I-3 Canary Current: LME #27

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The Canary Current LME is a major upwelling region off the coast of northwest Africa, bordered by Morocco, Mauritania, Senegal, Guinea-Bissau, the Canary Islands (Spain), Gambia, Cape Verde and Western Sahara (a disputed, non-self governing territory). It is strongly influenced by the Canary Current, which flows along the African coast from north to south between 30° N – 10° N and offshore to 20° W (Barton 1998). The surface waters of the Canary Current are relatively cool as a result of the entrainment of upwelled water from the coast as it flows southwards (Mittelstaedt 1991). Several drainage systems in this region flow only seasonally because of the high seasonal variation in rainfall, e.g., the Senegal and Gambia Rivers. The LME has an area of about 1.1 million km^2, of which 0.77% is protected, and contains 0.12% of the world's sea mounts and 0.01% of the world's coral reefs (Sea Around Us 2007). There are 7 major estuaries and river systems draining into the LME including the Casamance, Senegal and Gambia. Books, book chapters and reports pertaining to the LME include Bas (1993), Prescott (1993), Roy & Cury (2003), Chavance *et al.* (2004) and UNEP (2005).

I. Productivity

The Canary Current LME is a Class I, highly productive ecosystem (>300 $gCm^{-2}y^{-1}$). Hydrographic and climatic conditions play a major role in driving the dynamics of this LME, which shows seasonal and longer-term variations (Bas 1993, Roy & Cury 2003). Climatic variability is the primary driving force, with intensive fishing being the secondary driving force, of biomass changes in the LME (FAO 2003, Sherman 2003). The biomass of small pelagic fish species is clearly influenced by the LME's oceanographic conditions (Bas 1993). A cyclonic gyre in the west acts to accumulate plankton from the north. The massive nutrient-rich upwelling stimulates, although with fluctuating intensity, seasonal bursts of primary productivity, then progressively of zooplankton and small pelagic fishes, other opportunistic feeders and predators, including mackerel, tuna and marine mammals in the pelagic zones. The normal community of zooplankton is composed of copepods, but mysid shrimps are also very important in this LME (Bas 1993). Inhabited by a large number of endemic and migrant species, the Canary Current LME is a unique ecosystem of global significance.

Oceanic fronts (after Belkin et al., 2009): Persistent northerly winds along the coast of Northwest Africa cause a year-round coastal upwelling. The upwelled water is drawn offshore by the Canary Current and also by current jets formed farther south, protruding transversally several hundred km offshore (Barton 1998, Barton *et al*. 1998). These processes create a large number of surface-intensified fronts that develop seasonally, synchronised with coastal upwelling (Figure I-3.1). The upwelling zone expands in winter and shrinks in summer and fall. It also migrates meridionally as the season progresses. The zone begins its southern advance in October and reaches its maximum southward extent (5°N) in January-March, then retreats northward, reaching 15°N in late summer.

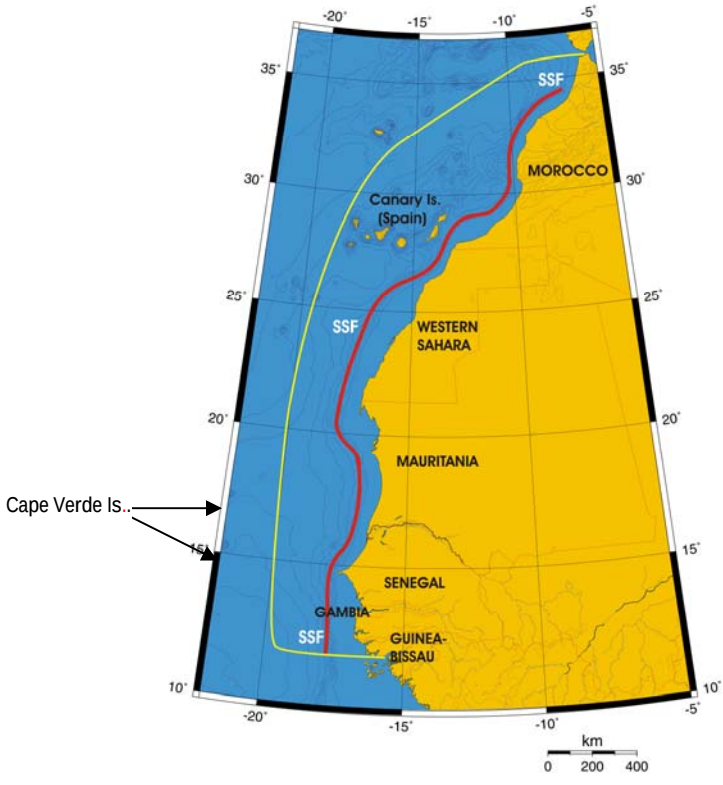

Figure I-3.1 Fronts of the Canary Current LME. SSF, Shelf-Slope Front. Yellow line, LME boundary. After Belkin et al.(2009).

Canary Current SST (after Belkin, 2009)
Linear SST trend since 1957: 0.48°C.
Linear SST trend since 1982: 0.52°C.

The moderate-rate warming since 1957 was interrupted by reversals (Figure 1-3.2). The most significant cold spell occurred after the warm event of 1969 and lasted a decade. The near-all-time maximum of 1969 was concurrent with the all-time maximum in the Caribbean Sea LME. This simultaneity likely was not coincidental since both LMEs are strongly affected – and connected – by trade winds blowing westward across the North Atlantic. The synchronism of both maxima across the North Atlantic, over a 5,000-km distance, strongly suggests a dominant role of atmospheric teleconnection, albeit westward advection by trade wind currents could also have played a role.

The Canary Current is one of four major areas of coastal upwelling in the World Ocean. Global warming is thought to increase the strength of equatorward winds, and hence to increase the upwelling intensity, leading to cooling in major upwelling areas. While the California Current LME and Humboldt Current LME indeed cooled over the last 25 years, the Canary Current actually warmed, as did the Benguela Current LME. This result is especially striking since the 20th century intensification of coastal upwelling off Northwest Africa is well documented (McGregor et al., 2007). The ongoing warming in the Mauritanian waters area is shown to have been beneficial for round sardinella (*Sardinella aurita*), which thrives after upwelling intensification in spring followed by retention of upwelled water – and primary production enhancement - over shelf in summer (Zeeberg et al., 2008).

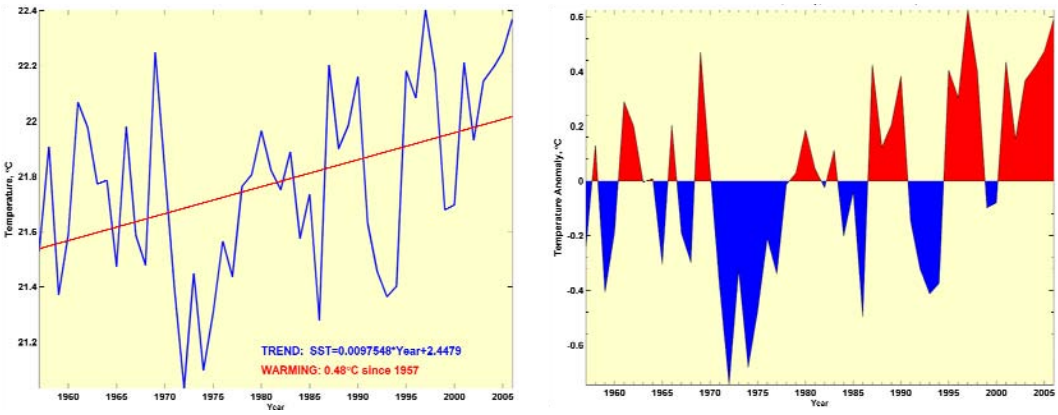

Figure 1-3.2 Canary Current LME mean annual SST (left) and SST anomalies (right), 1957-2006, based on Hadley climatology, (after Belkin, 2009).

Canary Current Trends in Chlorophyll and Primary Productivity: The Canary Current LME is a Class I, highly productive ecosystem (>300 $gCm^{-2}y^{-1}$).

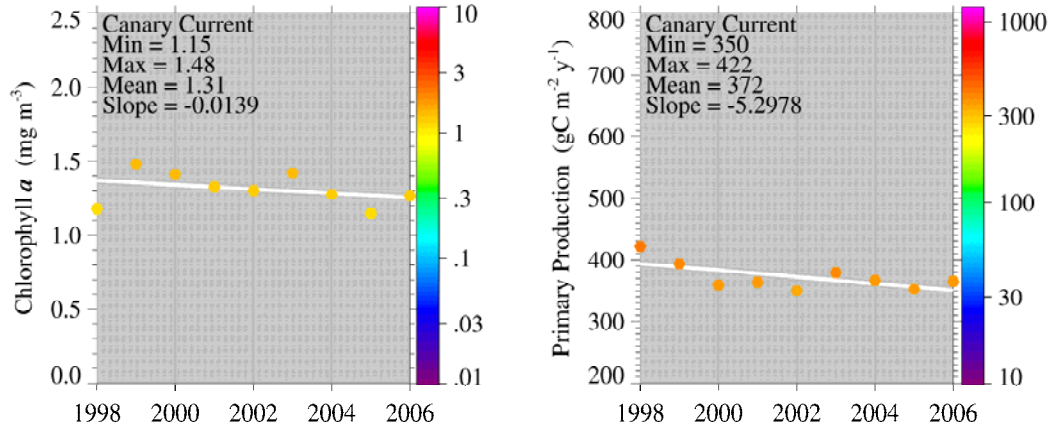

Figure I-3.3. Canary Current LME trends in chlorophyll *a* (left) and primary productivity (right), 1998-2006. Values are colour coded to the right hand ordinate. Figure courtesy of J. O'Reilly and K. Hyde. Sources discussed p. 15 this volume.

II. Fish and Fisheries

The Canary Current LME is rich in fisheries resources among which are the small pelagic fish such as sardine (*Sardina pilchardus*), sardinella (*Sardinella aurita*, *S. maderensis*), anchovy (*Engraulis encrasicolus*), chub mackerel (*Scomber japonicus*) and horse mackerel (Trachurus spp.) constitute more than 60% of the catch in the LME. Other species caught in the LME include tuna (e.g., *Katsuwonus pelamis*), coastal migratory pelagic finfish, hakes (*Merluccius merluccius*, *M. senegalensis* and *M. poli*), a wide range of demersal finfish including *Pagellus bellotti*, Pseudotolithus sp., *Dentex canariensis*, *Galeoides decadactylus* and *Brachydeuterus auritus*, cephalpods (*Octopus vulgaris*, Sepia spp., and *Loligo vulgaris*) and shrimps (*Parapenaeus longirostris* and *Penaeus notialis*). Most of these species are transboundary or migratory, with the distribution of tunas often extending beyond the bordering countries' EEZs into international waters. Fishing activities in the LME have increased over the last three decades. In addition to

small national fleets, the EEZs of Mauritania, Senegal, Gambia and Guinea Bissau all accommodate large distant water fleets from the European Union and Asia (FAO 2005a).

Total reported landings in the LME increased steadily to about 2.4 million tonnes in 1976, followed by a series of large fluctuations between 1.5 and 2.5 million tonnes (Figure I-3.4). The fluctuations in the total landings are also reflected in their value, which varies between US$1.5 billion and just under US$3 billion (in 2000 US dollars; Figure I-3.5). In recent years, however, both total reported landings and especially their value have undergone a noticeable decline.

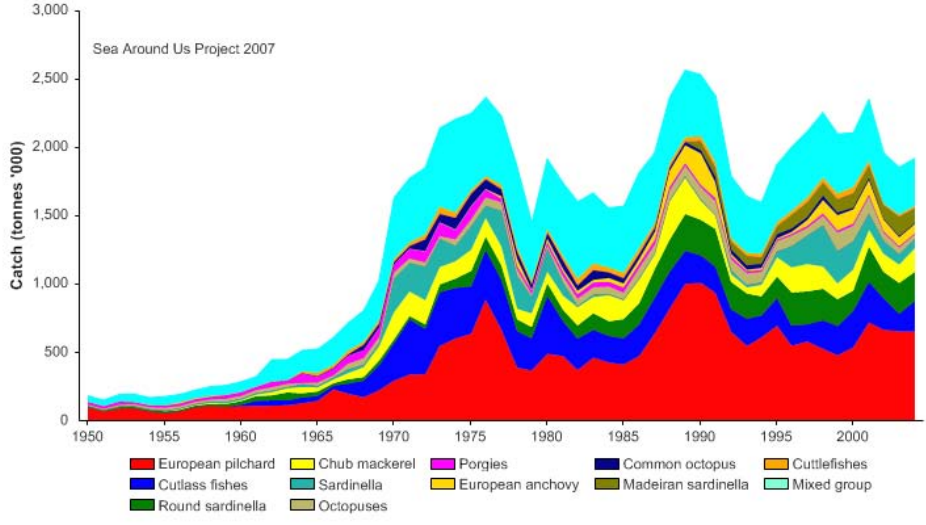

Figure I-3.4. Total reported landings in the Canary Current LME by species (Sea Around Us 2007).

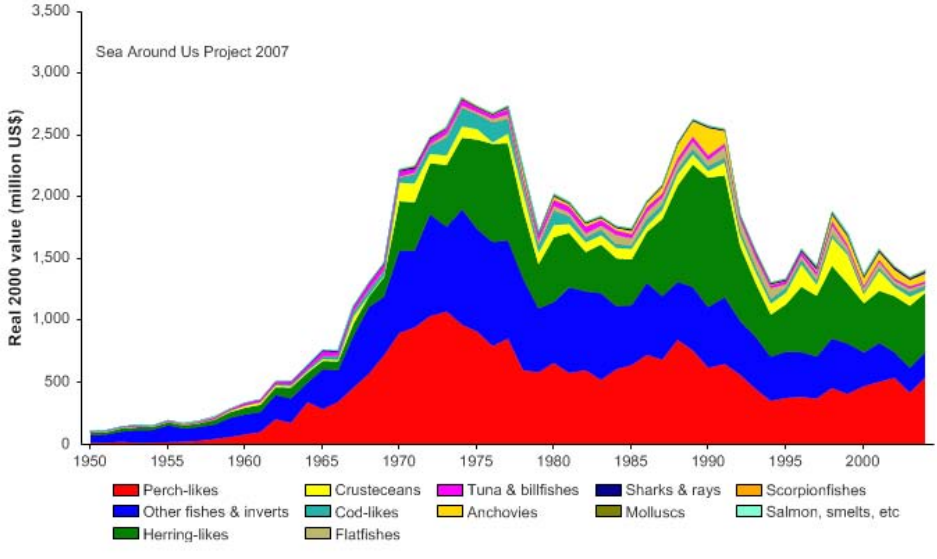

Figure I-3.5. Value of reported landings in the Canary Current LME by commercial groups (Sea Around Us 2007)

From the late 1960s to early 1990s, distant-water fleets from members of the former USSR, Spain and others countries accounted for most of the landings from the LME (Bonfil *et al.* 1998). In 1992, reported landings from the former USSR ceased, and the bulk of the landings were reported by the now independent countries of the former USSR. Substantial foreign fishing continues, notably off Mauritania (Gascuel 2007).

The primary production required (PPR; Pauly & Christensen 1995) to sustain the reported landing in the LME reached 25% of the observed primary production in the early 1970s, but has since fluctuated to about 15% (Figure I-3.6). Spain, Morocco and Senegal are currently the countries with the largest ecological footprints in this LME, although the Soviet Union's republics (Russian Federation, Ukraine, Lithuania, Latvia, and Estonia) also accounted for large footprints in the 1970s and 1980s.

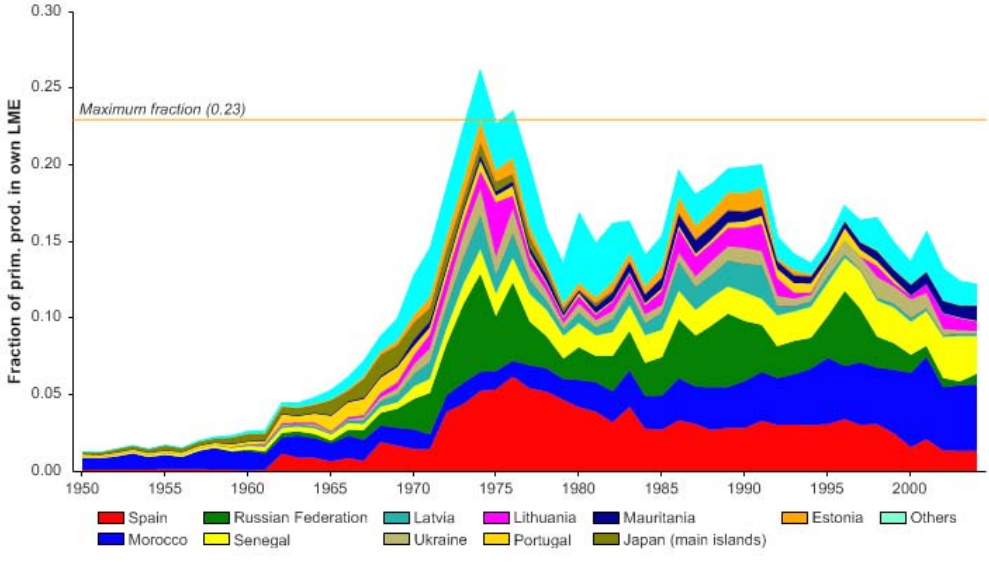

Figure I-3.6. Primary production required to support reported landings (i.e., ecological footprint) as fraction of the observed primary production in the Canary Current LME (Sea Around Us 2007). The 'Maximum fraction' denotes the mean of the 5 highest values.

The mean trophic level of the reported landings (i.e., the MTI; Pauly & Watson 2005) has declined since the mid 1970 (Figure I-3.7 top), an indication of a 'fishing down' of the food web (Pauly *et al*. 1998). The FiB index indicates a possible slight decline during this period (Figure I-3.7 bottom), suggesting a situation in which catches that should increase when trophic levels decrease, are in fact decreasing (Pauly & Watson 2005).

The Stock-Catch Status Plots show that about 40% of exploited stocks can be considered collapsed, and another 40% are overexploited in the LME (Figure I-3.8, top). Still, over 70% of the catch originates from stocks that are classified as 'fully exploited' (Figure I-3.8, bottom).

Thus, overexploitation is of major concern in the bordering countries (UNEP 2005) of the Canary Current LME. Many fish stocks are being fished at or beyond maximum sustainable yield (MSY) levels in Senegal, Mauritania, Morocco and Gambia, and in some countries such as Morocco, Senegal and Gambia, demersal production over the past decade has been near and even above the MSY level (FAO 2005a). With the exception of Cape Verde, the intensification of fishing activities in the region has had a

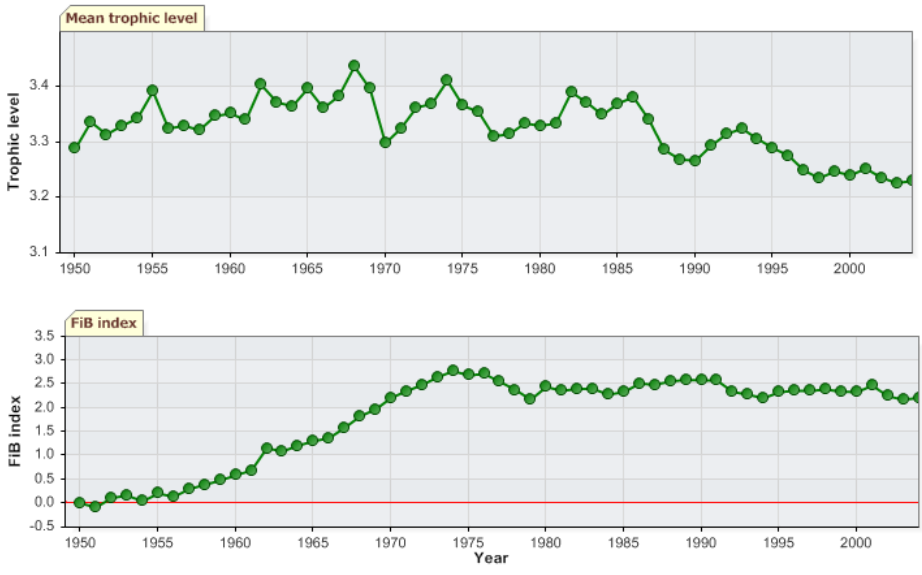

Figure I-3.7. Mean trophic level (i.e., Marine Trophic Index) (top) and Fishing-in-Balance Index (bottom) in the Canary Current LME (Sea Around Us 2007).

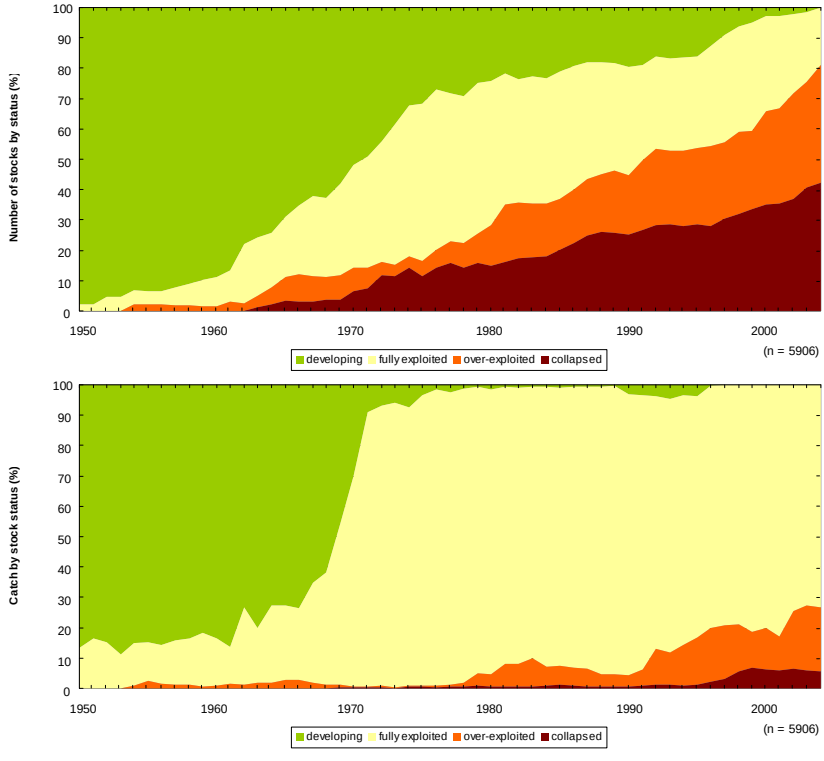

Figure I-3.8. Stock-Catch Status Plots for the Canary Current LME, showing the proportion of developing (green), fully exploited (yellow), overexploited (orange) and collapsed (purple) fisheries by number of stocks (top) and by catch biomass (bottom) from 1950 to 2004. Note that (n), the number of 'stocks', i.e., individual landings time series, only include taxonomic entities at species, genus or family level, i.e., higher and pooled groups have been excluded (see Pauly *et al*, this vol. for definitions).

drastic impact on the pelagic resources, which have undergone a strong decline in productivity (Fonseca 2000). High fishing pressure has also led to the marked decline in the catch of the demersal finfish fishery accompanied by the opportunist expansion of fisheries targeting octopus (Bas 1993, European Commission 2005). Bycatch and discards were assessed as moderate, and can be attributed to the use of small-meshed nets, especially in the artisanal fishery (UNEP 2005), although high discard rates were observed in the Spanish cephalopod trawl fishery in Morocco (Balgueiras 1997). Cephalopod trawlers fishing in Mauritania and Senegal were also found to discard 72% and 60-75% of their total catch, respectively, while the Senegalese mixed fleet targeting finfish and shrimps in shallow waters had a discard rate of 67%. Pech et al. (2001) explore the difficulties in fitting a model of flexible multifleet–multispecies fisheries to Senegalese artisanal fishery data.

Fish stocks in the LME are also expected to be influenced by global warming and the consequent rise in sea surface temperatures. Upwelling intensity and sea surface temperatures are strongly linked, and are believed to affect both the spatial distribution and abundance of fish in the LME (Cury & Roy 1991, Roy & Cury 2003). For example, periods of high sardine abundance appear to be associated with the ENSO variability (Roy & Cury 2003). Positive values of the Southern Oscillation Index are also associated with enhanced upwelling and coincide with higher catch rates (Roy & Reason 2001). The impact of climate on fish stock abundance and distribution must be taken into consideration in the development of fisheries management programmes in this LME.

III. Pollution and Ecosystem Health

Pollution*:* Pollution is a major concern in localised hotspots, especially in emerging coastal mega-cities that are primary centres of industrial development and high population densities (UNEP 2005). There is strong evidence of serious localised degradation in the coastal environment of this and adjacent LMEs (Gordon & Ibe 2006). Eutrophication and the decay of organic matter create anoxia and subsequent fish mortality particularly in areas around major cities, bays and ports. Most countries in the Canary Current LME have environmental laws related to industrial, toxic, hazardous and medical wastes. However, enforcement of these regulations is inadequate, and pollution from these sources is evident in localised areas, especially near expanding coastal cities like Dakar (pop. 2,500,000 in 2007) in Senegal and Dar-el-Beida (Casablanca: pop. 3,900,000 in 2007) and Rabat (pop. 1,810,000 in 2007) in Morocco.

Some common features across the countries of the Canary Current LME are desertification, overgrazing on fragile rangelands, cultivation of crops on steep slopes (Cape Verde) and soil erosion. The resulting run-off and increased turbidity in the major rivers leads to increased turbidity in coastal waters throughout the LME. Domestic and industrial solid waste management and disposal are of concern in the bordering countries, and efforts are being made to address the problem. Spills around oil refineries are a chronic source of localised water column contamination. There is some evidence of minor spills of hazardous materials, but this is limited to harbours and fishing ports (UNEP 2002)

Habitat and community modification: Industrial development in the coastal zone of the Canary Current LME, as well as migration of people from inland rural areas to the coastal industrial centres, have led to increasing threats of coastal degradation and moderate habitat modification in this LME (UNEP 2005). Over the last 2 - 4 decades, marshes, swamps and mangroves have been degraded and lost through natural factors such as drought, but more significantly, through human activities such as unsustainable agricultural practices, urbanisation, mining and other industries, natural resources

exploitation, and modification of rivers that has reduced water supply to wetlands and marine areas.

Approximately 30% of the surface area of wetland habitats has been permanently destroyed. Those that have not been destroyed are being modified largely because of continuing human activities. In some coastal lagoons there is a progressive decline of certain endemic algae species such as *Psidona oceanica*, due to the spread of *Caulerpa prolifera*. The replacement of mangroves by 'tannes', with a complete disappearance of mangroves, is evident in some areas. The construction of dams across certain tributaries of, for example, the Gambia and Senegal Rivers, has resulted in the die-back of extensive areas of mangrove forests. Significant quantities of sand from coastal erosion also contribute to mangrove death, by preventing the influx of sea water into mangrove areas. In addition, data indicate the extension of aquatic plants in estuaries and bays, particularly due to flow alteration and reduction (UNEP 2002). Ongoing and planned initiatives aimed at the control of pollution and the conservation of important habitats of the Canary Current LME (see Governance) are expected to lead to an improvement in the health of this LME (UNEP 2005).

IV. Socioeconomic Conditions

The total population of the countries bordering the Canary Current LME is about 58 million, of which an estimated 70% are directly reliant on the LME for their livelihoods. More than 60% of the population lives in the coastal areas where most cities and industrial infrastructure are located (UNEP 2002). These coastal populations are engaged mostly in marine fisheries, agriculture and tourism activities. The backbone of the countries' economy is based on agriculture and fisheries, with a very weak industrial sector contribution to GDP.

Fisheries provide livelihoods, fish protein supplies and revenue for the bordering countries, several of which are classified as Low-Income Food-Deficit Countries (FAO 2005b). These countries do not necessarily benefit from increased fish supplies or increased government revenue when foreign fleets access their waters (Kaczynski & Fluharty 2002). Much of the catch of the foreign fleets is exported or shipped directly out of the region, while compensation for access is often low compared to the value of the catch.

Overfishing has severe socioeconomic consequences in this LME, and includes reduction in national incomes, loss in fishing industries, reduction of food supply, loss of employment and increase in the cost of maritime surveillance as well as reduction of biological diversity. Loss of employment (which may be as high as 80% in Senegal) translates to impoverishment and suffering of people, among them being vulnerable groups such as women, children and the elderly. Overfishing also leads to conflicts among different user groups for dwindling resources. Depleted fisheries resources accentuate protein deficiency particularly in small children, leading to diseases such as kwashiorkor. This situation is aggravated mostly in rural areas where livestock is under severe threat from droughts. Management of the fisheries of the Canary Current LME to ensure sustainability is therefore of prime concern to all the bordering countries.

The economic sectors affected by pollution and habitat modification and loss are agriculture, fisheries, and tourism. Impacts on fisheries as well as the agriculture sectors can have severe economic ripples since they make a significant contribution to the overall national product (more than 30% of GDP in the region). Socioeconomic impacts include those of overfishing, as described above, as well as loss of tourism and recreational amenities. Migration of people (occasionally transboundary) including conflicts over resources could also arise. Loss of or modification of wetlands also results

in shortage of firewood that is vital to the majority of households in rural areas. Pollution around densely populated coastal cities such as Dakar is a major cause of losses in the tourism industry in Senegal. In addition, pollution of coastal waters presents significant public health risks, through contaminated bathing beaches and consumption of contaminated fishery products. Loss and degradation of habitats also compromise the quality of water as wetlands generally act as sinks for pollutants from land-based activities. This in turn aggravates public health problems.

V. Governance

Several regional and sub-regional institutions and programmes are operating in the Canary Current LME region, including the UNEP Regional Seas Programme for the West and Central Africa Region (see the Benguela Current LME for more information), the Gambia River Development Authority, the Senegal River Development Authority and the Sub-Regional Fisheries Commission. The Ministerial Conference on Fisheries Cooperation among African States Bordering the Atlantic Ocean and the Fishery Committee for the Eastern Central Atlantic bring together all the states sharing the basins and coastal areas to ensure the proper use and management of their resources. Most of the bordering countries are signatories to various international environmental conventions, including the Abidjan Convention and Dakar Convention. Cape Verde, Guinea, Morocco and Senegal are members of the International Commission for the Conservation of Atlantic Tunas and have formally agreed to the subsequent Protocols of 1992 and 1997. All the Canary Current LME countries, except Mauritania and Morocco, are members of the Economic Community of West African States.

The coordinated management of this LME is a challenge (Prescott 1993). The historically fragmented nature of coastal and marine resource management is a legacy of the colonial past as well as of the political situation in these countries. There are regionally incompatible laws and there is a paucity of environmental regulations. The preparatory phase of the project 'Protection of the Canary Current Large Marine Ecosystem' has been finalised and a full scale project developed. The long-term environmental goal of the CCLME program is to "reverse the degradation of the Canary Current Large Marine Ecosystem caused by over-fishing, habitat modification and changes in water quality by adoption of an ecosystem-based management approach" and the CCLME project objective is to "enable the countries of the Canary Current Large Marine Ecosystem to address priority trans-boundary concerns on declining fisheries, associated biodiversity and water quality through governance reforms, investments and management programs." A Preliminary TDA has confirmed the focus of regional concern on depleted fisheries and on habitat, associated biodiversity and water quality critical to fisheries.

The project will assist the seven participating countries to meet the sustainable fisheries target of WSSD including contribution to implementation of the Environment Action Plan under NEPAD. Close linkages are to be developed with GEF projects for the river basins draining into the LME and the neighbouring GEF International Waters projects on the Guinea Current and the Benguela Current LMEs. Consistent with other GEF LME projects, a TDA and SAP will be prepared for the Canary Current LME.

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