XVII-56 Humboldt Current: LME #13

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The Humboldt Current LME extends along the west coast of Chile and Peru. It has a surface area of 2.5 million km^2, of which 0.11% is protected, and contains 0.42% of the world's sea mounts and 24 major estuaries (Sea Around Us 2007). The LME's circulation patterns are described by several authors including Wyrtki (1967), Alheit & Bernal (1993) and Wolff *et al*. (2003). Ekman offshore divergence due to the southerly trade winds gives rise to the world's largest coastal upwelling system that characterises this LME. This system shows high climatic as well as oceanographic variability associated with seasonal, interannual, decadal and longer-term changes. Considerable interannual variability occurs when the normal seasonal upwelling is interrupted by ENSO, which results in intrusions of warm, clear oceanic waters from the west and north (Wolff *et al*. 2003, Alheit & Ñiquen 2004). Book chapters and reports pertaining to this LME are by Alheit & Bernal (1993), Wolff *et al*. (2003), UNIDO (2003) and UNEP (2006).

I. Productivity

The upwelling of cold, nutrient-rich waters promotes high primary production in the Humboldt Current LME. Intense upwelling cells are located along the coast. However, the average level of primary productivity is estimated as moderate (150-300 gCm^{-2}yr^{-1}), Class II. Climatic variability is thought to be the primary driving force of biomass change in this LME, promoting marked regime shifts (Alheit & Bernal 1993, Alheit & Ñiquen 2004, Cubillos et al. 2002; Sifeddine et al., in press). Four species of pelagic schooling fish dominate this LME: anchoveta (*Engraulis ringens*), sardine (*Sardinops sagax*), jack mackerel (*Trachurus murphyi*) and chub mackerel (*Scomber japonicus*). The long-term dynamics of this LME are defined by shifts between alternating anchovy and sardine regimes that restructure the entire ecosystem from phytoplankton to the top predators, often under the influence of El Niño (Alheit & Ñiquen 2004; GTE IMARPE 2003; Klyashtorin 2001; Bouchón et al. 2000). Valdés et al. (2008) have shown that sardine and anchovy do not always vary synchronously. Phases with mainly negative temperature anomalies parallel anchovy regimes while the warm periods have been characterised by sardine dominance. Planktonic food sources for juvenile and adult anchovies are reduced because of decreased plankton production due to restricted upwelling in warm years and the diminution of the abundance of large copepods, their main food source (Alheit & Ñiquen 2004, Ayón et al. 2004, Ayón et al. in press; Yañez et al. 2003). Devastating consequences arise for the pelagic fisheries off Chile and Peru (see Fish and Fisheries) as well as for the marine fauna that rely on these normally highly productive areas. The coincidence in the fluctuations of small pelagic fish in the Humboldt, Kuroshio and California Current systems suggests teleconnections among them (Kawasaki 1991, Lluch-Belda *et al*. 1992). See Serra et al. (2002) for an extended discussion of climate change and the variability of pelagic fish stocks in the Humboldt Current Ecosystem.

Oceanic fronts (Belkin et al. 2009; Belkin & Cornillon 2003): The most important front off Peru is caused by wind-induced coastal upwelling (Figure XVII-56.1). The Peruvian Upwelling Front (PUF) extends along the shelf break from 5°S to 19°S. Farther south, the coastline sharply changes its orientation and is no longer favorable to wind upwelling. A new summertime front has been described from satellite data, called the Nasca Front (NF) because of its proximity to the Nasca Ridge (Belkin & Cornillon 2003). The Nasca Front (NF) departs from the Chilean coast at 25°S-27°S and extends northwestward, best developed in March. This front is a major tuna fishing ground, especially important for the yellowfin tuna fishery. The Subtropical Frontal Zone, bounded by the North and South Subtropical Fronts (NSTF and SSTF respectively), crosses the South Pacific zonally between 35°S-40°S, impinges Chilean coast and bifurcates, with its branches flowing meridionally but in opposite directions along Chilean coast. The attendant fronts between the Subtropical Frontal Zone waters and Chilean coastal waters are observed year-round. South of 40°S, the Chilean Archipelago low-salinity waters form a salinity front at the contact with oceanic waters.

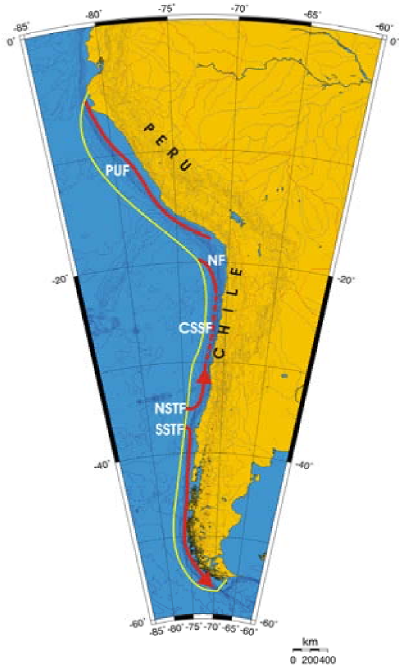

Figure XVII-56.1. Fronts of the Humboldt Current LME. Acronyms: CSSF, Chilean Shelf Slope Front (r probable location); NF, Nazca Front; NSTF, North Subtropical Front; PUF, Peruvian Upwelling Front; S South Subtropical Front. Yellow line, LME boundary. After Belkin et al. (2009).

Humboldt Current LME SST (Belkin 2009)
Linear SST trend since 1957: 0.41°C.
Linear SST trend since 1982: -0.10°C.

The thermal history of this LME (Figure XVII-56.2) can best be interpreted in the El Niño-Southern Oscillation (ENSO) framework. The northern part of this LME is strongly affected by El Niños and La Niñas (National Weather Service/Climate Prediction Center, 2007). The southern part of this LME is not directly impacted by these events. The El Niños of 1983 and 1997 were pronounced in this LME; other El Niños are barely noticeable in our time series, partly because of the area-weighed averaging over this exceptionally long LME, most of which is not affected by El Niños. In the long-term, the Humboldt Current warmed by 0.41°C since 1957. The long-term warming trend was not uniform. In fact, the Humboldt Current experienced a 1°C cooling in 1957-1973, followed by a decade-long warming that culminated in 1983. These opposite trends represent two major oceanic regimes. Biologically, these regimes manifest as “alternating anchovy and sardine regimes that restructure the entire ecosystem from phytoplankton to the top predators” (Alheit and Niquen, 2004, p. 201). Except for the warm events of 1983 and 1997 linked to El Niños, there was hardly any long-term warming in the Humboldt Current over the last few decades. Moreover, the linear trend over 1982-2006 yields a slight cooling of -0.10°C.

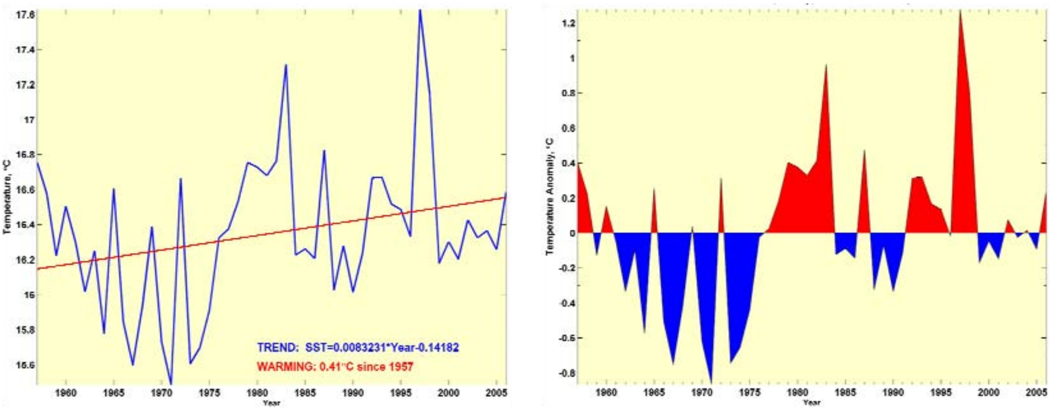

Figure XVII-56.2. Humboldt Current LME annual mean SST (left) and SST anomalies (right), 1957-2006, based on Hadley climatology. After Belkin (2009).

The Humboldt Current LME and the California Current LME are the two LMEs that experienced ***cooling*** over the last 25 years. Both LMEs are located in the East Pacific coastal upwelling zones, where the upwelling intensity is near its global maximum. In these zones, equatorward alongshore winds cause offshore transport of warm surface waters and upwelling of cold subsurface waters. The observed cooling in these areas suggests an increase in the upwelling intensity, likely caused by an increase in the strength and/or persistence of the upwelling-favorable alongshore equatorward winds. This hypothesis is supported by observed data and numerical modeling experiments (for the California Current, see Schwing & Mendelssohn 1997). The fact that California and Peru both show decreasing SST trends is clearly related to a multi-decadal shift that occurred in the mid-1990s. Chavez et al., 2003 provide a conceptual model of what happens in the Pacific during these shifts and a preliminary description of the mid 1990s shift). This shift led to shallower than average thermocline in the eastern Pacific, cooler SSTs and higher chlorophyll and primary productivity. Note that Pennington and others (2006) found significant variations in monthly values for chlorophyll and primary productivity of sub-systems of the Humboldt Current.

Humboldt Current LME Chlorophyll and Primary Productivity: The average level of primary productivity is estimated as moderate (150-300 $gCm^{-2}yr^{-1}$), Class II.

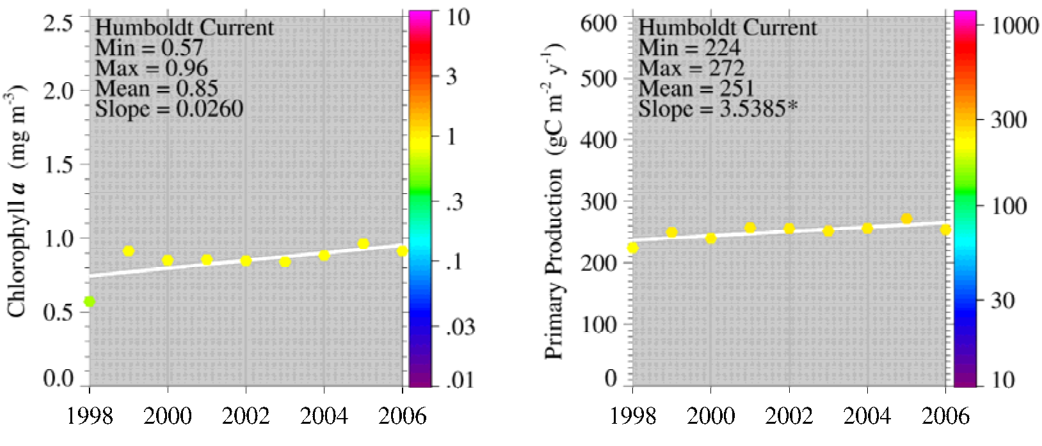

Figure XVII-56.3. Humboldt Current LME trends in chlorophyll *a* (left) and primary productivity (right), 1998-2006, from satellite ocean colour imagery. Values are colour coded to the right hand ordinate. Figure courtesy of J. O'Reilly and K. Hyde. Sources discussed p. 15 this volume.

II. Fish and Fisheries

The Humboldt Current LME's high productivity supports the world's largest fisheries. In 1994, fisheries catches by Peru and Chile amounted to 12 million tonnes. These two countries account for between 16% to 20% of the global fish catch--mostly small schooling pelagic fish such as sardines, anchovies (especially the 'anchoveta', *Engraulis ringens*), jack mackerel, chub mackerel and hake, whose dynamics off Peru was reviewed in contributions in Pauly & Tsukayama (1987), Pauly *et al.* (1989), Barría et al. 2003 and Bertrand et al (In Press-a). Highly migratory resources shared between Chile and Peru (UNIDO 2003) include tuna, sword fish, shark, and giant squid. Tropical and temperate molluscs, crustaceans and sea urchins are also important resources. Total reported landings fluctuate, with two major peaks at over 11 million tonnes in 1970 and 1994 (Figure XVII-56.4) but actual catches may be much higher. For example, Castillo & Mendo (1987) estimated a maximum catch of 18 million tonnes from the Northern-Central stock of Peruvian anchoveta. The VMS control system implemented by the government in Peru in 2004, and the SGS report control system have reduced the underreporting of catches. The value of the reported landings also fluctuates, reaching about US$10 billion (in 2000 US dollars) in 1970 (Figure XVII-56.5).

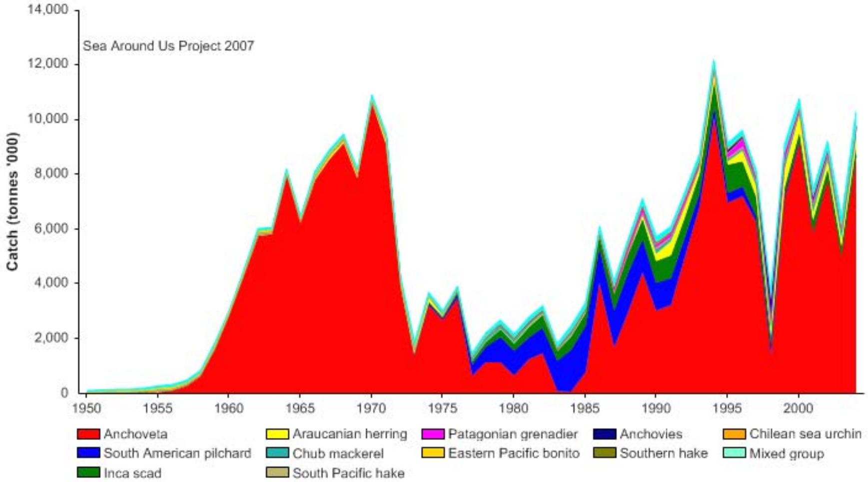

Figure XVII-56.4. Total reported landings in the Humboldt Current LME by species (Sea Around Us 2007).

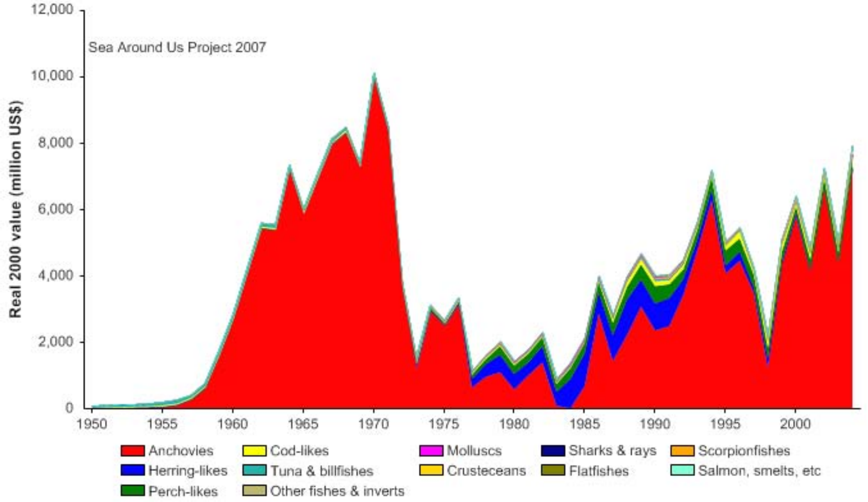

Figure XVII-56.5. Value of reported landings in the Humboldt Current LME by commercial groups (Sea Around Us 2007).

The primary production required (PPR; Pauly & Christensen 1995) to sustain the reported landings reached 20% of the observed primary production in the LME in the mid 1990s, and has fluctuated at this level in recent years (Figure XVII-56.6). Peru and Chile account for almost the entire ecological footprint in this LME.

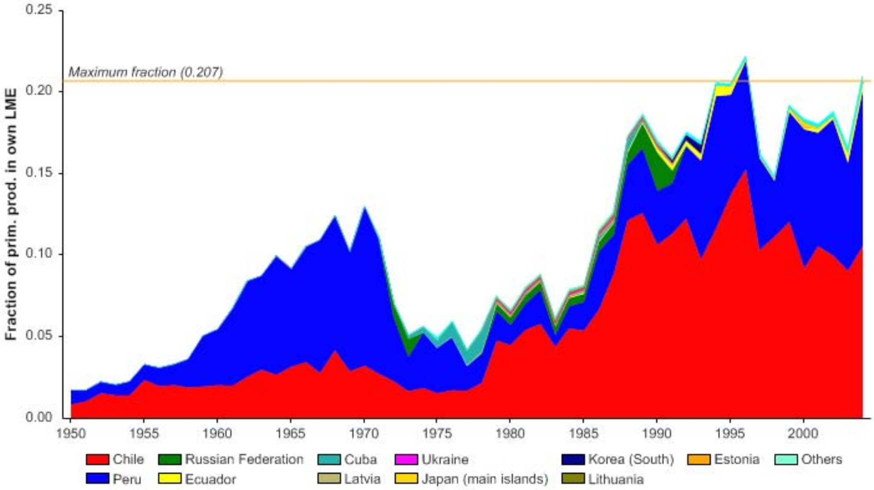

Figure XVII-56.6. Primary production required to support reported landings (i.e., ecological footprint) as fraction of the observed primary production in the Humboldt Current LME (Sea Around Us 2007). The 'Maximum fraction' denotes the mean of the 5 highest values.

The mean trophic level of reported landings (i.e., the MTI, Pauly & Watson 2005) in this system, which in the early 1950s looked like most other LMEs (MTI of about 3.4), plunged as soon as the fisheries for anchoveta, a low-trophic level species, took off (Figure XVII-56.7, top). Indeed, for two decades, this fishery was the largest single-species fishery in the world, with some of its fluctuations in landings reflected in the FiB index (Figure XVII-56.7, bottom). Because of the dominance of anchoveta in the landings of the LME, Figure XVII-56.8 is not informative as to the status of the ecosystem. Note that in the 1940s and 50s, the Peruvian fishery was based on species like Bonito and Tuna (due to the high demand of the liver oil of these species in the US market during the II WW and Korean wars). The Anchoveta fishery started around 1955 and became the most important species during the 1960´s. This explains why the MTL diminishes in such a way during the 50´s and the FIB increases.

Pauly & Palomares (2005) studied a time series of these indices for the Peruvian segment of this LME and found that the fish assemblages exploited by coastal fisheries show strong signs of 'fishing down' (as in Pauly *et al.* 1998). Such trends can also be examined at www.seaaroundus.org, by computing the indices without anchoveta landings.

The Stock-Catch Status Plots indicate that over 80% of commercially exploited stocks in the LME are either overexploited or have collapsed (Figure XVII-56.8 top). The plots also indicate that collapsed stocks contribute over 80% of the reported landings (Figure XVII-56.8, bottom). This is, at least in part, a definitional artefact, because of the classification of anchoveta as an overexploited stock, having experienced its maximum catch in the early 1970s, even though its catches have recovered in recent years. Here again, the analysis may benefit from being conducted without the anchoveta catch (see www.searoundus.org).

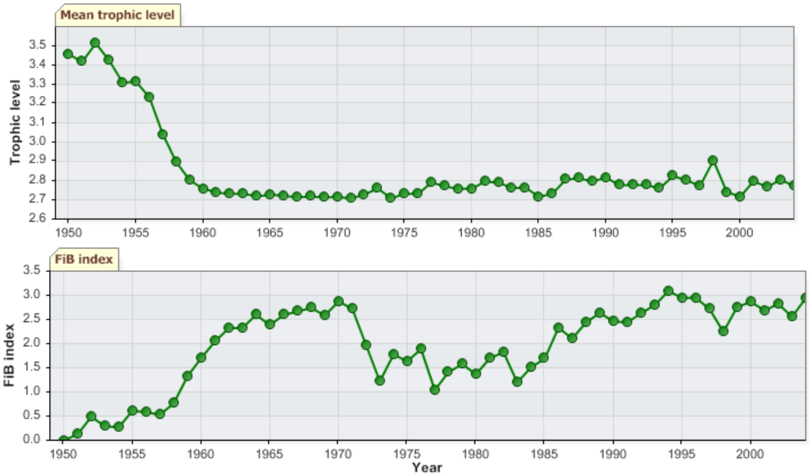

Figure XVII-56.7. Mean trophic level (i.e., Marine Trophic Index) (top) and Fishing-in-Balance Index (bottom) in the Humboldt Current LME (Sea Around Us 2007).

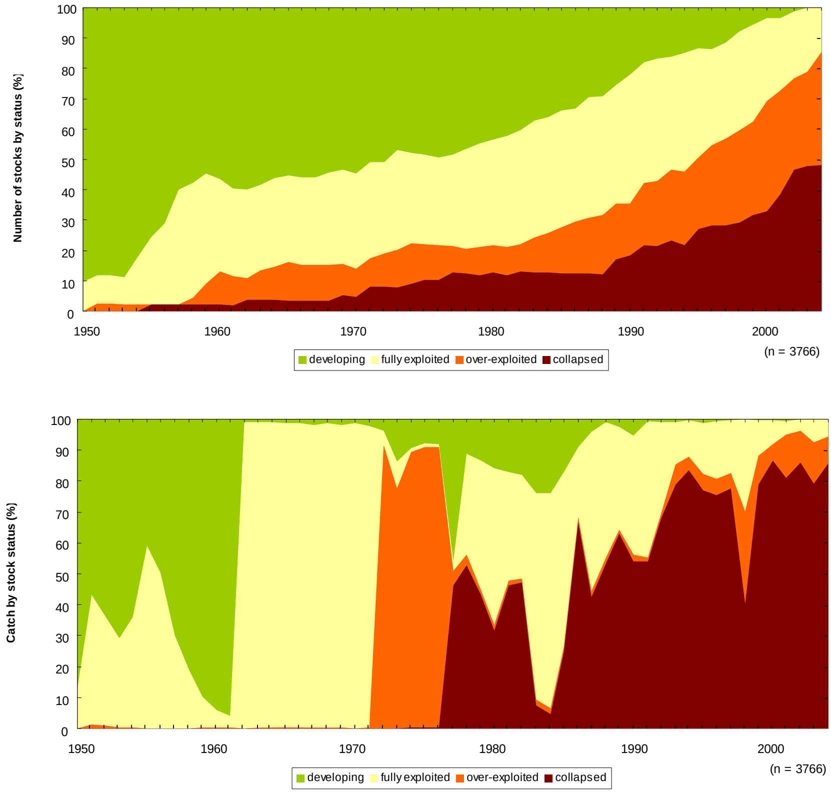

Figure XVII-56.8. Stock-Catch Status Plots for the Humboldt Current LME, showing the proportion of developing (green), fully exploited (yellow), overexploited (orange) and collapsed (purple) fisheries by number of stocks (top) and by catch biomass (bottom) from 1950 to 2004. Note that (n), the number 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).

The marked climate-driven changes in fish biomass and distribution have a drastic impact on their fisheries. Since the early 1950s, the pelagic fishery has experienced dramatic changes in total catch as well as in the catch composition (Wolff *et al*. 2003), notably in the occurrence of anchoveta and sardine. Landings of anchoveta reached the lowest levels after the 1982/1983 El Niño. From the late 1980s, anchoveta landings recovered and remained high through 2004 except for the drop in 1998 because of El Niño (Schwartzlose *et al*. 1999, Alheit & Ñiquen 2004, Bertrand et al. 2004, Gutiérrez et al. 2007, Serra et al. 2002). The jack mackerel has also shown significant population booms and declines (Wolff *et al*. 2003). Schwartzlose et al. (1999) examine El Niño as the signal of inter-annual variation, but there are other sources of inter-decadal variation that should be mentioned in the text. For information on other sources of inter-decadal variation, review the published FAO documents and Chavez *et al.* (2003).

In addition to climatic variability, intense fishing pressure has also contributed to the changes in total catch as well as to changes in catch composition over the past decades. In fact, overexploitation was found to be the main concern in relation to fisheries in the LME (UNEP 2006). A fundamental problem is the enormous overcapacity of vessels and fish processing plants (Csirke & Gumy 1996, Fréon et al. in press). Demersal resources show a variable degree of exploitation. In Peru there are signs that the abundance, mean size caught and size at first maturity of some species have decreased. Since the beginning of the 1990s, young hake have increasingly appeared in catches as a response to overfishing, adverse climatic regime, and changes in species interactions (Wosnitza-Mendo & Guevara-Carrasco 2000, Guevara-Carrasco and Lleonart 2008, Ballón et al. in press). Catches of small hake are far above the 20% rate recommended to sustain the fishery. Furthermore, large, older females have been gradually fished out, resulting in low egg production of the stock (Wolff *et al*. 2003, Ballón et al. in press). Economic overfishing of the hake fishery occurred in 1999 as a result of increase in fishing effort by the national fleet (Wolff *et al*. 2003). The Chilean hake fishery showed a sudden decline in 2004.

An important fishery for the giant squid (*Dosidicus gigas*) occurs along the coast of Peru (Rodhouse 2001). Catches increased from 10,000 tonnes in 1989 to at least 200,000 tonnes in 1994, and have fluctuated in the past decade. Landings during 2002 and 2003 were 100,000 tonnes (Ministerio de la Producción de Perú 2004). The fishery for this species is considered to be under-to-fully exploited. Updated information on the Chile hake and giant squid fishery can be found on www.supesca.cl. Pérez and Buschmann (2003), provide analysis on the sustainability of the major Chilean fisheries; Payá (2003) and Payá et al. (2000, 2002) provide analysis on the Chilean hake fishery.

In general, excessive bycatch and discards appear to be minimal (UNEP 2006). The anchoveta and sardine fisheries have very low bycatch rates (1% - 3%). Sea turtles have been targeted and/or taken as incidental catch during the last three decades. The most common bycatch species in Peru is the common dolphin. Other species caught incidentally include the South American sea lion and marine birds. In Peru significant quantities of discards occurred in the hake fishery (20% of the total catch). Present values are much lower since the implementation of the VMS (vessel monitoring system) and direct onboard observers system in 2004.

In Peru, the decrease of fisheries resources as well as changes in the composition and abundance of species in the coastal areas are attributed to the deterioration of coastal habitats from trawling and the use of purse seine nets with small mesh size. The decreases have other causes including fishing, climate variability and coastal degradation that is largely restricted to enclosed bays and limited coastal areas. There is no specific study on the effects of trawling and pollution on coastal resources. The importance of each one of these sources in the fisheries is a matter of present research.

The use of explosives in both industrial as well as artisanal fisheries is increasing (IMARPE 2002). Substantial changes in the structure of the food web as a result of decades of intensive fishing are evident (Wolff *et al*. 2003). This has had a negative effect on the resilience of the system as a whole. The long term changes observed in the Peruvian ecosystem are also explained by environmental fluctuations. The concept of "Regime Shifts" has been argued to explain these changes and the causes have been documented by Chavez, et al (2003), Schwartzlose et al. (1999), Alheit & Ñiquen (2004), Csirke et al. (1996) and in the Bulletins of IMARPE. Not all the changes in the food web structure can be explained by the impact of the fishing activities.

Overfishing may be a major threat to the genetic integrity of fish populations and ecosystem structure in the LME (Cury & Anneville 1998, UNIDO 2003), leading to further system destabilisation through an increase in the amplitude of annual stock variations (Anderson et al. 2008). In the past, the lack of integrated fisheries management policies incorporating an ecosystem approach and natural environmental variability has had severe impacts on this LME's fisheries resources. The sustainability of the fisheries in the Humboldt Current LME is strongly dependent on the continuing combined efforts of Chile and Peru to achieve scientifically informed, adaptive, governance that takes into account the many driving forces within this important large marine ecosystem. A comprehensive vision of the fisheries of this region was published by FAO in the series: Review of the State of Marine Fishery Resources (FAO Fisheries Technical Paper 457 (2005). Chapter B.15 Southeast Pacific by Jorge Csirke).

III Pollution and Ecosystem Health

Pollution: Pollution of the coastal zone may be increasing due to population growth and concentration in the coastal zone, industrialisation, agriculture, urban development, tourism as well as maritime transport (UNIDO 2003). Most of the pollution problems are related to the lack of adequate treatment of domestic and industrial wastewater, agrochemicals and heavy metals from mining runoff. However, this issue is an important subject on the agenda of the environmental agencies of both countries and present legislation requires industries to treat liquid residuals before discharge to the environment. Pollution is not significant in the LME except for some specific hotspots (UNIDO 2003, UNEP 2006). Microbiological pollution arising from untreated sewage was identified as being a priority concern. In Peru, up to 86% of domestic wastewater is not treated (CPPS 2001) and is discharged into coastal areas (Sánchez 1996).

High levels of nutrients have been found in areas with chronic problems of pollution and continuous discharges such as Callao, Ilo and Ite in Peru and Valparaiso, Concepción, San Vicente, Bio-bio River in Chile (Zúñiga & Burgos 1996). Wastes from fish canneries as well as fishmeal factories are among the most important sources of nutrient enrichment in coastal areas, especially in some locations in the north of Chile and in Chimbote, Paita and Pisco in Peru. High values of chlorophyll *a* and low levels of oxygen with a tendency to hypoxia are typically found off these ports. The increase of organic wastes in semi-closed bays of Peru has produced HABs that have caused the mortality of fish as well as invertebrates (IMARPE[1], unpublished data).

The presence of chemicals such as DDT, DDE, and Lindane was reported in water and sediments along the coast, and in some marine species (e.g., mullet, croaker and molluscs) (Cabello & Sánchez 2003). Regional assessments of heavy metals in coastal waters, sediment and marine organisms showed that significant concentrations of copper, lead, cadmium, zinc, mercury and chromium are related to municipal wastewater discharges and mining runoff (CPPS/UNEP/IOC 1988). Despite the permanent risk of oil

[1] The Peruvian Institute of Marine Research.

spills, levels of hydrocarbons in water are generally low except in localised areas where petroleum activity and maritime traffic are concentrated. In these areas, high concentrations of hydrocarbons have been found in water and sediments (Jacinto & Cabello 1999).

Habitat and community modification Although a large part of the coast is arid, it contains a variety of habitats such as mangroves, estuaries and sand dunes, some of which serve as important breeding as well as nursery areas for many marine species including marine mammals and turtles. These habitats are also of socioeconomic importance to the region, but their economic value is largely unknown and not integrated in coastal development (UNIDO 2003). Habitat modification was assessed as moderate in the LME and generally linked to the development of the coastal zone for infrastructure, urbanisation, tourism, aquaculture farms and industrialisation (UNEP 2006). Pollution is also a major cause of degradation of coastal habitats in localised areas. Fishing gears such as demersal trawls are among the potential causes of physical alteration of bottom habitats in the northern part of the region (UNIDO 2003).

Deforestation of mangroves is probably the most evident case of habitat loss in the region. Several mangrove areas are considered to be under a high level of threat. Peruvian mangroves have been cleared to build shrimp farms and degraded through the extraction of biological resources.

The introduction of alien species for culture purposes or through ballast waters has been of concern (CPPS 2003). Canepa *et al*. (1998) reported 14 introduced species (11 microalgae, three fish and molluscs) in the coastal environment in Peru. In Chile, Báez *et al*. (1998) reported 43 alien species in the marine environment, including algae, molluscs, crustaceans and several species of fish.

The health of this LME is expected to improve with the implementation of measures to reduce the impact of human activities and other ongoing initiatives in the region (UNEP 2006).

IV. Socioeconomic Conditions

The population of the two bordering countries, Chile and Peru, is 17 and 28 million respectively. There is increasing development and urbanisation along the coast, with almost 60% of the population of Peru's and 19% of Chile's population living in coastal areas (CPPS 2001). The economy of the two countries is mainly based on agriculture, fisheries, coastal industries, oil-related industry, ports and ocean transport (CPPS 2001). Coastal tourism is becoming increasingly important, whereas aquaculture is one of the most dynamic and important sectors of the Chilean economy (FAO 2000a).

Fisheries are of major socioeconomic importance to the two countries. In 2001, fish exports from Peru represented 16% of the total, with a value of over US$1 billion and contributing 0.49% of the GNP. Chile's fish exports (including salmon and fishmeal) in 2001 were valued at about US$1 billion or 5.5% of the total exports and contributed 1.4% to the GNP. Artisanal fisheries production makes an important contribution to the regional economy. The fisheries sector provides employment for thousands of persons in both countries. It is estimated that in 1999 more than 80,000 people worked in fishing and aquaculture (FAO 2000b).

The economic impacts of overexploitation of fish are severe (UNEP 2006). The variability in stock abundance and distribution as a consequence of environmental changes as well as high fishing pressure has had devastating consequences for the fishing industry and the economies of the two countries. For example, several hundreds of millions of US dollars in foreign currency were lost as a result of the collapse of anchovy stocks following the strong ENSO of 1972/1973 (Wolff *et al*. 2003). A TDA conducted by Chile and Peru with funding from GEF (UNIDO 2003) has identified several socioeconomic consequences of overexploitation of fisheries resources in the Humboldt Current LME. These include loss of access to potential markets, loss of investments, increase in conflicts between industrial and artisanal sectors, reduction in employment and food security, migration and occupational displacement. Overexploitation of fisheries resources will also have negative consequences on food security as well as on the eradication of poverty and hunger in the region.

The socioeconomic impacts of pollution are low but are of growing concern in the region because of its potential impact on the quality of life (UNEP 2006). Untreated domestic wastewater discharged into coastal waters poses a major health risk through direct contact.

Unsanitary conditions, as well as poverty and the eating habits of the population were associated with the 1991 cholera outbreak in some coastal areas. In addition to the risk to human health, pathogens also affect aquaculture in the region due to the reduction in quality water, e.g. in Peru the presence of the hepatitis. Other socio-economic consequences of pollution include loss of investments and employment opportunities, diminished fisheries productivity and reduced market competitiveness (UNIDO 2003).

Mangrove loss has a significant impact on the artisanal fishery, through loss of shelter and nursery areas for commercially important fish and invertebrates. Shrimp aquaculture is also affected by reduced water quality, due to the loss of the natural purification functions of coastal habitats, increase of coastal erosion as well as loss of nursery areas for shrimps. The Environmental Performance Review of Chile conducted jointly by the OECD and UN ECLAC recommended in 2005 that Chile continue to strengthen its environmental institutions to improve air, water, waste and nature management at national and regional levels, and especially in metropolitan areas. The estimated cost to replace the loss of the natural treatment ability of coastal ecotones may be comparable with that in Ecuador of one billion US$ (Hurtado *et al*. 2000).

V. Governance

Chile and Peru share the governance of the Humboldt Current LME. Each country has institutions (e.g., the Sub-Secretary of Fisheries and the Vice Ministry of Fisheries, respectively) mandated with management of its marine and coastal resources, national laws, and a national institute responsible for fisheries research: the Fisheries Research and Development Institute (IFOP) in Chile and the Marine Research Institute (IMARPE) in Peru. Both Chile and Peru have established a national environmental authority responsible for environmental conservation and natural resource management – the National Environment Commission (CONAMA) and the National Council for the Environment (CONAM), respectively. In May 2008 Peru merged the CONAM and the recently created Ministry of the Environment.

Regional frameworks for the management, including monitoring, of the LME and its resources, have been developed. Chile and Peru, along with Colombia and Ecuador, are members of the Permanent Commission for the South Pacific (CPPS 2003a; 2003b), the regional maritime organisation responsible for the coordination of the maritime policies of its Member States. The Framework Agreement for the Conservation of Living Marine Resources in the High Seas of the Southeast Pacific (Galapagos Agreement) and the Convention for the Protection of the Marine Environment and Coastal Areas of the South-East Pacific (Lima Convention) as well as other complementary agreements are the basis for a fruitful regional cooperation among Chile, Peru and other countries for the conservation of the marine environment.

The Lima Convention and its protocols provide the general legal framework of the Plan of Action for the Protection of the Marine Environment and Coastal Areas of the South-East

Pacific, which comes under the South-East Pacific Regional Sea Programme. The Plan of Action binds the contracting parties to make an effort to adopt the appropriate measures to prevent, reduce and control the pollution of the marine environment and coastal areas as well as secure adequate management of the natural resources in the South East Pacific.

Other programmes include the Tropical Ocean-Global Atmosphere, the World Ocean Circulation Experiment, the Joint Global Ocean Flux Study, the Global Ocean Ecosystem Dynamics Programme on Small Pelagics and Climate Change and an EU-sponsored project (Climate variability and El Niño Southern Oscillation: Implications for natural coastal resources and management). The GEF is supporting a project (Integrated Management of the Humboldt Current Large Marine Ecosystem) to enhance national as well as regional efforts to achieve integrated and sustainable management of the LME. The first phase of the project included the development of a TDA and a preliminary SAP to address both the threats to the LME and the gaps in knowledge essential to the sustainable management of the ecosystem. Under this project, an interim coordinating executive committee was established to implement agreements under the Bilateral Humboldt Current Compact.

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