XIII-37 Celtic-Biscay Shelf: LME #24

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The Celtic-Biscay Shelf LME is situated in the Northeast Atlantic Ocean, and covers an area of 756,000 km^2, of which 0.98% is protected, with 0.01% of the world's sea mounts (Sea Around Us 2007). At its southern limit the shelf is steep and narrow, but it widens steadily along the west coast of France, merging with the broad continental shelf surrounding Ireland and Great Britain. Three countries, Ireland, Great Britain, and France border this LME. Spain is not part of this LME. However Spain has fishing rights in both the French Biscay and in the Celtic Shelf (e.g. the Great Sole Bank, a major fishing ground).The Celtic-Biscay Shelf is characterised by a strong interdependence of human impact and biological and climate cycles (see Koutsikopoulos & Le Cann 1996). River systems and estuaries include the Seine, Gironde (Garonne River), Bristol Channel and Firth of Clyde. Two important book chapters pertaining to this LME are Valdés & Lavin (2002) and Lavin et al. (2006), both on the Bay of Biscay. The OSPAR reports provide information on the geography, hydrography and climate of Regions 3 and 4 that together cover the Celtic-Biscay Shelf LME, (www.ospar.org). See also the ICES working group WGRED annual report at http://www.ices.dk/iceswork/wgdetailacfm.asp?wg=WGRED

I. Productivity

The Celtic-Biscay Shelf LME is considered a Class II, moderately productive ecosystem (150-300 gCm^{-2}yr^{-1}). This LME is influenced by the North Atlantic Drift in the north, and by the Azores Current in the south. For information on circulation and currents, see Koutsikopoulos & Le Cann (1996). The region undergoes a seasonal climatic cycle that strongly affects the pelagic ecosystem through forcing factors: sunlight exposure, heat input, and mechanical forcing on the surface by wind. For more information on seasonal variability, the vertical structure of coastal and oceanic waters, river plumes, coastal runoff and tidal fronts, see Valdes & Lavin (2002) who also describe the coastal upwelling in the Bay of Biscay that affects mainly Iberian coast, being very weak and only occasional along the French coast; they also describe the warm and salty Navidad Current. Living marine resources include a wide range of organisms. The LME is a region of transition that is rich in floral and faunal species. It is difficult to determine the states of equilibrium of species and communities, since natural variability occurs on a wide range of space and time scales (seasonal, inter-annual, decadal and centennial cycles). This LME is positioned in the eastern North Atlantic, in the cyclical North Atlantic Oscillation.

Oceanic fronts (Belkin et al. 2009): The most important front within this LME is the Shelf-Slope Front (SSF) that extends along the shelf break/upper continental slope from the Bay of Biscay around the British Isles up to the Faroe-Shetland Channel where it joins the North Atlantic Current Front (Figure XIII-37.1). This front is distinct year-round but is best defined in fall when its separation from the Mid-Shelf Front (MSF) becomes evident. The SSF is associated with the Shelf Edge Current, believed to be continuous all the way up to the Faroe-Shetland Channel. The SSF, however, does not appear continuous, suggesting that the Shelf Edge Current is likely not always continuous. The areas where the SSF is broken most often are near Goban Spur and Porcupine Bank; these bathymetric features are clearly responsible for the front's instabilities in these areas. The Mid-Shelf Front (MSF) is located between the SSF and the coasts of France, United Kingdom and Ireland. Tidal mixing fronts exist off Ushant Island, south of the Irish Sea, south of Ireland, and over the Malin Shelf.

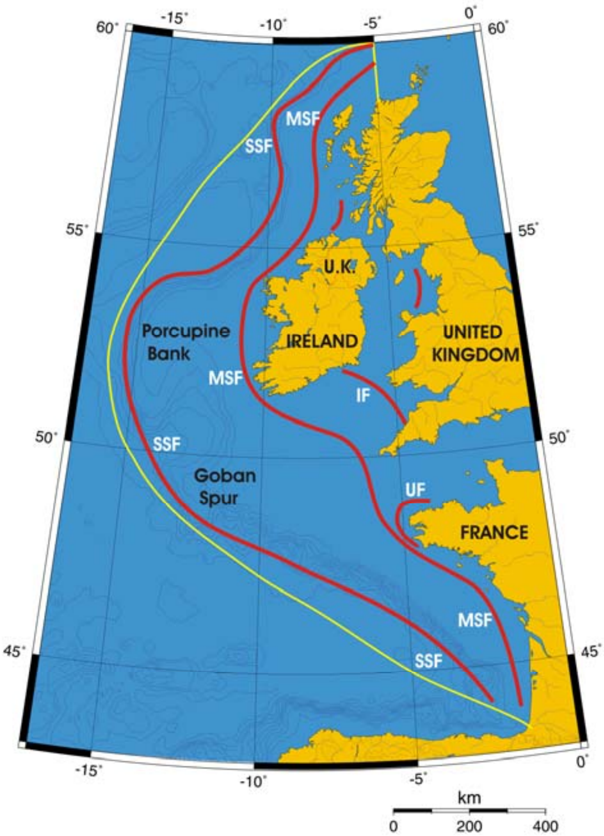


Figure XIII-37.1. Fronts of the Celtic-Biscay Shelf LME. IF, Irish Front; MSF, Mid-Shelf Front; SSF, Shelf-Slope Front; UF, Ushant Front. Yellow line, LME boundary. After Belkin et al. (2009).

Celtic-Biscay Shelf LME SST (Belkin 2009)(Figure XIII-37.2)
Linear SST trend since 1957: 0.41°C.
Linear SST trend since 1982: 0.72°C.

The thermal history of the Celtic-Biscay Shelf included (1) abrupt cooling in 1959-1963; (2) cold period until the all-time minimum in 1986; (3) very fast warming at a rate of 1.3°C over 20 years, accentuated by a major warming peaked in 1989 and interrupted by a cold spell in 1991-94.

The sequence of alternating, well-defined extremums in 1986 (cold), 1989 (warm), and 1991-94 (cold) is strongly correlated with similar events in the adjacent Iberian Coastal LME. The latter is oceanographically connected to the Celtic-Biscay Shelf 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. Given the short distance between the two LMEs, all three events occurred nearly simultaneously in both LMEs. The same sequence of three alternating cold-warm-cold events of 1986, 1989, and 1991-94 in the Celtic-Biscay Shelf LME can be tentatively correlated with a similar cold-warm-cold event sequence of 1986, 1990, and 1995 in the Norwegian Sea LME located downstream of the Celtic-Biscay Shelf and connected to the latter by the Slope Current and North Atlantic Current. The less conspicuous minimum of 1972 on the Celtic-Biscay Shelf was likely related to the all-time minimum of 1972 in the Iberian LME. The previous minimum of 1963 was also simultaneous in both LMEs. The near-all-time maximum of 1959 on the Celtic-Biscay Shelf can be tenuously linked to the all-time maximum of 1961 in the Norwegian Sea. The above correlations suggest a dominant role of oceanic advection in transporting thermal signals across the Northeast Atlantic. The ongoing warming has already significantly affected this LME. For example, in the southern Bay of Biscay (43°–47°N), cold-water species of fish and sea birds declined; two species (puffin and killer whale) disappeared; populations of warm-water species increased; all these changes could amount to a regime shift in this LME (Hemery et al., 2007).

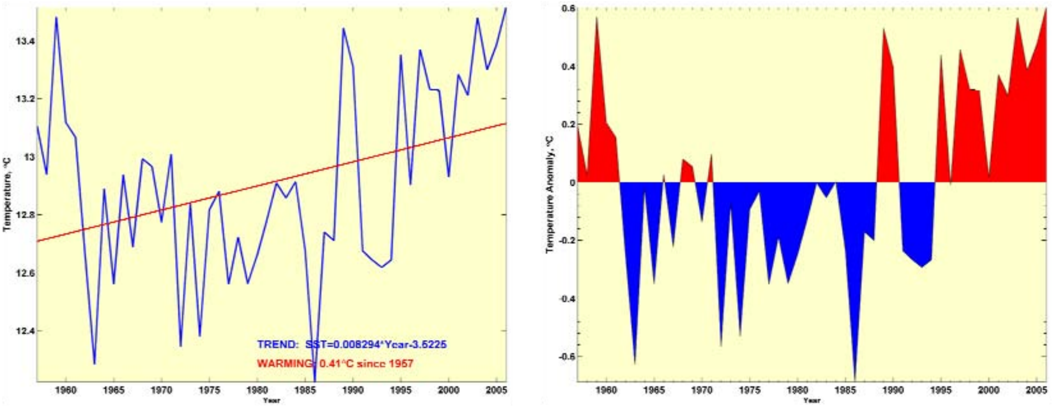


Figure XIII-37.2. Celtic-Biscay Shelf LME annual mean SST (left) and annual SST anomalies (right), 1957-2006, based on Hadley climatology. After Belkin (2009).

***Celtic-Biscay Shelf LME Chlorophyll and Primary Productivity*:** This LME is considered a Class II, moderately productive ecosystem (150-300 $gCm^{-2}yr^{-1}$)(Figure XIII-37.3).

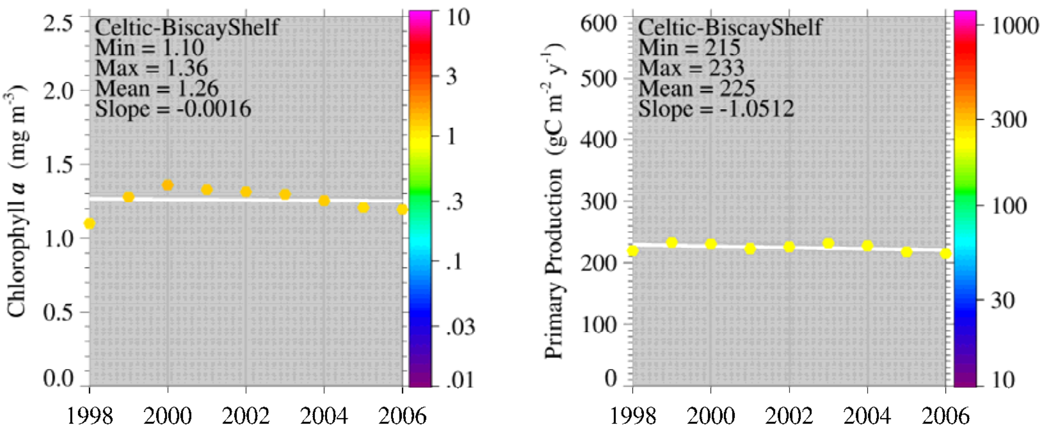


Figure XIII-37.3. Celtic-Biscay shelf LME trends in chlorophyll *a* (left) and primary productivity (right), 1998-2006. Values are colour coded to the right hand ordinate. Figure courtesy of J. O'Reilly and K. Hyde. Sources discussed p. 15 this volume.

II. Fish and Fisheries

The natural environmental variability in this LME adds a high degree of uncertainty to the management of marine resources. Cyclical oscillations, such as the North Atlantic Oscillation, have been linked to fluctuations in the abundance of albacore and bluefin tuna (see Ortiz de Zarate *et al*. 1997 and Santiago 1997). Many stocks in the LME are intensively exploited or depleted and TAC-based regulations have been implemented for anchovy, hake and blue whiting. ICES provides general information on fisheries and other topics pertaining to the LME, while OSPAR reports on biodiversity and evolution of catches of same depleted stocks, but not with an intention of doing any management.. The main marine resources exploited in the LME include molluscs, seaweed, herring, redfish, sand eel and mackerel. The most important fish caught in its shelf waters include various pelagic fish species, as well as cod and hake. Sardine is not as important a resource in this LME as in the Iberian Coastal LME. For more on sardine recruitment, see Valdés & Lavin (2002).

Total reported landings in this LME show changes in biomass and catch composition (Figure XIII-37.4). The landings recorded a peak of 1.4 million tonnes in 1998, and declined to 1 million tonnes in 2004. The value of the reported landings reached US$1.6 billion (in 2000 US dollars) in 1976 (Figure XIII-37.5).

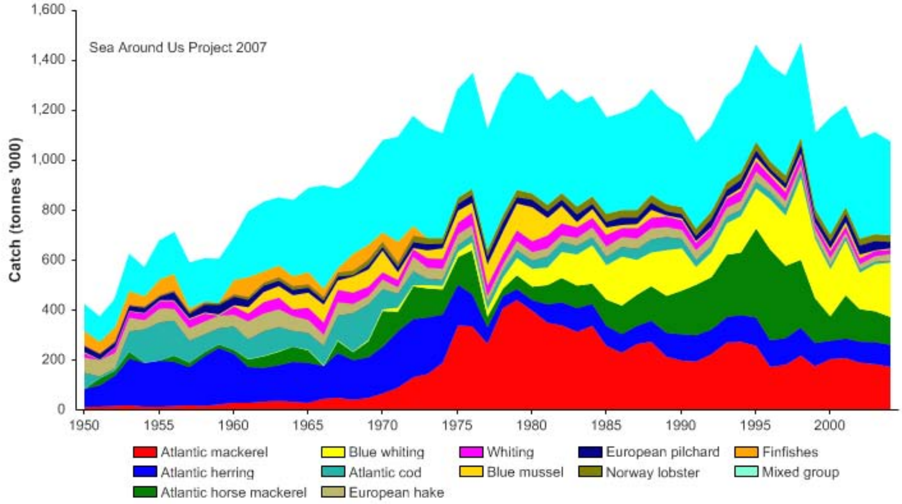


Figure XIII-37.4. Total reported landings in the Celtic-Biscay Shelf LME by species (Sea Around Us 2007).

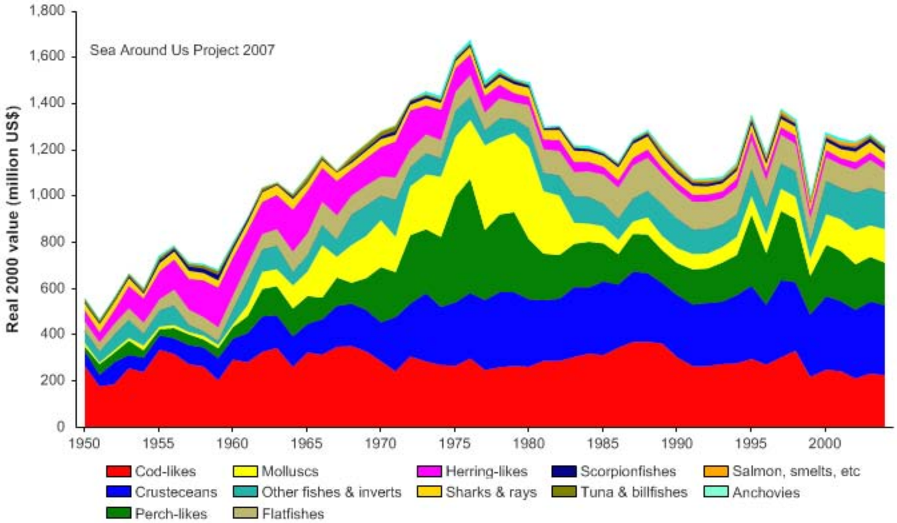
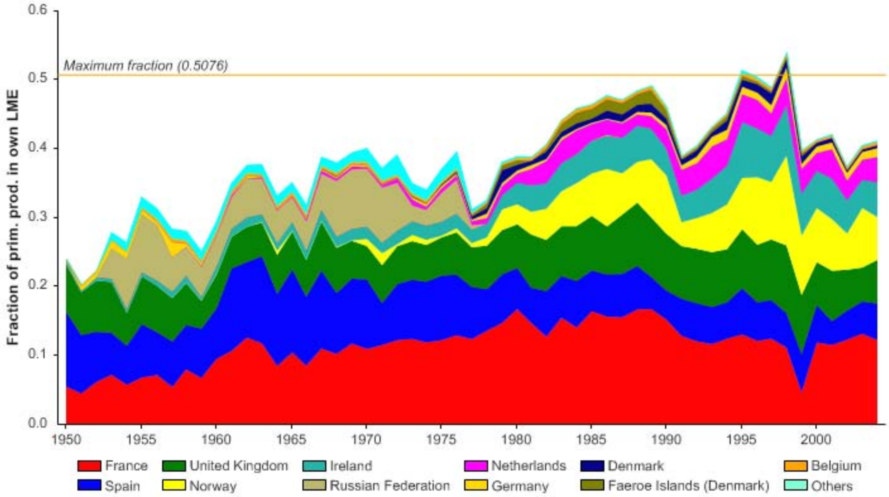


Figure XIII-37.5. Value of reported landings in the Celtic-Biscay Shelf LME by commercial groups (Sea Around Us 2007).

The primary production required (PPR; Pauly & Christensen 1995) to sustain the reported landings in this LME reached 50% of the observed primary production in the mid-1990s, but has declined to 40% in recent years (Figure XIII-37.6). France and the UK account for the largest share of the ecological footprint in this LME.



FigureXIII-37.6. Primary production required to support reported landings (i.e., ecological footprint) as fraction of the observed primary production in the Celtic-Biscay Shelf LME (Sea Around Us 2007). The 'Maximum fraction' denotes the mean of the 5 highest values.

The mean trophic level of fisheries catches (i.e., to the MTI; Pauly and Watson 2005) declined over the three decades from 1950 to 1980. In the early 1980s, however, it underwent a strong increase (Figure XIII-37.7, top) while the FiB index reached a new plateau (Figure XIII-37.7, bottom). These trends indicate that a 'fishing down' of the food web occurred from 1950 to the 1980s (Pauly *et al.* 1998), after which the effect was masked by expansion of the fisheries into new stocks (e.g., blue whiting, Figure XIII-37.4). This also confirms the results of Pinnegar *et al*. (2002), who, using fine-resolution data, concluded "there has been [in the Celtic Sea - ICES divisions VII f–j] a significant decline in the mean trophic level of survey catches from 1982 to 2000 and a decline in the trophic level of landings from 1946 to 1998."

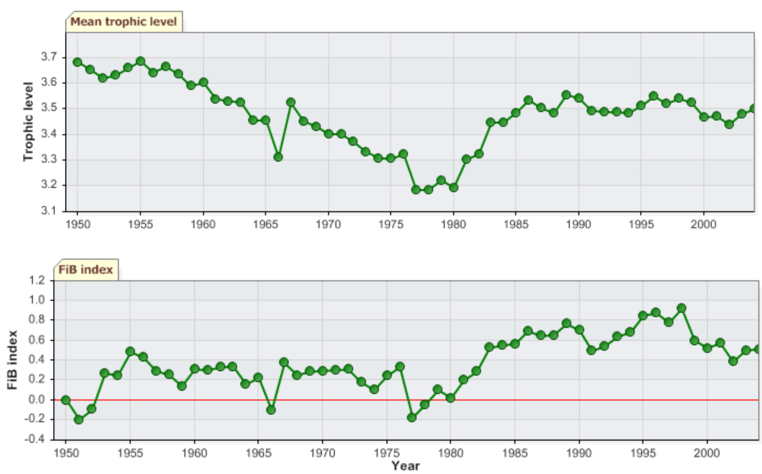


Figure XIII-37.7. Mean trophic level (i.e., Marine Trophic Index) (top) and Fishing-in-Balance Index (bottom) in the Celtic-Biscay Shelf LME (Sea Around Us 2007).

The Stock-Catch Status Plots indicate that collapsed stocks make up half of all stocks exploited in the LME (Figure XIII-37.8, top), but that fully exploited stocks contribute almost 60% of the reported landings biomass (Figure XIII-37.8, bottom).

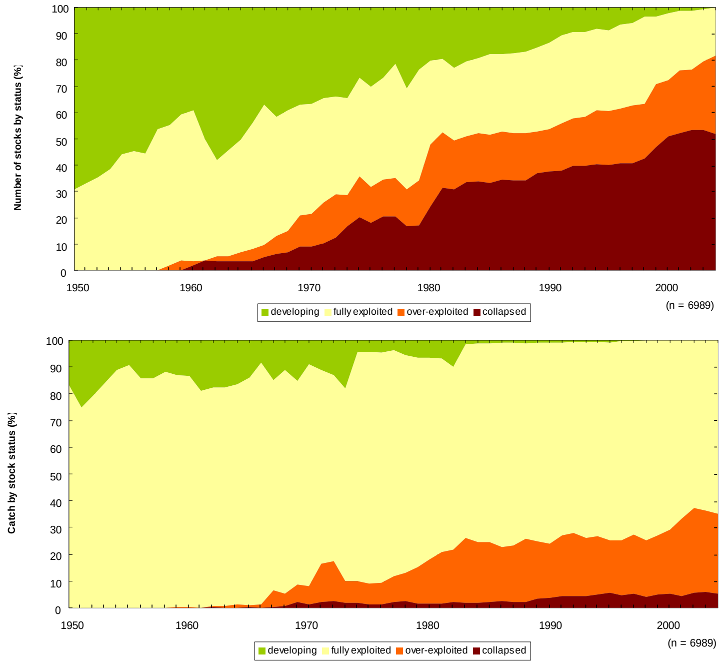


Figure XIII-37.8. Stock-Catch Status Plots for the Celtic-Biscay Shelf LME, showing the proportion of developing (green), fully exploited (yellow), overexploited (orange) and collapsed (purple) fisheries by number of stocks (top) and by catch biomass (bottom) from 1950 to 2004. Note that (n), the number 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).

III. Pollution and Ecosystem Health

The Celtic-Biscay Shelf LME has experienced ecological disturbances of target fish species, with alterations in the abundance, distribution and diversity of fish and marine mammals. Pollution and global change are impacting the coastal habitats (estuaries, coastal lagoons, rocky cliffs, rocky shores, sandy and muddy shores). Estuaries and coastal lagoons receive most of the impact of microbiological contamination of urban origin. Effects of ecosystem variability and human impact on species and habitats of the Bay of Biscay are described by Valdés & Lavin (2002). The ecosystem is affected by alterations to the seabed, the introduction of non-indigenous species, agriculture and sewage (Valdés & Lavin 2002). Introduced species are naturally transported by currents or are human-induced, caused by an intensification of fisheries and by transport in ballast water of commercial vessels. The use of DDT in agriculture has now been banned. There is pressure on the coastal margins from urban sources and from industrial activities, such as paper mills, petroleum refineries, iron and steel works and chemical plants.

Industrial discharges, inorganic and organic compounds, mercury (associated with paper mill industries), and PAHs (linked to human activities such as marine oil extraction, industry and oil traffic), are described by Valdés & Lavin (2002). Major oil spills have occurred in the area, listed at the EEA's website <epaedia.eea.europa.eu>, for example Torrey Canyon off Cornwall in 1967, the Ammoco Cadiz off Brittany, France in 1978, and the Sea Empress off Wales in 1992. In December 1999, the supertanker *Erika* spilled

10,000 tonnes of oil in shallow waters off the coast of France. Due to the strong wind in the area, the 'black tide' moved to the coast of the Bay of Biscay and large expanses of French beaches were contaminated by oil. The EEA reports that the remains of this ecological disaster can still be seen.

OSPAR provides information on the chemical aspects of the North-East Atlantic, the inputs of contaminants and nutrients, and their concentrations in different environments (www.ospar.org). It identifies pollution trends, the effectiveness of measures, the major causes of environmental degradation within the area and the managerial and scientific actions needed to redress this. The OSPAR Integrated Report on Eutrophication (2003) points out that in all participating countries many coastal areas, fjords and estuaries showed increased riverine N and P inputs, and some fjords and offshore sedimentation areas received increased transboundary nutrient inputs. Also reported were elevated levels of winter DIN and DIP concentrations, elevated levels in winter N/P ratios, elevated levels of chlorophyll *a* and elevated "nuisance bloom" or toxic assessment levels.

IV. Socioeconomic Conditions

Traditionally, the LME has been a region of intense fishing activity. Whale hunting began along the Spanish coast in the Middle Ages. Human activities in the coastal areas also include aquaculture and farming. Population densities at the coastal edges of the Celtic-Biscay Shelf LME are increasing. OSPAR estimates that 47.2 million people live in the catchment areas draining into the Bay of Biscay and Iberian coastal waters. In Brittany in France, more than 90% of the entire population lives on the coast, according to the EEA SOE report 2005 Part A, Ireland (together with the Mediterranean coast of Spain) has one of the two fastest growing coastal area populations in Europe, with increases of up to 50% in the past decade (http://epaedia.eea.europa.eu). Rapid population growth and socioeconomic development have resulted in environmental imbalances. EEA cites as principal threats to the Celtic Sea, Bay of Biscay and Iberian coast, eutrophication from sewage, agriculture, and fish farming; threats to fishing from overfishing, bottom trawling, discards and catch of non-targeted species; threats from industry in the form of chemicals and radionuclides; and threats from shipping accidents, pollution and oil spills. Additional pressure comes from tourism, urbanisation of coastal areas, transportation and recreational uses of beaches and shores.

V. Governance

A new Marine Strategy Framework Directive was recently enacted which promotes and integrates environmental considerations into all relevant policies areas and which forms the basis for a future Maritime Policy for the EU. The countries bordering this LME are all members of the European Union. The use of natural marine resources is governed by a number of conventions, declarations and regulations, including the European Commission directives and regulations within the Common Fisheries Policies. A large number of instruments from international bodies, such as the UN, the International Maritime Organisation and the European Union, 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. The EEA online summary for the Northeast Atlantic Ocean, lists the major political instruments as OSPAR, ICES, EU Birds and Habitats Directives, North Atlantic Marine Mammal Commission (NAMMCO), the Bern convention and other conventions covering part of the area including Ramsar for wetland protection, the Bonn convention for migratory species, MARPOL73/78IMO convention of marine pollution from ships in additional to national laws, and NGO organisations such as WWF are working to accelerate the establishment of no-fishing zones and offshore marine protected areas (www.eea.org).

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