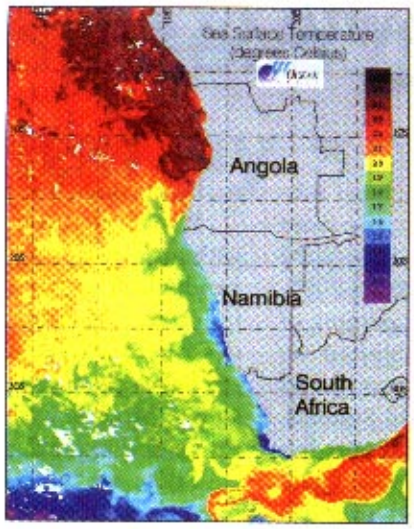


The BCLME region encompasses the cold Benguela Current upwelling system and the warm-water Angola Current to the north and Agulhas Current to the south. (Credit: NOAA & OceanSpace)

Benguela ecosystem survival project

Civil war in Angola, apartheid regimes in South Africa and Namibia, the last vestiges of Portuguese, German, Dutch and English colonial influences — for decades these factors combined to alienate the countries bordering the Benguela Current ecosystem from one another. Now they've united in a joint effort to manage the resources of the ecosystem in an integrated and sustainable manner, reports

Sue Matthews

After five years in the making, the Benguela Current Large Marine Ecosystem (BCLME) Programme has been kick-started with a $15M contribution by the Global Environment Facility (GEF) through the United Nations Development Programme (UNDP).

Its primary goal is to improve the structures and capacities of the three countries to deal with problems and issues that occur across national boundaries, so that the ecosystem can be managed as a whole.

The LME concept had its origins in the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992, when it was recognised that an ecosystem-

Above: Dead fish litter the St Helena Bay shore after South Africa's first 'black tide' in 1994. (Credit: Marine & Coastal Management)

The frequency of red tides appears to be increasing in the BCLME region. (Credit: Marine & Coastal Management)

based strategy was needed for managing the marine environment. About 60 LMEs — areas of the world's oceans characterised by distinct bathymetry, hydrology, productivity and trophic interactions — have since been identified, but only a handful are the focus of holistic research and management programmes.

Highly changeable environment

'The BCLME Programme is a very exciting one, because it's the first that addresses an open ocean ecosystem,' says Mick O'Toole, the programme's Chief Technical Advisor. 'The other LME programmes being developed, such as the Gulf of Guinea programme, have a completely different approach, focussing on pollution and habitat destruction in coastal environments and the impact of this on resources.'

The BCLME area spans some 30 deg of latitude, from Angola's Cabinda province —just north of the Congo River — to Port Elizabeth on the south coast of South Africa. As such, it includes the retroflection area of the warm Agulhas Current, the cold waters of the Benguela Current upwelling system, and the warm, stratified waters of Angola, which makes for a highly changeable environment.

Apart from the inherent variability associated with pulsed upwelling systems, the southern Benguela may experience cold water events caused by prolonged winds and hence increased upwelling, and sometimes even intrusions of sub-Antarctic water. Warm water of Agulhas Current origin also periodically intrudes into the southern Benguela, dramatically influencing its oceanography and productivity.

'The sea turned black and the stench of rotting eggs filled the air'

At the BCLME's northern extreme, the Congo River discharges the second highest volume of freshwater into the oceans after the Amazon, intensifying the stratification of Angolan surface waters and significantly influencing the environmental variability of the Benguela region.

Rich deposits

The BCLME is one of the world's most productive ocean areas, with primary production levels about six times higher than the North Sea ecosystem. It supports a number of commercially important fisheries, while its marine mammals, seabirds and scenic landscapes offer considerable ecotourism opportunities. The seafloor has rich deposits of minerals — particularly diamonds — as well as oil and gas reserves.

In the past, the three countries felt justified in focusing their management efforts on their own waters because the BCLME area is conveniently split into three sub-systems. At the principal upwelling cell at Lüderitz, close to the South Africa-Namibia border, a cone of cold, turbulent surface water acts as a barrier to the movement of pelagic fish and plankton species, effectively dividing the Benguela upwelling system into two.

The northern boundary of the Benguela upwelling system is marked by the Angola-Benguela Front, off the Namibia-Angola border, while the Angola Front near Cabinda separates Angolan waters from the equatorial Gulf of Guinea system to the north.

Nevertheless, adult stages of fish such as hake, tuna, and snoek are able to cross the Lüderitz barrier — which sometimes also weakens enough to allow pelagic fish from South Africa to be advected into Namibian waters — and sardine, horse mackerel, dentex and deep-sea crab move between Namibia and Angola, either by crossing the Angola-Benguela Front or migrating with it as its position fluctuates.

'To date there's been no common monitoring or shared research and management strategies for these transboundary fish stocks,' says Dr O'Toole. 'The need for a more integrated approach has also been highlighted by the recognition that the BCLME is a critical area in terms of marine catastrophic events. The most dramatic of these was the wide-scale advection of low-oxygen water into the northern Benguela from Angola in 1994 and the Benguela Nino the following year, which had grave consequences for the Namibian economy.'

Disastrous effect

These 'Benguela Ninos,' so-called because of their apparent similarity to El Nino events in the Peruvian upwelling system, occur when periodic warming in the tropical eastern Atlantic drives warm water into the northern Benguela region. In March 1995 the entire coast from Cabinda to central Namibia was covered by abnormally warm water — in places up to 8°C above average — to a distance of more than 300 km offshore.

The effect was disastrous. Sardine, horse mackerel and silver kob died *en masse*, while those sardine that managed to escape the warm water by moving south were subject to heavy fishing pressure because of their increased availability to the Walvis Bay fleet. The anchovy stock, already at a low level, collapsed completely. The seal population was almost halved after many adult seals succumbed to starvation and the entire cohort of pups either died or aborted.

That Benguela Nino was the most severe on record, because

it aggravated hypoxic conditions over the entire shelf of the Benguela region. Low-oxygen water is a ubiquitous but variable feature of the shelf area, and originates from two sources. Dense phytoplankton blooms, which develop after upwelling of nutrient-rich water, ultimately die, sink to the bottom and decay, causing localised depletion of oxygen through bacterial decomposition, but there is also some advection of low-oxygen water from more distant sources, as occurred in 1994.

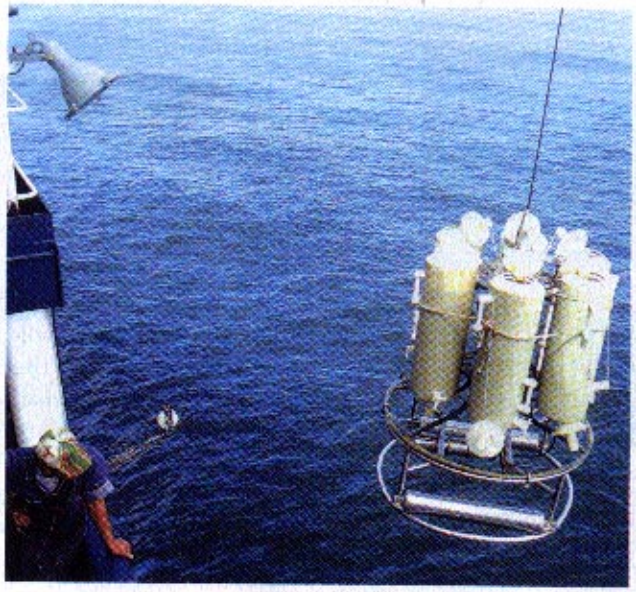
The relative importance of these processes is still poorly understood, but it was clear that the 1995 Nino-warming caused strong stratification of the water column, compounding oxygen depletion below the thermocline and resulting in a mass mortality of bottom-dwelling hake. The Namibian fishing industry, already teetering on the brink after the previous year's Nino, went into freefall.

Further south, the system-wide hypoxia was a contributing factor in the first 'black tide' ever recorded in South Africa. The respiration and subsequent decomposition of a bloom of dinoflagellates, trapped in St Helena Bay by gentle onshore winds, exhausted what little oxygen was left in the water. This created an ideal environment for anaerobic, sulphate-reducing bacteria to convert sulphates in the water to hydrogen sulphides, which turned the sea black and filled the air with the stench of rotting eggs.

Suffocation

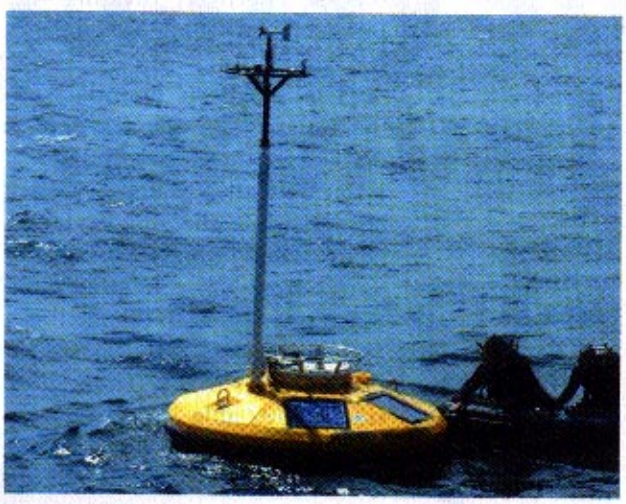
Marine organisms in the bay died because of suffocation or hydrogen sulphide poisoning, or from being stranded on the shore after moving into shallow water in search of oxygen. A 30 km stretch of shoreline was littered with the carcasses of 1500t of fish and 60t of rock lobster.

Marine mortalities resulting from sulphur eruptions are common occurrences in Namibia's Walvis Bay, and low-oxygen water frequently causes rock lobster 'walk-outs' along both the Namibian and South African coastlines. In addition, the threat of red tide exists throughout the Benguela upwelling area.



A CTD is deployed on the FRS *Africana*. Ongoing monitoring of physical-chemical parameters will establish a baseline against which environmental variability and decadal change can be measured. (Credit: Sue Matthews)

'We need to have mechanisms in place so that we can understand, model and predict these catastrophic events,' says Dr O'Toole. 'One of the most important deliverables that we've committed to having in place by the end of the five-year programme is an Early Warning System. This will involve setting up key environmental monitoring stations along the coast – both inshore and offshore – that can provide real-time data for models. We need predictive capability not just in terms of the timing and extent of events, but also their ecosystem consequences and socio-economic impacts, so we can develop the necessary contingency plans.'



Moorings such as this Seawatch buoy will provide real-time data for an Early Warning System. (Credit: CSIR)

Early warning system

The creation of an Early Warning System is one of a suite of policy actions outlined in the BCLME Programme's Strategic Action Plan, endorsed by the relevant Ministers of the three countries. Others focus on harmonising management of shared fish stocks and conducting joint surveys; developing regional mariculture policies, oil-spill contingency plans, and monitoring programmes for harmful algal blooms; co-ordinating efforts to minimise the negative impact of mining and pollution; maintaining ecosystem health; conserving biodiversity and strengthening capacity.

'Capacity building is probably our biggest challenge,' says Dr O'Toole, 'but we envisage that the GEF funding will be used to ensure that by the end of the programme the skills and structures will be in place to continue the initiative. That would also necessitate a sustainable source of funding, and part of our objective is to use the GEF's contribution to lever funds from other donor agencies, as well as the private sector. In the last year or two the reconstruction initiatives in Angola have drawn considerable donor-funding into the region, while the oil industry in Cabinda is proving to be a very supportive stakeholder both in terms of joint funding and buy-in to a number of projects, either by providing data or allowing platforms to be used for monitoring purposes.'

The BCLME Programme clearly presents enormous opportunities for the three countries to improve their understanding and management of a highly complex ecosystem. If they get it right, it could serve as a blueprint for LME initiatives in other upwelling regions and elsewhere in the developing world.