XVI-55 Patagonian Shelf: LME #14

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The Patagonian Shelf LME extends along the southern Atlantic coast of South America from the Río de la Plata (La Plata River) to southern Patagonia and Tierra del Fuego, covering an area of about 1.2 million km^2, of which 0.18% is protected (Sea Around Us 2007). The continental shelf is one of the widest in the world, and encompasses the Falkland Islands/Malvinas some 760 km east of the mainland. Two major wind-driven currents influence the LME: the cold, northward flowing Falkland/Malvinas Current and the warm, southward flowing Brazil Current (Bakun 1993). The Falkland/Malvinas Current provides the LME with a distinctive ecological boundary to the east. This LME is also influenced by low salinity coastal waters (principally outflow of the Río de la Plata) and upwelling of cold Antarctic waters caused by the prevailing westerly winds. Major estuaries include the Rio de la Plata, Rio Colorado, Rio Negro and Chubut. LME chapters and reports pertaining to this LME include Bakun (1993), Bisbal (1995) and UNEP (2004).

I. Productivity

The Patagonian Shelf LME is one of the world's most productive and complex marine systems, and is a Class II, moderately productive ecosystem (150-300 gCm^{-2}yr^{-1}). Extensive mixing of the Falkland/Malvinas Current and the Brazil Current in the La Plata region results in a highly productive confluence zone. This mixing has biological, physical, and meteorological consequences that impact the entire LME. The outflow from the Río de la Plata, the second largest drainage basin (3.2 million km^2) in South America, also contributes to the high biological productivity on the continental shelf and slope. The waters of the sub-tropical Brazil Current show lower productivity. Phytoplankton species are dominated by dinoflagellates, coccolithophorids, and cyanophyceans, with few diatoms. The zooplankton community shows a high abundance of calanoid copepods, chaetognaths, salps and hydromedusa.

Biological diversity is rich, with species from warm, temperate and cold waters. Some endemic species such as the migratory Plata dolphin (*Pontoporia blainvillei*) are also found in this region. The coastal area has favourable reproductive habitats for small, pelagic-spawning clupeoids (Bakun & Parrish 1991). Some species (e.g., tuna and marine mammals) are migratory and are of outstanding global ecological, economic, and social importance. The LME supports significant seabird and marine mammal populations as well as fish and invertebrates (Bakun 1993, DRIyA 2001), and is particularly rich in fisheries resources.

Oceanic Fronts (Belkin et al. 2009) (Figure XVI-55.1): Three year-round fronts are distinguished over the Patagonian Shelf: Valdes Front (VF) at 42°S, San Jorge Front (SJF) at 46°S, and Bahia Grande Front (BGF) at 51°S. The origin of VF and SJF might be related to intense tidal mixing (Glorioso 1987, Glorioso and Flather 1995, 1997). Two seasonal fronts are the Bahia Blanca Front (39°S) and Magellan Front (MF), the latter consisting in fall (April-June) of two branches, the Patagonian-Magellan Front and Tierra del Fuego Front. The origin of MF and its branches is related to the influx of cold, fresh Pacific water via the Strait of Magellan. The offshore boundary of this LME coincides with the Falkland (Malvinas) Front/current that extends along the Patagonian shelf break and upper continental slope of the Argentinean Sea.

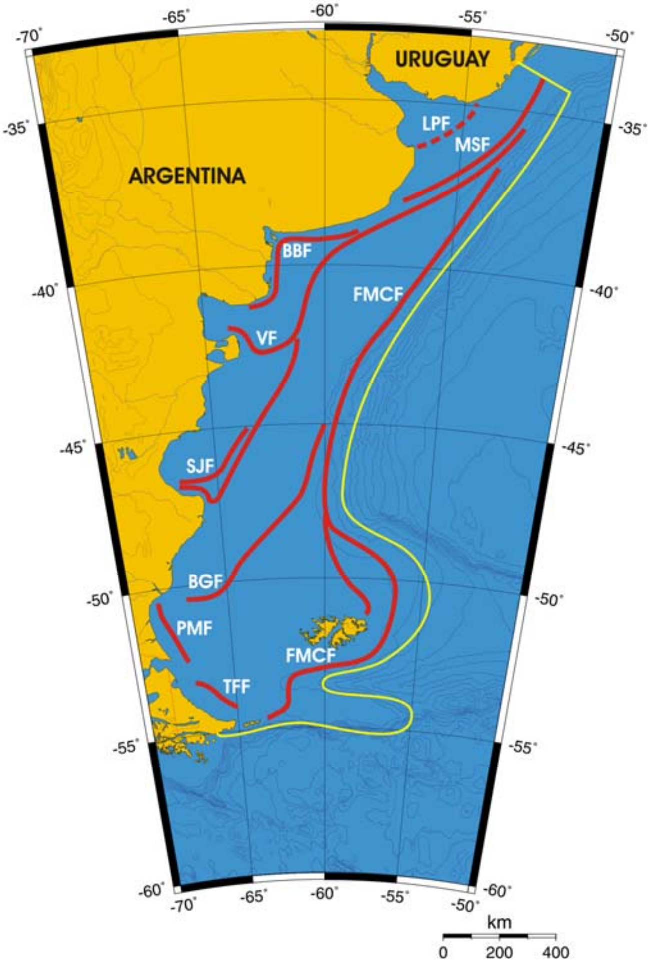


Figure XVI-55.1. Fronts of the Patagonian Shelf LME. BBF, Bahia Blanca Front; BGF, Bahia Grande Front; FMCF, Falkland/Malvinas Current Front; LPF, La Plata Front; MSF, Mid-Shelf Front; PMF, Patagonian-Magellan Front; SJF, San Jorge Front; TFF, Tierra del Fuego Front; VF, Valdes Front. After Belkin et al. (2009).

Patagonian Shelf LME SST (Belkin, 2009) (Figure XVI-55.2):
Linear SST trend since 1957: 0.15°C.
Linear SST trend since 1982: 0.08°C.

The Patagonian Shelf experienced a very gradual, steady warming over the last 50 years. The most dramatic event occurred in 1961-62, when SST rose from the all-time minimum of 10.3°C to the all-time maximum of >11.3°C. The most likely cause of the observed stability of the Patagonian Shelf is the constant influx of sub-Antarctic waters with the Falkland/Malvinas Current (see the Falkland/Malvinas Current Front, FMCF, associated with the namesake current. These waters in turn are stabilized by the Antarctic Circumpolar Current. Another possible cause of the Patagonian Shelf thermal stability is an extremely rich and well-defined frontal pattern; this pattern persists, albeit constantly evolving, year-round. Many fronts are tidal mixing fronts separating vertically mixed areas from vertically stratified areas. Naturally, SST in tidally mixed areas is more stable than elsewhere.

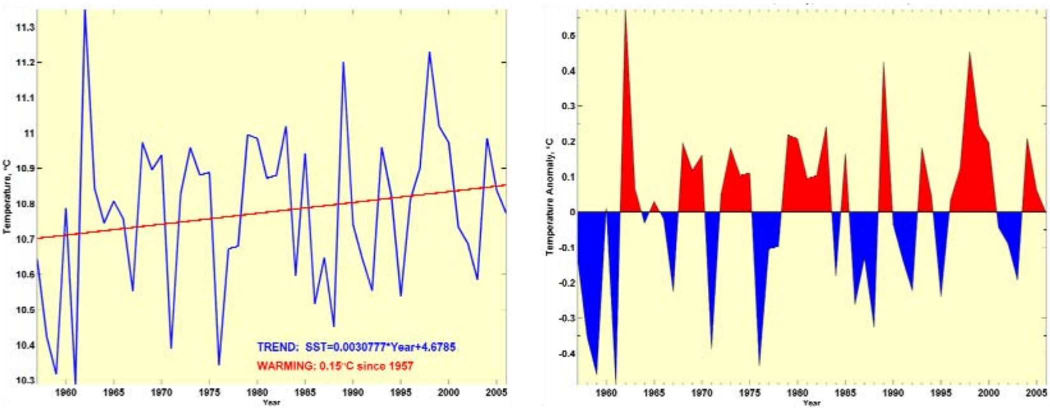


Figure XVI-55.2. Patagonian Shelf LME annual mean SST (left) and SST anomaly (right), 1957-2006, based on Hadley climatology. After Belkin (2009).

Patagonian Shelf LME Chlorophyll and Primary Productivity

This LME is a Class I, moderately productive ecosystem (150-300 $gCm^{-2}yr^{-1}$) (Figure XVI-55.3).

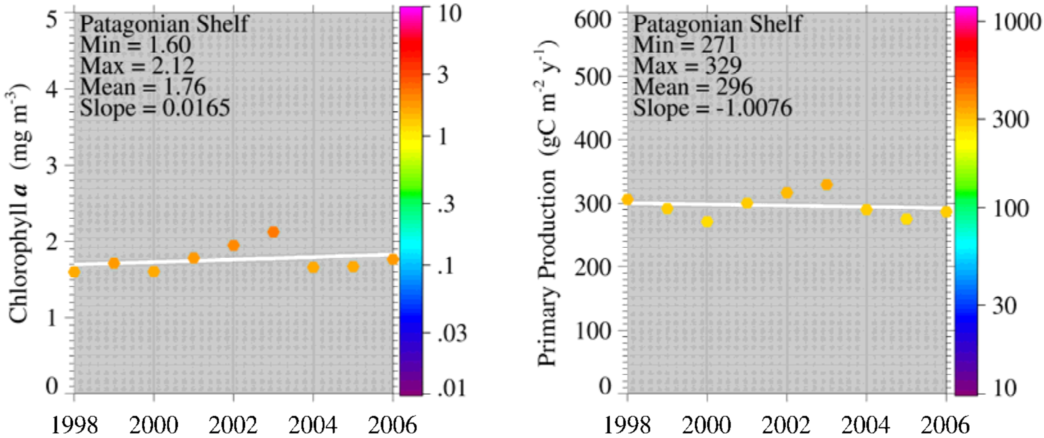


Figure XVI-55.3. Patagonian Shelf LME trends in chlorophyll *a* (left) and primary productivity (right), 1998-2006, from satellite ocean colour imagery. Values are colour coded to the right hand ordinate. Figure courtesy of J. O'Reilly and K. Hyde. Sources discussed p. 15 this volume

II. Fish and Fisheries

Fisheries in the Patagonian Shelf LME have undergone accelerated growth in the last decades involving mostly Argentine hake (*Merluccius hubbsi*), Argentine shortfin squid (*Illex argentinus*), southern blue whiting (*Micromesistius australis*), Patagonian grenadier (*Macruronus magellanicus*), and prawns (*Pleoticus muelleri*). Total reported landings have increased over the past three decades, recording 1.5 million tonnes in 1997 with Argentine hake and shortfin squid accounting for the majority share (Figure XVI-55.4). The landings have since declined to 970,000 tonnes in 2004 (Figure XVI-55.2). The value of the reported landings has been over US$1 billion (in 2000 real US dollars) since the mid-1980s with a peak of US$1.6 billion recorded in 1987 (Figure XVI-55.5). However, the value has been declining in recent years.

The Secretariat of Agriculture, Livestock, Fisheries, and Food (SAGP&A) reports landings of hake by the Argentinian fleet for the 2008 January through 4 September 2008 at 180,051.1 tonnes of common hake landed in Argentine ports, down 6% from the same period the previous year. (SAGP&A). The Joint Technical Commission for the Argentine-Uruguay Maritime Front (CTMFM) has banned *Merluccius hubbsi* fishing in the Common Fishing Area from 6 October through 31 December, 2008, to protect juvenile hake concentrations and "encourage rational exploitation of the resource" (www.fis.com/fis/worldnews, Tuesday, 7 October 2008).

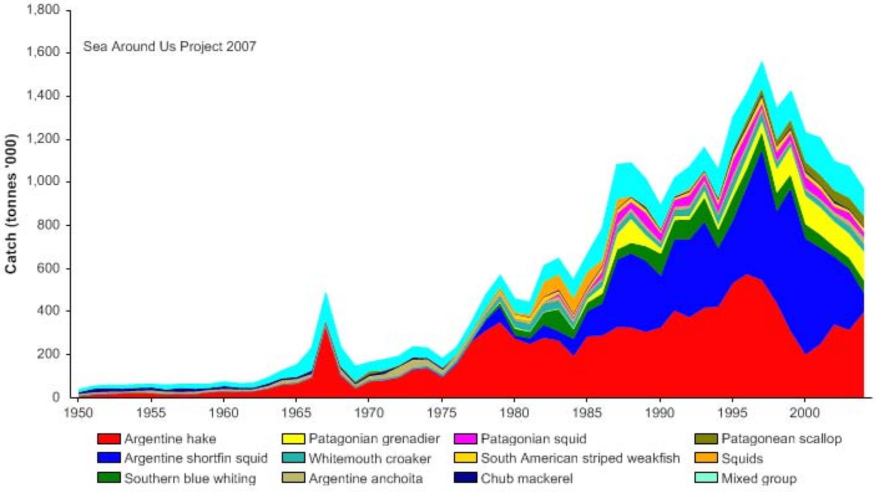


Figure XVI-55.4. Total reported landings in the Patagonian Shelf LME by species (Sea Around Us 2007).

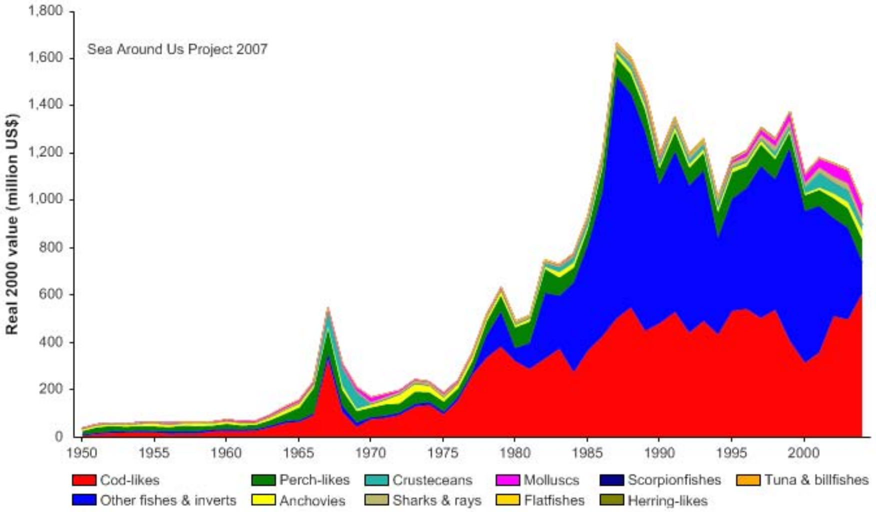


Figure XVI-55.5. Value of reported landings in the Patagonian Shelf LME by commercial groups (Sea Around Us 2007).

The primary production required (PPR; Pauly & Christensen 1995) to sustain the reported landings in this LME reached 25% of the observed primary production in the mid-1990s, but has declined to 20% in recent years (Figure XVI-55.6). Argentina accounts for the largest share of the ecological footprint in this LME (Figure XVI-55.6).

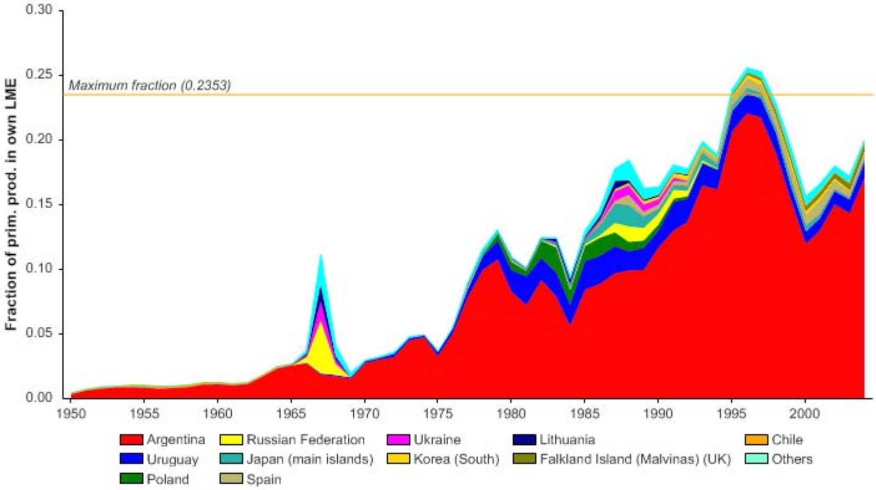


Figure XVI-55.6. Primary production required to support reported landings (i.e., ecological footprint) as fraction of the observed primary production in the Patagonian Shelf LME (Sea Around Us 2007). The 'Maximum fraction' denotes the mean of the 5 highest values.

The mean trophic level of the reported landings (i.e., the MTI; Pauly & Watson 2005) shows a decline since the late 1970s (Figure XVI-55.7, top), an indication of a 'fishing down' of the food web in the LME (Pauly *et al*. 1998). Over the same period, the FiB index has remained flat (Figure XVI-55.7, bottom), implying that the increasing reported landings in Figure XVI-55.4 were due not only to ecological compensation, but also to a geographic expansion of the fishery. These compensatory mechanisms worked until the mid-1990s, at which points the number of overexploited and collapsed stocks increased (see Figures XVI-55.8, top and XVI-55.8, bottom).

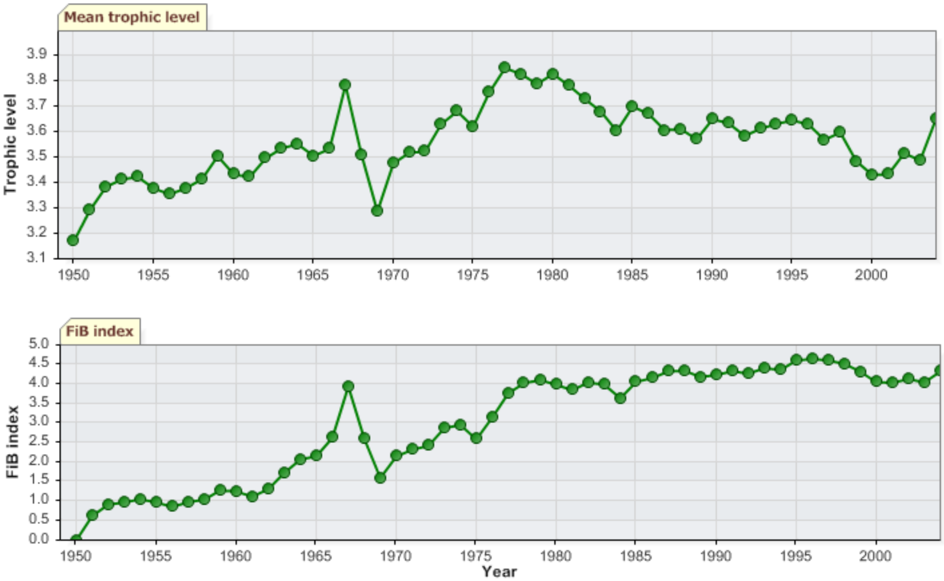
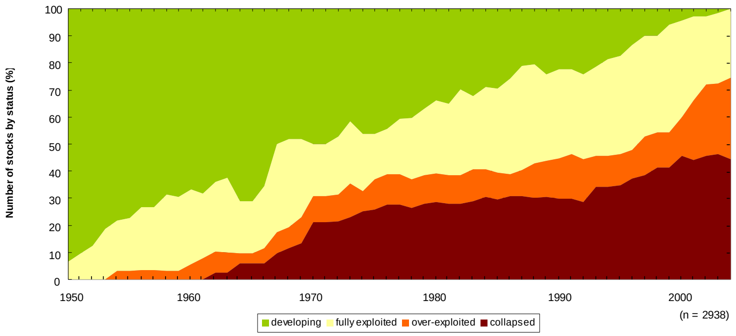


Figure XVI-55.7. Mean trophic level (i.e., Marine Trophic Index) (top) and Fishing-in-Balance Index (bottom) in the Patagonian Shelf LME (Sea Around Us 2007).

The Stock-Catch Status Plots shows that over 70% of commercially exploited stocks in the LME are either overexploited or have collapsed (Figure XVI-55.8, top), with 70% of the reported landings supplied by overexploited stocks (Figure XVI-55.8, top). However, the transition from fully exploited to overexploited stocks in the early 2000s was rather abrupt.



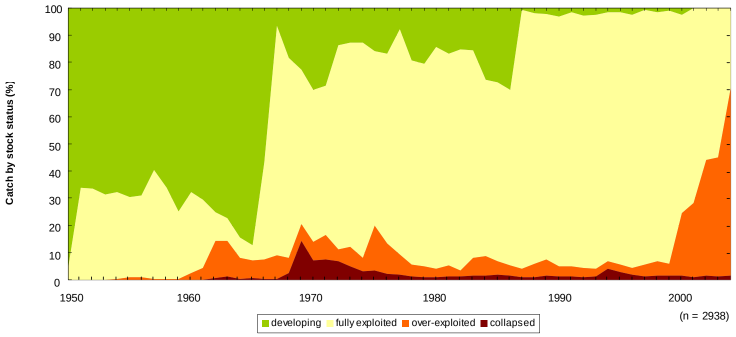


Figure XVI-55.8. Stock-Catch Status Plots for the Patagonian Shelf LME, showing the proportion of developing (green), fully exploited (yellow), overexploited (orange) and collapsed (purple) fisheries by number of stocks (top) and by catch biomass (bottom) from 1950 to 2004. Note that (n), the number 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).

Despite the low exploitation levels of some species (e.g., Atlantic anchovy and southern blue whiting), intensive exploitation of other species by Argentina and Uruguay has resulted in moderate to severe overexploitation in the LME (UNEP 2004). This is particularly serious in the Buenos Aires coastal system and Common Argentine-Uruguayan Fishing Zone. Overexploitation of hake in the Mar del Plata area became evident in 1997, with increased fishing effort (Bertolotti *et al*. 2001) and catching of large quantities of juvenile and spawning fish (DRIyA 2001). Between 1988 and 1999, the proportion of hake in the total landings fell from 62 to 31% (DRIyA 2001). Subsequently, catch limits and other controls were implemented to allow recovery of the stocks. In 2000, the hake reproductive stock south of 41ºS was the lowest since 1986 (Pérez 2001). Total biomass of the northern and southern hake stocks decreased, reproductive biomass was lower than the biologically acceptable level, and the fishery was sustained by a few year classes (Aubone 2000, Pérez 2000). This led to the collapse of the hake stocks, which may have caused important changes in productivity and community structure as shown by a decrease in trophic levels of the catch and an increase in anchoita stocks between 1993 and 1996 (DRIyA 2001).

A number of other fish and invertebrate species are also overfished. The squid fishery was established in the 1980s, with catches by both Argentina and Uruguay off the Río de la Plata. In 1987, there were indications that squid stocks were being maximally exploited and probably overfished (Csirke 1987). However, this fishery has been highly variable in subsequent years and this has probably been driven by environmental variability. Most species of bony fish targeted in the multi-species coastal fishery show a decreasing trend in biomass. The estimated population of the southern blue whiting (*Micromesistius australis*) was found to be about 77% lower than previous levels, and its exploitation rate relatively high (Wöhler *et al*. 2001). Biomass of mackerel (*Scomber japonicus*), corvina (*Micropogonias furnieri*) and shore ray species have decreased since 1996. The cod (*Genypterus blacodes*) stock is near its maximum sustainable limit of exploitation (Cordo 2001, Perrota & Garciarena 2001).

The use of non-selective fishing gear results in the capture of large quantities of bycatch and discards (DRIyA 2001). Bycatch rates of the freezer and factory fleet vary between 9.9-24.3%, and 2.3-7.2% respectively (Cañete *et al*. 1999). The high seas fleet discards about 25%-30% of its catch, while the coastal fleet discards about 25% (Caille & González 1998). From 1990-1996, between 20 and 75 thousand tonnes per year of young hake (under two years old) that represented between 80 and 300 thousand tonnes of adult fish were caught as bycatch. The cod fishery has been declining since 1999 because of high levels of bycatch of this species in the hake fishery (Cordo 2001). Trawl fishing also affects mammals such as sea lions and dolphins, as well as penguins, albatross, petrels, and seagulls. Incidental capture of macrobenthic organisms is also a common occurrence in the San Jorge Gulf and Chubut coastal areas (Roux 2000). Some species historically discarded in Argentina, such as *Myliobatis* spp., are possibly ‘keystone species’ (Power *et al*. 1996).

III. Pollution and Ecosystem Health

***Pollution*:** The coastal areas of the Patagonian Shelf LME face accelerating development pressures. Although pollution is generally slight, its occurrence in several localised areas is cause for concern (UNEP 2004). The effects of pollutants from land-based sources are exacerbated in large river basins such as the La Plata, which contains important urban centres as well as agricultural and industrial activities. The Rio De La Plata and coastal areas are sinks for substantial urban, agricultural and industrial wastes. Pollution of the water and sediments of the Rio De La Plata and its maritime front from land-based and aquatic activities is a key transboundary issue. Some pollution problems arise from the coastal cities of Buenos Aires and Montevideo, which are densely populated and have a high concentration of economic and industrial activities.

Raw sewage is commonly discharged into coastal areas mainly in the vicinity of cities due to the general lack of sewage treatment facilities. This has led to serious microbial pollution in some localised areas. Pathogens, which in some cases have exceeded international recommended levels for recreational water, have been detected in coastal areas (Fundación Patagonia Natural 1999). Toxic red tides are becoming more frequent and of longer duration in the outer La Plata River and maritime front.

The Patagonian coastal zone experiences slight to moderate toxic chemical pollution. For example, lead, zinc and copper concentrations in sediments were registered in San Antonio Bay and in San Matías Gulf. Cadmium was also found in these two localities, affecting local flora and fauna, and threatening migratory birds. High cadmium concentrations were detected in the kidneys and livers of Commerson’s dolphins and dusky dolphins, and in kidneys of kelp gulls. Persistent organic pollutant (such as pp'-DDE) was detected in penguins and kelp gulls. Significant halogenated residues have been found in dead new-born cubs of sea lions, suggesting maternal transmission (Fundación Patagonia Natural 1999).

A sharp increase in turbidity has been observed in localised marine areas due to mining and alteration of the natural vegetation cover of extensive sedimentary areas in Southern Patagonia. About 30% of the Patagonia region is experiencing desertification, basically caused by overgrazing by sheep and cattle (SAyDS 2003). This has increased water runoff and soil losses and in many cases, has resulted in an increase in suspended solids, which cause moderate pollution in coastal areas. Pollution from solid wastes is concentrated mainly in urban areas near the coast where disposal of solid wastes in open dump sites is common.

The LME is subject to heavy shipping and oil tanker traffic. Chronic oil pollution is a problem in the vicinity of ports and oil terminals that have become pollution 'hot spots'. Ecologically sensitive areas are potentially at risk when winds and marine currents transport these persistent pollutants beyond the port facilities. Beaches are often affected by the presence of tarballs and marine birds are frequently covered with oil. Occasional major oil spills occur in the Patagonian Shelf LME, with significant impact at local levels. Petrogenic hydrocarbons in sediments show the highest concentrations in oil shipping locations where oil and ballasts washing are discharged.

Habitat and community modification: The Patagonian Shelf LME coastal areas have been under pressure from population and industrial growth over the last 15 years, with attendant habitat degradation, fragmentation and loss (Gray 1997). Although this occurs in localised areas, some impacts, for example on migratory species, may be transboundary. Overall, habitat and community modification is moderate, but is expected to worsen in the future (UNEP 2004). Physical alteration and destruction of habitats in the coastal areas occur mainly through mining, dredging, port activities, urban and coastal development, tourism, and destructive fishing methods (DRIyA 2001). Urban and industrial pollution also contribute to this problem. The operation of harbours and oil shipping facilities in some areas along the shore results in localised pollution 'hot spots' that harm coastal habitats and associated communities.

Sediments from the continuous dredging of the La Plata River alter marine benthic communities and re-suspend sediments and pollutants. Human-induced erosion is another cause of habitat modification. Most beaches of Buenos Aires have suffered significant erosion and consequent altered coastline. For instance, in Mar Chiquita beach, the rate of the beach retreat reaches 5 m/year in some localities (Bonamy *et al*. 2002). Coastal erosion has also degraded sand dunes, salt marshes and coastal lagoons. In spite of the severe erosion problems that affect the coastline, sand extraction for construction purposes continues.

There is evidence of fragmentation of sandy foreshores, the littoral belt system, and coastal fringes, mainly in the province of Buenos Aires. The La Plata estuary is a highly impacted system because of land use practices in the drainage basin. Modification of the structure of coastal communities and mortality of fauna, mainly on the Buenos Aires coast, has been attributed to habitat degradation. Biodiversity is seriously endangered (Fundación Patagonia Natural 1999); this situation is aggravated by the accidental introduction of exotic species, such as brown alga (*Undaria pinnatifida*), Asian clam (*Corbicula fluminea*) and acorn barnacle (*Balanus glandula*), in some areas. The brown alga, introduced in ballast water, has quickly spread in the Nuevo Gulf area (Casas & Piriz 1996). The persistence of brown alga in this LME is thought to be a consequence of sewage, oil spills and wastes discharged from ships (Fundación Patagonia Natural 1999). Other species such as brown trout, rainbow trout (*O. mykiss*), pacific oyster (*Crassostrea* *gigas*), Chilean oyster (*Tiostrea chilensis*), Chinook salmon (*Onchorhynchus tshawystcha*) and beavers were intentionally introduced.

In the long-term, a slight improvement is expected due to governmental action, the influence of environmental NGOs, enhanced community awareness and commitment and increased self-regulation of industry. However, improvements in pollution control will require major investments by the private and public sectors.

IV. Socioeconomic Conditions

This LME includes the entire coastlines of Argentina and Uruguay. The combined population of the coastal cities of Montevideo and Buenos Aires is close to 16 million inhabitants. Both countries have a high urbanisation rate, with the urban population significantly exceeding the rural population. Fisheries contribute less than 1% to the GDP of these countries. Other marine-related economic activities include tourism and offshore oil exploration. The overall socioeconomic impact of unsustainable exploitation of fisheries in the Patagonian Shelf LME is moderate, and could become worse in the future if regulations are not implemented and enforced (UNEP 2004). In particular, overfishing of hake has resulted in severe social problems, loss of employment, and the closure of fishing enterprises. Since 1997, employment has decreased by about 22%, while more recently it decreased by about 13% in the Patagonian region (Bertolotti *et al*. 2001). Between 1999 and 2000, employment by the high seas fleet decreased by about 9%. Likewise, in the same period, employment by the freezer and factory fleets decreased by up to 14% (Bertolotti *et al*. 2001). Argentine fish exports decreased in 2002, mainly due to international and national market conditions, but also to reduced hake landings, which led to the closure of many fish plants (Bertolotti *et al*. 2001). Of the 38 established plants only 26 were operative in 2001. Since 1998 there has been an ongoing trend towards poorer working conditions and lower incomes. The likelihood of conflicts among different sectors also increases as a result of overfishing.

Toxic algal blooms have a negative economic impact on the private sector engaged in fisheries exploitation and seafood production, when harvests and sales are prohibited due to toxic algal blooms. Algal blooms and oil spills demand major economic investment in contingency measures. Toxic algal blooms together with shellfish toxicity have serious consequences for public health, and have caused some deaths in the Patagonian Shelf LME region. Habitat and community modification have significant economic and social impacts on coastal populations, particularly those related to fisheries exploitation. Generally, the impacts on local communities are quite harsh. Economic losses and elevated costs associated with this issue affect both the State and private sectors comprised mainly of small enterprises, cooperatives, and individuals, who are most vulnerable. Damage to urban infrastructure and disruption of coastal activities by coastal erosion has strongly affected tourism revenues and promoted conflicts among different users (tourism, aquaculture, and fishing). Many affected municipalities are now executing projects to address problems created by coastal degradation.

V. Governance

Argentina and Uruguay have national and local environmental authorities and have developed national policies and programmes aimed at the protection and management of the natural environment. The two countries are in the process of strengthening the regulatory capacity of their national environmental authorities with support from the Inter-American Development Bank. The environmental action plans of Argentina and Uruguay have set as goals the conservation and rehabilitation of the coastal habitats of the Rio de la Plata and Atlantic Ocean and strengthening the management of common resources and boundary areas.

An area held in common by both Argentina and Uruguay is the Rio de la Plata and its maritime front. The Treaty of the Río de la Plata and its Maritime Front, signed in 1973 by both countries, established the legal framework for the bi-national management of this area. This framework includes two bi-national governmental Commissions responsible for the preservation, conservation and rational use of living resources and the prevention and elimination of pollution. The Argentine-Uruguayan Technical Commission for the Rio de la Plata Maritime Front has jointly managed the shared hake stock since 1975.

The Patagonian Shelf LME, along with the East and South Brazil Shelf LMEs, forms the Upper South-West Atlantic Regional Sea Area. In 1998, in cooperation with the UNEP/GPA Coordination Office and the UNEP Regional Office for Latin America and the Caribbean, a Regional Programme of Action on Land-based Activities and a regional assessment for the Upper South-West Atlantic were prepared and endorsed by representatives of the three governments. The first steps in implementing the programme, which covers the coast from Cape São Tomé in Brazil to the Valdés Peninsula in Argentina, are under development. The Argentine Federal Fisheries Council (CFP) has requested that the National Fisheries Research and Development Institute (INIDEP) implement a mechanism that provides updated scientific information on the status of the resource [www.cfp.gov.ar/funciones_ing.htm].

Argentina and Uruguay have embarked on a joint project supported by GEF and implemented by UNDP: 'Environmental protection of the Rio de la Plata and its Maritime Front: Pollution Prevention and Control and Habitat Restoration'. The project will contribute to the mitigation of current and emergent transboundary threats to the water body by assisting Argentina and Uruguay to prepare a Strategic Action Plan (SAP) as a framework for addressing the most imminent transboundary issues. Preparation of the SAP would be preceded by finalisation of a TDA, building on assessments already completed by prioritising issues, filling data gaps, and performing an in-depth systems analysis of cause/effect variables, including socioeconomic and ecological factors.

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