

APPENDIX 1 - WATER COLUMN AND SEDIMENTARY ENVIRONMENT

1.2 Cruise Report: Verification Survey MV DP Star

NAMIBIAN MARINE PHOSPHATE

VERIFICATION SURVEY

CRUISE SUMMARY REPORT

Prepared for:

Namibian Marine Phosphate (Pty) Ltd.

Prepared by:

Lwandle Technologies (Pty) Ltd.
Report compiled by Andrew Russell



4 September 2013

Job no: 149

LWANDLE TECHNOLOGIES (PTY) LTD
The Old Warehouse, Black River Park, Fir Road, Observatory 7925, South Africa
Directors: C.P. Matthysen, B.J. Spolander
Co Reg. No. 2003/015524/07

SECTION D, APPENDIX 1 - WATER COLUMN AND SEDIMENTARY ENVIRONMENT
1.2 Cruise Report: Verification Survey MV DP Star

MARINE SPECIALIST TEAM

Robin Carter – Lwandle Technologies, Cape Town
Andrew Russell – Lwandle Technologies, Cape Town
Henry Gilham – Lwandle Technologies, Cape Town
Timothy McClurg – Lwandle Technologies, Cape Town
Sunette Gildenhuys – Metocean Services International

Date	Version	Revised	Reviewed
20/08/2013	1	Andrew Russell	Kate Munnik
2/09/2013	2	Andrew Russell	Jeremy Midgley
04/09/2013	3	Andrew Russell	Kate Munnik

CONDITIONS OF USE OF THIS REPORT

COPYRIGHT © NAMIBIAN MARINE PHOSPHATE (PTY) LTD 2014

ALL RIGHTS RESERVED

© NMP 2014. All rights to the intellectual property and/or contents of this document remain vested in Namibian Marine Phosphate (Pty) Ltd. (NMP). This document is issued for the sole purpose for which it is supplied. All rights reserved. No part of this publication may be reproduced, distributed, or transmitted in any form or by any means, including photocopying, recording, or other electronic or mechanical methods, without the prior written permission of Namibian Marine Phosphate (Pty) Ltd, except in the case of brief quotations embodied in critical reviews and certain other non-commercial uses permitted by copyright law. For permission requests, write to Namibian Marine Phosphate (Pty) Ltd, addressed "Attention: Administration Manager," at the address below.

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

contents

1	INTRODUCTION	1
2	WORK CARRIED OUT	1
2.1	SAMPLING SCHEDULE	1
2.2	SAMPLING ROUTINE	5
2.2.1	<i>Sediment grabs</i>	5
2.2.2	<i>Water column profiling and sampling</i>	8
2.3	VARIATION TO METHODS	9
2.4	LESSONS LEARNT	9
2.5	SAMPLE PROCUREMENT AND ANALYSIS	10

figures

Figure 2.1:	The verification sampling stations.	4
Figure 2.2:	Example: Detail of site sample label	5
Figure 2.3:	Wilsons autosiever used for sorting benthic samples.	7
Figure 2.4:	Shell debris left over after sieving on the 3 mm sieve.	7
Figure 2.5:	Hydrobios multiple water sampler and CTD deployment	9
Figure 2.6:	Scientific survey team	10

tables

Table 2-1:	Summary of the sampling completed on the verification and buoy sites:	2
Table 2-2:	Summary of the sampling of the monitoring sites:	3

1 INTRODUCTION

Prior to the commencement of dredging activities involved in the recovery of phosphates from the Sandpiper-1 (SP-1) marine deposit off the Namibian coast, Namibian Marine Phosphate (NMP) commissioned a marine 'verification survey' which was undertaken by Lwandle Technologies. This verification survey was carried out from the vessel MV *DP Star* from the 24th of July until the 4th of August 2013. This component of the marine survey focused on the sampling of sediments and the water column at the verification sites and monitoring sites (identified as reference and impact sites) situated across the NMP Mining Licence Area, with specific reference to the primary dredge target area SP-1. Due to adverse weather conditions the collection of benthos samples from secondary dredge targets SP-2 and SP-3, which fall outside the planned 20-year mine plan, could not be undertaken.

On completion of this component of the verification assessment Lwandle Technologies, through the review of Dr Robin Carter, will provide an evaluation of the impacts of the proposed dredging activities on the marine environment.

The details of the survey plan and sampling methods are described below.

2 WORK CARRIED OUT

2.1 SAMPLING SCHEDULE

The Lwandle team arrived in Walvis Bay on Tuesday 23rd July 2013, and boarded the vessel MV *DP Star* on Wednesday 24th July 2013. Sampling commenced at location SP1VS15 (mooring site) on the 26th of July, after being delayed by bad weather. It was also at this site that the Metocean Services International (MSI) buoy and instrument string was recovered successfully. The buoy and instrument string was successfully redeployed on the 2nd of August. Over the next 9 days a total of 38 sites were sampled. Out of these sites, 6 comprised CTD and rosette deployments as well as Day grab deployments. The remainder (32) were solely Day grab deployment sites, where benthic sediment samples were collected.

Before the survey could begin the GOMEX box corer was trialled to test whether it could retrieve samples of adequate volume and composition. It was first trialled twice at SP1VS15, which was known to be consolidated sediment and then twice at SP1VS01, an area of supposedly soft sediment. It failed on all four attempts. From this point onward the Day grab was used to collect sediment samples, as specified in the Project Execution Plan (PEP). This method ensured sample collection uniformity, allowing for subsequent sample analysis standardisation and conformity. The box corer was again trialled (3 deployments) at SP1VS12, and again failed to retrieve samples of adequate volume and composition.

In order to standardise sample collection and storage the Lwandle team worked as a unit for the first 2 working days of the survey. This also helped to familiarise the guests and independent observers from the University of Namibia with the sampling procedure. Subsequently, a 24-hour schedule divided into 8 hour shifts was initiated.

SECTION D, APPENDIX 1 - WATER COLUMN AND SEDIMENTARY ENVIRONMENT
1.2 Cruise Report: Verification Survey MV *DP Star*

The sampling requirements of SP-1 were met and all samples were recovered and stored successfully.

The breakdown of the executed daily activities for the cruise is provided below (Table 2-1).

Table 2-1: Summary of the sampling completed on the verification and buoy sites:
Environmental survey of SP-1 (24th July - 4th August 2013).

DATE	Sampling Sites	Activities at site
	VERIFICATION SITES	
26-Jul-13	SP1VS01	benthos grab (Day grab)
27-Jul-13	SP1VS02	benthos grab
27-Jul-13	SP1VS03	benthos grab
28-Jul-13	SP1VS04	benthos grab + CTD and rosette
27-Jul-13	SP1VS05	benthos grab
26-Jul-13	SP1VS06	benthos grab
27-Jul-13	SP1VS07	benthos grab
27-Jul-13	SP1VS08	benthos grab
28-Jul-13	SP1VS09	benthos grab + CTD and rosette
27-Jul-13	SP1VS10	benthos grab
26-Jul-13	SP1VS11	benthos grab
27-Jul-13	SP1VS12	benthos grab
27-Jul-13	SP1VS13	benthos grab
30-Jul-13	SP1VS14	benthos grab + CTD and rosette
27-Jul-13	SP1VS16	benthos grab
30-Jul-13	SP1VS17	benthos grab
30-Jul-13	SP1VS18	benthos grab
31-Jul-13	SP1VS19	benthos grab
30-Jul-13	SP1VS20	benthos grab + CTD and rosette
31-Jul-13	SP1VS21	benthos grab
30-Jul-13	SP1VS22	benthos grab
30-Jul-13	SP1VS23	benthos grab
31-Jul-13	SP1VS24	benthos grab
30-Jul-13	SP1VS25	benthos grab + CTD and rosette
31-Jul-13	SP1VS26	benthos grab
	Buoy - mooring site	
26-Jul-13	SP1GC15	benthos grab + CTD and rosette
26-Jul-13	SP1GC15	Recovery of MSI buoy
02-Aug-13	SP1GC15	Redeployment of MSI buoy

SECTION D, APPENDIX 1 - WATER COLUMN AND SEDIMENTARY ENVIRONMENT
1.2 Cruise Report: Verification Survey MV *DP Star*

Table 2-2: Summary of the sampling of the monitoring sites:

Environmental survey of SP 1 (24th July - 4th August 2013).

	REFERENCE SITES (north)	
31-Jul-13	SP1RS01	5x benthos grab
31-Jul-13	SP1RS02	5x benthos grab
01-Aug-13	SP1RS03	5x benthos grab
01-Aug-13	SP1RS04	5x benthos grab
	IMPACT SITES	
01-Aug-13	SP1IS01	5x benthos grab
01-Aug-13	SP1IS02	5x benthos grab
02-Aug-13	SP1IS03	5x benthos grab
02-Aug-13	SP1IS04	5x benthos grab
	REFERENCE SITES (south)	
31-Jul-13	SP1RS05	5x benthos grab
02-Aug-13	SP1RS06	5x benthos grab
02-Aug-13	SP1RS07	5x benthos grab
03-Aug-13	SP1RS08	5x benthos grab

SECTION D, APPENDIX 1 - WATER COLUMN AND SEDIMENTARY ENVIRONMENT
1.2 Cruise Report: Verification Survey MV *DP Star*

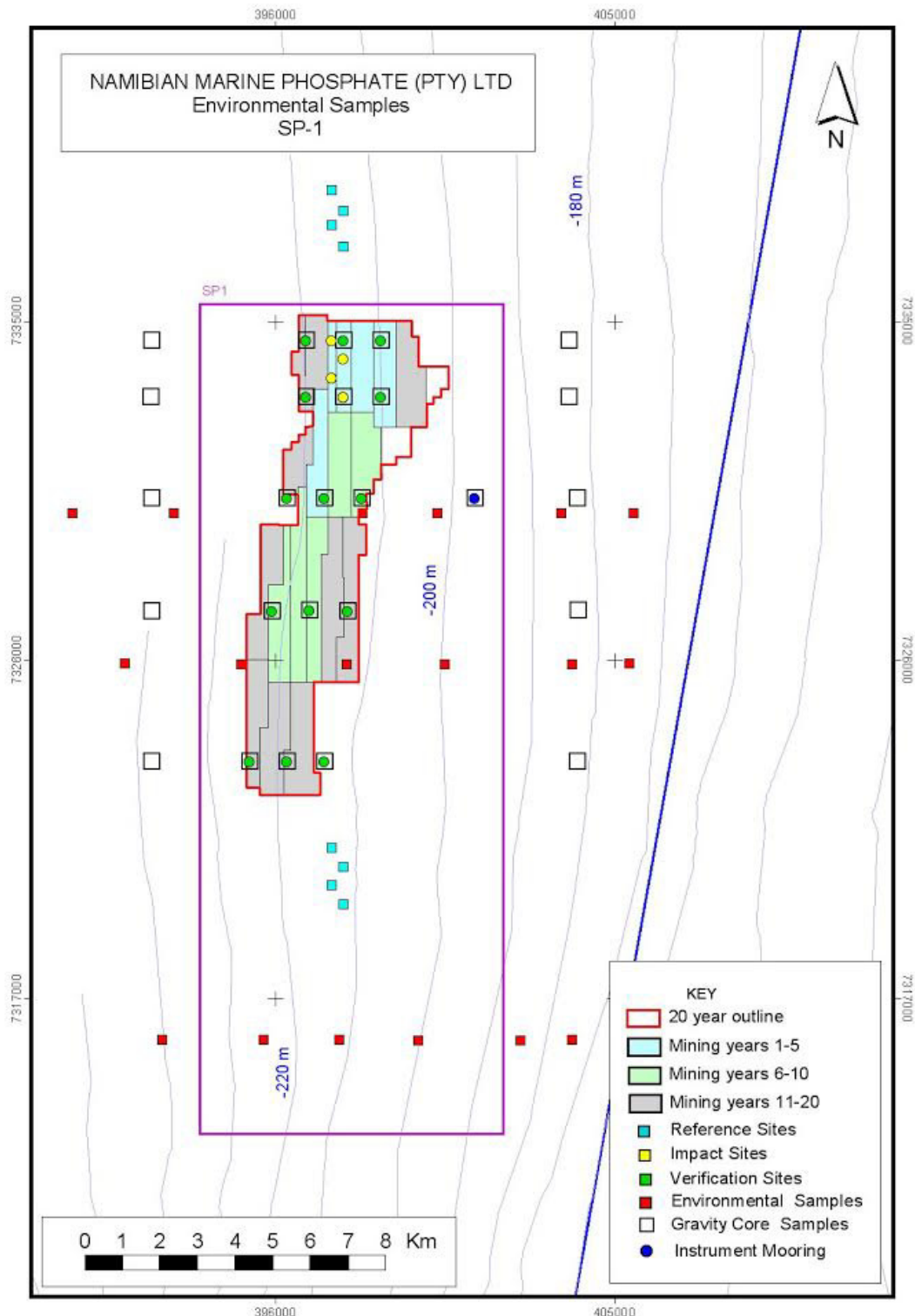


Figure 2.1: The verification sampling stations.

SECTION D, APPENDIX 1 - WATER COLUMN AND SEDIMENTARY ENVIRONMENT
1.2 Cruise Report: Verification Survey MV DP Star

At the clear squares a single benthos grab was taken. The clear squares with green dots indicate sites where macrofauna samples were collected from single benthos grabs. The clear square with the blue dot represents the site where the mooring was recovered and redeployed. The light blue squares north and south of the verification sites represent the reference sites. The yellow dots at the north of the verification sites represent the impact sites. The reference and impact sites make up the monitoring sites that will be used in future surveys.

2.2 SAMPLING ROUTINE

Before each shift a toolbox meeting was held and the activities that needed to be completed in that shift were discussed. This included a handover discussion between the respective teams.

2.2.1 Sediment grabs

Following the failure of the GOMEX box corer to recovery samples, the Day grab was used at all sites to collect benthos samples. The grab was attached to a winch and was lowered down through the water column until the cable went slack, indicating that the grab had reached the bottom. The grab was then brought back onto the vessel. Grabs that were less than 40% full were regarded as failed. When a failed grab occurred the grab was redeployed at the same site until an adequate sized sample was collected. On retrieval of each grab, the following procedures were followed:

Physical analysis (on all grabs):

The fullness of the grab was estimated and the space remaining between the upper level of sediment and the lid of the grab was also noted. This number can be used to convert the fullness of the grab into actual volume of sediment, using the dimensions of the Day grab. A photograph was then taken of the surface of the sediment within the grab. This photograph included a detailed label (site number, date and where needed a replicate number) as well as a scale object (the label size remained the same throughout the survey). The label was written on white paper, which serves as a colour comparison between the different sediment samples. The colour of the sediment within the grab was noted. All necessary information was recorded on datasheets provided in Appendix 1.1, Annexure 3.



Figure 2.2: Example: Detail of site sample label (site number, date and where needed a replicate number).

SECTION D, APPENDIX 1 - WATER COLUMN AND SEDIMENTARY ENVIRONMENT
1.2 Cruise Report: Verification Survey MV *DP Star*

Chemical, metal and particle size analysis:

Two benthos samples, which would be later used to analyse the chemical, metal and particle size composition of the sediment, were taken at each of the verification, reference and impact sites.

Using a 50 mm plastic tube a core of the benthos was sampled and stored in a pre-labelled 375 ml glass jar, which was then placed in the freezer. This sample would be used for analysis of organic substances. The field team were careful to allow enough headspace in each of the glass bottles to ensure they did not crack when frozen.

The same method was used to collect a 750 g subsample to be used in the metal and particle size analysis. The first core for this sample was used to record the ORP (Oxygen Redox Potential) reading. This was done by using a 50 mm tube with a hole 8 cm from the bottom. Before the tube was inserted into the benthos the hole was covered with duct tape. When the core was recovered the tape was removed and a clean syringe was quickly inserted into the hole. The benthos that filled the syringe was removed and upon the syringe leaving the hole the ORP probe was inserted. The probe had a line of Vaseline petroleum jelly approximately 3 cm from the tip to create a seal when inserted into the tube. The reading was recorded on the data sheet. After 750 g of sample was collected, the sample was placed into a pre-labelled plastic Ziploc bag before being placed into the on-board freezer.

As soon as the sub-sampling from each grab was finished, the necessary details were recorded on the datasheets.

Meiofauna analysis:

A subsample of the sediment from each grab was taken with a 50 mm plastic tube and stored in a pre-labelled 250 ml honey jar. This sample was fixed in 10% neutralised formalin and stored in a black crate out of direct sunlight. The amount of formalin added to the container was equal to the volume of seawater already present in (or on top of) the sample, this then resulted in a final formalin concentration of ~4-5 %.

Note: A quarter of the grab was used to collect chemical, metal and particle size, and meiofauna samples. The other three quarters were used for the macrofauna sample.

Macrofauna analysis

A 5 ℓ subsample was taken from the grab using a series of 75 mm plastic tubes. These tubes were used as cores to subsample the benthos. This method ensured a controlled representative sample of the surface and the deeper layers of the sediment were collected. This method of sampling was problematic when the sediment was loose (watery) as the sediment moved into the areas that had already been sub-sampled.

The 5 ℓ subsample was then placed into the Wilsons autosiever (Figure 2.3). The autosiever had two tiers of sieves, which were placed above the incoming seawater jets. The top sieve had an aperture of 3 mm (Figure 2.4) and the bottom sieve had an aperture of 300 µm (Recommended by N. Steffani, as part of the evaluation of optimisation on subsequent monitoring assessment protocol). A hand held hosepipe was used to wash the sediment from above. At first the entire sample was placed on the top sieve. It was soon noticed that this method caused the bottom sieve to clog. The sample was then added in small amounts to ensure that the bottom sieve did not clog.

SECTION D, APPENDIX 1 - WATER COLUMN AND SEDIMENTARY ENVIRONMENT
1.2 Cruise Report: Verification Survey MV *DP Star*

Great care and time was taken to wash the sediment thoroughly. The shells in the sample were meticulously washed and only once all sediment had passed into the 300 μ m were these discarded. The 3 mm sieve was then checked for any fauna that were stuck on the mesh.

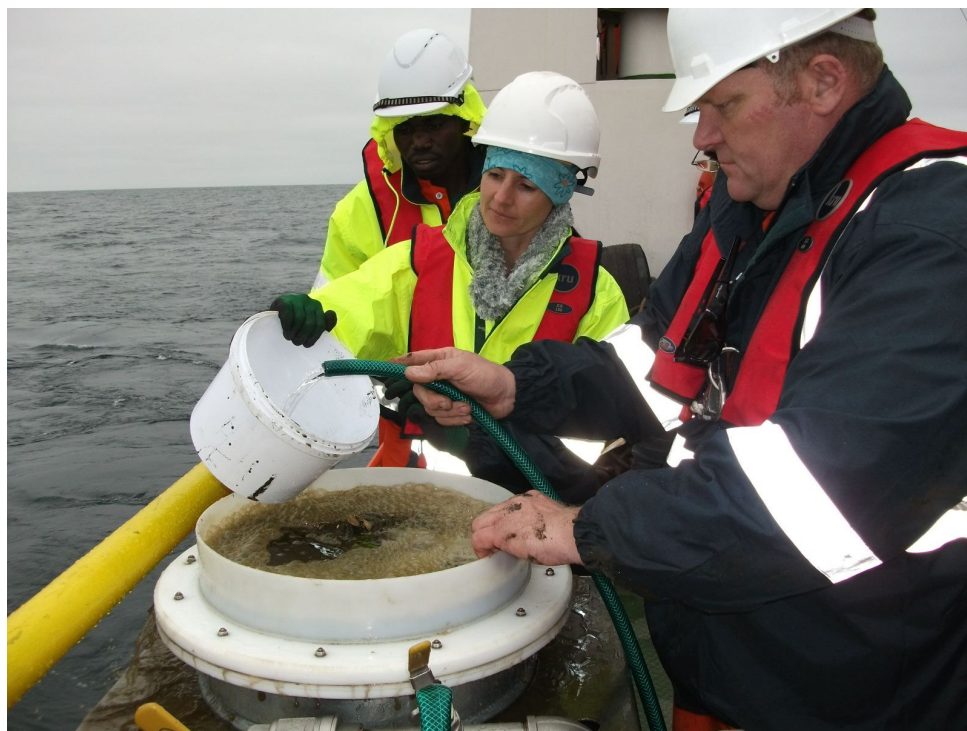


Figure 2.3: Wilsons autosiever used for sorting benthic samples.



Figure 2.4: Shell debris left over after sieving on the 3 mm sieve.

During sieving of the sediment used for the macrofauna sample any organisms that were found were placed in a separate container using forceps. 3 to 4 plastic containers were used to store each macrofauna sample. All macrofauna samples were fixed with 10% neutralised formalin. The amount of formalin added to the container was equal to the volume of seawater already present in (or on top of) the sample, this then resulted in a final formalin concentration of ~4-5 %.

2.2.2 Water column profiling and sampling

Sampling of the water column was achieved by using a Hydrobios multiple water sampler (rosette), which had a RBR CTD attached to it (Figure 2.5). This equipment was attached to the winch cable and lowered through the water column at a rate of $\sim 5 \text{ m.s}^{-1}$ to a depth of approximately 200 m (the water depth varied between sites). It was brought up to the surface at $\sim 5 \text{ m.s}^{-1}$ and only once it was stable and secured to the vessel, was the water collected from the Niskin bottles and the data downloaded.

Each time this equipment was used, the time and details of the equipment were recorded on recovery and deployment sheets, see Appendix 3.

Water sampling (Hydrobios multiple water sampler)

Before each deployment the on-board computer was programmed and the trigger depth for each individual Niskin bottle was set. The Niskin bottles were set and the taps were checked and closed. The multiple water sampler was tracked on descent and ascent using a Fuduro fish finder transducer and a sonar bell transmitter. This allowed the Lwandle technician to know the depth of the sampler in real time. Once it had reached the unlocking pressure depth it was brought back up through the water column at $\sim 5 \text{ m.s}^{-1}$.

On retrieval the multiple water sampler was securely set on the deck and the water from each Niskin bottle was sampled. After the dissolved oxygen and pH readings were taken the 1 ℓ, 250 ml, and 150 ml containers were filled (in that order). Each sample bottle was thoroughly rinsed with water from the associated Niskin before being filled with sampled water. The 1 ℓ bottles were stored in black crates out of direct sunlight, while the 250 ml and 150 ml bottles were stored in the freezer.

Once sampling was complete, the multiple water sampler was removed from the aft deck and placed close to the work station. It was then connected to the field laptop and the data were downloaded and saved. These data were later saved to an external hard drive.

Water column profiling (CTD)

The CTD was programmed, using Ruskin software, to sample the water column at a given frequency and for a set period. After deployment and recovery the data stored by the CTD was downloaded using the software Ruskin. This was later saved to an external hard drive.

All necessary information was recorded on datasheets provided in Appendix 1.1, Annexure 3.

SECTION D, APPENDIX 1 - WATER COLUMN AND SEDIMENTARY ENVIRONMENT
1.2 Cruise Report: Verification Survey MV *DP Star*



Figure 2.5: Hydrobios multiple water sampler and CTD deployment

2.3 VARIATION TO METHODS

Variations to the intended sampling methods had to be made to ensure completion and consistency of the sampling set across the target sampling area – SP-1. This was primarily due to the use of the Day grab, following the failure of the GOMEX box corer to penetrate the shell-rich marine sediments. It was found to be difficult to subsample using “vertical” cores from the Day grab when using the 75 mm tubes. To ensure that the recommended 5 ℓ of benthos was obtained the subsamples were taken at an angle so that at least ± 10 cm of sediment could be collected at a time. In the case of very wet samples the tubes were used to scoop the sediment out of the grab. Even though there were variations in the benthos sampling method the surface and the bottom layers of the grab were always sampled.

2.4 LESSONS LEARNT

- The volume of sediment needed to be stored for macrofauna analysis was significantly more than estimated, this being due to the retention of sediment by the 300 μ m sieve. This led to the plastic storage containers being used up very quickly. For the next cruise 1 ℓ - 1.5 ℓ containers should be used for storage of macrofauna samples.
- The lighting on deck was not sufficient to sieve at night. Fortunately we had a head torch that made it possible for us to work at the auto-siever throughout the night.
- The ORP reading varied between samples and because of this we feel that the reading may not have given a representative measurement of the oxygen redox potential. It is possible to measure the concentration of nitrates in the pore water of the samples at the CSIR laboratories. This information can then be used to indirectly calculate the concentrations of sulphide in the pore water.
- We had difficulty detecting the location of the multiple water sampler once it had been lowered past a depth of approximately 180 m. To ensure this problem does not occur again we have looked into using a stronger transducer head.

2.5 SAMPLE PROCUREMENT AND ANALYSIS

All collected samples were clearly labelled and stored in the appropriate storage containers. On arrival back into Walvis Bay the cargo was offloaded and stored at Manica Freight Services.

The equipment and unfrozen samples were transported back to the Lwandle offices on the 16th of August 2013. On the same day the frozen samples were delivered to the CSIR (Stellenbosch) where they were offloaded and stored in another freezer.

The samples have since been grouped according to importance of the associated analyses. The “Key samples” are those that need to be analysed first. This group is made up of the samples taken from the verification sites found in row 2 and column 4.

The balance of the verification sites make up the next most important group, while the monitoring sites (reference and impact sites) make up the final set and will be analysed last.

The macrofauna samples have been sorted, grouped and delivered to Professor Mark Gibbons of the University of the Western Cape for pre-analysis screening.



Figure 2.6: Scientific survey team