XIII-40 Iberian Coastal: LME #25

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The Iberian Coastal LME is a continental shelf region of the Eastern Atlantic Ocean lying between approximately 36° N (Gulf of Cadiz) and 44° N (Cantabrian Sea), and bordered by Spain and Portugal. A temperate climate characterises this western boundary current ecosystem. The continental shelf in this region varies from 12 to 50 km, being the narrowest in the Northeast Atlantic margin. The LME has an area of about 300,000 km^2, of which 0.45% is protected, and contains about 0.07% of the world's sea mounts (Sea Around Us 2007). One of the main geomorphological features of the Iberian Coastal LME is a series of extremely steep and deep marine canyons. The coast of Asturias has the canyons of Avilés, Lastres and Llanes; these are so abrupt that in only 7 km from the coastline the depth reaches 4500 m, making these features the steepest and deepest near-shore canyons in the world. It seems that these canyons are the refuges of giant squids (*Architeuthis dux* and *Taningia danae*) which are found here quite often (usually in October) dead on the beaches. Off Portugal there is a remarkable canyon Nazaré. Other interesting features in this LME are the seamounts or relic shelves offshore, such as the Bank of Galicia and the Bank of Le Danois (known in Spain as El Cachucho), which has been recently protected as an AMP in the Northern Spain. The Iberian seaboard has a highly convoluted coastline indented with drowned river valleys called *ria*. Book chapters and articles pertaining to this LME include Wyatt & Perez-Gandaras (1989) and Wyatt & Porteiro (2002). This LME together with the Bay of Biscay is included in OSPAR as Region 4. This is the same regionalization that the EU has done in the recently published Directive on Marine Strategy (25/06/08). ICES is supporting a Working Group named WGRED which had done quite extensive regional descriptions, including Iberian shelf. The report of last year can be found at: www.ices.dk/iceswork/wg detailacfm.asp?wg=WGRED. Additional general information on this region can be found in Valdés and Lavín (2002) and Lavín et al. (2006).

I. Productivity

Productivity and resource abundance in the Iberian Coastal LME are driven by climate and upwelling, with intensive fishing being the secondary driving force. The importance of climate is suggested by the link between sardine catches and Ekman drift, and by the link between anchovy catches in this LME and biological changes in the Western English Channel (see Wyatt & Perez-Gandaras 1989). The coastal upwelling is the most important feature in terms of natural variability in the entire LME. Upwelling takes place in late spring and summer along the coast of Portugal, Western Galicia up to the Cape Peñas in the North Spanish coast (mid-Cantabrian Sea). For more on changes in oceanographic conditions in this LME, see Wyatt & Porteiro (2002).

The Iberian Coastal LME is considered a Class II, moderately productive ecosystem (150-300 gCm^{-2}yr^{-1}). Margalef (1956) identified marked changes in the phytoplankton composition of Galician waters during the 1950s sardine crisis. The LME is characterised by favorable conditions for the production of clupeoids and other small pelagic fishes. For biomass changes in sardine, see Wyatt & Perez-Gandaras (1989). Changes in the upwelling regime affected the sardine stock. There were changes in the phytoplankton composition and in the patterns of water exchange between the rias and the open sea. Major changes in sardine abundance were accompanied by equally radical changes in other trophic levels. Good sardine productivity is linked with the presence of the diatom *Melosira (Paralia) sulcata*, and poor productivity with *Thalassiosira rotula* invasions. There are marked changes in the abundance of certain dinoflagellate species. See the ocean triads model for an explanation of upwelling, concentration of larval food brought about by convergences, and mesoscale circulation patterns that help to maintain larval retention (Wyatt & Porteiro 2002). Galicia is the most important region in the world in terms of production of mussels cultured in rafts (extensive culture in the rias), with annual average rates of ~250,000 tons.

Oceanic Fronts (Belkin et al. 2009): The frontal pattern off Iberia (Figure XIII-40.1) is fairly complicated and variable, especially on the seasonal and interannual scales. Most fronts are caused by coastal wind-induced upwelling, which is similar to the Northwest African coastal upwelling (Barton 1998) and also broadly similar to the California Current upwelling (Haynes *et al*. 1993). The upwelled water is entrained into large filaments that extend hundreds of kilometres offshore. SST fronts are most pronounced during the peak of the upwelling season, from July through September. The wintertime frontal pattern is quite variable from one year to another and depends, at least partially, on the poleward coastal warm current that emerges once the trade winds collapse (e.g. Garcia-Soto et al 2002); this current is, however, confined to a very narrow near-coastal band, 25-40 km wide; its thermal signature is just 1.0-1.5°C.

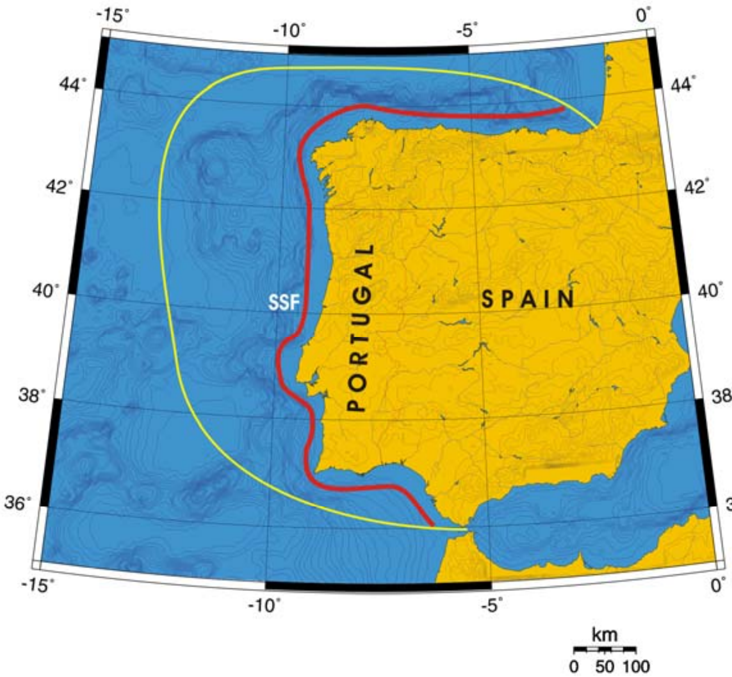

Figure XIII-40.1. Fronts of the Iberian Coastal LME. SSF, Shelf-Slope Front. Yellow line, LME boundary. After Belkin et al. (2009)..

Iberian Coastal LME SST (Belkin 2009):
Linear SST trend since 1957: 0.80°C.
Linear SST trend since 1982: 0.68°C.

Since 1957, the Iberian Coastal LME went through a cooling until the all-time minimum of 1972, followed by a rapid warming, 1.7°C over 34 years (Figure XIII-40.2). Several major events in the Iberian Coastal LME occurred practically simultaneously – within a year – with similar events in the adjacent Celtic-Biscay Shelf LME located downstream of the Iberian Coastal LME and connected to the latter by the Iberian Poleward Current and its extension off northern Spain dubbed “Navidad” (e.g. Garcia-Soto et al., 2002) flowing from the Iberian LME onto the Celtic-Biscay Shelf. These events include three minima of

1963, 1972, and 1986; a maximum of 1989; and a minimum of 1991-94. The observed synchronism between both LMEs may be more appearance than reality since annual mean data does not allow for a study of anomaly propagation over short distances where propagation time is a few months, not years. The very fast post-1972 warming by 1.7°C over 34 years has already profoundly affected this LME. Observations in the southern Gulf of Biscay in 1974-2000 revealed substantial restructuring of local ecosystems caused by the ongoing warming: cold-water fish and sea bird species dwindled, whilst two species – puffin and killer whale – disappeared completely; whereas warm-water species proliferated; taken together, these changes likely manifest a regime shift (Hemery et al., 2007).

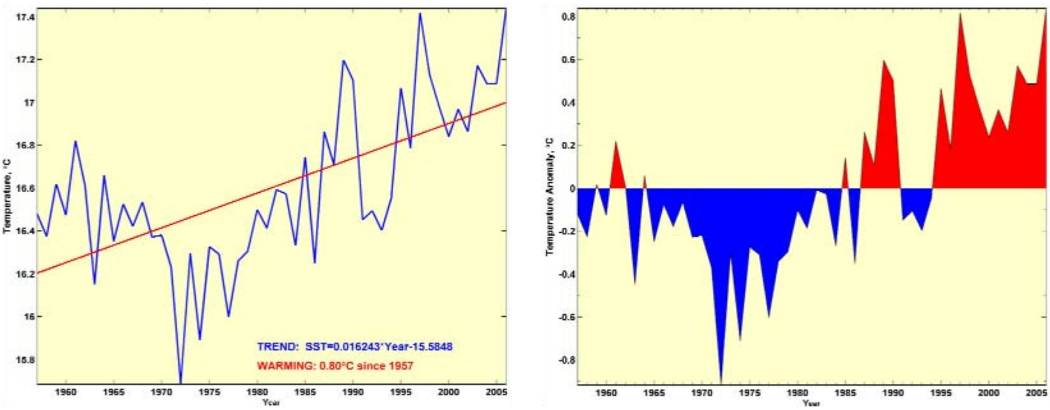

Figure XIII-40.2. Iberian Coastal LME annual mean SST (left) and SST anomalies (right), 1957-2006, based on Hadley climatology. After Belkin (2009).

Iberian Coastal LME Chlorophyll and Primary Productivity: This LME is considered a Class II, moderately productive ecosystem (150- 300 $gCm^{-2}yr^{-1}$)(Figure XIII-40.3).

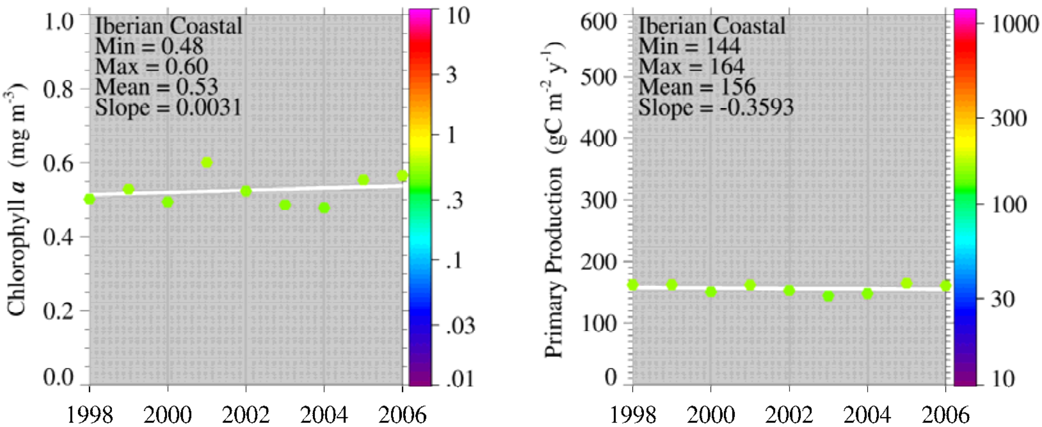

Figure XIII-40.3. Iberian Coastal LME trends in chlorophyll *a* (left) and primary productivity (right), 1998-2006. Values are colour coded to the right hand ordinate. Figure courtesy of J. O'Reilly and K. Hyde. Sources discussed p. 15 this volume.

II. Fish and Fisheries

The catch in the Iberian Coastal LME is essentially composed of three groups: herring, sardine and anchovy (42%), other pelagic fish (28%), and cod, hake and haddock. Coastal species harvested are anchovy, sardine, mackerel and horse mackerel. Hake, blue whiting, bream, bogue, pilchard, sprat and tuna are also caught. For examples of biomass changes in sardine, sprat, anchovy and other species, as well as for landings of fish in 1981, and for a description of fisheries geography and Iberian sardine fisheries in crisis in the 1940s and 1950s, see Wyatt & Porteiro (2002). Total reported landings in the LME peaked at 575,000 tonnes in 1972, but in general have fluctuated between 250,000 to 350,000 tonnes (Figure XIII-40.4). The value of the reported landings reached almost US$700 million (in 2000 real US dollars) in 1972, after which it dropped precipitously and fluctuated between US$200 million and US$500 million ever since (Figure XIII-40.5).

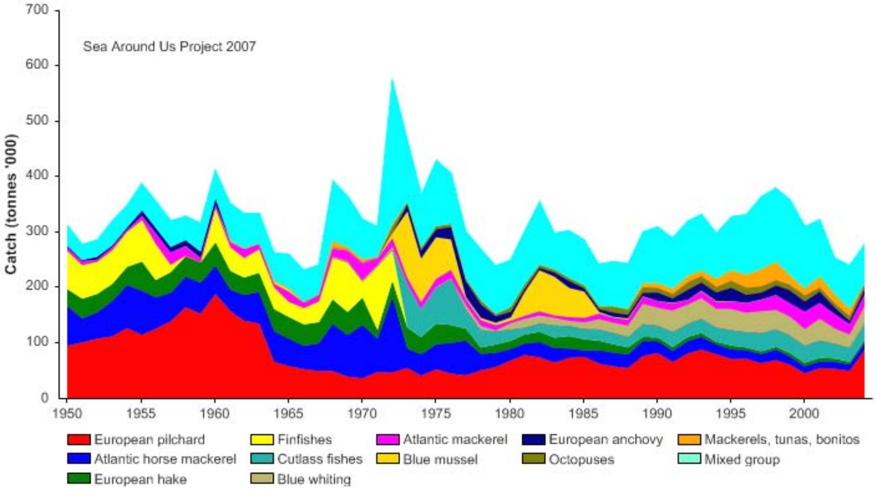

Figure XIII-40.4. Total reported landings in the Iberian Coastal LME by species (Sea Around Us 2007)

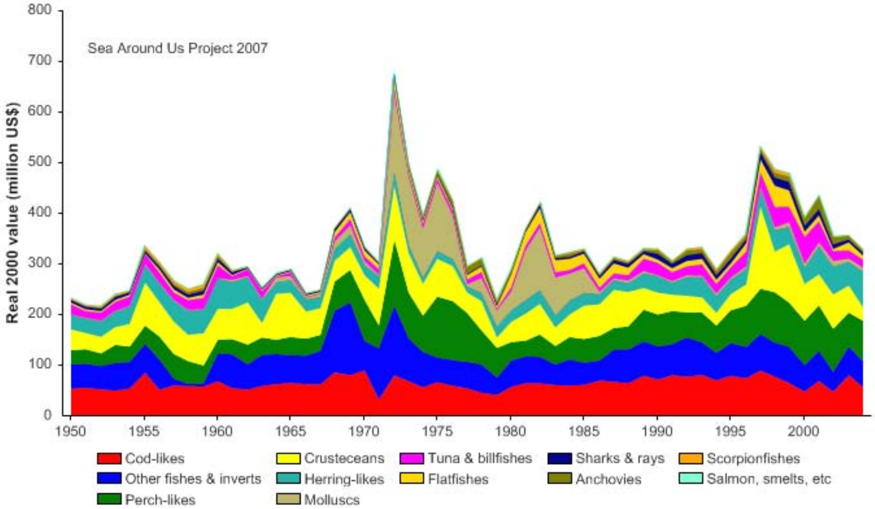

Figure XIII-40.5. Value of reported landings in the Iberian Coastal LME by commercial groups (Sea Around Us 2007)

The primary production required (PPR; Pauly & Christensen 1995) to sustain the reported landings in this LME reached extremely high level in the mid 1970s, but has declined to 30% by 2004 (Figure XIII-40.6). Spain and Portugal account for most of the ecological footprint in this LME.

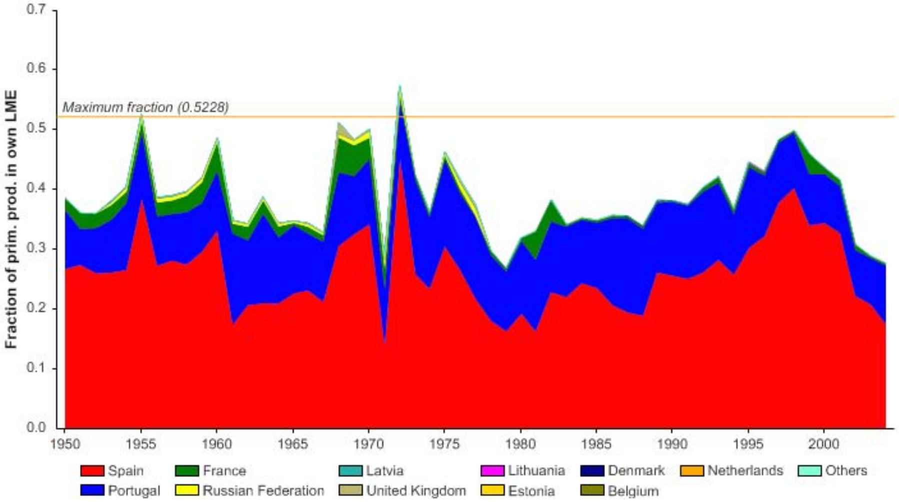

Figure XIII-40.6. Primary production required to support reported landings (i.e., ecological footprint) as fraction of the observed primary production in the Iberian Coastal LME (Sea Around Us 2007). The 'Maximum fraction' denotes the mean of the 5 highest values.

The mean trophic level of the reported landings (i.e., the MTI; Pauly & Watson 2005) remained more or less even, except for two 'dips' in 1973 and 1983, likely associated with the high landings of (possibly farmed) mussels (XIII-40.7, top). The FiB index is also rather uninformative, except for the very last years, which reflects the decline in the landings (XIII-40.7, bottom). The sustainable mussel farming here (established in the 1950's) stably produced ~250,000 tonnes/year since 1970's, making it one of the most important farming cultures in the world..

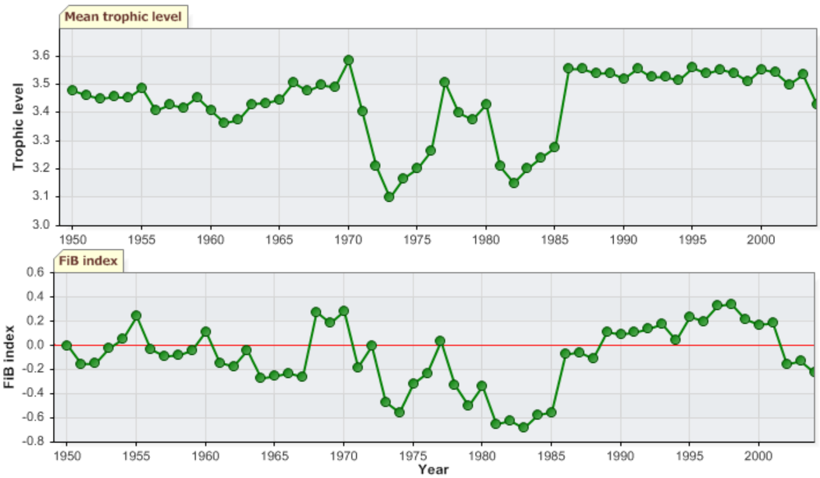

Figure XIII-40.7. Mean trophic level (i.e., Marine Trophic Index) (top) and Fishing-in-Balance Index (bottom) in the Iberian Coastal LME (Sea Around Us 2007)

The Stock-Catch Status Plots indicate that the number of collapsed stocks has been increasing, accounting for over 60% of the commercially exploited stocks in the LME (Figure XIII-40.8, top), while the majority of the reported landings biomass is supplied by overexploited stocks (Figure XIII-40.8, bottom).

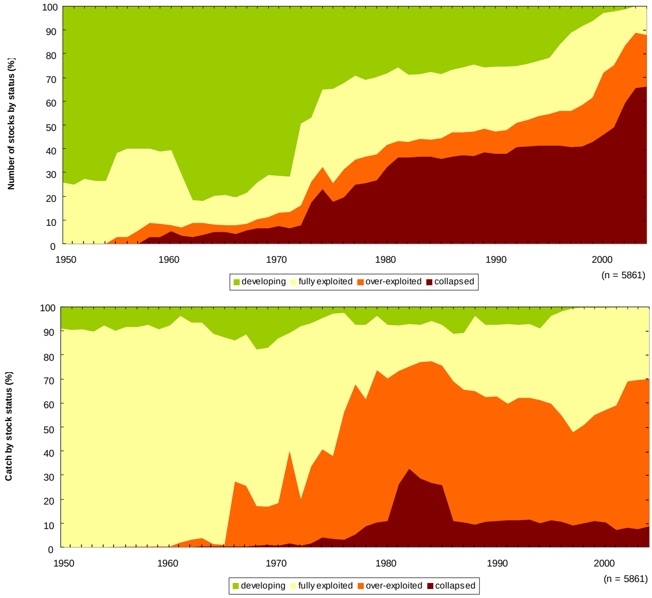

Figure XIII-40.8. Stock-Catch Status Plot for the Iberian Coast LME, showing the proportion of developing (green), fully exploited (yellow), overexploited (orange) and collapsed (purple) fisheries by number of stocks (top) and by catch biomass (bottom) from 1950 to 2004. Note that (n), the number of '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).

III. Pollution and Ecosystem Health

Red tides were a more or less annual occurrence in the Rias Bajas from the beginning of the 20th Century until the 1950s. These were almost always due to the dinoflagellate *Gonyaulax*, and sometimes to the ciliate *Mesodinium*. Since the 1970s, *Gonyaulax* blooms have not been reported in the Rias Bajas. Instead, there have been occasional blooms of the toxic dinoflagellates *Alexandrium tamarense, A*. *minutum* and *Gymnodinium catenatum*. These phytoplankton changes are seen as part of a worldwide increase in the frequency and intensity of harmful algal blooms, and are attributed to various causes including eutrophication and ballast water transport. Perez *et al*. (2004) report that under strong insolation and weak synoptic forcing, typically in the summer, sea breezes and mountain-induced winds develop to create re-circulations of pollutants along the eastern Iberian coast. According to Wyatt & Porteiro (2002), on the whole, pollution is not of major importance in the Iberian LME, except in a few localised areas. OSPAR lists ballast water, mariculture itself; coastal installations intensifying stratification. Anthropogenic inputs and fluxes of nitrogen into areas susceptible to eutrophication; unbalanced nutrient ratios in N: P and N:Si for example; hydroelectric power plant exceptional discharges; and increasing inputs of humic substances from rivers are threats to mariculture (OSPAR 2000). The EEA in "Eutrophication in Europe's Coastal Waters" reports in July 2001 that the Bay of Biscay and Iberian coast eutrophication problems are restricted to estuaries and coastal lagoons, especially Ria Formosa and Huelva. The concentration in this region of ship transport towards Northern Europe requires special regulation to prevent and control pollution. The waters around

Finisterre are regulated to avoid collisions of tankers and carriers. This region has seen a high number of oil spills from wrecks such as the recent Aegean Sea (1992) and Prestige (2002). A map with the location of events can be found in Lavin et al. 2006.

IV. Socioeconomic Conditions

In its reports for 2000, OSPAR estimates population in the “Atlantic arc,” the coastal regions of France, Spain and Portugal, at 36.6 million inhabitants or 106 inhabitants per km^2. In Spain, the three northern coastal regions are densely populated: Pais Vasco (>110 inh/km^2), Cantabria (100 inh/km^2) and Asturias (104 inh/km^2). Population is concentrated in the coastal areas as are most of the economic activities and industries.

Spain and Portugal are important fishing nations in the European Union, with Spain having the largest distant water fleet of any European country. The total number of vessels in the Spanish fishing fleet decreased during the 1990s and is currently around 9000, and only part of it operates in this LME. Spanish artisanal vessels fish for hake and mackerel in the winter, anchovy in spring, and sardine and albacore in summer and autumn. Sardine is one of the most important species in both landings and price. The focus of the Spanish anchovy fishery has moved eastwards, resulting in almost the entire catch being landed in Basque ports. Technical changes in the Basque fishery accounted for part of the increase in landings after the 1960s (Igelmo *et al*. 1984). Spain is gradually being excluded from several of its traditional extraterritorial fishing grounds, and will need to focus on the management of its local resources. A blue mussel farming industry, initiated in the 1950s in the Rias Bajas, produces about 250,000 tonnes annually. In the main area of raft cultivation, the Ria de Arosa, the standing stock of mussels is near or above carrying capacity of phytoplankton production.

Coastal erosion is a major concern, with subsequent salt water intrusion into estuaries, coastal lagoons, wetlands and groundwater as sea level rises likely (OSPAR 2000). The quality of farmed shellfish, particularly near outfalls discharging domestic wastewater, is also a major concern. HABS that affect the human consumer, episodes of acute shellfish toxicity, coastal development including urban expansion, and sea invasion of important agricultural areas, present a number of environmental issues to this coastal population. Compared to its Mediterranean coast, Spain’s Atlantic coast is not a frequent destination for tourists; the total number of overnight stays in local hotels on the Atlantic coast represents 6% of overnight stays in Spain and 87% of the visitors are Spanish (OSPAR 2000) (the French Atlantic Coast represents 24%). Tourism that adds pressure to existing marine ecosystems is also a force for maintaining clean beaches, potable water and uncontaminated fish and shellfish. Currently there is no sewage sludge dumped at sea along the Atlantic coast by France, Spain or Portugal, either from land or ships.

V. Governance

Spain and Portugal are both members of the EU. Being relatively small, the LME can be surveyed with the resources already available in the two countries. Both countries collaborate effectively in various fisheries contexts. The exploitation of the natural marine resources of the Iberian Coastal LME follows a number of conventions, declarations and regulations, including the European Commission directives and regulations within the Common Fisheries Policies. All in all, a large number of instruments from international bodies, such as the UN, ICES, OSPAR, International Maritime Organisation (IMO) and the EU, exist to conserve natural resources, protect the environment and ensure health and safety standards. The European Community laws protect the environment in terms of air and noise, chemicals and industrial risks, nature conservation, waste and water. See the OSPAR website for more information (www.ospar.org).

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