

# SANDPIPER PROJECT

Verification Programme Report:  
Mining Licence Area No. 170

## SECTION D : APPENDICES

# APPENDIX 4

## Process Documentation

- 4.1: Verification Programme Activities
- 4.2: MFMR Response to the 2012 EIA
- 4.3: Final Scope of the Verification Programme submitted to the authorities



## APPENDIX 4 – PROCESS DOCUMENTATION

- 4.1 Verification Programme Activities
- 4.2 MFMR Response to the 2012 EIA
- 4.3 Final Scope of the Verification Programme  
submitted to the Authorities

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November 2014

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## **4.1**

### **VERIFICATION PROGRAMME ACTIVITIES**

## 4.1 VERIFICATION PROGRAMME ACTIVITIES

<b>Activities relating to the development and execution of the Verification Programme (2012 – 2014)</b>	
<b>1</b>	<b>EIA Submission</b>
<b>2</b>	NMP EIA submitted to MET for consideration for issue of Environmental Clearance certificate (Date 11 April 2012)
<b>3</b>	Environmental Commissioner requires further consultations (Letter dated 23 Apr 2012)
<b>4</b>	The Environmental Commissioner submits the NMP EIA to external independent review
<b>5</b>	<ol style="list-style-type: none"> <li>1. SAIEA (Namibia), assessment undertaken by Ms. B. Walmsley (RSA) and Dr M. O'Toole (Ireland)</li> <li>2. Professor L. Levin of Scripps Institute of Oceanography (USA). Professor J. Davis, University of Florida, Gainesville (USA)</li> </ol>
<b>6</b>	<b>Additional consultation</b>
<b>6</b>	Governor of the Erongo Region, Honourable Cleophas Mutjavikua. Facilitates meeting between NMP and representatives of the Fishing Industry, NatMIRC and IA&Ps in attendance (Meeting date: 04 July 2012)
<b>7</b>	Respective parties issues presented and discussed. Fishing industry requested NMP engage with NatMIRC /MFMR to closeout on matters
<b>8</b>	Governor of the Erongo Region, Honourable Cleophas Mutjavikua. Facilitates meeting between NMP and NatMIRC (Meeting Date: 10 Sept 2012)
<b>9</b>	Approaches and considerations to the scientific content NMP of the verification programme (described in the 2012 EMP) discussed, in consideration of the (expanded) requirements of MFMR and I&APs.
<b>10</b>	<b>Verification Programme Commissioned</b>
<b>11</b>	In accordance with recommendations of the SAIEA report of the scientific content (2012 EIA) NMP initiates an expanded verification Programme. The scope is inclusive of 2012 EMP, MFMR requirements, and of the MET appointed independent reviewing parties. (November 2012)
<b>12</b>	NMP board allocates funding of N\$ 20 m for the verification study
<b>13</b>	Expanded verification work programme forwarded to MFMR, MET, MME (letter dated 15 November 2012)
<b>14</b>	<b>Appointments</b>
<b>15</b>	J Midgley & Associates. Project manage the environmental process (November 2012)
<b>16</b>	CSIR, Mr P. Morant. Independent Programme Reviewer and Process Advisor, (November 2012)
<b>17</b>	Under CSIR guidance, the appointment of specialist consultants: CapFish, Lwandle, Metocean, Steffani Environmental Consultant to undertake the verification assessments identified in the expanded survey

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	scope (November 2012)
18	University of Namibia, Dr S. Mafwila, external independent assessment of the <i>processes</i> (analytical and technical) of the Verification Programme (22 May 2013)
19	<b>Phase 1 of the Verification Programme: Instrument Mooring</b>
20	Instrument mooring deployment: 09 June 2013 deployed, 16 September recovered: 100 days. Metocean processes the recovered data, Lwandle analyses the data
21	<b>Phase 2 of the Verification Programme: Marine Biogeochemical Survey</b>
22	MME, MET, MFMR and UNAM representatives invited to participate in the surveys. UNAM representative join survey. 2 UNAM students and 6 scientists participate: CSIR analyses the sediments and water samples, Lwandle interprets the results
23	2a: - 10 day cruise (July / August 2013). Collecting: seabed surface sediment samples, water column samples, macrofauna and meiofauna from primary target dredge site SP-1 (ML 170)
24	2b: - 4 day cruise (August 2013). Collecting cores from the primary target. CSIR analyses the sediments and water samples, Lwandle interprets the results dredge site SP-1 (ML 170)
25	2c: - 5 day cruise (February / March 2014). Collecting thiobacteria samples from the primary target dredge site SP-1 (ML 170). UWC (Department of Biotechnology) analyses the sediments, Lwandle interprets the results
26	<b>Phase 3 of the Verification Programme: Geophysical Survey</b>
27	7 day (September 2013), Geophysical survey: 55 km line length in SP-1, and 175 km line length survey over the route of the intended fisheries biomass survey (ML 170)
28	Technical survey team of 5 persons, supported by 2 technicians to recover the instrument mooring
29	Geophysical data interpretation provided by Marine Data Consultants
30	<b>Phase 4 of the Verification Programme: Fisheries Survey Biomass / Biodiversity</b>
31	Survey managed by CapFish
32	CapFish meet, discuss and confirm the scope and methods of survey with NatMIRC/MFMR
33	MFMR advises (July 2013) that their survey vessel FRV <i>Welwitchia</i> is available for a biomass survey in November 2013.
<b>Announcement of moratorium on marine mining of phosphate – September 2013</b>	
34	MFMR advises that their survey vessel FRV <i>Welwitchia</i> is not available for private charter (September 2013)
35	Biomass survey, reconfigured to biodiversity survey following consultations with MFMR NMP charts commercial monk trawler
36	MFMR issues permit for the biodiversity survey to NMP (06 June 2014)
37	8-day biodiversity trawl survey in June 2014 over SP-1. CTD deployments per station. 12 day and 12 night stations trawled.



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38	NatMIRC/MFMR technician and scientist, accompany the 5 CapFish scientists
39	CapFish analyses the biodiversity survey data, subsequently providing report. KZN Coastal Impact Consultants report on the epifauna. Lwandle report on the water column character
40	<b>Phase 5 of the Verification Programme: Auxiliary studies to the Fisheries Assessment</b>
41	Commissioned by CapFish
42	CapFish meet, discuss and confirm the scope of the supporting studies with NatMIRC/MFMR. MFMR approve provision of relevant data.
43	Biomass and Stock estimates: Monk and Hake: Mr. J. Gaylard
44	Reproductive dynamics assessment: Dr H. Ndjaula
45	Ecosystem assessment statement: Dr K. Chocrane
46	<b>Phase 6 of the Verification Programme: Independent Peer Review of Specialist Verification Studies</b>
47	CSIR manage the selection and appointment of International recognised peer review team: Dr A. Payne, Dr M. O'Toole, Dr B. Clark, Prof. A. Roychoudhury
48	Key documents issued to review time prior to workshop June - July - August 2014 Documents for review: Specialist reports, supporting text, scope of verification programme, external review reports (of the EIA 2012), MFMR communications
49	August: 2 day workshop in Cape Town CSIR, UNAM / UCCB in attendance as independent observer to the workshop process. Workshop: Specialists presentations, peer interviews of specialist consultants, and initial peer review assessment statements
50	Independent Peer review report Issued with recommendations, August 2014
51	NMP specialists, recommended work completed September - October 2014
52	UNAM: Report issued, September 2014: Independent Review of the NMP Verification Programme Process. Dr S Mafwila.
53	CSIR: Report issued: Independent Review of the NMP Verification Programme Report (November 2014)
54	<b>Integrated Report Compilation</b>
55	Compilation of the Verification Programme Report November 2014
56	<b>Report Submission to MET</b>
57	Verification Report submitted to MET, December 2014.

## **4.2**

### **MFMR RESPONSE TO THE 2012 EIA**

## 4.2 MFMR RESPONSE TO THE 2012 EIA

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The Ministry of Fisheries and Marine Resources responded to the Minister of Environment and Tourism on the NMP 2012 EIA in a letter dated 15 June 2012. This letter contained 13 bullet points that required amendments to the Verification Programme as originally detailed in the 2012 EMP. The following 13 bullet points have been extracted verbatim from the letter and are presented below:

- The exact concentrations of hydrogen sulphide in the sediment (sampled fresh) need to be determined before any statement of the effect of H<sub>2</sub>S can be made in the MLA. Also the effect of sulphides being possibly released to cause low oxygen in the water needs to be studied.
- The secondary effects of the possible release of hydrogen sulphide into the benthic layer (lowering of dissolved oxygen) must be assessed, because oxygen levels are critical in Oxygen Minimum Zones such as the central Benguella region.
- Dissolved nutrient inputs from sediments need to be quantified as these can be substantial, with cascade effects in the water column. Dissolved nutrients (pore water and water column) in the sediment properties or sediment plume behaviour study need to be measured. A sediment properties survey should also look at methane concentrations in the gravity cores because methane may be released when dredging to 3m depth. At least four surveys at three month intervals should be done at different times of the year to cover the seasonality.
- Trace metals and other potential noxious compounds released into the water column must be evaluated. Over and beyond the long term (>5 years) elevated trace metals incorporated into the food chain will have serious implications to the marketing of this products such as hake, monk and shellfish, as food quality regulations for export are stringent.
- Baseline information on Thio-bacteria must be collected in order to evaluate the possible impacts of disturbing these during mining operations.
- Faunal studies in Oxygen Minimum Zones must include animals to a minimum size of 300µm, not only >1mm as was the case in the studies on which the assessments were based, therefore base-information is incomplete and additional studies need to be conducted.
- A once-off survey to measure the *in situ* currents with an ADCP is not sufficient to cover the temporal variability. From literature it is established that there is strong seasonal variability in current speed and direction. Therefore at least four surveys would need to be done at three month intervals to capture the seasonality. A current meter should be moored near the MLA for a 12 month period.
- The behaviour of plumes needs to be modelled using current, sediment particle characteristics, nutrient, heavy metal and trace metal data from the site collected during different seasons.
- Changes in Redfield ratio in surface waters (due to release of overspill water from dredging) leading to preferential phytoplankton blooms of species other than diatoms in surface waters, and therefore a change in the food web as well as the possibility of harmful algal bloom problems, need to be measured and assessed.

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- Most marine predators, including hakes and African penguins are relying on visual clues to forage, and increased turbidity affects their ability to feed in a drastic way. Field studies and *in situ* turbidity measurements need to be done in order to quantify the extent of the potential mining sediment plume and importance of the mining sites for foraging of predators.
- Very little information on spawning activities in the mining area is available. This information therefore needs to be collected before the effects of the project on recruitment of any species can be assessed.
- The area needs assessment as a nursery area for juvenile hakes, inferred patterns of size frequency distribution of hake in the seal diet over the seasonal cycle for the last 15 years point to a nursery area in the vicinity of Walvis/Conception (at mid shelf) for fish 3 to 7cm total length (TL) and a shift further south for fish 8 to 16 cm TL. As the hake surveys are not designed to find juvenile hakes of these sizes (acoustic need to be used in addition to bottom trawls as these fish are monthly in their pelagic phase) and because the timing of the surveys carried out by the MFMR is not covering the seasonal changes, we do not have any direct information on the importance of this area for hake pre-recruits but this area could be a very important nursery area, so that changes in oxygen, sulphide and or turbidity could have major implications on recruitment. Surveys for juvenile fish covering the full annual period, must be undertaken.
- Ecosystem-functioning impacts must be assessed: these include food web interactions.

### **4.3**

## **FINAL SCOPE OF THE VERIFICATION PROGRAMME SUBMITTED TO THE AUTHORITIES – NOVEMBER 2012**

## 4.3 FINAL SCOPE OF THE VERIFICATION PROGRAMME SUBMITTED TO THE AUTHORITIES – NOVEMBER 2012

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### **NMP Consolidated Verification Survey – Sediment Properties and Water Column Features**

*Prepared by Dr R. Carter  
Lwandle Technologies (Pty) Ltd*



#### **4.3.1 NEED FOR VERIFICATION SURVEY**

The conclusions and predictions of the environmental effects of dredging marine pelletal phosphate ore reserves on the Namibian continental shelf are primarily based on the sediment properties in the dredging areas. We consider that the information on this is robust as it is drawn from the seminal work conducted by Bremner (1978), direct surveys of sediment properties across one of the dredging areas by Rogers (2008) and because it is consistent with adduced distributions of turbulent energy across the shelf which control sediment texture distributions. All of this indicates that the sediments in the dredging areas are predominantly muddy sand. Hydrogen sulphide, methane and other chemical flux rate measurements conducted by, *inter alia*, Namibian and South African marine scientists indicate that these are low as sedimenting pelagically produced particulate organic matter (POM) does not accumulate on these sediments. Further, the phosphate ore body is considered to be derived from estuarine deposition in the Pliocene (2.6—1.0 MA, Compton 2012) so any organic material incorporated in the ore body would be extremely refractory. This implies that the only sources of sulphur in the ore body itself would be pyrites which have low dissolution rates.

On the basis of the above the water quality and associated environmental risks associated with the dredging process, were considered to be predominantly physical as opposed to biogeochemical. Consequently the conclusions on sediment textures in the mine licence area are of pivotal importance in the environmental assessment.

It is clear from comments received from interested parties in Namibia especially that this is a contentious issue as, although no data or analyses (peer reviewed or not) are presented in support of alternative views, there is a persistent concern that sulphidic sediments will be exposed during dredging with important consequences for water quality.

In our view the only practical response to this is to conduct a verification survey in the identified dredging areas on sediment properties, water quality and local oceanographic processes prior to the commencement of any dredging operations.

#### **4.3.1.1 Proposed Verification Survey**

##### **4.3.1.1.1 Scope**

The verification survey will focus on:

**A) Sediment properties** including:

- Surficial particle size and sediment texture distributions (box core). This is to confirm conclusions reached in the EIA studies that sediments in the proposed dredging areas are mainly fine and medium sands with minimal mud. Although this has been done via analyses of sediment core samples from the dredging areas post the EIA, which have shown 80-90% sand, the companion measurements on sediment properties that will be made (below) can only be properly understood in terms of the host sediment environment (**NatMIRC bullet points 1, 2 & 8**);
- Subsurface sediment particle size and texture distributions to ~2.5 m depth in the sediment (gravity core) (indirectly **NatMIRC bullet points 1,2 & 8**);
- Surficial and deep sediment organic content, POC and PON concentrations (indirectly **NatMIRC bullet point 1&2**);
- Surficial and deep sediment trace metal concentrations (**NatMIRC bullet point 4**)
- Surficial and deep sediment trace metal elutriation measurements to show the proportion of trace metals held in the particulate phase in the sediment that may be released into the dissolve phase and thereby become bioavailable (**NatMIRC bullet point 4**);
- Sediment pore water inorganic nutrient (N, P & Si) concentrations to demonstrate risks of departures from Redfield ratios when translocated to the upper water column during dredging (**NatMIRC bullet point 9**);
- Sediment pore water hydrogen sulphide concentrations to show potential fluxes to the water column when disturbed by dredging (**NatMIRC bullet point 1 & 2**);
- Methane detection of methane concentrations in sediment pore water will also be measured (**NatMIRC bullet point 3**).

NatMIRC (**bullet point 5**) express a need for the collection of baseline information on Thio-bacteria. There are no regional distribution data that we would be able to match whatever was found. The presence and role of these organisms depends on H<sub>2</sub>S flux which requires organic matter supply and its incorporation in the sediments. We will be able to see this from sediment properties and the turbulence estimates from the moored Aquadopp current meter. Therefore from the acquired sediment property data we will be able to make probability statements on the presence and roles of this class of bacteria.

**B) Water column properties** including:

- Vertical profiles of the distributions of temperature, conductivity, dissolved oxygen (DO), chlorophyll fluorescence (Chl) and turbidity measured by a multi-probe internal logging CTD extending from the sea surface to within 5 m of the sea bed (partially addresses **NatMIRC bullet point 2**);
- Near sea bed temperature, conductivity, DO and turbidity time series measurements to elucidate background concentrations and possible variations linkable to internal tide generated turbulence (**NatMIRC bullet point 2**);
- Near sea bed high frequency current measurements (Aquadopp – see Figure 1) to determine turbulence and sediment resuspension events linkable to internal tide generated turbulence. This will be complementary to the DO and turbidity time series

- (**NatMIRC bullet point 2** and confirmatory data for the internal tide generated turbulence control of POM capture in Namibian continental shelf sediments hypothesis), and
- Currents and indirect measurements (beam attenuation) of suspended sediments (equivalent to turbidity) through the upper water column (<100 m depth) measured by upward looking ADCP (Figure 1) (partially addresses **NatMIRC bullet points 7 & 8**).

In their commentary NatMIRC expresses a need for 'site specific' simulation modelling of dredge plume behaviour 'using current, heavy metal and trace metal data'<sup>1</sup> from the site collected during different seasons' (**NatMIRC bullet point 8**). This requirement appears to be based on some misconceptions of the effectiveness of simulation modelling in providing unique, 'site specific' predictions on dredge plume and constituents of dredge plume behaviour.

Dredge turbidity plume simulations in commonly applied modelling platforms, (e.g. Delft 3D, DHI's Mike 21) primarily utilise currents, water column density structure and sediment particle sedimentation (sinking) velocity. The latter is an important determinant of plume distributions and is well established theoretically (Stoke's Law) and through direct measurement in, e.g., settling tubes. This to the point that standardised coefficients are employed with the main caveat being whether the particles will behave individually or cohesively. The latter is more characteristic of clay sized sediments and has the net result of accelerating sedimentation for these smaller and lighter particles. Figure 2 summarises settling velocity for a range of fine grained sediments. This figure ignores cohesive behaviour and therefore represents minimal velocities. Currents obviously advect the sinking sediment particles down the current path but also play a role in plume dispersion as dispersion is proportional to current velocity. The higher the velocity the higher the model coefficient for plume dispersion will be. This is also a predetermined relationship and is independent of the site being modelled.

Consequently two of the important determinants of turbidity plume behaviour are treated generically in modelled simulations. It is this and the broad similarity of measured plume behaviour between sites with wide ranges of sediment types and hydrodynamics that allow the extrapolation of modelled and real plume metrics and behaviour to the NMP case. The reliability of the extrapolation is enhanced by the very good investigation conducted by CSIR into dredge plumes from the bulk dredging of sediments for diamond recovery in southern Namibia where the upper water column at least is similar to that of the NMP licence area.

Therefore unless NatMIRC has information that shows that sediment properties in the dredge area are such that vastly different dynamic behaviour will arise or that the upper water column deviates from that described by Boyd and summarised by Shannon I see no value, but quite some cost, in conducting simulation modelling. Note that this also applies to heavy metals as these would be modelled as a conservative tracer, i.e. dilution alone will predict their concentrations, making their behaviour similar to that predicted for the sediment plume.

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<sup>1</sup> In common usage these are the same group of elements comprising the transition metals, metallic elements such as arsenic and cadmium and lanthanides.



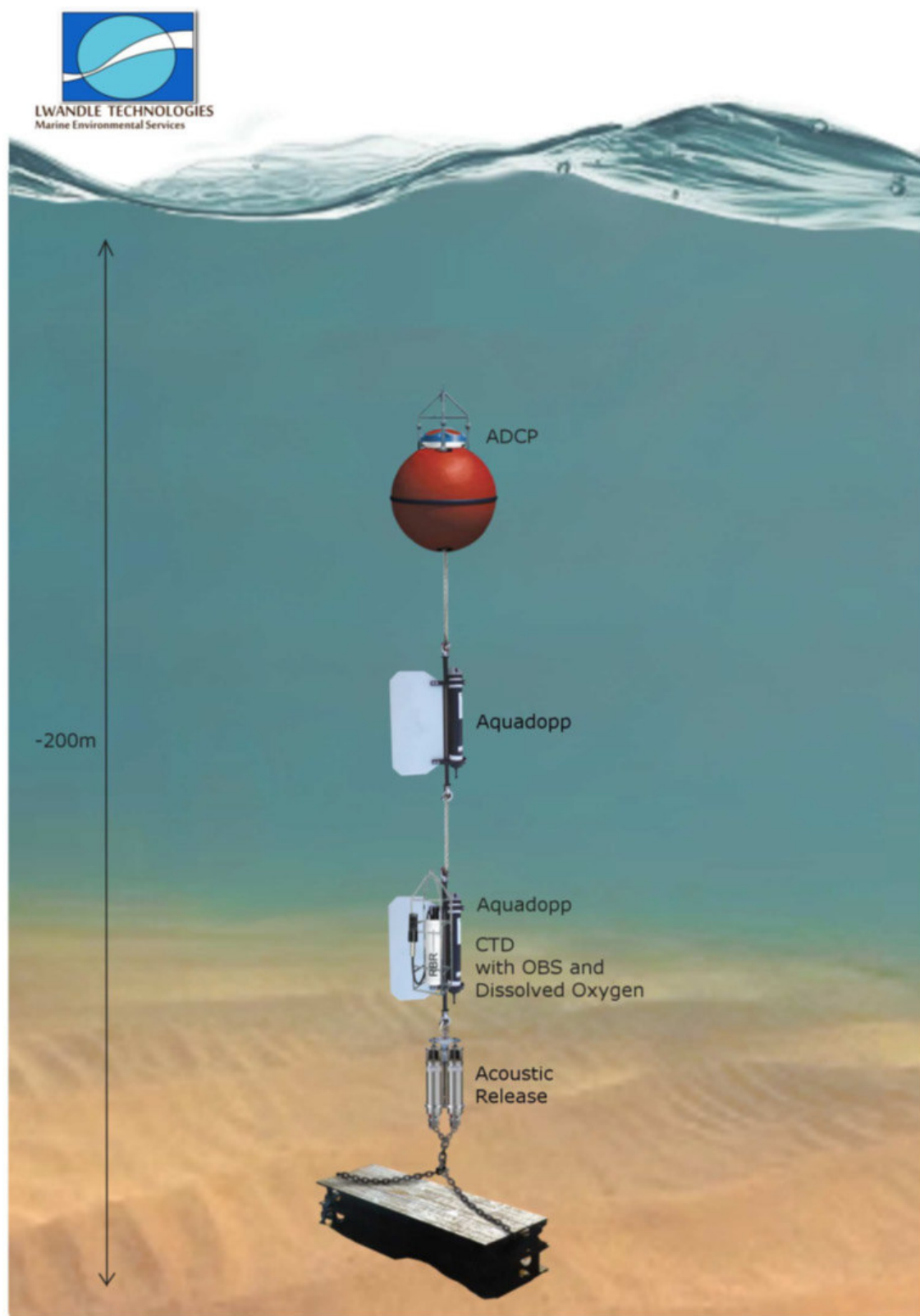


Figure 1: Schematic representation of ADCP, Aquadopp and CTD+DO+turbidity mooring to be deployed as part of the NMP verification survey.

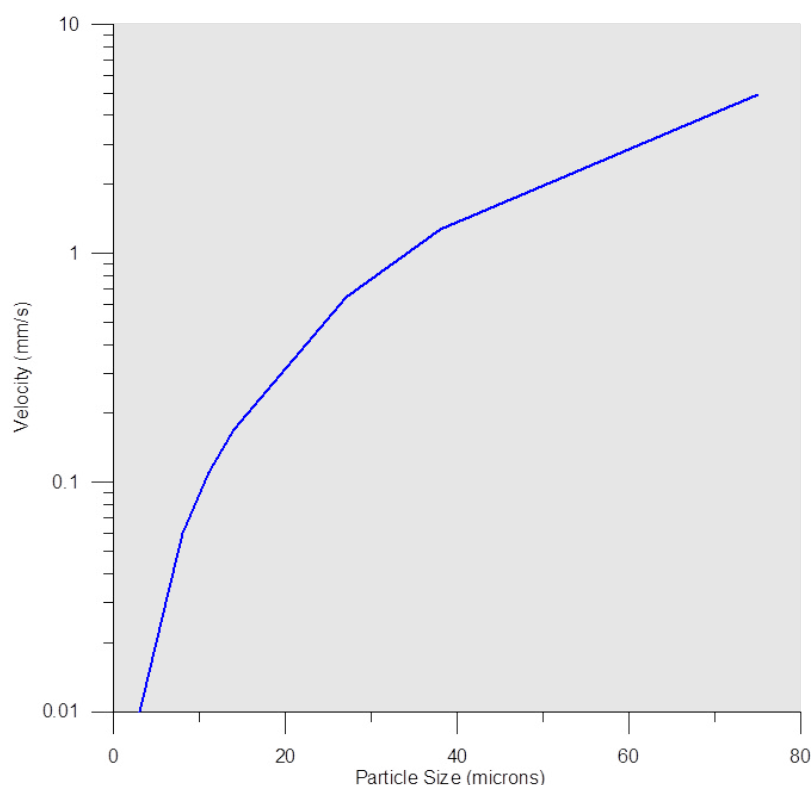


Figure 2: Sedimentation velocity for a range of fine grained sediment particle sizes as predicted by Stoke's Law.

#### 4.3.1.2 Survey area

The survey area is defined as dredge area SP-1. A grid of sampling sites will be placed across SP-1 such that the broad distributions of sediment properties can be determined. Figure 3 shows the provisional sampling station layout (Black open squares). These are planned to coincide with the benthos sampling sites where possible. The provisional location of the moored instrumentation is shown.

The provisional sampling grids will generate 26 box core samples in SP-1 in a configuration of 5 transects of 5 stations each plus the additional sample at the moored instrumentation site. Samples on the transects will be aligned with the stations identified by Dr Nina Steffani. In a separate survey gravity core samples will be taken from these sites. In addition to the above, sediment samples will be obtained from the benthos verification sites in SP-2 and SP-3 (Steffani) and analysed for particle size, organic C and N content.

CTD profiling (6 Hz) and water sampling will be conducted at one site on each of the transects. One of these will be at the mooring location. Water sample depths will be 0 m, 10 m, 20 m, 50 m, 100 m, 150 m and 200 m.

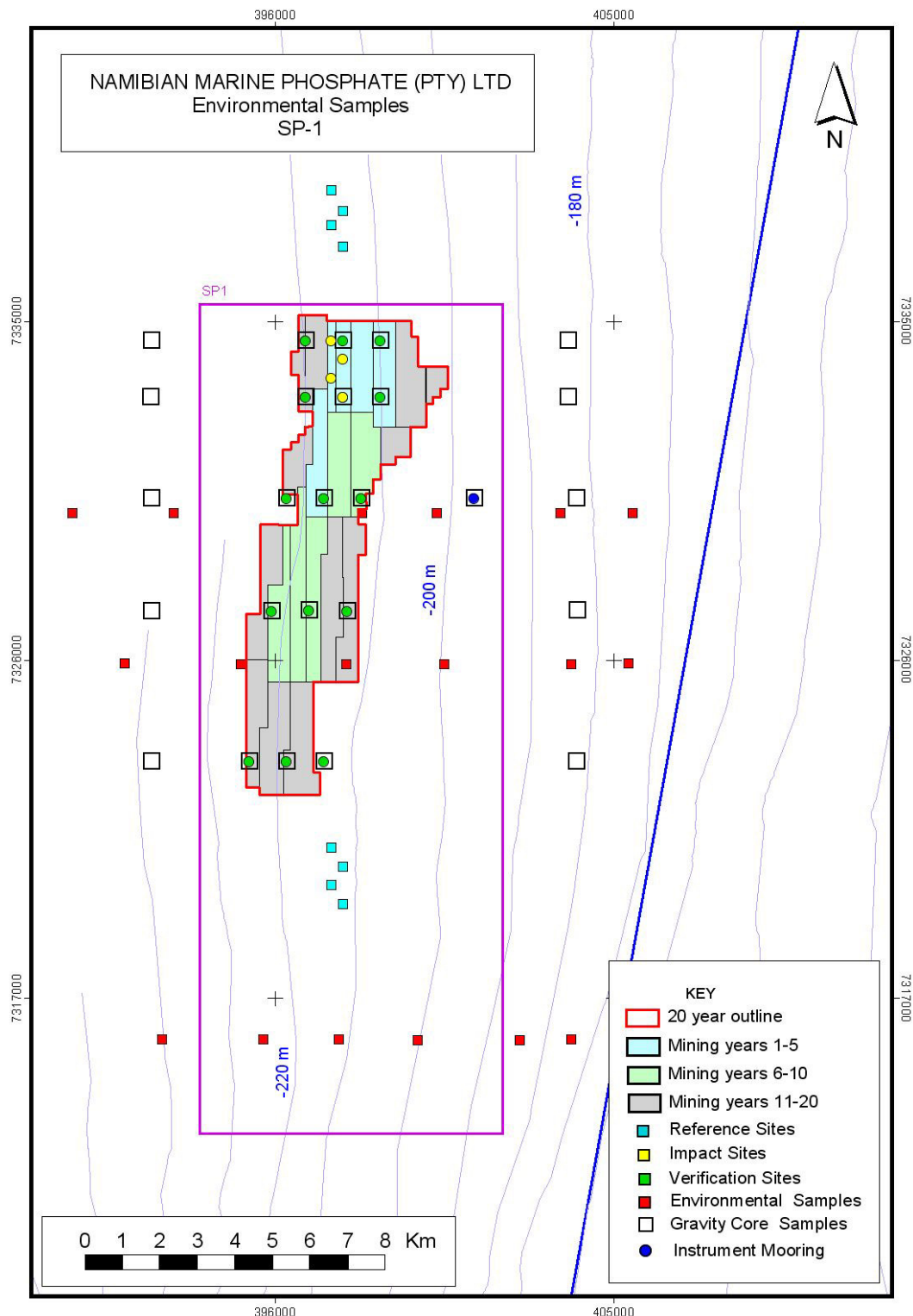


Figure 3: Provisional verification sampling sites in Dredge Area SP-1. Note that the verification survey sites are represented by black open squares. Green squares represent sites identified for benthos sampling (Steffani); additional sampling sites for the benthos monitoring programme are shown in yellow (impact) and blue (reference). The blue square shows the provisional moored instrumentation site.

#### **4.3.1.3 Survey temporal coverage**

##### **4.3.1.3.1 Moored instrumentation**

The planned duration for the moored instrumentation deployment (ADCP, Aquadop, CTD+DO+Turbidity) is 90 days<sup>2</sup> within which will be a service interval at ~45 days. The 90 day period is predicated on the frequency of lunar barotropic internal tides and associated sediment resuspension events (Monteiro et al 2005). The intention of the mooring is to capture a number of these events (~6) and link concurrent variability in near sea bed oxygen and turbidity levels. The reason for the mid-deployment service interval is that the mooring recovery record for the Namibian continental shelf is not good (similar to South Africa and Mozambique) and the relatively short service interval will ensure that at least 50% of the planned measurements will be obtained. I.e. if the mooring is lost post service the initial measurement period data would have been downloaded at the end of the 1<sup>st</sup> measurement period, if the mooring is not recovered at the service visit a duplicate set will be deployed giving coverage for the 2<sup>nd</sup> measurement period.

##### **Water column profiling and sediment sampling**

The water, sediment and benthos verification survey will be a once-off event with a duration of 8-10 days at sea. The survey will be conducted in conjunction with the service visit for the moored instrumentation. Seabed coring will be conducted during a separate survey of the dredging areas (date and duration to be determined).

#### **4.3.1.4 Reporting and deliverables**

The following reports will be issued:

- An installation report immediately prior to survey commencement with equipment specifications and calibration and method statements for each of the procedures to be employed
- A mooring deployment report
- A preliminary field survey report listing measurements and sampling with commentary on the water quality, sediment properties and benthos survey
- A mooring recovery and redeployment report
- A final mooring recovery report, and
- A draft final verification report to be delivered in paper and electronic copies to the Namibian Marine Phosphate (Pty) Ltd within three weeks of the completion of sample processing (physical, chemical and biological). This report will be a fully referenced, scientific document.

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<sup>2</sup> NatMIRC suggest a 12 month deployment period for the ADCP to show seasonal variation. The area is highly variable on a range of space and time scales and to properly constrain seasonal variability would require at least a multi-year deployment programme. This is beyond the scope of the verification measurements.

## **NMP Consolidate Verification Survey – Benthos**

*Prepared by Dr N. Steffani*  
*Steffani Marine Environmental Consultant*



### **4.3.2 INTRODUCTION AND SCOPE**

Namibian Marine Phosphate (Pty) Ltd (NMP) has been awarded a 20-year mining licence (ML 170), which is located on the Namibian continental shelf offshore Conception Bay in water depths ranging from 180 to 300 m covering a total area of 2233 km<sup>2</sup>. Within the mineralized resource zones of the licence area, also named Sandpiper licence area, three target areas have been identified, i.e. Sandpiper-1 (SP-1), 2 (SP-2), and 3 (SP-3). SP-1 is in the north of ML 170 in water depth from 190-235 m, SP-2 is in the centre in depth 245-285 m and SP-3 is in the south at 235-270 m depth.

With the exception of a benthic macrofauna and sediment property survey derived from 20 stations in SP-1, information on the physical and biological environment specific to the ML 170 is very sparse. Most of the impact assessments discussed in the Benthic Specialist Study are thus based on assumptions that are arrived from publicly available data from areas outside the Sandpiper licence area. The assumptions drawn from these data are deemed robust, but nonetheless it is recommended that an initial 'verification' survey to confirm these. An important aspect of this verification survey is the sampling of the macrofauna communities in all three dredging target areas. Continuing from this initial verification survey, the severity of the removal and destruction of benthic communities by the dredging process and the subsequent recovery (functional recovery) process need to be ascertained. A post-dredging benthic monitoring programme thus needs to be established.

#### **4.3.2.1 Benthic Habitat**

Dredging for offshore marine phosphate deposits is destructive by nature and thus inevitably affects the benthic communities of the receiving environment. The sea bed disturbed by the dredging activity is home to many communities, living on (epifauna) or in (infauna) the superficial sediments of the sea floor, with the greatest abundance to a depth of ~20 cm. The fauna is typically divided by size into megafauna (>10 cm), macrofauna (large enough to be retained on a 1-mm sieve, while some researchers also use a 500-micron sieve), meiofauna (0.1-1 mm) and microfauna (<0.1 mm). The macrofauna usually constitute the dominant biomass or organisms within marine sediments and typical taxa include polychaete annelids, smaller crustaceans (e.g. amphipods, isopods, shrimps, crabs), and molluscs (gastropods and bivalves) besides many other phyla. Megafauna include large crustaceans, molluscs, and echinoderms, and are often associated with the surface of the sea floor. The meiofauna is dominated by the large and diverse groups of nematodes and harpacticoid copepods, while microfauna include bacteria and protists. Macrofauna and other benthic fauna are a major food source for fish and other benthic predators, and play important roles in ecosystem processes such as nutrient cycling, pollutant metabolism, and dispersion and burial of organic matter.

The northern and central Benguela regions are characterised by the occurrence of natural shelf hypoxia, which is referred to as Oxygen Minimum Zone (OMZ) (Monteiro *et al.* 2011). OMZs have dissolved oxygen concentrations of  $\leq 0.5 \text{ ml/l}$  and typically impinge upon the continental margins of upwelling regions. Off Namibia, this layer extends between at least  $18^{\circ}\text{S}$  and  $28^{\circ}\text{S}$  and up to 60 km from the shore. The hypoxic conditions depict seasonal variation, locally shifting to anoxic conditions in late summer-autumn (Monteiro *et al.* 2008). A further significant feature of the central Namibian middle shelf is an extensive mud belt comprising organically rich diatomaceous oozes originating from planktonic detritus from the high productivity in the upwelled waters. The diatomaceous mud belt with a thickness of up to 14 m extends over 700 km in an N-S direction and 100 km in an E-W direction. Depending on the local bathymetry and dynamic current intensity, the landward flank of the mud belt is found at 15-104 m water depth, and the seaward flank from 45-151 m (Bremner 1983). The mud belt is characterised by often anoxic bottom water conditions and high  $\text{H}_2\text{S}$  fluxes, occasionally resulting in  $\text{H}_2\text{S}$  eruptions with devastating effects on the local fauna. These natural events can spread over  $20\,000 \text{ km}^2$  (Weeks *et al.* 2004).

The Sandpiper Mining Licence Area lies offshore from the mud belt at the fringe of the central Namibian OMZ and is thus affected by variable dissolved oxygen conditions with bottom-water oxygen concentrations probably below  $0.5 \text{ ml/l}$ , but it is likely to be less affected by high  $\text{H}_2\text{S}$  concentrations in the surficial sediments or near-bottom waters, or severe anoxic conditions. Despite oxygen depletion, benthic assemblages can thrive in OMZs as many organisms have developed highly efficient ways to extract oxygen from oxygen-depleted water (e.g. small bodies, enhanced respiratory surface area, blood pigments, and specialised enzymes) (Levin 2003). Within OMZs, foraminiferans, meiofauna, and macrofauna typically exhibit high dominance and relatively low species richness (Levin 2003). In contrast to meiofauna, macrofauna and megafauna often have depressed densities and low diversity in the cores of OMZs, where the oxygen concentration is lowest, but they can form dense aggregations at the OMZ edges (Levin 2003, Levin *et al.* 2009).

Very little is known about the Namibian OMZ benthic infauna (see Arntz *et al.* 2006, Zettler *et al.* 2009). In May 2010, a macrofauna baseline survey was conducted by NMP in SP-1 as this is the initial priority area for proposed dredging operations (Steffani 2010a). Overall species richness of the benthic macrofauna assemblages was relatively low and strongly dominated by polychaetes (64% of species), followed by crustaceans, and molluscs. Most species found in the study area have a larger geographical distribution and/or have been recorded elsewhere from the Namibian and/or South African west coast (e.g. Savage *et al.* 2001, Steffani 2007, 2009, 2010b, Steffani & Pulfrich 2004, 2007, Zettler *et al.* 2009). The most abundant species was the polychaete *Paraprionospio pinnata* (44% of overall abundance), which is a low-oxygen indicator species prevalent in OMZs worldwide. Generally, the benthic community composition in terms of species diversity and phyla dominance is in agreement with studies from other OMZs around the world (e.g. Gutierrez *et al.* 2000, Levin *et al.* 2000, Gallardo *et al.* 2004, Gooday *et al.* 2009, Levin *et al.* 2009).

In contrast to the core of OMZs where macrofauna density is often reduced, macrofauna has been found to increase at the edges of OMZs dominating the benthic fauna (e.g. Mullins *et al.* 1985, Gooday *et al.* 2009, Levin *et al.* 2009). Levin *et al.* (2009), for example, reported dramatic changes in macrofaunal dominance from the core of the OMZ at the Pakistan margin to the lower boundary and documented the existence of dissolved oxygen thresholds for macrofauna between  $0.1$  and  $0.2 \text{ ml/l}$ . Below such thresholds, most taxa are excluded through physiological intolerance to hypoxia, while above them selected taxa are able to take advantage of an abundant food supply. The availability of both oxygen and organic carbon seem to determine the richness of macrofaunal species in OMZs until the oxygen content rises to about  $0.45 \text{ ml/l}$ ; above that level oxygen is much less important

(Levin & Gage 1998). It has been further hypothesized that under conditions of permanent hypoxia, small-bodied animals, with greater surface area for O<sub>2</sub> adsorption, should be more prevalent than large-bodied taxa (Levin 2003). However, body sizes were found not to be smaller within the lower OMZs of the Oman (Levin *et al.* 2000) and Pakistan margins (Levin *et al.* 2009), and it was suggested that the abundant food supply in the lower or edge OMZs promotes larger macrofaunal body size. Zettler and co-workers (2009), who studied the macrofauna community in the OMZ off northern Namibia (offshore the Kunene River mouth, which is at the northern fringe of the OMZ), reported a far lower species diversity in the hypoxic zone than compared to oxygenated nearshore areas, but the high dominance of molluscs (not typically found in core OMZs) led them to suggest that the community is probably rather representative of the fringes of the upwelling cells of the northern Benguela than of the centre where severe anoxia and high hydrogen sulphide concentrations occur. Molluscs also contributed a relatively significant proportion to the fauna in the SP-1 target area and as the Sandpiper licence area is situated at the southern fringe of the OMZ, a similar scenario is likely to apply, suggesting that the macrofauna is playing a significant role in the benthos of the target areas. Similarly, in an early study by Sanders (1968) of the benthos in the Namibian OMZ, a reduction in macrofauna species diversity has been observed in the core, whereas higher abundances and biomasses have been recorded from the edge of the OMZ.

#### 4.3.2.2 Objectives and Key Questions

As part of their Environmental Management Programme for the Sandpiper licence area, NMP has committed to undertaking a benthic macrofauna verification survey to collect information on general macrofauna distribution patterns in the three target areas. This will also aid in verifying some of the assumptions on which the assessment of impacts was based. This initial survey will be followed by a macrofauna monitoring programme, whose principal objective is to study the rate of recovery of disturbed macrofaunal communities once the dredging activity has ceased in a particular dredge block. Recovery has been shown to be both spatially and temporally variable, and to confidently measure the ecological recovery rate of mined areas, it is therefore necessary to develop a benthic monitoring plan that is not only appropriate in the medium-term (~5 years), but has the flexibility and potential to be extended into the long-term.

The key objectives for the *verification survey* are:

- Establish a data set on general macrofauna distribution patterns in all three target areas;
- Relate the distribution patterns to environmental factors such as water depth, sediment texture, near-bottom oxygen concentrations, organic carbon content, and H<sub>2</sub>S concentrations; and
- Investigate the relative importance of the smaller macrofauna size fractions.

The key questions for the *monitoring programme* are the following:

- What is the rate of recovery of the physical environment e.g. in-filling of mined-out areas with unconsolidated sediments?
- What is the process of the recovery of the benthic macrofauna?
- How long after the disturbance does it take for the benthic community to recover to at least an ecologically functional community?
- How does the physical environment (e.g. sediment particle size, organic matter, dissolved oxygen) influence the recovery rate?

### 4.3.2.3 Survey Method and Design

#### 4.3.2.3.1 General Sampling Design

Sampling for macrofauna will involve the use of a Day grab or box corer. Both sampling tools are capable of retrieving a sediment sample with an undisturbed surface. The Day grab has the advantage that it can be handled from a smaller surveying vessel. Once retrieved, macrofauna samples will be taken from the larger grab with subcorers with an inside diameter of 9.6 cm x 30 cm length (72.4 cm<sup>2</sup>). It is proposed to take one to two subcorers per grab. The sample volume collected with this method is in agreement with other studies conducted in OMZs (e.g. Gallardo *et al.* 2004, Gooday *et al.* 2009, Levin *et al.* 2000, but see Zettler *et al.* 2009). From the same grab, sediment particle size and total organic carbon (TOC) will be determined. In addition, near-bottom dissolved oxygen concentrations will be measured with a CTD and H<sub>2</sub>S concentrations in the pore water analysed for a selected number of grabs, and in addition in a number of gravity cores down to depth. These measurements are described in the proposal for the sediment properties verification survey (Lwandle 2012). The measurement of the H<sub>2</sub>S concentrations will shed light on the possibility of the presence of substantial amounts of thio-bacteria in the sediments (**NatMIRC bullet point 5**).

The original macrofauna baseline survey in SP-1 used a 1-mm sieve to separate the macrofauna from the sediment as this is the traditional standard mesh size used in macrofauna surveys (Rumohr 2009). Studies on macrofaunal abundance in OMZs, however, often use smaller sieve sizes in anticipation that many macrofauna species will be generally smaller (e.g. Gallardo *et al.* 2004, Gooday *et al.* 2009, Levin *et al.* 2009). Sieve sizes used in OMZ studies vary between 0.3 mm (e.g. Gallardo *et al.* 2004, Gooday *et al.* 2009, Levin *et al.* 2000, 2009), 0.5 mm (e.g. Sahling *et al.* 2002, Gutiérrez *et al.* 2000, Palma *et al.* 2005), and 1 mm (e.g. Rosenberg *et al.* 1983, Zettler *et al.* 2009, see also Levin & Gage 1997 for references on studies using sieve sizes ranging from 0.3 to 1.0 mm). For example, the only recently published study on the Namibian OMZ macrofauna (northern Namibia), has used a 0.1m<sup>2</sup> van Veen grab and a sieve size of 1 mm (Zettler *et al.* 2009), similar to the Sandpiper benthic baseline study. To determine the relative importance of the various size fractions, it is proposed to sieve the samples on-board through a 0.3-mm sieve. In the laboratory sorting procedure, the 0.3 - 0.5 mm, 0.5 - <1 mm, and the >1 mm size fractions will be separated for a number of samples with a nested sieve design and analysed separately to indicate the right mesh size for the long-term monitoring study and also permit comparison to the baseline study. (**NatMIRC bullet point 6**). Sieving of the samples will be conducted with an automated Wilson autosiever that gently keeps the material in the sieve in motion by flotation with water from below instead of spraying with water from above. This will reduce damage to fragile organisms. As found during the benthic baseline survey and substantiated by the extensive geological mapping by NMP, it can be expected that the surficial sediment layers (top >30 cm) will contain significant amounts of large broken shell pieces. This not only will drastically increase the amount of material retained on the 0.3 mm screen and thus the sieving time, but may also damage the organisms. It is thus proposed to use a 3 mm or 5 mm screen to separate this shelly layer from the actual macrofauna sample. Careful visual inspection of the material retained on the larger screen will ensure that any larger organisms retained are transferred to the macrofauna sample. The sieved sample will be stored in 10% buffered formalin.

In the laboratory, macrofauna samples will be re-sieved through a 0.3-mm sieve and sorted under a stereo binocular microscope at 10-25 x magnification. If needed, the sample may be stained with Rose Bengal to aid in the sorting. Specimens will be identified to the lowest taxon possible and counted. Wet biomass will be estimated by blot-drying the specimens on absorbent tissue for a



standard period of time and weights recorded per species per sample using an analytical balance. Taxa retained on the 0.3 mm screen that traditionally are considered to be meiofauna (e.g. nematodes, copepods, ostracods and foraminifera) will not be included in counts, biomass measurements or subsequent analyses. This is in line with other studies on OMZ macrofauna (e.g. Levin *et al.* 2000, Gallardo *et al.* 2004). At first, a minimum of ten samples will be sorted with a nested sieve design separating the three size fractions. After analysis of the absence/presence and relative importance of macrofauna in the various fractions, a final sieve size will be determined.

#### **4.3.2.3.2 Sampling Layout**

For the verification survey, an increased spatial coverage has been opted for at the expense of replication per site. This will provide a better resolution of macrofaunal distribution patterns across the three target areas. Small scale patchiness, however, cannot be investigated with this design but increased replication per site in the monitoring survey will provide data on small-scale variability (see Monitoring Programme below). Sampling stations will be spread across the target areas in a grid pattern with increased spatial coverage in the mine blocks proposed for dredging within SP-1 and SP-2. Proposed numbers of sample stations are 16 in SP-1 (plus 4 monitoring sites, see below), 18 in SP-2, and 12 in the smaller SP-3; this amounts to a total of 46 samples (plus the four impact and four reference sites for the monitoring survey, see below). Figures 4 (a - c) illustrate the proposed layouts of the sampling stations in the three target areas SP-1, SP-2, and SP-3.

#### **4.3.2.3.3 Monitoring Programme**

Continuing from the initial assessment survey, the severity of the removal and destruction of benthic communities by the dredging process and the subsequent recovery (functional recovery) process need to be ascertained. A post-dredging benthic monitoring programme thus needs to be established.

Worldwide, the study of benthic assemblages has been used to investigate the impacts on the seafloor of human activities. There is continuous debate whether such monitoring programmes should focus on macrofauna or meiofauna, or on both (e.g. Somerfield *et al.* 1995, Coull & Chandler 1998, Kennedy & Jacoby 1999, Schratzberger *et al.* 2001). Typically macrofauna is the preferred option as sample collection and species identification is comparatively easier (Kennedy & Jacoby 1999). Macrobenthos is commonly used as biological indicator because as a group they are relatively sedentary and reflect the quality of their immediate environment, many benthic species have relatively long life spans and their responses integrate water and sediment quality changes over time, and they include diverse species with a variety of life history characteristics and tolerances to stress and can usually be classified into different functional groups. Examples of the use of macrofaunal monitoring surveys include studies on the effects of oil pollution (e.g. Dauvin *et al.* 2003), organic enrichment (Pearson & Rosenberg 1978, Macleod *et al.* 2004), offshore drilling operations (Daan *et al.* 1995, 1996), submarine tailings disposal (Ellis 1982, Burd 2002), and particularly of marine aggregate dredging operations (e.g. Newell *et al.* 1998, Herrmann *et al.* 1999, Newell *et al.* 2004).

In low-oxygen environments such as OMZs, body size seems to be very important as small organisms are best able to cover their metabolic demands in the OMZ, and besides adaptation to low oxygen often have a capability to conduct anaerobic metabolism. Meiofauna may thus increase in dominance in relation to macro- and megafauna (Levin 2003). However, the Sandpiper licence area and specifically the target areas are at the edge of the OMZ, and several studies have shown that

macrofauna has been found to increase at the edges of OMZ dominating the benthic fauna (see above). The difficulty in conducting meiofauna monitoring surveys in comparison to macrofauna studies thus favours the use of macrofauna for long-term studies, and the extensive use of macrofauna surveys for a wide variety of anthropogenic disturbances suggests that data on macrofauna composition and abundance should be able to shed light on it. Macrofauna is also routinely and often solely collected in studies on OMZ benthos (e.g. Levin & Gage 1998, Levin *et al.* 2000, 2009, Ueda *et al.* 2000, Gallardo *et al.* 2004, Arntz *et al.* 2006, Gooday *et al.* 2009, Zettler *et al.* 2009).

In identifying and assessing the impacts of phosphate dredging on the macrobenthic communities, it is important to recognize that the marine environment can be very variable both in space and time. An impact should not therefore be characterized as being the difference in some measure at a particular site before and after a disturbance, but should be distinguished as being the relative difference between changes at a disturbed/impact site compared with changes that have occurred in a similar undisturbed reference site (Underwood 1992, 1993, 1994). In other words there must be some change from before to after a disturbance and such change must be significantly different from what occurred in undisturbed reference areas. Community parameters, however, vary both spatially as well as with time, fluctuating in response to natural variations in the environment (these may be monthly, seasonal or annual variations). Without adequate indices of natural variability, it will be inherently difficult to place dredging-related impacts in context. It is therefore important to have a number of impact sites in association with a number of reference sites that are in a similar environment (e.g. depth and sediment texture) but will remain undisturbed over the period of the monitoring programme. Here it is important to note that it would be prudent to select sites that will also not be affected by other anthropogenic activities such as trawling. If possible, the sites should either be located in areas not utilised by the trawling industry or trawling should be excluded from the immediate area for the duration of the monitoring programme. This is important as effects of trawling may have traditionally affected parts of the mining licence area beyond the 200-m isobath but since trawling will not occur in the target areas once phosphate dredging operations commence (due to safety issues), this impact should also be avoided for the reference sites. The envisaged position of the reference sites are, however, such that conflict is expected to be low as trawling usually occurs in deeper waters.

The proposed position of the sampling stations is illustrated in Figure 4 (a - c). For operations in SP-1, four impact stations and four associated reference sites are proposed. At each site, five replicate samples will be taken. Included in the sampling procedure should be at least the sampling for sediment properties (i.e. grain size analysis) as well as near-bottom dissolved oxygen concentrations and organic matter content. Sites have been selected according to the currently proposed mine schedule to fall into the mine blocks that will be mined in Year 1 and Year 2 of the schedule. This ensures that any information on recovery processes can be collected as early as possible to inform the Environmental Management Programme. Prior to operations being initiated in SP-2, a second monitoring programme needs to be established and similarly for activities in SP-3.

Sampling in SP-1 should be undertaken both before the start of operations, as well as at regular intervals after completion of dredging to determine the (functional) recovery rates of the benthic communities. One of the basic assumptions of developing a benthic monitoring programme is that recovery of disturbed macrofaunal communities does in fact occur. The process and rate of recovery is, however, strongly dependent on the rate of the in-filling of sediment in the mined-out areas, and the type of sediment. A wide range of recorded recovery rates highlight the inherent difficulties in the application of general impact/recovery predictions to sites with varying environmental

characteristics (Robinson *et al.* 2005). From existing information on the natural rehabilitation of mined-out areas in the deep-water diamond mining licence area in southern Namibia, it is known that despite the reduced wave and current action at the depths at which mining is currently being conducted (100-150 m), significant smoothing and in-filling of mined areas is visible in sidescan sonar surveys 1 - 2 years after mining (Penney & Pulfrich 2004). However, such information cannot be simply extrapolated to the central Namibian shelf, where the sedimentation and near-bottom current regime is likely to be very different. It is recommended that high resolution geophysical surveys (e.g. side scan sonar) are conducted immediately after dredging, and 2-3 years post-dredging (and potentially at later years depending on the results) to determine the depth of the dredged trenches and the sediment infilling-rates. Depending on the geophysical survey results, it is assumed that the first post-dredging survey can be conducted 2-3 years after cessation of dredging (three years for Target Block 1 and two years for Target Block 2 of the SP-1 resource). The subsequent sampling interval can best be determined after the first post-dredging sampling campaign, but an appropriate interval may be every 2-3 years. Periodically reviewing the monitoring plan as new data are collected and analysed will ensure that the monitoring plan and associated sampling schedule remains a dynamic process.

Traditionally, the ecological recovery of the disturbed seafloor has been defined as the establishment of a successional community of species, which progresses towards a community that is similar in species composition, population density and biomass to that previously present. Measures used to assess recovery typically include biodiversity analysis such as the numbers of species and/or individuals in an assemblage. However, this approach presents a number of challenges, especially when the physical characteristics of the sediment have been altered to such an extent that it can no longer accommodate its original assemblage. Recovery in the sense of the above definition may thus not be achieved (only when the sediment properties revert to their original state). For this reason, it may be more sensible to consider the functional capacity (or health) of the ecosystem rather than simply the range and proportion of species present. Some ecosystem functions can be undertaken by a variety of different organisms, leading to the notion of possible functional redundancy, whereby the loss of a particular species may not affect the basic functioning of an ecosystem as long as the function performed by that species is taken up by another species from the same functional group. To address this issue, many studies have recently focussed on functional diversity to assess faunal recovery following anthropogenic perturbations by incorporating biological differences among species showing that function- or trait-based diversity metrics may represent appropriate additional methods for assessing changes in ecosystem function (e.g. Borja *et al.* 2003, 2010, Bremner *et al.* 2006, Josefson *et al.* 2009, Cooper *et al.* 2008, Hussin *et al.* 2012). In terms of dredging impact on functional diversity, communities of organisms inhabiting an area of dredged seabed may possibly differ in composition or diversity from the pre-dredged state, but may develop similar functional capacity through the recovery process (functional recovery). Therefore, system recovery may not require similar biomass, biodiversity or community composition. It is thus proposed to utilise a variety of analyses including biodiversity measures, multivariate approaches as well as functional traits analyses to describe the macrofaunal colonization process after the dredging impact.

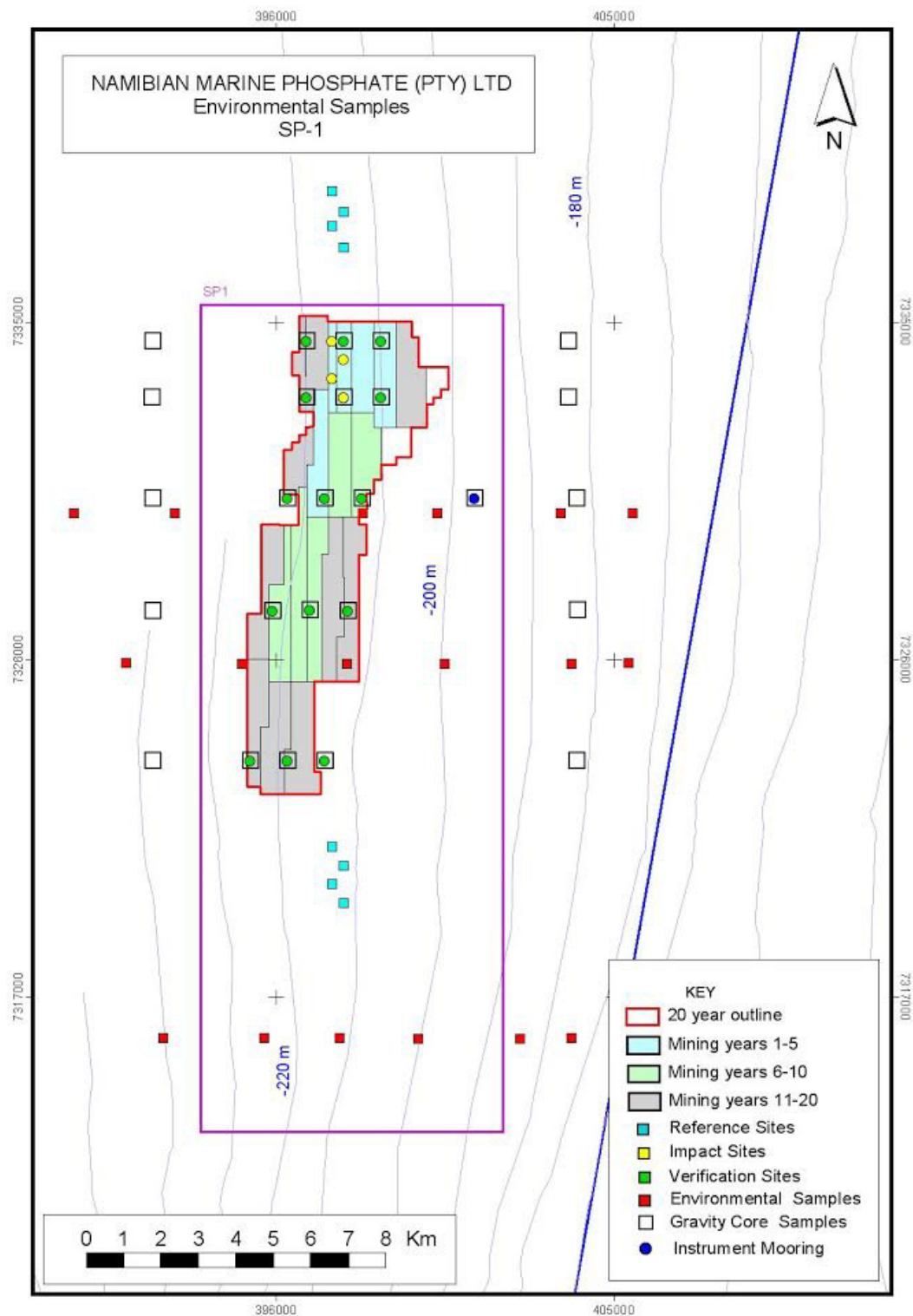


Figure 4 (a): Layout of macrofauna sampling stations for the verification and monitoring survey in SP-1.

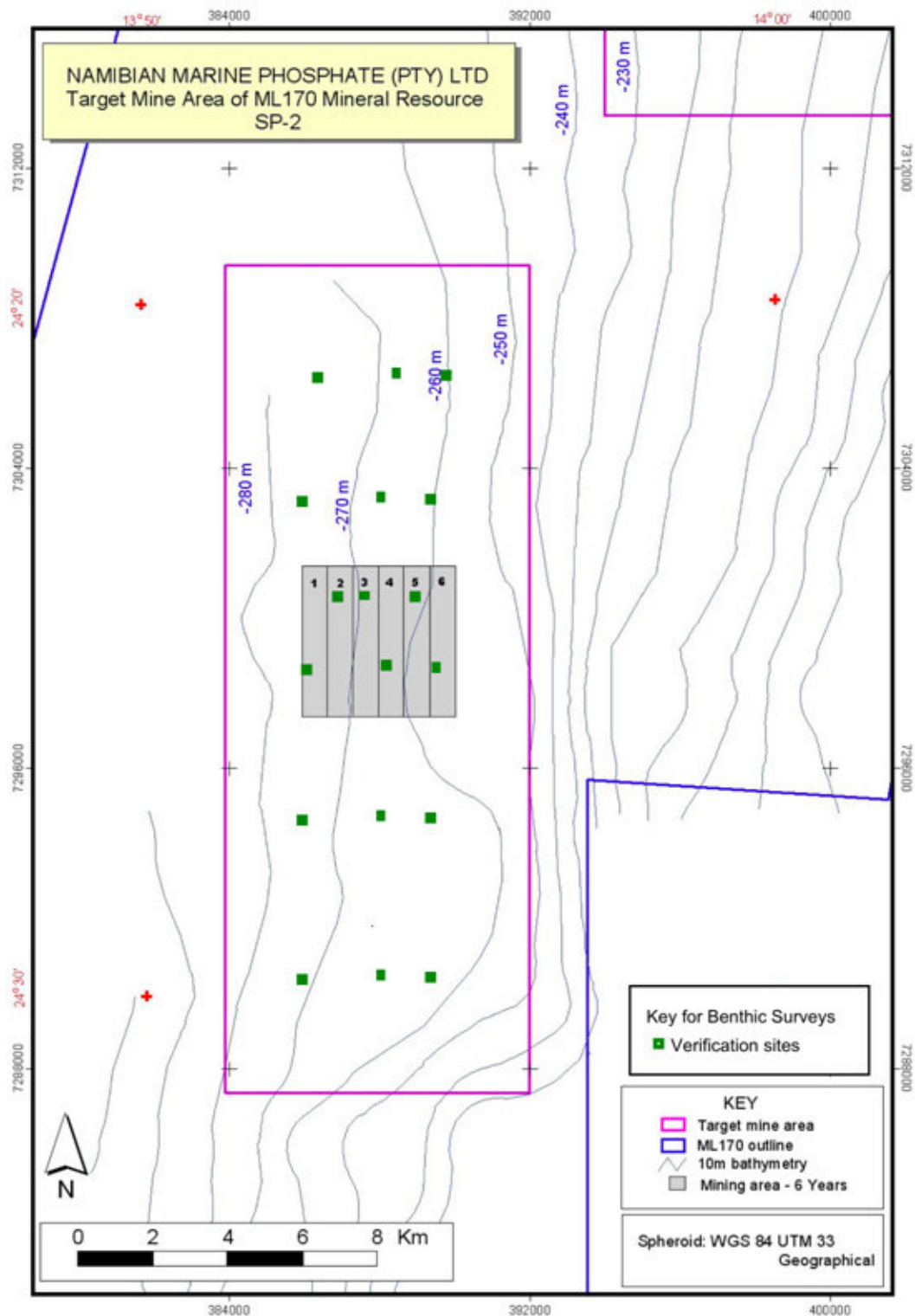


Figure 4 (b): Layout of macrofauna sampling stations for the verification survey in SP-2.

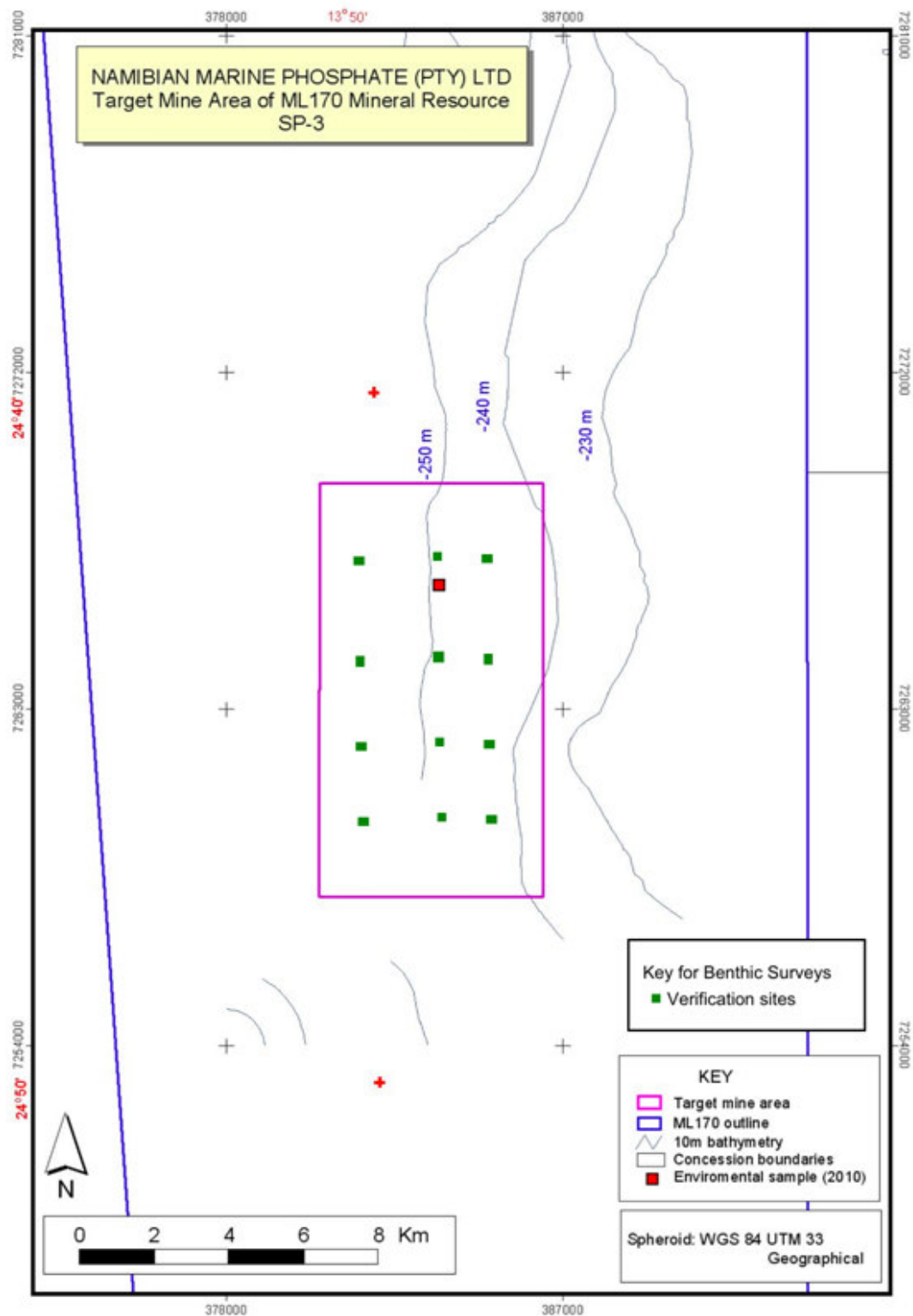


Figure 4 (c): Layout of macrofauna sampling stations for the verification survey in SP-3.

## **NMP Consolidated Verification Study - Fish, Mammals and Seabirds**

*Prepared by Mr. D. Japp  
Capricorn Fisheries Monitoring cc*



### **4.3.3 INTRODUCTION**

The Environmental Impact Assessment (EIA) for the proposed phosphate mining in ML-170 specialist report Appendix 1a on fish resources, fisheries, marine mammals and birds identified five primary impacts viz.

- 1) the likely impact of dredging on commercial fisheries;
- 2) the likely impact of dredging on the main commercial fish species;
- 3) the likely impact of dredging on the recruitment of commercially important species;
- 4) the likely impact of dredging on fish biodiversity and
- 5) the likely impact of dredging on seabirds and marine mammals.

These impacts and the associated estimates of environmental risk were in part based on marine survey data provided by NatMIRC as well as historical information on fisheries and the Benguela Ecosystem as a whole. The risk assessment has therefore had to use information from surveys etc. in the proximity of the MLA and made assumptions on impacts such as fish recruitment and biodiversity, by extrapolating data from the nearest sampling points from which relevant data were available.

These data have therefore provided a baseline which informed the risk assessment, based on the best available information. The EIA also included a proposal for the verification of the EIA assessment.

Responses to the EIA from NatMIRC were outlined in a letter dated 16 June 2012 and discussed with NatMIRC in a meeting (Facilitated by the Governor of Erongo Province) on 10 September 2012 in Swakopmund. NatMIRC concerns and issues included 13 bullet points. Of these, four (bullets 10, 11, 12 & 13,) related to the component of the EIA relating to Fish resources, mammals and seabirds.

Summarised these concerns were :

1. Turbidity affecting marine predators that use visual cues to forage prey;
2. Spawning activities of fish in the dredging area was relatively unknown;
3. The importance of the proposed dredging area as a nursery ground for juvenile hake;
4. Impacts of the proposed dredging on the ecosystem impacts was uncertain – in particular trophic (feeding) interactions.

#### **4.3.3.1 Actions to Address the Identified Issues**

In the discussions between NMP and NatMIRC to address the concerns in 1-4 above the following was proposed:

- a) A risk assessment been undertaken – this would form a basis on which to inform on the potential risk to the main commercial species if the proposed phosphate mining were to proceed. In particular the risk associated with SP1 and scaled up to include the associated risk if dredging were to expand to SP2, SP3 and or the simultaneous expansion of dredging in other mining lease areas across the Namibian shelf.
- b) The outputs of the proposed risk assessment model can then be compared to the risk levels identified in the NPM EIA;
- c) Undertake a structured survey of the proposed dredging area – in particular focus on the area proposed to be dredging in the first phase (SP1). This survey will aim to verify the current assumed baseline for biodiversity, fish abundance (density), recruitment (size distribution) and other biological aspects (diet of main commercial species for trophic studies, spawning state of main commercial species etc).
- d) These data would then be used to :
  - i) verify the assumed baseline historical data used in the EIA;
  - ii) provide additional inputs and supporting information for the risk assessment model;
  - iii) provide inputs into the current trophic modelling initiatives for the Benguela and the risks to the ecosystem associated with the likely mining impacts.

The proposal to address the issues is therefore a step-wise approach that first assesses the likely risk based on a modelling approach, then verification of the baseline EIA assumptions using in-situ survey data and also further inputs into the risk model derived from the survey as well as providing baseline data for inputs in trophic models currently applied to the broader Benguela ecosystem.

##### **4.3.3.1.1 Terms of reference for proposed activities**

#### **1) Risk Assessment**

It is proposed that appropriate modelling skills be sourced to undertake a mathematical risk assessment. To do this the following is needed (although the modeller may have alternative or additional requirements). Note also that typically these risk assessments are well-established procedures in fisheries stock assessments and include forward projections for set periods e.g. 20 years.

Key Inputs to the risk assessment:

- 1) Use the current models used to assess the key fish stocks in Namibia – hake, monk, horse mackerel and small pelagic;
- 2) These models are based on many sets of criteria, reference sets / data, indices etc. Outputs for the annual setting of TACs assess risk to determine the effects of different levels of TACs, variability in indices and numerous other parameters that have elements of uncertainty associated with them (General Linear Modeling is a common statistical methodology used);



- 3) The proposal therefore aims to incorporate the additional risk to the main commercial resources that may or may not be impacted by the introduction of phosphate mining. Key elements could include (the modellers can inform on this) the following :
  - a. Biomass estimates (fish density) and the exclusion of dredging areas from the overall abundance of key commercial stocks. This can include for example only SP1 and also a scaling effect around the dredged area(s) and also any potential expansion of dredging from other concession holders (it may also require alternative stratification methods);
  - b. The potential impact / loss of recruitment to the known key fisheries stocks, in particular hake, monk, sardine and horse mackerel (scaling effects also applied).
  - c. Possibly the potential loss of spawn for key species if it can be shown conclusively that spawning occurs in the mined area(s);
  - d. Potential displacement of stock – i.e. fish moving out of the mined areas due to disturbance.
  - e. Input additional information that may inform the model after the monitoring and verification surveys.

The outputs from the model could then inform on any changes or additional risk to the stocks associated with mining and consolidated with the cumulative impacts that may be associated with other impacts (fishing, dredging /mining etc).

## 2) In-Situ Survey(s)

The proposal is to conduct a survey within and surrounding the proposed dredging site. It is critical that this survey is compatible and data are consistent with the current survey methods used for the fish stock assessments. This will most likely require that the proposed survey be integrated with the current fishery surveys – this will ensure compatibility of data, reduce overall costs and ensure adequate expertise is available on the survey.

Typically the survey design will incorporate :

- a) Fisheries swept area surveys (demersal);
- b) Fisheries Acoustic survey (integrated with swept area surveys); and
- c) Marine mammal, seabird and other marine fauna observations.

### 4.3.3.2 Survey Design

A simple transect design using swept areas, and if considered necessary, simultaneously the collection of acoustic data, is proposed. Schematically the survey design with sampling stations is shown in Figure 5. *Note :*

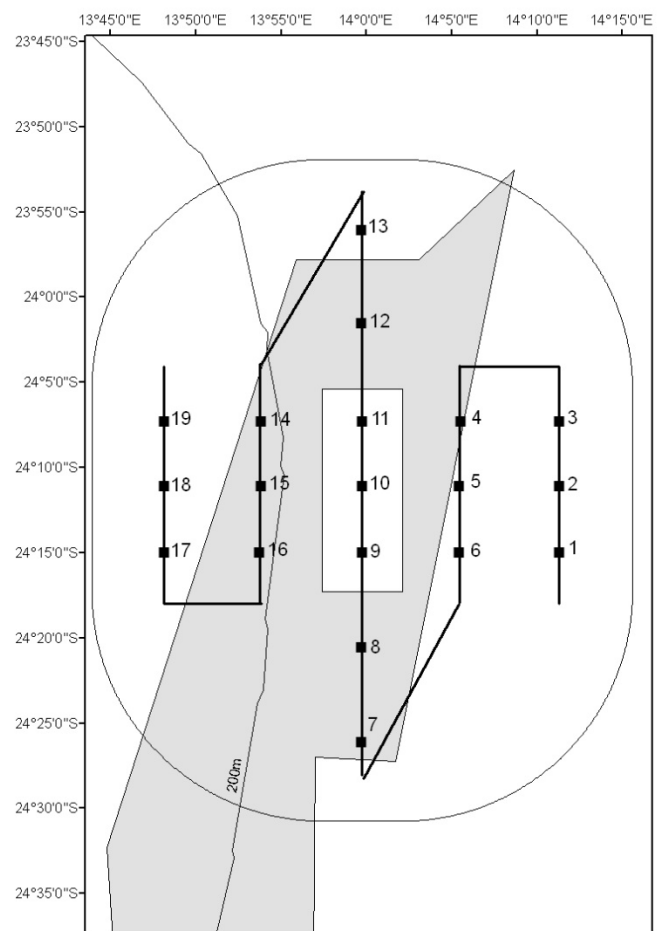


Figure 5: Location of survey stations in SP-1

This is not intended to be prescriptive and will need refinement and discussion with marine scientists at NatMIRC.

#### **4.3.3.2.1 Key elements of the survey**

- a) Trawls are undertaken north to south following the bathymetry;
- b) Typically trawls will be for 20-30 minutes each (max. 1.5 nm);
- c) Stations to be positioned within the area to be dredged (SP-1 initially) and thereafter at suitable intervals in a perimeter around the dredge area;
- d) Standardisation of trawl gear (similar to that used in biomass surveys);
- e) It is essential that stations cover the dredge area prior to any dredging that may take place as well as stations within the MLA and then some distance (to be agreed) outside the MLA and within the 25 km zone used in the fisheries EIA report (Appendix 1a). A total of no more than 20 stations are proposed taking approximately 3-6 days of survey time.
- f) Acoustics can also be run along transects and between lines (primarily to determine small pelagic targets) – this is not a high priority but the need can be determined in discussion with the Namibian marine scientists.

#### **4.3.3.3 Expected Outputs**

1. A comparative relative abundance estimate of the main commercial species in the dredged area and adjacent grounds (biomass). This can potentially show any changes in relative abundance due to dredging (such as species displacement to areas adjacent to the dredged area);
2. Verification of relative species abundance in the area with the on-going and historical abundance estimates of the main commercial species;
3. Species counts and classification of all flora and fauna (including fish and mega fauna) captured in the trawls. This can be compared with stations from adjacent historical surveys;
4. Provision for a marine mammal and seabird specialists or suitable marine observers to record mammals, seabirds, turtles and other interactions while in the survey area;
5. Length frequency measurements of the main species and sex ratios;
6. Basic biological data collection on main commercial species including gonad staging for comparative spawning and recruitment indices;
7. Use of digital photography to record species;
8. Deployment of CTDs (if an appropriate vessel is used) to determine essential water conditions (conductivity, temperature, depth).

#### **4.3.3.4 Time Frames**

A survey prior to the commencement of dredging should be undertaken. Preferably this should be coordinated with other swept area surveys in the area (most likely monk or hake surveys) using the same vessel. The survey can be repeated annually (for the first 5 years as reviewed) at the same time for the duration of the dredging activity. Transects can subsequently be included in the other proposed dredging areas (SP-2 and SP-3), but due to the initiation of the project in SP-1, it is recommended that priority should be given to a focused survey around this target area.

#### **4.3.3.5 Conclusions**

Correctly designed and undertaken with professional staff and a suitable sampling platform, the survey can provide a baseline from which the changes in fish availability, abundance, recruitment,

biodiversity (as best can be determined from swept area trawls), marine mammals, seabirds and other flora and fauna can be estimated.

This baseline is a “snapshot” that can be compared with historical data in the proximity of the MLA. Changes of the many parameters measured can be tracked over the lifetime of the exploitation and can be used to determine the effects (environmental impacts) of the proposed project over time. The data would be subjected to scientific and statistical scrutiny for accurate interpretation.

**Amended Scope of Fish, Mammals and Seabirds Verification Survey,  
following discussions with MFMR – July 2013.**

*Prepared by Mr. D. Japp  
Capricorn Fisheries Monitoring cc*





**CAPRICORN FISHERIES MONITORING**

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25 February 2014

Namibia Marine Phosphate (Pty) Ltd  
127 Theo-Ben Gurirab Str,  
WALVIS BAY, Namibia

Attention : Mr M Woodbourn

**Re: Verification of Fisheries Data used in the NMP Impact Assessment**

Dear Mr M Woodbourn

We refer to the verification survey of the proposed phosphate mining area. In particular we submit herewith our suggested actions to address the fisheries issues raised by NatMIRC and the peer reviewers of the EIA.

The information used by the fisheries impact assessment team was primarily data provided from numerous surveys undertaken by NatMIRC (MFMR). The concerns raised by MFMR and the reviewing parties primarily relate to these data mostly not specifically coinciding with the proposed mining area.

We wish to stress however, that the survey data provided by NatMIRC (MFMR) is based on globally accepted practice when surveying fish stocks. The method employed either uses randomised trawls or fixed transects. The data provided by NatMIRC (MFMR) were a mixture of both.

A key point is that these surveys undertaken by NatMIRC (MFMR) are standardised and apply internationally -recognised sampling practice. Because of the extent of the ocean and the nature of the grounds on which commercial fish stocks are found, surveys sample a very small part of these areas and rely on extrapolations to estimate biomass and other parameters used in fisheries.

Namibian Marine Phosphate (NMP) in their quest to find suitable vessels such that the verification process would be as close as possible to the methodology used by the Namibian and other international research scientists (e.g. Nansen programme) requested that the vessels used by the ministry (MFMR) be utilised for the purposes of verifying the information used in the fisheries component of the EIA. Regrettably it has proven impossible for numerous reasons to get access to these vessels, in particular the *FV Welwitchia* which has historically been used to assess the monk stocks. A further complication was that for the biomass estimates to be compatible using an alternate vessel e.g. an industry trawler, it would require a costly and time-consuming calibration exercise at sea, involving the unavailable *FV Welwitchia*.

Given these difficulties, and the willingness of NMP to explore all options the following approach to the verification process has been adopted.

1. Employ an independent fisheries quantitative scientist (Dr James Gaylard) to assess the likely biomass of the main commercial fisheries stocks that may be impacted by dredging. This involved using the NatMIRC historical biomass estimates and extrapolating these estimates to the actual area to be mined i.e. SP-1, and licence area of the NMP Sandpiper deposit.
2. Employing a professional consultant (in this case a Namibian fisheries scientists Dr Hillka Ndjaula) to assess the likely recruitment impact on the main commercial fish species (using data acquired from the NatMIRC scientists)

The results from both these studies are pending and will be submitted in due course for review.

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*Capricorn Fisheries Monitoring (CapFish)*  
Members: D. Japp - C. Heinecken – J. Wissema  
Providing : Marine Monitoring Services - Marine Observers – Fisheries & Aquaculture

The key results from these studies show that the area to be mined is proportionately extremely small (compared to the total area of the main commercial fish species) and that no significantly (in the context of the EIA) useful information would be obtained by undertaking a biomass-directed survey that would have been standardised to the historical biomass surveys conducted in Namibia. This conclusion applied equally to the biomass estimates of spawner biomass and recruitment. The study did show that there is a significant difference between monk and hake, where monk is in greater numbers and biomass than hake in the MLA. Nevertheless the estimates of biomass of these two key groundfish species in the twenty year mine target area of SP-1 is miniscule.

The work undertaken by Dr. H. Ndajula is still in process but suggests that the proposed mined area has no unique spawning processes, or at least no spawning indicators that suggest it is different from any other areas in Namibian waters.

Given all of the above we have concluded that undertaking of a calibrated, standardised survey of the MLA focused on the SP-1 area will produce no significantly useful additional quantitative information on the biomass of monk and hake. Consequently we advise NMP to adopt a different strategy, one that we envisage would be supported by NatMIRC / MFMR.

The recommendation: NMP are to charter a dedicated monk (commercial) vessel and undertake a structured sampling survey using standard monk trawl gear. Although this will not provide directly comparable biomass estimates it will allow for the following to be done by a group of professional scientist in a rigorous manner:

1. Quantify all fish species caught in and around SP-1 and the immediate area of the MLA. This would include weighing and measuring, of key species;
2. Quantifying all species captured, estimating their relative proportions in the catch and undertaking biological analysis of key species (similar to that done by NatMIRC on their surveys);
3. Recording all species captured – this will provide a baseline comparison of biodiversity with the historical surveys;
4. Recording at the same time the nature of the substrate and bottom profile;
5. Measuring common environmental parameters – salinity, oxygen, temperature, water depth, water clarity (CTD) etc
6. Recording the occurrence of surface species such as large pelagics, marine mammals and birds.

The survey is designed to quantify the biodiversity of the area and compare this with the known information of the region, i.e. a biodiversity verification assessment.


The survey will also obtain full commercial data on target catch (monk), hake and the other bycatch species. This will allow for a crude biomass estimate on spawner biomass and recruitment that can then form a baseline for future surveys in the area.

From this point, it is necessary that:

- A suitable commercial vessel is obtained from which to conduct the biodiversity assessment;
- That NatMIRC / MFMR acknowledged the scientific reasoning and approach as adopted; and
- That NatMIRC / MFMR provide the necessary approvals, if they have not already done so.

We trust that this meets with your approval, and we look forward to working on this project with you.

Yours sincerely

  
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Dave Japp  
CapFish cc

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