TRANSBOUNDARY DIAGNOSTIC ANALYSIS

A regional commitment to the integrated management, sustainable development and protection of the Benguela Current Large Marine Ecosystem by Angola, Namibia and South Africa

Transboundary Diagnostic Analysis
November 1999

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The Benguela

BACKGROUND AND INTRODUCTION

A Unique Environment

The Benguela Current Large Marine Ecosystem (BCLME) is situated along the coast of south-western Africa, stretching from east of the Cape of Good Hope in the south equatorwards to the Angola Front, near the northern geopolitical boundary of Angola (see Figure 1). It encompasses one of the four major coastal upwelling ecosystems of the world which lie at the eastern boundaries of the oceans. Like the Humboldt, California and Canary systems, the Benguela is an important centre of marine biodiversity and marine food production. The BCLME's distinctive bathymetry, hydrography, chemistry and trophodynamics combine to make it one of the most productive ocean areas in the world, with a mean annual primary productivity of 1.25 grams of carbon per square metre per year – about six times higher than the North Sea ecosystem. This high level of primary productivity of the BCLME supports an important global reservoir of biodiversity and biomass of zooplankton, fish, sea birds and marine mammals, while near-shore and off-shore sediments hold rich deposits of precious minerals (particularly diamonds), as well as oil and gas reserves. The natural beauty of the coastal regions, many of which are still pristine by global standards, have also enabled the development of significant tourism in some areas. Pollution from industries and poorly planned and managed coastal developments and near-shore activities is, however, resulting in a rapid degradation of vulnerable coastal habitats.

The Namib Desert, which forms the landward boundary of a large part of the BCLME, is one of the oldest deserts in the world, predating the commencement of persistent upwelling in the Benguela (12 million years before present) by at least 40 million years. The upwelling system in the form in which we know it today is about 2 million years old. The principal upwelling centre in the Benguela, which is situated near Lüderitz in southern Namibia, is the most concentrated and intense found in any upwelling regime. What also makes the Benguela upwelling system so unique in the global context is that it is bounded at both northern and southern ends by warm water systems, viz the tropical/equatorial Eastern Atlantic and the Indian Ocean's Agulhas Current respectively. Sharp horizontal gradients (fronts) exist at these boundaries of the upwelling system, but these display substantial variability in time and in space – at times pulsating in phase and at others not. Interaction between the BCLME and the adjacent ocean systems occurs over thousands of kilometers. For example, much of the BCLME, in particular off Namibia and Angola, is naturally hypoxic – even anoxic – at depth as a consequence of subsurface flow southwards from the tropical Atlantic. This is compounded by depletion of oxygen from more localised biological decay processes. There are also teleconnections between the Benguela and processes in the North Atlantic and Indo-Pacific Oceans (e.g. El Niño). Moreover, the southern Benguela lies at a major choke point in the "Global Climate Conveyor Belt" whereby on timescales of decades to centuries warm surface waters move from the Pacific via the Indian Ocean through into the North Atlantic. (The South Atlantic is the only ocean in which there is a net transport of heat towards the equator!) As a consequence, not only is the Benguela at a critical location in terms of the global climate system, but it is also potentially extremely vulnerable to any future climate change or increasing variability in climate.

Centuries before the arrival in southern Africa of the first European explorers and settlers, indigenous coastal peoples harvested intertidal and near-shore marine life. Commercial exploitation in the BCLME commenced in the first part of the seventeenth century with the harvesting of fur seals, and was followed by extensive whaling operations in the eighteenth and nineteenth centuries. Commercial trawling started around 1900 and commercial purse-seine fishing for sardine some 50 years later. Fisheries expanded rapidly in the 1960s and 1970s during a period when there was heavy exploitation of resources by foreign fleets – resulting in the severe depletion and collapse of several fish stocks. Superimposed on this fishing pressure was the impact of the inherent natural environmental ecosystem variability and change. Together with the other factors mentioned in the following paragraphs, this has made the sustainable use and management of BCLME living resources difficult.

Fragmented Management: A Legacy of the Colonial and Political Past

Following the establishment of European settlements at strategic coastal locations where victuals and water could be procured to supply fleets trading with the East Indies, the potential wealth of the African continent became apparent. This resulted in the great rush for territories and the colonisation of the continent – mostly during the nineteenth century. Boundaries between colonies were hastily established, often arbitrarily and generally with little regard for indigenous inhabitants and natural habitats. Colonial land boundaries in the Benguela region were established at rivers (Cunene, Orange). Not only were the languages and cultures of the foreign occupiers different (Portuguese, German, English, Dutch) but so were the management systems and laws which evolved in the three now independent and democratic countries of the region – Angola, Namibia and South Africa. Moreover, not only were the governance frameworks very different, but a further

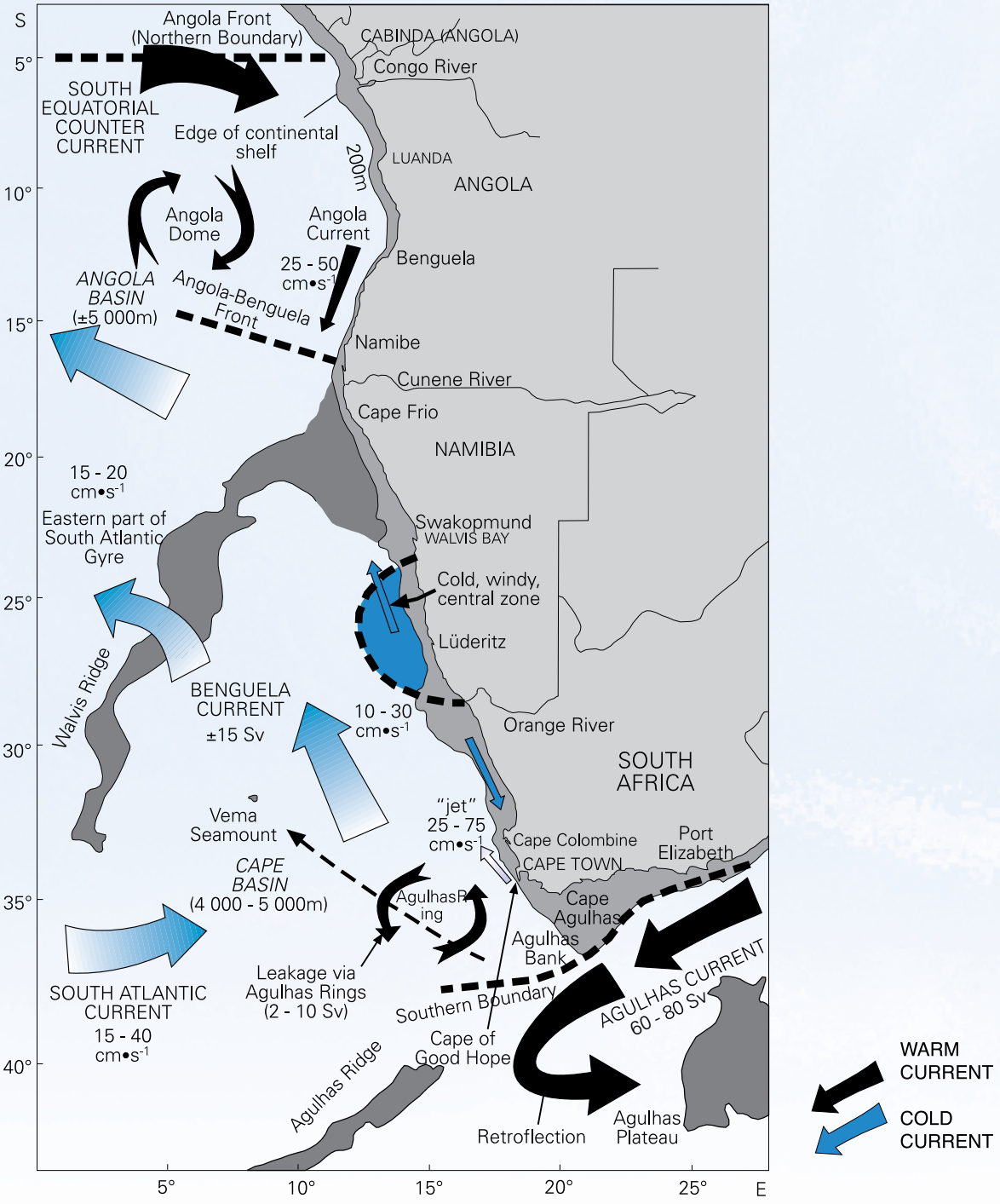

FIGURE 1 Ocean currents in the Benguela region

consequence of European influence was the relative absence of inter-agency (or inter-ministerial) frameworks for management of the marine environment and its resources, and scant regard for sustainability. To this day mining concessions, oil/gas exploration, fishing rights and coastal development have taken place with little or no proper integration or regard for other users. For example, exploratory wells have been sunk in established fishing grounds and the well-heads (which stand proud of the sea bed) subsequently abandoned. Likewise the impact of habitat alterations due to mining activities, and ecosystem alteration (including biodiversity impacts) due to fishing, have not been properly assessed.

Prior to the coming into being of the United Nations Convention on the Law of the Sea and declaration and respecting of sovereign rights within individual countries' Exclusive Economic (or Fishing) Zones, there was an explosion of foreign fleets fishing off Angola, Namibia and South Africa during the 1960s and 1970s – an effective imperialism and colonisation by mainly First World countries of the BCLME, and the rape of its resources. This period also coincided with liberation struggles in all three countries, and associated civil wars. In the case of Namibia, over whom the mandate by South Africa was not internationally recognised, there was an added problem in that prior to independence in 1990, an EEZ could not be proclaimed. In an attempt to control the foreign exploitation of Namibia's fish resources, the International Commission for the South-east Atlantic Fisheries (ICSEAF) was established, but this proved to be relatively ineffectual at husbanding the fish stocks. In South Africa prior to 1994, environmental issues and sustainable management were low on the political agenda. Moreover, the legacy of the past has resulted in a marked gradient in capacity from south to north in the region. Consequences of the civil wars have been the human population migration to the coast, localised pressure on marine and coastal resources (e.g. destruction of coastal forests and mangroves), and severe pollution of some embayments.

While mineral exploration and extraction and development in the coastal zone obviously occurs within the geographic boundaries of the three countries (i.e. within the EEZs), and can to a large degree be independently managed by each of the countries, mobile living marine resources do not respect the arbitrary geographic borders. This has obvious implications for the sustainable use of these resources, particularly so in the case of straddling and shared fish stocks.

Thus the legacy of the colonial and political past is that the management of resources in the greater Benguela area has not been integrated within countries or within the region. The real challenge of the BCLME will be to develop a viable joint and integrative mechanism for the sustainable environmental management of the region as a whole, i.e. at the ecosystem level.

The Need for International Action

In the BCLME the issue of sustainable ecosystem management, under conditions of environmental variability and uncertainty within a developing regional context, provides an ideal opportunity for the international community to provide material assistance to enable the three countries, via a joint partnership, to establish and implement the appropriate framework for management actions. Countries such as Norway and Germany are already providing much-needed expertise and assistance through the co-ordinated regional BENEFIT mechanism (discussed in the next section), but there is a clear need for greater international involvement to enable the region to, for example, repair the damage done by the ravages of gross over-exploitation of fish resources by foreign fleets in the 1960s, 1970s and 1980s. As previously mentioned, there exists a sharp capacity gradient (human and infrastructure) from south to north in the BCLME, and while there is a very obvious willingness in the region to share knowledge, expertise and facilities with those who are more disadvantaged, international commitment from the Global Environment Facility (GEF) International Waters Programme towards capacity and institutional strengthening and integrated management will greatly help to accelerate this process.

As has been noted, the mobile components of the BCLME do not respect the arbitrary geopolitical (country) boundaries. Several fish stocks straddle or are shared between the countries or otherwise migrate through the Benguela. Actions by one country, e.g. over-exploitation or habitat destruction of their part of a migrating or shared resource, could in effect negatively impact on one or both neighbouring countries. Joint management and protection of shared stocks is one of the few available options to the countries bordering the BCLME. In this manner, a better sense of ownership of the region's resources can be attained, and "owners" tend to protect their property more so than those enjoying a free service. There is thus a strong need for harmonising legal and policy objectives and for developing common strategies for resource surveys, and investment in sustainable ecosystem management for the benefit of all the people in the Benguela region. Only concerted regional action and enablement from the international community to develop regional agreements, and legal frameworks and assessment/implementation strategies, will in the longer term protect the biological diversity of the greater Benguela.

While shared living resources present the most obvious case for co-management, there are many activities and issues which can benefit from expertise and management structures developed and implemented in individual countries. These include *inter alia* mining, declining coastal water quality (pollution abatement and control, oil spill clean-up technology), oil/gas extraction, coastal zone development, tourism and eco-tourism development, mitigation of the effects of introduced species (aliens) and harmful algal blooms – which can also have system-wide impacts.

The BCLME Programme, which builds on existing regional capacity and goodwill, could serve as a blueprint for the design and implementation of LME initiatives in other upwelling regions and elsewhere in the developing world. Moreover, the BCLME Programme will address key regional environmental variability issues that are expected to make a major contribution towards understanding global fluctuations in the marine environment, including climate change.

The Success Story of BENEFIT

In April 1997 a major regional co-operative initiative was launched jointly by Angola, Namibia and South Africa together with foreign partners "To develop the enhanced science capacity required for the optimal and sustainable utilisation of living resources of the Benguela ecosystem by (a) improving knowledge and understanding of the dynamics of important commercial stocks, their environment and linkages between the environmental processes and the stock dynamics, and (b) building appropriate human and material capacity for marine science and technology in the countries bordering the Benguela ecosystem". This BENEFIT (BENguela-Environment-Fisheries-Interaction & Training) Programme evolved out of a Workshop/ Seminar on "Fisheries Resource Dynamics in the Benguela Current Ecosystem" held in Swakopmund in mid-1995. The workshop was hosted by the Namibian Ministry of Fisheries and Marine Resources in partnership with the Norwegian Agency for Development Co-operation (NORAD), the German Organisation for Technical Co-operation (GTZ) and the Intergovernmental Oceanographic Commission (IOC) of UNESCO. BENEFIT was developed in the region by Angola, Namibia and South Africa and is jointly managed and directed by the three countries. BENEFIT has attracted substantial incremental support from overseas countries and international donor agencies. It remains, however, essentially a regional "self help" initiative, and has been endorsed by the Southern African Development Community (SADC) and accepted as a SADC programme. It is providing a unique opportunity for development of partnerships within and beyond the southern African region in science and technology, to promote optimum utilisation of natural resources and thereby greater food security in the region.

BENEFIT has been planned in two five-year phases (1997-2002, 2002-2007). The science and technology component of BENEFIT has three foci, viz resource dynamics, the environment (of the resources) and linkages between resources and the environment. These foci are increasing knowledge of resource dynamics through improved research on the resources and their variable environment. The capacity development component of the Programme is being addressed through a suite of task-orientated framework activities to (a) build human capacity, particularly in areas of greatest need and greatest historical disadvantage, (b) develop, enhance and maintain regional infrastructure and co-operation, and (c) make the countries in the region and the region as a whole more self-sufficient in science and technology. The BENEFIT Secretariat is based in Namibia, while management meetings are held on a rotating basis in Angola, Namibia and South Africa.

The launch of BENEFIT in April 1997 coincided with two major research cruises/surveys that focused on the fisheries and environment of the Angola-Benguela Front. (This front is situated west of Angola and is thought to play an important role as a permeable internal "boundary" within the BCLME, demarcating the northern extent of pronounced coastal upwelling.) During the past two years BENEFIT increasingly gathered momentum with funding for priority projects being allocated and real progress in human capacity development being made. Some recent achievements are briefly as follows:

- Several reports and scientific/technical papers have been published on the results of the 1997 Angola-Benguela Front surveys, and several regional scientists and technicians received hands-on training at sea, in the laboratory and in data analysis
- A German sponsored BENEFIT Training Course was conducted in Namibia in 1997 and a number of regional scientists received further training subsequently in Germany and in Norway
- Fifteen fisheries and fisheries-environment (incremental) projects have been approved for funding in 1999
- Two training workshops have taken place (1998 and 1999) and a BENEFIT Training Plan to comple-ment the Science Plan is under development this year
- In the first half of 1999 over 50 persons from the broad SADC region have been trained during three BENEFIT cruises, including a 40-day survey of resources and the environment, which extended between Cape Town and Luanda, primarily funded by the African Development Bank and the World Bank.

In addition to the above, strong links have been built between BENEFIT and three parallel (but distinctly different) programmes, viz South Africa's established and internationally acclaimed Benguela Ecology Programme (BEP), ENVIFISH (a three-year European Union funded project between seven EU states and Angola, Namibia and South Africa, focussing primarily on the application of satellite data in environment – fisheries research and management, and which commenced in October 1998) and VIBES (a bilateral French-South African initiative focussing on the variability of pelagic fish resources in the Benguela, and the environment and spatial aspects of the system, which also commenced in 1998). In all of these initiatives the emphasis is on science and technology per se, and not on the much-needed transboundary management issues.

BENEFIT and related activities provide clear evidence of the desire and capability of Angola, Namibia and South Africa to work together to solve common problems in the Benguela region in partnership with the international community. This can form a strong base on which to develop integrated management structures.

The Emerging BCLME Programme

The seed for the BCLME Programme was sown at the Workshop/Seminar on Fisheries Resource Dynamics in the Benguela Current Ecosystem, held in Swakopmund, Namibia, in May/June 1995 – the same meeting which laid the foundation for BENEFIT. However, whereas BENEFIT focuses on science and technology as applied to fisheries and the fish environment, and science capacity development, the focus of the BCLME Programme is different. In contrast to BENEFIT, the Benguela Current LME programme is a broad-based multi-sectoral initiative aimed at sustainable integrated management of the Benguela Current ecosystem as a whole. It will focus on a number of key sectors including fisheries and environmental variability, sea-bed mining, oil and gas exploration and production, coastal zone management, ecosystem health, and socio-economics and governance. Transboundary management issues, environmental protection and capacity strengthening will be of primary concern to the BCLME programme.

Inspired by the 1995 Workshop/Seminar and the progress being made on sustainable management of other LMEs – the Black Sea LME in particular – and in order to develop a viable action plan to ensure the sustainable management of the greater Benguela ecosystem, the three countries bordering the Benguela (Angola, Namibia and South Africa) requested support from the Global Environment Facility (GEF), a fund established in 1991 under the management of The World Bank, the United Nations Development Programme (UNDP) and the United Nations Environment Programme (UNEP). An embryonic GEF/PDF Block B Grant application was developed by a small group in late 1995, subsequently refined with the assistance of UNDP staff, and submitted to the GEF. Following grant approval, US$344 000 was made available by the GEF in 1998 to enable the development of a comprehensive project proposal including the necessary instruments, such as the synthesis and assessment of information on the BCLME (contained in six comprehensive Thematic Reports), a Transboundary Diagnostic Analysis (this document), a Strategic Action Programme and Project Brief.

What Has Been Achieved?

Following the approval of the PDF Block B Grant, a small Management Committee was established, with members being appointed to represent the governments of the three countries, UNDP and some donors. A Project Co-ordinator was appointed, based in Windhoek, Namibia, with logistical, administrative and infrastructure support provided by the Namibian Ministry of Fisheries and Marine Resources (as implementing agency) and administrative assistance by the UNDP Office in Windhoek.

In July 1998 the First Regional BCLME Workshop was held in Cape Town, which was followed by a formal meeting of key stakeholders. The Workshop was attended by approximately 100 regional and international experts and stakeholders representing a broad cross-section of the public and private sectors in Angola, Namibia and South Africa. The following were among the organisations in the three countries represented at the workshop:

From Angola: Ministry of Fisheries, Ministry of Environmental Affairs, Ministry of Science and Technology, Augostino Neto University, TEXACO, National Oil Company (SONANGOL), National Fishing Industry, Swedish International Development Agency (SIDA)

From Namibia: Ministry of Environment and Tourism, Ministry of Fisheries and Marine Resources, Ministry of Agriculture, Water and Rural Development, Ministry of Works, Transport and Communication, Ministry of Trade and Industry, Ministry of Mines and Energy, NAMPORT, Meteorological Service, BENEFIT Secretariat, Southern African Development Community (SADC), Desert Research Foundation, National Petroleum Corporation of Namibia (NAMCOR), Shell Exploration Namibia, Lalandii, UNDP, Namibian Minerals Corporation (NAMCO), German Organisation for Technical Co-operation (GTZ).

From South Africa: Department of Environmental Affairs and Tourism, Department of Mineral and Energy Affairs, National Parks Board, Cape Nature Conservation, Western Cape Provincial Administration, Northern Cape Provincial Administration, SA Pelagic Fishing Industry Association, SA Deep Sea Trawling Industry Association, University of Cape Town, Port Nolloth Sea Farms, Eco-Africa, University of the Western Cape, SOEKOR, CSIR, PORTNET, Ocean Diamond Mining, South-east Coast Inshore Fishing Association, Tuna and Linefish Association, De Beers Marine, various consultancies.

The Workshop, which was moderated by an independent international facilitator, generated a wealth of information and ideas relevant to the development of a viable BCLME Programme. The objectives of the Workshop were to identify issues and problems/constraints in the Benguela, to attempt to prioritise these and propose possible solutions, to forge consensus among the various stakeholders and roleplayers, to develop an implementable work plan and a mechanism for consultation and co-operation. At the Workshop, keynote addresses were delivered on other LMEs (Yellow Sea, Baltic, Bay of Bengal, Gulf of Guinea), the LME concept, International Waters and the GEF, and on various aspects of the Benguela per se, viz the environment, fisheries, oil and gas industries, mining, coastal zone management and pollution. These overviews provided useful inputs for the subsequent group discussions from which the consensus on problems and priorities emerged. The Stakeholders Meeting held after the conclusion of the Workshop addressed issues such as communication, the budget, donor involvement, studies/ consultancies, project co-ordination and the work plan.

Subsequent to the First Regional Workshop, consultants were appointed to prepare comprehensive syntheses and assessments of information on the BCLME. This resulted in the production of six Thematic Reports ("Integrated Overviews") on:

- Fisheries
- Oceanography and Environmental Variability
- Diamond Mining
- Coastal Environments
- Off-shore Oil and Gas Exploration/Production
- Socio-economics of Some Key Maritime Industries

A Second Regional BCLME Workshop was held at Okahandja near Windhoek, Namibia, during April 1999. At this Workshop the Thematic Reports were briefly reviewed. These syntheses, together with the output from the First Workshop, served as a basis for the development of a draft Transboundary Diagnostic Analysis (TDA). Many of those who had attended the First Regional BCLME Workshop participated in the Second Workshop, and this provided a fair balance across the various stakeholders in the three countries. Although there were necessarily fewer participants (40), all were either acknowledged regional experts on the BCLME representing the main stakeholders or international LME experts (refer to the Report of the Second Regional Workshop for more comprehensive information). At the Workshop the participants divided into three groups to address the three major issues in the BCLME, viz (1) utilisation of resources, (2) environmental variability and (3) ecosystem health and pollution. A breakdown of the sectoral and stakeholders' involvement in each of these three groups is shown in Table D. Excellent progress was made at the Workshop thanks to the quality of leadership provided by the facilitator, the guidance by the international representatives of UNDP-GEF and NOAA (LME concept), and the spirit of co-operation and goodwill of the participants. The essential elements for the TDA were formulated (and prioritised) as per the path: issues > problems > causes > impact > uncertainties > socio-economic consequences > transboundary consequences > activities/ solutions > priority > outputs > costs. This consensus Workshop product forms the basis for the present TDA. Prior to the conclusion of the Workshop, the framework for the Strategic Action Programme was defined and a Work Plan to finalise the BCLME project development phase was formulated.

A small task team was appointed to draft a TDA document based on the output of the Second Regional BCLME Workshop. The draft TDA was circulated to the members of the BCLME Management Committee for comment in July 1999, and was revised so as to comply with GEFSEC requirements, before being endorsed at a meeting of the Management Committee held in Cape Town on 30 September - 1 October 1999.

Towards a Sustainable Future: The Next Steps

What was clear by the end of the Second Regional Workshop was that an enormous amount of goodwill, information and ideas has been generated within the region relevant to the sustainable management of the Benguela Current ecosystem. This bodes well for the future and provides a strong foundation, not only to develop a really viable LME approach to the Benguela Current region, but also to provide a blueprint for how "convex" or open-system LMEs should be developed internationally. This contrasts the approaches for the existing predominantly "concave" or closed-system LMEs that have already been developed; in other words, sustainable integrated management of a highly variable open-boundary ecosystem.

Correcting decades of over-exploitation of resources in the Benguela ecosystem and fragmented management actions (the consequence of the colonial/political past and greed) will require a substantial co-ordinated effort during the next decade, to be followed by sustained action on a permanent basis. A task of this magnitude will require careful planning not only by the government agencies in the three countries bordering the Benguela Current, but also by all the other stakeholders. There already exists the willingness on the part of the key players to collaborate to achieve this objective, but the real challenge will be to develop systems and structures that take cognisance of the naturally highly variable and potentially fragile nature of the BCLME and its coastal environments within the context of a changing society and world. The many issues and problems, as well as possible solutions, have been identified and prioritised in the Transboundary Diagnostic Analysis tables. The resolve of the governments of Angola, Namibia and South Africa to correct the wrongs of the past, and move forward with a new vision to ensure that the BCLME can be sustainably utilised and enjoyed by future generations for the benefit of all, is embodied in the elements of the Strategic Action Programme. The SAP is much more than just a piece of paper; it is a pragmatic, workable framework and unambiguous statement of common goals and objectives and the means of their achievement. Success will depend on thorough implementation of the principles, commitments and actions embodied in the SAP, both explicit and implicit.

In the TDA synthesis and analysis tables a number of major transboundary problems in the BCLME have been identified. These include *inter alia*, non-optimal harvesting of living resources, uncertainty regarding ecosystem status and yields in a highly variable environment, deterioration in water quality, habitat destruction and alteration, loss of biotic integrity and threat to biodiversity, harmful algal blooms, introduction of alien species and inadequate regional capacity (human and infrastructure). Over-arching generic actions which are needed to address these transboundary problems must focus on capacity strengthening and training, policy development and harmonisation, and development of regional collaboration or networking in respect of surveys and assessment of the ecosystem status. These actions are appropriate within the context of a GEF project and it is envisaged that the role of the GEF in the implementation phase of the BCLME Programme will take the form of institution building, strengthening capacity needed in the region to facilitate integrated management, and sharing the costs of the actions with the three governments and donors. The GEF should be catalytic in helping to leverage sustainable (long-term) funding and mobilise private-sector funding. Through such a process it is anticipated that, following the conclusion of the GEF-funded BCLME component, the necessary capacity and institutional structures and sustainable funding will be available in the region to ensure the on-going integrated management of the BCLME. Specific actions in which the GEF will play a role will include *inter alia*:

- Development of appropriate transboundary frame works and mechanisms at both regional, national and local levels for consultation, co-ordination and co-operation
- Development of institutional capacities of the key agencies and institutions in the region that contribute to the integrated sustainable management of the BCLME
- Effective ecosystem assessment and development of an early warning system for ecosystem change
- Actions to fill the gaps in our understanding of the BCLME, its functioning, and the factors which affect it (biophysical, social, economic and political)
- Harmonisation of policies and legislation relating to activities affecting the BCLME
- Increased external support for activities to minimise and mitigate the negative impacts of development (mining, urbanisation, tourism development, resource exploitation) through the promotion of sustainable approaches and the use of appropriate tools
- Measures to improve sustainable resource management
- Measures to protect biological diversity
- Quantification of the role of the BCLME as a source/sink of CO_2 and clarification of the role of the BCLME as a targeted early warning site for global change.

This is seen as compatible with the three elements of the GEF-funded International Waters activities to meet incremental costs of:

1. Assisting groups of countries to better understand the environmental concerns of their international waters and work collaboratively to address them
2. Building capacity of existing institutions, or through new institutional arrangements, to utilise a more comprehensive approach for addressing transboundary water-related environmental concerns, and
3. Implementing sustainable measures that address priority transboundary environmental concerns.

Policies, structures and actions developed during the implementation phase of the BCLME Programme, i.e. over the next five years, must by the end of the period be self-sustainable in the region. To achieve this it is essential that mechanisms be in place to encourage – indeed ensure – a substantial degree of co-financing of activities. This can best be done by involving and developing partnerships with maritime and coastal industries, the international community, and present and future beneficiaries, i.e. all those who have a stake in the long-term health and viability of the Benguela as an LME.

Users' Guide to the TDA

Definitions and TDA Objective

A Transboundary Diagnostic Analysis is a scientific and technical assessment, through which the water-related environmental issues and problems of a region are identified and quantified, their causes analysed and their impacts, both environmental and economic, assessed. The analysis involves the identification of causes and impacts (and uncertainties associated with these) at national, regional and global levels, and the socio-economic, political and institutional context within which they occur. The identification of the causes should, where appropriate, specify sources, locations and sectors. The TDA assessment should indicate which elements are clearly transboundary in character and list and prioritise activities or solutions to address the issue/problem and the root causes.

Within the context of the TDA, transboundary environmental issues include *inter alia*:

- regional/national issues with transboundary causes/sources
- transboundary issues with national causes/sources
- national issues that are common to at least two of the countries and that require a common strategy and collective action to address
- issues that have transboundary elements or implications (e.g. fishery practices on biodiversity/ecosystem resilience).

The objective of the Benguela Current TDA is to provide, on the basis of clearly established evidence, structured information relating to the degradation and changing state of the Benguela Current LME, to scale the relative importance of the causes and sources of the transboundary water-related problems, and to elucidate practical preventative and remedial actions to ensure the sustainable integrated management of this unique environment. The TDA provides the technical basis for the development of a Strategic Action Programme (SAP), and the Project Brief, for the BCLME within the International Waters Area of the GEF.

Design of the TDA

Comprehensive information about the status of the BCLME, the principal issues and problems, and their causes and impacts generated at the First Regional BCLME Workshop in mid-1998 and through a suite of Thematic Reports subsequently prepared by regional/international experts, was examined at the Second Regional BCLME Workshop (April 1999), synthesised and then condensed into a series of analytical tables. These are presented in this document.

The current TDA has been designed at two operational levels. These are as follows:

(a) *Level One: Synthesis:* The issues and perceived main transboundary problems, root causes and areas where action is proposed.

This level, consisting of a Synthesis Matrix and some explanatory text about the transboundary characteristics of the BCLME, serves as a logistical "map" for the TDA. It considers the main issues and major perceived environmental problems which must be addressed for the sustainable integrated management of the BCLME. It examines the transboundary elements of the problems (i.e. elements shared by at least two of the three countries) and then relates them to their major underlying institutional, societal or global root causes. In all cases the root causes are common to a large number of problems and require changes to the role given to environmental issues within the priorities of the governments and the public in general. The matrix identifies three generic areas (issues) where proposals for action can be formulated, viz utilisation of resources, environmental variability and pollution/ecosystem health. For each of these generic areas a number of more specific issues ("sub-issues") are identified, which are developed at the next level of the TDA. A simplified version of the Synthesis Matrix is given in Figure 2.

(b) *Level Two: Specifics:* Comprehensive information on the issues, sub-issues, problems, causes, impacts, uncertainties, socio-economic consequences, the perceived solutions, priorities, outputs and costs.

Working on the basis of the issues and major problems perceived in Level One, the tables and text which comprise Level Two examine the nature of the specific problems identified as contributors to ecosystem degradation and change in the Benguela Current region. They examine the management uncertainties (in the case of environmental variability, the uncertainty of the variability per se) and knowledge gaps which need to be filled. They present priority practical and implementable proposals for inclusion in the BCLME SAP and the cost of the required international action where possible. Finally the series of tables identify the outputs (products) which should be obtained through the successful implementation of the action and lists the stakeholders for each problem and action area identified. Explanatory text is provided for each sub-issue table.

More Information

Readers requiring more information about the BCLME, present state of knowledge about ecosystem structure and functioning, its complexity, ecosystem status, ongoing work and principal management problems are referred to the following:

- Report on the First Regional BCLME Workshop
- Report on the Second Regional BCLME Workshop
- Background Papers for the First Regional BCLME Workshop
- Synthesis and Assessment of Information on the BCLME: Thematic Reports 1-6
- Proceedings of the International Symposium on Environmental Variability in the South-east Atlantic, March/April 1998 (approx 600pp)
- Proceedings of the Workshop on Environmental Variability, Environmental Monitoring and Environmental Strategic Planning, April 1998 (28pp)
- The Benguela and Comparable Ecosystems (*South African Journal of Marine Science*, Vol.5, 1987: 957pp)
- Benguela Trophic Functioning (*South African Journal of Marine Science*, Vol.12, 1992: 1108pp)
- Benguela Dynamics (*South African Journal of Marine Science*, Vol.19, 1999: 512pp)

BCLME Transboundary Diagnostic Analysis

Geographic Scope & Ecosystem Boundaries

Conducting a comprehensive transboundary analysis is only possible if the entire LME, including all inputs to the system, is covered in the study. In the case of the Benguela, which is a very open system where the environmental variability is predominantly remotely forced, this should then include the tropical Atlantic *sensu latu*, the Agulhas Current (and its link with the Indo-Pacific), the Southern Ocean, and the drainage basins of all major rivers which discharge into the greater Benguela Current region, including the Congo River. Clearly such an approach is impracticable, and more realistic and pragmatic system boundaries have to be defined in order to develop and implement a viable ecosystem management framework. The principal external and internal system boundaries are shown in Figure 1.

- *Landward boundary:* With the exception of the Congo River, the main impact of discharges from rivers flowing into the South-east Atlantic tends to be episodic in nature, i.e. in terms of significant transboundary concerns, these are limited to extreme flood events. (Their drainage basins never-theless do include a major part of the southern African hinterland.) The Congo River, however, exerts an influence which can be detected over thousands of kilometers of the South Atlantic and drains much of Central Africa. From a practical point of view, it is quite beyond the scope of the BCLME to attempt to include the development of any management structures for a river such as the Congo. With respect to land sources of pollution in the BCLME (excluding the Congo River area), these are only really significant in the proximity of the principal port-cities (e.g. Cape Town, Luanda, Walvis Bay), and the effects are generally very localised. Nevertheless, some of the problems experienced in these areas are common in nature and could be addressed through similar remedial actions. Like coastal development, their impacts generally do not have a transboundary character. (In contrast, pollution from ships, major oil spills, introduction of alien species and associated harmful algal blooms, etc. are transboundary concerns.) From a BCLME perspective, the landward boundary can thus, for all practical purposes, be taken as the high water mark at the coast. Specific allowances can be made in some areas on a case by case basis (e.g. during episodic flooding from the Orange and Cunene Rivers, which are situated at the country boundaries of South Africa-Namibia and Namibia-Angola respectively).
- *Western boundary:* The Benguela Current is generally defined as the integrated equatorward flow in the upper layers of the ocean in the South-east Atlantic between the coast and the 0° meridian. The BCLME Programme will accordingly use 0° as the western boundary, but for practical management purposes the focus will be on the areas over which the three countries have some jurisdiction, i.e. their Exclusive Economic Zones extending 200 nautical miles seawards from the land.
- *Southern/Eastern boundary:* The upwelling area of the BCLME extends around the Cape of Good Hope, seasonally as far east as Port Elizabeth. This extreme southern part of the ecosystem is substantially influenced by the Agulhas Current, its Retroflection (turning back) and leakage of Indian Ocean water into the Atlantic south of the continent. As the variability of the BCLME is very much a function of the complex ocean processes occurring in the Agulhas Current – Retroflection area, this will be taken as the southern boundary with 27°E longitude (near Port Elizabeth) being at the extreme eastern end.
- *Northern boundary:* While the Angola-Benguela Front (more correctly a series of fronts) comprises the northern extent of the main coastal upwelling zone, upwelling can occur seasonally along the entire coast of Angola. There are, in any event, strong linkages between the behaviour of the Angola-Benguela Front (and the oceanography of the area to the south of it) and processes occurring off Angola, especially the Angola Dome and the Angola Current. Unless these are considered as an integral part of the BCLME, it will not be feasible to evolve a sustainable integrated management approach for the Benguela. Moreover, there is a well-defined front at about 5°S, viz the Angola Front, which is apparent at sub-surface depths. It is this front which is the true boundary between the Benguela part of the South Atlantic and the tropical/equatorial Gulf of Guinea system. A northern boundary at 5°S would thus encompass the Angola Dome, the coastal Angola Current, and the area in which the main oxygen minimum forms and the full extent of the upwelling system in the South-east Atlantic. A pragmatic northern boundary is thus at 5°S latitude, which is in the vicinity of the northern boundary of Angola (Cabinda) and the southern extent of the Gulf of Guinea Large Marine Ecosystem (GOGLME). Strong links will need to be built between the BCLME and the GOGLME (and other initiatives in the tropical Atlantic) in order to develop an eventual holistic approach to the management of the South-east Atlantic Ocean.

Level One: Synthesis

The Issues and Perceived Main Transboundary Problems, Root Causes and Areas where Action is Proposed

Seven perceived major transboundary problems have been identified. These are listed below, together with a short description of the transboundary characteristics of each of them. The Synthesis Matrix or "logistical map" and Figure 2, which follow the description, encapsulate the essence of the TDA. They highlight the transboundary elements and root causes associated with each problem and schematically show how the proposed actions serve to address the causes and help solve the problems.

Problem (i): **Decline in BCLME commercial fish stocks and non-optimal harvesting of living resources**

Transboundary Characteristics: Country boundaries do not coincide with ecosystem sub-boundaries; most of the region's important harvested resources are shared between countries, or move across national boundaries at times. Over-harvesting of a species in one country can therefore lead to depletion of that species in another, and in changes to the ecosystem as a whole. Moreover, many resource management difficulties are common to all the countries.

Problem (ii): **Uncertainty regarding ecosystem status and yields in a highly variable environment**

Transboundary Characteristics: The Benguela environment is highly variable and the ecosystem is naturally adapted to this. However, sustained large-scale environmental events – such as Benguela Niños, episodic hypoxia/anoxia, Agulhas intrusions and changes in winds – affect the ecosystem as a whole, compounding the negative effects of fishing. These events and changes generally have their origin and cause outside the BCLME, but are of such a scale that the impacts occur in the international water areas of all three countries, i.e. the changes propagate across external BCLME boundaries and internal geopolitical boundaries. The poor ability to predict the events and change limits the capacity to manage effectively system-wide. In addition, the BCLME is believed to play a significant role in global ocean and climate processes and may be an important site for the early detection of global climate change.

Problem (iii): **Deterioration in water quality – chronic and catastrophic**

Transboundary Characteristics: Although most impacts of chronic deterioration in water quality are localised (national issues), they are common to all of the countries and require collective action to address. Moreover, chronic pollution can favour the development of less desirable species, and result in species migration. Catastrophic events (major oil spills, maritime accidents) can impact across country boundaries, requiring co-operative management and sharing of clean-up equipment and manpower.

Problem (iv): **Habitat destruction and alteration, including *inter alia* modification of seabed and coastal zone, and degradation of coastscapes**

Transboundary Characteristics: Although most impacts may appear localised, habitat alteration or loss due to fishing and mining can cause migration of fauna and system-wide ecosystem change. Uncertainties exist about the regional cumulative impact on benthos resulting from mining and associated sediment remobilisation. Moreover, certain mining activities are conducted close to national boundaries and negative consequences may be transmitted across into the adjacent country's EEZ. Inadequately planned coastal developments result in degradation of coastscapes and reduce the regional value of tourism. Shallow water/beach mining is a major environmental concern.

Problem (v): **Loss of biotic integrity (changes in community composition, species and diversity, introduction of alien species, etc.) and threat to biodiversity/endangered and vulnerable species**

Transboundary Characteristics: Most harvested fish species are shared between countries and straddle geopolitical boundaries. Past over-exploitation of targeted fish species has altered the ecosystem as a whole, impacting at all levels – including top predators – and reducing the gene pool. Some species (e.g. African penguin), are threatened or endangered. Exotic species have been introduced into the Benguela. (This is recognised as a global transboundary problem.)

Problem (vi): **Inadequate human and infrastructure capacity to assess the health of the ecosystem as a whole (resources and environment, and variability thereof)**

Transboundary Characteristics: There is inadequate capacity, expertise and ability in the region to monitor and assess adequately the shared living resources and system-wide environmental variability. Moreover, there is unequal distribution of this capacity between the three countries.

Problem (vii): **Harmful algal blooms (HABs)**

Transboundary Characteristics: HABs occur in all three countries, which face similar problems in terms of impacts and management, and which require collective regional action to address.

SYNTHESIS MATRIX

Perceived Major Problem	*Transboundary Elements*	*Major Root Causes*	*Action Areas*
Decline in BCLME commercial fish stocks and non-optimal harvesting of living resources	Most of the region's important harvested resources are shared between countries, or move across national boundaries at times, requiring joint management effort	1,2,3,4,5,6,7	A,B (C)
Uncertainty regarding ecosystem status and yields in a highly variable environment	Environmental variability/change impacts on ecosystem as a whole, and poor predictive ability limits effective management. The BCLME may also be important to global climate change	1,2,3,7	A,B,C
Deterioration in water quality – chronic and catastrophic	While most impacts are localised, the problems are common to all three countries and require collective action to address	2,3,4,5,7	C
Habitat destruction and alteration, including *inter alia* modification of seabed and coastal zone, and degradation of coastscapes	Uncertainties exist about the regional cumulative impact from mining on benthos and ecosystem effect of fishing. Degradation of coastscapes reduce regional value of tourism	2,3,5,6,7	A,C (B)
Loss of biotic integrity* and threat to biodiversity/endangered and vulnerable species *Changes in community composition, species diversity, introduction of alien species etc.	Fishing has altered the ecosystem as a whole, reduced the gene pool, and caused some species to become endangered or threatened. Introduced alien species are a global transboundary problem	1,3,5,6	A,C (B)
Inadequate capacity to assess ecosystem health (resources and environment, and variability thereof)	There is inadequate capacity in the region to monitor the shared resources and the system-wide environmental variability, and unequal distribution of the capacity between countries	1,2,5,7	A,B,C
Harmful algal blooms (HABs)	HABs are a common problem in all three countries and require collective action to address	1,2,3,6,7	A,B,C

Main Root Cause	*Areas where Action is Proposed*
1. Complexity of ecosystem and high degree of variability (resources and environment) • Changing state of the Benguela • Inadequate information and understanding • Difficulty in monitoring and assessment • Poor predictability	**A. Sustainable management and utilisation of resources** • Facilitation of optimal harvesting of living resources • Assessment of mining and drilling impacts and policy harmonisation • Responsible development of mariculture • Protection of vulnerable species and habitats • Assessment of non-harvested species and role
2. Inadequate capacity development (human and infrastructure) and training • Colonial/political past • Institutional downsizing and brain-drain • Limited inter-country exchange (training)	
3. Poor legal framework at the regional and national levels • Regionally incompatible laws and regulations • Ineffective environmental laws and regulations	**B. Assessment of environmental variability, ecosystem impacts and improvement of predictability** • Reducing uncertainty and improving predictability • Capacity strengthening and training • Management of consequence of harmful algal blooms
4. Inadequate implementation of available regulatory instruments • Inadequate compliance and enforcement (over-fishing, pollution) • Indifference and poor communication • Posts not filled (some inappropriately)	
5. Inadequate planning at all levels • Inadequate intersectoral co-ordination • Poorly planned coastal developments • Limited time horizon of planners • Rapid urbanisation and informal settlements	**C. Maintenance of ecosystem health and management of pollution** • Improvement of water quality • Prevention and management of oil spills • Reduction of marine litter • Retardation/reversal of habitat destruction/ alteration • Conservation of biodiversity
6. Insufficient public involvement • Lack of awareness, and public apathy • Conflicts about rights of access	
7. Inadequate financial mechanisms and support • Low country GDPs • Ineffective economic instruments • Insufficient funding for infrastructure and management; poor salaries	

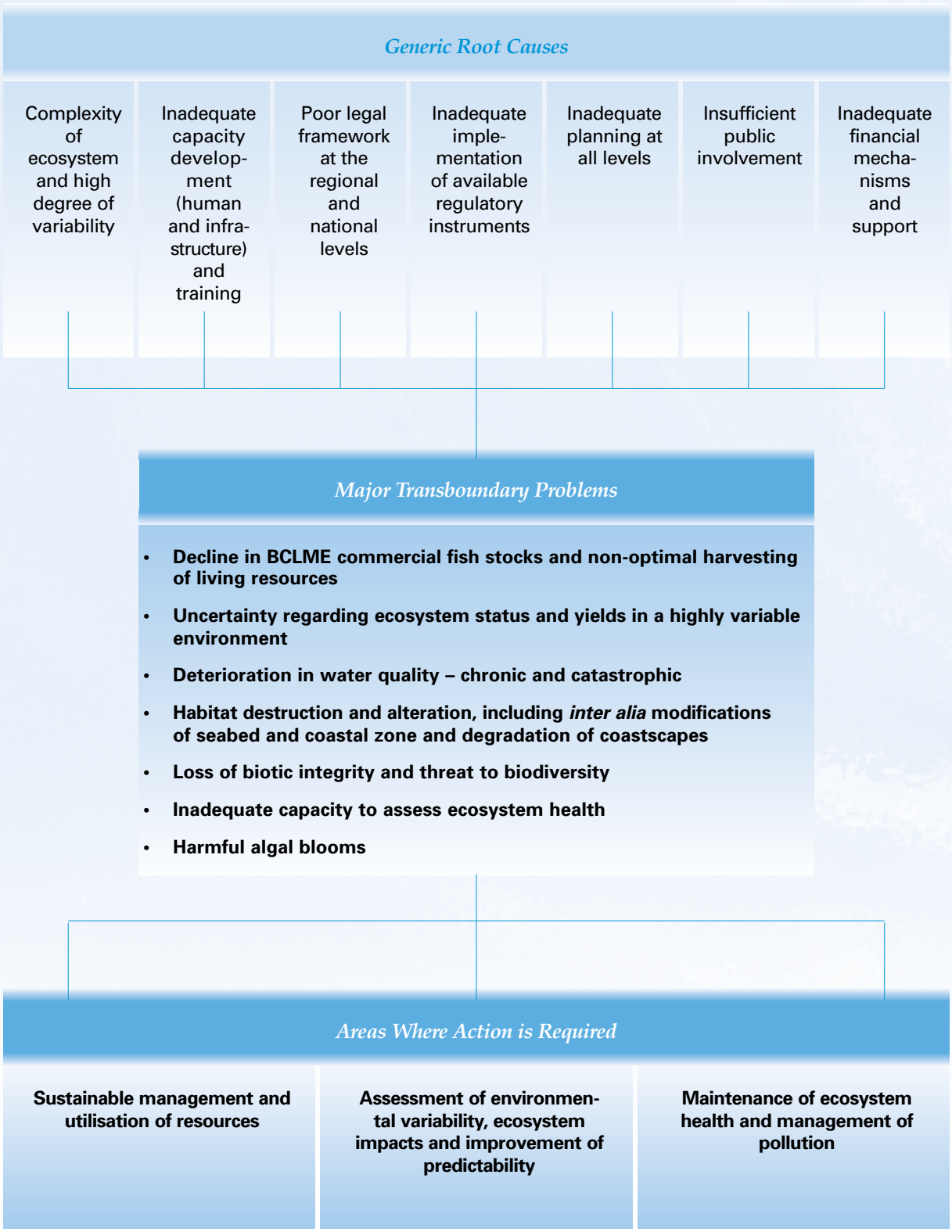

FIGURE 2 Major transboundary problems, generic root causes and areas requiring action

Level Two: Action Areas

An Overview of Specific Transboundary Problems, Causes, Impacts, Actions Required and Anticipated Outputs

In Level One: Synthesis, three broad action areas were identified in order to address the perceived major BCLME problems and the main root causes of these problems. The action areas correspond to the three main issues in the BCLME, namely utilisation of resources, environmental variability, and ecosystem health and pollution. For each action area a set of more specific actions was specified in the Synthesis Matrix. These specific actions were formulated collectively through consensus among stakeholders at the Second Regional BCLME Workshop to identify the specific problems associated with each main issue. These have been prioritised and the outputs or solutions emanating from the specific actions have been listed and costed. The essential information has been summarised in the set of analysis tables which follow. These tabular summaries are necessarily brief – often in point form – and where additional clarification has been deemed necessary, this has been provided following each table in the form of explanatory notes.

What is not immediately apparent from the Level Two tables, developed by consensus at the Second Workshop, is that there are a number of generic actions which cut across the specific actions within each of the three broad action areas, and indeed even between the broad action areas. For the sake of completeness the essence of this alternative but complementary approach is as follows:

Action Area A:
Sustainable management and utilisation of resources

Generic Actions:

- Capacity strengthening and training
- Joint surveys and assessments of shared resources and intercalibration
- Policy harmonisation and integrated management
- Co-financing with private sector/industry
- Development of new industries (e.g. mariculture, tourism)

Action Area B:
Assessment of environmental variability, ecosystem impacts and improvement of predictability

Generic Actions:

- Capacity strengthening and training re transboundary concerns
- Regional networking and international linking
- Development of regional early warning system, assessment and prediction capability (including re-assessments) and joint response policies
- Cross-cutting demonstration projects

Action Area C:
Improvement of ecosystem health and management of pollution

Generic Actions:

- Capacity strengthening and training
- Policy harmonisation, and development
- Development of regional framework for assessment
- Establishment of effective surveillance and enforcement agencies
- Development of stakeholder participation structures

What emerges quite clearly from the above approach is that generic actions, such as capacity strengthening and training, the development of regional collaboration or networking in respect of surveys and assessments, and policy development and harmonisation, are over-arching actions. These are obvious priorities for GEF support.

Analysis Tables and Explanatory Notes

NOTE: The numbering of these Tables corresponds with the Action Areas identified in the Level One Synthesis Matrix

TABLES A: SUSTAINABLE MANAGEMENT AND UTILISATION OF RESOURCES

TABLE A1: FACILITATION OF OPTIMAL HARVESTING OF LIVING RESOURCES

Problems	*Causes*	*Impacts*	*Risks/Uncertainties*
A1. Non-optimal harvesting of living resources: **Non-optimal harvesting includes over-harvesting, such as over-fishing, as well as wastage through dumping of bycatch and the catching and dumping of under-size fish. It also includes not taking ad-vantage of resources with the potential to offer sustainable devel-opment oppor-tunities (e.g. seaweed, some invertebrates). This often results from a lack of technology or knowledge of the opportunities available.**	• Fishing over-capacity • Inadequate tools • Non-sustainable utili-sation of resources • Lack of collaborative assessment and monitoring • Inadequate information • Inadequate manage-ment • Inadequate control • Lack of collaborative management of shared resources • International policy on seal harvesting	• High by-catch and undersize catch • Fisheries impacting productivity cycle • Ecosystem change • Resource depletion • Human population movements (local and regional) • Large variation in landings • Variation in food supply for birds, seals etc. • Conflict (e.g. artisanal vs. commercial vs. recreational; conflict with mining) • Exploding seal population • Competition for exploited resources	• Irreversible ecosystem change • Biodiversity change • Habitat destruction • Collapse of commer-cially important stocks

A1 EXPLANATORY NOTES PROBLEM: NON-OPTIMAL HARVESTING OF LIVING RESOURCES

Causes

- Fishing over-capacity – Too many fishers, too many boats, excess processing capacity.
- Inadequate tools for assessment – Currently available tools for assessment do not always produce effective results, data for assessment are not equally available and are not in a uniform format. Assessment tools that are available are not applied equally within the region, and fishing methods are not sufficiently selective.
- Non-sustainable utilisation of resources due to over-fishing, high bycatch, catches of small fish and non-targeted species. This is a tradition in world-wide fisheries management.
- Lack of collaborative assessment and monitoring – there is no effective mechanism within the region to ensure that collaborative assessment takes place.
- Inadequate information – The biology of all harvested and potentially harvested species is not always well known. In the latter, some groups with economic potential, such as seaweeds and some invertebrates, are very poorly known within the region.
- Inadequate management – Management due to insufficient information, vulnerable to pressure from industry, over-riding socio-economic and political pressures. Lack of informed advice sometimes results in ill-advised management decisions.
- Inadequate control – Even when assessments and quotas are used to manage fisheries, the control and enforcement mechanisms are often lacking.
- Lack of collaborative management of shared resources.
- International policy on seal harvesting – Conservation pressure on national governments prevents utilisation of seals, and contributed to the increase in seal populations, with implications for other components of the ecosystem.

Socio-Economic Consequences	Transboundary Consequences	Activities/Solutions	Priority	Incremental Cost (5y)	Anticipated Outputs
• Variable and uncertain job market • Loss of national revenue • Lack of food security: artisanal /industrial • Erosion of sustainable livelihoods • Missed opportunities (under-utilisation and wastage) • Loss of competitive edge on global markets	• Most harvested resources are shared between countries, or cross national borders, over-fishing in one country can cause depletion in a neighbouring country • Common problems • Shared solutions	• Provision of information: to facilitate regional assessments of shared resources and ecosystem impacts • Joint surveys and assessments • Gathering and calibration of baseline information • Analysis of socio-economic consquences for the whole ecosystem • Assessment of potential of new resources • Establish a regional forum for stock assessment, ecosystem assessment and annual advice	1 1 1 1 2 1	$ 500 000 $ 2 000 000 $ 400 000 $ 400 000 $ 1 000 000 $ 800 000	• Optimal sustainable resource utilisation • Improved forecasting • Establishment of a regional forum • Prevention of irresistable ecosystem change

Impacts

- Resource depletion – This is an obvious effect of over-harvesting, a depletion of the resource below optimal levels.
- High bycatch and undersize fish catch – This reduces the productivity of fisheries, and may lead to ecosystem change (uncertainty) and decreased yields.
- Fisheries impacting productivity cycle – The depletion of, for example, a grazer such as pilchard from the system could cause the diversion of production into eutrophication with subsequent sulfur eruptions that might kill off zooplankton grazers and further shift the system out of balance. Changes in the system could reduce yields in other ways too, e.g. changes that favour large gelatinous plankton. Recruitment fisheries result in productivity and yields that are less than what they could be under better management.
- Ecosystem change – Over-harvesting of ecologically important species may change the nature of the ecosystem, such as diverting productivity into decompositional pathways that may lead to increases in frequency/intensity of anoxic events. (S.Afr. J.Mar.Sci.12)
- Human population migration (local and regional) – Declines in opportunities in resource harvesting at the coast leads to increased migration into cities, and the expansion of urban poverty, exacerbated by large slumps in catches. (BCLME Thematic Report 6)
- Large variation in landings – Results should be precautionary approach leading to reduced levels of over-harvesting. Regularity of employment, reliability of markets etc., all suffer when variation is great.
- Variation of food supply for birds, seals etc. Humans and other organisms compete for food. Over-harvesting of resources by humans may lead to a decrease in food supply available to seabirds, seals, and other marine organisms that may themselves be important as tourism resources. (S.Afr. J.Mar.Sci.12)
- Conflict (e.g. artisanal vs. commercial vs. recreational) – Artisanal, recreational and commercial fishers often compete for the same resources. Conflicts among these sectors may increase when resources become depleted.

- Exploding seal population.
- Competition for exploited resources – Harvesting of pelagic resources has had a huge impact on food availability for other top predators.

Risks/uncertainties

- Irreversible ecosystem change – The degree to which changes that take place in the ecosystem (as a result of over-harvesting) are reversible is not known.
- Biodiversity change – Changes in biodiversity (genetic, species, ecosystem) may occur as a result of the over-harvesting of resources, but the lack of good baseline data makes this difficult to assess. Hence we do not know the degree to which over-fishing affects biodiversity.
- Habitat destruction – The degree to which over-harvesting affects habitat through impacts on dominant species, or directly through impacts of the harvesting technology (e.g. bottom trawls) is unknown. Baseline data are lacking.
- Actions in one country can cause collapse of a shared commercially important stock (e.g. collapse of Benguela hake stock in 1970s as a result of gross over-fishing by foreign fleets).

Socio-economic consequences

- Financial and job numbers – Over-harvesting of resources reduces the number of jobs and the financial gain accruing to coastal communities. Jobs lost in one country may result in an increase in job opportunities in another country due to changes in employment opportunities.
- Loss of national revenue – If resources are over-harvested, or if opportunities for developing new resources on a sustainable basis are missed, then the contribution of those resources to the national revenue base is reduced.
- Lack of food security (artisanal/industrial) – Artisanal fishers depend on fisheries resources directly for protein; over-harvesting by the industrial sector may erode the food security of coastal artisanal fishers and their families. Loss of jobs in the industrial sector may also increase poverty, and decrease food security.
- Erosion of sustainable livelihoods – Livelihoods of coastal people may often depend on activities that are based on assets (e.g. fish resources) that are harvested by other sectors. Over-harvesting of those assets, either by coastal dwellers themselves or by industrial harvesting, may erode the livelihoods of coastal people, and bring about increased urban migration and increases in urban poverty and the spreading of poverty-related diseases.
- Missed opportunities (under-utilisation and wastage) – There may be many opportunities for the novel utilisation of marine resources. Examples include drugs from both inshore and deep-water invertebrates, as well as drugs and other low-volume, high-value products from seaweeds. A co-ordinated regional assessment of such resources and co-ordinated development could bring regional benefits in this area.
- Competitive edge on global markets – Lost markets are difficult to regain, and could have global impacts (retain dominating role in hake market, regain role in fishmeal market). Increases or reductions in yields in one area may impact upon another area (country), resulting in market competition among the BCLME countries. To retain a competitive edge in rapidly changing markets, stability of the throughput and quality enhancement that comes with that stability are essential.

Transboundary consequences

- Most of the region's important harvested resources are shared between countries (i.e. straddle national boundaries), or move across national boundaries at times. (See Oceanogr. Mar. Biol. Ann. Rev. Vol 25, pp 353 - 505, and also BLCME Thematic Report 1.) Over-harvesting of a species in one country can therefore lead to depletion of that species in another, and in changes to the ecosystem as a whole. (For example, the collapse of the Namibian sardine in the 1970s followed the collapse of the sardine in South African waters.)
- Inappropriate management of regional resources endangers sustainability of resources and consistency of catches, and leads to sub-optimal use, resulting in lower food production, loss of jobs and national revenue, and increased reliance on foreign aid.

- Potential irreversible changes in nature of ecosystem due to depletion of widely distributed ecologically important species. (S.Afr. J.Mar. Sci.12)
- Movement of vessels and humans across borders in response to depletion of resources. Increased local and regional conflicts. (Refer to ICSEAF reports)
- Depletion and/or large-scale distributional shifts in predator species in response to reduced prey abundance (S. Afr. J. Mar. Sci 12). For example, there is evidence that the Namibian seal population was severely depleted and some animals migrated into Angola and South African waters following the 1995 Benguela Niño.

Activities/solutions

- Co-financing with industry – Co-financing from the fishing industry and other donors is a priority for effective management.
- Provision of information to facilitate regional assessments of shared resources. This will be augmented by BENEFIT outputs (co-financed). A structure should be established to conduct regional stock assessments, ecosystem assessments, evaluate resource-environmental linkages, and facilitate post-harvest technology.
- Joint surveys and assessments carried out co-operatively will help produce enhanced management and optimal utilisation. These joint surveys will be offered as a five-year demonstration of the benefits to the individual nations of joint transboundary assessments.
- Gathering and calibration of baseline information – This should be done on resources, potential resources before harvest, as well as ecosystems.
- Co-operative analysis of socio-economic consequences – Analyses of the socio-economic consequences of non-optimal and improved use of resources should be done with a view to appropriate intervention within the framework of improving sustainable livelihoods.
- Co-operative training – Co-operative training will be essential to generate regional capacity needed to address the transboundary issues, and to promote sustainable integrated management. Co-operative training targeted at communities will be necessary. Training – in management, enforcement, and the creation of new opportunities.
- Co-operative assessment of potential new resources. Many biological resources and potential new resources in both offshore and inshore areas are common to the BCLME, and assessments should be conducted co-operatively. Only those activities which address transboundary problems requiring incremental funding are listed.

Priority

- Proposed activities are ranked on a scale of 1-3 in terms of their perceived priority. Only those activities which address transboundary problems requiring incremental funding are listed.

Anticipated outputs

- Optimal resource utilisation – This is the most obvious output from the suggested solutions; there will be a reduction in the exploitation level of resources that are deemed to be over-harvested so that stocks can be rebuilt to optimum levels, and an increase in the benefit to coastal communities from the exploitation of novel or currently unexploited resources.
- Improved forecasting – Joint assessment will enable/improve predictions of sustainable resource-harvest levels.
- Establish regional structure – This regional structure will be responsible for producing annual stock assessment reports, annual ecosystem reports, and provide advice or suggestions of resource harvesting levels, and other matters related to resource use, particularly fisheries.
- Training packages on management, enforcement, and opportunity creation – all at the regional level to advance the concept of sustainable integrated management of the BLCME.

TABLE A2: ASSESSMENT OF MINING AND DRILLING IMPACTS AND POLICY HARMONISATION

Problems	*Causes*	*Impacts*	*Risks/Uncertainties*
A2. Mining and Drilling Impacts: **Exploration for oil and gas and minerals such as diamonds is expanding throughout the Benguela. This involves drilling, dredging and seismic exploration. There is substantial oil extraction in northern Angola (Cabinda) while the development of oil/gas fields (with pipelines) are planned further south (e.g. Namibia). Capped wellheads hamper fishing while drill cuttings and hydrocarbon spills impact on the environment. Extensive diamond mining is being conducted using dredging equipment along the coasts of and continental shelves of Namibia and South Africa. Ecosystem effects of these activities are not fully known.**	• Pipelines • Drilling and dredging • Seismic exploration	• Habitat destruction • Seabed modification • Coastal soil, beach, intertidal and subtidal profile destruction • Conflicts (fish, diamonds, gas) • Behaviour of resources • Mortality of larvae	• Cumulative impacts • Effects on benthos • Change of biodiversity • Cost/ benefit

A2 EXPLANATORY NOTES
PROBLEM: MINING AND DRILLING IMPACTS

Causes

- Pipelines
- Drilling and dredging
- Seismic exploration

Impacts

- Habitat destruction – Habitat destruction from drilling may be localised, but dredging for diamonds disrupts large areas of seabed, disturbs the sediments and changes the particle size distribution. The impact of this on benthos and other resources, particularly fisheries resources, needs to be assessed and mitigated if necessary.
- Seabed modification – Seabed modification, related to habitat destruction, may impact on the exploitation of other resources; for example, pipelines and wellheads and their potential impact on availability of bottom areas to trawl fishing.
- Coastal soil, beach, intertidal and subtidal profile destruction. Coastal mining moves the coastal soils, alters the beach profile and destroys coastal vegetation, and intertidal and subtidal habitats.
- Conflicts (fish, diamonds, oil and gas). Conflicts may arise between different sectors. Appropriate strategies are needed to decrease the potential for conflict, and to resolve conflicts that arise (e.g. lobster/ diamond, fishing/oil).
- Behaviour (e.g. scaring of mammals and fish during seismic surveys) and mortality (e.g. mortality of larvae) of resources – Fish migrating away from, and fish larvae being killed by, activities.

Risks/uncertainties

- Cumulative impacts – The cumulative impacts of lots of smaller impacts from mining, as well as the cumulative effects over time, are unknown, but may be significant within the context of the ecosystem.
- Effects on benthos – The effects of mining on benthic communities are uncertain.
- Change of biodiversity – It is not known whether mining impacts lead to a reduction in biodiversity in the mined areas
- Cost/benefit – Costs and benefits to the environment from mining and drilling in this perspective are unknown.

Socio-economic consequences

- *Negative:* Exclusion zones around mining operations, wellheads on Agulhas Bank

  Positive: Reserves – A negative effect of mining is the closure of large areas of coastline, restricting access to living resources by coastal dwellers or potential dwellers. A positive effect is that exclusion zones could act as biotic reserves.
- Reduced artisanal fisheries – This is a negative effect of the exclusion, as well as the impact of mining-related coastal activities.
- Coastal tourism – The closure of large areas of coast reduces the potential for tourism development in affected areas.

Socio-Economic Consequences	Transboundary Consequences	Activities/Solutions	Priority	Incremental Cost (5y)	Anticipated Outputs
• Financial and employment benefits • -ve: exclusion +ve: reserves • Reduced artisanal fisheries • Coastal tourism • Onshore development • Effects on coastal communities, post-mining	• Three countries share common problems • Cumulative impacts are unknown but may be substantial • Shared solutions	• Policy harmonisation • Enhanced consultation – sectoral and regional • Cumulative impact assessment for BCLME	1 2 1	$ 100 000 ($ 100 000) $ 500 000 ($ 500 000) industry	• Environmental management plan • Integrated management • Solution to capacity problem

- Onshore development – Onshore development increases opportunities for jobs, but also modifies habitats through construction and pollution. In addition, coastal migration, urbanisation and poverty may be an impact where open towns are adjacent to mining areas.
- Effects on coastal communities post mining – Mines eventually close, leaving former mine workers without obvious sources of sustainable employment.

Transboundary consequences

- Mining activities occur in all three countries (see BCLME Thematic Reports 3 and 5). Most of the impacts are localised but uncertainty exists regarding cumulative impacts of oil/gas and diamond mining which added to impacts of fishing and pollution could be significant, especially regarding benthos. As such, an assessment of the cumulative impacts of mining/drilling is a prerequisite for sustainable integrated management of the BCLME.
- The mining industry in RSA, Namibia and Angola undertake EIAs for all projects. The oil/gas and diamond industry in RSA and Namibia are working together to consolidate baseline information. This results in an appreciable level of co-financing.
- All three countries share common problems. For example, conflicts between resource users and lack of post-mining opportunities.
- Regulation of mining activities needs to be standardised within the region.

Activities/solutions

- Policy harmonisation – Co-operative harmonisation of mining policies, particularly related to shared resources and cumulative impacts and their mitigation, will be needed.
- Cumulative impact assessment for BCLME (industry co-funding) – An overall impact assessment of the mining industry is needed.
- Enhanced consultation (sectoral and regional) is needed to reduce impacts of mining and ensure benefits accrue and conflicts are reduced.
- Co-operative training will be needed for the effective management of mining impacts, as well as developing activities following cessation of mining.

Priority

- Proposed activities are ranked on a scale of 1-3 in terms of their perceived priority. Only those activities which address transboundary problems requiring incremental funding are listed.

Anticipated outputs

- Environmental management plan – An overall environmental management plan for the whole BCLME will be produced, including management plans for mitigating mining and other impacts.
- Integrated management – this will be the output of the above plan.
- Solution to capacity problem – This will be the result of training to improve assessment and management capacity with respect to the transboundary issues.
- Regional training packages on managing mining impacts, community development following mine closure.

TABLE A3: RESPONSIBLE DEVELOPMENT OF MARICULTURE

Problems	*Causes*	*Impacts*	*Risks/Uncertainties*
A3. Mariculture is under-developed but this is rapidly changing: **Mariculture has the potential throughout the Benguela region to provide labour-intensive employment, protein and foreign currency from export of high-value products. The respnsible development of a mariculture industry is hampered by lack of information and capacity, and lack of harmonised/regional policy.** **Ecosystem effects of mariculture developments are uncertain; for example introduction of exotic species and transboundary consequences thereof.**	• Inadequate policy • Differential regional policy – policies differ in the three countries • Space • Lack of information	• Threat to biodiversity • Diseases • Conflict over space/ markets • Eutrophication	• Environmental variability • Market uncertainty • Feasibility

A3 EXPLANATORY NOTES
PROBLEM: MARICULTURE REQUIRES RESPONSIBLE DEVELOPMENT

Causes

- Introduction of exotics – Mariculture may use exotic species, which can create threats to biodiversity and ecosystem function.
- Inadequate policy – While some countries have policies in place, others do not. Policy may not be enacted even where it exists, although at least Namibia apparently has a good policy that is about to be enacted.
- Differential regional policy – Policies differ among the three BCLME countries. It will be necessary to harmonise policies to minimise transboundary effects of mariculture.
- Space – The coastline of the region experiences mostly a high-energy wave climate. This means that sheltered water space needed for mariculture is limited, and other sectors also make use of sheltered water, including ports, fisheries and tourism. This results in conflict with other sectors.
- Lack of information – One of the reasons mariculture is poorly developed in the region is lack of information and lack of capacity. This is particularly true when it comes to the use of mariculture to develop and broaden the livelihoods of coastal communities.

Impacts

- Threat to biodiversity – The introduction of exotic species for mariculture purposes may threaten indigenous biodiversity by displacing indigenous species.
- Diseases – Introduction of species for mariculture may spread disease, and cause other unwanted side effects.
- Conflict over space/markets – Conflicts among sectors for limited sheltered water space are common. Transboundary conflicts over markets may occur, and countries without clear policies may be denied certain markets.
- Eutrophication is a consequence of uncontrolled development of feed-based mariculture systems. Such development must occur only within the confines of strictly enforced guidelines.

Risks/uncertainties

- Environmental variability – This creates uncertainty about the suitability of the limited sheltered water space for mariculture.
- Market uncertainty – Means that the development of mariculture carries high risk for potential entrepreneurs.
- Feasibility – The feasibility of mariculture is not known for many potential species.
- Threat to biodiversity, introduction and spread of diseases.

Socio-economic consequences

- Employment and sustainable livelihoods – Mariculture has the potential to allow the broadening of the livelihoods of coastal communities if developed with a sustainable community development policy.
- Revenue – Revenue may accrue not only to entrepreneurs but also to local communities and to the national revenue base. However, the latter will be small due to the limited water space available.

Socio-Economic Consequences	*Transboundary Consequences*	*Activities/Solutions*	*Priority*	*Incremental Cost (5y)*	*Anticipated Outputs*
• Employment and sustainable livelihoods • Revenue • Potential growth industry	• Biological invasion to adjacent country by alien species • Threat to biodiversity • Common problems, shared solutions	• Undertake socio-economic and feasibility assessment as basis for and harmonisation of national policy, and develop regional policy to mitigate against potential problems and promote responsible development of mariculture in the BCLME	1	$ 300 000	• Report on socio-economic assessment • Feasibility report • Harmonised policy and regional policy • Training package

- Potential growth industry – Mariculture is one of the few industries based on living resources that has growth potential. There is very limited capacity for the expansion of harvesting from the wild. Clear sight must be kept of the limited space availability though.

Transboundary consequences

- Mariculture is under-developed in all three countries and is being activity promoted throughout the region in view of its economic and employment potential. Co-operative transboundary activities that promote the responsible development of mariculture will minimise negative environmental consequences and also help reduce pressure on traditionally (over-) harvested resources.
- Differences in policy among countries in the BCLME could lead to conflicts (e.g. as a result of the spread of disease from one country to another, alien species invasion of the ecosystem from a country point source, market conflicts etc), and differential development of the mariculture industry. Harmonisation of policy will reduce the potential harmful effects of differential development.
- The introduction of exotic species into the region for mariculture, by any one country, has the potential to lead to transboundary biological invasions of the target organism or other species accidentally introduced with it. Such invasions have the potential to be a threat to the biodiversity of the BCLME as a whole.

Activities/solutions

- Socio-economic assessment of potential – A full socio-economic assessment needs to be conducted into the ability of mariculture to contribute to regional economy and the improvement in the living conditions of coastal communities.
- Feasibility assessment – The feasibility of mariculture for particular species in certain areas of the region needs to be assessed, and the best species for development need to be chosen on the basis of this assessment.
- Formulate harmonised policy for the region – Crucial if the negative effects of one country's policy on the economic potential of another are to be precluded.
- Training – Training will be needed, particularly in terms of promoting community-based mariculture, as well as the overall management of mariculture in the region.

Priority

- Proposed activities are ranked on a scale of 1-3 in terms of their perceived priority. Only those activities which address transboundary problems requiring incremental funding are listed.

Anticipated outputs

- Report on socio-economic assessment, including advice for action, particularly targeted at communities.
- Feasibility report, including advice on recommended species and areas for regional initiatives.
- Policy statement looking at overall and community potential.
- Training package aimed at managers, communities and potential entrepreneurs.

TABLE A4: PROTECTION OF VULNERABLE SPECIES AND HABITATS

Problems	*Causes*	*Impacts*	*Risks/Uncertainties*
A4. Threats to vulnerable species: **Human impact on the ecosystem by way of fishing, increasing pressure on the coastal zone, pollution etc. has impacted negatively on components of the system, in particular top predators such as coastal birds, e.g. penguins and gannets.** **Vulnerability of habitats: Several habitats, in particular coastal habitats, have been perturbed or lost as a consequence of development and other human impacts, e.g. loss of wetlands, destruction of mangroves, lagoons, etc. These have transboundary consequences and may be significant globally.**	• Salt production • Population migration to coast • Pollution • Reduction of prey through fishing • Historical harvesting • Competition for space and prey (seals, birds, humans)	• Threat to global biodiversity of coastal birds • Ecosystem change • Loss of wetlands • Population reduction • Competition for exploited resources	• None given

A4 EXPLANATORY NOTES PROBLEM: THREATS TO VULNERABLE SPECIES AND VULNERABILITY OF HABITATS

Causes

- Salt production – Changes to wetlands and lagoons.
- Population migration to coast – Especially mangroves. This is a worldwide trend. Logical consequence is a threat to habitats and resources that are attractive to tourists.
- Pollution – Impacts on threatened populations, especially penguins.
- Reduction of prey through fishing – Humans catch fish that are the food of seals and seabirds, reducing food available for them, and can lead to breeding failures in some years as an example.
- Historical harvesting – Especially penguins and gannets, particularly eggs and guano. This is one of the reasons these populations are in a depressed state.
- Competition for space and prey (seals, birds, humans) – Seals and seabirds compete with one another for food and breeding space. Both are in competition for food and space with human populations.

Impacts

- Threat to global biodiversity of coastal birds e.g. African penguins, bank cormorants. Various scientific publications by R.J.M Crawford and co-workers refer – also see BCLME Thematic Reports 1-5 for overviews and references to changes documented in the BCLME.
- Ecosystem change
- Loss of wetlands
- Population reduction – This has happened to several resources.
- Competition for exploited resources – Harvesting of pelagic resources has had a huge impact on food availability for other top predators.

Socio-Economic Consequences	*Transboundary Consequences*	*Activities/Solutions*	*Priority*	*Incremental Cost (5y)*	*Anticipated Outputs*
• Tourism	• Most vulnerable species occur throughout the region or migrate between countries. National activities have transboundary consequences. • Common problems, shared solutions.	• Assessment of status of vulnerable species and habitats – both those which are shared between countries and those which play a key role in the whole ecosystem.	1	$ 500 000	• Ecosystem status assessment and report

Risks/uncertainties

➤ None were identified.

Socio-economic consequences

➤ Tourism – Marine mammals, seabirds, turtles and vulnerable habitats (e.g. wetlands) contribute extensively to tourism.

Transboundary consequences

➤ Most vulnerable species, including several endemics, occur throughout the region and in some cases internationally. Some vulnerable habitats occur regionally (e.g. wetlands and lagoons), others in one country (e.g. mangroves), but many are of importance to migratory species. Therefore the consequences of any actions, whether national, regional or international, will have direct transboundary consequences and may be of significance globally.

➤ National policies to enable protection of vulnerable species and habitats need standardisation throughout the region.

Activities/solutions

➤ Assessment of status of vulnerable species and habitats – Work has started in some countries, but a holistic regional study is sought.

Priority

➤ Proposed activities are ranked on a scale of 1-3 in terms of their perceived priority. Only those activities which address transboundary problems requiring incremental funding are listed.

Anticipated outputs

➤ Ecosystem report – A report on the status of the eco system, and the impacts of human activities on the relationships among non-consumptive resources, together with management advice.

TABLE A5: ASSESSMENT OF NON-HARVESTED SPECIES AND THEIR ROLE IN THE ECOSYSTEM

Problems	*Causes*	*Impacts*	*Risks/Uncertainties*
A5. Role of non-harvested species in the ecosystem is unknown. **Assessments of non-harvested species (except for some seabirds and marine mammals) are not conducted. Some of these species probably have high biomass (e.g. light and lantern fish), have potential for harvesting (and with it job and wealth creation), yet the consequences of harvesting on the food webs and presently harvested species are uncertain. There is a general lack of knowledge on the subject.**	• Lack of information	• All impacts are unknown	• Unable to predict impacts of changes in abundance of unharvested species upon harvested species • Predator/prey relationships • Large unknown biomass • Market potential • Economic viability • Unknown impact of harvest • Ecosystem impact of pollution

A5 EXPLANATORY NOTES
PROBLEM: UNKNOWN ROLE OF NON-HARVESTED SPECIES IN THE ECOSYSTEM

Transboundary consequences

➤ Many unused or under-used taxa in the BCLME have transboundary distributions, and therefore any exploitation or shared knowledge gained in one country would have an effect in all countries. Such ecosystem effects ought to be addressed in a dedicated manner by gaining basic knowledge of what is in the system, its biology, and what role it plays, and how it can be impacted by anthropogenic activity.

Activities/solutions

➤ Joint dedicated surveys and assessment – Such surveys need to be dedicated to the non-harvested species because of the special technology needed.

Priority

➤ Proposed activities are ranked on a scale of 1-3 in terms of their perceived priority. Only those activities which address transboundary problems requiring incremental funding are listed.

Anticipated outputs

➤ Information on non-harvested species and assessment of their role in the ecosystem.

➤ Ecosystem model as a tool for sustainable integrated management of the BCLME.

Socio-Economic Consequences	*Transboundary Consequences*	*Activities/Solutions*	*Priority*	*Incremental Cost (5y)*	*Anticipated Outputs*
• Food security potential • Jobs • Revenue	• Many non-targeted species have trans-boundary distributions. Some have potential for harvesting, but their role in the ecosystem is uncertain. In the absence of information, action by one country could disturb the ecosystem. • Common problem, shared solutions.	• Dedicated joint surveys and assessments of non-harvested trans-boundary species to provide baseline for integrated ecosystem management.	1	$ 1 000 000	• Information on non-harvested species, assess-ment of ecosys-tem role. • Ecosystem model for management.

TABLES B: ASSESSMENT OF ENVIRONMENTAL VARIABILITY, ECOSYSTEM IMPACTS AND IMPROVEMENT OF PREDICTABILITY

TABLE B1: REDUCING UNCERTAINTY AND IMPROVING PREDICTABILITY

Problems	*Causes*	*Impacts*	*Risks/Uncertainties*
B1. ***The BCLME is a complex and highly variable system for which there is evidence of system change and fragmentary but important evidence of increasing instability/variability.*** **Scales of variability include: A. large scale sustained events; B: decadal changes; and C: high frequency short-lived events and/or episodic events.** **Human impacts on the BCLME (e.g. by fishing) is superimposed on the inherent natural variability, and the combined effect of anthropogenic disturbance and this variability has been implicated in ecosystem change and the collapse of harvested resources.** **There is also considerable uncertainty regarding ecosystem status and yields. Lack of information about and understanding of environmental variability and system-wide impacts hampers sustainable management of BCLME resources and results in the non-optimal utilisation of these resources.**	• Complexity of processes • Poor understanding of processes and cause and effect relationships • Poor understanding of global driving forces (linkages) • Lack of data/ information • Inadequate mathematical models • Lack of capacity	• Change to coastal ecosystems from altered wind field/rainfall • Changes in coastline morphology • Damage to coastal infrastructure • Unpredictable variations in zooplankton and fish egg/larval survival • Unpredictable changes in fish growth, mortality and recruitment • Unpredictable changes in species' abundance, composition, distribution and availability • Regime shifts • Cross-boundary movements of fish, seabirds and seals • Change in flux of CO_2, methane and H_2S between atmosphere, ocean and sediments • Difficulties in managing resources sustainably • Operational difficulties with resource utilisation • Assessment of anthropogenic impacts difficult	• Long-term net change or natural cycles? • Time periods sufficiently long to detect changes?

B1 EXPLANATORY NOTES PROBLEM: HIGHLY VARIABLE SYSTEM, UNCERTAINTY REGARDING ECOSYSTEM STATUS AND YIELDS

Causes

The Benguela upwelling area is a highly variable "convex" system with three open and variable boundaries. It is unique in that it is bounded at both equatorial and poleward ends by warm water (tropical) systems viz the Tropical Atlantic and Agulhas Current. It is sensitive to environmental events (variability and change) in the Atlantic, Indo-Pacific and Southern Ocean. Unlike the Humboldt Current there are few long-term data series to form a baseline against which changes can be predicted or assessed. There is an uneven spread of data between disciplines and between the participating countries. Difficulties in predicting changes in the system is a consequence of:

- Complexity of physical, chemical and biological interactions and processes, and the difficulties in predicting environmental variability.
- Our limited understanding of cause and effect relationships, compounded by the problems of predicting environmental variability and eco-system impacts.

Socio-Economic Consequences	Transboundary Consequences	Activities/Solutions	Priority	Incremental Cost (5y)	Anticipated Outputs
• Uncertain employment (job losses and gains) • Variation in revenue • Over- and under-utilisation of resources. • Lack of food security • Human population migration • High production costs • National/regional conflicts • Reduced capacity to support artisanal fisheries • Changes in government revenue, private income and exports.	*Climate Change:* • Contribution to global climate change (CO_2, methane flux) *Ecosystem:* • Shifts in distribution of biota • Loss of species/ biodiversity • Altered food webs • Disruption of faunal migrations *Fisheries:* • Unsustainable management of shared and straddling stocks • Altered fish spawning patterns and population shifts • Unpredictable fluctuations and availability of fish stocks • Unpredictable and variable distribution of fishery benefits • Regional economic instability and unemployment • Regional conflicts with other users *Coastal infrastructure:* • Costly maintenance of coastal infrastructure	• Develop regional early warning system for environmental change • Targeted feasibility assessment of PIRATA link-up/application to BCLME • Targeted transboundary assessment of large-scale hypoxia/impacts • Assess role of upwelling systems as CO_2 source/sink • Analyse plankton data archives for measurement of decadal change • Develop transboundary state of the environment analysis/reporting system • Develop links with CLIVAR • Adapt/develop predictive models • Establish regional advisory groups • Data gathering community projects • Transboundary environmental variability networking (including Internet) • Establish links with the Gulf of Guinea LME	1 1 1 2 1 1 2 2 2 1 1	$ 1 600 000 $ 400 000 $ 250 000 ($ 300 000) $ 100 000 $ 250 000 ($ 50 000) $ 300 000 $ 50 000 $ 100 000 $ 400 000 $ 50 000	• Regional early warning systems for major environmental events/ change • Quantification of utility/application of PIRATA for SADC • Information needed to design monitoring/predictive systems • Quantification of CO_2 flux • Record of decadal ecosystem changes • Regional environmental analysis/ reporting system/ network • Knowledge and expertise on global climate links • Predictions and models • Regional advisory groups • Availability of important/useful data • Regional environmental variability network • Links with Gulf of Guinea LME

- Our limited understanding of driving forces (global linkages). There is evidence from case studies that inter-annual variability in the northern Benguela is associated with changes in zonal (east-west) winds in the equatorial Atlantic, and also that there are some common features in the variability of the north and south Atlantic. There is also fragmentary evidence linking variability in the Pacific El Niño/La Niño (ENSO). Thus, although there are pointers to the importance of remote physical (global climate) forcing of the Benguela, the linkages and mechanisms are not understood.
- Lack of data/information: Long-term data series are few, and except for the extreme southern Benguela, the ecological processes are poorly understood.
- Inadequate mathematical models applicable to the region: Very little mathematical modeling of the Benguela has been done internationally, and there is a general lack, in the region, of the capacity (skills and technology) to adapt available models from elsewhere, to run these or to develop new models. This applies to physical, chemical and biological (ecosystem) modeling. This is a serious drawback to developing predictive capacity.

- Lack of capacity, exacerbated by a south-north gradient in capacity (number of qualified personnel, equipment, vessels etc): The colonial political past in the region has resulted in insufficient persons with the necessary expertise/skills. Moreover, downsizing and emigration has resulted in further shrinkage of the skill pool. There is a marked north-south gradient in human and infrastructure capacity in the BCLME, with Angola being the worst off by far, yet with the greatest needs. Thus available capacity is barely sufficient to meet present national needs, and insufficient to address the priority transboundary problems.

Impacts

Processes that give rise to variability in the Benguela occur on three temporal and spatial scales (A: large scale sustained events; B: decadal changes; and C: high frequency short-lived events and/or episodic events). There is evidence that environmental change/variability does impact on the BCLME in a number of ways. However, in order that these changes can be predicted sufficiently well to be useful for ecosystem management, the cause and effect must be properly quantified. The impact of environmental variability/change includes *inter alia* the following:

- Change to coastal ecosystems from altered wind field (strength and direction) and/or rainfall (quantity and distribution) (A,B). Changes in wind frequency direction and strength impact on the supply of nutrients (for productivity), currents and stratification. In addition there is evidence that SST is related to rainfall in the region (although the process mechanisms are not understood).
- Changes in coastline morphology as a result of climatic regime changes and short-term events (storms) (B,C).
- Short-term events (storms) leading to damage to coastal infrastructure (C).
- Variations in zooplankton and fish egg/larval survival and higher level impacts (A, B and C) through changes in primary production and stratification/turbulence caused by changes in wind frequency, direction and strength.
- Changes in species' abundance, composition, distribution and availability (A, B and C) i.e. ecosystem response to environmental change.
- Changes in fish growth, mortality and recruitment (A, B and C) – these have major implications for resource management.
- Cross-boundary movements of fish, seabirds and seals (A, B and C). The majority of harvested species of fish either straddle country EEZ boundaries or otherwise move across these boundaries from time to time. These movements/shifts are associated with the life histories of the species and also changes in the environment. The implications of this for sustainable management are obvious.
- Regime shifts i.e. increased variability or a net change towards altered state (B). For example, switching between species such as anchovy and sardine or between sardine and jellyfish. These regime shifts can occur naturally – there is evidence in the sediment record of such occurrences having taken place historically (prior to fishing). The impact of fishing exacerbates the problem. Moreover cyclical changes in wind stress result in north-south shifts in some straddling fish stocks.
- Change in flux of CO_2, methane and H_2S between atmosphere, ocean and sediments (B). It is not known with certainty whether the BCLME is a source or sink of CO_2, although it appears to be a net sink. Changes in climate could perturb this balance and feed back to climate. The BCLME could be a useful targeted site for assessing the role of climate change on upwelling systems and feedback to climate from CO_2 release/uptake.

Risks/uncertainties

Limited understanding of this highly variable system means that it is uncertain whether the observed variability reflects sustained long-term net change or natural cycles, and whether the available data series are sufficiently long to enable us to determine this.

Socio-economic consequences

The quality of advice given to resource managers is reduced by our ability to predict, with confidence, short-, medium- and long-term changes in the Benguela system. A consequence of this is that responsible resource management must err on what is perceived to be (but which may not be) the conservative side. This leads to:

- Uncertain employment (job losses and gains)
- Variations in revenue
- Sub-optimal utilisation of resources (particularly by artisanal fisheries)
- Lack of food security
- Human population movements in response to variable resource availability
- High production costs e.g. in fish processing
- National/regional conflicts
- Changes in government revenue, private income and exports

Transboundary consequences

Sustained major environmental events (e.g. Benguela Niños), decadal change and major short-term perturbations (e.g. 10- or 50-year storm events) do not respect country EEZ boundaries, but rather impact on the BCLME as a whole. In other words the types of environmental variability/change which are the focus of the BCLME programme are system-wide and in essence transboundary. Moreover, the BCLME is believed to play a significant role in global ocean and climate processes besides its importance to Angola, Namibia and South Africa. Many of the transboundary consequences listed below would occur regardless of the high variability of the system. Nevertheless our ability to manage them effectively is limited by our predictive capability. Some of the consequences of increased variability or sustained change include:

Climate Change

- Changes in the status and/or functioning of the BCLME may affect its contribution to global climate change through its role as a source/sink of CO_2 and source of methane. Moreover the geographic location of the Benguela at a choke – a major route for the transfer of heat between the Indo-Pacific and Atlantic – means that the BCLME may be an important site for early detection of global change.

Ecosystem

- Shifts in distribution of biota – for example, decadal scale shifts in sardine and anchovy distribution between Namibia and Angola have been documented
- Loss of species/biodiversity – alien species have also displaced indigenous species (e.g. spread of Mediterranean (blue) mussel from near Cape Town to central Namibia)
- Altered food webs
- Disruption of fish, bird and mammal migrations – cf. 1995 Benguela Niño

Fisheries

- Unsustainable management of shared and straddling stocks
- Altered fish spawning patterns and population shifts
- Unpredictable fluctuations and availability of fish stocks, e.g. collapse of anchovy stock around 1990
- Unpredictable and variable distribution of fishery benefits, e.g. which resulted in the closure of fish-canning factories
- Regional economic instability and unemployment
- Regional conflicts over declining resources/stocks

Coastal infrastructure

- Costly maintenance of coastal infrastructure

Activities/solutions

Without good baseline information and wider regional co-ordination and articulation, major problems and issues facing the three countries bordering the BCLME cannot be resolved. It is necessary to undertake targeted assessments of priority environmental variability issues/ problems and to develop appropriate systems, linkages and networking.

- Development of a suitable needs-driven, cost-effective regional environmental early warning system for the BCLME by cross-linking existing national systems.
- Transboundary assessment of low oxygen water formation, dynamics and continuity, and transboundary impacts.
- Feasibility assessment of extension of and/or link-up to the PIRATA moored buoy array in the tropical Atlantic to enhance understanding of links between weather, climate and fish. (PIRATA is an Atlantic equivalent but smaller version of an ocean buoy network in the Pacific, which is used to forecast El Niños and La Niñas. The value of linking the BCLME with the PIRATA system would be in the forecasting of Benguela Niños and anomalous events originating in the tropical Atlantic.) If the feasibility assessment were to prove successful (and it looks like it will), then there is also an excellent chance of ongoing involvement between the region and PIRATA being funded from country sources and donors.
- Determination of the role of upwelling systems as a CO_2 source/sink and methane source. The value of this to the international community has previously been commented on. Moreover it will provide an obvious link between the International Waters and Climate Change components of GEF. A modest demonstration project would be appropriate.
- Development of community projects for cost-effective environmental information gathering and environmental education. Public awareness and involvement are seen as essential components for the successful implementation of the BCLME Programme – both for cost-effective information gathering/ monitoring and also to help reduce anthropogenic environmental impacts on the ecosystem.
- Analysis of plankton archives and other (oceanographic) data collections – baseline information for measurement of decadal change. These collections are unique assets and initial indications are that they may hold the key to unravelling some of the decadal variability which has characterised the BCLME of the last 50 years and which has hampered sustainable harvesting of living resources.
- Develop state of the environment analysis/reporting system for use on a regional basis in the BCLME.

- Develop links with CLIVAR and CLIVAR Africa (CLIVAR = Climate Variability and Predictability Project of the World Climate Research Programme).
- Adapt/develop predictive mathematical models applicable to the region. The utility of this has been referred to elsewhere.
- Establishment of regional advisory groups and net working centres. This is a low-cost activity with potential large benefits.
- Develop transboundary environmental variability networking for region. This links in with the proposed early warning system (see above). It will make extensive use of the Internet.
- Establish links with the Gulf of Guinea LME. Clearly the BCLME does not function in isolation from the rest of the south Atlantic, so building bridges/networking with other LME projects could provide valuable spin-offs in both directions.

Priority

- Proposed activities are ranked on a scale of 1-3 in terms of their perceived priority. Only those activities which address transboundary problems requiring incremental funding are listed.

Anticipated outputs

- Proven/validated regional environmental early warning system appropriate for the BCLME in a form which could be used to leverage future country and donor co-financing for permanent implementation.
- Assessment of utility/application of a PIRATA-type buoy array for the BCLME.
- Documented assessment of information needed to design monitoring/predictive systems.
- Assessment of decadal ecosystem changes in the BCLME since the 1950s based on historical/archival data and collections.
- An established regional environmental analysis/reporting system/network and activity centre.
- Assessment using the best available knowledge and expertise links between the BCLME and the global climate system.
- Quantification of CO_2 and methane source/sink relationships in the BCLME with an understanding of its applicability to other boundary systems and climate models.
- Useful predictions and models.
- Identification of cost-effective early-warning indicators of environmental changes that impact on fish stocks in the BCLME.
- Establishment of regional environmental network and reporting system – making full use of remotely sensed products and the Internet – in a form that can be self-sustaining operationally.

TABLE B2: CAPACITY STRENGTHENING AND TRAINING

Problems	*Causes*	*Impacts*	*Risks/Uncertainties*
B2. **There is a lack of capacity, expertise and ability to monitor environmental variability, to assess the linkages and ecosystem impacts of this variability and to develop a predictive capability required for sustainable integrative BCLME management.** **There is also an unequal distribution and availability of capacity (human and infrastructure) between participatory countries.**	• Limited inter-country exchange (training) • Degrading and down-sizing of research institutions • Inadequate training programme • Lack of running funds • Lack of skills to maintain equipment • Lack of equipment and supplies • Lack of person power • Low salaries • Lack of concern from the policy makers on the ecosystem issues • Brain drain	• Inability to participate in regional decision making processes • Regional imbalances in: baseline information, predictive capacity, data collection ability etc. • Inadequate information for finding indicators of future change • Lack (low) interaction between institutions • Information which is not comparable/cannot be integrated across the region	• Commitment to supporting capacity development by governments of the BCLME region • Political and economic uncertainty

B2 EXPLANATORY NOTES
PROBLEM: LACK OF CAPACITY, EXPERTISE AND ABILITY TO MONITOR ENVIRONMENTAL VARIABILITY

Causes

The three countries (Angola, Namibia and South Africa) bordering the BCLME are developing countries with requirement to meet the basic living needs of their peoples. These countries have emerged from long periods of colonialism and oppression and are attempting to develop their economies and social structures. Funding for marine monitoring and assessment activities are very limited and policy makers are not always fully aware of the importance of environmental variability/change in ocean management applications. Viewed collectively, the lack of capacity can be ascribed to the following:

- Lower priority placed on environmental issues by policy makers.
- Limited inter-country exchange of personnel for liaison, experience sharing and training.
- Degrading and downsizing of research institutions as a result of pressure to reduce the size of the civil service.
- Inadequate training/skill development programmes.
- Limited funds to meet day to day running expenses, let alone to invest in hardware and capital items.
- Limited skills to maintain equipment.
- Limited availability of equipment and supplies – most high-tech equipment needs to be sourced abroad, and unfavourable local currency exchange rates have made this equipment unaffordable.
- Severely limited numbers of trained personnel – the lack of trained personnel is a direct consequence of colonialism and also the former apartheid policy applied in Namibia prior to 1990 and in South Africa prior to 1994. This has resulted in a legacy of a poor skills pool and an unequal distribution of skills within countries and between countries.
- Inadequate remuneration for government researchers (competition from the private sector).
- Brain drain: loss of personnel to the private sector and overseas because salaries are not competitive and career prospects uncertain.

Socio-Economic Consequences	*Transboundary Consequences*	*Activities/Solutions*	*Priority*	*Incremental Cost (5y)*	*Anticipated Outputs*
• Sub-optimal or over utilisation of renewable resources due to lack of information, knowledge and understanding required for resource management • Unequal opportunities for resource access/ management • Absence of full stakeholder participation • Creation of conflict • Poorly informed/ advised governments at all levels • Low institutional sustainability	• Unco-ordinated resource management, research and monitoring programmes • Management of overall system by all three countries is not harmonised. Capacity gradient (south-north) leads to uneven research monitoring effort in the system as a whole with consequences for resource management • Difficulties with resource co-operation • Inability to monitor or manage the system as a whole	• Address capacity needs to address transboundary issues • Devise strategy* for developing job opportunities, salaries and infrastructure • Develop training partnerships with private sector • Creation of regional multidisciplinary working groups • Devise, develop and implement appropriate training courses • Interchange of personnel between countries to gain/ transfer expertise and knowledge • Improve networking via Internet • Improve public information/environmental education (pilot project)	1 N/A to GEF 1 1 1 2	$ 25 000 $ 250 000 $ 25 000	• Capacity development strategy for region • Strategy for job creation (and salaries) • Improved regional management of resources and establishment of new institutional networks • Shared expertise

Impacts

The consequences of insufficient funding of research in the BCLME include:

- Regional imbalances in baseline information, predictive capacity, data collection ability etc. There is a sharp gradient in the numbers of trained personnel from south to north.
- Limited ability to participate in regional decision making processes, as too few people are available to do the tasks at hand.
- Inadequate information for identifying indicators of future change.
- Limited interaction between institutions. This problem is fast disappearing as a consequence of these countries to collaborate.
- Collection of information which is not comparable/ cannot be integrated across the region.

Risks/uncertainties

- Although the governments of the region are committed to capacity (skill/expertise development), this commitment is according to perceived national priorities. There is uncertainty with regard to the priority status of marine science, technology and management at the regional level.
- Political and economic uncertainty results in potential "recruits" choosing more lucrative careers – particularly those that favour mobility (emigration).

Socio-economic consequences

The underestimation by policy makers of the importance of developing and maintaining sufficient research capacity to manage the resources of the BCLME has resulted in numerous socio-economic problems including:

- Sub-optimal or over-utilisation of renewable resources
- Unequal opportunities for resource access/ management
- Absence of comprehensive stakeholder participation
- Creation of conflicts
- Poorly informed/advised governments at all levels
- Low institutional sustainability.

All of the above are in turn direct consequences of inadequate/inappropriate communication and in some case lack of trust between various players.

Transboundary consequences

The Benguela ecosystem is believed to play a significant role in global ocean and climate processes besides its importance to Angola, Namibia and South Africa. Consequences of poor national and regional management practices thus have wide-reaching consequences including:

- Non cost-effective resource management, research and monitoring activities (fragmented, poorly planned and unlikely to achieve the objectives of ensuring sustainable management).
- Management of overall system by all three countries is not harmonised. Capacity gradient (south-north) leads to uneven research monitoring effort in the system as a whole with consequences for resource management e.g. possible bias in information and advice leading to inappropriate decision making.
- Difficulties with co-operation in respect of sustainable resource utilisation. A holistic approach is needed to correct the damage done in the past from fragmentation and ad hoc "crisis" management.
- Inability to monitor or manage the ecosystem as a whole – The transboundary nature of the issues and problems in the BCLME necessitates a holistic approach.

Activities/solutions

- The first action must be a comprehensive study of the real needs for human capacity and infrastructural development/maintenance relevant to the identified transboundary issues in which clear priorities are listed. This must be executed in co-operation with all stakeholders to ensure a proper balance and minimum vested interest bias.
- Institutional downsizing, freezing/reduction/non-creation of posts, poor salaries and career prospects are limiting factors. If not addressed, recruitment and training initiatives will provide little or no long-term benefits. It is thus vital that a comprehensive strategy be developed to address the above. (Much of the problem stems from incorrect perceptions and poor communication.) This activity, although very important, is inappropriate for GEF funding, and will be pursued through other avenues.
- Develop training partnerships with private sector. This will promote private sector "buy-in" and provide a point of departure for long-term co-financing with industry and business.
- Devise, develop and implement training courses appropriate for the needs of the region. (The focus of courses developed for application in Western Europe and North America is not always suitable for implementation in developing countries.)

- Creation of regional multidisciplinary working groups. This will be a cost-effective mechanism for consultation, co-operation, skill development, trust building etc.
- Interchange of personnel between countries to gain/transfer expertise and knowledge. To be successful this must be tri-directional.
- Improve networking via Internet. It is envisioned that increased use of electronic media is the key to the success of the BCLME programme at all levels. It will be particularly beneficial for training and system monitoring.
- Improve public information/environmental education (pilot project). There is a relative lack of public awareness about the BCLME, human impacts on the ecosystem, problems to be addressed to ensure its sustainable utilisation and conservation of biodiversity, opportunities for job creation and wealth generation etc. A pilot project designed to increase awareness at all levels is seen as important.

Priority

- Proposed activities are ranked on a scale of 1-3 in terms of their perceived priority. Except for activity asterisked, only those activities which address transboundary problems requiring incremental funding are listed.

Anticipated outputs

- Capacity development strategy for the region relevant to addressing transboundary concerns as per the Strategic Action Plan.
- Strategy to ensure secure posts for existing and newly trained personnel (including market related remuneration).
- New institutional networks taking advantage of the Internet and world wide web.
- Improved regional management of resources.
- Increased multilevel public awareness of the issues and problems and the need for sustainable integrated management of the BCLME.
- Improved infrastructure and improved availability of persons with the necessary skills.

TABLE B3: MANAGEMENT OF CONSEQUENCES OF HARMFUL ALGAL BLOOMS

Problems	*Causes*	*Impacts*	*Risks/Uncertainties*
B3. Harmful algal blooms are a conspicuous feature of upwelling systems: **The frequency of occurrence, spatial extent and duration of harmful algal blooms appear to be increasing in the BCLME. The harmful effect of these blooms is manifested in two main ways: production of toxins which cause mortalities of shellfish, fish and humans; and anoxia in inshore waters which also can lead to massive mortalities of marine organisms.**	• Natural processes • Introduction of cysts in surface waters • Nutrient loading of coastal waters from anthropogenic activities • Changing state of the Benguela ecosystem • Introduction of exotic species	• Poisoning and mortality of human consumers of marine organisms • Mortality (mass) of marine organisms • Disruption of mariculture activities • Interference with recreational use of the sea • Anoxia which in turn may cause massive mortalities of marine organisms	• Increase or decrease in incidence and intensity of HABs • Role of HABs in the system as a whole • Contribution of anthropogenic nutrient loading to incidence of HABs

B3 EXPLANATORY NOTES
PROBLEM: HARMFUL ALGAL BLOOMS (HABs)

Causes

- Natural processes – HABs occur naturally in the BCLME. Human impact can cause these HABs to spread, and introduce exotic HAB species into the BCLME.
- Introduction of cysts into surface waters – Human activities such as drilling, mining (dredging) and certain types of fishing disturb the sediments and release cysts of HAB species into the water column, thereby triggering new blooms, and expanding the area impacted by HABs.
- Nutrient loading of coastal waters from anthropogenic activities – Increased nutrient loading of coastal waters from, for example, sewage discharges and industries increase the probability of occurrence of HAB outbreaks.
- Perceived increase in frequency of HABs may be the result of changes in the state of the Benguela ecosystem. (System-wide monitoring for HABs is needed to discern any definite trend.) Nevertheless the changes in SST and wind stress observed in the BCLME this century would be compatible with an increase in HAB frequency and distribution.
- Introduction of exotic species (through ballast water, bilge water, mariculture operations etc.) – There is little or no control over the discharge of ballast water from ships entering national waters in the three countries, and there is a suspicion that these discharges may be responsible for the spread of HABs in the BCLME.

Impacts

HABs affect a wide spectrum of activities in the marine environment. The impacts include:

- Poisoning and mortality of human consumers of marine organisms. There is documented evidence of human mortalities in the BCLME as well as non-fatal impacts.
- Mortality (mass) of marine organisms. The species' at highest risk are the filter feeders (e.g. mussels) and organisms that consume these filter feeders. Mortality can be caused directly by toxins and clogging of gills, and indirectly by depletion of oxygen in the water column.
- Disruption of mariculture activities – Mariculture is dependent on good water quality. HABs result in disruption or closure of mariculture facilities necessitating expensive water treatment, isolation of facilities, etc. Depending on the nature of the mariculture venture and the HAB, the closure/disruption can be short-lived or permanent.
- Interference with recreational use of the sea – Apart from being toxic and unsightly, some HABs cause respiratory problems in swimmers and those living in close proximity to the sea.
- Anoxia which in turn may cause massive mortalities of marine organisms. For example, in a single episode in St Helena Bay, a biomass of rock lobster equivalent to or greater than the annual total allowable catch in the entire southern Benguela was lost as a result of a single HAB outbreak.

Socio-Economic Consequences	*Transboundary Consequences*	*Activities/Solutions*	*Priority*	*Incremental Cost (5y)*	*Anticipated Outputs*
• Human mortality • Loss of tourism revenue • Increased cost of shellfish production (monitoring, testing, depuration) • Loss of fish/ shellfish/ mariculture markets and jobs	• Occurrence of HABs in all three countries • Migrations of species across national boundaries	• Develop an HAB reporting system for BCLME region as a whole • Regional HAB contingency plans • Community projects linked to ministries of health • Mitigation of impacts of HABs • Improve national capacity to monitor toxins/species	2 2 2 2	$ 50 000 $ 100 000 $ 50 000 ($ 50 000) (National)	• HAB regional network • Regional contingency plan • Training of public health officials • Public education materials • Proactive management

Risks/uncertainties

- Increase or decrease in incidence and intensity of HABs as a consequence of insufficient monitoring
- Role of HABs in the system as a whole
- Contribution of anthropogenic nutrient loading to incidence of HABs

Socio-economic consequences

- Human mortality – Deaths have occurred and numerous people have suffered respiratory difficulties and gastro-intestinal problems as a consequence
- Loss of tourism revenue (see impacts)
- Increased cost of shellfish production (monitoring, testing, depuration)
- Loss of fish/shellfish/mariculture markets and jobs – Mariculture is a potentially valuable growth industry in the BCLME, but is constrained by a general lack of knowledge, including lack of information about the extent of the HAB problem in the BCLME.

Transboundary consequences

- Incidence and effects of HABs are common to all three countries
- HAB outbreaks can be extensive and straddle national boundaries. In addition, advective processes together with shipping operations, bottom trawling and mining (dredging) can redistribute cysts across national boundaries.

Activities/solutions

- Develop an HAB reporting system for the BCLME region as a whole – This is seen as a high priority within the BCLME, and is also essential for the development of a sustainable mariculture industry
- Community awareness projects linked to national ministries of health to alert the public to dangers associated with HABs
- Develop national/regional HAB contingency plans which include early warning systems and guidelines for medical practitioners to deal with HAB associated problems
- Improve national capacity to analyse for toxins and identify harmful species by sharing expertise between countries
- Mitigation of impacts of HABs on mariculture operations (e.g. relocation of mussels rafts, treat blooms with "herbicides").

Priority

- Proposed activities are ranked on a scale of 1-3 in terms of their perceived priority. Only those activities which address transboundary problems requiring incremental funding are listed.

Anticipated outputs

- Established HAB regional reporting network, with transboundary early warning system (to alert neighbouring state when required)
- Regional contingency plans for dealing with effects of HABs implemented in all three countries
- Public education materials prepared and distributed regionally
- Substantial contribution to the sustainable and responsible development of mariculture within the BCLME
- Proactive integrated management in general.

TABLES C: MAINTENANCE OF ECOSYSTEM HEALTH AND MANAGEMENT OF POLLUTION

TABLE C1: IMPROVEMENT OF WATER QUALITY

Problems	*Causes*	*Impacts*	*Risks/Uncertainties*
C1. Deterioration in coastal water quality: **Coastal developments and rapid expansion of coastal cities, much of which was unforeseen or unplanned, has created pollution "hotspots".** **Aging water treatment infrastructure and inadequate policy/monitoring/ enforcement aggravates the problem.**	• Unplanned coastal development • Chronic oil pollution • Industrial pollution • Sewage pollution • Air pollution • Mariculture • Lack of policy on waste and oil recycling • Growth in coastal informal settlements	• Public health • Reduced yields • Unsafe edible organisms • Changes in species dominance • Ecosystem health and resilience • Loss of jobs at regional level	• Few or no baseline data • Performance standards and thresholds • National commitment to capacity-building • Cause and effect relationships

TABLE C2: PREVENTION AND MANAGEMENT OF OIL SPILLS

Problems	*Causes*	*Impacts*	*Risks/Uncertainties*
C2. Major oil spills: **A substantial volume of oil is transported through the BCLME region and within it, and this is a significant risk of contamination of large areas of fragile coastal environments from major accidents, damage to straddling stocks and coastal infrastructure.**	• Sea worthiness of vessels/equipment • Military conflict • Sabotage • Human error	• Coastline degradation • Mortality of coastal fauna and flora	• Recovery period • Cost recovery mechanisms • Return to peace in Angola

TABLE C3: REDUCTION OF MARINE LITTER

Problems	*Causes*	*Impacts*	*Risks/Uncertainties*
C3. Marine litter: **There is a serious growing problem throughout the BCLME.**	• Growth of coastal settlements • Poor waste management • Little public awareness and few incentives • Illegal disposal from vessels • Poverty of coastal communities • Ghost fishing • Fishing discards	• Faunal mortality • Negative aesthetic impacts • Damage to fishing equipment	• Accumulation zones • Illegal hazardous waste disposal

Socio-Economic Consequences	Transboundary Consequences	Activities/Solutions	Priority	Incremental Cost (5y)	Anticipated Outputs
• Loss of tourism • Higher health costs • Altered yields • Reduced resource quality • Aesthetic impacts • Lowered quality of life • Loss of employment	• Transboundary pollutant transport • Migration of marine organisms, e.g. seals • Negative impacts on straddling stocks • "Hotspots", common solutions	• Develop standard environmental quality indicators/criteria • Establish regional working groups • Training in marine pollution control • Plan/adapt regional pollution monitoring framework • Establish effective enforcement agencies* • Demo projects on pollution control and prevention • Joint surveillance	1 1 2 1 1 2 2	$ 100 000 $ 50 000 $ 100 000 $ 50 000 (National) $ 500 000 $ 200 000	• Shared solutions for water quality management • Regional protocols and agreements • Improved pollution control • Socio-economic uplift

Socio-Economic Consequences	Transboundary Consequences	Activities/Solutions	Priority	Incremental Cost (5y)	Anticipated Outputs
• Opportunity costs (e.g. tourism, fisheries, salt production) • Altered yields • Reduced resource quality • Aesthetic impacts	• Resource sharing for containment, surveillance, rehabilitation, etc. • Ramsar site protection (border wetlands) • Transboundary pollutant transport	• Regional contingency plan development • Research/ modeling of recovery periods • Public awareness of notification procedures • Port state control	1 3 3 3	$ 50 000	• Regional contingency plan • Shared resources • Rehabilitation plans • Regional protocols and agreements

Socio-Economic Consequences	Transboundary Consequences	Activities/Solutions	Priority	Incremental Cost (5y)	Anticipated Outputs
• Loss of fishing income • Public health • Cleanup costs • Loss of tourism • Job creation in informal sector	• Transboundary transport	• Litter recycling • Harmonisation of packaging legislation • Public awareness • Port reception facilities • Regulatory enforcement • Standardised policies • Seafarer education	2 3 1 1 2 2 1	 $ 50 000 $ 100 000 $ 50 000	• Cleaner beaches • Education material/documents available regionally • Standardised policies and legislation on packaging/ recycling incentives

C1 EXPLANATORY NOTES
PROBLEM: DETERIORATION IN WATER QUALITY

Causes

- Activities are mainly focused around urban centers, increasing urbanisation and associated knock-on effects. Worst affected are Luanda, Walvis Bay and Cape Town.
- Various sectors contributing to pollution, with varied degrees of cross sector co-operative management.
- Knock-on effect of introduced mariculture species and associated water quality pollution effects in protected embayments.
- Variable consistency in application of policy, both nationally and regionally.
- Informal and formal settlements vary in their control of pollution discharges, which are increasing due to urbanisation.
- Shipping activities and hydrocarbon exploration and production are major sources of chronic oil pollution.

Impact

- A variety of factors are responsible for deterioration of human health and ecosystem health/resilience (Refer to BCLME Thematic Reports 1-6).
- Species invasion (poorly planned mariculture enterprises), changes in species dominance, reduced yields from ecosystem.
- Loss of jobs at regional level, reduction of regional tourism potential.

Risks/uncertainties

- Limited data available from which to evaluate existing water quality, so it is difficult to establish a regional baseline.
- Validity of existing standards and thresholds within the regional context is uncertain.
- Tracing of impacts back to initial causes is difficult and causation is often unknown.
- Reduction of pollution in worst affected areas may not be practicable in short/medium term.

Socio-economic consequences

- Input of nutrients and associated pollution may cause a short-term increase in production, combined with longer-term stock failure.
- These consequences are interrelated: pollution decreases tourism, which reduces jobs, which increases poverty, which in turn increases pollution.

Transboundary consequences

- Deterioration of water quality may cause species migration (temporary/permanent). Pollutants from industries/activities near to country borders can be transported across boundaries by prevailing currents.
- Impacts are (variably) common to each of the participating countries – a "generic" project with flexibility to meet nations' needs should be established. Establishment of common policy is necessary to minimise transboundary impacts.
- Most water quality issues are common to at least two of the countries and require common strategies and collective action to address.

Activities/solutions

- An overall regional working group should be established to effectively co-ordinate integrated solutions to:
  - Environmental quality indicators
  - Marine pollution control and surveillance
  - Regional monitoring/inspection of coastal zone
  - Regional enforcement of standards
  - Prevention of "polluters" slipping over the border.

Priority

- Proposed activities are ranked on a scale of 1-3 in terms of their perceived priority. Except where asterisked, only those activities which address transboundary problems requiring incremental funding are listed.

Anticipated outputs

- Integrated local, national, or regional system implementation with decrease in pollution and associated long-term savings in clean-up and education costs. It is anticipated that the benefits which will be demonstrated by the proposed actions will be such that leverage of national or donor funding for continued implementation following the conclusion of the BCLME will be possible, in view of the benefits which will accrue from a modest investment.

C2 EXPLANATORY NOTES
PROBLEM: MAJOR OIL SPILLS

Causes

- Variability of seaworthiness of vessels operational from the region, as well as transport through the region.

Impacts

- General coastal degradation (temporary habitat loss), with varied recovery rate, depending on species vulnerability and spill intensity. Associated monitoring of fauna/flora recovery is essential.

Risks/uncertainties

- Recovery period in system is sensitivity-dependent.
- Regional and national peace and political stability are most conducive to programme success.
- General environmental deterioration leads to aesthetic deterioration and then tourism loss.

Socio-economic impacts

- Revenue loss is a function of spill intensity and environmental sensitivity, and duration of spill.

Transboundary consequences

- Regional co-operation needed in use of equipment/manpower.
- Riparian/estuarine boundaries are particularly vulnerable.
- Co-operative management of spills moving across borders. (Management/clean-up of a major spill near a country boundary can only be effective if commensurate actions are taken by the neighbouring state.)

Activities/solutions

- Regional co-operation paramount in standards development: policy, equipment, and techniques.

Priority

- Proposed activities are ranked on a scale of 1-3 in terms of their perceived priority. Only those activities which address transboundary problems requiring incremental funding are listed.

Anticipated outputs

- Regional policy and optimal utilisation of resources.

C3 EXPLANATORY NOTES PROBLEM: MARINE LITTER

Causes

- Rapid urbanisation and unplanned settlement, with variable and limited/no control by authorities.
- Existing formal infrastructure unable to cope with expanding formal developments.
- Public apathy/indifference and difference in behavior across cultural groups.
- "Lost" fishing equipment and associated "wastes."
- Non-returnable/disposable nature of packaging containers used in the region (absence of regu-lations and incentives for return of containers and use of biodegradable materials).

Impacts

- Aesthetic and multiple impacts are associated with economic loss, although there may be job creation in the informal sector (waste management).
- Plastics and ropes (including fishing lines) present a significant and growing hazard to marine mammals and seabirds (entanglement, ingestion).

Risks/uncertainties

- Volume of hazardous substances dumping unknown.
- Need to identify areas of waste accumulation through natural processes.
- Positive impacts (job creation in informal sector) are balanced by lack of incentives not to litter.
- Potential degree of transboundary movement.
- Issues common to all three countries – create a "blueprint" and apply flexibly to all countries.

Activities/solutions

- Public awareness is key to successful implementation and a sustained clean environment – primary focus is seafarers.
- Common policy/practice and implementation – i.e. "return" (bottles) product incentives – common policy re boundary transfer and legislation (packaging) review.

Priority

- Proposed activities are ranked on a scale of 1-3 in terms of their perceived priority. Only those activities which address transboundary problems requiring incremental funding are listed.

Anticipated outputs

- Clean coastal zone
- Educated and uplifted public
- Improved legislation and co-ordinated standards implementated from local/national/regional levels
- Reduction in negative impacts on marine mammals and seabirds (particularly relevant to threatened/endangered species).

TABLE C4: RETARDATION/REVERSAL OF HABITAT DESTRUCTION/ALTERATION

Problems	*Causes*	*Impacts*	*Risks/Uncertainties*
C4. Habitat alteration/destruction (see also A4): **Several habitats have been altered or lost as a consequence of development and other human impacts. Impacts can be categorized into three areas, viz:** **1. Coastal – progradation/redistribution** **2. Nearshore (< 30m)** **3. Shelf/slope (200m)**	• Diamond mining • Demersal trawling • Variable river sediment input and changing land use • Oil/gas exploration/ production and spills • Mariculture • Natural sediment transport (altered erosion) • Built coastal structures • Human settlement and resource use • Mangroves/coastal deforestation • Coastal vehicle tracks	• Increased turbidity (sediment plumes, etc) • Benthic community destruction • Mobilisation of heavy metals • Faunal impacts e.g. reproductive failure • Increased frequency of HABs • Coastal erosion • Organic loading/anoxic conditions	• Near-complete lack of data • No framework for impact monitoring • Cumulative local vessel impacts • Climate change • Distinguishing impacts from natural spatial and temporal variation

C4 EXPLANATORY NOTES
PROBLEM: ECOSYSTEM HEALTH DECLINING

Causes

- Coastal progradation – former mining activities, subsequent longshore redistribution of sands – sedimentation of mangroves and other natural processes.
- Coastal destabilisation due to anthropocentric activities.
- Natural sediment movement (natural rehabilitation of mined areas) – masking actual impacts, which may possibly pop up later and be more severe.
- Various fishing activities.

Impacts

- Mining-generated sediment plumes – potential re mobilisation of heavy metals (food chain impacts) and water quality deterioration.
- Mariculture can cause local organic loading and anoxic conditions.
- Habitat modifications impact on HABs.

Risks/uncertainties

- Incomplete/lack of data – severely limiting – but increasingly available due to mining companies' existing programmes.
- Should standardise framework for evaluation of impacts.
- Impacts from multiple vessels in close proximity unknown – carrying capacity to be determined.

Socio-Economic Consequences	*Transboundary Consequences*	*Activities/Solutions*	*Priority*	*Incremental Cost (5y)*	*Anticipated Outputs*
• Costly infrastructure, rehabilitation and maintenance • Loss in mariculture production • Decreasing human health via heavy metal contamination • Loss of fisheries productivity/revenue, e.g. rock lobster • Opportunity costs	• Sediment transport • Common problems, e.g. erosion • Redistribution of marine fauna as a consequences of habitat alteration e.g. hakes, seals	• Document fully presented status • Adapt and apply regional marine and coastal early warning system and action plan • Assess causality of habitat alteration • Adapt and apply standard environmental quality criteria • Adapt and apply regional structure to address problems • Adapt and apply expertise in coastal processes	1 1 2 1 1 1/2	$ 50 000 $ 150 000 $ 100 000 $ 50 000 $ 100 000 ($ 50 000)	• Comprehensive status report • Regional early warning system and action plan • Transboundary causality established • Regional structures and agreements • Improved coastal planning

- Necessary to distinguish anthropogenic impacts from natural variability.
- Altered sediment structure and particle size composition with consequence for bethos and remobilisation of certain minerals (metals).

Socio-economic consequences

- Unknown costs of rehabilitation and subsequent evaluation of rehabilitation success.
- Human health affected through knock-on effect in food chains.
- Loss of revenue from renewable resources.

Transboundary consequences

- Marine fauna migrating due to habitat loss.
- Sediment remobilisation.

Activities/solutions

- The present status requires proper documentation, and establishment of a baseline at regional level.
- Establish/identify regional parameters for approach to early warning systems and associated quality performance standards.
- Develop mechanisms of co-operation between industries, ministries and other stakeholders, and strengthen capacity.
- Needs-assessment to improve coastal management expertise.

Priority

- Proposed activities are ranked on a scale of 1-3 in terms of their perceived priority. Only those activities which address transboundary problems requiring incremental funding are listed.

TABLE C5: CONSERVATION OF BIODIVERSITY

Problems	*Causes*	*Impacts*	*Risks/Uncertainties*
C5. Loss of biotic integrity: **This refers to ecosystem impacts including changes in community composition, species diversity, and introduction of alien species – a set of measures of ecosystem health.**	• Introduction of alien species • Selective fishing mortality (targeted fishing) • Incident mortality bycatch/discharges • Pollution impact • Over-harvesting • Habitat alteration (e.g. destruction of mangrove areas) • Lack of implementation of international laws	• Local extinction especially of benthic species • Introduction of pathogens • Genetic impoverishment (loss of resilience)	• Source of alien commensals? • Invasive ability? • Beneficial or harmful? • No baseline data

C5 EXPLANATORY NOTES
PROBLEM: LOSS OF BIOTIC INTEGRITY

Causes

- Introduction of alien species.
- Changes in community composition, population distribution and abundance due to overfishing, selective fishing (targeted at a particular species), and incidental (bycatch) mortality.
- Other identified causes included pollution impacts, habitat alteration (including mangrove destruction), and lack of implementation of international conventions (e.g. Convention on Biological Diversity and marine treaties).
- Lack of holistic approach to ecosystem management, i.e. only management of individual species/components in isolation.

Impacts

- Introduction of pathogens and other commensal species: Alien species (intentionally or inadvertently imported) may arrive with unseen viruses, ectoparasites, and other commensals.
- Genetic impoverishment refers to the loss of genetic variability as a result of population 'bottlenecks' (severe crash in population numbers) which will normally reduce population resilience and fitness (ability to cope with future environmental change).

Risks/uncertainties

- Invasive ability: the ability of introduced species to survive, reproduce and replace indigenous species.
- Beneficial or harmful? The "beneficial" assessment is a socio-economic one (e.g. mussels are tasty and easier to grow in mariculture than indigenous ones), but the "harmful" assessment is primarily an ecological one. (In the longer term, what may at present be perceived as beneficial may not be sustainable. This has serious implications for sustainable integrated management of the ecosystem.)

Socio-economic consequences

Alien species:

- Potential public health impacts refer primarily to pathogens imported with ballast water aliens.
- Opportunity costs: for example, alien infestations can cause a loss of diving tourism revenue.

Fishing impacts:

- Political pressure to over-harvest: In a population recovery period, low quotas often cannot be implemented due to political pressure (leading to a very much longer recovery period).
- Prolonged recovery periods strain the industry through loss of revenue. Uncertainty of sustainable livelihoods: Government policy incentives are needed to encourage alternative job creation to sustain fishers during low yield periods, or a temporary industry shutdown.
- Modification of food source of consumers: in Namibia especially, some cultures will not willingly eat marine fish (although inland fish are eaten). It is a policy attempt to improve national food security, given that maize is imported and 80-90% of marine fish is exported. Not an option in present-day Angola.
- Migration of fishers – when over-harvesting causes depletion of fish stocks, fishers may be forced to move.

Socio-Economic Consequences	*Transboundary Consequences*	*Activities/Solutions*	*Priority*	*Incremental Cost (5y)*	*Anticipated Outputs*
• Loss in community income from fishing and mariculture • Potential public health impacts • Opportunity costs, e.g. tourism • Political pressure to over-harvest • Lost income – prolonged recovery time • Uncertainty of sustainable livelihoods • Modification of food source of consumers	• Transfer of alien species via shipping/ mariculture • Natural processes • Fisher migration • Shared stocks	• Harmonise regional policies • Link with GEF ballast water project • Regional fishing policies co-management • Identification of MPAs (including transboundary areas) • Identify genetic populations structures • Develop forum for stakeholder participation and negotiation of biodiversity code of conduct	1 2 1 1 2 1	$ 50 000 $ 30 000 $ 150 000 $ 20 000 $ 50 000	• Harmonised regional policy • Co-financing • Biodiversity conservation baseline • Regional protocols • Reduction/ control of alien introductions, policy decisions, forum established • Establishment of negotiated marine protected areas

Activities/solutions

- Cognisance is taken of the existing GEF international ballast water management project in which Saldanha Bay is to be used as a model for a port management plan (cf. SADC application).
- **NB: Angola is very concerned about uncontrolled dumping/flushing from ships generally (including bilge waters – not just marine litter and ballast water).
- Regional (BCLME region) policy on aquaculture/ mariculture should be developed and then harmonised with those of neighbouring countries, including SADC region and (Refer to B3).
- Regional (and national) management plan for biodiversity conservation must include a framework for assessment and prediction of environmental change impacts.
- Identification of marine protected areas: As the national borders within the BCLME region include two estuaries: a Ramsar site (Orange River mouth) and a proposed Ramsar site (Cunene River mouth), attention can also be given to possible transboundary marine protected areas.
- Identify genetic structure of populations: an essential component of a regional biodiversity conservation management plan. It has important implications for fisheries management (do countries manage the same or different stocks of individual species?). BENEFIT focuses on genetic structure of shared fish stocks in the region, but BCLME must focus on genetic diversity implications of marine resource management: genetic pollution, loss of heterozygosity, etc.
- Harmonisation of national policies and the development of a regional policy.
- Establish/identify regional parameters for approach to early warning systems and associated quality performance standards.
- Develop mechanisms of co-operation between industries, ministries and other stakeholders, and add capacity.
- Needs-assessment to improve coastal management expertise.

Priority

- Proposed activities are ranked on a scale of 1-3 in terms of their perceived priority. Only those activities which address transboundary problems requiring incremental funding are listed.

Anticipated outputs

- Regional quality indicators: Adapt and apply existing environmental quality indicators to the BCLME for specified variables.
- Policy decisions on allocation of seabed: There is a need for a policy decision on whether to renegotiate existing concessions, hold back the granting of new concessions. "Windows of opportunity" exist between the granting of exploration and production licenses, during which marine protected areas can probably be established. (However, this would lead to MPAs being restricted to areas rejected by industry, not the proactive establishment of biodiversity-rich MPAs.)
- Harmonised regional policy and emergence of regional protocols.
- The establishment of a forum for stakeholder participation in negotiating a biodiversity code of conduct is seen as an important outcome.

TABLE D: BENGUELA CURRENT LARGE MARINE ECOSYSTEM STAKEHOLDERS

Stakeholders	*SUSTAINABLE MANAGEMENT AND UTILISATION OF RESOURCES*	*ENVIRONMENTAL VARIABILITY*	*ECOSYSTEM HEALTH AND POLLUTION*
MINISTRIES RESPONSIBLE FOR:			
Fisheries	✔	✔	✔
Environment	✔	✔	✔
Energy	✔	✔	✔
Finance	✔	✔	✔
Health		✔	✔
Immigration			✔
Tourism	✔	✔	✔
Trade			✔
Transport	✔	✔	✔
Mining	✔	✔	✔
Police			✔
Defence			✔
Works		✔	
Communication		✔	✔
PRIVATE SECTORS:			
Fishing Companies	✔	✔	✔
Mining Companies	✔	✔	✔
Oil and Gas Companies	✔	✔	✔
(Offshore Exploration and Production)			
Shipping Companies			✔
Tourism Companies	✔	✔	✔
OTHERS:			
International Donor Agencies	✔	✔	✔
Relevant NGOs	✔	✔	✔
Research Institutions and Universities	✔	✔	✔
Coastal Communities	✔	✔	✔
Municipalities		✔	✔
Port Authorities		✔	✔
Meteorological Services		✔	✔
Interested Individuals	✔	✔	✔

LIST OF ACRONYMS

BCLME	Benguela Current Large Marine Ecosystem
BENEFIT	Benguela Environment Fisheries Interaction and Training
BEP	Benguela Ecology Programme
CLIVAR	Variability and Predictability Project of the World Climate Research Programme
CO2	Carbon dioxide
EEZ	Exclusive Economic Zone
ENVIFISH	Environmental Conditions and Fluctuations in Distribution of Small Pelagic Stocks
ENSO	El Niño Southern Oscillation
GEF	Global Environment Facility
GDP	Gross Domestic Product
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
GOGLME	Gulf of Guinea Large Marine Ecosystem
HAB	Harmful Algal Blooms
ICSEAF	International Commission for the South-East Atlantic Fisheries
IOC	Intergovernmental Oceanographic Commission
LME	Large Marine Ecosystem
MPA	Marine Protected Area
NOAA	National Oceanic and Atmospherics Administration
NORAD	Norwegian Agency for Development Co-operation
PDF	Project Development Fund
SADC	Southern Africa Development Community
SAP	Strategic Action Plan
SST	Sea Surface Temperature
TDA	Transboundary Diagnostic Analysis
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Education, Scientific and Cultural Organisation
VIBES	Variability of Exploited Pelagic Fish Resources in the Benguela Ecosystem in relation to Environmental and Spatial Aspects (Programme)


BCLME
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