DREDGING BEYOND SP-1 OR EXPANSION INTO OTHER AREAS ON THE NAMIBIAN SHELF

The conclusions of the specialist reports in Appendices a), b) and c) of the EIA (Midgley 2012) were that any impacts on the ecosystems and biodiversity of the dredging activity would be of low or medium significance at most. In relation to commercial species, only impacts on the monk trawl fishery were above low significance: it was estimated that just over 1% of the historical catch would be directly impacted in the dredged areas and that impacts of unknown magnitude on monkfish recruitment are likely. Further, it is stated in specialist report Appendix 1 c (of the EIA) that the available information indicated a benthic environment of generally sandy conditions in which benthic species diversity was generally low. This suggests that it is unlikely that the benthic habitat in the dredged area has a particularly key role in ecosystem processes.

A major factor mitigating higher risks in the EIA is the small size of the proposed dredging area. If this area is increased, the impacts will increase, at least in direct proportion to the increase in area and, above certain thresholds, impacts could increase disproportionately. The same principle applies to any wider ecosystem impacts. As a result of the generally low significance of the direct impacts, it is concluded here that the ecosystem impacts are likely to be similarly low. If the direct impacts are scaled-up by increasing the dredging area, the ecosystem impacts will also be scaled-up, probably linearly but with the likelihood of encountering critical thresholds, above which the impacts could lead to disproportionately severe consequences. The nature and value of these thresholds is currently unknown. They could include, for example, damage to habitats critical in the life cycle of one or more species or reduction of predation mortality to a degree that causes important shifts in trophic relationships and structure. As stated above this lack of knowledge and limited understanding of the functioning of the ecosystem as a whole requires the application of a precautionary approach. Therefore, before a significant increase in dredging area is contemplated, it will be essential to reconsider the potential for ecosystem impacts. This should include revisiting the value of ecosystem modelling and wider *in situ* sampling extended over at least a year in order to monitor seasonal differences.

7 COMMENTS ON THE IMPLICATIONS OF THE RESULTS OF THE VERIFICATION BIODIVERSITY SURVEY: AN ECOSYSTEM PERSPECTIVE

As part of the verification programme of the EIA, a biodiversity survey was undertaken to investigate and verify, if appropriate, some of the findings of the desk-top reports of the EIA and to establish a baseline for future reference for biodiversity, abundance of the main commercial fish species, recruitment and size distribution and some other biological aspects within the actual MLA and SP-1 target dredge site. The results from the survey were to be compared with the available information on these features from the region (Section C, Chapter 3.1). The survey was undertaken from 18 to 27 June 2014.

A total of 48 different species was identified of which 17 were fish, 14 were epifauna species, 15 were seabirds and 2 were marine mammals. The shallow water hake (*Merluccius capensis*) was the dominant fish species caught, accounting for 40 % by weight of the total fish catch, with monk (*Lophius vomerinus*) accounting for 35%, rattail (*Coelorinchus simorhynchus*) for 14%, sole (*Austroglossus microlepis*) for 3%, goby (*Sufflogobius bibarbatus*) for 2 %, while horse mackerel (*Trachurus capensis*) accounted for 0.4 % of the total fish catch. The size distribution of fish species was generally consistent with previous results. Juvenile monk fish were abundant, making up 45% of the total number sampled from the catch, while less than 6% of the sampled hake were juveniles. No horse mackerel juveniles were observed. Full details of the results for fish and other components of the biodiversity are presented in Section C, Chapter 3.1.

Japp and Smith (Section C, Chapter 3.1) reported that the results of the survey were consistent with and therefore supported the information and conclusions provided in the initial specialist report (Appendix 1a of the EIA, Midgley 2012) on fish resources (see summary earlier in this report). These included that the biomass of the main commercial species likely to be impacted by dredging would be low and that the impacts on recruitment, including recruitment to the monk stock, would be low.

The results of the survey also indicated that the area did not possess any unique features in relation to biodiversity and oceanographic conditions.

8 CONCLUSIONS

Ecosystem modelling is often a valuable tool for investigation of indirect and ecosystem ramifications of natural or human impacts on a part of the ecosystem. Spatially disaggregated ecosystem models have been applied in a number of localities and ecosystems around the world and have been found to be useful. In this case, however, the combination of the high uncertainty typically associated with projections by ecosystem models and the small area that will be impacted by the proposed dredging mean that it is unlikely that ecosystem modelling would expose any unexpected, highly significant threats that have not already been considered in the specialist studies.

That conclusion might not apply, however, if the area to be impacted by the dredging was found to be of particular importance in the ecosystem or in the life cycle of one or more key species, and therefore that some ecological impacts could be disproportionately higher than would be expected from considering only the impacted area as a proportion of the total area of a species distribution or of the ecosystem as a whole. The results from the Verification Biodiversity Survey did not produce any results to suggest that the proposed impacted area has any unique or unusual features that would indicate such a disproportionate importance.

The expected ecosystem impacts of the dredging can be considered in the context of other actual or potential environmental impacts in the region, such as from trawling and other fishing impacts, diamond mining, and oil and gas exploration. At this stage, the only other anthropogenic activity taking place in the MLA is fishing with trawl nets, as reported in specialist report (Appendix 1a – Japp, in Midgley 2012). The impacts of dredging in the specific area planned to be dredged can be expected to have considerably greater, and longer-lasting, direct impacts on the biota in that area than does bottom trawling. However, the limited area currently designated to be dredged means that, overall, these impacts will almost certainly be considerably less across the northern Benguela shelf and southern slope environments as a whole than have been the impacts of trawling on these environments, noting that the impacts of trawling are well-managed and considered to be sustainable.

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Annexure 1: Species and species groups

Species and species groups identified as having preferred habitats on the Shelf and Southern Slope in Heymans and Sumaila (2007) Ecospace model (* indicates species or species group included in the EcoSpace model but not in these two habitats).

Group	Shelf	Southern Slope	Roux *et al* EwE Model
Marine mammals	X	X	X (Cetaceans)
Seals*			X
Birds	X	X	X
Sharks	X	X	X (Chondrichthyans)
Tuna	X	X	X (large pelagics)
Snoek	X	X	
Other linefish	X	X	
Anchovy juveniles	X		
Anchovy adults	X		X (single category)
Sardine juveniles	X		
Sardine adults	X		X (single category)
Goby juveniles	X		
Goby adults	X	X	X (single category)
Other small pelagics	X	X	X
Mesopelagics	X	X	X
Horse mackerel juveniles	X		X (small)
Horse mackerel adults	X	X	X (large)
Hake juveniles	X	X	X (small *M. capensis)*)
Hake adults		X	X (large, split into *M. capensis* and *M. paradoxus*))
Monkfish		X	
Other demersals	X	X	X (split into pelagic-feeding and benthic feeding demersals)
Cephalopods	X	X	X
Macrobenthos	X	X	X
Crabs		X	
Lobster*			
Jellyfish juveniles	X	X	
Jellyfish adults	X	X	
Gelatinous zooplankton			X
Macrozooplankton	X	X	X
Mesozooplankton	X	X	X
Microzooplankton			X
Benthic producers*			
Phytoplankton	X	X	X
Detritus	X	X	X