SANDPIPER PROJECT

Verification Programme Report:
Mining Licence Area No. 170

SECTION D : APPENDICES

APPENDIX 5

Curricula Vitae and Terms of Reference

APPENDIX 5

CURRICULA VITAE & TERMS OF REFERENCE

Email: info@namphos.com
127 Theo-Ben Gurirab Street
Walvis Bay
Namibia

contents

5.1: CURRICULA VITAE

5.1.1 Independent Programme Reviewer and Process Quality Controller

5.1.1.1 Mr P Morant : Abbreviated Curriculum Vitae

Name:	Patrick Digby Morant
Date of birth:	24 February 1946
Place of birth:	Dar-es-Salaam, Tanzania
Current Employment:	Independent Environmental Consultant, CSIR Associate
Experience:	36 years in coastal and marine environmental management. 25 years in environmental impact assessment
Qualifications:	M.Sc. Environmental Science (University of Cape Town) B.Sc. (Hons) 1st class: Microbiology (University of Cape Town)
Professional	Registered Professional Natural Scientist
Registration:	No 401514/83

Patrick Morant is a practicing professional environmental scientist and manager with a primary focus on the marine and coastal environment. Since graduating with an M.Sc. in Environmental Science he has headed the CSIR's Estuarine and Coastal Research Unit and managed a number of multidisciplinary research and consulting groups in the CSIR. He has led and/or participated in over forty environmental impact assessments of marine diamond mining in Namibia and offshore petroleum exploration and production along the west coast of Africa from Cameroon to South Africa. Currently he is associated with the CSIR's Environmental Management Services (EMS) group and variously leads and contributes to EIA and SEA projects besides reviewing reports and mentoring interns.

Patrick Morant also was part of the team that established the Benguela Current Large Marine Ecosystem (BCLME) Programme and contributed two thematic reports to the foundation documentation. He played an active role in the programme throughout its existence and led two studies: Oil Spill Contingency Planning in the BCMLE Region; and Cumulative Impacts of Oil Exploration and Production on the Northern Angolan Continental Shelf. He has also authored or co-authored two book chapters and a number of publications in the peer-reviewed literature.

I certify that to the best of my knowledge and belief, this CV correctly describes myself, my qualifications, and my experience. I understand, that any willful misstatement described herein may lead to my disqualification or dismissal, if engaged.

5.1.2 Specialist consultants

5.1.2.1 Prof. J Compton: Abbreviated Curriculum Vitae

Education:

Harvard University	Earth Science	Ph.D.	1986
University of California, San Diego	Chemistry/Earth Science	B.A.	1981

Professional Background:
2004-present Associate Professor, Department of Geological Sciences, University of Cape Town

Supervised: Honours students (28), Masters students (20), Doctoral Students (4) Post Doctorates (4)

Areas of Specialisation:
Low-temperature and sedimentary geochemistry of marine sediments.
Geochemical cycles and Earth history.

Professional Societies – Offices held:
American Geophysical Union
Southern African Society for Quaternary Research (SASQUA) President 2003-2005
SCOR (Scientific Committee on Oceanic Research) Executive Committee 2008-2012
South African National Committee member 2005-2012; President 2009-2012
Geological Society of South Africa (Council Vice Chair of the Western Cape Branch 2005-2011)

Publications (sample) - Articles in Refereed Journals: 2012 – present.

Wigley, R. and **Compton**, J.S., 2012. Microstratigraphy of a Miocene layered phosphatic pebble from the western margin of South Africa. *Sedimentology* 60, 666-678. doi: 10.1111/j.1365-3091.2012.01355.x

Viglietti, P.A., Smith, R.M.H., **Compton**, J.S., 2013. Origin and palaeoenvironmental significance of Lystrosaurus bonebeds in the earliest Triassic Karoo Basin, South Africa, *Palaeogeography, Palaeoclimatology, Palaeoecology*, doi: 10.1016/j.palaeo.2013.08.015.

Brumfitt, I.M., Chinsamy, A., and **Compton**, J.S., 2013. Depositional environment and bone diagenesis of the Mio/Pliocene Langebaanweg bonebed, South Africa. *South African Journal of Geology*, 116, 241-258 doi:10.2113/gssajg.116.2.241.

Toms, J.A., **Compton**, J.S., Smale, M., van der Heyden, S., 2014. Variation in palaeo-shorelines explains contemporary population genetic patterns of rocky shore species. Biological Letters 10: 20140330. http://dx.doi.org/10.1098/rsbl.2014.0330

Cawthra, H.C., Bateman, M.D., Carr, A.S., **Compton**, J.S., Holmes, P.J., 2014. Understanding Late Quaternary change at the land-ocean interface: A synthesis of the evolution of the wilderness coastline, South Africa. *Quaternary Science Reviews*

5.1.2.2 Dr R Carter: Abbreviated Curriculum Vitae

1. **Proposed Position**: Principal Scientist

2. **Name of Firm**: Lwandle

3. **Name of Staff**: Robin Carter

4. **Date of Birth**: 07/05/1946
Nationality: South African

5. **Education**: 1978 MSc – Biological Oceanography
1983 PhD – Marine Ecology

6. **Membership in Professional Associations**: Registered as Professional Natural Scientist in marine science with the South African Council for Natural Scientific Professions (registration # 400245/060) and a professional member of the South African Institute of Ecologists and Environmental Scientists.

7. **Further Training Courses**:

8. **Countries of Work Experience** : South Africa, Mozambique, Angola, Namibia

9. **Languages**:

	speaking	reading	writing
English	good	good	good
Afrikaans	fair	fair	fair

10. **Employment Record**

Period: 9 years
Employer: Lwandle
Position held: Principal Scientist

11. **Detailed Tasks Assigned**: 12. **Work undertaken that best illustrates capability to handle tasks assigned:**

Name of Assignment or Project: Marine light monitoring
Year: 2014
Location: Mozambique
Client: ERM – Environmental Resource Management
Main project features: Monitoring of light radiation in the marine and terrestrial environment. Deployment and recovery of equipment and data curation.
Positions held: Principal Scientist
Activities performed: Management of project

Name of Assignment or Project: NMP Environmental Survey - Verification survey for water column and sediment properties
Year: 2013
Location: Namibia
Client: Namibian Marine Phosphate
Main project features: Verification (metocean, water column and benthic) survey for water column and sediment properties in an offshore marine phosphate mining lease area in Namibia for Namibian Marine Phosphate, Namibia.

Positions held: Principal Scientist
Activities performed: To oversee sampling regime and manage field team.

Name of Assignment or Project: Anadarko LNG Project
Year: 2014
Location: Palma Bay, Mozambique
Client: Anadarko Petroleum Corporation
Main project features: Marine Ecology surveys
Positions held: Principal Scientist
Activities performed: Post ESHIA marine environmental and monitoring systems design for an LNG plant.

Name of Assignment or Project: Marine ecology assessments for proposed extensions to the Port of Ngqura
Year: 2013
Location: Coega Industrial Development Zone, Algoa Bay, Eastern Cape, South Africa
Client: CSIR
Main project features: Expansion of existing harbour and associated facilities into Algoa Bay by dredging and construction and operations.
Positions held: Principal Scientist
Activities performed: Marine ecology specialist study as part of an EIA for the establishment of a manganese bulk handling facility.
Name of Assignment or Project: Bio-monitoring program Transnet
Year: 2013
Location: Port of Cape Town
Client: Transnet
Main project features: Field work associated with bio monitoring program on the effects of dredging and dredge spoil behavior.
Positions held: Principal Scientist

Name of Assignment or Project: Block 1506 West Hub
Year: 2012
Location: Angola
Client: ARC
Main project features: Block 1506 West Hub offshore Angola marine environmental survey for ARC on behalf of Eni.
Positions held: Principal Scientist

13. **Certification**:
I certify that to the best of my knowledge and belief, this CV correctly describes myself, my qualifications, and my experience. I understand, that any willful misstatement described herein may lead to my disqualification or dismissal, if engaged.

5.1.2.3 Mr D Japp: Abbreviated Curriculum Vitae

David William Japp	South African Citizen
DOB :	30 June 1956
Current Employment :	International consulting Fisheries and Marine Scientist
Professional Registration :	**SA COUNCIL FOR NATURAL SCIENTIFIC PROFESSIONS or SACNASP**
Highest Qualification :	Master of Science in Ichthyology and Fisheries Science (Rhodes university)

David William Japp is a practising professional marine and fisheries scientist. His career includes 10 years as a navigator in the Merchant Navy, 8 years of study (University of Cape Town and Rhodes University), 10 years as a principal researcher (Sea Fisheries Research Institute and Marine and Coastal Management) and 18 years as a consultant in the marine environmental field. He is a founder and full partner in the Marine and Fisheries consulting group *CapFish (SA) (Pty Ltd*. In addition to the management functions in CapFish he consults broadly in the marine and fisheries field. His specialisation includes direct fisheries assessments and in impacts of offshore oil and gas activities. He has done 25 scientific publications and more than 100 technical reports.

Since 2004 David Japp has contracted to the World Bank and the Food and Agricultural Organisation of the United Nations (FAO) undertaking project development in East Africa where he specialises in fisheries and coastal zone management. Since 2004 he has managed fisheries projects in South Africa, Mozambique, Kenya, Uganda, Angola and Tanzania. He was responsible for the management and implementation of the fisheries components in the Marine and Coastal Management Project (MACEMP) from 2006 - 2012, the South West Indian Ocean Fisheries Project (SWIOFP) from 2008 to 2013 and currently the development of the Tanzanian fisheries programme under the SWIOFISH project. These projects have ranged in value from $15 – $65 million.

Mr Japp has worked on policy and governance aspects of fisheries in the region (South Africa, Kenya, Tanzania), Fisheries economics (Namibia and South Africa) and many fisheries-related programmes involving fisheries management and biology. Mr Japp has also undertaken numerous MSC assessments, including South African hake, Tristan da Cunha lobster and Russian Sea of Okhotsk Pollock. Other MSC-related activities include pre-assessments of SA Tuna pole, SA longline hake, Kenya Lobster, Tanzania Octopus, Namibia hake, Uruguay hake and Mozambique shallow and deep-water shrimp. In Mozambique he is currently working with WWF in a Fisheries Improvement Project for shallow and deep-water shrimp.

In addition to fisheries, Mr Japp works broadly as an environmental practitioner involved extensively in Environmental Impact Assessments. His specialisation is on ecosystems and also the offshore oil and gas sector where he manages a specialist team of consultants providing assessments, spatial mapping (GIS), Marine Mammal (MMO), Passive Acoustic (PAM) and Fisheries Liason (FLO) services to the hydrocarbon industry.

5.1.2.4 Dr N Steffani: Abbreviated Curriculum Vitae

Company Profile

Steffani Marine Environmental Consultant was established in 2002 by Dr. Nina Steffani. The office is based in Cape Town, South Africa and includes laboratory facilities for the taxonomic identification of benthic macrofauna invertebrates. Dr. Steffani is registered with the South African Council for Natural Scientific Professions (SACNASP) as *Professional Natural Scientist*.

Summary Profile of C. Nina Steffani

Nina Steffani has extensive experience in marine biological research resulting in the completion of two postgraduate degrees and scientific publications in international and national high-class rated journals. Her main area of scientific research is in the field of rocky shore ecology and invasive biology. At the University of Cape Town, she was employed as scientific diver, research assistant, postdoctoral research fellow and research associate.

Since 2002, Nina has worked as a Senior Marine Environmental Consultant at Steffani Marine Environmental Consultant and is primarily involved in the preparation of Marine Baseline Studies, Marine Specialist Reports, Environmental Impact Assessments and Environmental Management Plans, focussing both on rocky and soft-bottom substrates. She is highly experienced in the taxonomic identification of benthic macrofauna species, and has many years of experience in leading and conducting rocky shore and sandy beach field surveys. Furthermore, she is a registered scientific diver.

She has a proven track-record of successful project completion with work conducted for e.g. De Beers Marine, De Beers Marine Namibia, Namdeb, CSIR, Pisces Environmental Services, Lwandle Technologies, Anchor Environmental Consultants, EnviroAfrica, EcoSense, BCLME, DAFF (M&CM), SAMICOR, Transhex, De Beers Namaqualand, Portnet, Transnet, and IMT.

Academic Qualification

1996 – 2001	Ph.D. Zoology, Department of Zoology, University of Cape Town, South Africa
1987 – 1994	Diplom (equivalent to M.Sc.) Biology, Studies in Biology, University of Hamburg, Germany

5.1.2.5 Prof M Gibbons: Abbreviated Curriculum Vitae

Address: Department of Biodiversity and Conservation Biology, University of the Western Cape, Private Bag X17, Bellville 7535, South Africa. Tel: +27 21 959 2475, Fax: +27 21 959 2312, Email: mgibbons@uwc.ac.za

Educational History

- 1984 - 1988 University of Cape Town PhD Zoology
- 1980 - 1983 University of Liverpool, UK B.Sc. (Honours) Marine Biology.

Employment History:
Biodiversity and Conservation Biology Department, UWC 01/01/2006 – present, Full Professor

Research Interests:
Marine ecology, specifically pelagic ecology and biological oceanography: I have a special interest in zooplankton and in the processes responsible for structuring assemblages at all temporal and spatial scales. I have also run a research programme (with colleagues at UCT and the NHM, London) on marine invertebrate biodiversity, which essentially follows an interest in training students in the taxonomy and systematics of marine invertebrates. Recent interests are focused on understanding the changes to pelagic ecosystems of Namibia following the collapse of pelagic fish populations there at the end of the 1960s.

Postgraduate and Research Students:

- Ph.D. – Six current students, five past students
- M.Sc. – Three current students, 15 past students
- B.Sc. (Hons) – Three current students, 28 past students

Research Outputs:

- Publications in Peer Reviewed Journals – 94
- Books and/or Chapters in Books – 6
- Technical Reports – 15
- Popular Scientific Articles – 24
- Presentations at Conferences and Workshops – >150

Recent Publications – 2014 / 2013:

Toefy R and Gibbons MJ. (2014) Regional generalisations about the relationships between the environment and foraminifera. *Marine Pollution Bulletin* http://dx.doi.org/10.1016/j.marpolbul.2013.12.034

Rohner CA, Couturier LIE, Richardson AJ, Pierce SJ, Prebble C, Gibbons MJ and Nichols PD (2014). Diet of whale sharks *Rhincodon typus* inferred from stomach content and signature fatty acid analyses. *Marine Ecology Progress Series* **493:** 219–235.

Gibbons MJ and Richardson AJ (2013) Beyond the jellyfish joyride and global oscillations: advancing jellyfish research. *Journal of Plankton Research* **35:** 929-938

Harkins GW, D'Amato ME and Gibbons MJ (2013) Self-maintaining or continuously refreshed? The genetic structure of *Euphausia lucens* populations in the Benguela upwelling ecosystem. *Journal of Plankton Research* **35:** 982-992

Moloney CL, Fennessy S, Gibbons MJ, Roychoudhury A, Shillington FA, von der Heyden BP and Watermeyer K. (2013). What is the evidence for offshore marine ecosystem change in South Africa? *African Journal of Marine Science* **35:** 427-448

Roux J-P, van der Lingen CD, Gibbons MJ, Moroff NE, Shannon LJ, Smith ADM and Cury PM (2013) Jellyfication of marine ecosystems as a likely consequence of overfishing small pelagic fish: Lessons from the Benguela. *Bulletin of Marine Science* **89:** 249-284

Utne-Palm AC, Locatello L, Mayer I, Gibbons MJ and Rasotto MB (2013) An insight into the reproductive biology of the bearded goby, *Sufflogobius bibarbatus* (von Bonde, 1923). *Journal of Fish Biology* **82:** 725-731
Zootaxa, **2504:** 20-30.

Other:

- Assistant editor: *African Journal of Marine Science.*
- Associate Editor: *Journal of Plankton Research* (2008-2011).
- Editorial Board Member: *Journal of Plankton Research* (2012-present).
- Member: Small Invertebrates and Seaweeds Scientific Working Group (DAFF: 2012-present)
- Member: Scientific Advisory Board of De Beers Marine Namibia (Pty) Ltd (2012-present)
- NRF Rating: B2
- H Index: 25 (http://scholar.google.co.za/citations?user=8akWJoUAAAAJ&hl=en)
- Awarded JDF Gilchrist Medal, 2014.

5.1.3 Project Coordinator

5.1.3.1 Mr J Midgley: Abbreviated Curriculum Vitae

Jeremy Luke Midgley:	South African Citizen
DOB:	31 March 1963
Current Employment:	J Midgley & Associates (14 years) Environment – Health – Safety Consulting
Professional Registration:	SA COUNCIL FOR NATURAL SCIENTIFIC PROFESSIONS. No. 400205/09
Qualifications:	M/Sc.: Environmental and Geographical Sciences (University of Natal) B.Sc. (Hons.): Geology (University of Cape Town)
Masters Thesis:	Towards a Financial Evaluation of a Semi-disturbed Indigenous Habitat through its Precipitation-runoff Attenuation Capabilities.
Honours Thesis:	A bathymetric investigation of the south east Cape Basin titled: Submarine topography of the Cape Passage.

Jeremy Luke Midgley is a practising professional environmental and Health and Safety consultant. His career includes two years as a mine geologist at Barbrook Mine Barberton (Rand mines), one year working in Angola (Roan Selection Trust) as a diamond exploration geologist based in Cafunfu. This was followed by five years with the marine diamond mining company Namibian Minerals Corporation (NAMCO) with group responsibilities for Environment, Health and Safety. During this period the company was accredited to the international environmental standard ISO 14001. The liquidation of NAMCO provided the opportunity to start his own consulting company, J Midgley and Associates, for which he is the principal consultant.

This company has successfully served a variety of clients (marine and terrestrial) with a wide range of environmental, health and safety services for the last 14 years. These services focus primarily on risk assessments and mitigation, considering environment, safety and quality aspects of these operations. Impact assessments, management plans, compliance monitoring protocols and compliance reporting systems have been prepared for marine and terrestrial diamond mining and exploration companies in both Namibia and South Africa. Environmental management plans have been developed for several brick mining and manufacturing operations. A number of safety systems have been developed and implemented for marine salvage companies, and specialist (HV) and (LV) electrical companies. More recently environmental consulting and project management services have been provided to a number of marine phosphate projects in Namibia. A number of companies have been progressed to certification standards of the International Maritime Organisation (IMO) and NOSA. J Midgley and Associates often works in collaboration with other consultancies, both large and small.

In his personal capacity Jeremy is a qualified stress management practitioner.

5.2: TERMS OF REFERENCE

5.2.1 Independent Programme Reviewer and Process Quality Controller

The CSIR (Mr P Morant) was appointed to oversee environmental quality control / process control of the NMP EIA (2012). Following the decision to undertake the verification requirements as detailed in the EMP (2012), NMP requires the continuity services of the CSIR (Mr P Morant), providing similar services for the verification programme.

Independent Review of the Verification Programme Report

Namibian Marine Phosphate (Pty) Ltd (NMP) requires the continuity of document review services and environmental compliance guidance of the CSIR, as provided by Mr P. Morant during the EIA phase of NMP's environmental assessment of the impact of the dredging of marine sands rich in phosphate from ML 170. This continuity of services extends to the verification programme, when a number of studies will be undertaken to gather data specifically from the mining licence area. This information will subsequently serve to verify the original impact assessment (EIA of 2012).

Work – Proposal and Quotation request.

The principal services to be provided by the reviewer (Mr P Morant) of CSIR are:

1. The reviewer will serve as the overall quality controller for the Verification Survey and Report including:
    - Review of the individual specialists' verification reports
    - The re-assessment of the potential environmental impacts as determined from the verification assessments;
    - The environmental management plan (EMP);

2. The reviewer will provide advice on an ad hoc basis throughout the Verification Programme.

Specialist Studies

Specialist whom you will need to contact that form part of the broader investigations of this verification programme include:

- Dr Robin Carter: (+ 27 (0) 829223504 – robin@lwandle.co.za),
  Water Column and Sediments and Related Studies

- Dave Japp (+ 27 (0) 827886737 – + 27 (0) 21 4256226 – dave@capfish.co.za),
  Fish, Mammals and Seabirds and Related Studies.

- Dr Nina Stefani: (+ 27 (0) 21 – 7059915 – 0722172060 – ninasteffani@telkomsa.net),
  Macrofauna Assessment.

- Tim McClurg: (+ 27 (0) 31 7621 1356 – mcclurgs@telkomsa.net),
  Epifauna

- Dr Simon Forster (simon.forster@physalia.demon.co.uk),
  Meiofauna

- Dr Bronwen Kirby (+27 (0) 21 959 3033 bkirby@uwc.ac.za),
  Thiobacteria

- Roy van Ballegooyen (+ 27 (0) 21 8882400 - RvBalleg@cisr.co.za),
  Plume Modelling

- Gordon Rigg (+27 (0) 832570731 - Gordon.rigg@marinedataconsultants.co.za),
  Geophysical Data Assessment.

Project Coordination

NMP has appointed Jeremy Midgley & Associates to coordinate the verification programme, the CSIR (in the person of Mr. P. Morant) will be required to work closely with Mr. Midgley.

5.2.2 Specialist consultants

5.2.2.1 Prof. J Compton: Terms of Reference

Terms of Reference for
1) A review of offshore phosphorite deposits on the Namibian margin; and,
2) The establishment of a preliminary model for the origin, age and deposition of phosphorite in ML 170

i) Scope of work:
- Strontium isotope analysis of the lithological units from a series of cores from the ML 170;
- Confirmation of the stratigraphy;
- Core logs / stratigraphy verification;
- Full literature review of west coast phosphorites; and,
- Provision of a compendium of all references.

ii) Expected outputs
- Preliminary model for the age and origin for the deposition of phosphorites;
- Description of the geological setting of the origin and depositional history;
- Review / confirmation of the stratigraphy; and,
- Integrated report.

iii) Analytical methods considered
The application of strontium isotope analysis to a series of cores from ML 170 will establish the age of phosphorite formation as well as the final depositional age of the deposits. Strontium isotope analysis is a highly informative and an extremely powerful technique for determining the complex geological history of these deposits.

Process approximately 24 Sr samples from the major lithological units of the cores. Select from key stratigraphic samples different grain types (pelletal phosphorite grains, skeletal phosphorite grains, calcareous foraminifera and mollusc shell if present) and compare with the Sr-derived ages. From these different sediment components we can determine when the phosphorite formed, when it was reworked and finally when it was deposited.

From these results a geological / depositional model for the deposit integrating the strontium ages with the overall stratigraphy is to be written up.

iv) Primary Resources

The following cores can be provided for the assessment; they have been collected from ML 170. These are from shallow to deep as follows: 1364, 1397, 1384, 1441, 1442, 1478, 1479.

v) Note

The development of a depositional model for the deposits offshore and the use of Sr isotope ages could be fundamental to verifying / substantiating the chronology as currently determined for the phosphorite deposits offshore South Africa.

5.2.2.2 Dr R Carter: Terms of Reference

Verification Assessment
Sediment Properties and Water Column Features
Verification of Impacts in the proposed Mining Area ML 170

i) Need for Verification Assessment

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.

ii) Proposed Verification Survey

Scope

The verification survey will focus on:

- **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**);
    - If the CSIR methane detection system is operational methane concentrations in sediment pore water will also be measured.

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_2S 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.

- **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[1] 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.

---

[1] In common usage these are the same group of elements comprising the transition metals, metallic elements such as arsenic and cadmium and lanthanides.

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.

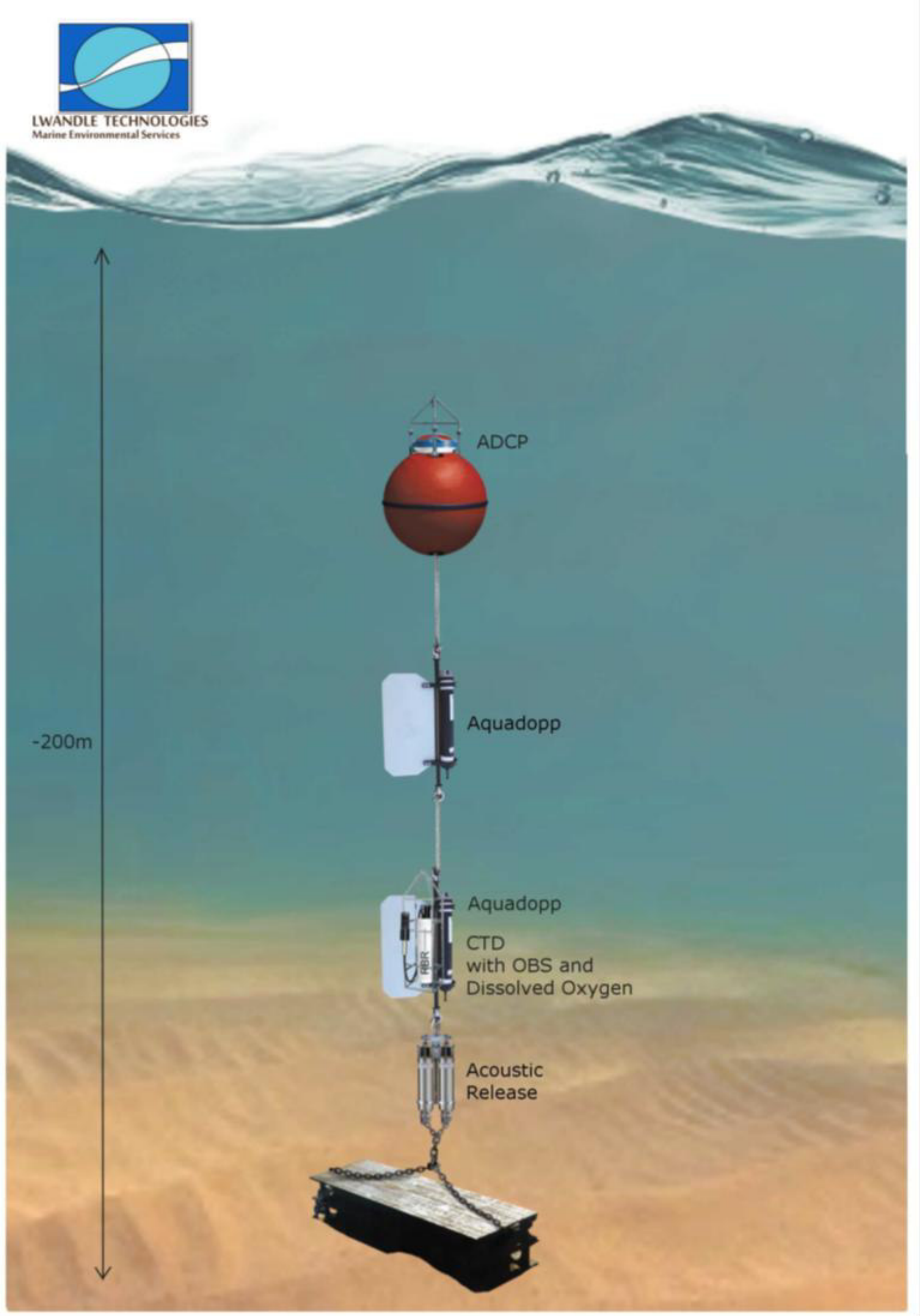

Figure 1: Schematic representation of ADCP, Aquadopp and CTD+DO+turbidity mooring to be deployed as part of the NMP verification survey.

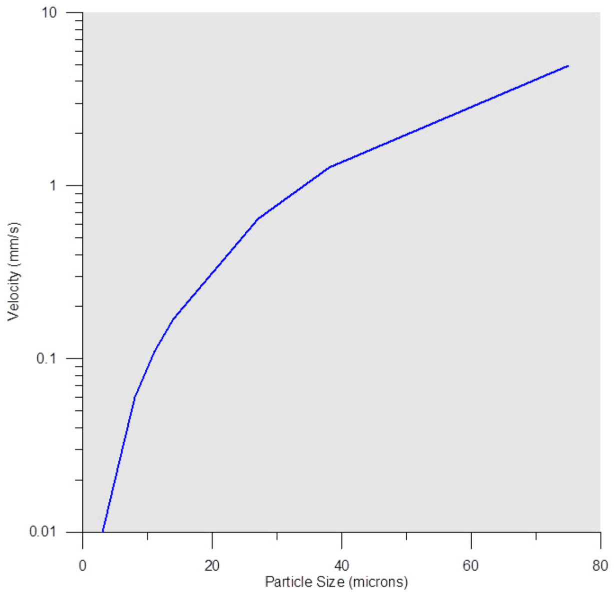

Figure 2: Sedimentation velocity for a range of fine grained sediment particle sizes as predicted by Stoke's Law.

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.

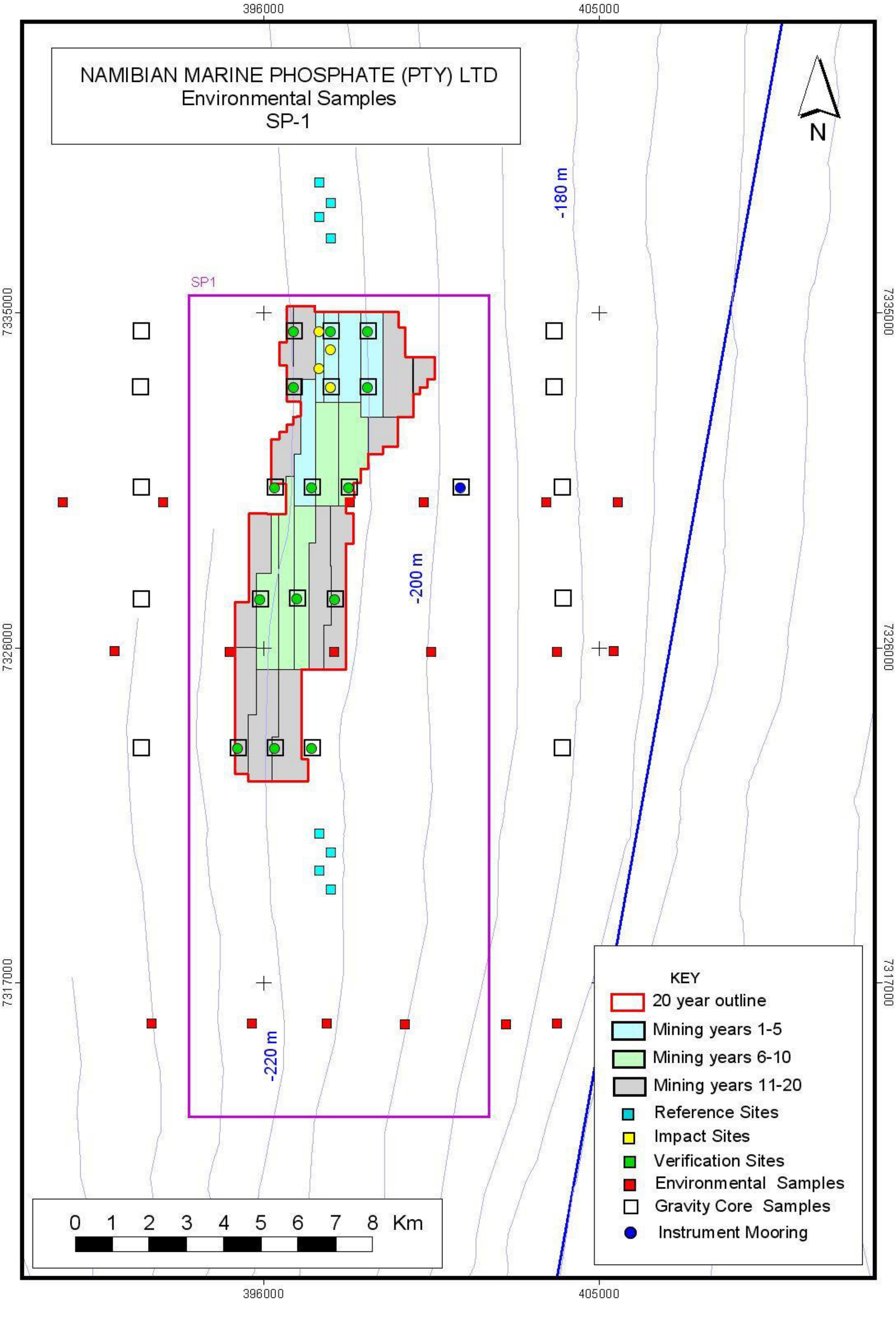

Figure 3: Provisional verification sampling sites in Dredge Area SP-1. Note that the verification survey sites are represented by black open squares. Green squares represent sites identified for benthos sampling (Steffani); additional sampling sites for the benthos monitoring programme are shown in yellow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

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 0m, 10m, 20m, 50m, 100m, 150m & 200m.

iii) Survey temporal coverage

Moored instrumentation

The planned duration for the moored instrumentation deployment (ADCP, Aquadopp, CTD+DO+Turbidity) is 90 days[2] 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 1st measurement period, if the mooring is not recovered at the service visit a duplicate set will be deployed giving coverage for the 2nd 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).

iv) 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

[2] 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.

- 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.

5.2.2.3 Mr D Japp: Terms of Reference

Verification Assessment
Fish, Mammals and Seabirds:
Verification of Impacts in the proposed Mining Area ML 170

i) Need for Verification Assessment

The Environmental Impact Assessment (EIA 2012) 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.

ii) Proposed 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 be 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 modeling 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 modeling 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.

iii) Terms of reference for proposed activities

1) Risk Assessment

It is proposed that appropriate modeling skills be sourced to undertake a mathematical risk assessment. To do this the following is needed (although the modeler 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:

i) Use the current models used to assess the key fish stocks in Namibia – hake, monk, horse mackerel and small pelagic;
ii) 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);
iii) 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 modelers 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.

iv) 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 1. *Note* : This is not intended to be prescriptive and will need refinement and discussion with marine scientists at NatMIRC.

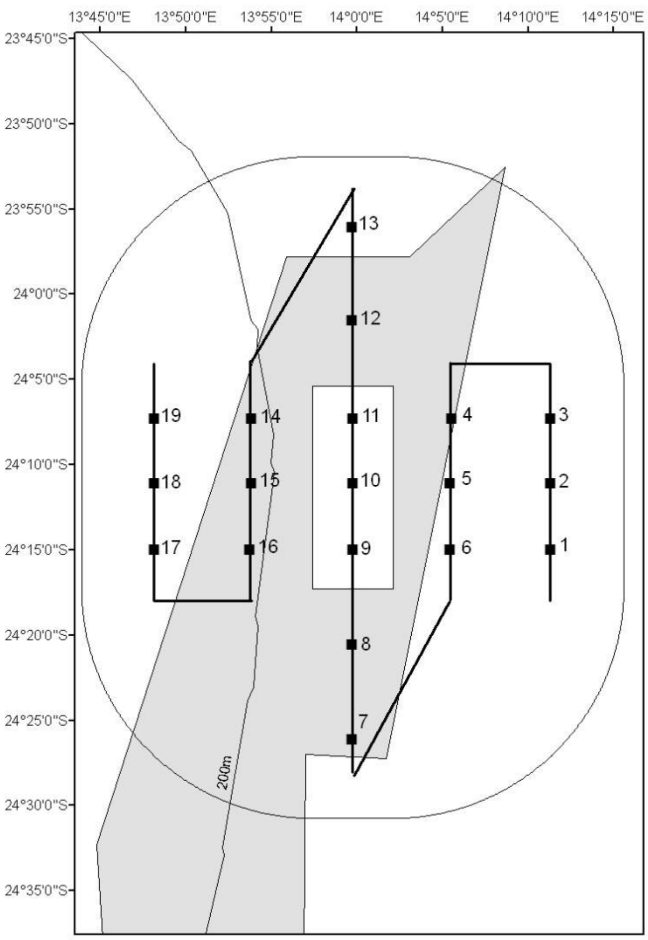

Figure 1 Location of survey stations in SP –1

Key elements of the survey are :

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.

v) Expected Outputs

I. 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);
II. Verification of relative species abundance in the area with the on-going and historical abundance estimates of the main commercial species;
III. 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;
IV. 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;
V. Length frequency measurements of the main species and sex ratios;
VI. Basic biological data collection on main commercial species including gonad staging for comparative spawning and recruitment indices;
VII. Use of digital photography to record species;
VIII. Deployment of CTDs (if an appropriate vessel is used) to determine essential water conditions (conductivity, temperature, depth).

vi) 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.

vii) 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.

viii) Adjustment

Verification Assessment

Adjustment Programme

for

Fish, Mammals and Seabirds

Verification of Impacts in the proposed Mining Area ML 170

CAPRICORN FISHERIES MONITORING
Reg. No. CK 99 / 24441 / 23
Unit 15 Foregate Square, Table Bay Boulevard, Cape Town, South Africa, 8002
P.O. Box 50035, Waterfront, Cape Town 8001
Tel/Fax : (021) 425 2161 Fax: 425 1994 Cell: 082 – 788 6737

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.

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

Dave Japp
CapFish cc

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

5.2.2.4 Dr N Steffani: Terms of Reference

Verification Assessment
Benthos

i) Need for Verification Assessment

Namibian Marine Phosphate (Pty) Ltd (NMP) has been awarded a 20-year mining licence (ML170), 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^2. 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 ML170 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 ML170 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.

ii) 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 ≤0.5ml/ℓ and typically impinge upon the continental margins of upwelling regions. Off Namibia, this layer extends between at least 18°S and 28°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 H_2S fluxes, occasionally resulting in H_2S eruptions with devastating effects on the local fauna. These natural events can spread over 20 000 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 ml/ℓ, but it is likely to be less affected by high H_2S 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 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 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_2 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.

iii) 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_2S 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?

iv) Survey Method and Design

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^2). 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_2S 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_2S 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^2 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 points 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.

v) 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 1 (a - c) illustrate the proposed layouts of the sampling stations in the three target areas SP-1, SP-2, and SP-3.

vi) 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 1(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.

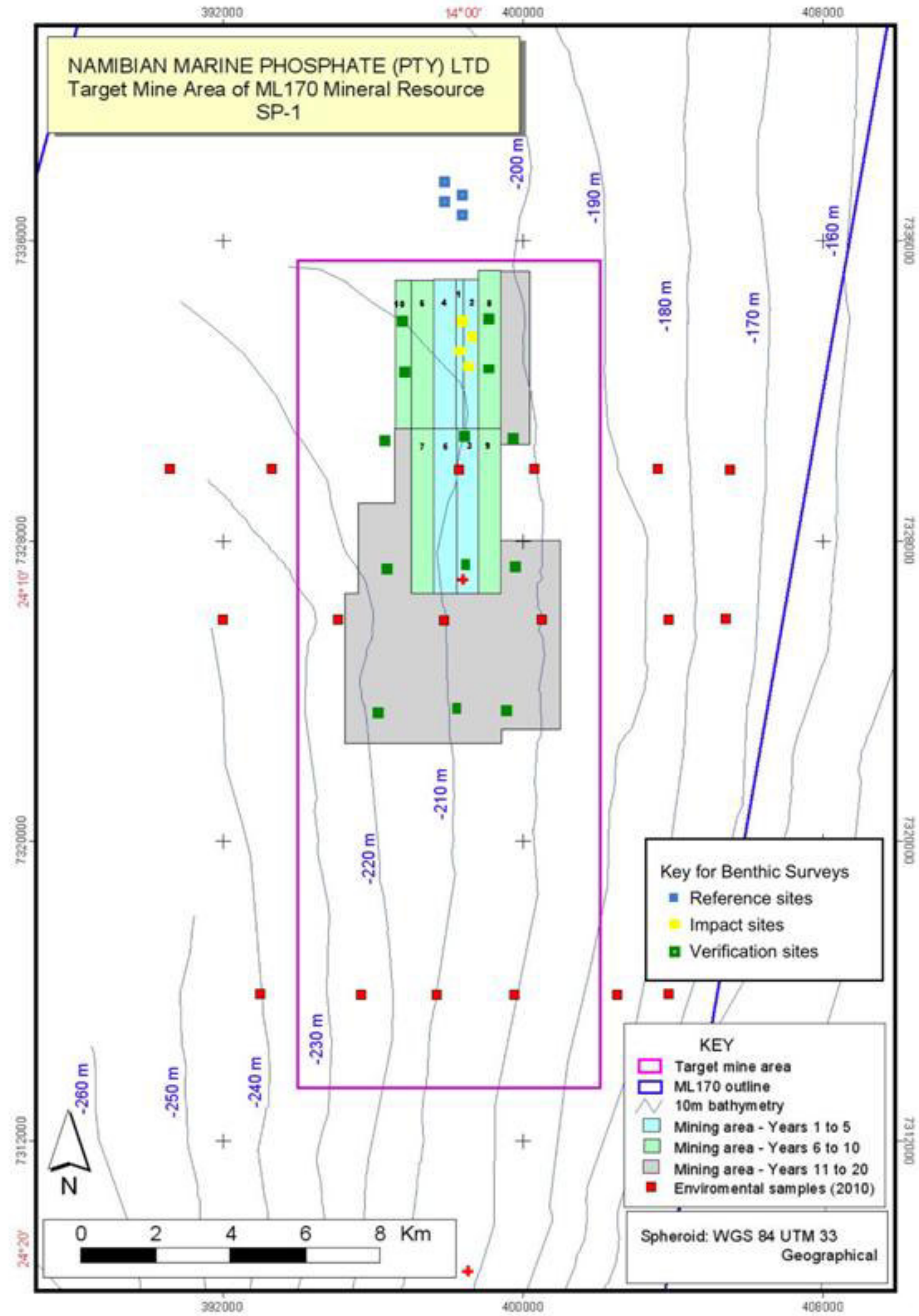

Figure 1 (a): Layout of macrofauna sampling stations for the verification and monitoring survey in SP-1.

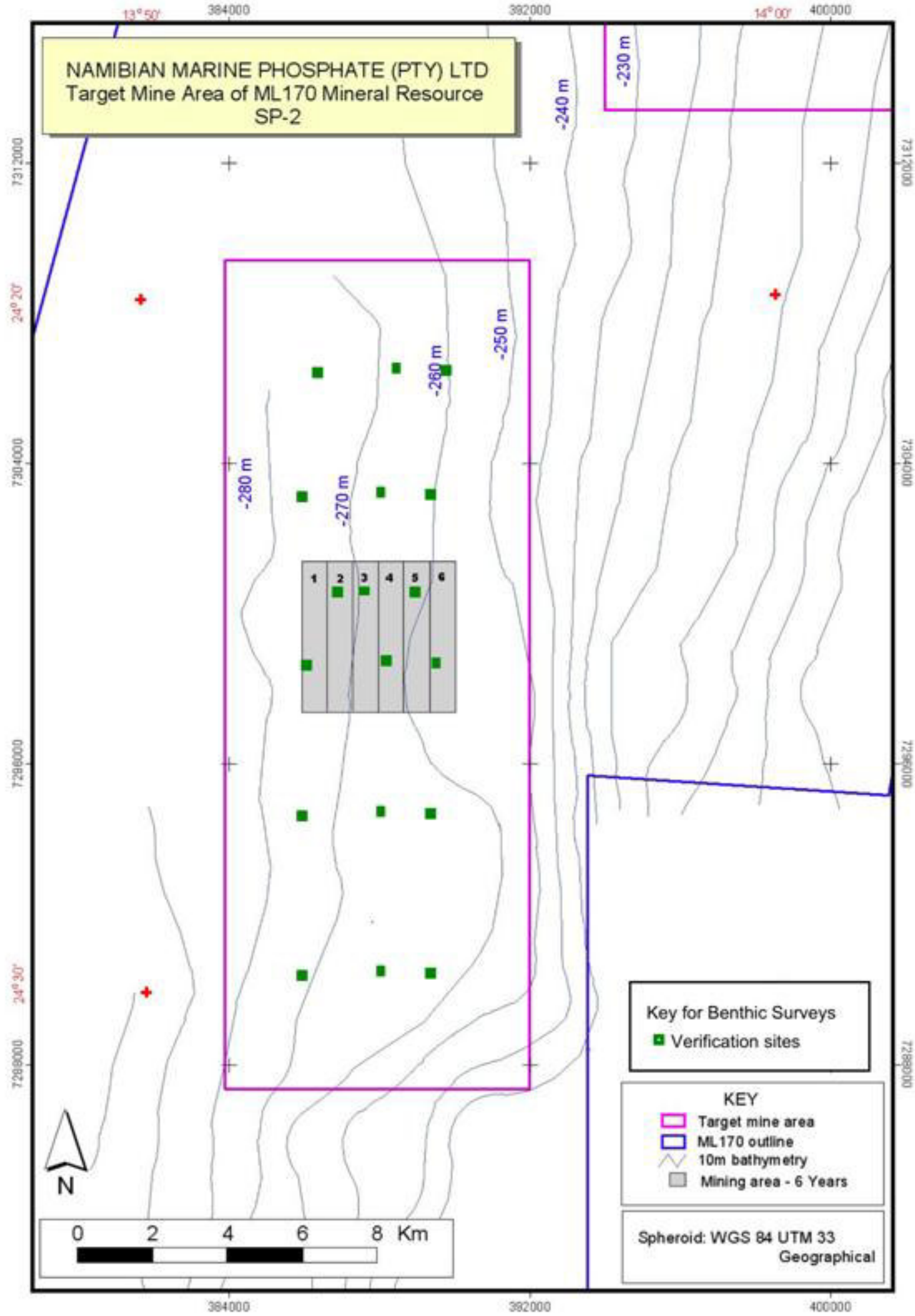

Figure 1 (b): Layout of macrofauna sampling stations for the verification survey in SP-2.

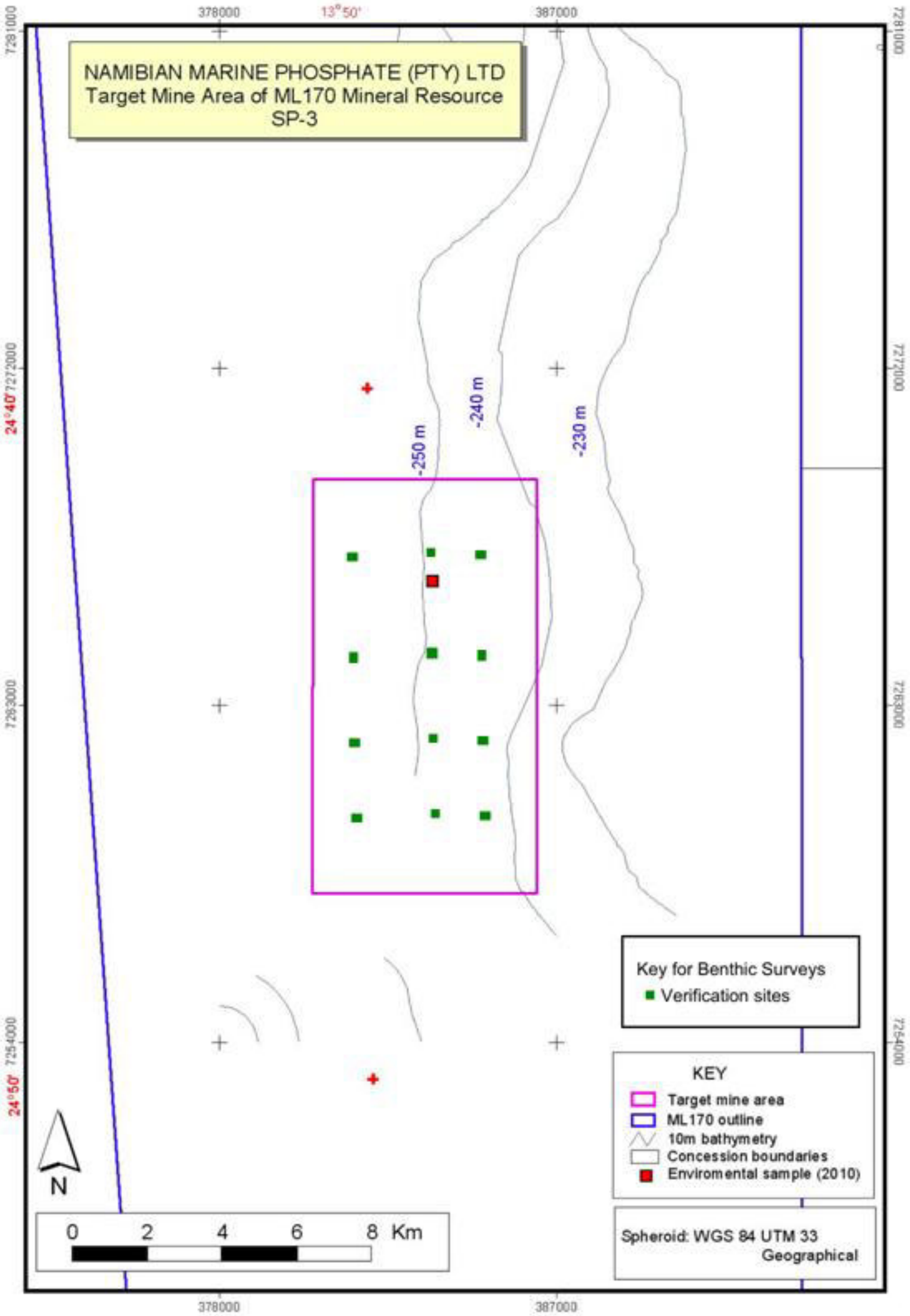

Figure 1 (c): Layout of macrofauna sampling stations for the verification survey in SP-3.

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 colonisation process after the dredging impact.

5.2.3 Project Coordinator

5.2.3.1 Mr J Midgley: Terms of Reference

Terms of Reference: Verification Survey
Project Management, Environmental Supervision and Consultation
Verification of Impacts in the proposed Mining Area ML 170

Scope of services required:

- Liaising with the Client's representative:
    - Provide regular progress reports;
    - Provide immediate deviation reports;
    - Confirm progressive budget utilisation;
    - Confirm timelines; and,
    - Participate / lead / present / report on any meetings that the client deems approximate, to any audience as required.
- Identifying and confirming specialist consultants and independent reviewers suitable to undertake the required tasks competently:
    - Ensuring that they are provided with review reports, and all documents of relevance so that they can provide an assessment in context;
    - Ensuring timeous delivery of their work;
    - Coordinate and facilitate a peer review (of the specialists' assessments) workshop when the individual reports are completed (final draft); and,
    - Ensure that the appointed independent reviewers provide reports covering the scope of their assessments.
- Project management including:
    - Management of all appointed specialist consultants;
    - Management of respective scope of works;
    - Meeting of the agreed timelines of delivery;
    - Obtaining budgets for work to be undertaken;
    - Managing the respective budgets;
    - Optimising the work done by each of the specialist consultants and coordinating work modules between them; and,
    - Managing, producing, compiling an integrated verification study report.
- Environmental services
    - Providing an overall assessment of the impacts of the project based on the findings of the individual specialist studies and any peer / independent reviews undertaken; and,
    - Assessing habitat conditions from input data.
- Logistics, for the various marine surveys:
    - Obtain quotes and options for vessels, insurance and related transfer of equipment, samples and personnel across all disciplines; and,
    - Manage all budgets related to such.
- Travel and participate;
    - In marine cruises, acting as the client's representative.
- Payment approvals
    - Approve all consulting parties' invoices, verifying that work done, matches the scope of work agreed to be undertaken.
- Final report:
    - This must consist of:

        - A verification programme report, with appendices;
        - A executive summary (standalone);
        - Independent reviewers report; and,
- These reports must be provided in a high quality finish.
- Adjustments: advise client and provide reasons for any adjustments in respect of:
    - Time lines; and,
    - Budgets.