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<td>Laura Weston</td>
<td>Sue Lane, Raissa Philibert, Robin Carter</td>
<td>Robin Carter</td>
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Disclaimer:

Any opinions, findings, conclusions or recommendations expressed in this report are those of the authors and do not necessarily reflect the views of the Benguela Current Convention and/or the Ministry of Foreign Affairs, Norway.
ABOUT LWANDLE

Lwandle Technologies (Pty) Ltd contracted by the Benguela Current Convention (BCC) to [provide the nature of the contract and work]

Lwandle has taken all necessary steps to collect data and information necessary to make findings, conclusions and recommendations contained in this report. The findings, conclusions and recommendations contained herein are based on the data and information that was available at the time.

Any opinions, findings, conclusions or recommendations expressed in this report are those of the authors and do not necessarily reflect the views of the Benguela Current Convention.

Authors: Raissa Philibert*, Laura Weston*, Sue Lane, Robin Carter, Kate Dodds, Diandra Kuyler, Lisa Holton

* Equal Contribution.

Lwandle Technologies (Pty) Ltd is a 57% black owned, BB-BEE company launched on 1 November 2003. It brings together a management team with over 50 years of experience in the field of physical oceanography, marine ecology, marine biology and biogeochemistry.

- An ISO 9001 certification from SGS Systems & Services Certification for professional services ensures Lwandle’s commitment to provide high levels of customer satisfaction with an effective system that pass the rigours of an independent, external audit.
- Lwandle provides multifaceted capabilities and provides services that include physical MetOcean measurements, Marine/estuarine water & sediment quality assessments, Marine/ coastal ecological and biological survey and measurement, Marine and coastal aquaculture development, Hydrographic surveys, Marine environmental monitoring, and provision of specialist studies in these disciplines to Marine and coastal Environmental Impact Assessments and Management Plans.
- Lwandle is also involved in the sales and maintenance of oceanographic instrumentation and has trained technical personnel to assist clients with all aspects of marine instrumentation and applications.
- With access to the latest state of the art equipment and use of approved environmental assessment procedures, Lwandle provides professional, cost effective solutions in response to our clients’ needs.

Our mission is to work together to properly apply science in realizing opportunity in the marine environment responsibly. We apply science rigorously, obviously building on the excellence of others and never taking shortcuts. We are insatiably curious so we get out into the environment and we strive to find even better ways of getting things done.
EXECUTIVE SUMMARY

The aim of this project is to support Member States (Angola, Namibia and South Africa) of the Benguela Current Convention (BCC) in setting up monitoring programmes at various hotspot locations, so that appropriate mitigation measures and procedures for the prevention and abatement of pollution can be developed by the authorities concerned. The information presented in this final report summarises the findings from the process followed by Lwandle to develop a comprehensive plan for pollution monitoring at hotspot locations within the Benguela Current Large Marine Ecosystem (BCLME).

As a first step, potential pollution hotspots in the BCLME were identified based on the location of pollution sources such as dredging in ports to domestic waste water treatments and activities such as mining and petroleum activities. The pollution hotspots in South Africa include: Nelson Mandela Bay metropolitan area, Knysna, Mossel Bay, Hermanus, Cape Town, False Bay, Saldanha Bay, St Helena Bay, Port Nolloth, and Alexander Bay. In Namibia, the pollution hotspots include: Oranjemund, Luderitz, Walvis Bay and Swakopmund. The pollution hotspots in Angola are: Namibe, Benguela and Lobito, Luanda, Ambriz, Soyo, and Cabinda. The list of hotspots may be revised as more information regarding pollution sources within each Member country becomes available.

The monitoring needs, monitoring capabilities and existing monitoring programmes were identified through stakeholder engagement as well as a desktop search. The stakeholder engagement included the distribution of questionnaires as well as a training workshop conducted in Windhoek in May 2017. The similarities between the pollution sources and effects in all hotspots across the three Member States of the BCC emphasised the need for an integrated and standardised approach to pollution monitoring throughout the BCLME. This led to the development of a two-phased monitoring programme.

Phase 1 monitoring is more descriptive in nature, with fewer sampling sites and only a small number of selected indicators. The objective of this monitoring phase is to provide data on the pollution status of a hotspot and serves only to identify whether pollution is present or not, and whether its presence results in an ecological effect. Contaminant indicators within the sediment and the benthic community structure as well as plastics on beaches are included in Phase 1 monitoring.

Measurements of contaminants within biological tissue are only prescribed if there is an absence of sediment depositional areas within a hotspot. In this case, biological tissue sampling can be undertaken in place of sediment sampling. All Phase 1 monitoring is to be conducted on an annual basis at one selected site within each hotspot for all indicators with the exception of beach litter. The latter is to be monitored twice a year.

Phase 2 monitoring is more investigative in nature, and is intended to be implemented after a number of years of Phase 1 monitoring, and only after a significant pollution effect has been identified and trends in increasing pollution have been observed (stipulated thresholds have been exceeded and an ecological or health response has been identified). Phase 2 monitoring is intended
to be more extensive than the Phase 1 monitoring, and survey design is to be decided on a case by case basis. An annual report detailing the pollution status of each hotspot is recommended. The results from these reports will be used to decide whether to escalate the hotspot pollution monitoring from Phase 1 to Phase 2. Additionally, management decisions, if required, can be based on these reports.

Throughout the process of the development of the monitoring plan and the various steps involved in determining the applicability of the plan to each of the hotspots, a number of recommendations have come to light. These recommendations will assist in the future implementation of the programme in the BCLME and ultimately summarise the way forward for the BCC. These can be summarised as follows:

- To ensure the sustainability and achievability of the proposed pollution monitoring plan, it is recommended that the measurement and analysis of the Phase 1 indicators be integrated into existing monitoring programmes within each hotspot as far as possible.
- As a next step to this plan, a pollution-specific implementation strategy needs to be developed by the BCC, to guide the actions that need to be taken by the BCC and relevant Member States.
- In order for the monitoring to be implemented, pollution committees need to be formed in each Member state. These committees are to meet annually and consist of a range of governmental and non-governmental institutions with expertise in pollution monitoring.
- A data management system and appropriate structures within each Member State need to be developed, and possibly can be integrated into the existing data management project being run by the BCC.
- To facilitate the regional coordination of data management and allow for data sharing, a data sharing policy needs to be developed within each country.
- In terms of the implementation of the monitoring itself, hotspots need to be prioritised. This will allow for countries to allocate resources more easily.
- Where possible, alignment with internationally funded cruises should be taken advantage of, e.g. the Nansen cruise. This will allow for the pooling of resources to overcome financial restraints.

Overall, the implementation of a regional programme of this magnitude will take time. The BCC and participating institutions from each Member State need to be cognisant of this. A common implementation plan needs to be followed, taking the information presented in this plan into account. Coordination between all three Member States is a key to success.
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1 INTRODUCTION

The Benguela Current Convention (BCC) is an inter-governmental body established between Angola, Namibia and South Africa to manage activities affecting the transboundary resources of the Benguela Current Large Marine Ecosystem (BCLME). The BCC’s area of interest includes the coastlines and exclusive economic zones (EEZs) of all three countries extending from Cabinda in Angola to Port Elizabeth in South Africa. In 2014 the BCC Member States adopted a five-year Strategic Action Programme (SAP) addressing the environmental threats facing the BCLME region, for implementation between 2015 and 2019. Pollution is considered to be one of these threats and forms one of eight thematic areas in the SAP. The reason for this is that marine pollution in the BCLME is increasing due to expanding coastal zone urbanisation, expanding shipping and offshore drilling and mining activities. Deterioration of coastal water quality; pollution from river catchment areas; discharges of effluents into estuaries; potential oil spills; marine litter; noise pollution and emissions of greenhouse gases are identified as key issues in marine pollution. To control and manage this pollution, scientifically sound environmental monitoring and mitigation measures are required.

To achieve this the BCC has contracted Lwandle Technologies (Pty) Ltd. (Lwandle) to identify and assist in developing monitoring plans of pollution at “hotspot” locations within the coastal waters of the BCLME. Under the Nairobi Convention Protocol on land-based activities, pollution hotspots are defined as "a geographically defined marine or coastal area or other areas of the sea, of national, regional or international significance, whose conditions are such as to adversely affect human health, threaten the functioning of ecosystems and biological diversity or degrade resources and amenities of economic and social importance in a manner that warrants priority management attention" (UNEP 2010). As such, a pollution hotspot comprises pollution “sources” as well as local pollution “receptors” areas.

The aim of this project is to support Member States (Angola, Namibia and South Africa) in setting up monitoring programmes at the various hotspot locations, so that appropriate mitigation measures and procedures for the prevention and abatement of pollution can be developed.

It is intended that the information obtained during monitoring will be used to establish a temporal trend in the level and effects of pollution at each identified hotspot. Further than this, where a significant increase in pollution is identified, along with related ecological or health effects, it is intended that the monitoring information is used to describe and quantify the extent of this pollution at a particular hotspot. It is anticipated that Member States will be able to use the information obtained during monitoring in developing mitigation measures and policies for the prevention and abatement of pollution.
2 SCOPe OF WORK AND APPROACH

2.1 SCOPe OF WORK

The scope of work defined by the BCC required Lwandle to undertake the following:

1. Conduct preliminary surveys to define the pollution “hotspots” areas;
2. Assess the needs of national / local institutions regarding the monitoring of pollutants;
3. In consultation with stakeholders, design monitoring programmes for pollutants from land-based sources and from ships;
4. Make recommendations about the implementation of each monitoring programme;
5. Recommend what laboratory supplies would be needed for the monitoring programmes;
6. Facilitate the integration of the monitoring programmes into the national policy of each country to ensure sustainability beyond this project;
7. Provide monitoring training to technicians within national / local institutions in order to build capacity and enable sustainability and implementation of the monitoring programmes beyond this project.

The project was started in July 2016 and throughout its duration Lwandle has submitted a number of deliverables to the BCC, addressing the points detailed above:

- Deliverable 1 (Lwandle 2017a) involved the identification and description of pollution hotspots within each of the Member States. This was based on microbiological contamination, high suspended solids, chemical pollution, eutrophication and marine litter.
- Deliverable 2 (Lwandle 2017b) provided an assessment of the pollution monitoring needs at each identified hotspot. This was achieved through engagement with stakeholders and an initial identification of appropriate indicators representing each of the pollution categories mentioned above, and their related thresholds. Further to this, potential overlaps between the current monitoring programmes within each hotspot and the identified monitoring needs, and the resulting gaps, were highlighted.
- Deliverable 3 (Lwandle 2017c) builds on the monitoring needs identified in Lwandle (2017b), and proposes a monitoring plan to be implemented within each hotspot.
- Deliverable 4 (Lwandle 2017d) provides recommendations on integrating the proposed monitoring plan into the existing pollution monitoring activities of each Member State within each hotspot. It also details recommendations on the integrative work that needs to be done by the BCC to ensure the achievability and sustainability of the proposed pollution monitoring programme, beyond the above described scope of work.
- To address the point under bullet 7 above, a training workshop was hosted between the 22 and 24 May 2017, to provide an overview of the proposed monitoring plans for each of the identified hotspots, and to provide advice/training to the relative stakeholders that will be tasked with implementing the monitoring. Deliverable 5 (Lwandle 2017e) provided an
This report is the final report associated with this project, and aims to provide a summary of the process followed by Lwandle in developing the proposed monitoring plan. In doing so, a summary of each of the deliverables detailed above is provided. Final versions (version 2) of each of the above deliverables are provided as Appendices to this report, and are referred to throughout. Recommendations on the way forward for implementation of the plan are provided.

## 2.2 Approach

The aim of this project as a whole is to support Member States (Angola, Namibia and South Africa) in setting up pollution monitoring programmes at the various hotspot locations, so that appropriate mitigation measures and policies for the prevention and abatement of pollution can be developed. The aim of the pollution monitoring plan is therefore to provide a general status assessment of the environment within each hotspot. As such, the plan has two major objectives. Firstly, the aim is to establish a temporal trend in the level and effects of pollution at each identified hotspot. Secondly, where a significant increase in pollution is identified, along with related ecological or health effects, the objective is to describe and quantify the extent and the effect/s of this pollution at the particular hotspot.

The complexity of the physical, chemical and biological properties within any marine system can make pollution difficult to monitor and therefore manage. For this reason, to achieve the aims and objectives described above, a reference framework was used throughout this project to provide a structured approach to the development of a monitoring plan.

The Frame of Reference Approach (Garel et al. 2014) was used. It provides for a breakdown of complex pollution sources into simple, generic categories and guides the establishment of a set of indicators that can efficiently reflect the pollution status (for a wide range of ecosystems) of a hotspot before the actual impacts of the stressors on receptors are quantified. It describes environmental issues in terms of:

- **stressors** (factors inducing an environmental change; e.g. oil, or zinc in storm water as a pollution source),
- **receptors** (the elements of the ecosystem/environment that may be affected by the stressor(s) e.g. seawater and organisms depending on it such as fish, plankton, birds, surfers),
- **initial effects** (the way in which the receptor is affected by a stressor or multiple stressors, e.g. through changes in receptor quality or behaviour from smothering by oil, or illness from zinc - from specific pollution sources) and
o evaluated impacts (the severity, intensity and duration of these effects, and whether effects are positive or negative e.g. loss of 25% of a fish population, 95% of surfers suffered eye infections, etc.).

The first stage in this approach is to formulate strategic objectives based on a long-term vision about the desired status of the system. These objectives and aims are described above. This is followed by setting short-term “tactical” objectives which are action orientated and aim to ensure that the long-term strategic objective is met. The next step, referred to as defining a “quantitative state concept”, involves the selection of measurable parameters (indicators). Such environmental indicators facilitate management decisions as they provide the necessary information for decision-makers about where and when to act. This followed by the establishment of a “benchmarking procedure” which is used to determine whether the ecosystem/environment is at the defined desired state. Each indicator is assigned a threshold value or range of values, above which, detrimental effects on the ecosystem can be expected. Should such thresholds be exceeded, evaluating the extent or severity of any pollution effect present is then required.

Once this information is known, an intervention procedure can be decided on, where necessary, to control the stressor and/or mitigate the associated effects and impacts. Finally, an evaluation or review procedure is required to determine the success of the monitoring and management programme, including whether the set environmental objectives are met. These last two listed procedures are to be undertaken by the authorities who commission the monitoring.

This approach is summarised in Figure 2.1 and forms the basis of thinking for this project, ultimately allowing for the development of the pollution monitoring plan presented in this report.
2.3 LIMITATIONS

In the development of this plan, only existing sources of pollution have been considered. Future industrial and/or infrastructure development as well as the effects of climate change can alter pollution sources, and the monitoring needs within the hotspots may change over time. The spatial extent of hotspots may also change and hotspots may need to be removed from or added to the programme as a result. As such, a re-evaluation of the spatial extent and monitoring needs of all hotspots may be required every 5 years, or so.

2.4 REPORT STRUCTURE

The information presented here summarises the process followed in developing a regional pollution monitoring plan for pollution hotspot areas identified in the BCLME. The report is compiled as follows:
   o A brief description of the pollution hotspot areas identified within each Member State (Angola, South Africa and Namibia).
o An explanation of the stakeholder engagement process undertaken.

o A description of the pollution monitoring needs of the identified hotspots.

o A summary of the proposed monitoring plan.

o A description of the recommendations for integration of the proposed monitoring plan into existing monitoring activities within each member State, and the suggested roles that the BCC and relevant Member State institutions can play in this integration.

o A summary of the training workshop held in Windhoek between the 22 and 24 May 2017, where the monitoring plan was presented to stakeholders, and the outcomes of this workshop.

o Recommendations to take the implementation of this monitoring plan forward.

3 THE DESCRIPTION AND IDENTIFICATION OF HOTSPOTS

As a first step in developing a pollution monitoring programme within the BCLME, a description and identification of pollution hotspots in the region was provided. This constituted the first deliverable for this project (Lwandle 2017a) and is attached as APPENDIX 1: DELIVERABLE 1. A summary is provided here.

Under the Nairobi Convention Protocol on land-based activities, pollution hotspots are defined as "a geographically defined marine or coastal area or other areas of the sea, of national, regional or international significance, whose conditions are such as to adversely affect human health, threaten the functioning of ecosystems and biological diversity or degrade resources and amenities of economic and social importance in a manner that warrants priority management attention" (UNEP 2010). As such, a pollution hotspot comprises pollution "sources" as well as local pollution "receptors" areas.

In describing the pollution hotspots, the Frame of Reference approach was employed whereby pollution sources were considered to be stressors. The main sources of pollution in the BCLME include: urban developments, sewage outfalls, various industries including oil refineries and food processing facilities, ports, mining and petroleum activities, fishing and aquaculture, rivers and agricultural runoff, and atmospheric pollution. The effects of these pollution sources were divided into five categories: microbiological pollution, marine litter, chemical pollution, eutrophication and high suspended solids. These pollution effects/categories impact beneficial uses such as the aesthetic value of the marine environment, recreational uses and the production and collection of seafood.

The presence of multiple (more than three) significant pollution sources within a locality or region was considered to constitute a pollution hotspot. The pollution sources described were then mapped using GIS to allow for visual identification of areas where pollution sources were concentrated.
In the BCLME, the major sources of pollution were centred around the major coastal cities. This is mainly because these cities have high population densities, and hence anthropogenic pressures that affect the coastal and marine environment are increased. The pollution sources and effects in these areas are diverse ranging from dredging in ports to domestic waste water treatments. Other major sources of pollution in the BCLME are centred around areas that are important for mining and petroleum activities.

The pollution hotspots in South Africa include: Nelson Mandela Bay metropolitan area, Knysna, Mossel Bay, Hermanus, Cape Town, False Bay, Saldanha Bay, St Helena Bay, Port Nolloth, and Alexander Bay. In Namibia, the pollution hotspots include: Oranjemund, Luderitz, Walvis Bay and Swakopmund. The pollution hotspots in Angola are: Namibe, Benguela and Lobito, Luanda, Ambriz, Soyo, and Cabinda.

The major limitation in identifying and describing the hotspots was a lack of data about the exact location of certain pollution sources as well as a lack of quantitative data (e.g dredging or discharge volumes, aquaculture farm size). This lack of data precludes the evaluation of the significance of the impacts of these pollution effects on the marine environment. Through the stakeholder engagement process summarised in Section 4 and detailed in APPENDIX 2: DELIVERABLE 2 (Lwandle 2017b), it was found that stakeholders generally agreed with the identified hotspots. These hotspots therefore remained the focus of this report. Additional information regarding the severity of pollution effects and the location of hotspots may become available, in which case, hotspots can be added or removed.

4 STAKEHOLDER ENGAGEMENT

The development of an integrated marine pollution monitoring programme requires input of stakeholders representing each Member State of the BCC. Stakeholders are defined as individuals or representatives from governmental, non-governmental, non-profit organisations, academic and local communities who may be affected by a proposed project or programme. Their knowledge and experience of the areas of concern can provide invaluable information, vital for the success of the programme. Throughout this project, engagement with interested and affected stakeholders was therefore prioritised.

Contact details for a list of potential stakeholders were obtained and used to formulate a stakeholder database for the project. The contact details of the Management Board and Ecosystem Advisory Committees for Angola, Namibia and South Africa, as well as a list of BCC stakeholders were provided by the BCC. Additional stakeholders were identified through a desktop search. A broad range of sectors was targeted, with representatives from various levels of governmental departments and ministries, non-governmental organisations, port’s authorities, academic institutions and other marine associated industries being contacted.
Initially, all representatives were contacted via telephone. Thereafter, if the telephone call was successful, an email was sent explaining the project and the input required, and requesting that a questionnaire be completed. It was also requested that the questionnaire be forwarded to other interested parties within the representatives’ organisations.

The questionnaire was used to request important baseline and contextual information from stakeholders involved, associated with or interested in existing and future pollution monitoring taking place within the BCLME. The questionnaire focussed on four main sections: Roles and Responsibilities, Pollution Monitoring, Capacity Building and Levels of Engagement.

Overall, 68 individuals from Angola, 124 individuals from Namibia and 75 individuals from South Africa were contacted. Additionally, meetings with stakeholders were held in Cape Town, Swakopmund and Walvis Bay. Generally, there were challenges in getting responses from stakeholders, with a relatively low response rate. That being said, responsive stakeholders were very forthcoming with information and provided useful insights regarding coastal and environmental monitoring in their areas of concern. Additional stakeholder input was received at the Training Workshop (described in Section 8).

The stakeholder engagement process is detailed in APPENDIX 2: DELIVERABLE 2 (Lwandle 2017b). The findings from this process were included in the numerous deliverables completed throughout this project and included in APPENDICES 1 to 6 to this report.

5 THE POLLUTION MONITORING NEEDS WITHIN HOTSPOTS

Findings from the hotspot description and identification process and the stakeholder engagement were used in developing a list of monitoring needs within hotspots. The Needs Assessment constituted deliverable 2 for this project and is detailed in APPENDIX 2: DELIVERABLE 2 (Lwandle 2017b).

Using knowledge of existing pollution within hotspots (in terms of pollution sources and categories), a list of appropriate pollution indicators was developed. The aim of the pollution monitoring plan as a whole, is to provide a general status assessment of the environment within each hotspot. As such indicators measuring general ecosystem health were identified. Indicators in water, sediment and biological tissue samples were acknowledged as being important.

Overall indicators identified in the water column include: the number of harmful algal blooms per year, presence of oil spills, temperature, salinity, turbidity, pH dissolved oxygen, dissolved inorganic nutrients (e.g. nitrate, ammonium and phosphate) and chlorophyll-a. Indicators identified in the sediment and in the water column include: trace metals, organic contaminants (e. g PCBs, pesticides), total petroleum, oil and grease, presence of faecal coliforms and marine litter. A change in benthic community structure was identified as an important indicator of ecosystem health. Trace
metals and organic contaminants were identified as indicators measurable in biological tissues. It must be noted that, at this stage, these indicators were identified as a broad need, rather than as an absolute requirement. The list of indicators was refined at a later stage in the project to ensure the balance between the robustness and simplicity of the proposed monitoring plan (summarised in Section 14 and detailed in APPENDIX 3: DELIVERABLE 3).

Where possible, for each indicator, thresholds, above which deleterious effects on receptors (e.g. sensitive marine biota) can be expected, were identified. These were mostly based on BCLME water and sediment quality guidelines. However, in the case of pollutants not described in these guidelines, thresholds defined by international organisations and scientific literature were used.

Following the identification of indicators and thresholds per pollution category and per receptor, these were applied to each hotspot, according to the type of pollution present. This allowed for the development of the monitoring needs per hotspot. Where present, current monitoring of identified indicators within hotspots was highlighted. This information was utilised in the Integration phase of the project, summarised in Section 7 of this report and detailed in APPENDIX 4: DELIVERABLE 4 (Lwandle 2017d).

Findings from the stakeholder engagement were used in summarising the pollution capacity building needs within each member State. In terms of capacity needs, as identified by stakeholders, some pollution monitoring capacities are in place in Namibia and South Africa. However a lack of financial resources and a shortage of equipment was highlighted in both Angola and Namibia. In South Africa, a lack of coordination between different pollution monitoring entities was highlighted. Training related to sampling procedures was also highlighted as a need in both Namibia and Angola.

6 A SUMMARY OF THE DRAFT MONITORING PLAN

The similarities between the pollution sources and effects in all hotspots across the three Member States of the BCC, as highlighted in Section 3 and APPENDIX 1: DELIVERABLE 1 (Lwandle 2017a), emphasise the need for an integrated and standardised approach to pollution monitoring throughout the BCLME. Based on this, a draft monitoring plan was therefore compiled. The Draft Monitoring Plan is summarised here and detailed in APPENDIX 3: DELIVERABLE 3 (Lwandle 2017c). It proposes a generic monitoring framework developed using the Frame of Reference approach (Garel et al. 2014). This is to be applied to all hotspots. It builds on the monitoring needs identified within each pollution hotspot, summarised above in Section 5, and takes into account capacity restraints of Member States as highlighted by stakeholders. It provides a general principle for the design of a survey for pollution monitoring within each of the 19 hotspots.

A two-phased approach to the monitoring is prescribed. In both phases, appropriate data management and reporting are required. A schematic of the phased approach to monitoring is provided in Figure 6.1.
Figure 6.1: Schematic showing the proposed phased approach to pollution monitoring and the interaction between Phase 1 and Phase 2 within an identified pollution hotspot.
6.1 Phase 1 Monitoring

Phase 1 monitoring is more descriptive in nature, with fewer sampling sites and only a small number of selected indicators. The objective of this monitoring phase is to provide data on the pollution status of a hotspot and serves only to identify whether pollution is present or not, and whether its presence results in an ecological effect.

All Phase 1 monitoring is to be conducted on an annual basis at one selected site within each hotspot for all indicators (shown in Table 6.1), with the exception of beach litter. The latter is to be monitored twice a year. Sites are to be selected in discussion with stakeholders and following preliminary studies if necessary, but should be located in depositional areas (in the case of sediment sites) or downstream from pollution sources (in the case of biological tissue sampling). The surrounding sensitive habitats also need to be considered when selecting sites. More than one monitoring site within a hotspot may be required in cases where there are many important sensitive habitats within close proximity to pollution sources.

For the Phase 1 monitoring, the initial selection of indicators presented in APPENDIX 2: DELIVERABLE 2 (Lwandle 2017b) was refined to exclude the measurement of certain contaminants in the water column. This was done because of the high natural variability in levels of such contaminants and the resulting necessity for sampling at a high frequency (associated with high, often restrictive, costs). Contaminant indicators within the sediment and the benthic community structure as well as plastics on beaches are included in Phase 1 monitoring. Measurements of contaminants within biological tissue are only prescribed if there is an absence of sediment depositional areas within a hotspot. In this case, biological tissue sampling can be undertaken in place of sediment sampling.

Phase 1 indicators have been divided into two categories: system-state indicators and pollution indicators. Pollution indicators show changes that are directly attributable to pollution stressors within a hotspot and as such, will be responsive to the results of management actions (Shepard et al. 2015). On the other hand, changes in system-state indicators may not be directly attributable to pollution, but can provide useful supplementary information on pollution indicators and natural variability. A summary of the indicators to be measured during Phase 1 monitoring is detailed in Table 6.1 below. A more detailed account of each indicator is provided in APPENDIX 3: DELIVERABLE 3 (Lwandle 2017c).
Table 6.1: The various indicators identified for Phase 1 pollution monitoring, including measurement compartment and methods of collection and analysis.

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<th>Indicator</th>
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<th>Method and Analysis</th>
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<td><strong>System-State Indicators</strong></td>
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<tr>
<td>Particle size</td>
<td>Sediment</td>
<td>o  Sediment samples are to be collected using a Van Veen grab or similar;</td>
</tr>
<tr>
<td>Particulate organic matter, particulate organic carbon and particulate organic nitrogen</td>
<td></td>
<td>o  Samples are to be sent to accredited laboratory/laboratories for chemical analysis.</td>
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<tr>
<td><strong>Pollution Indicators</strong></td>
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| Plastics                           | Beach                | o  50 m stretch of beach near a pollution source must be selected  
 o  Daily accumulation survey of marine litter to be conducted along 50 m stretch over period of two weeks.                                        
 o  Over the two-week period, collect all plastics > 2 cm on daily basis.                                                                                                                                   
 o  Litter collected must be cleaned and dried as much as possible, before transport to a laboratory for categorisation and analysis |
| Trace metals, including AVS and SEM | Sediments            | o  Sediment samples are to be collected using a Van Veen grab or similar;                                                                                                                                             |
| Organic contaminants (organochlorine pesticides, PCBs) |                      | o  Samples are to be sent to accredited laboratory/laboratories for chemical analysis.                                                                                                                               |
| Total petroleum and PAH            |                      |                                                                                                                                                                                                                      |
| Changes in benthic community       | Sediments; benthic macrofauna | o  Sediment samples are to be collected using a Van Veen grab or similar;                                                                                                                                             |
|                                    |                      | o  Sediments are to be rinsed and sieved, and macrofauna retained for further identification and analysis.                                                                                                            |
| Contaminants (Trace metals and PCBs in biological tissue of sessile organisms) | Sessile intertidal and subtidal fauna | o  Indicator organisms are to be selected.                                                                                                               |
|                                    |                      | o  Live organisms are to be scraped from rocks at selected intertidal sites within each hotspot, and sent to accredited laboratories for depuration and chemical analyses. |

a) *To be conducted if there are insufficient depositional areas within hotspots to obtain sediment samples*
6.2 Phase 2 Monitoring

Phase 2 monitoring is more investigative in nature, and is intended to be implemented after a number of years of Phase 1 monitoring, and only after a significant pollution effect has been identified and trends in increasing pollution have been observed (stipulated thresholds have been exceeded and an ecological or health response has been identified). The objective of this monitoring phase is to quantify the extent of the pollution present and quantify the extent of the ecological or health response. Phase 2 monitoring is intended to be more extensive than the Phase 1 monitoring, and survey design is to be decided on a case by case basis, depending on the environmental characteristics of the hotspot, the characteristics of the pollution insult/s of concern, and in consultation with relevant stakeholders.

6.3 Data Management and Reporting

Both Phase 1 and Phase 2 monitoring requires appropriate data management and reporting. The development of a data management and quality control system is recommended to ensure that the data from the monitoring programmes (both Phase 1 and Phase 2) in the various hotspots are reliable and comparable. A good data management system will allow for adequate statistical analyses of data, required for sound decision-making about pollution control. It will also allow decision makers to determine whether the sampling strategies are providing representative samples or if they need to be adjusted. An annual report detailing the pollution status of each hotspot is recommended. The results from these reports will be used to decide whether to escalate the hotspot pollution monitoring from Phase 1 to Phase 2. Additionally, management decisions, if required, can be based on these reports.

An appropriate data management system will also allow the data to be shared with authorities in all the three Member States as well as with those who may want to use the data for other purposes (e.g. research). This should assist in the sustainability of the project.

7 Integration of the Monitoring Activities

To ensure successful implementation and sustainability of the proposed monitoring programme summarised above and detailed in APPENDIX 3: DELIVERABLE 3 (Lwandle 2017c), recommendations on integrating the proposed pollution monitoring plan into existing pollution monitoring activities of each Member State were provided. Further, an outline of roles and responsibilities of the BCC, the various BCC focal points and the institutions within each Member State in the proposed pollution monitoring were suggested. These recommendations are summarised here, and detail is provided in APPENDIX 4: DELIVERABLE 4 (Lwandle 2017d).

Different types of marine sampling and monitoring are currently being undertaken over various timescales by diverse bodies and organisations in each of the three Member States of the BCC. To
ensure the sustainability and achievability of the proposed pollution monitoring plan, it is recommended that the measurement and analysis of the Phase 1 indicators be integrated into existing monitoring programmes within each hotspot as far as possible. Where gaps exist and Phase 1 monitoring indicators are not currently measured, it is recommended that there is an expansion of existing programmes to incorporate these as additional monitoring requirements. Alternatively, where this is not possible, it is recommended that standalone Phase 1 monitoring programmes are established and implemented. In order to address these gaps, the BCC will need to work in partnership with identified Member State institutions and departments. Suggestions about how to integrate existing monitoring and how to ensure any gaps are filled efficiently and effectively are provided in the context of each country in APPENDIX 4: DELIVERABLE 4 (Lwandle 2017d).

The risk with aligning the proposed monitoring with existing monitoring programmes is that the latter may one day come to an end, leaving the BCC pollution indicators unchecked. It is therefore recommended that the co-ordination and oversight of the programme is handled by a national pollution committee, led by the BCC focal point or the primary department responsible for existing pollution monitoring within each country, and includes individuals from other departments responsible for pollution monitoring. Other stakeholders with interest in marine pollution, for example individuals from other governmental departments, non-governmental organisations, private industry and universities, should also be included in these committees.

Such committees would be responsible for communicating with the relevant institutions (at a national, provincial or municipal level) within each country to ensure the data are collected within each hotspot and possibly assist in aligning these activities with existing monitoring plans. The pollution committee in each country would need to be cognisant of any terminations of existing monitoring programmes or changes in sampling responsibilities within hotspots, and would need to ensure that sampling responsibility for the relevant indicators is passed on to a suitable body. Further than this, they would be responsible for collating, interpreting and reporting on the collected monitoring data from each hotspot. This can be done with assistance from the monitoring institutions responsible for implementing the monitoring within hotspots.

On an annual basis, the findings of the pollution monitoring within each member State would need to be communicated to the BCC Ecosystem Advisory Committee, and in partnership with the relevant pollution committees, decisions would be made on the progress of the monitoring and pollution status of each hotspot. This decision making process is especially important when deciding whether Phase 2 monitoring needs to be implemented at a hotspot.

The schematic shown in Figure 7.1 summarises these recommendations:
Effective and efficient data management and reporting is important for the success of the proposed monitoring. The BCC is currently running a project to develop a data management system, which could potentially integrate a pollution data repository. It is suggested that a central data repository, which can house all relevant pollution monitoring reports and data from each of the hotspots, should be defined, and that the BCC should be the custodians of this. National data repositories, which are overseen by the relative BCC focal point, and feed into the central repository, are also suggested. These are vital in order for the BCC’s data management system to be successful. It is also suggested that, where possible, the data management (including established data repositories) and reporting components of the proposed monitoring plan are integrated into existing structures within Member States in addition to the monitoring activities.

Recognition of pollution as a key issue within the BCLME is highlighted in both the Benguela Current Convention as well as within the Strategic Action Programme. Overall, the adoption of the proposed pollution monitoring plan by the BCC and the Member States should be detailed in a BCLME pollution specific policy. To an extent, elements of this has been addressed in the Strategic Action Programme, however, existing policies and/or programmes will need to be expanded upon.
to accommodate the proposed pollution “hotspot” monitoring, to guide the actions that need to be taken by the BCC and relevant Member States.

Overall, an implementation strategy needs to be developed and adopted by the BCC, to detail the various roles of the BCC and national institutions in facilitating the implementation of the proposed monitoring. Due to capacity limitations, the prioritisation of monitoring of specific hotspots may be required and should be detailed in the implementation strategy. An advantageous aspect of this is that successful implementation at a few example locations will help to ensure the buy-in of stakeholders in other locations; while if the first steps fail, stakeholders could lose interest in the programme all together.

8 TRAINING WORKSHOP

An overview of proposed monitoring plan to be implemented at each of the hotspots was presented to stakeholders at a training workshop hosted in Windhoek between the 22 and 24 May 2017. Thirty participants attended the workshop, with representatives from a variety of government departments from each Member State.

8.1 WORKSHOP OBJECTIVES

The primary objective of the training workshop was to convey as much useful information to participants as possible, about the proposed monitoring plan and its implementation in each of the hotspots. The objectives can be broken down into the following:

- To provide an overview of the proposed monitoring plan to stakeholders.
- To advise on basic technical skills required for personnel to carry out monitoring.
- To provide an overview of the recommendations for integration of the proposed monitoring plan into existing monitoring activities.
- To discuss requirements for successful implementation and sustainability of the programme as a whole.
- To obtain additional stakeholder input regarding the pollution hotspots and proposed monitoring.

8.2 CONTENT PRESENTED

During the three-day workshop, the project and the approach used by Lwandle in developing the proposed monitoring plan, was described in detail to participants. Additionally, advice/training was provided to the relative stakeholders tasked with implementing the monitoring. Interaction and discussion between participants was encouraged. The various conclusions emanating from these discussions contributed to stakeholder input and were taken into account in the finalisation of the monitoring programme. Topics addressed include:
An introduction to the project
An overview of pollution sources and effects
A description of pollution hotspots identified within the BCLME
Considerations to be taken account of when designing a monitoring plan
An overview of the proposed monitoring plan
An overview of the practical aspects of pollution monitoring. These included required equipment and equipment preparation, sample collection, preservation and storage, analytical techniques and quality control procedures.
An overview of the data management and reporting that is required to ensure success of the project.
An overview of the integration of the monitoring plan into existing programmes and how this can be taken forward.
An application of the proposed monitoring plan to a fictitious hotspot in a case study.
An overview of all existing hotspots, as they have been identified, and inclusion of any other stakeholder input on these hotspots.

More detail on the topics covered is provided in APPENDIX 5: DELIVERABLE 5 (Lwandle 2017e).

To build on the content presented at the workshop, APPENDIX 6: DELIVERABLE 6 (Lwandle 2017f) was developed and provides a training manual to assist in the implementation of the monitoring plan. It provides an overview of the sampling methodologies and analytical techniques to be used in Phase 1 monitoring.

8.3 Workshop Evaluation and Comments

Overall the training workshop was successful and the monitoring plan was well received. Evaluation questionnaires were distributed to participants and 24 were received (APPENDIX 7: WORKSHOP EVALUATION). On average, the course offering was scored 4.2 out of 5 and the presenters were scored 4.4 out of 5.

Valuable input from stakeholders was received through numerous discussion sessions held during the workshop. As mentioned, this input has since been taken forward into the finalisation process of the monitoring programme, which is detailed in this report.
9 CONCLUSION AND RECOMMENDATIONS

Recognition of pollution as a key issue within the BCLME is highlighted in both the Benguela Current Convention as well as within the Strategic Action Programme. The aim of this project was to support Member States (Angola, Namibia and South Africa) of the BCC in setting up monitoring programmes at various hotspot locations, so that appropriate mitigation measures and procedures for the prevention and abatement of pollution can be developed by the authorities concerned. To achieve this, the various hotspots were identified and described in terms of the pollution present within each area, and the pollution monitoring needs for each were established. The proposed monitoring plan was then developed, and recommendations for integration of this into existing monitoring activities were provided. Additionally, roles and responsibilities of the BCC, the various BCC focal points and the institutions within each Member State in the implementation of the proposed phases of the monitoring plan were suggested. A workshop was held in Windhoek from the 22 to the 24 May 2017 to present the findings to stakeholders and to obtain any additional comments for inclusion in this final report.

The information presented in this final report summarises the findings from the above process followed by Lwandle, and ultimately provides a comprehensive plan for pollution monitoring at hotspot locations within the BCLME. It builds on what were identified as “Strategic Solutions” for pollution in the Strategic Action Programme, and focusses on activities/actions that allow for the enactment of some of these solutions. With the implementation of this plan, and the generation of scientifically sound monitoring data, appropriate mitigation measures and procedures for the prevention and abatement of pollution in the BCLME can be developed.

Throughout the process of the development of the monitoring plan and the various steps involved in determining the applicability of the plan to each of the hotspots, a number of recommendations have come to light. These recommendations will assist in the future implementation of the programme in the BCLME and ultimately summarise the way forward for the BCC. These can be summarised as follows:

- As a next step to this plan, a pollution-specific implementation strategy needs to be developed by the BCC, to guide the actions that need to be taken by the BCC and relevant Member States. This will allow for resources and time to be allocated towards the monitoring of pollution within the BCLME. This implementation strategy needs to build on the information presented in the Strategic Action Programme, and incorporate the proposed pollution “hotspot” monitoring detailed in this report.

- In order for the monitoring to be implemented in all three Member States, pollution committees need to be formed. Ideally, this should occur at a national level, where individuals from a range of governmental and non-governmental institutions in each of the three Member States, with expertise in pollution monitoring, can be included. This committee should meet with the BCC Ecosystem Advisory Committee annually to discuss the
progress of pollution monitoring within the BCLME hotspots. Alternatively, this pollution committee can occur at a regional level, where it would operate at the level of other existing BCC Regional Working Groups. In forming these committees, whether it be at a national or regional level, the BCC needs to be cognisant of the overstretching of human resources.

- A data management system needs to be developed, and possibly can be integrated into the existing data management project being run by the BCC. In order for data management at the regional level to be successful, appropriate structures are needed within each Member State.

- To facilitate the regional coordination of data management and allow for data sharing, a data sharing policy needs to be developed within each country. The BCC already has a data policy, and so when regional data sharing is required, the BCC policy can be expanded to accommodate this.

- In terms of the implementation of the monitoring itself, hotspots need to be prioritised. This will allow for countries to allocate resources more easily. Prioritisation should form a part of the abovementioned implementation strategy.

- Where possible, alignment with internationally funded cruises should be taken advantage of, e.g. the Nansen cruise. This will allow for the pooling of resources to overcome financial restraints.

Overall, the implementation of a regional programme of this magnitude will take time. The BCC and participating institutions from each Member State need to be cognisant of this. A common implementation plan needs to be followed, taking the information presented in this plan into account. Coordination between all three Member States is a key to success.
10 REFERENCES


APPENDIX 1: DELIVERABLE 1

The Description and Identification of Pollution Hotspots Report (Lwandle 2017a) is included below.
APPENDIX 2: DELIVERABLE 2

The Needs Assessment Report, incorporating detail on the stakeholder engagement process (Lwandle 2017b) is included below.
APPENDIX 3: DELIVERABLE 3

The Draft Monitoring Plan (Lwandle 2017c) is included below.
APPENDIX 4: DELIVERABLE 4

The Integration Report (Lwandle 2017d) is included below.
APPENDIX 5: DELIVERABLE 5

The Workshop Plan (Lwandle 2017e) is included below.
APPENDIX 6: DELIVERABLE 6

The Training Manual (Lwandle 2017f) is included below.
APPENDIX 7: WORKSHOP EVALUATION

The workshop evaluation forms are included below.