Benguela Upwelling System

Interactions of Ocean Processes and Fisheries off Namibia

By Mick O'Toole and Chris Bartholomae

The Benguela is one of the world’s main cold water current systems and is characterised by strong coastal upwelling and high levels of plankton production. It sweeps northwards within 150 km off the west coast between latitudes 15° and 34° south, bringing cold Antarctic water into warmer subtropical regions. It flows in a north to northwesterly direction along the west coast of southern Africa and roughly follows the contours of the seabed. North of Walvis Bay (23°S), the current flow moves offshore away from the coast. A southward upwelling flow at deeper levels on the continental slope and nearer the coast at depths greater than 30 metres. The speed of the Benguela Current varies between 10 and 30 cm per second depending on the location off the coast, wind direction and speed and the time of the year.

During the upwelling process, surface water is transported in an offshore direction by the effects of the prevailing equatorward winds in combination with the rotation of the earth or the Coriolis force. This is compensated for by the movement of cold nutrient-rich bottom water into the upper layers at the coast (Figure 1). In the presence of sunlight, these nutrient-rich waters promote extensive blooms of phytoplankton and give rise to high levels of zooplankton production. The abundant food supply supports large shoals of pelagic fish such as pilchard, anchovy and juvenile horse mackerel which in turn provide food for large populations of higher predators such as hake, adult horse mackerel, seals, dolphins and seabirds.

The rate and intensity of upwelling fluctuates with seasonal variations in wind patterns. Bottom topography and the seaward extent of the continental shelf also influence the upwelling processes with high-energy areas being found where the shelf is narrowest and the wind strongest. The most intense and most important upwelling region off the Namibian coast is located in the south near Lüderitz (27° to 28°S). There are smaller and less intense upwelling cells at Cape Fria (18°S), Palgrave Point (20°30'S) and Conception Bay (24°S). Typical surface temperatures and salinity values in coastal upwelling areas off southern Namibia range from 11° to 14°C and 34.8 to 35.2 ppt respectively (Figure 2).

The marine environment off Namibia and the dynamics of the Benguela Current are controlled by seasonal changes in the south Atlantic high-pressure system. Southerly winds blow off Namibia throughout the year and tend to be...
strongest in winter and spring. In the Lüderitz area to the south, winds have highest velocities in spring and summer whereas in the central and northern regions they tend to be most intense in spring and autumn. Hot dry bergwinds from the east or north in autumn and winter also influence the coastal marine environment by locally suppressing upwelling and occasionally transporting large quantities of dust and sand far out to sea.

In summer and autumn, the southerly winds relax off central and northern Namibia and upwelling becomes weak. (Figure 3). These conditions are typical for this time of the year and are associated with increased solar radiation and the movement of the warm and more saline water of the Angolan Current southwards and mixing with the cooler water of the Benguela Current. This leads to stable stratified conditions with relatively shallow well-defined thermo-

clines forming in the upper layers of the ocean (Figure 4). The surface water temperatures during these periods can rise to between 17° and 22°C and salinities are usually within the range of 35.5 to 35.9 ppt. These frontal areas where the two currents converge usually have high plankton production and are important spawning and nursery grounds for pelagic fish.

**Monitoring the northern Benguela Current**

The Ministry of Fisheries and Marine Resources routinely monitors oceanographic conditions off the coast of Namibia and collects information on sea temperature, salinity, oxygen, primary production (phytoplankton) and nutrients such as phosphates, nitrates and silicates. These parameters together with the seasonal movements and interactions of cold and warm water off the coast of Namibia have a major influence on the timing and production of zooplankton, the movement of fish shoals and the extent, duration and success of spawning.

Research vessels of the Ministry of Fisheries and Marine Resources like the RV Welwitschia and the Norwegian funded RV Fridtjof Nansen, are equipped with modern oceanographic instruments and monitoring devices such as conductivity temperature depth recorders and fluorometers. Speed and direction of currents can also be measured using satellite-tracked buoys and acoustic doppler current meters. The results of these studies can assist in monitoring the transport and dispersal of fish eggs and larvae from the spawning grounds to the fertile coastal nursery areas. Information from surface drifter buoys also has important applications in oil spill contingency planning and studying migration patterns of pelagic fish. Cooperative projects between the Ministry of Fisheries and Marine Resources and NAMCOR, the Namibian national petroleum corporation, during 1994 – 1995 have yielded valuable information on the direction of movement and speed of surface water masses at a number of locations off the Namibian coast.

Satellite remote sensing plays an important role in marine fisheries management and surveillance in a number of countries throughout the world. Data are gathered over large areas in real time that contribute to the understanding of ocean and coastal processes and interactions with fisheries. The fishing industry increasingly uses information from satellites to locate favourable temperature regimes along ocean frontal systems where tuna and billfish concentrate to feed. Areas of high plankton primary productivity can also be detected by satellite imagery through specialised instruments that monitor changes in ocean colour. Such regions of high productivity are likely to be favourable feeding grounds for pelagic fish such as pilchard.

The upwelling processes off the Namibian coast are amongst the most intense in the world and the information collected by satellites is of great interest to Namibian scientists and the international scientific community. In 1994, the British Overseas Development Agency (ODA) donated a satellite receiving station and image processor to the National Marine Information and Research Centre at Swakopmund. This has been useful in studying the interactions between oceanographic processes and fisheries, in monitoring upwelling intensity and mapping major pertur-
bations in the marine environment such as the warm water event or Benguela Niño in 1995.

The prevailing south to southeast winds are the main driving force of the upwelling processes and surface currents off Namibia. Fluctuations in the seasonal strength and direction of the wind systems have a marked effect on upwelling intensity and the coastal oceanography of the region. This in turn greatly influences the physical and chemical processes and structures in the water column and subsequently the plankton production, fish migrations, spawning and egg and larval survival. Until recently, apart from the stations located at Pelican Point, near Walvis Bay and Diaz Point at Lüderitz, there had been little monitoring of winds in the nearshore environment especially at key upwelling coastal sites.

During the last few months of 1996, the Ministry of Fisheries in cooperation with the Meteorological Service and the financial support of the German Technical Cooperation Agency installed automatic weather stations at three important coastal upwelling centres: Chamaus Bay, Conception Bay and Cape Fria. These stations provide real-time information on coastal climate parameters such as winds, pressure, rainfall, fog and temperatures which are relayed several times a day by Meteosat satellite to the Weather Bureau in Windhoek (Figure 5). These data are then made available to the National Marine Research and Information Centre in Swakopmund where it can greatly assist in interpreting coastal oceanographic processes and pelagic fish shoal movements as well as providing useful information for designing models for oil spill contingency plans and the dispersal of sediment plumes from coastal diamond mining operations.

Industrial activities can detrimentally affect the marine environment through oil pollution, dumping of waste, release of toxic substances or disruption of the water chemistry. As the search for offshore diamonds, oil, gas and other deposits increases, so does the risk of environmental degradation. To prevent this, Namibia has made provisions in the Petroleum (Exploration and Production) Act, Act 2 of 1991 for registered license holders to conduct environmental impact assessments. License holders also have to prepare a detailed oil spill contingency plan. The national environmental assessment policy drafted by the Ministry of Environment and Tourism also regulates aspects of environmental protection and planning. Although the companies fund the assessments, the Ministry can at the cost of the licensee, appoint an independent reviewer to test or monitor the assessment. Some companies have already done comprehensive environmental impact studies.

The GTZ funded Marine Environmental Monitoring Project (Marenpro) has been assisting the Ministry of Fisheries and Marine Resources on various aspects of environmental monitoring particularly in relation to the potential impacts of diamond mining on rock lobster stocks in the Lüderitz area. The results will enable future changes in the coastal marine environment to be monitored more effectively and models to be tested as commercial developments proceed.

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