- 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 mari-culture 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 regulations 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)