MEFEPO

Making the European Fisheries Ecosystem Plan Operational

A technical review document on the ecological, social and economic features of the South Western Waters region

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TECHNICAL REPORT

A technical review document on the ecological, social and economic features of the South Western Waters region.

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CONTENT

0. Summary

This document gives an overview of present knowledge of the South Western Waters Region ecosystem and the human activities that affect it, with a specific focus on three fisheries case studies, their impact and economic perspective, the institutional governance setup for fisheries management and a vision on human activities.

It is recognised that much of the information and knowledge currently available to develop an ecosystem approach to fisheries management in Europe is not being used effectively as it is so widely dispersed (Connoly and Rice). The aim of this Work Package was to integrate the existing knowledge on ecological and socio-economical issues in the South Western Waters region.

In order to understand the ecological and physical processes that occur in the marine environment in this area, as well as to understand the degree of alteration produced by the impact of human activities, it is necessary to review the existing data concerning the locations, extensions and distribution of the habitats. In this regard, chapter one gives an overview of this knowledge starting in the first section with a description of the physical and chemical features of the northeastern Atlantic area (from Brittany as the northern limit, down to the Strait of Gibraltar to the south, including also the ultraperiferic regions of Madeira, Azores and Canary Islands) that form the conditions within which the biological features have evolved and depend upon. These biological features are described next, from benthic and algal communities to the fish communities and the marine mammals and sea birds. The second section describes the human activities occurring and impacting the South Western Waters environment. It gives an overview of the activities already occurring in the study area and the impacts caused by those activities, and it finishes with a future perspective for the different activities.

Chapter one finishes with the description of the socio-economic environment. This section focuses on the management around fisheries on a European scale, but with specific attention for western European issues. It provides an overview of the different management tools used to control the fishery activity. These tools can be divided into three overarching groups; input (e.g. area and time restrictions) and output (e.g. TACs and discard regulations) management, as well as economic incentive mechanisms (e.g. Individual tradable quotas and subsidies). This is followed by an overview of the socio-economic considerations of European fisheries and communities depending on the main fisheries in each of the case studies.

Chapter two focuses on three fisheries case studies in the South Western Waters Region. These case studies are chosen based on their importance in the area, their likely impact on the environment and due to data availability of these fisheries. The first case study focuses mainly on the Spanish and Portuguese purse seine fishery in SWW which, targets on small pelagic species such as sardine, anchovy, mackerel and horse mackerel. The second case study is the mixed demersal trawl fishery, which focuses mainly on Spanish and Portuguese trawl fishery targeting hake and horse mackerel, as well as French Nephrops mixed trawl fishery. The last case study focuses mainly on the Azorean demersal line fishery; whose dynamic seems to be controlled by black spot seabream, in spite of being a multispecies, multigear and multifleet fishery.

Following the description of these fisheries case studies, it was tried to combine the impacts of these fisheries case studies with the effect of socio-economic component on an extended list of ecological components (e.g. habitats, food web, all individual components

of the food web etc.) in a matrix presentation scheme. This Social and Ecological Component by Pressure Matrix (SECPM) provides an overview of the interactions between the fishery and various components of the fishery system, ecological and socio-economic. The matrices by case study were followed by an extensive description of the impacts on the specific Ecological components, which is supporting evidence for the inclusion of the interaction in the SECPM.

The next section identifies the problem of synergistic effects of the fisheries case studies with other human activities, and drivers (e.g. climate). This means that studies considering the impact of specific activities in isolation may misjudge their system-level effects. Fisheries effects, as well as natural variability caused by climate, need to be considered in the assessment and management of human activities and impacts.

The last section of this chapter describes models that are used for calculating the effect of the fisheries cases on the mortality of benthic and fish communities. In the particular case of the Cantabrian Sea, the shelf ecosystem was described using a mass-balance model of trophic interactions and the effects of different fisheries that operate in the area were studied.

The last chapter was intended to identify and collate data from national and international marine consultative initiatives. It summarises perceptions of French, Spanish, Portuguese and Azorean stakeholders involved in the SWW RAC region. Their viewpoints regarding both the situation of the marine environment and their preferred management tools were reported. Moreover, the socio-economic implication of such decisions was also analysed, studying the linkages between the ecological, economic and social perspectives on the system.

1. Overview of the South Western Waters region

The South Western Waters (SWW) Regional Advisory Council (RAC) area covers the southeastern part of the North Atlantic Ocean: with Brittany as the northern limit, up to the Strait of Gibraltar to the south, including also the ultraperiferic regions of Madeira, Azores and Canary Islands.

1.2 Ecological environment

1.2.1 Physical and chemical features

An overview of the main oceanographic features of the southeastern North Atlantic is presented (Figure 1). The principle features discussed are: topographic features and effects; water mass boundaries; forcing by wind, density and tides; fronts; upwelling and downwelling; poleward flows; coastal currents; eddies; nutrient distribution. The occurrence, and spatial and seasonal variability, of these features is described at regional level: Bay of Biscay; western Iberia; Gulf of Cadiz, and oceanic areas.

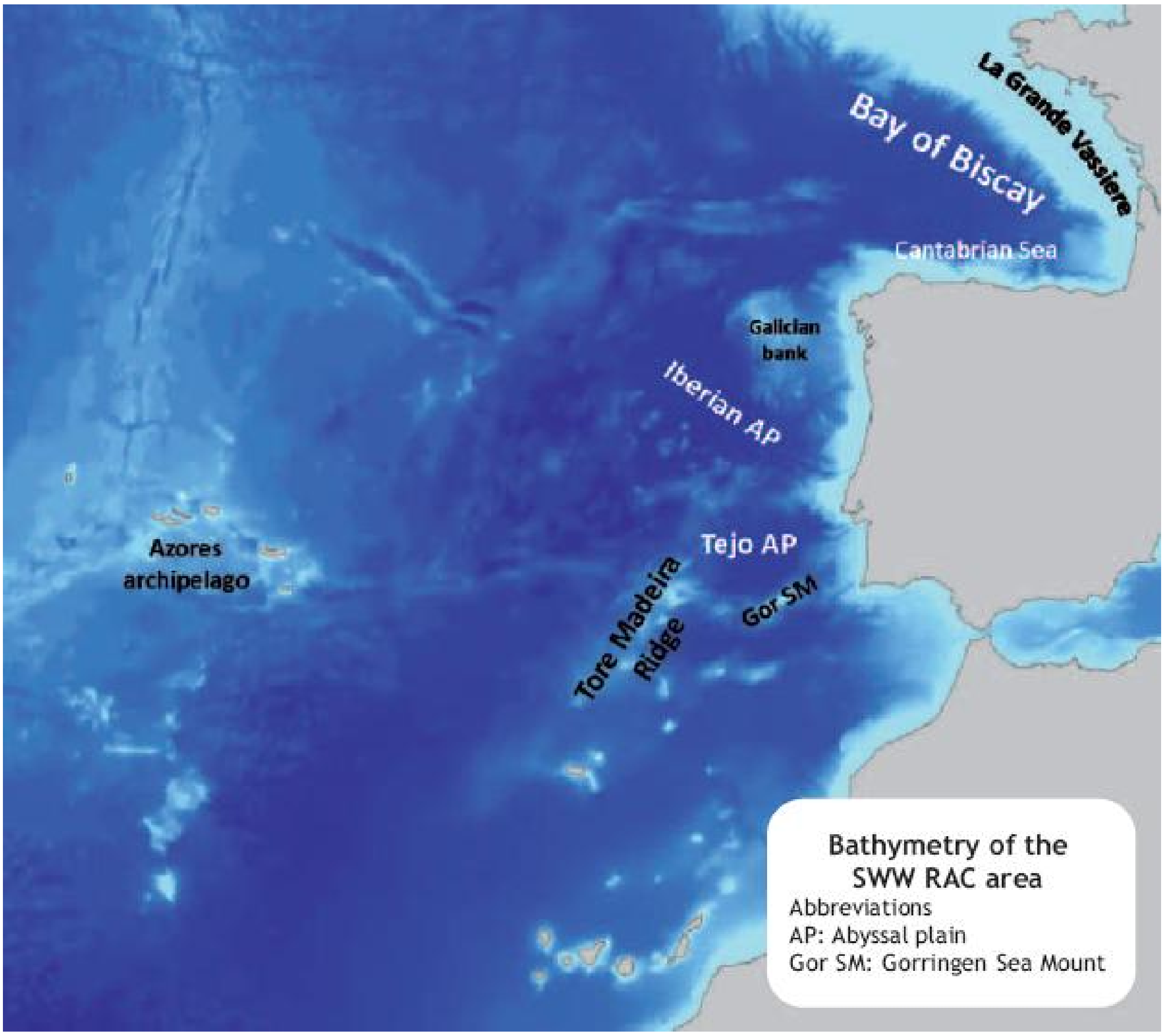


Figure 1. The eastern North Atlantic region (source: Velasco *et al*., 2009).

1.2.1.1 Topography and bathymetry of the seabed

The continental shelf in the northern Bay of Biscay is about 140km wide; it becomes narrower to the south (about 50km off southern France). From coast to offshore, the depth increases almost regularly down to 200m; the shelf is mainly flat with a very gentle slope of 0.12%. On the southern border of the Bay of Biscay, the continental shelf of the Cantabrian Sea is as narrow as 12km. The shelf-break occurs at depths of around 200m to the north of the advisory region, and at 130–150m in the Gulf of Cadiz. The continental slope, which marks the transition between the continental shelf and the deep-sea environment, is relatively steep throughout most of the region with a slope of the order of 10-12% and is dissected by numerous valleys. The slope is mainly steep and made of rough bottom, with canyons and cliffs, with the only exceptions of a few small terraces mainly to the north and the deep (500–800m) Landes Plateau in the southern Bay of Biscay (ICES, 2008a).

The Portuguese continental shelf is generally narrow, except for the area located between the Minho River and the Nazaré Canyon, and in the Gulf of Cadiz, where it is about 50km wide, particularly to the east (OSPAR, 2000). The slope is mainly steep with a rough bottom, with canyons and cliffs.

Seamounts such as Le Danois Bank and Galicia Bank (up to 450–600m depth) form deep canyons with the close Iberian continental shelf, influencing the local circulation of the water masses. Some of these canyons are particularly prominent, such as the Cap Breton Canyon, where 1000m isobath can be found only 3km from the coast.

The Iberian Basin comprises the Iberian Abyssal Plain and the Tejo Abyssal Plain; it is limited to the north by the Galicia Bank; and to the south by the Tore Madeira Ridge and the Gorringe Sea Mount (at locations shallower than 200m). The western limit of the basin is at approximately 16ºW (taking the Tore Madeira Ridge as the western end) and the eastern limit is the meridionally aligned margin of Western Iberia (Figure 1). The main connection linking the basin and the Gulf of Cadiz is a passage (4000m) that runs between the Gorringe Sea Mount and the coast (Peliz *et al*., 2005).

The continental shelf is an area of gentle slopes and small-scale rock outcrops (Vanney and Mougenot, 1981). These slopes reflect current sediment accumulation processes as well as long-term changes that have occurred since the last glaciation. The upper slope sediments originate mostly from the continent. The inner shelf (depth <100m) has mainly rocky or sandy substrate, whereas shelf/shelf break areas have predominantly muddy substrate. One major sedimentary area off South West Brittany is known as “Grande Vasière” (large muddy area). Muddy sediments are also present in the Galician inner shelf associated with the large estuarine systems of the "rías" (López-Jamar *et al*., 1992, Serrano *et al*., 2008). Contouritic deposits occur in the Cantabrian Sea and in the Gulf of Cadiz. In the latter, the slope is composed by muddy sands full enriched by hydrates, that triggers fluid escapes and cold seeps.

The rivers are the main source of fine particles in the Bay of Biscay. They discharge 2.5×10^6 tonnes of continental fine sediments per year, of which 60% comes from the “Gironde”. The “Grande Vasière” (Great mudflats) represents 75% of the total deposition of fine particles of the continental shelf of the Gulf of Biscay and 65% of the total flow of sediment is stored on the continental shelf (Jouanneau *et al*., 1999). Accumulation rates calculated by Lesueur *et al*. (2001; 2mm/yr) are of the same proportion as those of other continental shelves (1.5 to 6.3mm/yr for the Gulf of Lion, 1 to 3mm/yr for the east of Spain, 1.6 to 5.5mm/yr for the north of Portugal; Lesueur *et al*., 2001).

The current distribution of sediments is the result of a variety of hydrodynamic conditions: action of waves (Pinot, 1974), input current of rivers (Jouanneau *et al.*, 1999; Lesueur *et al.*, 2001) and eustatic changes in the level of the ocean. These events have left on the shelf terrigenous and varied deposits that transgressions were reworked and partially redistributed (Chassé and Glémarec, 1976; Lesueur and Klingebiel, 1976).

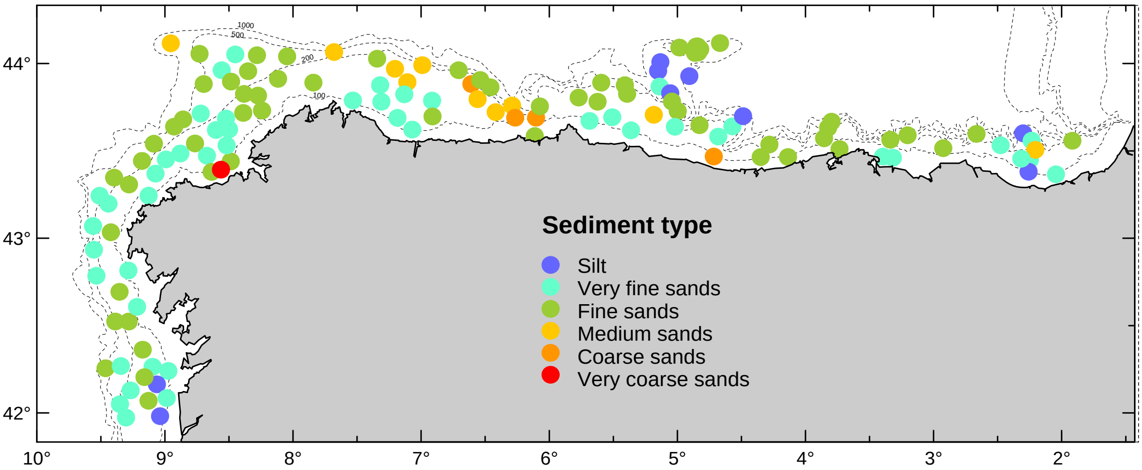


Figure 2. Sediment type distribution in the northern Spanish shelf (Cantabrian Sea and Galician shelves). IBTS "Demersales" survey data (ERDEM Project, IEO)

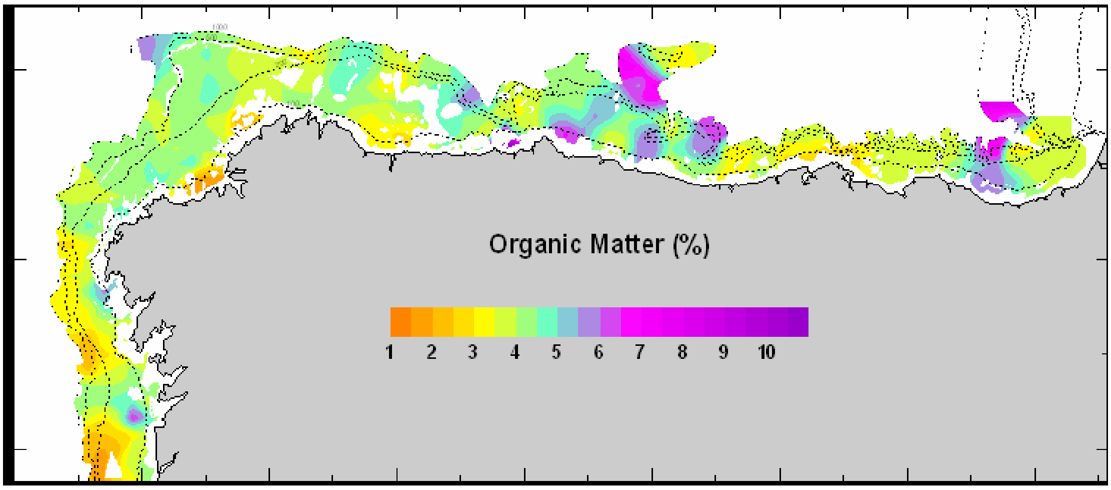


Figure 3. Organic matter content in the sediments of the northern Spanish shelf (Cantabrian Sea and Galician shelves). IBTS "Demersales" survey data (ERDEM Project, IEO)

Figure 2 and Figure 3 represent sediment types' distribution and organic content. The dominant sediment types are fine sands and very fine sands. Finer sediments, such as silts, are located mainly in the slope (in the Figure 2 this silt belt is only shown in the inner basin between Le Danois Bank and the shelf, since it is the only area sampled). In shallower grounds, silts are present in the easternmost areas, related to French rivers, and in front of the Rías Bajas, produced by their outwelling. Organic matter content is related with the presence of silts, and also in some areas of primary production enhancement (e.g. areas of eddy retention).

In the northern part of western Iberia, the coastline is mostly rocky and shallow. To the south of 41°N, a rectilinear sandy coast extends to just north of the Nazaré Canyon, interrupted only by Cape Mondego, just north of 40°N. Further south, beaches are replaced by cliffs which extend to Cape Raso, at the latitude of Lisbon. Carbonate rocks are eroded by wave action and the sediments rapidly transported out of the area. Sediment only accumulates at the mouths of small rivers and creeks. From Cape Raso to Cape Sines (38°N) two irregular rocky sections of coastline alternate with two smooth sandy sections. Steep cliffs occur to the south of Cape Sines, with a few beaches at the mouths of small creeks and coastal inlets (OSPAR, 2000).

In Portugal, submarine canyons such as Nazaré, Setúbal and São Vicente are responsible for carrying material from the shelf edge to deeper areas of the margin. The continental shelf and upper slope sediments originate mostly from the continent. Surface deposits on the shelf are dominated by sand, despite of the fine-grained material introduced by suspension transport during river floods events. The lower abundance of clay sediments is related to strong wave and current regimes, which prevent fine particles settling. The greatest terrigenous sedimentation is found in the northern area, due to a combination of high river flow and an absence of large sediment trapping estuaries.

Interaction topography / water dynamics

The variable nature of the seabed reflects the interaction between the processes that shape the Earth internally and those that work upon its surface. This interaction has occurred since the opening of the Atlantic Ocean. The resulting bottom topography is an important means of identifying current sediment dynamics (i.e. areas of sedimentation and erosion, and the routes by which sediments are transported).

Topographic features at the seabed, or the coastline itself, often play important roles in the formation of a number of physical phenomena, such as eddies and upwelling-related filaments. Localised and/or intensified coastal upwellings are often associated with the presence of capes or promontories. Coastal embayments may be linked to the retention of eggs and larvae, because they can be effective at retaining water and reducing alongshore flow (e.g. Monteiro and Largier, 1999). Offshore banks, such as the Galicia Bank, are responsible for quasi-permanent anticyclonic circulations; these are sometimes referred to as Taylor Column circulations (e.g. Heath, 1992). Closed around-bank flows may also be induced by tidal rectification (e.g. Huthnance, 1973). Tidal current interactions with offshore banks also promote the breakdown of stratification; these local mixing effects may be important in determining chlorophyll levels in the vicinity of the banks. Offshore canyons that intersect the continental slope may significantly modify the local circulation: these permit increased cross-shelf motion by allowing the geostrophic constraint on steep slopes to be broken. They also produce enhanced upwelling, typically at their equatorward sides. A topographic feature is the Joint Effect of Baroclinicity and Relief (JEBAR; Huthnance, 1995; Hill *et al.*, 1998). JEBAR plays a role in the generation of slope currents: an offshore pressure gradient develops as a result of differences between shelf and oceanic meridional gradients in steric height (sea level contractions/expansions related to temperature), which drives poleward along-slope flow. Thus, the local structuring of regional current flow patterns by topographic features can result in population boundaries and retention areas.

In the open ocean topographic features play an important role in ocean dynamics, as well as in the distribution of biological patterns. Most of the surface of the oceanic region around the Azores is abyssal plain with average depth >ca 4000m (Santos *et al.*, 1995a). The major topography feature is the mid-Atlantic Ridge (MAR) that follows a sinuous course southwards from Iceland, where it is known as Reykjanes Ridge, to the Azores.

Typically not reaching 1000m depth, MAR effectively stops even the upper ocean flows, forcing the North Atlantic Subtropical Gyre (SG) to recirculate mainly to the Western North Atlantic (Bower *et al.*, 2002). The limited cross-ridge exchange between the Western and Eastern North Atlantic basins is supported by the observed sea-surface isotherm tilt, maximum on the western side of MAR (Bashmachnikov *et al.*, 2004). The cross-basin connection principally occurs through the deep fracture zones and affects the whole North Atlantic circulation (see http://www.mar-eco.no, ICES 2008a). Topographic steering of the upper ocean currents was observed also in the shallowest part of MAR (the Azores plateau). After crossing MAR a branch of SNAC sharply turns south, resulting in cold water anomaly over the Central Azores (Bashmachnikov *et al.*, 2005).

Islands and seamounts are other prominent topographic features, which are characterised by very specific circulation patterns and play an important role in ocean biological system, representing oasises for many marine species. Localised dynamics around seamounts is characterised by amplified near-seabed currents, (semi)enclosed circulation patterns, doming of density surfaces and enhanced vertical mixing (White *et al.*, 2007). Theoretically, the higher biological productivity over seamounts should result from enhanced vertical nutrient fluxes to the euphotic zone due to either local upwellings or increased vertical mixing over their summits (Mullineaux and Mills, 1997). In practice, constantly moving localised areas of flow acceleration and stagnation/retention result in significant biological patchiness. Thus, an increase of primary productivity over a seamount is not always confirmed with observations. Comparatively high retention times around a seamount may result in a trap of organic matter fluxes transported by an impinging flow by the topographic rise. This may be another source of organic material, and forms another hypothesis for the observed higher fish concentrations over the seamounts (White *et al.*, 2007).

1.2.1.2 Hydro-physical characteristics

Water masses

The Northeast Atlantic waters (above 600-700m) are dominated by high-salinity North Atlantic Central Water (NACW), although there is considerable latitudinal variability (Figure 4). Three main modifications of NACW are identified (Figure 5a) (Pollard *et al.*, 1996). The first, West NACW (WNACW), is related to advection-diffusion penetration into the region of study. Various types of WNACW are described: 11-12^{o}C water, transported with NAC at 45-50^{o}N, 16^{o}C water transported across the Azores region in-between 37-45^{o}N and 18^{o}C water transported with AzC at 30-35^{o}N. WNACW influences the upper layer, mainly the western and north-western parts of the region. The second modification represents East NACW (ENACW). It has 0.1psu higher salinity than WNACW, and is divided into two branches: Polar and Tropical modes. The Polar mode ($ENACW_p$, 11-12^{o}C) is formed at the Bay of Biscay, to the east of 20^{o}W and in between 45-50^{o}N, and it diffuses towards the west and south-west, reaching the Azores. The southern variety of ENACW is called tropical ENACW ($ENACW_t$) and has 13^{o}C characteristic temperature. It is observed mainly close to the continental margin, between the Canaries and Iberia. $ENACW_t$ mode has been identified (e.g. Fiúza and Halpern, 1982; Fiúza, 1984; Ríos *et al.*, 1992) and is thought to originate at a frontal region near the Azores, spreading with the general eastward flow towards Iberia. Another hypothesis is that $ENACW_t$ is formed at the westward recirculation of the waters of the AzC, turning NW at the coast of Portugal and then mixing with $ENACW_p$ (Pollard *et al.*, 1996). Close to the continental margin it was detected as far north as off Cape Finisterre (43°N), where subsurface front exists between the $ENACW_T$ and the cooler and fresher $ENACW_P$ (e.g. Fraga *et al.*, 1982). In the region of each of these water mass boundaries, i.e. Cape Finisterre, intense upwelling is experienced (Fraga, 1981).

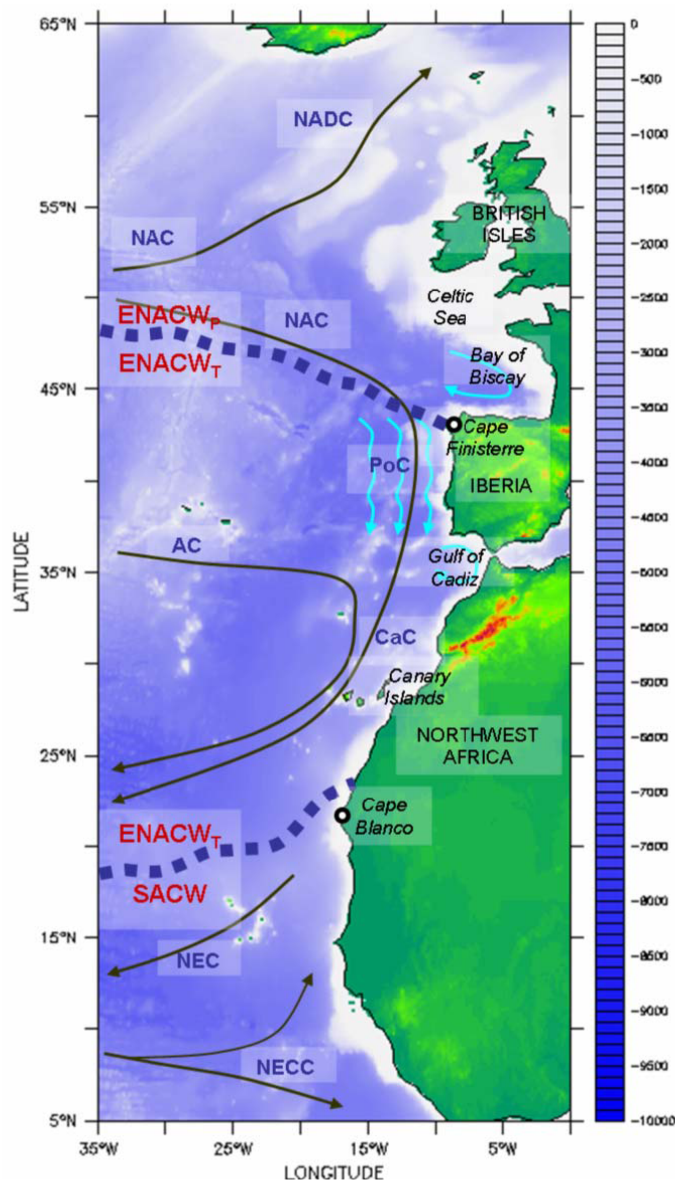


Figure 4. The main water masses in the Advisory region G are the North Atlantic Central Water of sub-polar (ENACWp) and sub-tropical (ENACWt) origins and South Atlantic Central Water (SACW). The main large Atlantic Current (NAC), the Azores Current (AC), the Canary Current (CaC), the Portugal Current (PoC), the North Atlantic Drift Current (NADC), the North Equatorial Current (NEC) and the North Equatorial Counter Current (NECC) are also shown. Dashed blue lines represent water mass fronts. The general circulation of the Bay of Biscay and the Gulf of Cadiz are indicated. Source: Mason *et al*., (2006).

Below the main thermocline, several water masses are identified: Mediterranean water (MW), Subarctic Intermediate water (SAIW) and Antarctic Intermediate water (AAIW). SAIW is formed at the frontal zone of the northern branch of NAC and has very limited area of presence (Figure 5b). It can be detected in the NW of the study region. Very modest freshening influence of modified AAIW (mAAIW), just overlying the MW upper salinity maximum, is limited to the south-easternmost part, where it penetrates north along the African coast to turn west just north of the AzC (Tsuchiya, 1989; Van Aken, 2000). The most pronounced water mass in the region is the MW, spreading west from the coast of the Iberian Peninsula at 800-1200m depth (Figure 5c). In the north-western part of the region (Figure 5d) the MW competes, and is partly underlain by Labrador Sea water (LSW, with the core at 1800-2100m). LSW can be traced only at the eastern side of MAR, north of the Azores. In the most of the region MW is spreading over the North Atlantic Deep Water (NADW), observed from 1200-1500 to 3500m depth. The deepest troughs in the region are filled with the Antarctic Bottom Water (AABW).

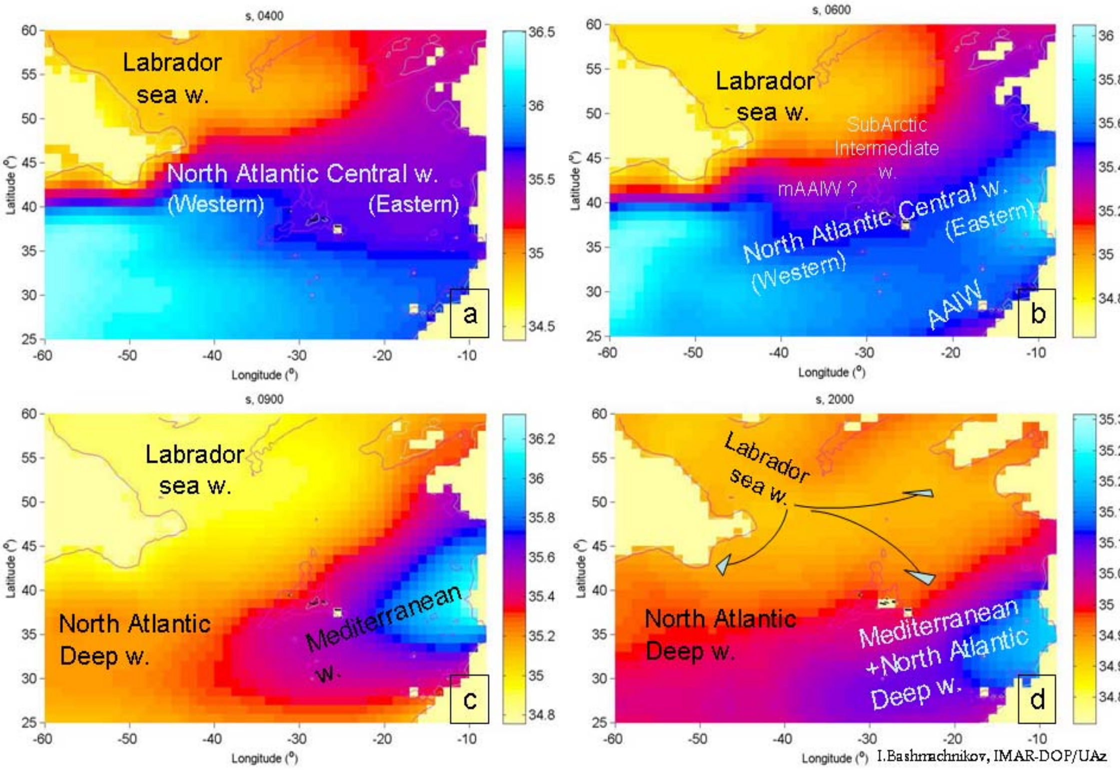


Figure 5. Distribution of water masses in North Atlantic: a-400m, b- 600m, c- 900m, d- 2000m. See text for abbreviations. The data are obtained from the World Ocean Atlas (WOA05) (Bashmachnikov and Martins, 2007).

Coastal upwelling occurs off the western Iberia mainly during the summer months (July, August, and September) as a result of coastal surface divergence due to northerly predominant winds. Space and time variations of this phenomenon were related to the wind patterns in the region (Fiúza *et al*., 1982; Fiúza, 1983). During the upwelling period, the wind forcing opposes the density forcing associated with the meridional density gradient. Upwelling causes the surface dynamic height to decrease towards the coast and the resulting equatorward geostrophic current can counter the poleward slope current at and near the surface, establishing a southward flow. However, waters below 100-200m still flow poleward as an undercurrent (Haynes and Barton, 1990). The consequences of subsurface waters being upwelled are not only the lowering of the sea surface temperature (SST) but also the increase of primary productivity as evidenced by satellite remote sensing images, respectively in the infrared and visible. The subsurface water that reaches the surface in the coastal zone during upwelling is transported to the open sea as relatively cold and nutrient-rich filaments, extending offshore for hundreds of kilometres. This is thus, a focal point for strong interaction and intensification of water, organic and inorganic matter exchanges, between the coastal region and the open sea. It also allows the exchange of carbon dioxide through the interfaces ocean-atmosphere and ocean-biosphere. The effect of the upwelling on the chemical parameters of the coastal waters off Portugal is also an important issue which was characterised by Coste *et al*. (1986). The mesoscale processes like jets, eddies, and counterflows associated with the upwelling have been investigated by Peliz *et al*. (2002). The high productivity consequences on the trophic chain are well-known in upwelling regions and the Portuguese fisheries benefits from this (Fiúza, 1979; Chícharo *et al*., 2003). Although upwelling off Portugal occurs mainly during summer months, there are also winter events which can have impact on the biology (Santos *et al*., 2004; Ribeiro *et al*., 2005). On occasions, water upwelled on the west coast extends around Cape St. Vincent eastward along the Algarve shelf (Fiúza, 1983).

There are three major nearly zonal flows, which divide the region of study into the Tropical, Subtropical and Mid-latitude North Atlantic areas (Figure 6). At the north, the southern branch of the North Atlantic current (SNAC, 45-48^{o}N over the MAR, passing mainly through Maxwell fracture zone) separates the Mid-latitudes and Subtropics (Bower and Appen, 2008). SNAC is a secondary branch of the North Atlantic Current (NAC), a major portion of which heads northeastward, passing through Charlie-Gibbs and Faraday fracture zones and becoming the North Atlantic Drift Current (NADC) located between Iceland and the British Isles. Further south the Azores current (AzC, 33-36^{o}N, crossing MAR through Oceanographer and Hayes fracture zones) separates Subtropics from Tropics (Klein and Siedler, 1989; Alves *et al*., 1994; Alves, 1996). Finally the southernmost tip of the region is a domain of the North Equatorial current (NEC), which separates Tropics from Equatorial waters, already outside the area of study. The most intensive NAC and AzC transport 35 and 12Sv (1 Sverdrup=$10^{6}m^{3}\cdot s^{-1}$), respectively (Stramma, 2001). NEC transports 9-12Sv. The SNAC and AzC exchange is enabled by the broad, slow, southward-flowing Portugal Current (PoC), which transports about 3Sv (Pérez *et al*., 2001). AzC and NEC are connected with the Canary Current (CaC), as well as 2-3 secondary branches of the AzC, channelling water south at different longitudes in-between MAR and the African coast (Krauss, 1996). The CaC transports 5Sv.

There are different opinions whether the Subtropical Atlantic region should or should not be included in the SG recirculation. In the Eastern North Atlantic basin Gould (1985) suggested associating the northern border of the SG recirculation with the AzC frontal interface (reaching 800m depth). This interface has the highest meridional temperature differences in the region (up to 1^{o}C per 50 km) and is marked by near the surface with 18^{o}C isotherm (typical SG, or more precisely − Sargasso Sea water temperature). Still, not all authors completely agree with this definition. As an argument for shifting the border of the SG to the front further north to SNAC, several works address dominance of the eastward mean drift in the upper 200-500m layer over the Azores region, which continues further to the east and finally turns south, merging the Portugal current (Pollard and Pu, 1985; Bashmachnikov *et al*., 2004). Thus, in some recent works, the Subtropical waters are included in the SG recirculation (Tomczak and Godfrey, 2001; Talley, 2003).

In the deep ocean the currents are typically bottom trapped. The major circulation patterns in the area of study are represented with the flows directed along the eastern wall of MAR to the south, and along the African-European continental margin to the north. Among those, the Labrador Sea water spreads to the south along the northern section of MAR, down to the northern slope of the Azores plateau (Bower *et al*., 2002). Dense Mediterranean Water (MW) leaves the Strait of Gibraltar and rapidly sinks to below 1000m in the Gulf of Cadiz. With a characteristically-high salinity and temperature, MW spreads to the north along the continental slope of the Iberian Peninsula, and further north along the Biscay bay. Part of the MW leaves the coast to form as a tongue far into the North Atlantic. The later process is partly maintained by a non-advective mechanism, involving the formation of Mediterranean Water Eddies (Meddies). Meddies gradually loose their heat-salt content. Collision with seamounts may result in abrupt release of the core contents to the surrounding water, reaching up to 25-40% of the material, transported thousands of km´s away from the continent (Richardson *et al*., 2000, Bashmachnikov *et al*., in press, a). Meddies diffuse the heat-salt anomaly not only in horizontal, but also in vertical direction, influencing the whole water column. They are also observed to trap and transport away stretches of upper layer frontal interfaces, thus executing thermohaline exchange also in the upper ocean layer (Bashmachnikov *et al*., in press, b).

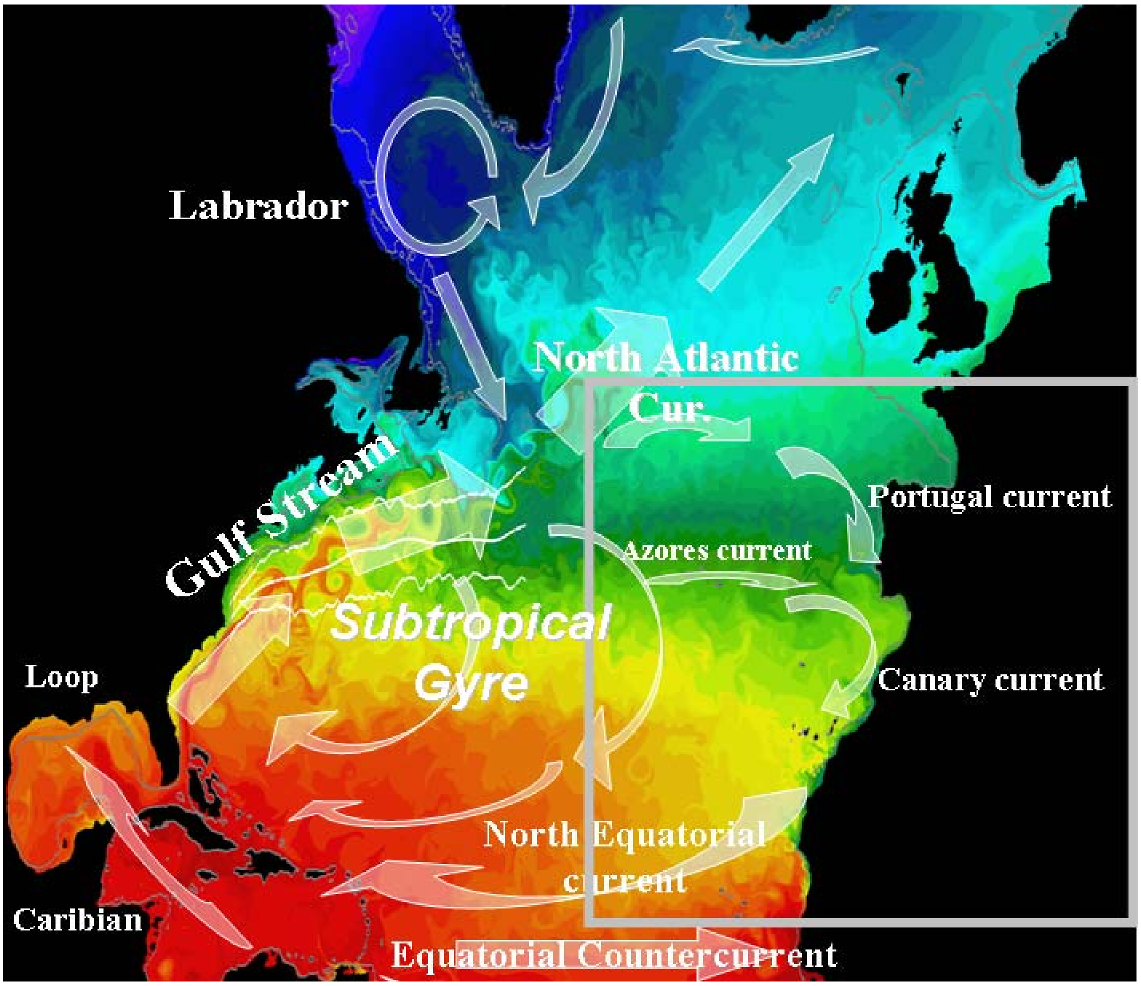


Figure 6. Scheme of general circulation patterns in the North Atlantic overlaid on the SST pattern, obtained from http://oceancurrents.rsmas.miami.edu/atlantic/atlantic-arrows.html). The grey square marks MEFEPO region.

Currents

The near-surface circulation is primarily driven by the wind. The circulation of the west coast of the Iberian Peninsula is characterised by a complex current system subject to strong seasonality and mesoscale variability, showing reversing patterns between summer and winter in the upper layers of the shelf and slope (e.g., Barton, 1998; Peliz *et al.,* 2005, Ruiz-Villareal *et al.,* 2006). During spring and summer northerly winds along the coast are dominant causing coastal upwelling and producing a southward current at the surface and a northward undercurrent at the slope (Fiúza *et al.*, 1982; Haynes and Barton, 1990; Peliz *et al.,* 2005, Mason *et al*., 2006). Off the Iberian Peninsula, meridional shifts in the atmospheric highs mean that the equatorward wind forcing reverses seasonally to become poleward in autumn and winter.

Further to the north, over the northwest European shelf, the wind stress has a more westerly component; the winds here are energetic and prevail for much of the year.The oceanic part of the Bay of Biscay is characterised by a weak (1-2cm/s) and variable anticyclonic circulation (Koutsikopoulos and Le Cann, 1996), as well as by cyclonic and anticyclonic eddies shed by the slope current (Pingree and Le Cann, 1990a). These features are illustrated below in Figure 7.

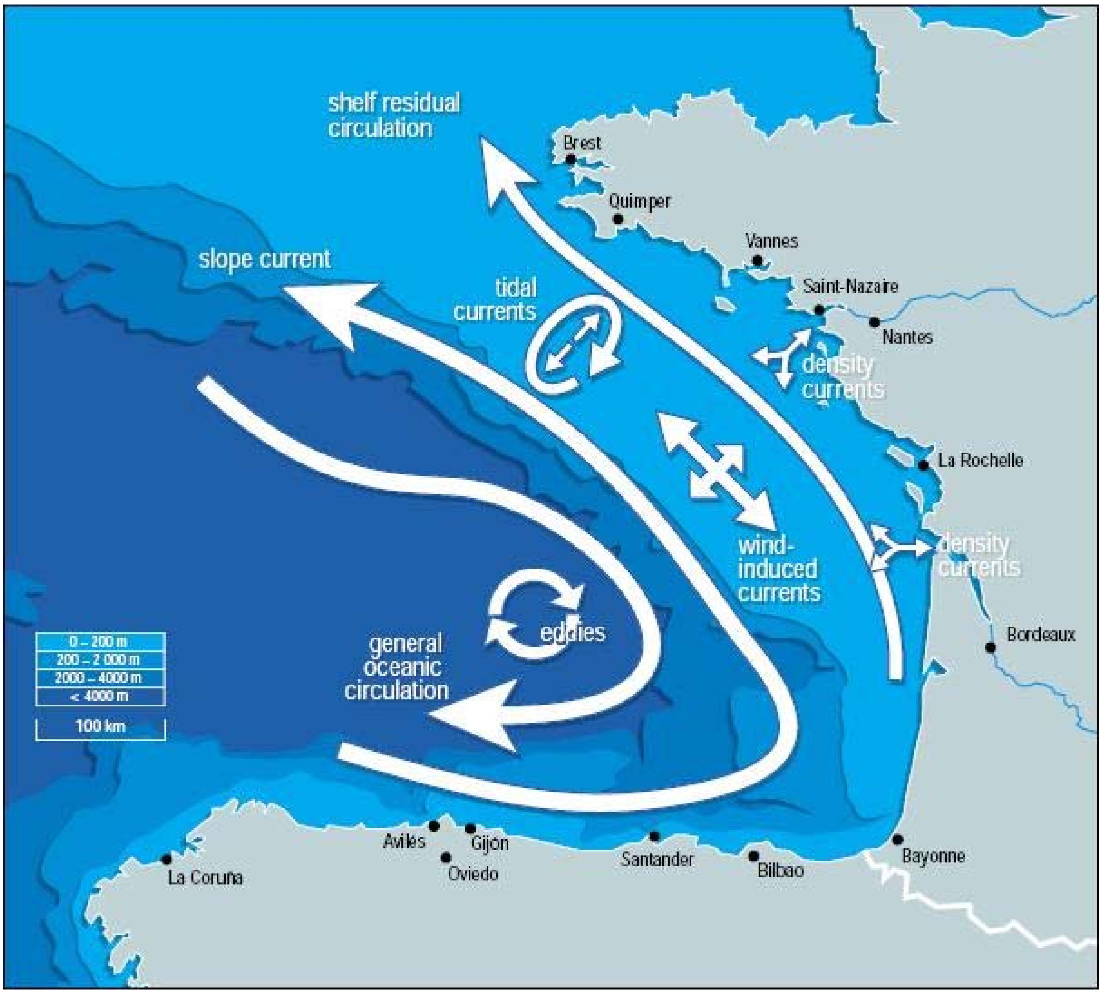


Figure 7. Schematic illustration of circulation in the Bay of Biscay. (Source: Koutsikopoulos and Le Cann, 1996).

The deep part is characterised by the presence of strong eddies. Such eddies of water warmer than the ocean water are generated at the continental slope, close to topographic features such as the canyon of Cap Ferret.

On the continental slope, currents go along isobaths and show many fluctuations at all scales of time. They seem to have a significant seasonal component. In winter and autumn, they are oriented towards the east along the Spanish coast and northward along the French coast. In spring, this trend weakens and can often be reversed (Lazure, 1997).

On the continental shelf, tide-driven currents become significant. They can become locally dominant at low depths: near to the coast, islands or shoals. Within these areas, vertical mixing is important and water bodies are well mixed from surface to bottom. However, on the majority of the continental shelf, at depths exceeding 30 m, tidal currents are weak and the water bodies are mainly set in motion by the winds. The strength and direction of ocean currents depend on the wind, which makes them highly variable (unlike tidal currents). Further, winds are likely to induce vertical movements (upwelling) near the coast, including off Landes. This rising water allows enrichment of coastal waters by nutrients (Lazure, 1997).

In the Cantabrian Sea the surface currents generally flow eastwards during winter and early spring and change westwards in late spring and summer following the wind forcing (Lavín *et al*., 2006). In autumn and winter, the surface circulation is predominantly northwards, partially driven by southerly winds and meridional alongshore density gradients (Peliz *et al*., 2003a, b), and transporting higher salinity, nutrients-poor and warmer (subtropical) waters over the shelf break (Frouin *et al*., 1990; Haynes and Barton, 1990; Pingree and Le Cann, 1990a; Ruiz-Villareal *et al*., 2006), the Iberian Poleward Current (Peliz *et al*., 2003b). The establishment of this poleward flow occurs as a response to the reversal of the wind regime and to meridional density gradients. The geostrophic flow of the northeast Atlantic is eastward in a broad band north of 33ºN, where a meridional density gradient, associated with the poleward cooling of the sea surface, is observed in the upper 200-300 meters (Pollard and Pu, 1985). Such a density gradient can force a poleward current, intensified over the slope and increasing northward (Huthnance, 1984). This Portugal Coastal Countercurrent carries relatively warm and salty subtropical water along the continental slope, at velocities around 0.2-0.3$m \cdot s^{-1}$, with increasing downstream transport, and seems to have important biological consequences, like the occurrence of subtropical origin species in the Gulf of Biscay region. It was first identified by using both remote sensing imagery and *in situ* measurements (Frouin *et al*., 1990; Haynes and Barton, 1990). An overview of the upper ocean circulation off the western Iberia is presented in Peliz *et al*. (2005).

The Iberian Poleward Current (Peliz *et al*., 2003b) contribute to fronts over the shelf that determine the coastal distribution of plankton, fish eggs and larvae (Fernández *et al*., 1993; González-Quirós *et al*., 2003) in western Iberia and the Cantabrian Sea (Villamor *et al*., 2005). Another important feature of the upper layer is the Western Iberia Buoyant Plume (WIBP) (Peliz *et al*., 2002), which is a low salinity surface water body fed by winter-intensified runoff from several rivers from the northwest coast of Portugal and the Galician Rias. The WIBP could play an important role in the survival of fish larvae (Santos *et al*., 2004). The intermediate layers are mainly occupied by a poleward flow of Mediterranean Water (MW), which tends to contour the southwestern slope of the Iberia (Ambar and Howe, 1979), generating mesoscale features called Meddies (e.g., Serra & Ambar, 2002), which can transport salty and warm MW over great distance. The exchange of water masses through the Gibraltar Strait is driven by the deep highly saline ($S>37$) and warm Mediterranean Outflow Water (MOW) that flows into the Gulf of Cadiz and the less saline, cool water mass of the Atlantic Intermediate Water (AIW) at the surface.

Hydrographic variability at small and middle scales

The main hydrological features of the Bay of Biscay show a marked seasonal variability (Koutsikopoulos and Le Cann, 1996). For example, slope current transport is maximum in the north in late summer, while along the Spanish slope, the transport of surface waters takes place towards the north in winter. At this season, the weakening of the wind to the south allows the development of a stream of warm water that enters the Gulf from the west coast of Spain around Christmas, giving origin to a current known as "Navidad (Puillat *et al*., 2004). The residual circulation is weak and directed to the north-west over the Armorican shelf. In the south, instead, the residual circulation is oriented to the NW in winter and to the SW the rest of the year showing a marked seasonality (Koutsikopoulos and Le Cann, 1996).

The main rivers in the French Atlantic coast, the Loire and the Gironde, show a seasonal rhythm synchronised transport of water within the sea. Their contribution is maximum in winter and it decreases in spring to reach a minimum in summer. In autumn, the flow of water begins to increase (Koutsikopoulos and Le Cann, 1996; Puillat *et al*., 2004, 2006).

In consequence of this seasonal pattern, the presence of riverine cold and fresh water on the shelf is important in winter and spring. Koutsikopoulos and Le Cann (1996) reported the reversal of vertical profiles of temperature (water surface colder than the bottom) in winter, a situation that the authors attribute to the input of rivers. In April the thermocline is shown in the western part of the plateau, and in May it is observed in the coastal region (Koutsikopoulos and Le Cann, 1996). Stratification lasts until mid-September, and then the progressive destruction of the thermocline is observed (Puillat *et al*., 2004). Thermal tidal fronts are formed in summer and early autumn as a consequence of the interaction of tidal currents with bottom topography (Koutsikopoulos and Le Cann, 1996). The interaction of currents and winds with the profile of the coast and the topography of the board are responsible for the formation of upwelling in the same season along the coast of the Landes and the Central Cantabrian Coast (Koutsikopoulos and Le Cann, 1996).

Regarding the sea surface temperature (SST), Koutsikopoulos and Le Cann (1996) reported the existence of temporal trends and spatial heterogeneities in the southern part of the gulf. These authors suggest that the temperature is 1°C higher in front of the Spanish coast than over the French shelf, from January to mid-April. A rapid increase is observed in spring. The rate of increase is higher in the south-east of the bay, and it is in this region that the warming begins. From May onwards, a north-south gradient is observed on the French shelf. Towards the end of August the difference between the north-west and south-east is 2°C. Three months later, the SST is almost the same on the French shelf, while the Spanish shelf water of the sea remains warmer.

The conditions from May to August, when the SST is higher in the southeastern Bay of Biscay, have been explained by a change in the wind regime (Koutsikopoulos and Le Cann, 1996). Wind records along the French coast have shown a seasonal pattern and a latitudinal gradient, with stronger winds in the northern gulf. Anticyclonic ocean circulation was also related to wind regime (Le Cann and Pingree, 1995). Regarding mesoscale structures, these authors have described upwellings in the southern part of Brittany caused by winds coming from north-northwest.

Puillat *et al*. (2004) concluded that the variations of winds at a scale of about 15 days and the river discharge at 3 to 6 months are responsible for the monthly distribution of surface salinity, and also contribute to the interannual variability of this parameter.

Hydrographic variability at large scale

The eastern North Atlantic boundary is a highly complex region which is largely meridionally orientated, but there are significant zonal and other anomalous stretches, particularly in the Bay of Biscay and the Gulf of Cadiz. Two further unique topographic features are the Strait of Gibraltar, where dense Mediterranean Water leaves the Mediterranean Sea passing through the Gulf of Cadiz, and the Canary Island archipelago, which disturbs the prevailing oceanic (and atmospheric) flows producing significant downstream variability. These features are, individually and in sum, major contributors to the complex and variable circulation system, onto which are superimposed the multi-scale seasonal and inter-annual variations in atmospheric forcing, heating, and input of buoyancy through river discharges.

Within the Bay of Biscay, large scale hydroclimatic variability has been shown to be driven by three main factors (1) the sea surface temperature (SST) (2) wind speed and (3) and river fluxes (Planque *et al*., 2003). These authors have shown that during the 90's, SST was higher, winds were stronger and continental water inputs were slightly lower compared to the mean values for these parameters during the previous century. Thus, according to various authors (Koutsikopoulos *et al*., 1998; Planque *et al*., 2003; Désaunay *et al*., 2006) SST would rise of some 0.6-to 1.2°C every ten years since the end of the twentieth century. Wind speed has also varied over the last century: the analysis of the COADS database (Comprehensive Ocean-Atmosphere Data Set, Woodruff *et al*., 1993) has shown that mean speed decreased from 1850 to 1920 and then increased regularly until 2000. Thus, mean wind speed between 1991 and 2000 was ~$1 m \cdot s^{-1}$ higher compared to mean wind speed of previous decades. Mean wind speed was also higher during non-winter periods (Planque *et al*., 2003) after 1990 and within the northern part of the bay. River inputs are highly interannually variable but they are shown that while such variability was still very high during the 1990 decade, those inputs were significantly lower than those of previous decades.

The upper waters of the Bay of Biscay have experienced progressive warming during the past and the present century. Mean surface water temperatures increased by 1.4ºC in the southeastern Bay of Biscay over the period 1972–1993 (0.6ºC per decade) and by 1.03ºC over the past century (Koutsikopoulos *et al*., 1996; Planque *et al*., 2003). The increase in heat content stored in the water column appears to be greatest in the 200–300m layer (González-Pola and Lavín, 2003), and it is in this layer that eastern North Atlantic central waters (ENACW) respond quickly to climate forcing in areas of water mass formation located in the northern Bay of Biscay and adjacent areas. In the southern Bay of Biscay, temperature has increased during the last decade in the ENACW by 0.032ºC y^{-1} and in the Mediterranean Water around 0.020ºC and 0.005 for salinity. These warming rates are from two to six times greater than those accepted for the North Atlantic in the course of the 20th century. The overall result is a net warming of 0.24ºC for this water column in the period 1992-2003 (Gonzalez-Pola *et al*., 2005). However, despite an increase of 0.26ºC per decade in the southeastern waters of the Bay of Biscay during the period 1977-2007, a slightly decreasing trend has been shown in the mean annual temperature for the period 1947-2007 (Goikoetxea et al., 2009).

The most important features enhancing primary production are coastal upwelling, coastal run-off and river plumes, seasonal currents, and internal waves and tidal fronts. Water temperature is highest to the south, where it is influenced by the MW. For example, the yearly mean temperature at 100m depth is 11.2°C to the north of the advisory region, 48°N, and 15.6°C to the south, 36°N (Levitus, 2001).

In northeast Bay of Biscay, mainly in summer, upwelling events occur off southern Brittany and the Landes coastline and may induce low-salinity lenses detached from the river plumes (Koutsikopoulos and Le Cann, 1996; Puillat *et al*., 2006; Lavín *et al*., 2006) (Figure 8). In Portugal, west of Galicia and in a narrow coastal band in the western Cantabrian Sea, upwelling events are a common feature, especially in summer (Figure 9) (Fraga, 1981; Fiuza *et al.,* 1982; Blanton *et al.,* 1984; Botas *et al.,* 1990; OSPAR, 2000). Summer upwelling is important in the Western Iberian Sea, as the occurrence of upwelling pulses injects nutrients to the surface layer. This fuels primary production. Under conditions of moderate upwelling, the innermost coastal 25km are about 10 times more productive than offshore waters and the upwelling centres are about 20 times more productive (ICES, 2006d). Upwelling generally develops between April and October. The Portuguese coastal upwelling is part of a more general system that extends southward to 15ºN, the Canary Current Large Marine Ecosystem (Santos *et al.*, 2001). Upwelling has been seen to influence fish growth (Muck, 1989) and recruitment (Peterman and Bradford, 1987; Cury and Roy, 1989; Borja *et al.*, 1998; Allain *et al.*, 2001; Santos *et al.*, 2001).

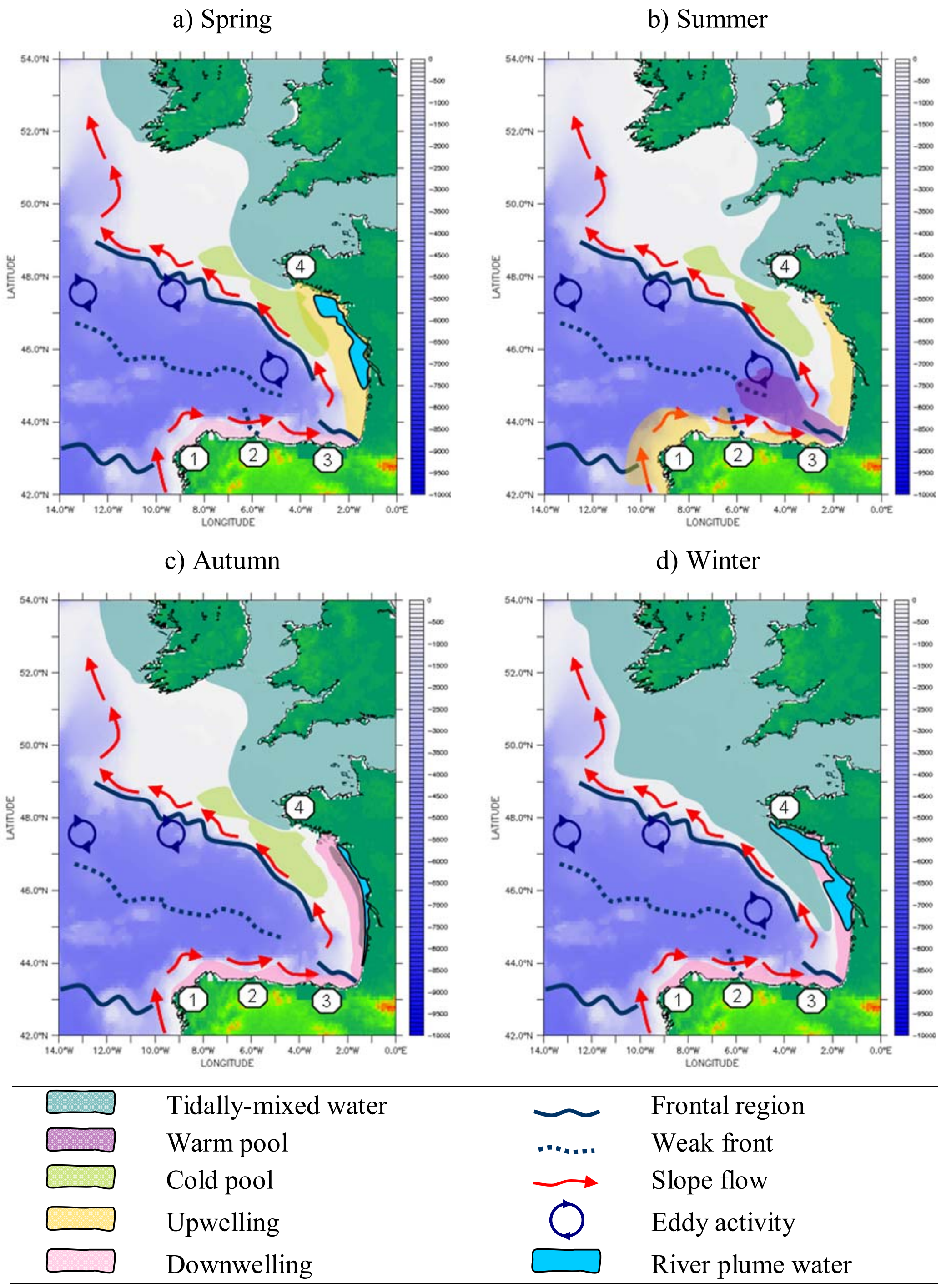


Figure 8. A series of four figures showing the seasonal features that characterise the Celtic Sea and the Bay of Biscay: 1) Cape Finisterre; 2) Cape Peñas; 3) Cape Matxitxako; 4) Ushant. Adapted from Koutsikopoulos and Le Cann (1996).

The Bay of Biscay shelf hydrology is structured in spring, and one large central area characterised by vertical stability and low temporal variability seems to have a persistently low pelagic fish spawning activity (Planque *et al*., 2006). There is no thermal stratification from January to April, stratification occurs from May to mid-September in a layer ~ 50m deep and disappears progressively in autumn. In contrast, the haline stratification is strong from March to June (Puillat *et al*., 2004).

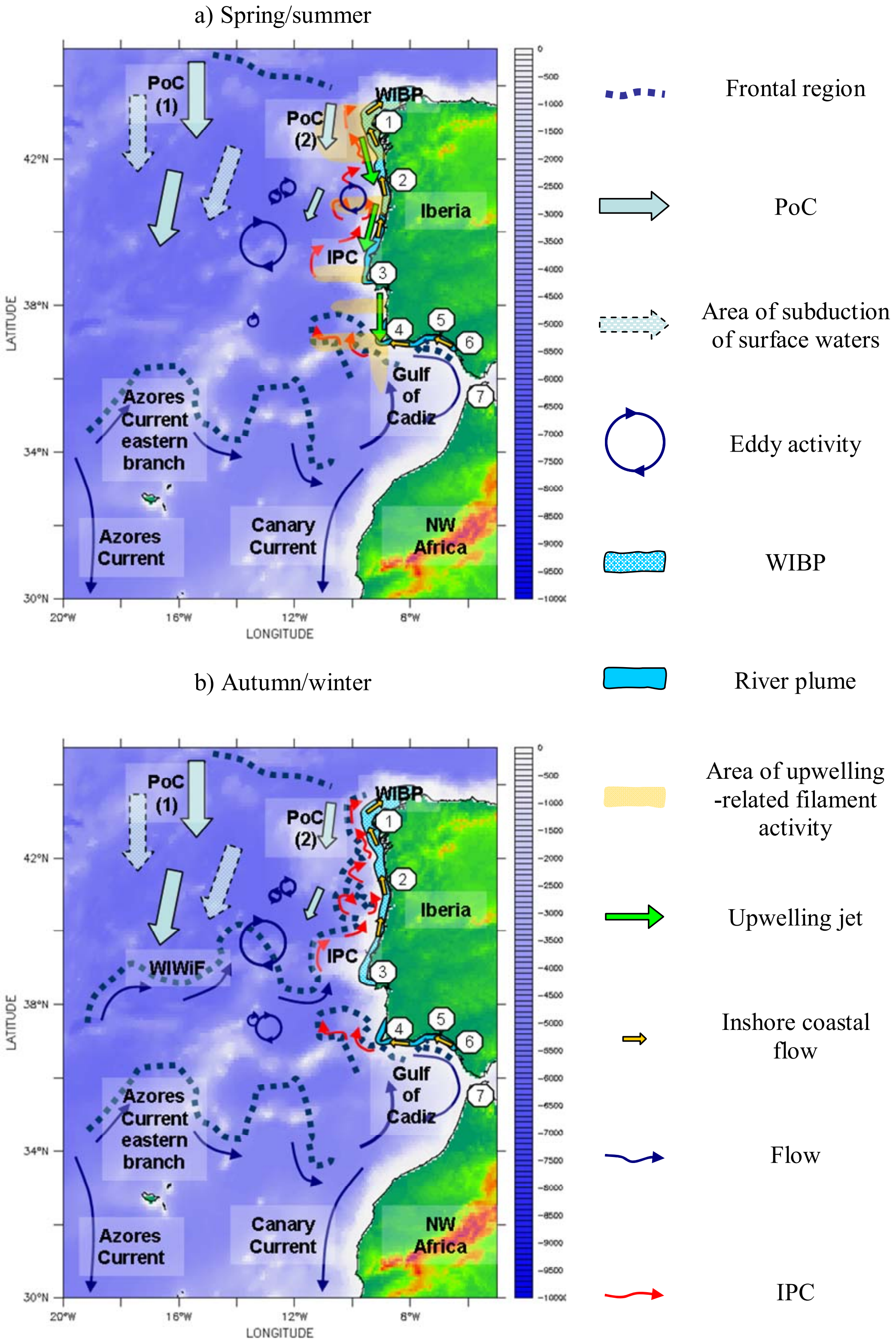


Figure 9. The western Iberia and Gulf of Cadiz regimes in a) spring and summer, and b) autumn and winter. 1) Cape Finisterre; 2) River Douro; 3) Cabo da Roca; 4) Cape St. Vincent; 5) Guadiana River; 6) Guadalquivir River; 7) Strait of Gibraltar. Adapted from Peliz *et al.* (2002; 2005).

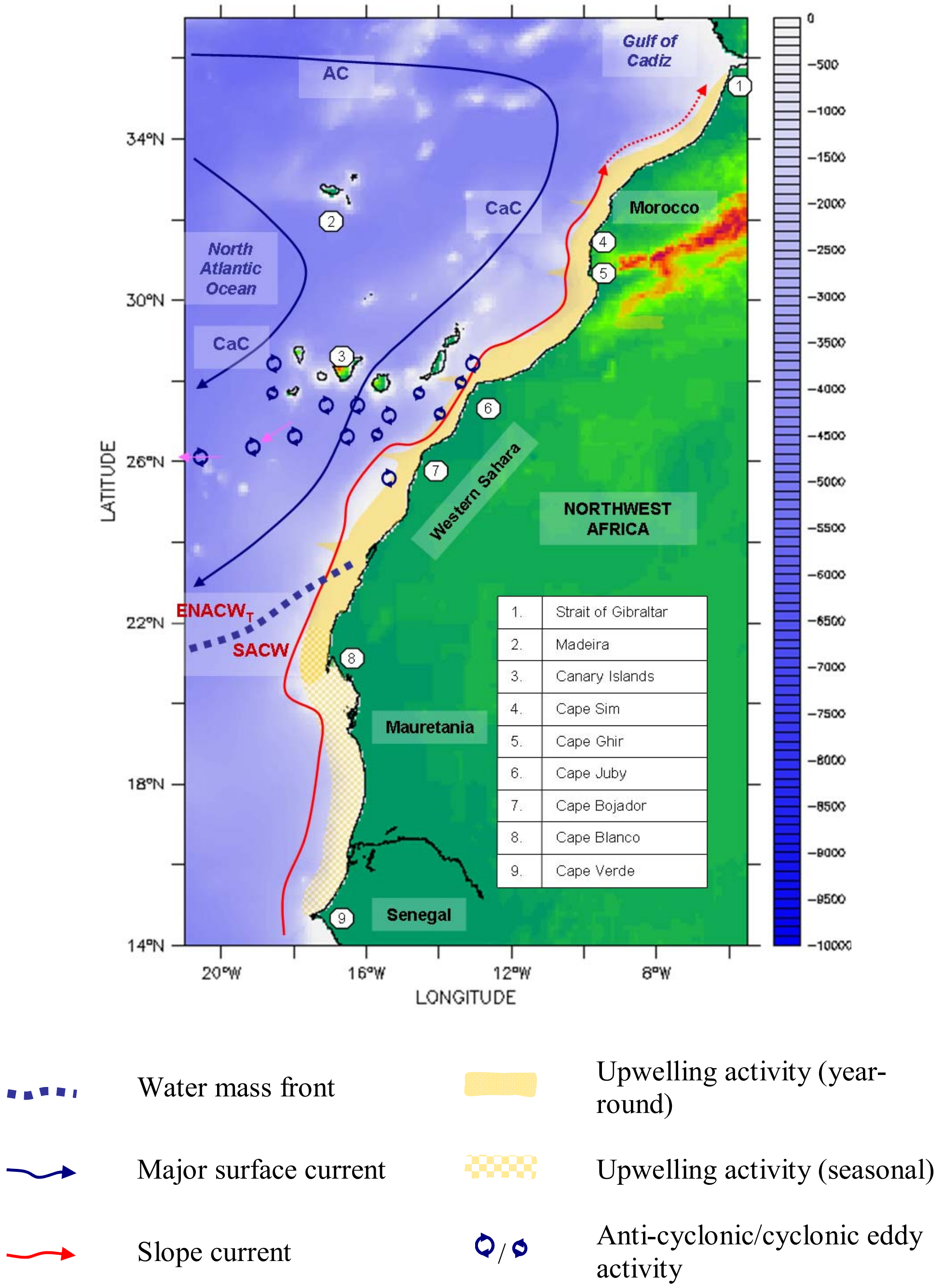


Figure 10. The northwest African upwelling region. Upwelling continues all year down to about 20°N; further south it is seasonal (January-May). AC-Azores Current, CaC-Canary Current, ENACWT-Eastern North Atlantic Central Water of sub-tropical origin, SACW-South Atlantic Central Water.

Since the 1940s annual mean speed has tended to decrease in the south of the Bay of Biscay whereas it has increased in the north. However, these trends are small compared with the degree of interannual variability at each station (Planque *et al*., 2003). A notable shift in the winds off northwestern Iberian has occurred during the last two decades, resulting in a reduction in the spring–summer upwelling (Cabanas *et al*., 2003).

On a yearly average, the French region received 2700$m^3 \cdot s^{-1}$ of run-off from the major rivers. The time-series of the flow of the Loire River (870$m^3 \cdot s^{-1}$ of annual mean flow) shows that recent years have been below average. Winter run-off and resuspension induce high non-living Suspended Particulate Matter (SPM) concentrations in the river plumes of the Bay of Biscay shelf; which has important ecosystem effects (Froidefond *et al.*, 2002). SPM extends over the entire Bay of Biscay shelf during winter with mean concentrations around 3$mg \cdot m^{-3}$ (Huret, 2005).

As regional examples, Figure 8, Figure 9 and Figure 10 show the Bay of Biscay, off western Iberia and Canary region principal seasonal features.

1.2.1.3 Spatial and temporal distribution of salinity

According to the analysis of hydrographic records on the French continental shelf during the 90's, Puillat *et al.* (2004) have identified two patterns of seasonal variation of surface salinity in spring and autumn. In spring the surface salinities are more variable (between 30 and 35.7). The waters of very low salinity (S <34) are close to the coast, while isohaline 35 is at the height of the isobath of 100m. In May-June water with very low salinity are still present, and those of low salinity are distributed beyond the isobath of 100m. These conditions coincide with the period of maximum discharge of water from rivers. Towards the end of the summer and in autumn the variability of surface salinity is lower. The destratification begins in September with the convective mixing caused by winds. The minimum salinity is between 33 and 34 this season. North of 46° N there is a significant increase in salinity in a coastal strip of about 100km wide, where water salinity below 34 is replaced by another of salinity greater than 35. A more or less of salinity was also found further offshore and further south. This increase is linked to reducing the discharge of rivers (Figure 11).

Differences in the distribution of salinity observed between years are related to the discharge of continental waters and winds (Puillat *et al.*, 2004).

Generally speaking, on the continental shelf, bottom salinity is close to 35. At slope depth, high salinities are found due to the MW (values around 37.0 in the Gulf of Cadiz and above 35.5 in the Bay of Biscay) (Figure 12).

The annual sequence of events generally follows the seasonal cycle of temperate seas. During winter, cold, low salinity waters occur over the continental shelf off the main rivers. As river water is colder than sea water during winter, thermal inversions sustained by haline stratification are commonly observed over the shelf. This is also the season when the warm, highly saline, poleward-flowing slope current presents its clearest surface signal and its northernmost extent.

Westerly or south-westerly winds keep the river plumes close to the coast. A change in the wind promotes vertical mixing over the inner shelf, a process that is further assisted by the presence of thermal inversions. River plumes will tend to dilute the water column, lowering salinity and temperature over the inner shelf and helping to sustain a cross-shore gradient between shelf water and the slope current. This process may be seen in satellite images of sea surface temperature.

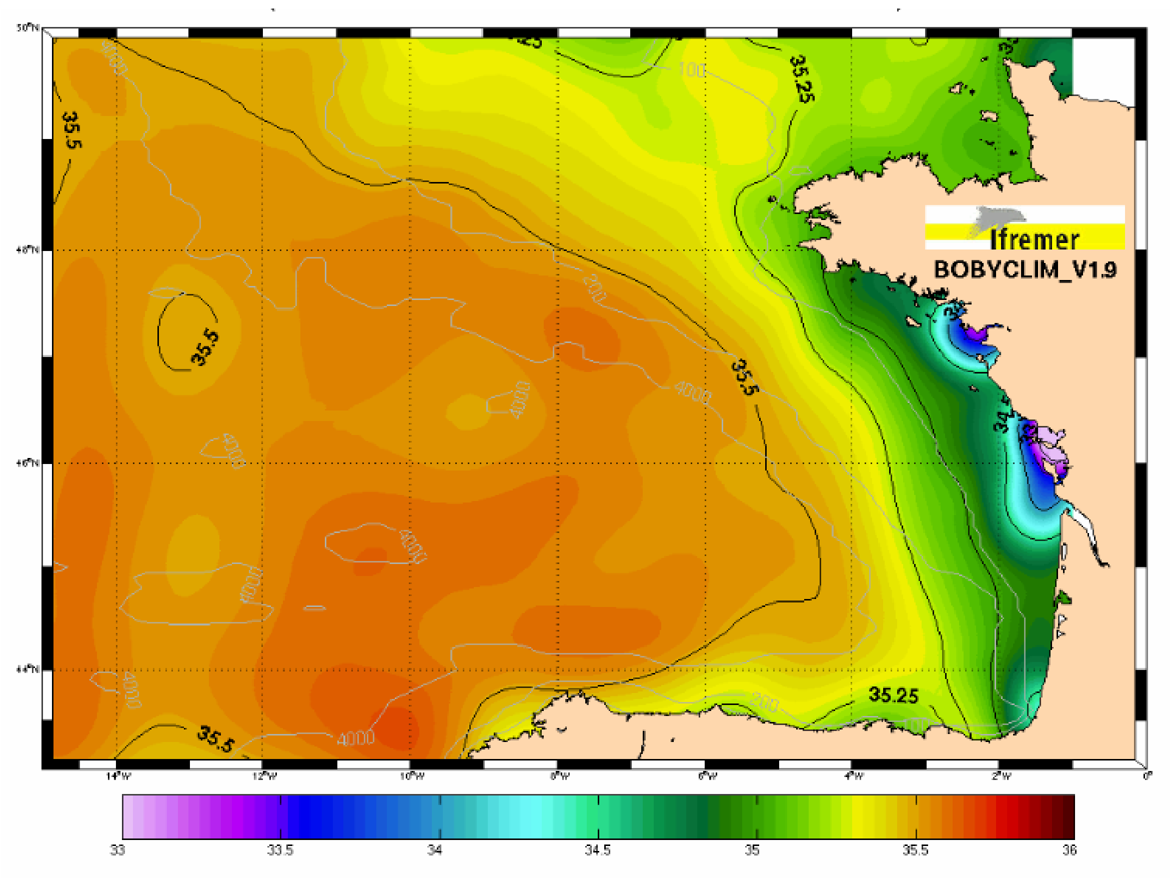


Figure 11. Surface salinity in the Bay of Biscay.

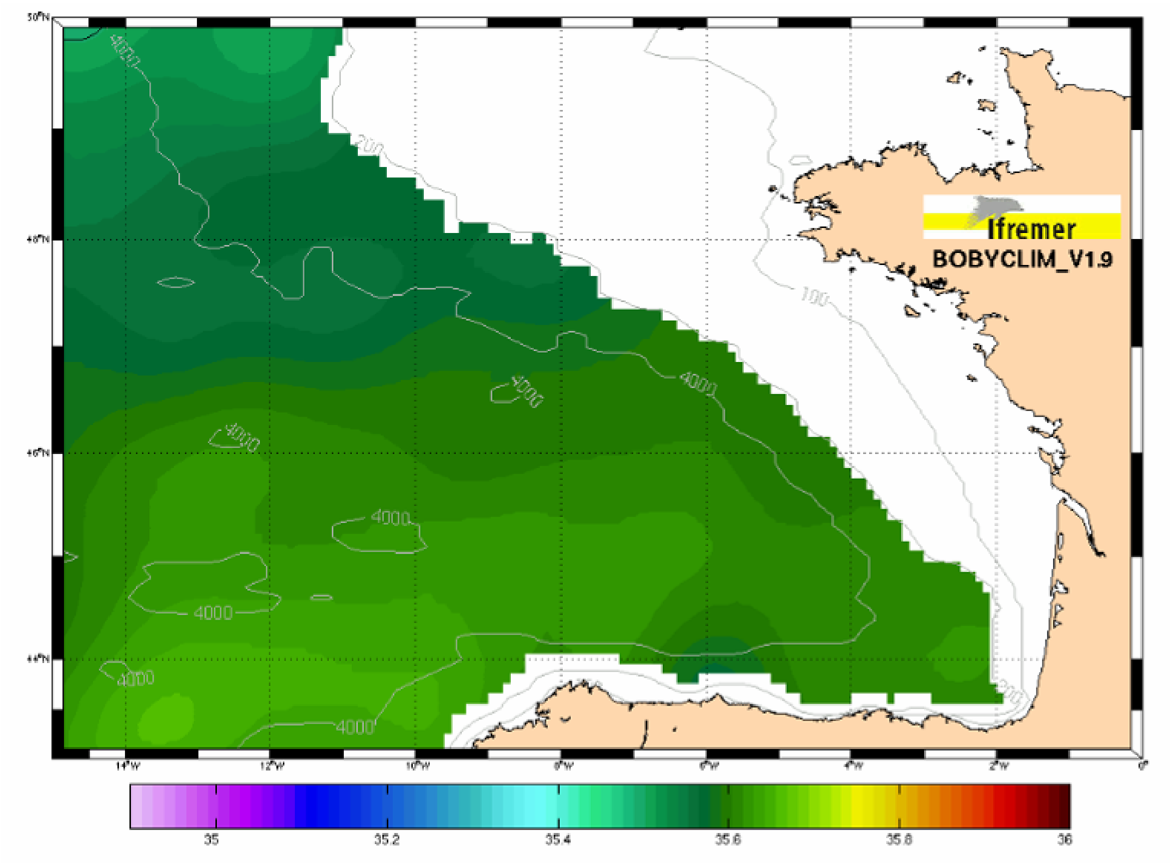


Figure 12. Salinity at 250 meters off the continental shelf of the Bay of Biscay.

In spring the low salinity waters cover a significant part of the continental shelf, depending on river run-off and the wind regime. The seasonal thermocline at the base of the thin wind-mixed surface layer appears on the outer shelf in April and the coastal area in May. Although the importance of river run-off is reduced during spring and summer, it does contribute to the thermal stratification. Below the seasonal thermocline, a cold cushion (11°C) of water centred over the 100m isobath appears off the French coast, extending from southern Brittany to the latitude of the Gironde Estuary. This is observed throughout the year, showing weak temperature variations (< 1°C).

In autumn, the haline stratification decreases because of low river discharge and wind-induced vertical mixing. North of 46°N, surface salinity increases by up to 1 inshore of the 100 m-isobath from spring to the end of summer. This seasonal evolution agrees with salinity measurements made on the inner shelf. They show a general decrease from north to south along the coast in summer, which may be linked to northwesterly wind conditions, favourable for driving surface water to the SW of the bay.

Off the Iberian Peninsula, coastal upwelling begins to become evident in late spring and reaches a maximum in summer, at which time it also occurs in the south-eastern Bay of Biscay. In summer and early autumn, the interaction of tidal currents and bottom topography results in the formation of seasonal thermal fronts in the Bay of Biscay, as is the case for example with the Ushant Front off western Brittany. Several other mixed areas occur along the French coast, generally in the vicinity of islands. Along the Armorican and Celtic slopes, frontal zones are induced by internal waves. At that time, upwelling filaments off the Iberian coast usually reach their maximum extent.

1.2.1.4 Spatial and temporal distribution of nutrients and oxygen

Nutrients

Concentrations of nutrients, namely nitrate, phosphate and silicate, in the oceanic waters are generally lower than in other oceans (Levitus *et al.,* 1993; Lozier *et al.,* 1995). The water masses that flow into the region contain relatively low concentrations of nutrients. Also, because the deep waters are relatively 'young' (i.e. they have been at the surface relatively recently), they contain relatively small concentrations of nutrients regenerated from the remineralisation of sedimentary particles. Thus, despite the comparatively great depths to which winter cooling overturns and vertically mixes the water column in the North-East Atlantic, particularly in the area to the west of the Bay of Biscay, overall productivity is not as high as in the North Pacific. Neither eutrophication nor the development of ‘red-tide’ blooms of harmful algae is likely to be induced in these open ocean waters.

Riverine inputs of nutrients are mostly removed by biological activity in estuaries and inshore waters, so further offshore the aeolian inputs assume greater importance (Duce *et al.*, 1991). These diminish downwind, but are still estimated to be providing up to 17% of the nitrogen available in the upper ocean in the subtropical waters to the south of the region.

Loire and Gironde rivers are the main nutrient input vectors overall the ecosystem. Their mean annual flow reaches $900 m^3 \cdot s^{-1}$ for each river, with peaks reaching $3000 m^3 \cdot s^{-1}$ during late winter/spring while it only reaches $200\ m^3 \cdot s^{-1}$ at the end of the summer (Lazure and Jégou, 1998).

A summary of nutrient concentrations in the Azores Current/Front (AzC or AzF) region is provided by Macedo *et al.* (2000). These authors found that mean nitrate concentrations for the first 350m can range from 0.18 to 9mmol·m^{-3}. In general, nitrate concentrations in the south of the islands are lower than those in the north and frontal areas, except between 200 and 350m when the south and AzF waters show similar concentrations. Within the first 100m nitrate profiles present a high degree of variability. Nevertheless, it is possible to observe in several stations a nutricline located between 60 and 100m; the north and front areas have a very similar nitrate concentration in this depth interval. Nitrite concentration ranges from 0 to 0.105mmol·m^{-3} and presents a completely different vertical profile from the nitrate, with higher values located between 60 and 100m. Mean phosphate concentration for the first 350m ranges from 0.03 to 1.04mmol·m^{-3}. In the AzC frontal zone, a maximum in phosphate concentration occurs in surface waters. Lower concentration values in the north and AzC front areas are observed between 20 and 80m. Mean silicate concentration ranges from 0.23 to 3.5mmol·m^{-3}. Silicate concentration is higher in the 15 MW than in the 18 MW, with the AzF showing intermediate values. The authors found that the lowest silicate values, for three surveyed areas, were observed between 20 and 80m. Nitrate, phosphate and silicate profiles, between 60 and 100m, showed that the mean concentration in the Front was very similar to that in the 15 MW, but below 200m the AzF nutrient concentrations were close to the 18°C MW values. Furthermore, there was a similarity between nitrate, phosphate and silicate mean profiles, presenting minimum values between 50 and 100m depth, which corresponded approximately to the Deep Chlorophyll Maximum (DCM) depth (Macedo *et al.*, 2000). Several cruises performed by the Department of Oceanography and Fisheries (University of the Azores) in the last two years around the Azores region provide new information on nutrients concentrations around the islands and adjacent ocean areas. These results are under statistical processing and shall be published this year (Silva *et al.*, in prep).

<u>Seasonal evolution of nutrients (sea water)</u>

Seasonal variations in nutrient inputs are described for the main rivers (Loire and Vilaine) flowing into the northern Bay of Biscay. The river plumes are high in N/P ratio in late winter and spring, but not in the inner plume during the summer. Conservative behavior results in most nutrients entering the estuary and eventually reaching the coastal zone. Temporal and spatial aspects of phytoplankton growth and nutrient uptake in the northern Bay of Biscay distinguish the central area of salinity 34 from the plume area.

Nutrient gradients are in general directed in the coast offshore direction (Lampert, 2001). During winter, the concentrations of the three main nutrients are important in the Loire plume (N = 22.2µM; P = 0.5µM; If =11.8µM, i.e. ~twice as much as the Gironde concentrations; Lampert, 2001). In early spring, the production is limited by silica and phosphorus (on the continental shelf, phosphorus concentration remain between 0.04 and 0.09µM and silica between 0.4 and 0.9µM; Lampert, 2001). Loyer (2001) has shown that phosphorus limitation is especially important within the coastal zone and occurs directly in late winter in front of the Gironde estuary. Through high nitrogen inputs from the rivers, the winter nitrate limitation may only be reached at the end of the summer or beginning of autumn (nitrogen concentration is close to 0.1µM in September according to Lampert, 2001). Nitrogen consumption is an ongoing process through spring despite early primary production limitation by phosphorus. Thus phosphate concentrations remain low and relatively constant during the summer (less than 0.1µM; Lampert, 2001). On the other hand, silicate concentrations show a clear increase during summer, indicating the importance of the regeneration processes from the shallow benthic compartment (Loyer, 2001).

The biogeochemical functioning of the northern continental shelf is also partially known. The extent and consequences of these continental loadings for nutrient and chlorophyll distribution were determined (Lampert *et al*., 2002; Loyer *et al*., 2006): the freshwater inputs induce a nitrate gradient from river mouths to offshore waters in the vicinity of the 100m isobath. The situation in early spring is characterised by high N/P molar ratios in front of the Loire and Vilaine estuaries which highlight the nitrate excess in river loadings. Phytoplankton mainly develops once haline or thermal stratification is established (Morin *et al*., 1991). The outflow of continental waters from the Loire and Vilaine estuaries modifies the hydrographic patterns in the northern Bay of Biscay. From January to June, the haline stratification is strong on a large part of the shelf in response to high Loire river runoff. During flooding, mesoscale structures, such as expanded river plumes or low salinity lenses, occur. Between May and September, thermal stratification occurs in a layer that can reach 50m in thickness (Puillat *et al*., 2004). These driving physical variables, associated with riverine nutrient inputs and meteorological conditions (particularly solar irradiance), can influence seasonal phytoplankton behavior in the northern Bay of Biscay.

In the southern part of the Bay of Biscay, the Gironde's discharge affects the timing of primary production as well as the structure of the phytoplankton community. Late winter phytoplankton blooms often begin at the edge of the Gironde plume, related to the haline stratification and anticyclonic "window" after mid-February (Labry *et al*., 2001, 2002). Thanks to satellite imagery, this phenomenon has also been observed once on the northern part of the continental shelf in late winter 2000 (Gohin *et al*., 2003), but its development is not as well known as in the southern Bay of Biscay.

Oxygen

Dissolved oxygen in aquatic systems is essential for marine life. The concentration of dissolved oxygen, also known as the oxygen saturation, depends on physical factors (such as air-sea exchanges at the water surface), chemical factors and biological factors (such as microbial respiration and oxidation). It is generally the biological processes which are of most significance in terms of levels of oxygen saturation.

The oxygen depletion is due to nitrification and oxidation. Anoxic conditions have not been observed in French coastal waters. Low oxygen concentrations occur in the large estuaries, in the zone of maximum turbidity, when river flow is low (i.e. July – October). As oxygen concentrations are related to the resuspension mechanism, they are a function of tidal amplitude; in the Loire Estuary the water column can become almost anoxic, whereas in the Gironde Estuary 30% saturation appears to be the minimum level likely.

Significant decreases in oxygen concentration along the Iberian Peninsula only occur in very restricted areas which receive large inputs of organic matter. Areas with oxygen concentrations of < 2mg/l occur in the Nervión Estuary at intermediate salinities and, in summer, low oxygen concentrations (i.e. < 4mg/l) occur in salt marshes within the Cantabrian rias Mundaka and Ribadeo. Within the Galician rias, hypoxia only occurs within the water in direct contact with the sediment surrounding mussel rafts. The pelagic system is always well oxygenated. With regard to the Portuguese coast, the average annual concentrations of dissolved oxygen within the Ria Aveiro showed little variability. In the Tagus and Sado estuaries, dissolved oxygen concentrations were normal except at a few sites where concentrations were lower, probably associated with the effects of industrial discharges or with the low rainfall.

Dissolved oxygen concentrations in the Ria Formosa were generally lower than in the estuaries of coastal Portugal. This could result from higher water temperatures throughout the year, together with less turbulence and thus less reoxygenation at the water surface.

Dissolved oxygen concentrations in the water column of the wider Atlantic region never fall low enough to limit the distribution of aerobic organisms (Mantyla and Reid, 1983). The lowest levels encountered, > 4 ml/l, occur at the oxygen minimum which is located where the water is oldest at the base of the permanent thermocline, i.e. at depths of about 900m (Lozier *et al.*, 1995). Similarly the upper layers of most sediments of pelagic origin are well ventilated and hence contain sufficient oxygen to support aerobic respiration by benthic species.

In the Azores region, with the exception of small inshore lagoons, anoxic conditions have not been observed in the islands coastal waters. Oxygen values in the Azores waters range from about 5-6 $ml \cdot l^{-1}$ at surface to <4 $ml \cdot l^{-1}$ in the bottom. North of the Azores surface values tend to increase slightly whereas south and southeast of the islands these values tend to decrease (http://oceano.horta.uac.pt/azodc/oceatlas.php).

1.2.1.5 pH and CO2 profiles

The oceans play a critical role in the global carbon cycle, and have been shown to absorb more than one-third of the anthropogenic CO_2. The uptake of excess CO_2 not only disrupts the marine carbon cycle and ecosystems, but also leads to acidification of the seawater. Climate change and ocean acidification are two of the most serious examples of global environmental change linked to CO_2 emissions. Absorption of CO_2 into the marine environment has lowered the average pH of the oceans by about 0.1 units from pre-industrial (1750) levels.

Continental shelves are significant sinks for atmospheric CO_2 at an average rate of $-1.9 molC \cdot m^{-2} \cdot yr^{-1}$ that scaled at European level corresponds to an absorption of atmospheric CO_2 of $-68.1 TgC \cdot yr^{-1}$. This sink is equivalent to the one reported for the terrestrial biosphere of $-66.1 TgC \cdot yr^{-1}$, based on carbon-stock change models. Estuaries are significant sources of CO_2 to the atmosphere at an average rate of $49.9 molC \cdot m^{-}2 \cdot yr^{-1}$ that is higher than the CO_2 emission to the atmosphere from rivers, streams and lakes. The scaled emission of CO_2 to the atmosphere from inner estuaries of about $67.0 TgC \cdot yr^{-1}$ would almost fully balance the sink of atmospheric CO_2 computed for continental shelves. However, the scaled emission of CO_2 from estuaries to the atmosphere is inconsistent with the potential emission of CO_2 based on the fate of river organic carbon during estuarine transit.

In the North Atlantic, the region that coincides with the formation of NADW to the north of 42°N, is estimated to be taking up to 0.2 - 0.5 Gt C annually, i.e. 5-10% of the fossil fuel emissions (Takahashi *et al*., 1993). Any reductions in deep water formation will slow the rate of uptake by the global ocean via the solubility pump. The creation of conditions with high concentrations of CO_2 will affect pelagic and benthic species by disrupting their physiological performances and general fitness. How such changes may be translated into ecological responses within the oceanic communities and the performance of commercially exploited species cannot at present be predicted and needs to be investigated (Omori *et al*., 1998). The physiological performance achieved by highly active predators, such as squid, is dependent upon blood pigments that are highly sensitive to the internal pH of the organism (Pörtner, 1997). Reductions in environmental pH may adversely affect these species and hence the structure and function of pelagic ecosystems.

1.2.2 Habitats

1.2.2.1 The predominant seabed and water column habitat types

Seabed habitats

Some authors considered the west point of Brittany as a limit of two biogeographic regions: Lusitanian in the South and boreal to the North (Ekman, 1953). In the Bay of Biscay, Le Danois (1948) considered the Poitou region as a threshold between the Armorique-Vendée region and Charente-Aquitaine region, like a boarder between the Northern Europe and the Southern Europe. Glémarec (1973, 1988) considered that the distribution of the benthic communities in the Bay of Biscay was mainly dependant on the temperature gradients and defined the «etage» concept. The etages which depends on bathymetry and latitude, explain the different zoobiogeographic groups. Actually, a part of the distribution of the macrobenthic communities are explained by the granulometric factors, but the temperature is also a strong factor controlling their structuration. On the basis of the temperature stability, it is possible to define a succession of temperate environment (i.e. climatic etages) on the continental platform: on an increasing depth gradient three main etages follow one another:

- Infralittoral, where temperature variations are tidal and daily (annual variability >10°C) Erected macroalgae fields, seagrass beds and associated communities are developed. Light is an environmental factor controlling the species distribution.
- Coastal circalittoral: temperate variations are seasonal (7-8°C). In the Bay of Biscay this step ranges from 15 to 70m depth.
- Offshore circalittoral: it shows stenothermic conditions (annual T variation 1- 2°C), it is a very stable environment. It spreads in the central part of the Bay of Biscay with the "Grand vasière" area, and the external margin to the boarder of the continental platform.

The Bay of Biscay belongs to the «medium temperate northern province» and is a transitional step with the warm temperate southern province. Consequently its fauna can originate not only from the median temperate region but also from southern and northern regions (Glémarec, 1991; Castel *et al.*, 1997). So, boreal species which are commonly distributed among the UK shores are observed deeper in the Bay of Biscay in the circalittoral or in the bathal zones (submerging principle). At the opposite, some species from the southern group originated from the African coasts which can settle in the Bay of Biscay, spread up to Ireland and Scotland.

The "Grand vasière" or "Great mud bank" which was firstly described by Le Danois (1948) as a monotonous and homogeneous geomorphological entity was finally a mosaic of various muddy sediment and communities with sparse rocky platforms (Glémarec, 1969). The great mud bank is the extension (from 70-90 metres depth) of the coastal sandy sediments back to the rocky barrier (Birvideaux reefs) and of the gravels extending between the rocky areas of Belle Ile island and Rochebonne reefs. Offshore, up to 120m depth, the muddy sediments are limited by hard bottoms separating the muddy sediments from sandy sediments (130-160m) which occupy the external margin of the continental platform (Glémarec, 1969; 1973).

These rocky substrata are locally covered by coarse muddy sands (< 20% gravels, 5-10% mud). These sediments are colonised by a *Circomphalus casina - Astarte sulcata* (bivalves) when pelitic fraction is less than 5%, while it is a *Aponuphis lineata* (polychaete) - *Timoclea ovata*, *Nucula hanleyi*, *Arcopella balaustina* and *Gari costulata* (bivalves) community when the pelitic fraction is higher than 5-10%.

The topography of the area is very variable. In the Cantabrian Sea the shelf is narrow (5 miles) and steep, with several submarine canyons. Westward, shelf is wider, being the Galician shelf wider and flatter. As a convention, slope is located at 200-300 m, but really this can be considered as a shelf-break zone, being slope located deeper. The sediment cover of the northern continental margin mainly consists of thick turbidity sheet-fan deposits. These alternate with deposits reflecting periods with less energetic sedimentation (ICES, 2008a). The continental shelf and upper slope sediments originate mostly from the continent. The inner shelf (depth <100m) is dominated by rocky outcrops, interrupted by sandy sediments in the mouth of rivers and Rías, whereas shelf and shelf break areas have predominantly muddy substrate. In the area, grain size of sediments decreases with depth, being medium and fine sands in shallower waters and silt in deeper ones (Rey and Medialdea, 1989). Thickness of sediment sheets increase with depth, especially in the head of canyons. In some areas, related to large estuarine systems (Rías, rivers Navia and Nalón, Cap Breton), silt is also present in shallower depths (López−Jamar *et al.*, 1992, Serrano *et al.*, 2008).

The benthic regime off the Galician coast of NW Spain was surveyed by López-Jamar *et al.* (1992) to assess biogenic enrichment from coastal upwelling and detritus outwelling from the rías, large coastal embayments: the Rías Altas along the northern and the Rías Bajas along the western coast, which have intense mussel aquaculture. Sub-bottom acoustic profiler records and grab and core samples identified two main mud deposits on the western shelf that were aligned north to south and parallel with the coastline. The major axis of the mud deposit, which extended south to the Portuguese border, is associated with the three most southern rias (Arosa, Pontevedra and Vigo) along the western shelf. Sediment particle size analysis showed that sediments on the western shelf were heterogeneous, and grain size increased from the inner shelf to the shelf break. On the northern shelf, sediments exhibited a more homogeneous textural distribution. Sediment organic matter followed a similar pattern with that of particle size. The highest organic matter values, 10%, occurred on the western shelf nearest the Rías Bajas, but these values decreased offshore to between 2 and 4%. On the northern shelf organic matter content was generally less than 4% but with patches of higher organic content.

The oceanic marine environment around the Azores is considered a deepwater one characterized by narrow or absent coastal island platform (the strata from 0 to 1000m represents about one percent of the total Azorean EEZ area) and large proportions of the abyssal areas (ca 4000m, with areas down to 1000m representing about 97 percent of the total Azorean EEZ) punctuated by seamounts where the fisheries occur (Martins, 1986, 1987; Isidro, 1996; Menezes, 2003; Pinho and Menezes, 2005, 2006; Morato *et al.*, 2008a). The seamounts (including knolls, hills or guyots) areas (strata from 0 to 1000m) are the predominant habitat (about two percent of the total EEZ) (see Morato *et al.*, 2008a). A density of about 3.3 peaks of all sizes per $1000km^2$ was estimated for the Azores EEZ, a value that may be of the same order of magnitude as that estimated on the Mid-Atlantic Ridge. A total of 63 large and 398 small seamount-like features are mapped and described in the Azorean EEZ (Figure 13). Notwithstanding the overall distribution suggesting that a large proportion of the seamounts occur in chains along the Mid-Atlantic Ridge, isolated seamounts are also present in the Azores region. This group of seamounts showed such a wide range of sizes (heights), depths of summits, slopes and areas that it is difficult to make generalisations about them. This diversity suggests that seamounts provide a variety of environmental conditions that can suit different biological assemblages (Morato *et al.*, 2008b, c). Recently, the EU Regulation 1568/2005 banned deep-water trawling in a large area of the Azorean EEZ. According this distribution of seamounts, this regulation protects

58 large and 207 small seamounts. Thus, 57% of the potential Azores seamounts are protected against deep-water trawling (Figure 13).

Several physical seamount characteristics, stratification and oceanic flow conditions interact to provide different local dynamic responses at seamount (see Pitcher *et al.*, 2007). These include Taylor columns or cones, doming of density surfaces, enclose circulation cells and enhanced vertical mixing. It has been also suggested on the literature that seamount dynamics generate conditions that increase vertical nutrient fluxes and material retention, promoting productivity that fuels higher trophic levels. However, there is little consistent evidence of this in observations or at least it is not the norm (see White *et al.*, 2007). Seamounts constitute a barrier to flow, and as such may receive material advected from a far field. For example, it is known that “Meddies”, the masses of Mediterranean water propagating from the Gulf of Cadiz, may impact on seamounts, including those on the Azores region (Bashmachnikov *et al*., in press, a). Seamounts may be a unique habitat for megabenthos, corals and mid and deep water fauna due to several distinctive environmental conditions. However, the knowledge of the species and physical dynamics associated to these features at different scales, particularly in the context of the oceanic areas like the Azores and the Mid Atlantic ridge is yet limited (Pitcher *et al*., 2007).

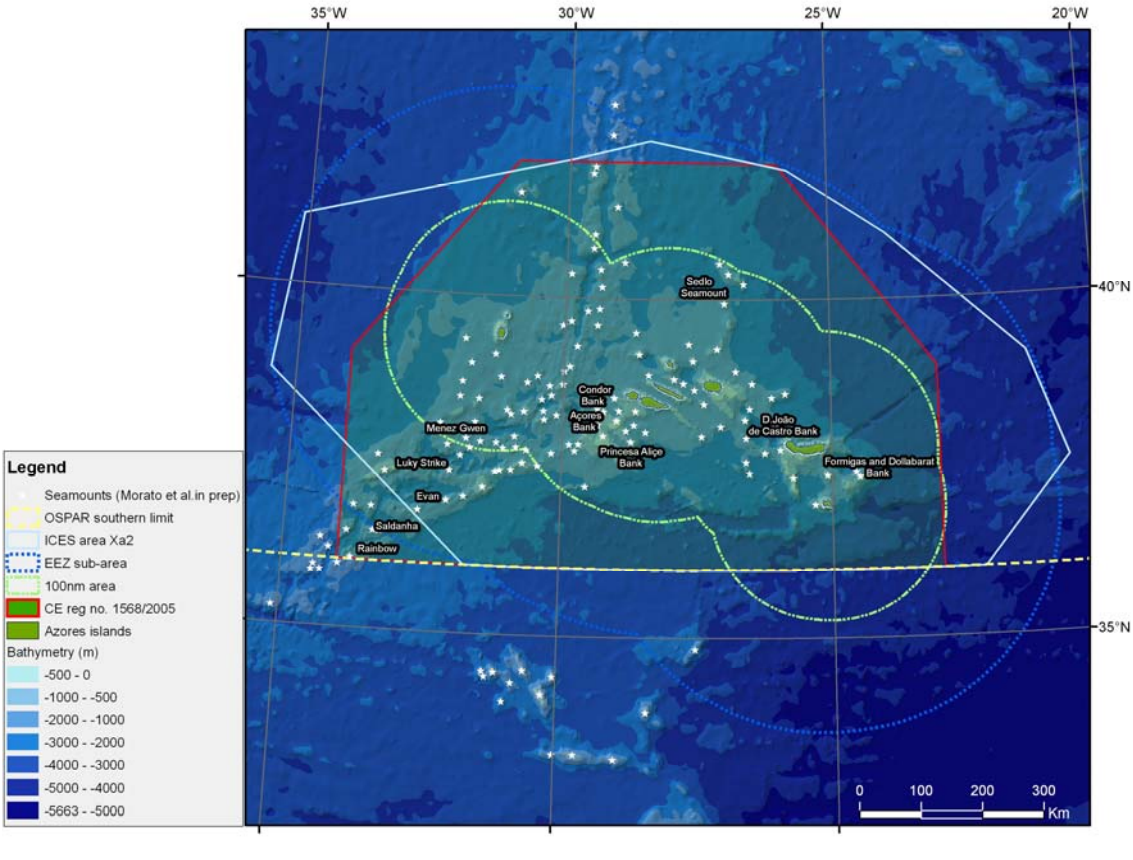


Figure 13. Seamounts distribution in the Azores region. Convention and law areas (OSPAR, ICES, EC regulations of 100 and 20miles and trawl banning) are included also on the figure. Main banks and seamounts as well as hydrothermal vents of the region are also illustrated in the figure (black). Source: ImageDOP.

Water column habitats

On the continental shelf North-Gascogne, mesoscale hydrodynamic phenomena depend mainly on climatic forcings at regional scales (river plumes, coastal "upwelling") rather than on the general oceanic circulation. A description of the spatio-temporal evolution of salinity and temperature has already been carried out by Lazure and Jégou (1998) on the basis of the MARS 3D circulation model, and also by Lampert (2001) who has been using bathysonde data.

In winter, with weak river contributions and strong winds, the distribution of the temperature and salinity is homogeneous on the entire water column. The faces associated thermics and towing-rope are then positioned parallel to the coast. At the time of strong rains of winter and spring and with winds of southwestern sectors, a stratification haline is established at the time when river water takes a northern direction under the effect of the currents baroclines (> $20 cm \cdot s^{-1}$ if the gradient towing-rope is important). This water remains near coasts as long as the balance between the rate of flow and dominant winds are favourable. The appearance of winds of the North sector allows desalinated river waters to spread out on sea surface towards the offshore and to take the same direction (South) if the rate of flows is low (Lampert, 2001).

Spring (March-April) is the transitional period between the winter conditions (surface river originating waters along the coast heading North) and estival conditions (dispersion of river water towards the offshore and or even South when North-western dominant winds). At that time of the year, wind seems to be the dominating factor for thermo-haline distribution of surface water over the whole Bay of Biscay. In winter and early spring, oceanic water is warmer than shelf waters, because of a pycnocline created by de-salted water acting like a barrier between surface and bottom waters. This supports surface waters heat losses towards the atmosphere and thus cooling of the surface layers. During this period, salinity conditions the density of the water mass and the position of the pycnocline (Lampert, 2001).

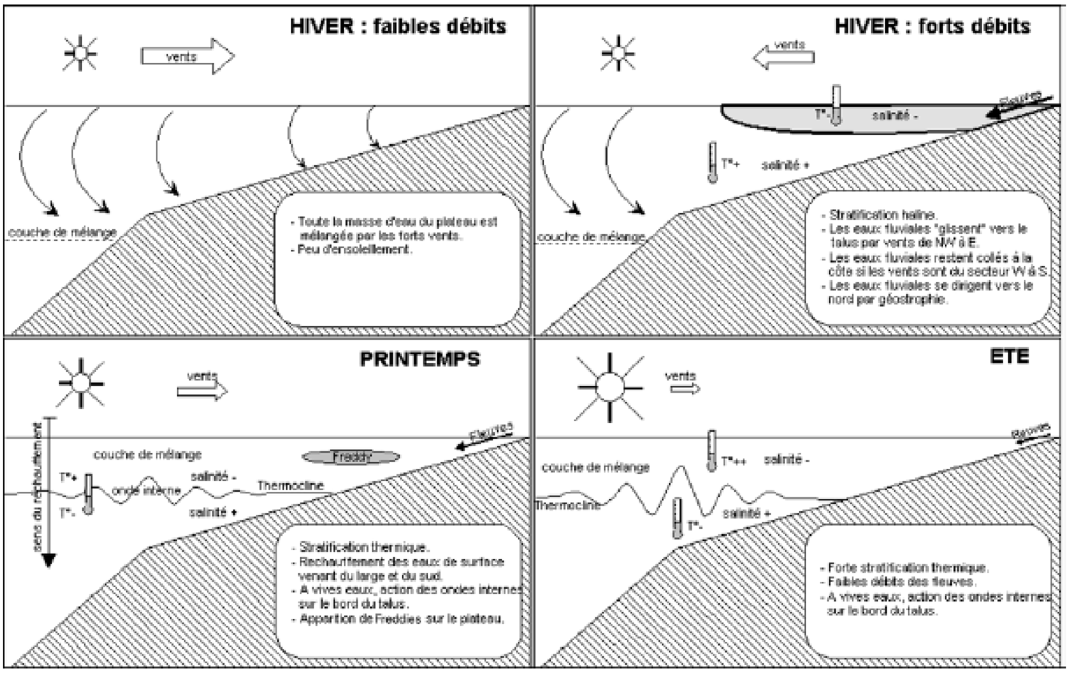


Figure 14. Scheme of the functioning of the continental shelf of the Bay of Biscay according to the physical and meteorological forcing (in Lampert, 2001).

During summer, the warming process of surface water comes from offshore towards the coast as well as from the southern part of the bay towards North. The increase in the solar radiation combined with low river inputs (minimum flow reached between July and September) generates a progressive replacement of the weak haline stratification by a thermal stratification. Thus, the increase in the stratification of water allows surface water to remain above oceanic waters towards offshore, and reach or even overpass the limit of the continental slope, depending on the direction and strength of the dominant winds (Lampert, 2001).

Figure 14 shows the main physical phenomena occurring on the continental shelf of the Bay of Biscay that are deeply implied in the control of primary production. First, the internal waves, generated near the continental slope in period of stable thermocline and during high tide levels, support the input of cold, nutrient rich deeper water to the system (Mazé, 1987). Internal waves thus improve primary production on the slope and the internal edge of the continental shelf (Holligan and Groom, 1986; Lampert, 2001; Lampert *et al.*, 2002). Then, the haline stratification due to strong river flows permits the circulation thanks to the density gradients. Eventually, the "cold pad" isolates cool bottom water from the Great Mud Bank from warmer surface water during spring and summer. Such cold and salted structure finds its origin in the tidal currents and bottom topography, which allows its sustainability independently from the weather variations (Le Cann, 1982).

Meteorological and oceanic parameters display variability over a range of scales, and this variability potentially influences the living marine resources at different trophic levels and in different ecosystems, particularly pelagic ecosystems, where the atmosphere/ocean interrelationship is close (Pitcher, 1995). Events such as depletion or increase in abundance of fish species (e.g. clupeoids or flatfishes) are often synchronous over geographically broad and widely separated areas, suggesting large-scale climate forcing (Schwartzlose *et al.*, 1999). In addition to large scale forcing, there may be local or regional events, such us upwelling or low-range thermohaline-forced currents, which can contribute extensively to recruitment variability (Lavin *et al.*, 2007). In this way, Santos *et al.* (2001) found that upwelling events in the coasts of Portugal during winter months had negative impact on recruitment of sardine and horse mackerel. However, in Lavin *et al.* (2007), who analyzed the oceanographic variables in the southern Bay of Biscay by principal component analysis, the horse mackerel recruitment is correlated negatively with the thermal component. The same authors also found that albacore catches in the southern Bay of Biscay (catches of age 3) were negatively correlated with the oceanic component (oceanic transport indices). The influence of environment and spawning dynamics on Bay of Biscay anchovy recruitment was studied among others by Allain *et al.* (2007). These authors found that the location of space-time survival windows, suggested major environmental mechanisms involved in simulated recruitment variability at the different scales-retention of larvae and juveniles in favourable habitats over the shelf margins and turbulence effects.

Mesoscale pattern seems to be very important in early stages of fishes (Sánchez and Gil, 2000). These authors examine the relationship between the recruitment of European hake (*Merluccius merluccius*) and environmental conditions in southern Bay of Biscay. In the eastern, progressively narrowing, shelf of the Cantabrian Sea, years of massive inflow of the eastward shelf-edge current produce low recruitment indices, due to larvae and pre-recruits being transported away from spawning areas to the open ocean. On the other hand, the transport of larvae within anticyclonic mesoscale structures moving towards the recruitment areas will be an aid to recruitment. These eddies displace westward according to the condition of potential vorticity conservation. When orographic features, such as big capes, occur in their drift path their eastern edges are held back. This situation causes patches of recruits to be located east of the main capes of the western Cantabrian Sea.

The North Atlantic Ocillation (NAO) index accounts for much of the atmospheric variability in the North Atlantic (Hurrell, 1995) and is therefore a dominant exogenous driving factor for biological systems. Low NAO index indicates weak westerly winds, and vice-versa (Hurrell *et al.*, 2003). Under low NAO, greater sardine recruitment success is reported related to prevailing winter/spring wind direction, reducing offshore drift of eggs and larvae (Guisande *et al.*, 2001). Annual abundance of the pelagic portunid crab *Polybius henslowii* abundance also occurs in negative phases of the NAO index (Signa *et al.*, 2008). In this case, a direct effect of environmental conditions on distribution of shoals is suggested, because (i) correlations between NAO and abundance were found only for simultaneous NAO data and (ii) September–October is outside its reproductive period (season with dominance of males: Alonso-Allende and Figueras, 1987), so aggregations for mating or reproduction can be excluded. Opposite effects are described for squids (Pierce *et al.*, 2005): high autumn/winter temperatures (high winter NAO values) produce high abundance and precocious maturation, favouring higher abundance the following year.

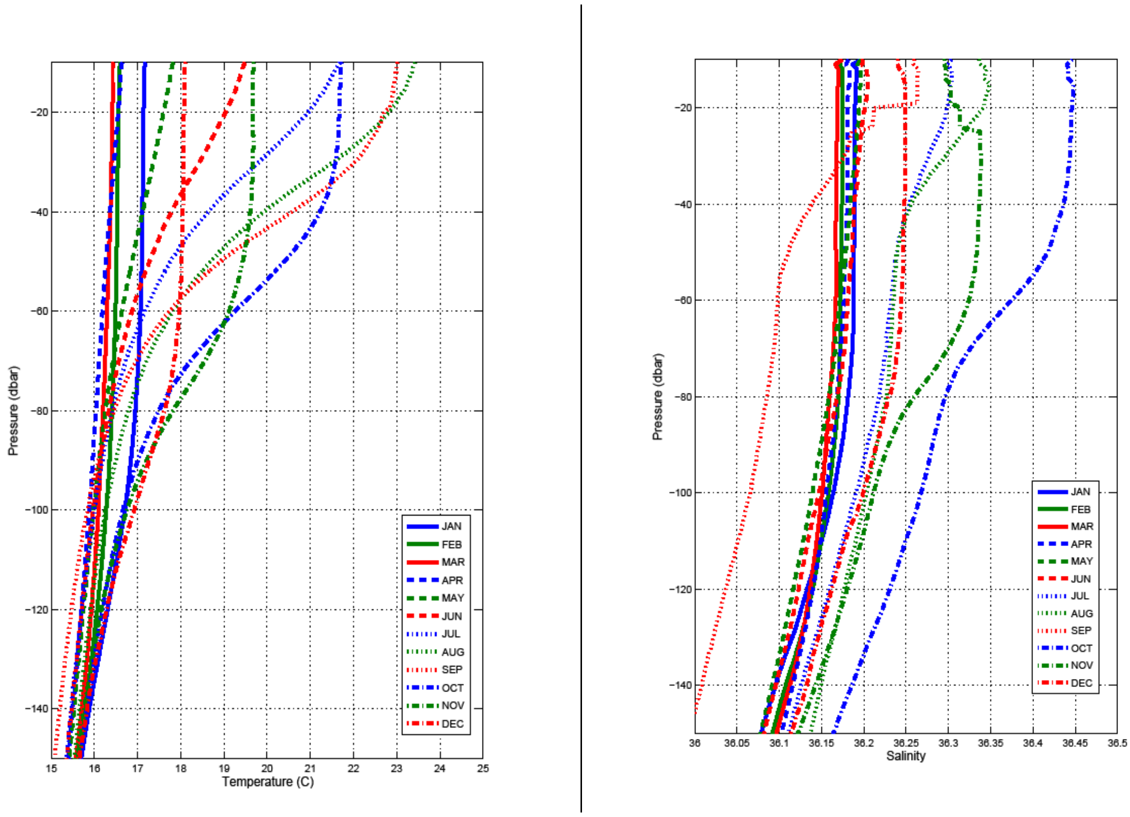


Figure 15. Monthly seasonal variation of (left) temperature (ºC) and (right) salinity (pps) vertical profiles for the Azores region (33-44ºN and 20-36ºW) for the first 200m layer (data obtained at the AZODC site, http://oceano.horta.uac.pt/azodc/oceatlas.php).

The Azores region is located in temperate latitudes, and therefore, both ocean and atmosphere seasonal variabilities are expressed by four typical seasons: spring, summer, autumn and winter. In the Azores region, the upper 200m layer is generally characterised by an eastward surface drift (Pollard and Pu, 1985), though separate jets of eastward following North Atlantic Current (NAC) branches and the Azores Current (AzC) can go deeper and reach 800m depth (Gould, 1985; Alves and Verdiere, 1999). The AzC is associated with Azores subtropical frontal zone (34-35ºN) which separates warm and nutrient-life poor tropical waters to the south from more reach subtropical ones to the north (LAMAR report, 2008). The unidirectional eastward circulation in the region forms ground for gradients of different oceanographic and biological characteristics in longitude direction. Specifically, due to intensive northward advection in the Western North Atlantic Basin (Gulf Stream), the upper layer waters in the Western North Atlantic are generally warmer and more saline than in its eastern part. The Mid-Atlantic Ridge (MAR) acts as a partially transparent border, in Subtropical Atlantic forcing most of the warm eastward flowing waters to recirculate in the Western basin, and allowing water to cross mainly along some fracture zones. In particular, this creates an isotherm tilt, maximum to the west of MAR (Krauss, 1996, in LAMAR report, 2008).

The circulation and water properties in the region experience quite small seasonal variability below the seasonal thermocline, separating the upper ocean mixed (and photosynthetically active) layer from the main thermocline layer. The seasonal thermocline disappears in January (Figure 15). Since then and up to March (lowest average surface temperature values, around 16^{o}C), the upper ocean mixed layer over the whole region of study is over 200m depth, smoothly merging with the main thermocline. Since April the seasonal thermocline starts to form, reaching its maximum intensity and minimum depth of 20-50m in August (average surface temperatures around 24^{o}C). At this month the vertical temperature gradient in the seasonal thermocline is 40 times higher than that of the main thermocline. To the north of the region the depth of seasonal thermocline remains at 20-50m up to October, though its intensity decreases. Thus in October, the ratio of the vertical temperature gradients is 20, and in November – 10. In November the seasonal thermocline starts moving down and weakens. It reaches its minimum in winter. Around the Azores the seasonal thermocline is mainly formed by solar heating. To the south of the AzC heat lost on evaporation adds to the thermocline enhancement. The seasonal picnocline has average depth of 30m in July and is 40-50 times more pronounced, than the main picnocline. It remains intensive at least one month longer than at the north, starting clear movement down only in December. (LAMAR report, 2008).

Highest average surface salinity values are found during October (36.4) and the lowest during the winter months (about 36.15 to 36.2) as a result of precipitation/evaporation processes and the influence of tropical waters in the region. The largest variability in salinity values is found in the upper layer, above 80m depth, where a halocline is sometimes observed during autumn months.

1.2.2.2 Special habitat types

Reefs

In the area, the presence of several vulnerable habitats has been described, following the OSPAR list of threatened and/or declining species and habitats (OSPAR, 2008); all of them grouped in the habitat type 1170 “Reefs” in the Natura 2000 Network (2007).

<u>Cold-water coral communities from Spain</u>

***Lophelia pertusa* reefs:**

There is a lack of studies on cold-water corals in the northern Spanish coast, consequence of the difficulty of sampling both in deep-waters and in rocky grounds. Reveillaud *et al*. (2008) published a revision on the distribution of scleractinian corals in the Biscay Bay. Figure 16 shows the occurrences of stony corals in the area, most of them belonging to two OSPAR declining or threatened habitats: *Lophelia* reefs and coral gardens

(*Madrepora oculata*, *Caryophyllia* spp, *Dendrophyllia* spp, gorgoniaceans, antiphatarians…).

The area with higher number of records of *Lophelia* is the shelf break in front of Peñas Cape, probably due to the higher number of studies. Probably small patches of *Lophelia* are common in the entire rocky slope. Depth ranges (Alvarez-Claudio, 1994) seems to be related with the Mediterranean Outflow Water. De Mol *et al*. (2005) reported that the depth range of the seabed cold-water coral banks coincides with the Mediterranean Outflow Water which may control indirectly the coral distribution. *Lophelia* reefs on Galicia Bank are studied from a trophic point of view, but not cartographied in Duineveld *et al*. (2004).

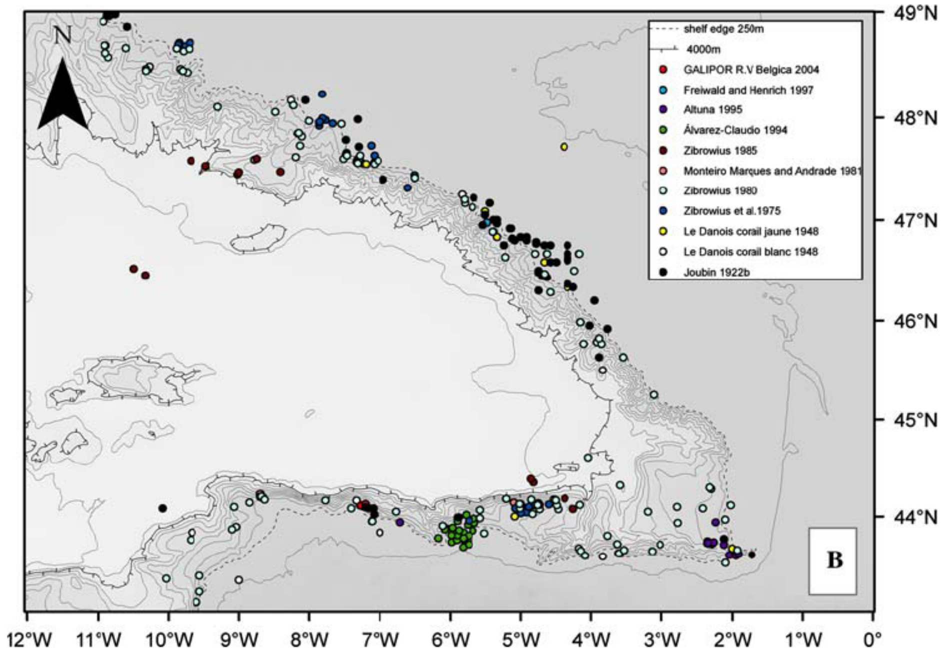


Figure 16. Findings of cold-water scleractinians cluster along the continental margin in the Bay of Biscay. The map is from Reveillaud *et al.* (2008) modified from Sibuet *et al.* (2004).

In Spain, maerl beds occur in the rías of Galicia (Adey and McKibbin, 1970; Solorzano *et al*., 1991; Peña and Bárbara, 2007a, b). In Galicia, live maerl is known to depths of less than 40m and can extend onto the lower shore, as occurs in the coastline of mainland Europe. This habitat is the most common in the Ria de Arousa (Figure 17). Peña and Bárbara (2007a) found that maerl beds in better conditions are located in protected areas such as the Islas Atlánticas National Park, or restricted to shallow areas (less than 9m depth) where mussel rafts cannot be settled.

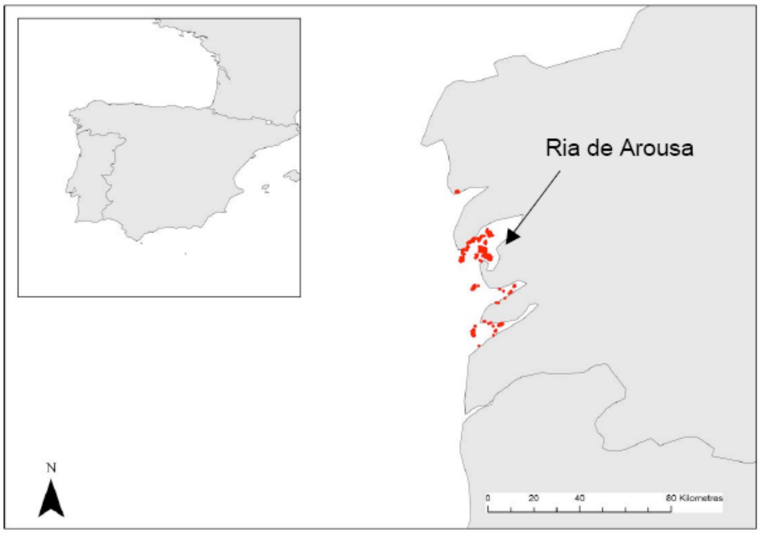


Figure 17. Distribution of maerl habitats in Galicia. NW Spain (inset, map of the Iberian Peninsula). (data from Peña and Bárbara, 2007a).

Coral gardens:

In the shelf break and in special areas as the Le Danois Bank, the gorgonian *Callogorgia verticillata* is common (Sánchez *et al*., 2008). In the shelf the presence of other gorgoniaceans has been reported (Altuna, 2006, Reveillaud *et al*., 2008), as *Acanthogorgia* spp, *Paramuricea* spp, *Eunicella* spp, *Swiftia dubia*, etc., but no data on distribution are available. The same occurs with bamboo corals (*Acanella arbuscula*, *Keratoisis* spp), black corals (*Bathypates patula*, etc) and diverse scleractinians (*Caryophyllia* spp, *Dendrophyllia* spp., *Stephanocyathus* spp, *Balanophyllia* spp. etc), most of them deep-sea species.

Deep-sea sponge aggregations:

Fields of large deep-water sponges have been recorded in Le Danois Bank (Sánchez *et al*., 2008), specifically the hexactinellid sponges *Asconema setubalense* and *Pheronema carpenteri*, and several species of the family Geodidae. This species have been also reported from other depth areas of the northern coast of Spain, but no data on distribution are available.

Seapens:

In the soft grounds of the shelf are common *Pennatula aculeata, Pteroides griseus*, and *Funiculina quadrangularis.* Maximum abundance of these species has been found in the middle shelf, but with slight bathymetric differences: *Pteroides griseum* in the range 100-150m, *Pennatula aculeata* in 130-180m, and *F. quadrangularis* in the 150-200m.

Quality status:

Seabed habitats in the northern Spanish shelf are highly affected by trawl fishing activities. Sedimentary grounds fauna in the area are characterised by a lack of large sessile species and fragile species. This fact is evident when the fauna of closed areas to fisheries is analysed. In these areas the presence of this fauna (anthozoans, sponges, urchins, etc) is higher. Rocky bottoms present a higher presence of habitat generating species as sponges, corals and gorgonians, although this fauna in the past was more important (e.g. well-developed cold coral reefs in some slope areas).

Cold-water coral communities from Azores

Contrasting with the considerable effort put on the study of cold-water coral communities in the North Atlantic region, their distribution on the Mid-Atlantic ridge is still poorly known. A high number of coral species have been recorded in the Azores over the last 4 years (81 species) providing a strong indication of the diversity displayed by those communities (Braga-Henriques *et al*., 2008b). A large and dense gorgonian forest dominated by *Dentomuricea* sp. and *Viminella flagellum* was recently discovered at the Condor de Terra seamount (Braga-Henriques *et al*., 2006; Tempera *et al*., 2009). These aggregations were patchily distributed over the seamount summit and showed substrate associations. The community included other less abundant Primnoidea gorgonians, sponges, hydrocorals, crabs and fishes. Additionally, reef-building corals associated with gorgonians were recorded at the Menez Gwen hydrothermal field. Available data sources include historical records, museum collections, occurrence of records from scientific missions and by-catch data from the local long-line fishery (Jourdan, 1895; Studer, 1901; Roule, 1905; Gravier, 1920, 1921, 1922; Thomson, 1927, Zibrowius, 1980; Braga-Henriques *et al*., 2008a; Ocaña *et al*. 2007; Matos *et al*., 2008; Sampaio *et al*., 2009).

Vulnerability and conservation of cold-water coral habitats are global concerns (ICES, 2002, 2003, 2004). Threats to these habitats include direct impacts of human activities related to the exploitation of deep-sea resources and sea-bed uses (e.g. fisheries, hydrocarbon extraction, mining), and pollution (e.g. contamination from land-based sources/activities, waste disposal, impacts of shipping). Indirect impacts relate to climate change and ocean acidification as a result of fossil fuel emissions.

Despite bottom trawling being forbidden in the Azores (Council Regulation (EC) N°1568/2005 of 20 September 2005), there is evidence that corals are present in the by-catch from the bottom long-line fishery. A recent study on the vulnerability of deep-sea corals to long-line fishing in the Azores found that gorgonians are the dominant group in the by-catch (21 taxa). Stony corals were also abundant (10 taxa) as well as hydrocorals (4 taxa) and black corals (2 taxa). The most common species were *Errina dabneyi*, *Leiopathes* spp., *Dendrophyllia* sp., *Caryophyllia cyathus* and *Callogorgia verticillata*. The scleractinia *Lophelia pertusa* was not present in the coral by-catch, probably because the species vertical range and the fishery operation depth range hardly overlap (Sampaio *et al*., 2008).

Moreover, demersal fishing surveys carried out by IMAR/DOP-UAz (ARQDAÇO-27-P07, DEECON-28-V07, ARQDAÇO-29-P08 and DEECON-30-V08) reports corals, hydrozoans, sponges and bryozoans as part of the bulk material. During the surveys 166 specimens of deep-water corals from 40 *taxa* were caught. Octocoralls were the most representative group with 21 species, being the Plexauridae and the Primnoidae the most common families with 6 and 3 species respectively. These soft corals were followed by the stony corals Scleractinia represented by 9 species, black corals (Antipatharia) with 5 species and hydrocorals (Filifera), represented by 3 species (Sampaio *et al*., 2009).

Increased ocean acidification and temperature is likely to reduce the calcification of corals with serious consequences to the whole ecosystem (Guinotte *et al*., 2006). Model calculations show that many cold-water corals live close to the aragonite saturation horizon (the depth below which aragonite dissolves) and will experience under-saturated waters (aragonite saturation state < 1) as early as 2020 (Guinotte *et al*., 2006), which may significantly reduce coral calcification rates. Experimental studies on coral calcification under different acidity and temperature conditions, at IMAR-DOP coral aquarium facilities, will help predict how corals will respond to future environmental changes (Carreiro-Silva *et al*., 2008).

Estuaries, rias and wetlands

<u>Estuaries</u>

Most Portuguese estuaries are shallow areas with extended intertidal sediments; the small coastal lagoons of the Ría of Aveiro, the Ría Formosa and the Tejo and Sado estuaries being the most representative. These estuaries are subject to considerable hydrological variability and have prolonged dry periods. They mostly have important ecological and economic roles. The Guadiana and Guadalquivir are the main estuaries in the Gulf of Cádiz. These areas are a complex mixture of wetlands, salt marshes and sand dunes protected from the sea by a barrier dune and connected to groundwater mainly through small lagoons located in both the dunes and marshes. They are largely used for shellfish and finfish aquaculture as well as for salt-ponds. Doñana, a national park within the Guadalquivir estuary, is one of the largest over wintering areas for birds in Europe. The main physical perturbations are the loss of estuarine habitats, mainly wetlands, salt marshes and sand dunes, due to land reclamation, salt and sand extraction, rice production and aquaculture. In addition, estuarine sediments often accumulate organic and inorganic pollutants, from mining and industrial activities for example, and this is the case for the Odiel and Tinto estuaries which are contaminated by metals from erosion and mining (OSPAR, 2000).

Estuaries occur at the transition between river basins and the ocean, often in association with wetlands, sometimes with rias. Coastal plain estuaries formed when sea level rose and drowned existing river valleys. Most northern estuaries belong to this category. Coastal plain estuaries are small meso-macrotidal shallow areas with relatively extended tidal flats. On the Atlantic coast of France tides may reach more than 7m in many places. Owing to their role in the transformation and transfer of material from land to sea, estuaries are the most productive and dynamic of the coastal ecosystems. Estuaries are also the most vulnerable to sea level rise and are subject to intense human pressures. On the basis of their geomorphology, the estuaries of Region IV fall into three categories: coastal plain estuaries, rías and bar-built estuaries (OSPAR, 2000).

Throughout history, estuarine areas have been the focus of dense human settlements. Most estuaries are affected by human activities to some extent, for example, agriculture, cattle breeding, industry, urbanisation, sanitation and transport. The Miño estuary however, is an example of one which has remained relatively undisturbed. The Miño is the second most important river on the northwestern Iberian coast; good water quality, a low population density and almost no industry at the margins have resulted in a relatively pristine environment suitable for conservation and protection (OSPAR, 2000).

Dams generally cause major changes in estuarine systems. One example of where major changes have occurred is the Vilaine estuary, in Brittany. Since the Arzal dam was completed in 1970, the length of the estuary has reduced by 80%, the fluctuating volume by 40% (Gouleau *et al*., 1981), the saline layer has increased and the sediment load has greatly reduced (Le Hir *et al*., 1986).

The Guadiana estuary on the southern Iberian Peninsula is another example. More than 40 dams, built since the 1960s, regulate about 75% of a catchment area where the precipitation has consistently fallen. The result is an extremely low run-off in summer (sometimes none) and a major decrease in the volume of sediment supplied from the river to the estuary. Jetties built since 1974 have also modified sediment dynamics within the delta, resulting in considerable changes in its morphology (Morales *et al.*, 1997). A major dam is currently being built far downstream on the Guadiana river; potentially this will create the largest artificial lake in Europe.

Harbours also affect estuaries. Since the mid 1800s dredging in the estuaries near Bilbao has greatly reduced the tidal flats. The Vouga Estuary, on the west coast of Portugal, is a coastal lagoon that has little interaction with the coastal ocean. A large complex of chemical industries located near the estuary has had a considerable impact on bottom sediments. Further south the waters of the Tinto and Odiel rivers, which discharge into the Gulf of Cadiz, are both acidic (occasionally falling to a pH of 2 or 3) and contain considerable quantities of metals derived from mining activities. Their fine estuarine sediments are significantly contaminated by heavy metals in apparent association with high levels of organic carbon, resulting from the precipitation of dissolved matter in the river (Nelson and Lamothe, 1993).

As a result of rising sea level many estuaries are currently becoming silted. Most of the sand particles transported by rivers, as well as by longshore drift, are retained in estuaries. Although fine particulate material (< 63mm), generally enters the oceanic environment in the form of surface plumes and bottom fans, studies suggest it is the dispersion of estuarine waters that is the principal mechanism by which particulate material is transferred to the ocean (OSPAR, 2000).

Rias

Rías are relatively deep and extensive in relation to their catchment area. Planktonic productivity within rías is mainly driven by the intrusion of nutrient-rich Atlantic water from coastal upwelling, which may last several months during the warmer seasons. They resemble fjords, although their width and depth tend to decrease monotonically inward, and their freshwater run-off is much less than through a fjord. Some rias support extremely productive ecosystems that form the basis of important economic activities. For example the Ria of Arosa, on the west coast of Galicia, has the world's largest mussel production site, producing > 100000 t/yr.

Most rias provide very good shelter from the open ocean and this has led to the establishment of important harbour facilities in some. Vigo is Spain's main fishing harbour and around 400000 people live in the vicinity of the ria. The mussel industry generates substantial quantities of suspended solids, in addition to those carried into the rias by the rivers. The near bottom water layers are therefore very murky, while the bottom is muddy and anoxic conditions occur in the sediments. Active circulation inside the rias however, prevents the development of anoxic conditions in the water column. The active circulation also prevents silting in the ria proper, but not necessarily in the estuarine sectors. Industrial pollution in the rias is negligible, except in areas close to harbours (OSPAR, 2000).

The rias have a common origin in the Miocene, Pliocene and Pleistocene Epochs, when erosive processes reshaped the bedrock through deep weathering in pre-existing fault areas (Cotton, 1956). A ria consists of three sections: the estuary (near the head), the ria proper (a central channel along the longitudinal axis) and the bay (at the mouth). Some of the bays are partly closed by islands, thus creating channels of different sizes and providing shelter from direct oceanic influence. Fine sediments with high organic contents cover the bottom of the estuary sections, while sand and gravel dominate the bay sections (OSPAR, 2000).

The basic pattern of circulation within a ria is caused by the density difference between the river water flowing out of the ria at the surface and the denser saline water flowing into the ria underneath, with some mixing between the two (Otto, 1975). The direct importance of the tide in the water exchange between the ria and the continental shelf is small (the tidal range is 2m). However, it does promote mixing, which thus reduces the salinity difference between the layers and increases the water volume that is exchanged (Fernández de Castillejo and Lavin, 1982).

The winds that blow over the continental shelf also act upon the rias (Blanton *et al.*, 1984, 1987). Northerly winds during summer promote the offshore displacement of surface water which is replaced at the coast by water upwelled from deeper levels. This water is cooler and richer in nutrients and so contributes to an increase in primary production near the coast (Fraga, 1981). The northerly winds also increase the flushing rates and the estuarine circulation within the rias, as well as increasing their nutrient contents by renewal with upwelled water. In contrast, the westerly or southerly winds during winter pile surface water up against the coast, a proportion of which sinks near the coast and promotes the intrusion of nutrient-poor water into the rias (Blanton *et al.*, 1984), reducing the estuarine circulation.

Wetlands

Coastal marshlands are situated on low-lying alluvial deposits at the edge of the tidal plains. Tides affect the flow of water through the marshes and they are important for the fish stocks of the neighbouring sea areas. The marshes protected by dikes that were traditionally used for salt production and aquaculture for example, are now used less and less for economic reasons, and 80% of those used for such purposes in France are now underexploited. On the French Atlantic coast the seventeen main groups of marshes form a link in the water cycle between land and sea. On the northern Iberian coast there are two main marshes: the Urdaibai (30km north-east of Bilbao) and the Oyambre (west of Santander) and these are both Nature Parks. On the western Iberian coast important salt marshes occur around the estuaries of the Vouga, the Tagus and the Sado rivers. They are important feeding areas for resident and migratory waterfowl, as well as for young fish. In the Gulf of Cadiz the major salt marshes occur in association with estuaries (OSPAR, 2000).

The main coastal lagoons of Region IV occur on the French Atlantic coast and in the Gulf of Cadiz. The Bay of Cadiz is a semi-enclosed shallow water lagoon; the external bay is influenced by the wind, tide and local currents, while the hydrodynamics of the inner bay are strongly related to tides. The innermost marshes and wetlands are dissected by meandering channels (OSPAR, 2000).

The Arcachon basin is a large Atlantic lagoon connected to the ocean. The region supports shellfish production and an important tourism industry. It is located in the middle of an area mainly characterised by forestry and associated industries. The Ria Formosa is a Nature Park on the southern Iberian coast. It is located between the mainland and a system of barrier islands formed after the Middle Ages, when sea level was considerably lower (Dias, 1987). Inappropriately referred to as a ria, the Ria Formosa has a very low freshwater input, virtually none in summer, and its dynamics are dominated by tidal flushing, with a significant residual circulation. The region supports fishing activities, aquaculture (fish and shellfish), tourism, a busy harbour, and the city of Faro and its airport. Rising sea levels, together with severe winter storms, are causing the coastline to retreat. Also, recent building activities on the barrier islands (particularly the westernmost island), and the construction of jetties to the west of the ria are affecting the dynamic balance of the system (OSPAR, 2000).

Small lagoons with intermittent communication with the sea also occur along the central Iberian west coast, for example at Óbidos, Albufeira, Melides and Santo André. They are minor fishing and shellfish collection sites and are also used for leisure activities (OSPAR, 2000).

MPAs

The existence of the above cited vulnerable habitats together with the birds and habitats-fauna-flora directives have driven to the creation of several MPAs in the SSW areas. There are several types of potential protected areas for a variety of marine system components. In the marine environment, the abbreviation MPA, if/when used here, merely denotes any marine protected area. Very often, however, a MPA would refer to an area at sea that is protected primarily for habitats or fish stocks. They are key areas for ensuring the survival of marine biodiversity and the establishment and management of such areas deserves special attention. MPA´s are a valuable tool for conserving the nation's natural and cultural marine resources as part of an ecosystem approach to management. MPAs of the SSW are showed in Figure 18 and Figure 19 (France), Figure 20 (Spain) and Figure 21 (Portugal). For Azores oceanic see below.

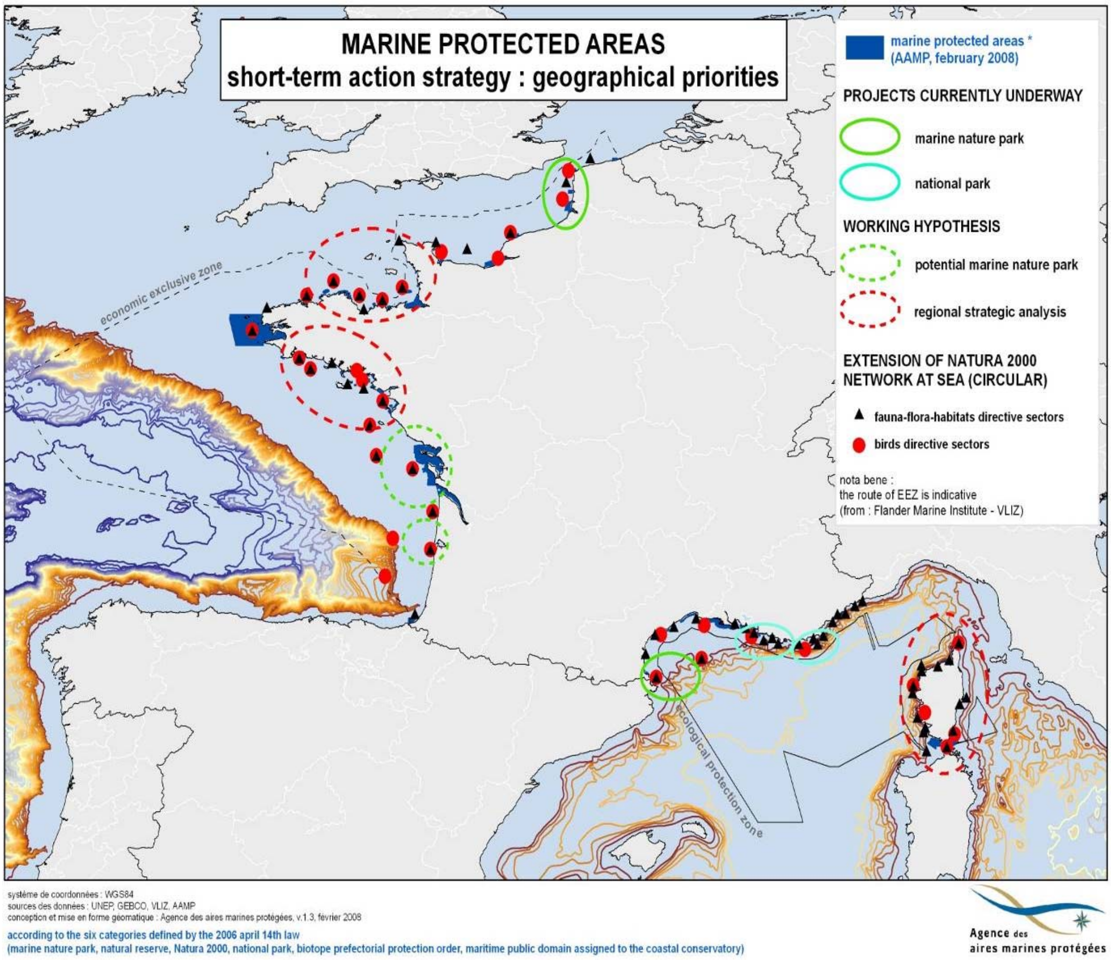


Figure 18. French MPAs (Source: Agency of MPA, 2006).

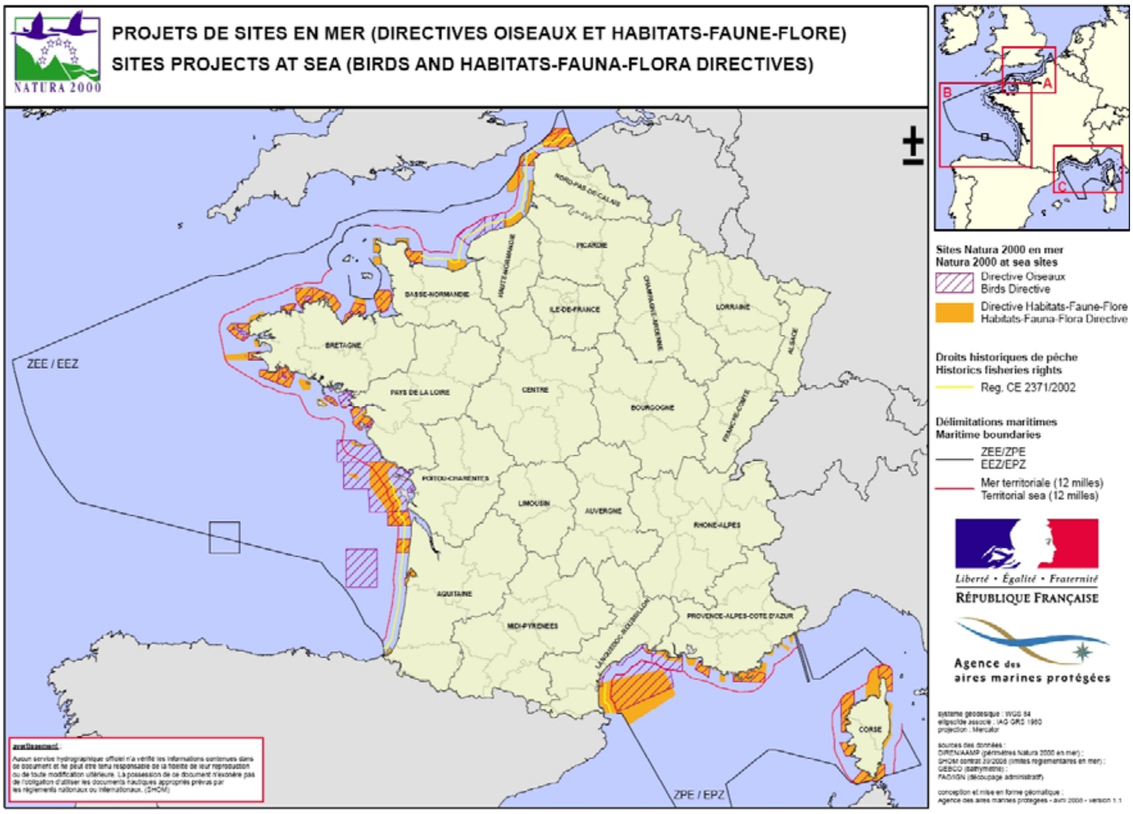


Figure 19. Protected sites under the birds and habitats-fauna-flora directives (Source: Agency of MPA, 2006)

Áreas de estudio del proyecto LIFE+ "Inventario y designación de la Red Natura 2000 marina en España" (INDEMARES)

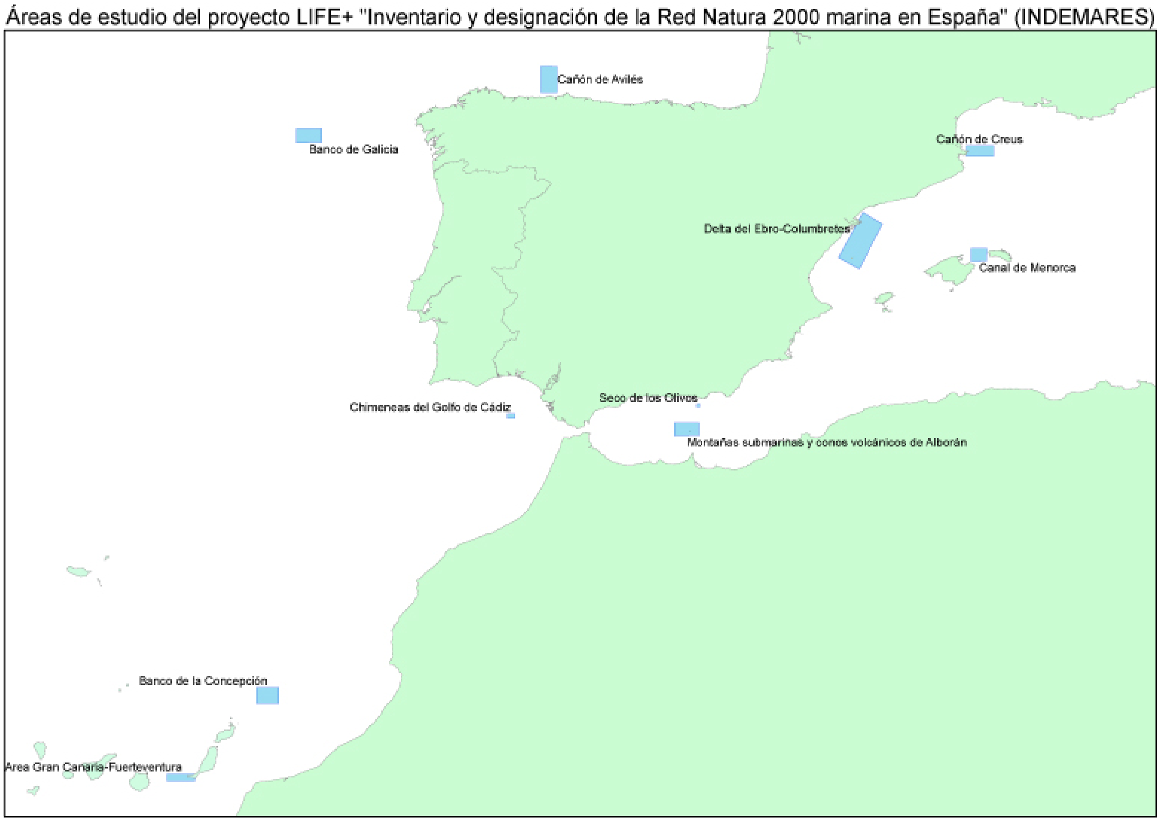


Figure 20. Areas under study in the INDEMARES project aiming to constitute the Spanish proposal of offshore MPAs.

In the Portuguese mainland there are three main marine protected areas: i) Berlenga Marine Reserve; ii) Arrábida Marine Reserve, and iii) Sudoeste Alentejano and Costa Vicentina Natural Park. Besides these marine protected areas we can find coastal protected areas. Most Portuguese coastal protected areas are estuaries with shallow areas and extended intertidal sediments. Estuaries occur at the transition between river basins and the ocean, often in association with wetlands, and rias. The Ria of Aveiro, the Ría Formosa and the Tejo and Sado estuaries are the most representative. Besides these larger areas we can also find in North Portugal the Minho and Coura estuaries, in Southwest the Pequena, St. Andre and Sancha lagoons and further south the small Gaivota island protected areas (Figure 21).

Besides the mentioned areas, two fishing closed areas are present in Portuguese waters, a closed area in southwest Portugal between Arrifana and Milfontes applied to all fishing gears, from 1 December to the last day of February and a permanent closed area for gillnets in the fishing ground "Beirinha" in South Portugal.

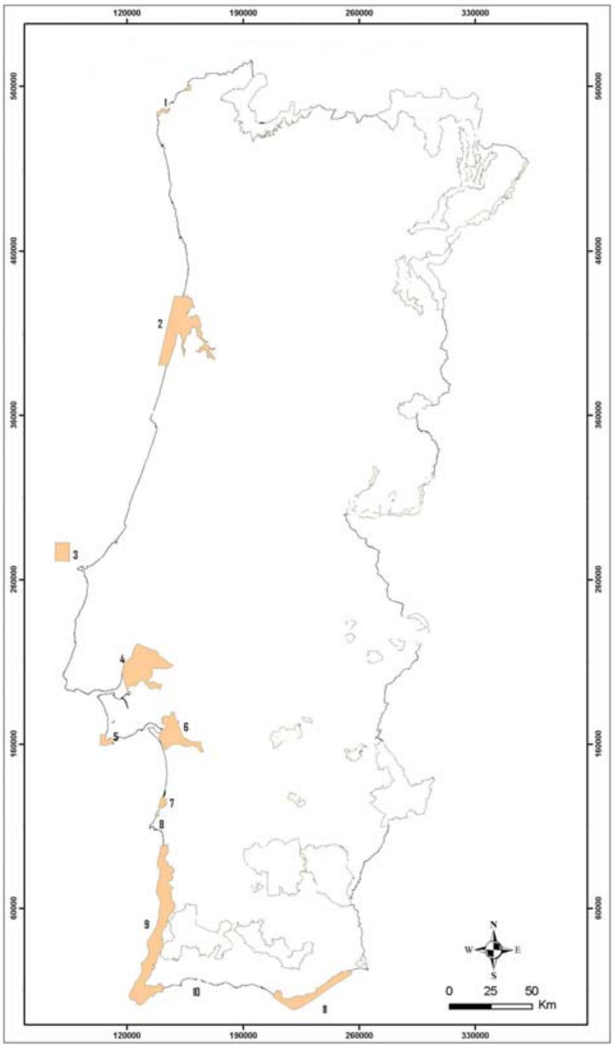


Figure 21. Portuguese marine and coastal protected areas: 1) Minho and Coura estuary, 2) The Ria of Aveiro, 3) Berlenga Marine Reserve, 4) Tejo estuary, 5) Arrábida Marine Reserve and Pequena lagoon, 6) Sado estuary, 7) St. Andre lagoon, 8) Sancha lagoon, 9) Sudoeste Alentejano and Costa Vicentina Natural Park, 10) Gaivota island and 11) Ría Formosa (modified from http://portal.icnb.pt/ICNPortal - Institute for Nature Conservation).

Oceanic areas

The diversity of open and deep ocean habitats (namely seamounts, abyssal bottoms and hydrothermal fields) endow the marine environment of the Azores with a considerable significance for marine conservation and biological studies (Santos *et al*., 1995a; Tempera and Santos, 2007). At a coastal level, this interest is enhanced by the young geological age of the islands and isolation of their shores and shelves in relation to the continental coasts.

Despite such geographical isolation, the marine resources of the region have experienced increasing impacts from human activities which have required the implementation of spatial-based management measures such as Marine Protected Areas (MPAs).

Throughout the 1980's and 90's a total of 9 marine protected areas were designated around 4 islands and on an offshore bank (Santos *et al*., 1995a). However, in our opinion, the results achieved have not done much for crediting this as a fisheries management measure. The detailed regulations were never issued for most areas, dedicated management was poorly implemented and enforcement of the few measures set by the MPA designation acts has been insufficient.

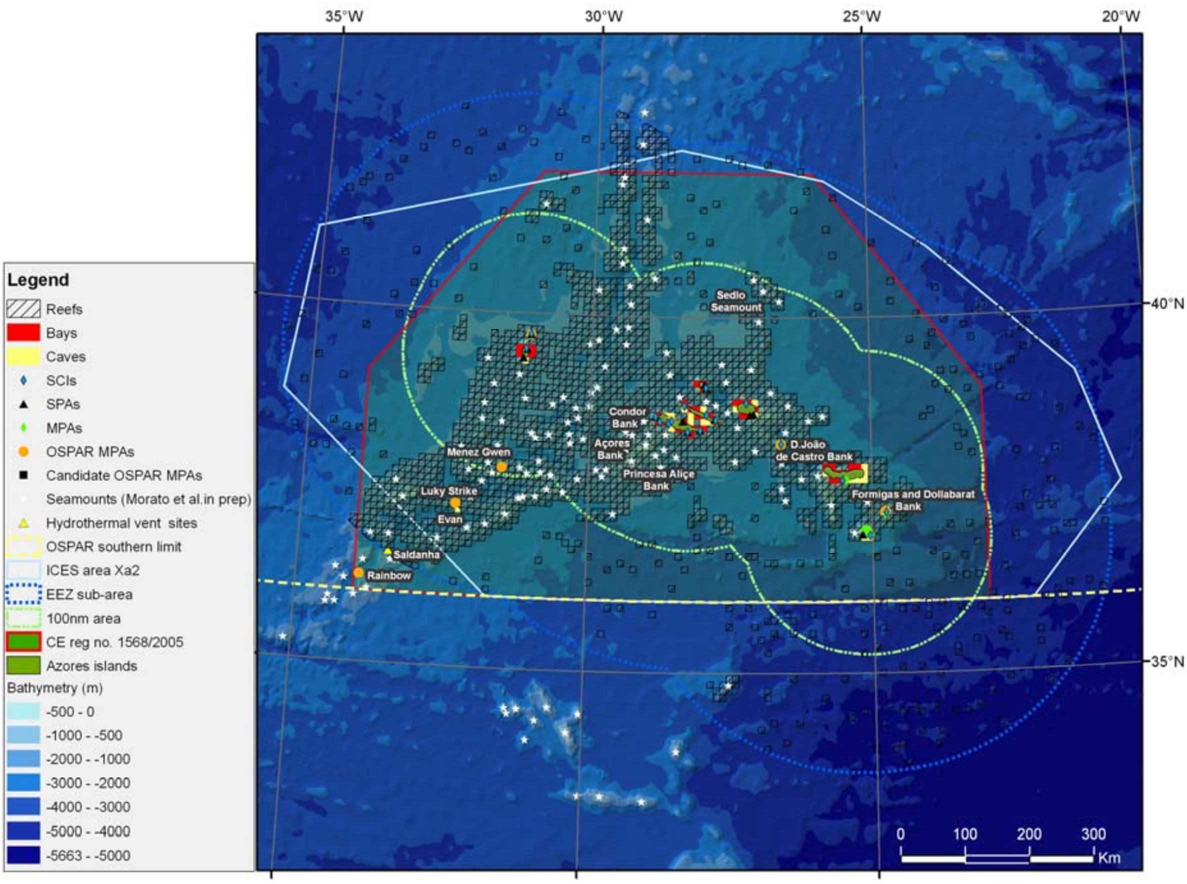


Figure 22. Habitats protected under the Natura 2000 network in the Azores including reefs, marine caves, shallow inlets and bays. Additional layers of relevant information on local bathymetry, Sites of Community Interest (SCIs), Special Protection Areas (SPAs), Seamounts, Marine Protected Areas (MPA), Hydrothermal Vent sites as well as conventional areas (OSPAR, ICES, EEZ) are also illustrated on the figure. Source: ImagDOP.

With the application of the EC “Birds” and “Habitats” Directives in the archipelago, conservation benefited from a new strategic perspective and driving force. An inventory by Santos et al. (1995a) partially informed the site selection process by listing 40 marine sites of conservation importance. In 2001, 17 Sites of Community Interest (SCIs), corresponding to about 8,759 ha of protected area, and 13 Special Protection Areas (SPAs) were eventually designated to protect marine features including reefs, marine caves, shallow inlets and bays (Figure 22), bottlenose dolphins and loggerhead turtles (Commission Decision 3998/C2001) (Figure 23). Since then, management planning proposals based on a characterization of both ecological and socio-economical factors were completed for all the marine Natura 2000 sites of the Azores. This was undertaken by projects *MARÉ* and *OGAMP* with specific contributions from *CLIPE*, *PAINHO*, *ASIMOV*, *MAROV* and *CETAMARH*. General measures for the Natura 2000 sites have been implemented by the *Sectorial Plan* (DLR 20/2006/A, 6th June) which is legally binding to all the administrative bodies.

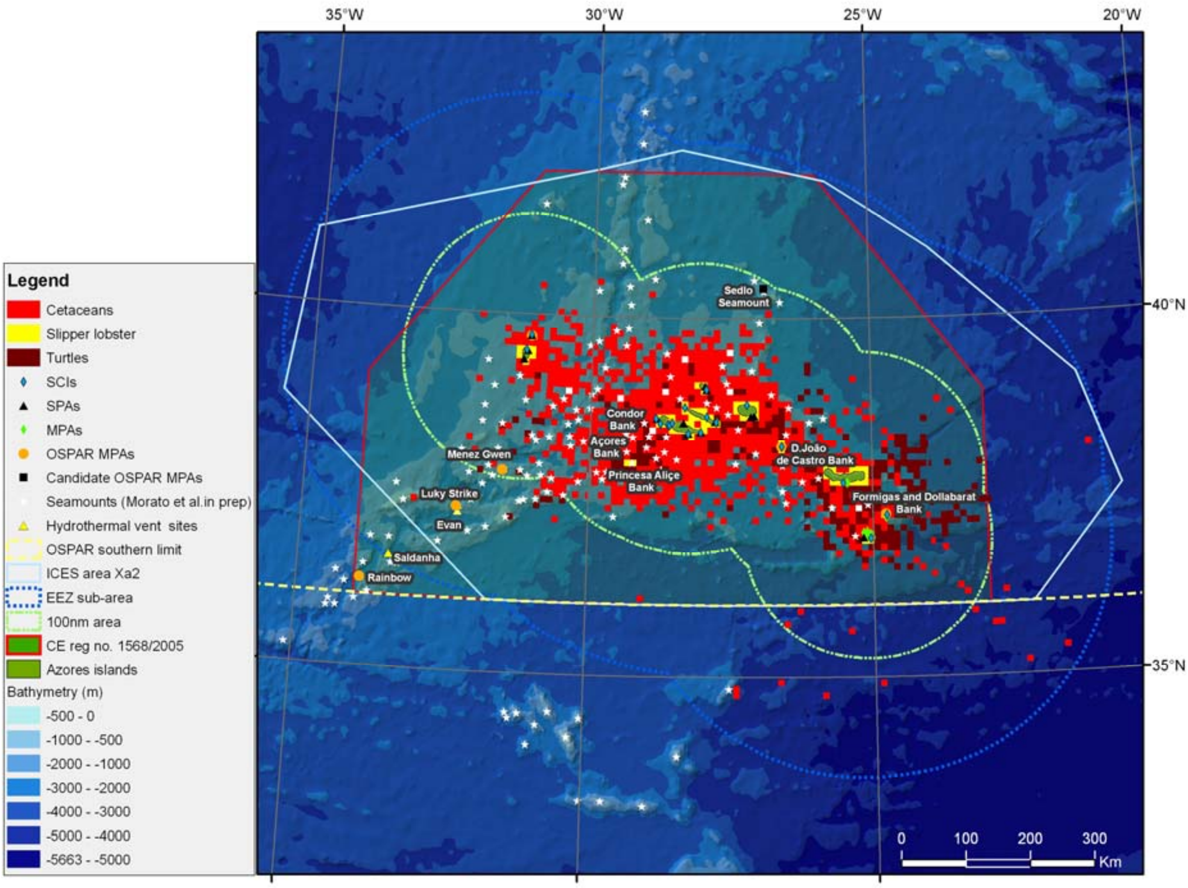


Figure 23. Distribution of the Azorean marine protected species under the Natura 2000 network: cetaceans, sea turtles and slipper lobster. Additional layers of relevant information on local bathymetry, Sites of Community Interest (SCIs), Special Protection Areas (SPAs), Seamounts, Marine Protected Areas (MPA), Hydrothermal Vent sites as well as conventional areas (OSPAR, ICES, EEZ) are also illustrated on the figure. Source: ImagDOP.

In the scope of the OSPAR Convention for the Protection of North-East Atlantic, seven areas (Formigas Bank, Faial-Pico passage, Corvo island, Dom João de Castro Bank, Sedlo Bank and the hydrothermal vent fields of Menez Gwen, Lucky Strike and Rainbow) have been included in the OSPAR network of MPAs (Table 1, Figure 23).

Table 1. Protected areas under the OSPAR convention, including the classification year and the area protected.

Classified areas	Year	Area (ha)
Formigas/Dollabarat	2006	52.527
Rainbow	2007	2.221
Lucky Strike	2007	19.023
Menez Gwen	2007	9.489
Corvo	2007	26.634
Canal Faial Pico	2007	12.193
Banco D. João de Castro	2007	1.648
Sedlo	Proposed	401.253

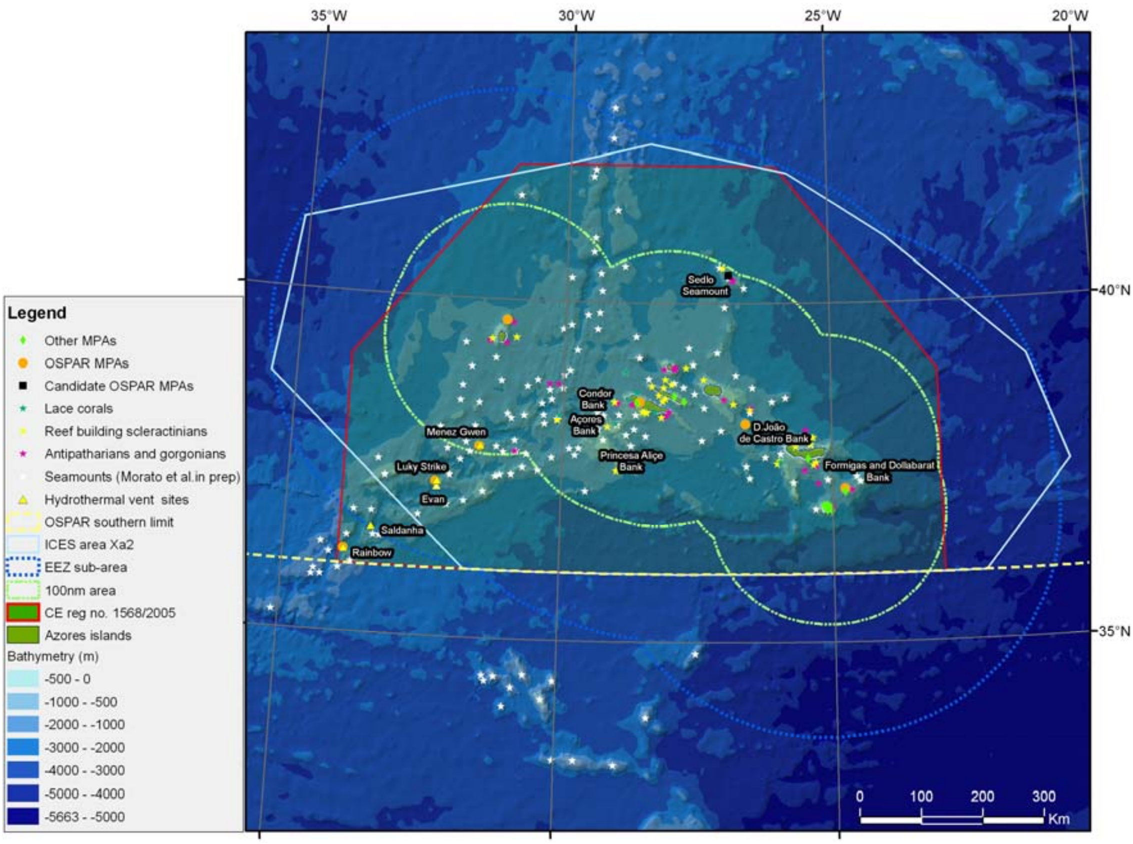


Figure 24. Areas included in the OSPAR network of Marine Protected Areas (MPAs). Other MPAs, seamounts and international, national and regional areas from conventions and laws are also presented. Deep sea corals, seamounts and hydrothermal vents information are included also on the figure. Source: ImagDOP.

The islands of Graciosa and Corvo and neighbouring marine areas have also been designated as biosphere reserves under the Man and Biosphere (MAB) UNESCO Programme.

An important set of 12 Azorean sites has also been classified in the scope of the *BIOMARE/MARBEF* network for Large-scale Long-term Marine Biodiversity Research in Europe (see Warwick *et al*., 2003 and http://www.marbef.org/data/sites.php). Some of them are expected to be used as standards of environmental quality due to the absence of significant anthropogenic impacts.

The Lucky Strike and Menez Gwen hydrothermal fields have been classified under the Program "Gift to the Earth" developed by the World Wildlife Fund (WWF).

In 2007, a new framework for the management of protected areas started to be implemented (DLR 15/2007/A, 25th June) that not only harmonised the protection categories used in the Azores with those adopted and promoted by IUCN- The World Conservation Union but also integrated the management of conservation features (Natura 2000 sites and regional protected areas) on an island basis. The new framework led to the designation of larger MPAs in coastal areas and revived the process to designate offshore and deep-sea areas such as the two deep-sea hydrothermal fields (Lucky Strike and Menez Gwen) and an offshore seamount (Sedlo) (Tempera and Santos, 2007).

Further designations

High Seas Important Bird Areas have recently been identified by Project *IBAS-Marinhas* and are expected to become SPAs as required by the EU.

A scientific reserve has been maintained in the biogeographic region of Macaronesia by the European Commission for the habitat named *Reefs* (Decision 2002/11/EC). As more scientific knowledge on the distribution of this habitat is collected, the submission of both enlarged SCIs (which is generally suggested by studies on cetacean and fish movements) and new sites (including seamounts, hydrothermal vents and sites containing coral reefs, coral gardens and deep sea sponge aggregations) is to be expected as they are identified in the region.

MPA-related scientific research

Several research lines aim at informing the design of current and future MPAs.

The potential effects of MPAs and design requirements for protecting coastal fish species of commercial importance with distinct habits have been assessed project MARÉFISH. The study included tagging and acoustic telemetry (with passive and active methods) to analyse the movement patterns and habitat preferences of fish species around the island of Faial. One of the major conclusions was that SCIs are undersized if they are to provide a robust protection for several reef-associated fishes of commercial interest that features large home-ranges. Similar conclusions were made for cetaceans under project CETAMARH.

Recent research on seabirds has focused on monitoring SPAs, identifying offshore Important Bird Areas, studying population dynamics and genetics, and assessing foraging ecology of selected species by telemetry. The latter has included tracking the movements of Cory's shearwaters at local and oceanic scales by radio and satellite throughout the breeding cycle. The results were relevant to the identification of High Seas IBAs.

Fine-scale habitat mapping has been conducted around the island of Faial-Pico passage using tools such as multibeam, phase-measuring swathe sonar associated to *in situ* validation by scuba-diving, ROV and drop-down camera surveys (Tempera, 2008). The resulting maps for seafloor nature and benthic assemblages should inform the zonation scheme of the local protected areas.

Environmental awareness

Since only a well-informed, involved and supportive public is believed to guarantee the continuation and success of the marine conservation programmes, a special emphasis has been given to raising the environmental awareness of local communities in parallel with the research and legislative efforts. Regular activities have included campaigns and information sessions for students, teachers, stakeholders and public in general, production of promotion material, exhibitions and guided tours in SCIs. A Marine Interpretation Centre dedicated to the "Ecosystems of the Azores Triple Junction & Mid-Atlantic Ridge" is currently being established in Faial Island and will be supported by a virtual version in a DVD format.

ACRONYMS:

CLIPE: Climatic effects on the ecology of littoral fishes: A geographic and phenological approach. (PRAXIS-XXI/3/3.2/EMG/1957/95).

PAINHO: Ecology and conservation of the temporally segregated populations of the Madeiran storm petrel *Oceanodroma castro* breeding in the Azores. (POCTI/BIA/13194/1998)

MAROV: Coastal marine habitats, thematic mapping of the seabed using GIS, AUV (Autonomous Underwater Vehicles) & ASV (Autonomous Surface Vehicles). (PDCTM/P/MAR/15249/1999).

MARÉFISH: Benefits of marine protected areas: testing the theory with field experiments. (POCTI/BSE/41207/2001)

CETAMARH: Ecology and population structure of bottlenose dolphins and sperm whales in the Azores: assessing the relationship with habitat features. (POCTI/BSE/38991/2001).

ASIMOV- Advanced system integration for managing the coordinated operation of robotic ocean vehicles. (MAST3- CT97-0092).

MARÉ: Integrated management of coastal and marine areas in the Azores (LIFE98 - NAT-P-5275)

BIOMARE: Implementation and Networking of large-scale long-term marine biodiversity research in Europe. (EVK2 - 1999 – 00250)

OASIS: Oceanic Seamounts: An Integrated Study. (EVK3 – CT 2002 – 00073).

OGAMP: Management of marine protected areas in Macaronesia (Azores, Canaries and Madeira) (INTERREG IIIb/MAC/4.2/A2 2001)

MARBEF – Marine Biodiversity and Ecosystem Functioning (FP6-GOCE-CT-2003-505446).

MARMAC – Knowledge, promotion and valorisation for a sustainable use of marine protected areas in Macaronesia. (INTERREG IIIb - 03/MAC/4.2/A2 2004).

EMPAFISH – European marine protected areas as tools for fisheries management and conservation. (FP6 2003 SSP3 – P006539)

1.2.2.3 Habitats subject to specific pressures

Nowadays, the project INDEMARES is focused on the study of other relevant areas to be proposed as MPA candidates by the Spanish Government. In the southwestern waters RAC two areas are located: the Galicia Bank (a seamount) and the Avilés canyon. In the Galicia Bank, several OSPAR habitats have been found (in addition with the habitat "Seamount"): Carbonate mounds, Coral Gardens, Deep-sea sponge aggregations, *Lophelia pertusa* reefs, and Sea-pen and burrowing megafauna communities.

River plumes in the Bay of Biscay constitute favourable habitats for spawning and recruitment of some pelagic fishes, and represent 'post-nursery' areas where 1-year-old small pelagics (anchovy, sprat, sardine) concentrate in spring (Massé, 1996). The concentration of anchovy spawning in river plumes may also be related to population structure: 1-year-old fish represent 70-80% of the stock which predominantly spawns in coastal plumes (e.g. Gironde), whereas older fish tend to spawn in the outer part of the shelf and shelf break (Motos *et al*., 1996).

Seamounts

Le Danois Bank (El Cachucho), the most relevant of the Cantabrian seamounts, is constituted by an almost flat surface located at a depth of 450-640m, slightly sloped to the coast, but separated from the continental shelf by a deeper inner basin (850m). The integrate study of the benthic-demersal ecosystem of this bank is the main objective boarded in the ECOMARG project. Le Danois Bank has been named as the first offshore MPA in Spain. In the bank the following habitats have been found in OSPAR terms: Coral Gardens, Deep-sea sponge aggregations, Sea-pen and burrowing megafauna communities.

In oceanic regions, seamounts have been habitats concentrating research and conservation efforts given their role as ecological and zoogeographical 'hot spots'. A baseline of published information on seamounts in the North East Atlantic was resumed during the OASIS project (http://www1.uni-hamburg.de/OASIS//) (Gubbay, 2003). An important resume about seamounts with the references for the area can be also found in Pitcher *et al.* (2007).

A total of 63 large seamounts (in the classical definition of "underwater elevations rising ≥1,000 metres above the surrounding seafloor") have been inventoried in the Azores EEZ but up to 368 significant elevations (200m≥h≥1,000) have been described (Morato *et al*., 2008a).

The case of the Sedlo seamount (located north of the archipelago) was exhaustively studied from an oceanographic, biological and economical perspective under the EU-funded project *OASIS*. Based on these assessments, a management plan was proposed for this area (Gubbay, 2005) which may become a conceptual model for the management of seamounts in the northeastern Atlantic.

The rocky volcanic nature of the slopes and seamounts provide a high energy environment ideal for sessile suspension-feeding fauna such as cold-water corals, sea fans and sponges. Around 150 different species of coral are known from this region, occurring from 500-1700m depth. This rich assemblage supports a complex and diverse community of deep-sea fauna which is highly fragile and vulnerable to damage by fishing gear (ICES, 2006b).

Benthic communities of the Azorean seamounts are currently protected from bottom trawling and deep-sea netting by a ban introduced by the EU Council Regulation (EC) No. 1568/2005.

In recent years a few seamounts have been surveyed using remote platforms such as ROVs and a drop-down camera. Imagery of great quality was obtained of coral assemblages (*sensu latu*) associated to these habitats and directly benefiting from the non-use and ban of towed nets.

Fishing effort on seamounts areas in the Azores EEZ have been increased and some local depletion may be occurring for some target demersal species (ICES, 2008c). Though poorly explored, ridges and seamounts on the oceanic areas of the SWW RAC have fisheries resources that have been exploited by international fleets for several decades (including Soviet and Russians, Faroes and UK), often in controversial and virtually unregulated operations. Fisheries usually developed before scientific knowledge has been acquired to provide satisfactory advice on management of habitats and resources. This has led to over-fishing, habitat destruction, and calls for global high-seas trawl bans and introduction of area closures or reserves. Defining sustainability criteria based on current knowledge of the resources and impacts of past and present exploitation is difficult.

Hydrothermal vent fields

Hydrothermal vents/fields have been found in areas of shallow and deep-sea tectonic activity in the Pacific, Indian and Atlantic Oceans. In the Atlantic they are associated with the Mid-Atlantic Ridge (MAR) (Figure 25). They are indirectly related with seafloor spreading and are located at the ridge axes. Hydrothermal vents form when hot, mineral rich water flows into the ocean floor through volcanic lava on a mid-ocean ridge volcanoes formed by sea-floor spreading.

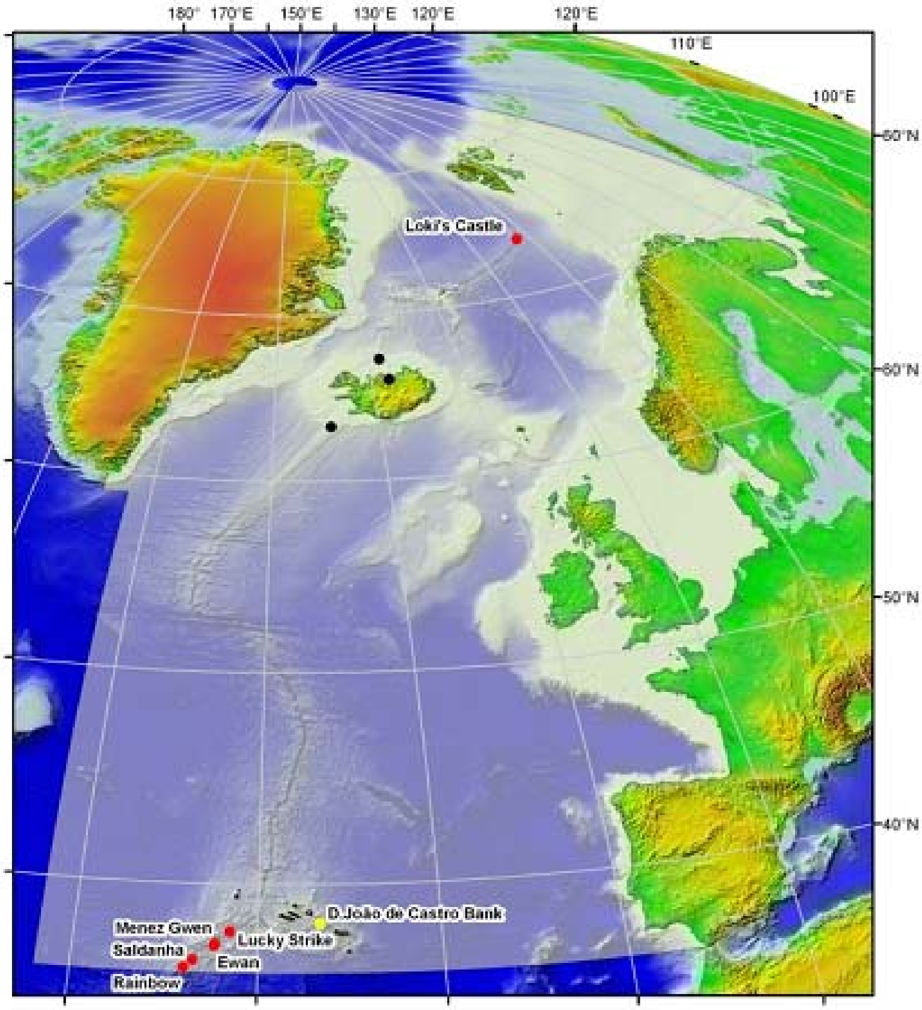


Figure 25. Main chemosynthetic deep-sea hydrothermal vents (red). In yellow shallow water (-40 metres) vent at D. João de Castro. In black hydrothermal vent sites (two at -100 to -200 and one at -200 to -500 metres deep) where no chemosynthetic associated macrofauna is known.

The hydrothermal activity around vents is caused by seawater penetrating the upper layers of the Earth crust through channels formed in cooling lava flows. The tall chimneys formed around the vents and the surrounding sediments are almost pure metallic sulphides and are a unique geological feature of hydrothermal vents (Tunnicliffe et al., 1998). Hydrothermal vents are the interface between the hot, anoxic up flow zone and cold, oxidised seawater. When hot fluids mix with cold seawater, many hydrothermal minerals precipitate within seconds to form the dense particle plumes characteristic of black smokers. The particles are predominantly a mixture of sulphides (e.g. pyrrhotite FeS, sphalerite ZnS, chalcopyrite $CuFeS_2$, etc.) and sulphates (anhydrite $CaSO_4$, barite $BaSO_4$). Some of these minerals become part of chimney structures that build up on the sea-bed, while others form plumes that disperse through the water (Colaço, 2001). Around these structures highly rich and diverse animal communities occur frequently. One of the most striking features of the exotic animal communities that are found at hydrothermal vents is that they are sustained by chemo-autotrophic bacteria. Until the discovery of hydrothermal vents, photosynthesis had been the best known metabolic process for the sustaining life on earth. Photosynthesis uses light as the source of energy and CO_2 as the inorganic source of carbon. In chemo-autotrophy, the source of carbon is again inorganic (CO_2), but the source of energy is chemical, obtained from sulphide or methane. Vent animals are therefore independent of sunlight and, for this reason, it has been suggested that hydrothermal vents could have been the location for the origin of life on our planet. The associated animal communities are particularly unusual as the species derive energy under conditions where photosynthesis is not possible, tolerate great extremes and variability in the temperature and the chemical composition of the surrounding water, and cope with potentially toxic concentrations of various heavy metals. Generally hydrothermal vent fields cover relatively small areas of the seabed in water depths of 850-4000m. The biological communities associated with hydrothermal vents are unusual as they are able to derive energy under conditions where photosynthesis is not possible. These habitats contain a huge diversity of chemo-autotrophic bacteria, which form the basis of the trophic structure around the vent. Characteristic species at the Mid-Atlantic Ridge vents in the OSPAR region V include the mussel Bathymodiolus azoricus and its commensal worm Branchipolynoe seepensis, the shrimps Mirocaris fortunata, Chorocaris chacei and Rimicaris exoculata (this last one being dominant on the southern vent fields of Lucky Strike), the crab Segonzacia mesatlantica, the polychaete Amathys lutzi, the amphipod Luckia strike and the limpet Lepetodrilus atlanticus.

Five active hydrothermal sites have been discovered in the OSPAR-Azores area since 1992 and up to now: the Menez Gwen site at 37°45'N, the Lucky Strike site at 37°15'N, the Saldanha site at 36°34'N, and the Rainbow site at 36°13.8'N, and the Evan site at 37°17.28' N / 32°16.49' W. These five sites differ by (i) their depth (from 850m to 2800m), (ii) the composition of their host rocks (mantle-derived, serpentinised peridotite or basalt), (iii) the nature of associated volcanism (explosive at depths shallower than 900m, effusive at greater depths), and (iv) their tectonic setting (in the centre of ridge segments, or within axial discontinuities). The ecosystems they associate with are also distinct at least in four sites, the biodiversity and biomass being greatest at the Lucky Strike site (Desbruyères et al., 2001).

Intensive and long-term research programmes have focused on hydrothermal vent fields within the Azorean EEZ sub-area over the last decade (see Santos et al., 2002). This fact, in conjunction with the potential of the sites for bio-prospecting and extended geological studies including deep-sea drilling, have called for conservation measures that safeguard these restricted deep-sea biotopes. Both the Lucky Strike and Menez Gwen sites (placed at around 1700m and 900m deep, respectively) are currently being established as

MPAs and submitted to the OSPAR MPA network. Their management plans aim not only at avoiding conflicts between different research programmes but also at combining preservation of these restricted habitats with requirements from scientific sampling (see Santos et al., 2003).

Artificial reefs

As a consequence of the high biodiversity of the Cantabrian Sea coastal and inner shelf, and its role as a nursery ground for several commercial species, bottom trawling in the area is forbidden by Spanish legislation in depths shallower than 100m. Nevertheless, illegal trawling operations are not uncommon. To prevent this, artificial reefs (concrete blocks) were placed on some of these shallow (Figure 26), soft grounds by the local fishery authorities (a description of the regulatory framework is available in Revenga *et al*., 2000). This measure allows analysing the recovery process of benthic and demersal communities in these inner shelf ecosystems (ICES, 2008e).

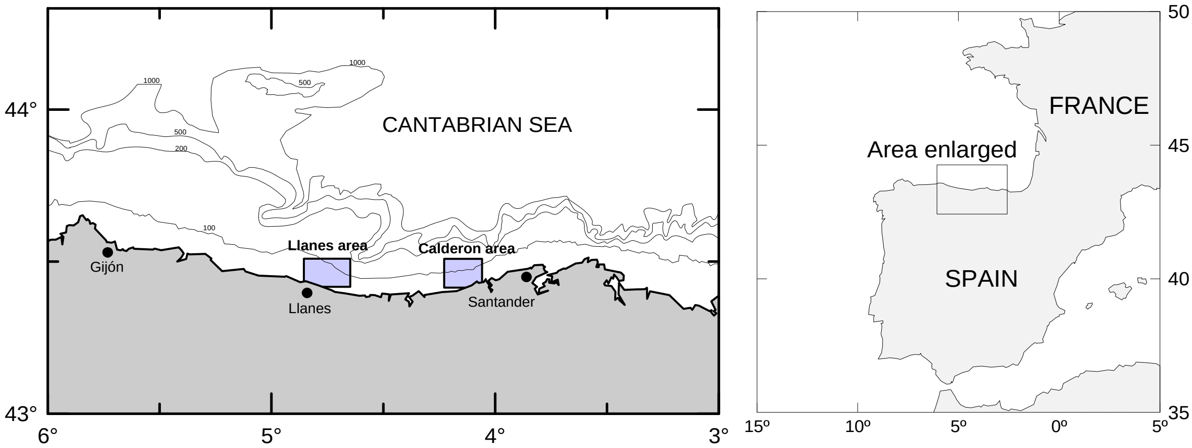


Figure 26. Artificial reefs for illegal trawl exclusion under 100m depth in the central Cantabrian Sea.

Since 1989, IPIMAR has been developing an artificial reef systems pilot project in the Algarve waters, which consists of a protection reef and an exploitation reef (Santos and Costa Monteiro, 1997). Artificial reefs aim to contribute to ecosystem conservation, fisheries sustainability, and because they can be helpful in zoning coastal areas in order to reduce conflicts between users (Claudet and Pelletier, 2004). These aims are achieved by the protection of juvenile fish populations, in particular commercially exploited species; the promotion of biodiversity and the diversification of catches. Artificial reefs should contribute to the recovery of coastal fishing resources by creating controlled exploitation fishing zones and developing exploitation strategies that take into consideration the nature and resources of the ecosystem.

Several studies have monitored the success of these reefs by testing artificial reef effectiveness in enhancing fish assemblages and yield. They have shown that the reefs have attracted and aggregated fish. The Artificial reef deployment has resulted in enrichment and diversification of the local fish community, with an increase in the total species richness, mean species richness and the species diversity indices. They have created new “habitats”; they have provided protection for juveniles and they have led to an increase in productivity and consequently fishery yields. (Santos *et al.*, 1995a; Santos and Costa Monteiro, 1997;

Neves Santos and Costa Monteiro, 1998; Moura *et al.*, 2006). Furthermore, the projects have contributed to the improved value of the artisanal fishery in the region, and have involved fishermen, leading to a process of co-responsible fisheries management, meaning that the reefs appear to represent a useful management tool on the South Portugal coast. Finally, the artificial reefs have been used for experiments with offshore aquaculture and for restocking initiatives with local species from local hatcheries.

1.2.3 Biological features

1.2.3.1 Communities associated with seabed and water column habitats.

In terms of biogeography, the SWW area is very wide including a continental part from France to Gibraltar which is a subtropical/boreal transition zone of the Eastern Atlantic, and an insular part constituted by the Azores, Madeira and Canary islands. Typical temperate water species from the south cohabit together with others of northern origin and, consequently, high biodiversity indices exist in relation to adjacent areas (Olaso, 1990; Sánchez, 1993; OSPAR, 2000). In addition, the topographical complexity and the wide range of substrates on its narrow continental shelf give rise to many different types of habitats. This diversity is reflected in the biological richness of the region, which includes a wide range of species, many of which are of commercial interest. Fisheries, in which approximately 200,000 tonnes of fish per year are landed, have an enormous effect on the structure and dynamics of the Cantabrian Sea ecosystem (Sánchez and Olaso, 2001, 2004). The West Iberian Sea waters can be classified as being a subtropical subprovince of the Lusitanian province (Dinter, 2001). Nevertheless, boreal species are also found in the ecosystem, at the southern most extreme of their distribution, meaning that species diversity is quite high in this region.

The environmental conditions of the ecosystem shape the trophic structure, in particular upwelling. Plankton availability is strongly related to upwelling events. Thus, a large proportion of the biomass and production are pelagic. Phytoplankton grazing is low, so detritivorous species are important. Suspension and deposit feeders constitute a high percentage of the biomass (Sanchez and Olaso, 2004). Abundant suprabenthic zooplankton is also available to pelagic and small demersal fish species (ICES, 2006d). Trophic interactions are important in this ecosystem. There are two main types of interaction: bottom-up and top-down controlled situations. Small pelagic fish species generally feed on plankton, while larger species are piscivorous, feeding on other fish species. Decapod crustaceans are important prey items for benthic fish species as megrims, gurnards, skates, and *Trisopterus* spp. (Rodriguez Marin, 2002, Serrano *et al*., 2003a), cephalopods are minor prey items for most of the demersal fish predators found in this area (Velasco *et al.*, 2001) together with polychaetes (Serrano *et al*., 2003b) . There are many important fish prey species and sardine, anchovy, mackerel, and horse mackerel have all been found in the diet of fish (e.g.: hake, tuna, John Dory, etc.) and cetacean (common dolphins (*Delphinus delphis*)) species (Silva, 1999; Santos *et al*., 2004). Blue whiting is one of most important prey species in this ecosystem (Velasco and Olaso, 1998; Preciado *et al*., 2008).

Understanding the trophic interactions of predator species is fundamental for fisheries management, in order to ensure there are always prey species available for the top predators. Work has been carried out to assess the seasonal and annual variability of prey in Portuguese waters (Hill *et al*., 1999; Hill and Borges, 2000). It has been seen that blue whiting is an extremely important forage species, both in terms of availability in the environment and in terms of importance in diet of several species (Olaso *et al*., 1994; Silva *et al*., 1997; Olaso *et al*., 1998; Velasco and Olaso, 1998). However, in the south of this ecosystem species such as anchovy, sardine and mackerel are more abundant than blue whiting. They are correspondingly more important prey species in this region (Hill and Borges, 2000).

Bacterioplankton communities

In open ocean, bacteria dominate the abundance, diversity and metabolic activity of the ocean (LAMAR report, 2008). Microbial cell concentrations are typically about 105 cells·ml^{-1} in the ocean surface layer (0–300m) (Ducklow, 2000). Efficient nutrient recycling, in which there is intense competition for scarce resources, sustains the microbial growth. Viruses and protozoa are main microbial predators. Microbial planktonic communities are influenced by biotic and abiotic factors. To determine the local impact of microorganisms on biogeochemical cycles it is important to study its spatial and seasonal variation. This study has to be consistently conducted at smaller scales to be then scaled up in order to obtain useful predictions of how marine ecosystems in the whole ocean might respond to global change.

Preliminary studies performed at the University of the Azores on surface water samples collected around the archipelago, provided the first estimates of microbial diversity on open ocean NE Atlantic, using novel metagenomic techniques through massive parallel pyro-sequencing and others (LAMAR report, 2008; Lino *et al*., 2008; Loureiro, 2008; Loureiro *et al*., 2008; Pereira *et al*., 2008; Lino, 2009). In general, higher diversity of micro-eukariotes was found at sites with lower microbial cell density. This may indicate strong predatory or competition factors at these diversity hot spots. Diatoms, dinoflagelates, golden algae, green algae, silicoflagelates, cyanobacteria, and Acantharea were among the groups identified within the biotic front area (at about 37°N, south of Faial island). From those preliminary data it was also possible to identify a microbial plankton spatial distribution pattern by comparing the Bacteria community structure and Archaea distribution. All samples within the dataset that were collected near the islands plateau presented higher similarities than they did when compared with more open ocean systems. These open ocean systems tended to group in separate clusters. According to recent studies of Lino (2009), during the summer (August 2007), the principal bacteria present in the surface layer of the Azores region are members of classes Gammaproteobacteria, Alphaproteobacteria and true Cyanobacterias. The main genera found in open sea environment, south of the Azores islands, were Pelagibacter, Alteromonas, Pseudoalteromonas, Opitutus, Psychroserpens, Acinetobacter, Polaribacter, Marinobacter, Pseudomonas, Sphingomonas, Sulfurovum, Ralstonia, Oceanobacter, Silicibacter and Streptococcus.

Phytoplankton communities

The annual phytoplankton cycle shows the pattern typical for a temperate sea, characterised by a winter mixing period followed by a stratification phase during summer. Phytoplankton blooms during the transition periods (i.e. in spring and autumn) are characterised by an almost absolute dominance of diatoms. During summer stratification, nutrient concentrations drop and phytoplankton biomass decreases to low levels. In winter, mixing and low light levels prevent phytoplankton growth despite high nutrient concentrations.

Like the entire northeast Atlantic, the Bay of Biscay region undergoes a seasonal climatic cycle, which strongly affects the pelagic ecosystem through three interrelated forcing factors over the year: sunlight exposure, heat exchange with the atmosphere input and mechanical forcing on the surface due to wind. The effect of these forces produces a regular pattern in hydrographical conditions characterised by winter mixing of waters, followed by summer stratification. Phytoplankton blooms occur during the transition between the two periods. In addition, productivity and plankton growth in the shelf seas of the Bay of Biscay are influenced by river discharges and freshwater advection, light availability and other mesoscale and submesoscale features (Labry *et al*., 2001; Gohin *et al*., 2003; Lavin *et al*., 2006).

The onset of the spring bloom occurs with remarkable regularity in March on the southern coast of the Bay of Biscay. By March-early April the spring bloom covers the entire Bay of Biscay. Spring (March-April) is the transitional period between the winter conditions (surface river originating waters along the coast heading North) and estival conditions (dispersion of river water towards the offshore and or even South when northwestern dominant winds). At that time of the year, wind seems to be the dominating factor for thermohaline distribution of surface water over the whole Bay of Biscay. In winter and early spring, oceanic water is warmer than shelf waters, because of a pycnocline created by desalted water acting like a barrier between surface and bottom waters. This supports surface waters heat losses towards the atmosphere and thus cooling of the surface layers. During this period, salinity conditions the density of the water mass and the position of the pycnocline (Lampert, 2001).

From May onwards, chlorophyll drops sharply, and the lower values are observed in summer. During summer, the warming process of surface water comes from offshore towards the coast as well as from the southern part of the bay towards North. The increase in the solar radiation combined with low river inputs (minimum flow reached between July and September) generates a progressive replacement of the weak haline stratification by a thermal stratification. Thus, the increase in the stratification of water allows surface water to remain above oceanic waters towards offshore, and reach or even overpass the limit of the continental slope, depending on the direction and strength of the dominant winds (Lampert, 2001). In this season new production is often related to mesoscale processes associated with topographical features.

The autumn bloom is quite variable in timing and intensity, and restricted to coastal areas: for example, high chlorophyll concentrations are found in the Rías Baixas, at the time of seasonal transition from upwelling to downwelling (Nogueira *et al*., 1997; Figueiras *et al*., 2002). During winter months and in the coastal areas chlorophyll estimates remain relatively high, presumably due to turbid plumes related to runoff and river discharges (Gohin *et al*., 2003).

The average total primary production over the whole Bay of Biscay shelf, estimated from a primary production model coupled to a hydrodynamic model and using satellite data (Gohin *et al.*, 2005; Huret *et al.*, 2007) is 83 g $C \cdot m^{-2} \cdot y^{-1}$ (6 year mean 1998-2003). Along the southern Bay of Biscay and western Galician coasts diatoms dominate the phytoplankton community during most of the year and specially during upwelling events, while microflagellates and small naked dinoflagellates dominate during winter. Small dinoflagellates dominate in warmer, stratified waters, offshore (Valdés *et al.,* 1991; Fernandez and Bode, 1994; Varela, 1996; Casas *et al.,* 1997).

Nevertheless, this main scheme is far from being unchanging and uniform since many regional characteristics may superimpose to this theoretical functional scheme: for instance, tidal currents forcing in the western of Brittany waters (Morin *et al*., 1991) and upwelling events along Spanish coasts (Botas *et al*., 1990). Most important features enhancing primary production are coastal upwelling, coastal runoff and river plumes, seasonal currents and internal waves and tidal fronts.

Upwelled waters are usually advected offshore forming filaments that extend westward following the 200m isobaths and transporting biological material towards oceanic waters. The appearance of upwelling pulses during the summer in the Bay of Biscay is important in the formation of a permanent and deep stratified surface layer, enhancing phytoplankton growth (Estrada, 1984; Botas *et al*., 1990; Tenore *et al*., 1995). Under conditions of moderate upwelling, the innermost coastal 25km are about 10 times more productive than offshore waters and the upwelling centres about 20 times more productive than offshore waters (Bode *et al*., 1996; Teira *et al*., 2003; Varela *et al*., 2003). On the French continental margin, mainly in summer, weak upwelling events are induced along South Brittany and the Landes coastline by northerly winds.

Filaments and fronts associated with high salinity water of subtropical origin (Eastern North Atlantic Water, $ENAW_T$, also called Navidad current) are important along the coast of the southern Bay of Biscay. During winter and spring, this current gives rise to a convergence front, which is localised in the boundary zone between the coastal water and the oceanic water. The effects on phytoplankton (distribution, standing stock, growth rates, species composition and functioning) were described by Botas *et al*. (1988), Fernández *et al*. (1993), Varela (1996), Varela *et al*. (1995, 1998). When saline intrusion is weak, the development of fronts and the formation of seasonal thermocline are enhanced and phytoplankton blooms occur. Intense saline intrusion causes strong vertical mixing, preventing phytoplankton growth during spring.

The Gironde, Loire and, to a lesser extent, the Vilaine and Adour rivers provide large volumes of fresh water (which are turbid but rich in nutrients from the mainland) at the end of the winter. This results in the formation of dilution plumes at the surface of coastal waters, which drive significant northward currents over the inner Armorican shelf. Because the tidal currents along the Atlantic coast are much weaker than in the English Channel, these plumes can extend over several hundred kilometres in length, becoming progressively diffuse. Because of the continual input of nutrients they provide, these river plumes maintain a very large amount of new phytoplankton production along the coastal fringe, and sometimes even to the edge of the continental shelf. Due to the haline stratification that maintains the phytoplankton cells in a very thin layer of water, phytoplankton production can start very early in the year. An anticyclone regime, frequent in the region during winter (January to March), may be favourable to triggering this production. Studies have shown that these winter blooms linked to plumes from large rivers are relatively short. A lower volume of river runoff and a much narrower shelf off the Iberian Peninsula act in tandem to make buoyant plumes much less persistent over the Cantabrian coasts than over the Armorican shelf (Prego and Vergara, 1998).

At the Armorican shelf break when the water column is vertically stratified in summer, tides generate internal waves that propagate both on- and off-shelf from about 5ºW to 9ºW. Such internal waves appear to be responsible for significant mixing and upwelling of nutrients and occur with remarkable regularity, starting in June or July at the shelf-break, where they have their maximum intensity, and thus their greatest impact on primary production. Biological signs of this tidal front include an increase in fluorescence values, zooplanktonic biomass, and eggs and larvae of pelagic fishes, e.g. sardine, mackerel and horse-mackerel (Lago de Lanzós *et al*., 1997). The abundant, sustainable new production makes this 100km wide fringe overhanging the continental shelf break, an oasis in the open sea and it is used by pelagic species as spawning grounds to nourish future larvae (Arbault and Boutin, 1968; Lago de Lanzós *et al*., 1997).

In Portugal, seasonal differences in river discharge can give rise to both river plumes and to lenses of lower salinity. These lenses are particularly rich in phytoplankton and are characterised by the near absence of coccolithophorid species during summer between the Minho and Douro rivers. Filaments and fronts associated with high salinity water of subtropical origin (Eastern North Atlantic Water, also known as the ‘Navidad’ Current) are important along the Iberian margin. During winter and spring, the Navidad Current results in a convergent front at the boundary between coastal and oceanic water. When saline intrusion is weak, the development of fronts and the formation of a seasonal thermocline are enhanced, leading to phytoplankton blooms. When saline intrusion is intense, strong vertical mixing occurs and prevents phytoplankton growth in spring. Along the Portuguese coast coccolithophorids act as tracers for this current. Upwelling of North Atlantic Central Water and even Eastern North Atlantic Water is a common feature along the Portuguese and Galician coasts and in the western Cantabrian Sea, especially in summer. Upwelling affects the thermal stratification/mixing cycle and may have important consequences for phytoplankton growth. Upwelling pulses during the summer prevent the formation of a permanent and deep surface layer, thus enhancing phytoplankton growth. Under conditions of moderate upwelling, the inner 25km of coastal water are about ten times more productive than offshore waters, and upwelling centres approximately twenty times more productive.

Toxic dinoflagellates and diatoms are regular components of the marine phytoplankton community and can render shellfish toxic at concentrations as low as 102-103cells/l, well below those causing water coloration (i.e. > 106cells/l). Their maximum concentrations exhibit interannual variations determined mainly by changes in the upwelling regime, river run-off, inoculum size and other environmental parameters. Cape Finisterre constitutes a biogeographic boundary for the proliferation of toxic species, such as *Gymnodinium catenatum, Dinophysis acuta* and *D. acuminata*. Different toxic outbreaks are delimited in time and space according to the species-specific niche requirements of the causative agents. **¡Error! No se encuentra el origen de la referencia.**Table 2 lists the phytoplankton species that have been associated with toxic outbreaks on the Galician and Portuguese coast and their associated toxins.

Table 2. Species associated with shellfish toxicity on the Galician and Portuguese coasts (OSPAR, 2000).

	Rías Altas	Rías Bajas	Portuguese coast
Paralytic Shellfish Poisoning			
Gymnodinium catenatum	-	+	+
Alexandrium minutum (=lusitanicum)	+	+	+
Diarrhetic Shellfish Poisoning			
Dinophysis sacculus	+	-	-
D. acuminata complex	+	+	+
D. acuta	-	+	+
D. caudata + D. tripos	+	+	+
Amnesic Shellfish Poisoning			
Pseudo-nitzschia australis	-	+	+

Toxicity was determined using High Performance Liquid Chromatography on monoalgal cultures or single cell isolation (except for *D. sacculus* and *D. tripos*).

+ toxicity occurred in shellfish when this species was present; - species present in very low numbers and below the threshold required to render shellfish toxic.

Certain species of phytoplankton produce toxins that can be harmful to both humans and marine life. High concentrations of these plankton is thus of concern. The effects of these algae can either be direct, or by bioaccumulation, in particular in filter feeding shellfish. Harmful algal blooms (HABs) in upwelling systems are linked to wind which is the main driving force in such systems. The HABs therefore vary at temporal scales related to atmospheric oscillations, such as the NAO, which either favour upwelling or downwelling (Kudela *et al*., 2005).

The participants of the GEOHAB Open Science Meeting on HABs in upwelling systems reviewed HABs in the West Iberian Sea in February 2005 (GEOHAB, 2005), the following text is taken from their report:

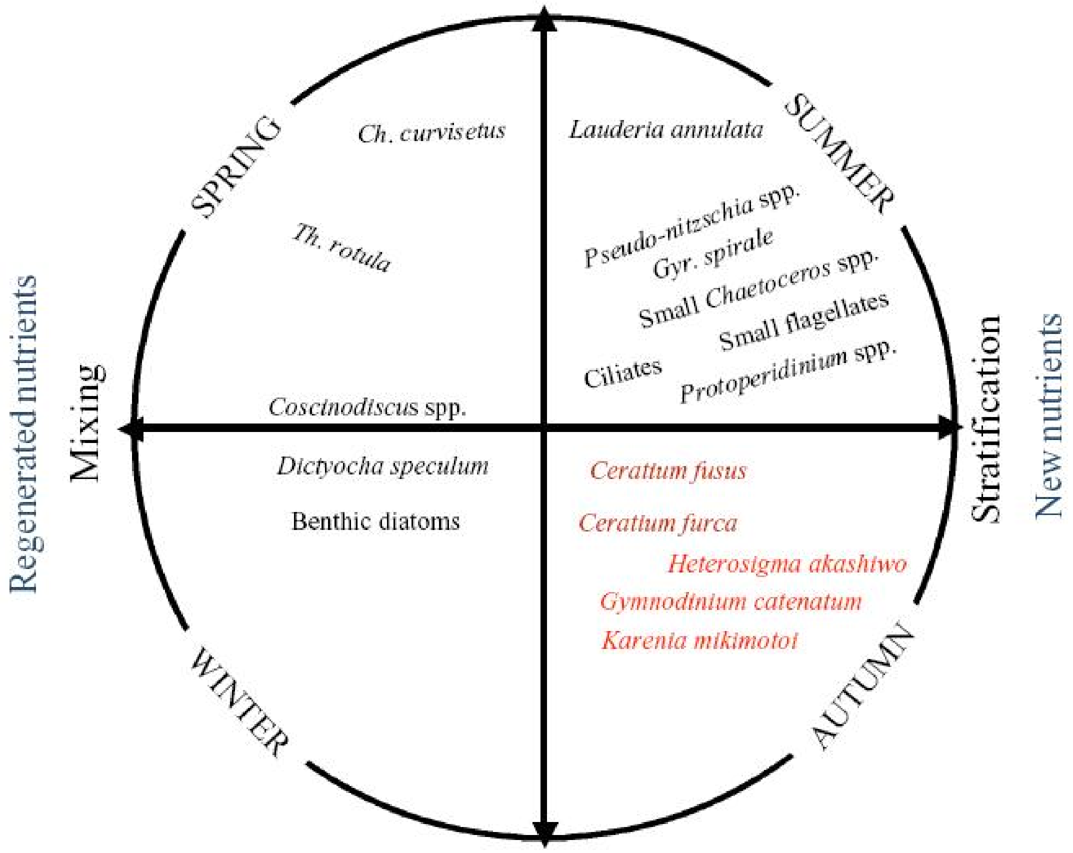


Figure 27. Annual cycle of phytoplankton abundance in the Rias Baixas of Galicia according to a mixing stratification (new vs. regenerated nutrients) gradient (source: GEOHAB 2005)

Harmful species in the Iberian upwelling system correspond to seasonal cycles modified by alongshore and cross-shelf gradients of stratification and upwelling intensity. Thus, *Pseudo-nitzschia* species are common members of the phytoplankton assemblage during the upwelling season (Figure 27) (Palma *et al.*, submitted). Hence, blooms of *Pseudo-nitzschia* species that produce ASP toxins are mainly associated with pulses of upwelling, although they can also be recorded in spring (Palma, 2003) and as early as February in the Galician Rías (Moroño *et al.*. 2000) when winter conditions still prevail. A phytoplankton time series from Cascais Bay indicates an increase in *Pseudo-nitzschia* species 5 or 6 days following an upwelling event (Palma *et al*., submitted). Similar results were observed on the Galician coast (Cuadrado *et al.*, in press). Short-lived blooms of *Pseudo-nitzschia* species, preceding dinoflagellate blooms, can also occur during the autumn transition following intermittent upwelling events. From all the Iberian *Pseudo-nitzschia* species that have been isolated, cultured, and tested for the presence of toxicity, only *P. australis* has been proven to produce domoic acid. However, several species present in the region, for example, *P. multiseries*, *P. subpacifica* and *P. pseudodelicatissima*, remain to be cultured and tested.

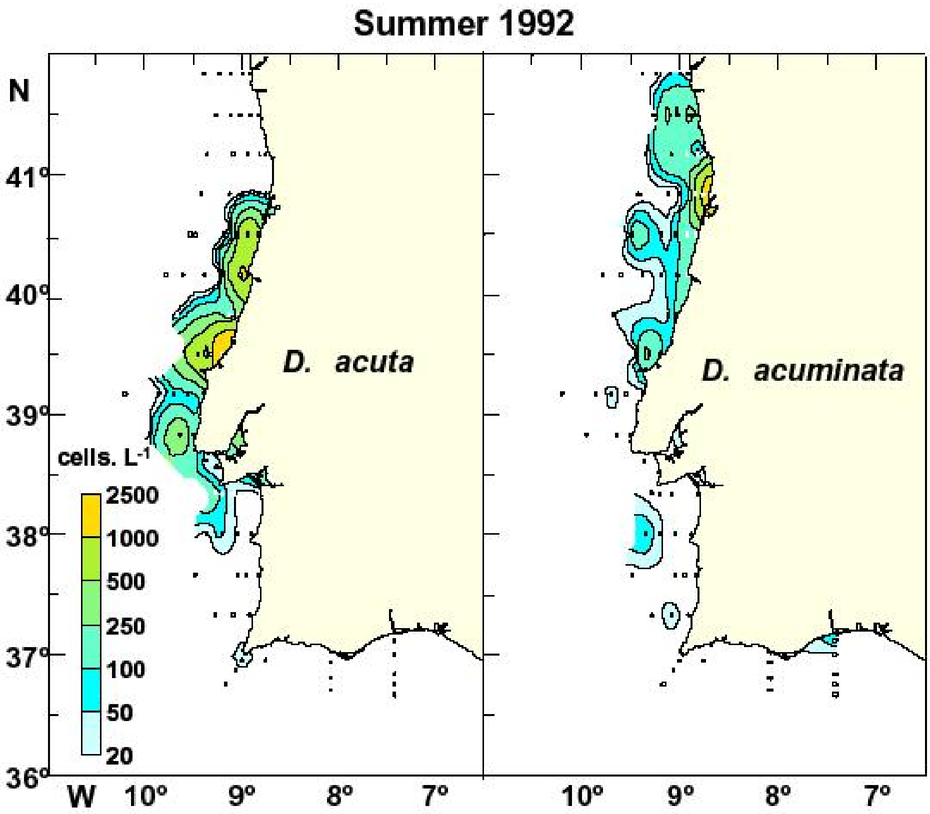


Figure 28. Distribution of *D. acuta* and *D. acuminata* during the summer of 1992 on the Western Iberian coast of Portugal (source: GEOHAB 2005).

The mixotrophic species *Dinophysis acuminata* and *D. acuta* are most abundant at the end of spring and during summer or in well-stratified water columns in upwelling shadows, where they are able to benefit from regeneration processes and food availability (Ríos *et al.*, 1995). Despite their preference for stratified waters, these species bloom inshore of the upwelling front during summer and may at times be the only dinoflagellate representatives within chain-forming diatom assemblages (Moita, 2001). *Dinophysis* species have the greatest economic impact on shellfish harvests owing to their persistence in the Iberian system for much of the year, albeit in very moderate numbers (102–103 cells·l^{-1}). *D. acuminata* and *D. acuta* often coexist but maximum concentrations do not coincide in space or in time. *D. acuminata* maxima are typically found in the north (Figure 28) and associated with lower temperatures and salinities, whereas *D. acuta* concentrations are typically higher in the south (Reguera *et al.,* 1993; Palma *et al.,* 1998). Consequently, when both species bloom along the western coast of Iberia, the highest concentrations of *D. acuminata* typically occur to the north of *D. acuta*. As summer progresses blooms of *D. acuta* can be displaced northward, reaching the Galician Rias. *D. acuta* on the Iberian coast therefore shows a marked seasonal presence occurring first on the Portuguese coast with autumn peaks to the north associated with the autumn upwelling-downwelling transition (Reguera *et al.,* 1995; Sordo *et al.,* 2001). In Galician waters it has also been suggested that extremely dry and hot summers combined with moderate upwelling favour thermocline development within the Rías at a depth providing optimum conditions for unusual blooms of *D. acuta* during August (Reguera *et al.,* 1995). The presence of increased numbers of *Dinophysis* species and DSP outbreaks has therefore been associated with two different scenarios: *in situ* growth favoured by periods of stratification between moderate pulses of upwelling, and downwelling events that favour the accumulation of *Dinophysis* (Reguera *et al.,* 1995; Sordo *et al.,* 2001; Reguera *et al.,* 2003).

The autotrophic dinoflagellates *Gymnodinium catenatum*, *Karenia mikimotoi* and *Lingulodinium polyedrum* are efficient swimmers and are frequently found in late summer-early autumn, at the time of the seasonal transition from upwelling to downwelling, when convergences are well developed along the western Iberian coast (Fraga *et al.,* 1988; Figueiras *et al.,* 1996; Moita *et al.,* 1998; Pazos *et al.,* 2003; Amorim *et al.,* in press). Their enhanced swimming capabilities (Fraga *et al.*, 1989; Hallegraeff and Fraga, 1998) provide these species with an advantage in areas of convergence. Between 1985 and 1995, major toxic events on the Iberian coast were ascribed to blooms of the chain-forming dinoflagellate and cyst producer *G. catenatum*, a species that seems to have spread along the Iberian coast over the years. However, the most recent blooms have been restricted to the Alboran Sea eddy in the Mediterranean Sea (Morales *et al.*, 2003). In recent years, *L .polyedrum* has bloomed in the southern Iberian Atlantic area, in warm stratified waters compressed by adjacent upwelling (Amorim *et al.*, in press), and in the northern Rías of Galicia, where major blooms were recorded in 2003 (Arévalo *et al.*, 2004).

<u>Trends in chlorophyll A</u>

The main patterns of phytoplankton biomass are related to water column stratification, nutrient availability and the intensity and persistence of upwelling conditions. Maximum values of chlorophyll usually occur in spring and summer (Nogueira *et al*., 1997; Moita, 2001), although high chlorophyll values may also be recorded in autumn, particularly in zones with elevated retention characteristics; for example, high chlorophyll concentrations are found in the Rías Baixas, at the time of the seasonal transition from upwelling to downwelling (Nogueira *et al.*, 1997; Figueiras *et al.*, 2002). In summer, a recurrent band of high chlorophyll concentration is found near the coast and associated with upwelled waters and strong cross-shelf gradients that separate upwelled and oceanic waters. Maximum values of chlorophyll near the coast occur in surface waters, while offshore these maxima extend subsurface and coincide with the nutricline (Moita, 2001; Tilstone *et al.*, 2003). Pulses of weak-to-moderate upwelling disrupt stratification and bring nutrients into the photic zone allowing phytoplankton growth on the inshore side of a well-developed thermal front, while stratified oceanic waters offshore of the front remain poor in phytoplankton owing to nutrient depletion (Moita, 2001). During strong upwelling events and weak thermal stratification, features typical of early spring, phytoplankton blooms are advected from the coast and occur offshore of a poorly developed upwelling front. Under these conditions, chlorophyll maxima are often found in an area of convergence or retention formed by poleward-flowing slope water which serves as a barrier to the offshore flow of surface upwelled waters (Moita, 2001; Santos *et al.*, 2004).

Upwelling modifies the phytoplankton assemblage composition, which follows a mixing-stratification gradient. Chain-forming diatoms of medium and large size, such as *Lauderia anulata*, *Detonula pumila*, *Chaetoceros* spp., *Pseudo-nitzschia* spp. and *Thalassiosira* spp. (e.g. *T. rotula*, *T. cf subtilis*), dominate spring and summer upwelling events in coastal waters (Figueiras and Rios, 1993; Moita, 2001). The offshore extent of the assemblage depends on the intensity of upwelling. Outside the areas of upwelling, in stratified and oligotrophic oceanic waters, phytoplankton is dominated by pico- and nanoplanktonic forms, where species of subtropical coccolithophorids such as *Calcidiscus leptoporus* are conspicuous (Cachão and Moita, 2000). This group of phytoplankton is a good indicator of oceanic waters converging over the shelf during upwelling relaxation or downwelling events and of the presence of the winter poleward current (Estrada, 1984; Castro *et al.*, 1997; Figueiras *et al.*, 1998; Moita, 2002). In summer, during stratified conditions, dinoflagellates in general and in particular species of the genera Ceratium, Dinophysis, Protoperidinium, Gymnodinium, Gyrodinium and Prorocentrum and the diatom *Proboscia alata* are abundant. The many heterotrophic species of this assemblage, including many ciliates (Figueiras and Rios, 1993; Moita, 2001), are partially responsible for the elevated concentrations of dissolved organic matter and regenerated nutrients present in the photic layer at the end of summer (Alvarez-Salgado *et al.*, 1997; Alvarez-Salgado *et al.*, 1999). Some of these species, for example, *Noctiluca scintillans* and *Mesodinium rubrum*, are responsible for recurrent discoloration of the water (Cabeçadas *et al.*, 1983). In August 1982, the autotrophic dinoflagellate *Scripsiella trochoidea* formed blooms extending over 100km on the northwestern shelf of Portugal. Blooms of efficient swimmers, several of them chain-forming dinoflagellates, such as *Gymnodinium catenatum* and *Alexandrium affine*, characterise the autumn upwelling-downwelling transition, when they concentrate in zones of convergence (Moita *et al.*, 1998). Especially remarkable are the blooms of these species in the Rías Baixas, in which retention is enhanced (Fraga *et al.*, 1988; Figueiras *et al.*, 1996).

Differences in stratification and in the intensity and pattern of upwelling imposed by the configuration and orientation of the coastline are reflected in the relative abundance of diatoms versus dinoflagellates and in their distribution. For example, the intensification of upwelling associated with the Capes Roca and S. Vicente give rise to small-scale spatial variability in the distribution of phytoplankton assemblages, with diatoms dominating upwelling plumes and dinoflagellates accumulating in the lee of these plumes (Moita *et al.*, 2003). Also, particularly notable are the effects of upwelling and downwelling in the Rías Baixas where rapid changes between phytoplankton communities dominated by diatoms and dinoflagellates are regularly observed during summer and autumn (Figueiras *et al.*, 1994).

For the Azores/Madeira region, primary production and phytoplankton data were obtained from OASIS (Oceanic Seamounts: an integrated study) project over two seamounts (Seine and Sedlo, NE Atlantic). The results of this project stress the complexity and the variability of seamount ecosystems. By contrast to the common view of highly productive seamounts, indications for an enhanced productivity and high stocks of seamount-associated organisms were weak at the two seamounts studied (Christiansen, 2006). The metabolic balance between gross and net community production (Pg; Pn) and community respiration (Rd) were determined using the oxygen method after incubations inside borosilicate bottles by Aristegui *et al*. (2009). Seine and Sedlo presented higher Rd values and lower Pn compared to reported average values from the global open ocean, and more specifically the north Atlantic (Robinson and Williams, 2005). Rd rates were particularly high in Seine during summer, presumably due to organic matter loading from the NW Africa upwelling system, as supported by the field and satellite data. Nevertheless, these results show an important degree of both spatial and temporal variability in metabolic rates and plankton biomass instead of a clear and persistent pattern around the seamounts, probably caused by variability at different scales in the physical environment. Sporadic increases in Chl a (and presumably in productivity) may take place, as observed in Seine during the spring survey, when Chl a and Pt (particulate proteins) were enhanced at the summit, although the seamounts studied seem to behave preferentially as trapping mechanisms for organic matter, rather than as local sources of productivity. Phytoplankton analyses for the Azores

Subtropical Front, during one summer and one spring cruises, show dominance of small cells, namely small flagellates and picoplankton (Head *et al*., 2002). However, large diatoms, in particular *Rhizosolenia stolterfothii*, were significant contributors to total phytoplankton biomass south of the Azores Front in April 1999. *Emiliania huxleyi* and holococcolithophorids were present on both transects, as was also observed by Schiebel *et al*. (2002). In addition heterotrophic dinoflagellates (*Gymnodinium* spp. and *Gyrodinuim fusiformis*) and ciliates (*Strombidium* spp. and tintinnids) contributed to a lesser extent to total microplankton biomass. Average phytoplankton carbon, across the Azores Current, during April 1999 (17.97 +/-9.96 mg $C{\cdot}m^{-3}$) was much higher than observations in August 1998 (8.54 +/- 3.51 mg $C{\cdot}m^{-3}$) (Head *et al*., 2002). Fernández and Pingree (1996) showed a close linkage between the Subtropical Front–Azores Current (STF-AC) physical feature and high levels of Chl *a*, with values 2-3 times higher at the frontal boundary. A high resolution survey showed Chl *a* fluorescence associated with the southern frontal boundary (consisting of chain forming diatoms and flagellates) and with the Azores Current (made up of cells less than 2 µm size class), respectively. Primary production rates measured in the frontal high-chlorophyll region (> 1 mg $C{\cdot}m^{-3}{\cdot}h^{-1}$) were much higher than previous measurements carried out in the same area in late spring and summer and about 2 times higher than regional and basin-scale models predictions for this area in winter. The same authors propose that the large spatial extension of the biological signature associated with the STF-AC system suggests that carbon fixation within the frontal structure could be significant for regional carbon budgets of the subtropical northeast Atlantic.

One of the principal applications of satellite ocean colour data is to derive chlorophyll *a* (Chl a) which gives a proxy of phytoplankton biomass and allows to infer main distribution patterns. Martins *et al*. (2007) provided an important insight towards ocean mesoscale variability in the Azores, Madeira, and Canaries regions (Figure 29), using satellite images from Ocean Colour (OC, derived Chl a) and Sea Surface Temperature (SST). The extensive daily analysis of six years (2001-2007) of MODIS (OC and SST) and AVHRR (SST) time series monthly and seasonal data allowed comparison of three groups of islands (Azores, Madeira, and Canarias) located in the NE Atlantic. Results suggest an inverse relationship between surface temperatures and Chl a distributions with lower temperature values being associated with regions of increased pigment concentration.

Sea surface temperature monthly means suggest distinct inter-annual seasonal cycles with seasonal warming clearly evidenced in all regions initiating during winter-spring and cooling during summer-autumn months. Furthermore, Azores generally reaches maximum SST values faster (i.e. with a time lag of about one month) than Madeira and Canaries which should be related with increased warm water transport in spring-summer across the MAR.

The mean Chl *a* general decrease towards southern latitudes results from a gradual transition from more productive colder and fresher eastern North Atlantic waters to permanently stratified oligotrophic warmer and more saline Subtropical waters, although several exceptions to this rule were observed in the OC mean images (i.e. recurrence of cyclonic and anticyclonic eddies, together with the presence of upwelling filaments throughout the year in Canaries, (Barton *et al*., 1998; Aristegui *et al*., 1997). Interesting is the clear tendency for Canaries OC variability to drop in Feb-Mar, when also have maximum peak in Chl a mean values (5-6 times higher during wintertime than the rest of the year, sometimes with a secondary maximum in October). This is most probably related to more stable (and strong) wind-upwelling conditions during late winter which generate high phytoplankton pigment concentration around Canaries (Pacheco and Hernandez-Guerra, 1999). This high pigment content is reduced in early spring, but still remains visible around the coast of the islands. Also, according to these authors, this secondary maximum is apparently due to spreading of upwelling filaments from south of the Canary Island. Regional inter-annual and seasonal variability are clearly depicted in the OC and SST imagery, providing relevant information to study ocean dynamic variability within the Azores, Madeira, and Canaries regions.

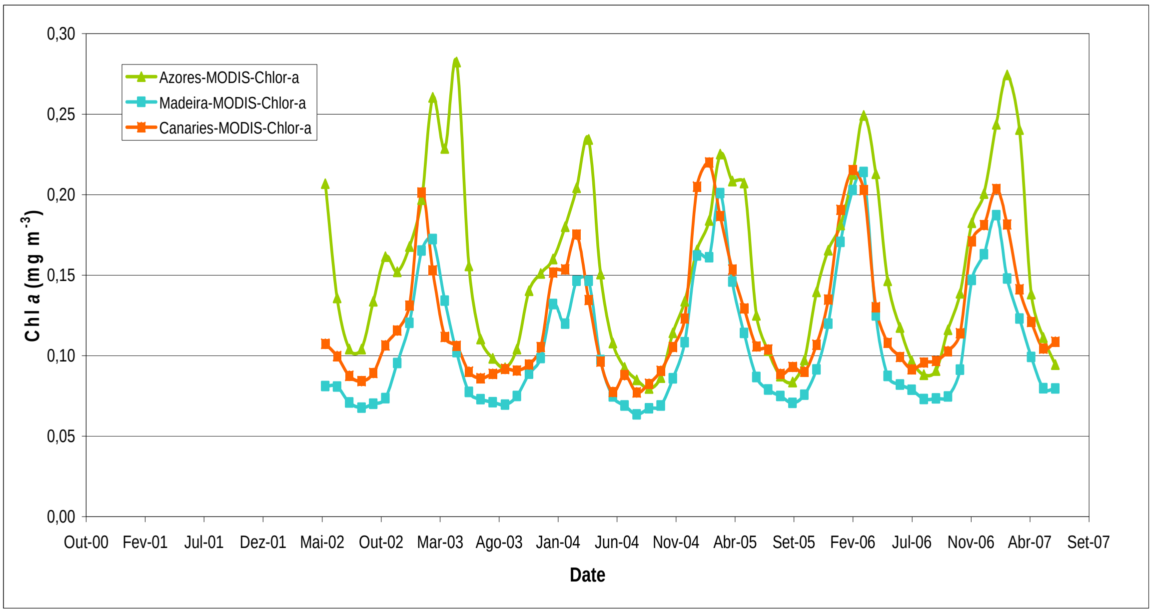
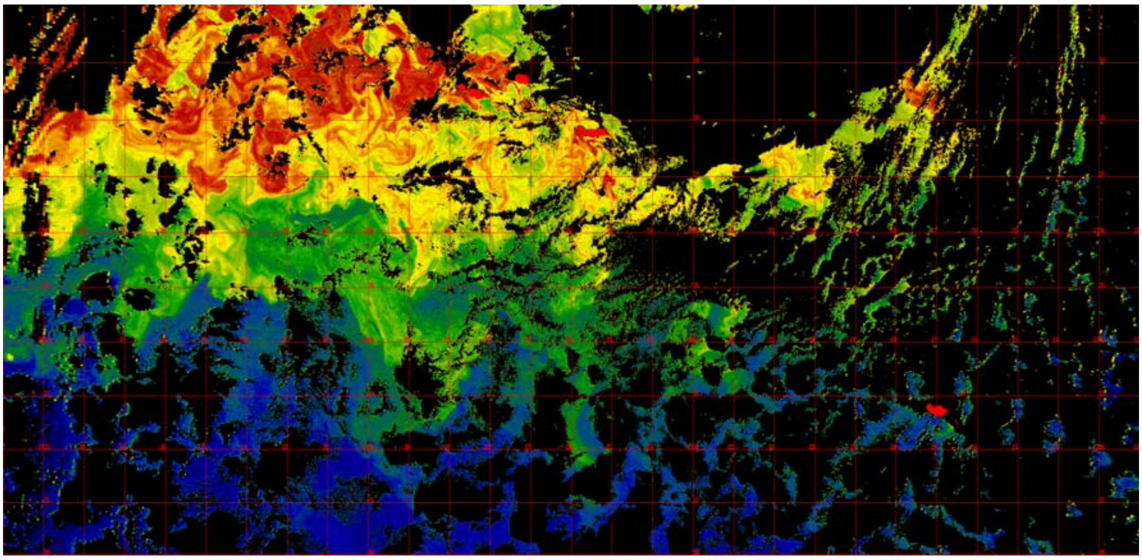


Figure 29. MODIS (2002-2007) OC (in Chl a mg m^{-3}) monthly medians for the Azores (green colours), Madeira (blue colours), and Canaries (orange colours) regions (Martins *et al*., 2007).

Martins *et al*. (2004) analysed four-year of SeaWiFS daily imagery for the Azores region and concluded that there were quite complex chlorophyll *a* patterns in the region. On a broader scale, zonal bands of increasing and decreasing chlorophyll *a* concentration values were observed towards the north and south, respectively. Three main chlorophyll a transition regions were identified in the images. Those with chlorophyll *a* concentrations: 1) below 0.1mg·m^{-3} (henceforth referred to as "southern transition region", in darker blue colours); 2) between 0.1mg·m^{-3} and 0.2mg·m^{-3} (henceforth referred to as "central transition region", in lighter blue and greenish colours); and 3) above 0.2mg·m^{-3} (henceforth referred to as "northern transition region", in yellow, orange, and reddish colours) (Figure 30). The southern transition region clearly showed a frontal interface rich in filaments, meanders and eddy-like structures, which was identified as the Azores Current and associated frontal zone. This was visible in several imagery approximately between 32º and 36ºN (Madeira archipelago is located within this region). The second region ("central") was located approximately between 34º and 37.5ºN, while the "northern" region was observed above 37ºN (the Azores archipelago is located within this region). The last two regions, and in particular, the northern one, showed extremely rich eddy-like structures. Cold and warm eddies were identified in the SeaWiFS imagery as cyclonic/anticyclone regions with higher/lower chlorophyll a concentrations in the centre of the eddy than in the surrounding waters, respectively. Significant Azores current meandering was observed with amplitudes that could reach as high as 3º in latitude and 5º in longitude.



10 May 2003 (Julian day 130)

Figure 30. Spatial distribution of a daily SeaWiFS derived chlorophyll a (in mg m-3) in the northeast Atlantic (image boundaries 30º to 40º N and 40º to 12º W). Black represents clouds. Chlorophyll concentrations are coloured from blue (lower concentrations) to red (highest ones). Three main zonal bands can be distinguished (Azores front, biotic zone and high increase concentration band to the north (from Martins *et al*., 2004).

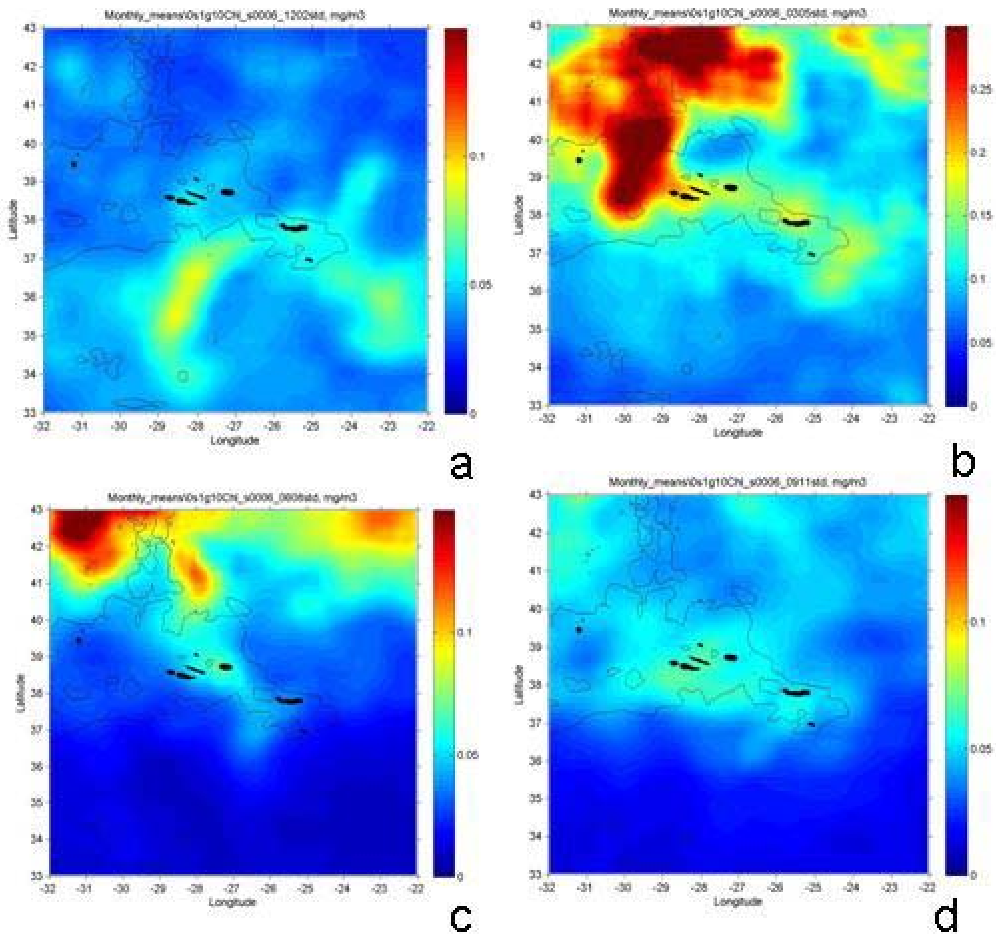


Figure 31. Chl-a seasonal STD (mg m-3): a-winter, b- spring, c- summer, d- autumn (from LAMAR report, 2008).

More recent studies, made in the Azores region under the framework of the regional project LAMAR (LAMAR report, 2008), used the most extensive data-pool available for the region to study the mean distributions of physical and oceanographic characteristics. Results of this study show that the Chl *a* standard deviation (STD) is quite different at various seasons (Figure 31). Most of the year (March to November) the high STD values correspond to areas of high Chl *a*. Also Chl *a* is generally more variable on the north. The only exception is winter-time, when the variability is maximum to the south of the Azores.

Furthermore, and also under LAMAR project, Cherkasheva and Foux (2008) obtained MODIS/AQUA satellite-estimated primary production (PP) mean and standard deviation maps for the Azores region (Figure 32). Such maps allowed estimation of inter-annual and inter-seasonal PP variability. Interestingly, these authors identified a biotic PP front between 36-37^{o}N (about 150 mgC/m^{2}per day) reported by Huskin *et al*. (2001) at 36^{o}N from hydrological characteristics and coincident with the "central transition region" previously described by Martins *et al*. (2004) with daily SeaWiFS-derived Chl *a* concentrations.

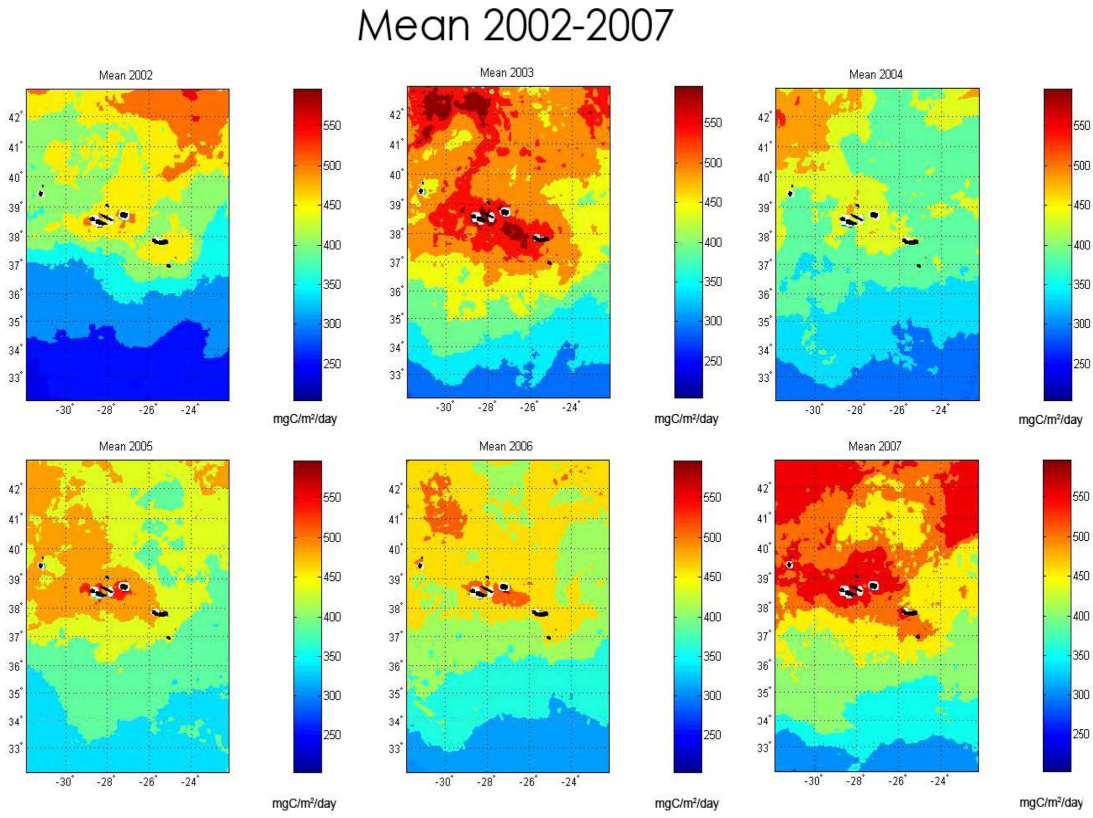


Figure 32. Mean primary production, mgC/m^{2} per day for the period 2002-2007 for the Azores region (from Cherkasheva and Foux, 2008).

Clear is the general tendency of primary production to decrease from north to south. The most intensive PP growth (higher than 450 mgC/m^{2}per day) is observed close to the islands (38º-39ºN and 26º-30ºW), and to the north-west of them. Some increase in PP, although not as pronounced is observed NE of the islands. The biotic front separates the more productive northern part of the region from the less productive southern.

Zooplankton communities

The high variability in time and space of zooplankton populations in the Bay of Biscay and their complex relationship with environmental factors severely limits our understanding of ecosystem functioning (Lavin *et al.*, 2006), but it is possible to outline the following patterns:

a) Main patterns in species composition:

Zooplankton in the Bay of Biscay is very rich in terms of taxonomic groups and species. The most important group by specific richness, persistence, abundance and ecological significance is that of copepods which account for 60% and 85% of total zooplankton abundance in coastal and oceanic areas respectively off the north coast of Spain. Copepods are present all the year round whereas other holoplankton and meroplankton groups have a marked seasonal distribution (D'Elbee and Castel, 1991; Poulet *et al.*, 1996; Valdés and Alvarez-Ossorio, 1996; Valdés and Moral, 1998).

b) Main patterns in dynamics:

In the north coast of Spain the annual cycle of abundance and biomass of zooplankton shows one main peak in spring corresponding to, but lagging behind, the pulse of phytoplanktonic production. Other less regular peaks may be observed in summer and autumn depending on the oceanographic conditions (upwelling, wind turbulence, etc.) (Bode *et al.*, 1998). Winter is well defined with the lowest values. The oceanic areas present a pattern of oligotrophic areas with slight variations in values of abundance and biomass throughout the annual cycle and a single period, which generally coincides with April, when communities develop and reach annual peaks. The regional pattern of the zooplankton biomass shows higher production on the Galician coast where for several months it surpasses 30mg DW m^{-3} and on many occasions the biomass is doubled. A significant portion of this production is linked to the frequency and intensity of summer upwelling (Bode *et al.*, 1998). It is clear that the thermal regime of the water column (heating of surface water, upwelling events, stratification of water column) strongly determines the abundance of zooplankton in the Cantabrian Sea and in Galicia and creates a well-defined regional pattern.

Regarding the whole Bay of Biscay, biomass distribution of mesozooplankton (200-2000μm) shows the same patterns as those described for phytoplankton. Zooplankton reach maximum abundances and biomass (values of ~70 mgDW m^{-3}) soon after the phytoplankton spring bloom, when high values are regularly observed over the whole continental shelf of both margins of the Bay of Biscay. Once the spring bloom relaxes, zooplankton also decrease in number and biomass showing a more patchy distribution with some hot spots coinciding with upwelling regions and freshwater plumes from big rivers. Oceanic and oligotrophic waters of the Bay of Biscay basin have very low abundances most of the time. In consequence these poor waters in the middle of the Bay of Biscay do not support spawning or nurseries of the main pelagic species.

c) Seasonal cycles and variability of key species:

Seasonal cycle and year-to-year variability of *Acartia* spp. and *Calanus helgolandicus* in the Bay of Biscay and Celtic Sea was studied by Valdés *et al.* (2001) using data from two sampling stations off Santander (N. Spain), L4 station off Plymouth (S. England) and the CPR routes in Biscay and Celtic Sea. Mean monthly abundances (1992-1999) of *Acartia* spp. show a gradual latitudinal pattern in seasonality of the *Acartia* population. The growth season starts earlier in the southern regions (February-March on the shelf and oceanic waters off Santander, and population decreases after August) than in northern regions (May on the shelf off Plymouth and population decreases in November). The growth season of *C. helgolandicus* also shows a latitudinal pattern in its seasonality. A spring peak occurs earlier (March-April) in Santander and the Bay of Biscay than in the Celtic Sea and Plymouth (May). These findings suggest a synchronicity at a regional scale in the biological cycles of these species.

Acartia clausi populations in the southern Bay of Biscay develop in the first half of the year. They exhibit coastal preferences and reach maximum abundances at the station located in the inner shelf, showing a remarkable year-to-year variability. Statistical trends on cumulative anomalies show an inter-annual cycle of a three year period: every third year abundance peaks to a maximum followed by a decay and a recovery in the next two years before peaking again in the third.

Temora stylifera populations reach maximum values in August and the growth season lasts for almost the whole of the second half of the year. Its presence in the Bay of Biscay has been reported recently and related to the increase in temperature due to climatic variations. The progression of this species towards northern waters was reported up to Helgoland (Halsband-Lenk *et al*., 2003). Both facts, shifts in seasonality and northern displacement, reveal a regional pattern that makes of *T. stylifera* a target species for understanding the effects of climatic variability on plankton populations (Villate *et al*., 1997).

Zooplankton blooms follow the pulse of phytoplanktonic production. In coastal zones, mesozooplankton abundance presents a seasonal variation with absolute values rarely over $3000 ind/m^3$ in spring. In winter, values are $250 ind/m^3$. The oceanic area off Iberia is oligotrophic and zooplankton biomass varies little throughout the year with a peak in April. For example, regarding the whole Bay of Biscay, since 1992, temporal and spatial biomass distribution of mesozooplankton (200-2000μm) show the same patterns described for phytoplankton with biomass (values of ~70 $mgDW\ m^{-3}$) closely after the phytoplankton spring bloom. After the spring bloom, zooplankton decreases showing a patchy distribution with some hot spots in coincidence with upwelling regions and freshwater plumes.

Zooplankton in the Iberian coastal and shelf waters is very rich in terms of taxonomic groups and species. Copepods account for 60-85% of total zooplankton abundance off the north coast of Spain, and are present all the year round, whereas other holoplankton and meroplankton groups have a marked seasonal distribution. Figure 33 shows the main holoplanktonic, meroplanktonic and copepod groups and their relative abundance. Copepods are the most important group in terms of species richness, persistence, abundance and ecological significance. At least 268 species of pelagic copepod have been recorded in the region since 1967. Nevertheless, despite this diversity only seven species of copepod characterise the region, accounting for 90% of the total abundance (Figure 33).

Abundant suprabenthic zooplankton is available to pelagic and small demersal fish species (e.g. sardine, horse mackerel, blue whiting, *Gadiculus argenteus*, *Capros aper*). The plankton community has changed over the last 50 years (Beaugrand, 2005). However, the change may be less pronounced that in more northern areas like the North Sea.

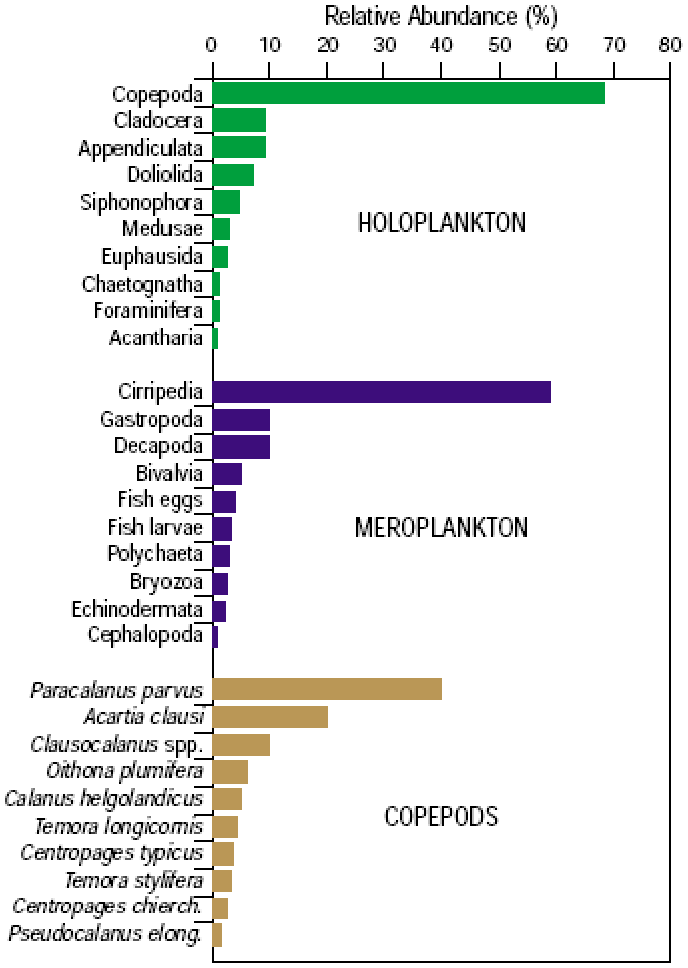


Figure 33. Relative abundance of the ten major groups and species of holoplankton, meroplankton and copepods in the region.

Nyctiphanes cochii and *Meganyctiphanes norvegica* are the most abundant euphausiids. Seven of the nine species of marine cladocerans are found in OSPAR Region IV (*Podon intermedius, P. polyphemoides, P. leuckarti, Evadne nordmanni, E. spinifera, Pseudevadne tergestina* and *Penilia avirostris*). At least eight species of chaetognath have been recorded; *Sagitta decipiens, S. lyra* and *S. friderici* being the most abundant. The Appendicularia *Oikopleura dioica* and *Fritilaria pellucida* are also very common in coastal and neritic areas of OSPAR Region IV. Copepods are present throughout the year, whereas other holoplankton and meroplankton groups have a marked seasonal distribution; cladocerans are abundant in late spring and summer, and chaetognaths are mainly present in summer. Fish larvae and meroplankton are abundant during the spawning and breeding seasons of the species concerned. Zooplankton composition, abundance and distribution are highly variable spatially, varying across the shelf with respect to latitude and coastal topography. For example, in terms of variations with latitude 95 species of copepod have been identified in the southern Bay of Biscay (accounting for 71.9% of the total zooplankton abundance), 85 species in Galician waters (62.9% of abundance), 89 species in northern Portuguese waters (63% of abundance), 144 species in southern Portuguese waters (30% of abundance) and 174 species in the Gulf of Cádiz. Topography and cross-shelf gradient are major causes of variability. Some species such as *Acartia discaudata* and *Podon polyphemoides* are restricted to enclosed areas, such as the Rías Bajas and the Ría of A

Coruña, while others are indicative of oceanic water (e.g. *Rhincalanus nasutus* and *Sagitta lyra*). Cross-shelf gradients in species composition and abundance are enhanced by the presence of meroplanktonic species in shallow waters. A gradient in meroplankton species occurs in the southern Bay of Biscay, with relative abundances of 15%, 9% and 2.5% in coastal, neritic and oceanic waters, respectively. An inverse pattern is observed for copepods, with relative abundances of 70%, 90% and 92%, respectively. On the western Iberian coast in areas subject to seasonal upwelling events, zooplankton is more abundant over the mid-continental shelf. There are two peaks in the annual cycle of zooplankton abundance and biomass in OSPAR Region IV. These occur in spring and autumn and correspond to, although lag behind, pulses of phytoplankton production. In coastal zones, the seasonal variation in mesozooplankton abundance ranges from a maximum of around 3000 ind/m^3 in spring to around 250 ind/m^3 in winter. In the oceanic sector of this region the annual cycle of zooplankton abundance and biomass is typical of oligotrophic areas, with only slight variations throughout the year and a single period, generally in April, when communities reach their annual peak. Superimposed upon this general scheme are features associated with the spatial topography and hydrodynamics of the region. The main deviations from the general scheme occur in estuaries and shallow coastal areas, where tidal action and winds force water column mixing. Nutrient inputs to such areas are almost constant and both phytoplankton and zooplankton are likely to be abundant, with several pulses of production throughout the year. In the neritic region of the Cantabrian, Galician and Portuguese coast upwelling is particularly important; this occurs episodically between May and September and results in favourable conditions for zooplankton during summer, which is the opposite of what generally happens in temperate seas.

In each region, the presence of species depends on environmental conditions. However, in the French Atlantic littoral there is a seasonal species succession characterised by specific dominance and abundances in each population. Cold water species (mainly jellyfishes and copepods) which are abundant in the winter period are followed in spring by various larvae of cirriped, annelids, and decapods. Then during the phytoplanctonic blooms in March and April, copepods (*Temora longicornis* and *Acartia discaudatade*), decapods, jellyfish (*Obelia* and *Phialella*) and lots of eggs and fish larvae (particularly *Solea solea*) dominate the zooplankton structure. Late spring and early summer are periods of richness in terms of specific biodiversity and abundance, with lots of copepods and jellyfishes as well as clupeids larvae, ammonodytidae, and decapods larvae as Porcellana sp., brachyoures, and gammarids. In summer, due to the upwelling, the regional zooplankton biomass production is highest off Galicia where it is often over 30 mg DW m^{-3} (60 mg DW m^{-3} peak are frequent) (Bode *et al*., 1998). Along the Cantabrian Sea the biomass decreases towards the east (Llope *et al.*, 2003).

<u>Oceanic areas</u>

Although zooplanktonic organisms play an essential role in oceanic ecosystem as a vital link between the primary producers, the phytoplankton, and the consumers of higher trophic levels, very few studies exist on zooplankton community structure and abundance in the waters ranging from the area surrounding the Azores Archipelago and the Mid Atlantic Ridge. Moreover, summarizing the information available is made difficult by the spatial and temporal discontinuity characterising the surveys carried out across the area as well as by the wide range of different sampling and analysis methods used.

a) General patterns in abundance

The large majority of the studies are focused on mesozooplankton (200µm - 2mm) dwelling in the first 200m depth, investigate taxonomic composition and estimate values of biomass and abundance in different periods of the year. Total biomass estimates are reported in

Table 3.

Table 3. Zooplankton biomass values found in the Azores region.

Biomass	**Study location**	**Depth range (m)**	**Sampling period**	**References**
15.2 ml100m^{-3}	South of Faial. Within 10nm from the coast	0-100	February to August, 1998	Sobrinho-Gonçalves and Isidro, 2001
280 mgC m^{-2}	27°-39° N; 20°-33°W	0-200	May 1997	Huskin *et al*., 2001
156 mgC m^{-2}			September 1997	
179 mgC m^{-2}			August 1998	
890 mgC m^{-2}			April 1999	
200 mg C m^{-2}	30°-38° N; 20°-23°W	0-200	August 1998	Head *et al*., 2002
740 mg C m^{-2}	28°-38° N; 21°-23°W		April 1999	

Descriptive studies found that abundance estimates for the Azores were similar to that of the Canary Islands and Iberian Peninsula continental shelf and higher than those typical of oceanic waters (Guénette and Morato, 1997; Sobrinho-Gonçalves and Isidro, 2001). It was also reported that abundances of mesozooplankton with individual volumes less than 5ml showed significant positive correlation with respect to both bottom depth and distance from the coast (Sobrinho-Gonçalves and Isidro, 2001).

Copepoda are the most abundant group representing between 68.9% and 91.3% of total mesozooplankton abundance (Sobrinho-Gonçalves and Isidro, 2001; Huskin *et al.*, 2001). The group Calanoida constitutes about 75% of Copepoda abundance and includes the most common species in the Azores region: *Clausocalanus arcuicornis*, *Pleuromamma gracilis*, *Calanus minor*, and *Acartia danae* (Head *et al*., 2002). Other major taxa are Chaetognatha, Euphausiacea, Ostracoda, Thaliacea, and Appendicularia.

Surveys carried out in different periods of the year showed evident seasonal changes in biomass/abundance of all the zooplanktonic groups identified, with peak in April/May (Sobrinho-Gonçalves and Isidro, 2001; Huskin *et al*., 2001; Head *et al*., 2002; Schiebel *et al*., 2002) which most likely corresponds to the spring "bloom" of the year, and minimum values recorded during the summer. This pattern is typical of temperate seas, following the thermal stratification of the water column, which is expected to occur in the Azores just in springtime (Isidro, 1996). As far as diel patterns are concerned, Huskin *et al*. (2001) found that Copepod abundance does not show any significant day-night difference.

b) Dynamics in the Azores Front

In general, all kinds of fronts are supposed to present associated increases in biological production (Le Fèvre, 1986). In the case of the Azores Front, rather little information is available on zooplankton biomass characteristics and seasonal changes in abundance (e.g. Irwin *et al*., 1983; Kahru *et al*., 1991), though some studies have addressed these issues and obtained different results. Fernandez and Pingree (1996) reported higher primary production at the front, but Fasham *et al*. (1985) and Angel (1989) did not find such a pattern. More recently Huskin *et al.* (2001) and Head *et al.* (2002) pointed out important effects of the Azores Front for mesozooplankton, with frontal stations showing biomass and copepod abundance significantly higher than surrounding areas (biomass: 341±81 mg C m^{-2} vs 221±95 mg C m^{-2}; abundance: 62±21 ind 1000m^{-2} vs 41±20 ind 1000m^{-2}) and stations north of the front presenting higher total biomass concentration than ones south. On the other hand, the few studies carried out within the Azores Front reported no taxonomic differences in zooplankton communities from both sides of the front (Angel, 1989; Huskin *et al.*, 2001), with the same group of main species found in all samples.

c) Influence of eddies

Physical processes associated with eddies in the open ocean are thought to increase primary production inside them (Falkoski *et al.*, 1991). The Azores Current has been proposed as an important source of mesoscale eddies (Gould, 1985), but a very few biological studies of these oceanographic features are available. The influence of eddies on zooplankton community structure at other locations has been reported for both anti-cyclonic (e.g. Pinca and Dallot, 1997) and cyclonic ones (e.g. Harris *et al.*, 1997). In general, cyclonic eddies present higher zooplankton biomass than surrounding waters, but there are many exceptions to this trend (Beckmann *et al.*, 1987). Huskin *et al.* (2001), in correspondence with the eddy LETICIA, located at 32-33ºN and 27-29ºW, measured lower mesozooplankton biomass than surrounding areas (549±141 mg C m^{-2} vs 836±302 mg C m^{-2}) and very similar to that reported by Harris *et al.* (1997) for a cyclonic eddy in the North Atlantic. However, those differences inside-outside the eddy were never significant and possibly correlated with downward zooplankton migrations in old eddies (The Ring Group, 1981).

d) Dynamics in Seamount areas

Evidence concerning mesozooplankton features over seamounts is conflicting. Some study measured increases in zooplankton abundance over mounts (Fedosova, 1974), while other detected a reduction, with gaps, in zooplankton biomass over them (Genin *et al.*, 1994). In the Azores region, Huskin *et al.* (2001) found significant increases in mesozooplankton biomass to the east of the Great Meteor Seamount located at 30ºN, 28.5ºW: 918±318 mg C m^{-2} to the west and 545±158 mg C m^{-2} to the east.

The results achieved within the project Oasis (Oceanic Seamounts: an Integrated Study: EVK3-CT2002-00073-OASIS) showed a reduced zooplankton biomass concentration above the summits of Seine and Sedlo seamounts (33°50'N - 14°20'W and 40°25'N - 26°55'W, respectively) with respect to the slope and far field stations. Moreover, this difference seemed to be independent of daytime and season (Oasis, 2006). Both in spring 2003 and 2004, the zooplankton concentrations above the summits were about one order of magnitude lower than above the slopes and at the far field stations, both at day and night. The highest values of all stations were found at the far field station at night. A seasonal pattern was registered with biomass being lower in summer than in spring. Distinct differences in the day/night distribution above the summit, i.e. vertical migrations, were not detectable in the smallest zooplankton size fractions (<2cm) but were found for larger organisms.

Other water column communities

Medel and López-Gonzalez (1996) compiled a catalogue of the hydrozoans distributed along the Iberian Peninsula including information on the species distributions. In their study they found a higher diversity of the Order Leptomedusae in Galician waters and Gulf of Cadiz. However, a great amount of information about the life cycle of the hydrozoan fauna still remains unknown, especially for pelagic or planktonic species.

Benthic communities

Benthic communities are mostly structured by depth and sedimentary type. Crustaceans and molluscs are the dominant taxonomical groups on the continental platform bottom, while sponges and cnidarians are encountered on deep hard substrata. Crustaceans such as *Nephrops norvegicus*, *Cancer pagurus*, and *Maia dactylabrachyata* as well as many bivalves are exploited in coastal zones and offshore. Some regions are heavily occupied by lots of Mytilus and oyster farms. The exotic species *Crepidula fornicata*, proliferates locally and competes for space and food with other users of the benthic substrata such as the young *Solea solea*.

There is a lack of studies on hard substrate ecosystems of the northern coast of Spain; the available information is focused on sedimentary areas. As it is widely described, depth is the main structuring factor in soft-bottom seabed (benthic and demersal) communities (Olaso, 1990; García-Castrillo and Olaso, 1995; Martínez and Adárraga 2001; Serrano *et al.*, 2006a, 2008). In the studies performed in the area, sediment characteristics (grain size and organic contents) have been shown as the main secondary factor, together with mesoscale structures controlling the distribution of both epibenthic an endobenthic communities (Sánchez, 1993, Serrano *et al.*, 2008).

Epibenthos

For the Cantabrian sea, Olaso (1990) described an increase of megaepibenthic species richness with depth, as a consequence of their predominantly detritivorous feeding habits, since in the area muddy substrates appear mostly in deeper areas. This fact does not occur in the Atlantic coast of Spain (Galicia) where mud is mostly coastal in relation to estuarine systems (Rías).

In sedimentary areas on the shelf, shallower benthic habitats are dominated by mobile invertebrates, detritivorous crustaceans and molluscs, while the same type of grounds in deeper areas are dominated by sessile filter feeders such as sponges and cnidarians. The latter are abundant on rocky bottoms together with echinoderms.

In a study on Cantabrian Sea epibenthos (Serrano *et al.*, 2006a), using a 3.5 beam-trawl, longitudinal differences in ecological indices were detected in relation to biogeographical and hydrographic patterns. Three main assemblage groups were identified using cluster analysis. The effect of environmental variables (depth, near-bottom temperature and salinity, sediment morphology, Atlantic influence) on assemblages was also identified, showing a pattern of two gradients: depth/water temperature and sediment characteristics. Assemblages identified by both methods were spatially coherent. The hermit crab *Diogenes pugilator* typify the poor fine sands of the inner shelf; fishes (*Arnoglossus laterna, Callyonimus maculatus, Pomatochistus* sp.) and a hermit crab, *Anapagurus laevis*, characterize the assemblage of inner and middle shelf sediments with higher organic content, and the echinoderm *Ophiura affinis*, the fish *Lepidorhombus boscii* and

Crangonidae Crustacea typify the deeper community of medium and fine sediments with intermediate levels of organic content.

In a similar study, on the mega- and macroepibenthos of the Galician shelf, using beam-trawl and otter trawl, Serrano *et al*. (2008) found that there were weak linear relationships between environmental variables and species richness, biomass and species diversity. However, depth and sediment characteristics greatly influence smaller epibenthic communities sampled by beam trawl. Six assemblages were obtained for beam trawls: inner shelf mud, inner shelf very fine sands, inner shelf fine sands, middle shelf sands, outer shelf very fine sands, and outer shelf fine sands. Five assemblages were identified for larger-sized and swimming epibenthos sampled with otter trawls. These assemblages were also determined according to depth and sediment type but sediment characteristics were less important. Otter trawl assemblages were the same as the beam trawl ones, except for on the outer shelf where no differences between sediment types were detected. For both gears, inner and outer shelf assemblages displayed a higher biotic variability than the middle shelf, as a consequence of a higher environmental heterogeneity. Typifying species were mainly eurytopic in the middle shelf, whereas eurytopic and stenotopic species characterised the inner and outer shelves.

Similarly, assemblages of the epibenthic community of the invertebrates decapoda from the Azores can be also defined assuming a structure by depth (50-1200m) (Pinho *et al.*, 2001a, b, c). Major species observed dominating the assemblages from the litoral to the deep strata are *Scyllarides latus* (slipper lobster), *Palinuros elephas* (lobster), *Cancer bellianus (toothed rock crab)*, *Chaceon affinis* (deep sea red crab). Other species occurring are *Charonia lampas, Calappa granulata* and *Dardanus arrosor* (200m), *Homola barbata* (300m), *Paromola cuvieri* (400m) and the crab *Bathynectes maravigna* (500m). Some caridea species, mainly from the pandalidae family were observed such as *Plesionika narval, Plesionika edwardsii, Heterocarpus ensifer, Plesionika ensis, Plesionika martia*, *P. gigliogi and P. williamsi.* Most, if not all, of these species are also found in Madeira and Canary Archipelagos with similar pattern of distribution by depth (see Gonzales, 1995). These resources are almost virgin stocks with no target commercial fisheries.

<u>Endobenthos</u>

Infaunal communities of the Cantabrian Sea were analysed by Martínez and Adarraga (2001), using a Van Veen dredge. A transect from coast to slope, located in the eastern part of the Cantabrian Sea, was sampled. The identified communities have been labelled as follows: Boreal Lusitanian *Tellina* community, *Venus* community, *Venus fasciata - Spisula elliptica - Branchiostoma* community and *Amphiura* community.

There is no information available on endobenthos from the Azores area.

<u>Meiobenthos</u>

Meiobenthos are those 1–0.06mm in size. Despite their importance in benthic trophic dynamics, meiofauna are still the least studied group of benthic fauna. Spatial distribution is related to the grain size, depth and organic matter content of the sediment. In the Galician rías of Muros, Arosa and in the estuary of the Foz (the Ría of Vigo), nematodes dominate, followed by harpacticoid copepods. Diversity of taxa is moderate. The Comesomatidae dominate in the Ría of Arosa, with *Sabatieria pulchra* and *Metacomesoma punctatum* indicating high levels of organic matter. In the Ría of Muros the Desmodoridae are the dominant family, comprising 43% of total biomass. In the Ría of Ferrol, characterised by coarse sands of *Amphioxus*, the dominant groups are polychaetes, followed by Tardigrada and Mistacocarida. On the continental shelf off the Rías Bajas of Galicia, an area of high oxygenation and low bioturbation of the sediments, meiofauna densities are 10 to 100 times greater than in the rías. Nematodes predominate, representing 78% of total biomass, and the Comesomatidae are the most abundant family. *Sabatieria pulchra* and *S. ornata* are the dominant species on the inner and outer shelves respectively. At sites 2000 and 4400m deep in the southern Bay of Biscay, the organic content of the sediment is not a limiting factor for meiofauna abundance, suggesting that in abyssal environments meiofauna may be more dependent on microbial activity, hydrodynamics and sediment stability. Abundance and species richness are lower at the deeper station, and the Monhysteridae dominate at both. At a site 5300m deep near the Galician coast, nematodes comprise > 95% of the meiofauna. Along the Portuguese coast, studies are limited to estuaries (such as the Sado estuary) and some deep-sea sites. The estuarine meiofauna is dominated by nematodes (representing > 50% in abundance), followed by copepods (up to 35%) and a group formed by turbellarids, polychaetes and ostracods (10%). The deep-sea meiofauna exhibits strong similarities to the meiofauna of the continental margins of the temperate North-east Atlantic. Major decreases in abundance are observed between 500 and 1500m. Between 2000 and 4000m the decrease in density is not significant. The dominant groups are nematodes (up to 92%), followed by copepods and nauplii (up to 8%).

Suprabenthos

This benthic compartment includes swimming bottom-dependant animals (mainly small-sized crustaceans) which perform, with varying amplitude, intensity and regularity, seasonal or daily vertical migrations into the water column (Brunel *et al.*, 1978). Suprabenthic animals are known to be an important source of food for many demersal fishes and decapods (Sorbe, 1981; Cartes, 1998). However, their trophic role in benthic ecosystems has been probably underestimated because they are inefficiently sampled by grabs and box corers.

Mysids, amphipods and decapods are usually the most abundant groups in coastal suprabenthic communities (Buhl-Jensen and Fossa, 1991; Hamerlynck and Mees, 1991; Cunha *et al.*, 1997), whereas isopods and cumaceans are often dominant in deeper bathyal areas (Elizalde *et al.*, 1993; Sorbe and Weber, 1995; Sorbe, 1999).

In the suprabenthic communities' studies of the NE Atlantic coast, the number of suprabenthic species increased from the shallower to deeper sampling sites. Higher species richness values have been recorded for deeper bathyal communities (Elizalde *et al.*, 1993; Sorbe and Weber, 1995; Frutos and Sorbe, 2008a, b, submitted). Amphipods are commonly the best represented group by species number in the NE Atlantic suprabenthos.

In Galician waters, this fauna has been studied at the shelf break off A Coruña and in the A Coruña Bay (Frutos, 2006; Frutos and Parra, 2002, 2003, 2004, 2006; Parra and Frutos, 2005). In the Cantabrian Sea Anadón (1993) studied mysid fauna from Asturian continental shelf.

In a multidisciplinary survey on the Le Danois Bank, suprabenthic communities were studied by Frutos and Sorbe (2004a, b; 2006; 2008a, b). In this site 2 species are described as new to Science: *Haplomesus longiramus* (Kavanagh and Sorbe, 2006) and *Liropus cachuchoensis* (Guerra-García *et al.*, 2008).

Finally, in the Capbreton area, Marquiegui and Sorbe (1999), Corbari and Sorbe (2001), Sorbe *et al.* (2008) and Frutos and Sorbe (2002, submitted) studied suprabenthic communities on the continental slope and canyon. The last ones focused the study on the Kostarrenkala fishing grounds.

There is a lack of studies on bathial ecosystems. The recent efforts to study the distribution and biology of the MAR through the MAR-ECO project will yield a better insight into the status of this remote eco-system (http://www.mar-eco.no/).

1.2.3.2 Angiosperms, macro-algae and invertebrate bottom fauna

Angiosperms and macro-algae

Marine plants include algae and some flowering plants. Algae live on rocky substrates extending from the coastline to depths of up to 20–30m. The Atlantic coast of Region IV shows a zonal distribution changing from localised northern species in French coastal waters and along the west coast of Galicia, to southern forms extending eastwards (Bay of Biscay) and southwards (Portuguese coast and the Gulf of Cádiz). The morphology of the coastal environment is very heterogeneous in terms of habitats and mesoscale processes. Consequently, algal biodiversity is high, with the overlapping of different species and the presence of island-like zones. Species characteristic of northern regions, such as *Laminaria* and *Saccorhiza*, advance and retreat together with a group of species in a general trend in which large populations of brown algae decrease from north to south.

Southern Brittany is the southernmost distribution limit for northern populations. Some species, which disappear to the south of the River Loire, reappear to the south in cold water areas (i.e. the Galician coast and to the north of the River Douro in Portugal). The Cantabrian area mainly comprises rocky shores and the algal communities show great similarity to those of the Mediterranean. A distinctive characteristic is the scarcity of Laminariales (which are totally absent from the Basque Country) and the abundance of Rhodophyceae, some of which (e.g. *Gelidium sesquipedale*) form large stands 5–15m deep, and which have been subject to industrial exploitation since the 1950s. The rocky littoral zone of the Basque Country is characterised by communities of a caespitose habit. The Cantabrian–Asturian area is one of transition towards more northern communities and stands of *Laminaria ochroleuca* and *Sargassum polyschides* appear more often. The infralittoral zone is dominated by *G. sesquipedale*. The Atlantic area from Cape Peñas to the River Minho is characterised by estuaries and rías, and is the most diverse, rich and complex of the habitats along the Iberian Peninsula. Western Asturias and northern Galicia have a mixture of southern and northern species and are characterised by an abundance of Fucales and other brown algae. In the infralittoral zone, *G. sesquipedale* populations are substituted towards the west by others, such as *Laminaria hyperborea* which forms dense stands. From Cape Ortegal to the River Minho, cold water from the seasonal upwelling events favours the settlement of northern species. Fucales are particularly abundant in the inner part of Rías Bajas which supports intensive mussel and oyster cultivation and facilitates the proliferation of blooms of other algae (e.g. Ulvales). Nevertheless, this appears to be a local imbalance, rather than a significant alteration in community structure. The Portuguese coast is orientated north to south and algal species can be grouped in two assemblages; northern species tend to occur between the rivers Minho and Tejo, while more southern species are found to the south of the River Tejo. More than 40 species have their southernmost European distribution in Portuguese coastal waters, and the northern limits of more than twenty southern and Mediterranean species occur primarily along the Algarve coast. Algae in the Gulf of Cádiz are very similar to those of the Basque country. Caespitose plurispecific communities occur in the littoral zone, Laminarians are very scarce, and the Fucales are represented by *Fucus spiralis limitaneus* and forms of *F. vesiculosus* in the large estuaries.

Macrofauna on hard substrates

Intertidal and shallow subtidal macrofauna (> 1mm in size) communities follow the ecological zonation described for European shores. Upper intertidal zones are dominated by sessile and slow-moving macrofauna while deeper zones are dominated by mobile macrofauna.

Hard substrates are the dominant habitat in shallow northern and north-western Spanish waters. The upper intertidal zone is characterised by a mixed community comprising barnacles, limpets, littorinids and topshells (Figure 34). The dogwhelk is common in the north-west, scarce in central regions and almost absent from the east. Mussels occur in patches in the Bay of Biscay but are more frequent to the north-west. Natural oyster beds are restricted to rocky outcrops inside rías and estuaries. The stalked barnacle, *Pollicipes cornucopia*, lives in very exposed locations. Lower intertidal and subtidal environments are dominated by dense stands of macroalgae interspersed with barren areas dominated by sea urchins (*Paracentrotus lividus* and *Echinus esculentus*). *Paracentrotus lividus* populations are intensively exploited and populations are now restricted to tide pools and comprise small-sized individuals. There is a diverse faunal community associated with intertidal and subtidal macroalgal stands, comprising prosobranchs, amphipods and isopods. Herbivores are the dominant trophic group. Southern species (e.g. *Idotea pelagica*) are more abundant to the east while northern species (e.g. *Idotea baltica*) are more abundant to the west. The large macrofauna comprise octopuses, crabs and lobsters and these are all intensively exploited.

On the Portuguese coast the upper intertidal fringe is characterised by the same groups as along the coast of north to north-west Spain, but with some northern species being replaced by southern species. Abundance varies according to the rate of exposure to desiccation and to wave action. Polychaetes, crabs and the cirriped *Balanus perforatus* are present in the lower intertidal area and the sea urchin *Paracentrotus lividus* occurs in small pools. In more exposed areas a facies of C*orallina mediterranea* occurs between the surface and 2m followed by a facies of Mediterranean mussel (2–12m). In the subtidal area over 300 species are present, comprising polychaetes, sipunculids, isopods, amphipods, decapods, polyplacophores, gastropods, bivalve molluscs, echinoderms, sponges, hydrozoans, anthozoans, ascidians and bryozoans. The zone from 12 to 42m is characterised by species of coralligenous biocoenosis (i.e. sponges, anthozoans and bryozoans).

Finally, three communities have been identified on hard bottoms between 350 and 4500m. The first group, of bathyal affinities, includes madreporarians (*Flabellum chunii, Lophelia pertusa*), polychaetes (*Lumbrineris flabellicola, Phyllodoce madeirensis*), crustaceans (*Bathynectes superbus, Dorhynchus thomsoni*), bivalve molluscs (*Bentharca pteroessa, Chlamys bruei*), the ophiuroid *Amphilepis norvegica* and the echinoid *Cidaris cidaris*. The second group shows abyssal affinities and includes the cnidarians *Amphianthus dohrnii* and *Antomastus agaricus*. The third group is the dominant group and has a wide bathymetric distribution. The main species are the madreporarians *Desmophyllum cristagalli* and *Flabellum alabastrum* and the echinoderms *Ophiactis abyssicola* and *Phormosoma placenta*.

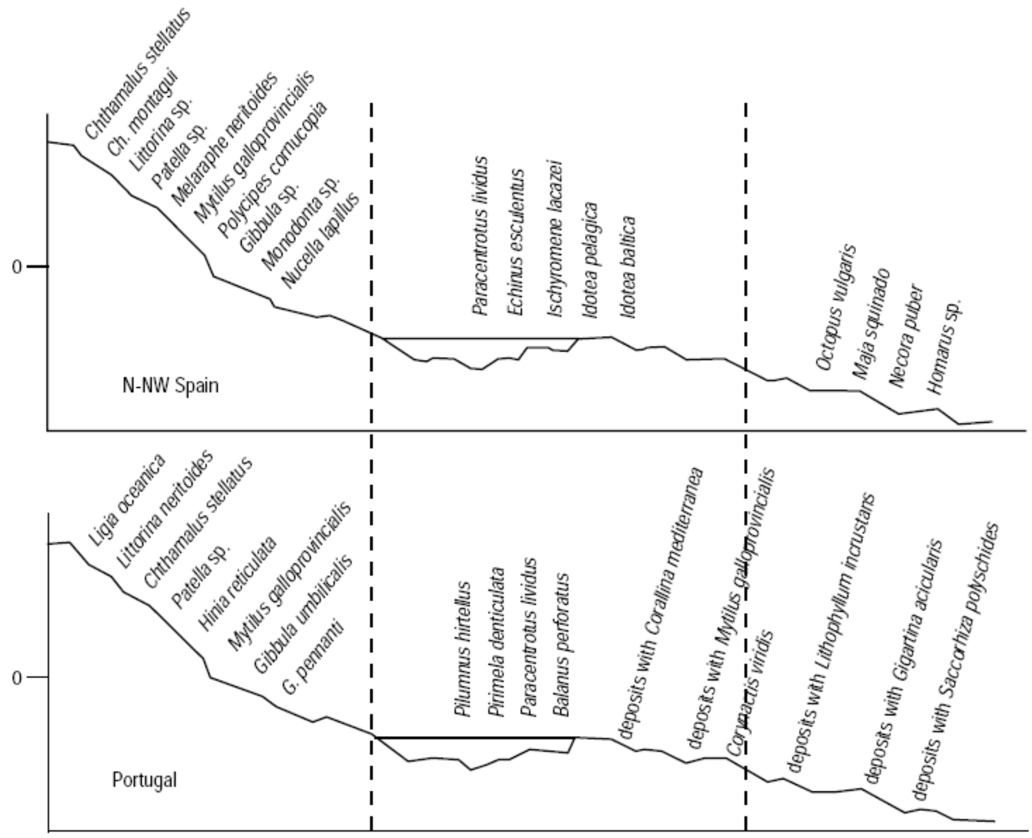


Figure 34. The main macrofaunal species on the rocky shores along the north and north-western coasts of Spain and Portugal (OSPAR, 2000).

Some information on rocky shore macro algae is available for the Azores (Neto *et al.*, 2005). They occur to as depth of 100m and may be limited to the coastal areas. Around 368 species have been recorded in the Azores, which 56 of Chlorophyceae, 75 of Phaeophyceae and 237 of Rhodophyceaea.

Macrofauna on soft substrates

Species distribution is strongly related to grain size, depth and the organic matter content of the sediment. In the intertidal and shallow subtidal zones of the north and north-west Spanish coasts, two major communities predominate: the reduced community of *Macoma* (which occurs on intertidal muddy sediments at the bottom of rías) and the Lusitanian boreal community of *Tellina* (which occurs at medium to low tidal levels on fine to medium sandy sediments).

The inner subtidal sediments of the Ría of A Coruña, which are muddy and occasionally hypoxic, are dominated by a very dense *Thyasira flexuosa* community. Subtidal sediments in the mid and outer part of the ría comprise fine sand and are inhabited by a *Tellina fabula–Paradoneis armata* community.

On the northern Galician shelf, where seasonal coastal upwelling results in benthic enrichment, small surface feeding and fast-growing polychaetes are dominant. The fauna on the western shelf mainly comprises subsurface deposit-feeding polychaetes and relates to the organic matter exported from the Rías Bajas to the shelf. Polychaetes, molluscs, cnidarians, echinoderms and crustaceans are the most abundant groups on the Cantabrian shelf and slope (31–1400m).

In the subtidal zone, the large macrofauna is dominated by decapods, fishes (mainly Gobiidae), echinoderms and coelenterates. The greatest abundance occurs in shallow waters. Ten species account for 92% of abundance and 70% of biomass. Crustaceans are the most abundant group, corresponding to 83% in terms of numbers and 59% in terms of biomass.

Over 70% of the intertidal zone along the Portuguese coast is composed of sand substrates with low faunal densities. In the subtidal zone (about 30m deep), fine sand is characterised by the bivalve *Chamelea striatula*. The bivalve molluscs *Dosinia exoleta* and *Spisula solida* are very abundant in medium to coarse sand. As the percentage of gravel in the sediment increases the cephalochordate *Amphioxis lanceolatus* becomes more common. From the lower infralittoral limit to 200m, the faunal community reflects the increase of mud in the sediments. Polychaetes are the most common group in sediments with up to 10% fines, although molluscs, crustaceans and sipunculids are also important.

Soft substrates predominate in the Gulf of Cádiz. Large macrofauna communities are related to depth and sediment type: shallow muddy bottoms off the river Guadalquivir (15–30m) are characterised by prawns, mantis shrimp, crabs, and common cuttlefish; the middle continental shelf (31–100m) is characterised by bivalve molluscs, gastropods, cephalopods and crustaceans; the outer continental shelf (101–200m) is characterised by a high abundance of the prawn *Parapenaeus longirostris*; the upper portion of the slope (201–500m) is dominated by shrimps and crabs; areas deeper than 300m are dominated by Norway lobster. Portuguese and Gulf of Cádiz macrozoobenthos include several commercially important species; mainly crustaceans (rose shrimp, red shrimp, brown shrimp, common prawn, Norway lobster, edible crab (*Cancer pagurus*), green crab and swimming crab) and mollusks (surf clam, razor clam, wedge shell, carpet shell, mussel, cockle, octopus and cuttlefish).

The main exploited invertebrates in the advisory region are: red shrimp (*Aristeus antennatus*), rose shrimp (*Parapeneus longirostris*), *Nephrops*, and Cephalopods (*Octopus vulgaris*, *Sepia officinalis*, *Loligo* spp., and others). Smaller fisheries exist for rocklobster (*Palinurus elephas*) and red crab (*Chaceon affinis*). *Nephrops* occurs in almost the entire advisory region and is exploited from coastal waters (e.g. south of Brittany) to the upper slope as in the Gulf of Cadiz. Various bivalve species are exploited on the coastal shelf and in the intertidal area (e.g. scallops *Pecten maximus* but also clam *Ruditapes decussatu*s, cockle *Cerastoderma edule*, telline *Donax trunculus*). Some species were introduced for aquaculture purposes, and some settled as wild populations (e.g. *Ruditapes phillipinarum*) that are now exploited. The introduced slipper limpet (*Crepidula fornicata*) is locally abundant. It may be a competitor of exploited filter-feeders and has a negative effect on the substrate availability to juvenile sole in their nurseries (Le Pape *et al*., 2003). This advisory region is locally suitable for shellfish aquaculture, e.g. more than 200,000 tonnes of mussels are produced per year in raft aquaculture off Galicia.

Yearly surveys on sedimentary grounds provide information on species composition, biomass and annual variability (no seasonal) of megaepibenthos and fish species (see point 1.2.3.1). Complete inventories of species can be found in Olaso (1990), García-Castrillo and Olaso (1995), Martínez and Adárraga (2001), Serrano *et al*. (2006, 2008).

1.2.3.3 Fish populations

The fish of the region SWW are well known from a descriptive point of view. In terms of biogeography, many species reach their southern or northern limits of distribution in the Bay of Biscay. The boundary for the cold temperature species is around 47°N. The shelf break in the Bay of Biscay is a major spawning area for species with a wide geographical distribution (OSPAR, 2000).

Despite the progress in the different methodologies applicable to stocks identification, the problem of defining the management units of the different species exploited commercially is far from being resolved (Lleonart and Maynou, 2003). Several international projects have been carried out with this purpose in the Bay of Biscay and Atlantic waters of Iberian Peninsula, some examples are: in relation with hake (e.g. GENHAKE - FAIR CT 97 3494), with horse mackerel (HOMSIR- QLK5 CT1999-01438), with sardine (SARDYNE – Q5RS-2002-000818) and mackerel with various tagging programmes.

The present limits of hake management units in the Bay of Biscay, whit two stocks separated by the Cap Breton canyon, are not supported by biological data (Lundy *et al*., 2000; Mattiucci *et al*., 2004; Cimmaruta *et al*., 2005). The boundaries of horse mackerel stocks in the Northeast Atlantic were revised after the multidisciplinary HOMSIR project results, resulting in a new boundary between the stocks now located in the Cape Finisterre in Galician waters (previously was set around the Cape Breton Canyon) (Abaunza *et al*., 2008). The population dynamics of sardine can be better explained in a metapopulation context (Carrera and Porteiro, 2003). At present the Atlantic area of the Iberian Peninsula constitutes a separated management unit from the rest of the Bay of Biscay but the biological information is not so conclusive. Variation in sardine length-at-age and growth within the Atlanto-Iberian stock area has implications for stock structure and needs to be taken into account in the calculation of weight and maturity-at-age for assessment purposes (Silva *et al*., 2008). Mackerel in the Northeast Atlantic is considered an unique stock, as was concluded after the results from the extensive tagging experiences (Uriarte and Lucio, 2001).

Abundance of age-class of commercial species are yearly determined in the ICES assessment groups. Distribution, abundance, and size-structure of all fish species (target and non-target) are obtained in the yearly autumn bottom-trawl surveys (for demersal and benthic fauna) and in the spring and autumn pelagic acoustic surveys.

The management areas adopted by ICCAT match neither the OSPAR regions, or ICES statistical areas, or SWW RAC areas nor the ranges of large pelagic species and deep water species (OSPAR, 2000). Hence, data available may have not enough resolution to derive stock sizes from this area. The structure of the majority of the stocks on the oceanic regions is unknown (See ICES 2007a and ICCAT, 2008).

Pelagic fish populations

<u>Iberian area</u>

Although fifteen pelagic species are common in OSPAR Region IV, only sardine, anchovy, mackerel, horse mackerel, albacore and bluefin tuna (*Thunnus thynnus*) are important in terms of abundance and commercial interest. Figure 35 shows the distribution of the small and medium-sized pelagic species over the French continental shelf.

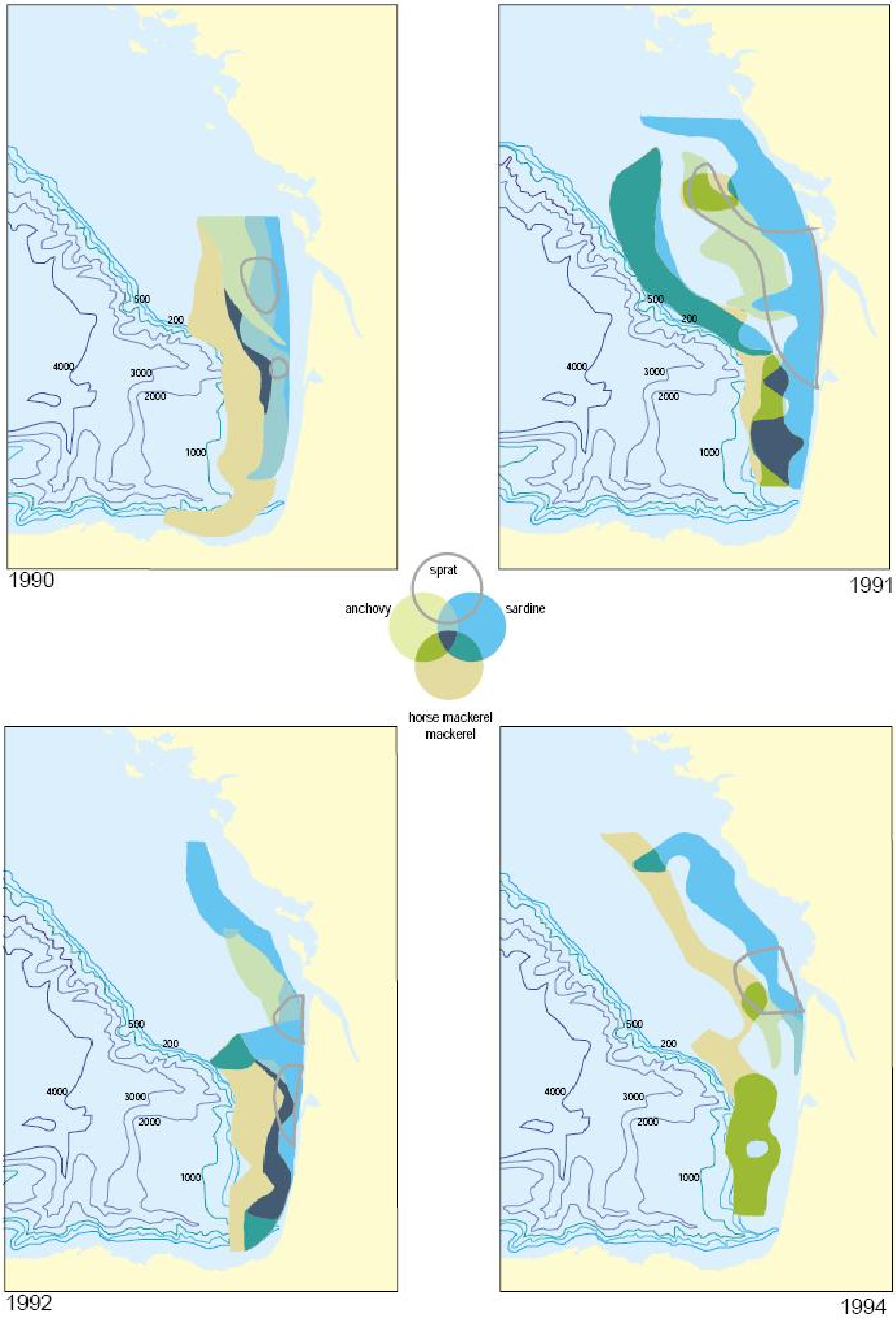


Figure 35. Distribution of the main pelagic fish species on the continental shelf to the east of the Bay of Biscay (source: Massé, 1996).

The sardine has a wide geographic distribution, from Mauritania to the British Isles. The Ibero-Atlantic and Bay of Biscay populations coexist in OSPAR Region IV. There are two main spawning areas and seasons: early winter in Galician/Portuguese waters and early spring in the Cantabrian Sea. Sardine spawning appears coupled to the normal wind regime, avoiding periods when the retention processes are lower. Recruitment occurs in the second half of the year.

Two anchovy populations coexist in OSPAR Region IV; one along the Atlantic coast of the Iberian Peninsula and the other in the Bay of Biscay. Spawning occurs in waters near the large rivers (i.e. the Garona and Guadalquivir rivers), in spring in the Bay of Biscay and in winter in the Gulf of Cádiz. In the Bay of Biscay, juveniles remain near the coast while adults make feeding and spawning migrations. Recent studies have suggested that anchovies in the Bay of Biscay may recruit off the shelf. Old larvae and early juveniles are transported into regions with low predatory pressure (off the shelf) before returning to the shelf as older juveniles (Irigoien *et al*., 2007; Aldanondo *et al*., 2008).

Horse mackerel is distributed from Norway to Cape Verde. Adults live near the bottom and are usually found in continental shelf waters, while juveniles display more pelagic habits. Spawning occurs over the mid continental shelf, beginning in winter in Portugal, continuing towards the Bay of Biscay to the North Sea where it reaches a peak in summer.

Mackerel also has a wide distribution and in contrast to horse mackerel, undertakes long spawning and feeding migrations. Feeding and wintering areas occur in northern European waters, mainly the Norwegian Sea. Around February there is a migration towards the spawning grounds, located mainly in the Bay of Biscay near the slope. Juveniles do not seem to follow this migration and their abundance is higher in southern waters.

Albacore and bluefin tuna live in subtropical areas of the western Atlantic and make annual migrations to the Bay of Biscay. Juvenile schools (from one to four years) move eastwards at the beginning of spring and reach their maximum concentration in the Bay of Biscay in summer. Large bluefin tuna adults pass through the Gulf of Cádiz when entering or leaving the Mediterranean Sea during their spawning migrations.

The geographical location of the Bay of Biscay favours a diversity of pelagic ichthyofauna where species characteristic of cold North Atlantic waters such as herring (*Clupea harengus*) share the area with those from more temperate subtropical waters such as chub mackerel (*Scomber japonicus*) (Lavin *et al*., 2006). The phenomenon of global warming seems to have led to an increase in the presence of temperate water fish species in the Bay of Biscay (e.g., among pelagic fishes *Megalops atlanticus*, *Seriola rivoliana*) over the last twenty years (Quéro *et al*., 1998; Stebbing *et al*., 2002).

From an ecological point of view and also in relation to fishing activity, pelagic fishes can be divided into three large groups: small-sized pelagics, middle-sized pelagics and large migrators (Bas, 1995).

Small pelagic fishes are distinguished by their low trophic level, feeding on phytoplankton and zooplankton typically in upwelling and surrounding areas. Growth is fast, reproduction early and lifespan short, giving rise to the formation of very large populations (Bas, 1995). The population dynamics of these species are dominated by the strength of the generation born each year (recruitment). The most representative species of this group in the Bay of Biscay are: anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*). Another characteristic species is sprat (*Sprattus sprattus*).

Middle-sized pelagic fishes are characterised by a greater plasticity in the food spectrum than that of the small pelagic fishes. They are closely tied to areas of high productivity but the relationship is looser and less direct than that of the small pelagic fishes (Bas, 1995). The diet is mainly made up of large copepods and mesozooplankton. They have greater mobility and make longer migrations, both horizontally and vertically, than the small pelagic fishes. They also have a longer lifespan and populations are made up of several age groups. All of these characteristics favour stability in the abundance of these species. This category mainly includes species from the Scombridae and Carangidae families. In the Bay of Biscay, the most important are mackerel (*Scomber scombrus*) and horse mackerel (*Trachurus trachurus*). Also characteristic are other species more common to temperate and subtropical waters, such as chub mackerel (*S. japonicus*), Mediterranean horse mackerel (*T. mediterraneus*) and blue jack mackerel (*T. picturatus*). Other families with species in this category are Mugilidae and Belonidae.

Large migratory pelagic fishes are strong swimmers, which enables them to perform long migrations. In general, the small and middle-sized pelagic fishes make up their primary food source, which places them at the highest levels of the trophic chain. Some families of the sub-order Scombroidae (tuna-like fishes) and sharks from the Carchariniforms and Lamniforms typically belong to this group. Tuna-like fishes are serial spawners whose spawning area is usually located in tropical and subtropical waters. In tropical areas food is relatively scarce and so tuna fishes have to actively search for food patches. This means that their life is nomadic, based on continuous long displacements (Helfman *et al*., 1997). In the Bay of Biscay the most characteristic species are albacore (*Thunnus alalunga*) and bluefin tuna (*Thunnus thynnus*). Other tuna and tuna-like fishes such as bigeye (*Thunnus obesus*), Atlantic bonito (*Sarda sarda*), skipjack tuna (*Euthynnus pelamis*) and swordfish (*Xiphias gladius*) may also be present. About the epipelagic sharks, in the Bay of Biscay are common: the blue shark (*Prionace glauca*), shortfin mako (*Isurus oxyrrinchus*) and porbeagle (*Lamna nasus*). The largest shark in the Bay of Biscay is the basking shark (*Cetorhinus maximus*), with a length of more than 9m. It is also characterised by its planktonic feeding (Quéro, 1984).

Azores area

About 460 fish species belonging to 142 families were recorded to occur in the Azores area, covering mainly pelagic (epipelagic, mesopelagic and bentopelagic) and demersal habitats (Santos *et al.*, 1997).

Major small pelagic species from the Azores are *Trachurus picturatus*, *Scomber japonicus*, *Sardina pilchardus and B. boops,* among others (Isidro and Carvalho, 2005). They occur in all coastal islands and juveniles of the former are observed on banks and seamounts (Pinho *et al.*, 1995). Adults of *Trachurus picturatus* are demersal one occurring in the coastal areas and seamounts (Menezes *et al.*, 2006).

Several large pelagic species, particular tunas and tuna-like species, temperate and tropical, have been reported on the oceanic regions of the South Western Waters, supporting important bait boat and longliner fisheries in the Azores (Pereira, 1995; ICCAT, 2008). The major target species of the live bait boats fishery are bigeye (*Thunnus obesus*), skipjack (*Katsuwonus pelamis*), yellowfin (*Thunnus albacares*), bluefin (*Thunnus thynnu*s) and albacore (*Thunnus alalunga*) and by the longliners swordfish (*Xiphias gladius*) (Pereira, 1988, 1996; Aires-da-Silva *et al.*, 2007). Other small tunas like black skipjack (*Euthynnus alletteratus*), frigate and bullet tunas (*Auxis thazard, Auxis rochei*), and Atlantic bonito (*Sarda sarda*), or tuna-like species (billfishes such as white marlin (*Tetrapturus albidus*), blue marlin (*Makaira nigricans*), sailfish (*Istiophorus albicans*) and spearfish (*Tetrapturus albidus*) occur also in the region. Other species of interest are the pelagic oceanic sharks that are caught incidentally by tuna fleets, mainly the longliners. These currently include species such as shortfin mako (*Isurus oxyrinchus*) and blue shark (*Prionaca glauca*) among others such as common thresher (*Alopias vulpinus*), bigeye thresher (*Alopias superciliosus*), smooth hammerhead (*Sphyrna zygaena*), tope (*Galeorhinus galeus*) and the galapagos shark (*Carcharhinus galapaguensis*) (Simões, 1998; ICES, 2005a; Clarke *et al.*, 2008).

Tunas are large pelagic and highly migratory fishes which need warm waters for reproduction and larval growth. Some species are able to bear cold waters because of a more efficient thermoregulation. This partially explains differences in the geographical and vertical distributions of tunas: Some, such as skipjack, bigeye and yellowfin tuna, are warm-waters species, whereas others, such as albacore and Atlantic bluefin tuna, are temperate-waters species. So, the distribution of some of this species is much broader than the regional Advisory area of SSW RAC. The occurrence of tuna species in the Azores is seasonal with a natural succession of the species on time and space and so, pure or mixed schools are observed (Pereira, 1995, 2005). Seasonality of the occurrence and interanual variability on the abundance may be correlated directly with sea surface temperature (http://oceano.horta.uac.pt/detra/). Large scale environmental forces like North Atlantic Oscilation (NAO) and small scale features like sea surface temperature, front systems and local anomalies on the environment interact directly with the ecology of the pelagic community affecting the distribution, abundance and fishing of the species (Pereira, 1995; ICCAT, 2008; Rouyer *et al.*, 2008).

Large pelagic species are assessed under the ICCAT framework. These species have an Atlantic distribution (Figure 36) and so, only fractions of the populations occur in the Azores. The important species for the Azores are the tropical species bigeye (*Thunnus obesus*) and skipjack (*Katsuwonus pelamis*). The temperate species albacore (*Thunnus alalunga*) is also caught in the Azores. All the species are caught mainly in the Azores EEZ area (Figure 37). The European fleets operate, under the Fisheries Common Policy, outside of the 100miles box, targeting mainly swordfish and an international fleet operates outside the 200miles, under the ICCAT convention, targeting tunas and swordfish.

Assessment of the species shows that they are intensively exploited or overexploited (ICCAT, 2008). Abundance of the main species caught in the Azores (bigeye and skipjack) present annual fluctuations with a decrease pattern for the bigeye (Figure 38) or lacking obvious trend in the case of the skipjack (Figure 39) (Pereira *et al*., 2008; Shannon *et al*., 2008; ICCAT, 2008). These patterns on the species annual abundance index may reflect the opportunistic character of the fishery, targeting different species of tuna depending of the local abundance of the tuna species and the season of the year. Local abundance of the different pelagic species on oceanic regions like the Azores is a function of a complex dynamic (Pereira, 1995). Very large scale climate forcing such as NAO, anomalies on oceanographic parameters, front systems dynamic like the Azores front, general circulation pattern of the main features like the gulf stream, eddy kinetic energy, surface wind speed, surface current speed, etc, are involved in the dynamic of these species and can substantially affect productivity (e.g., through changes in recruitment and growth). They also can modify both the horizontal and vertical distribution of some tropical tunas and consequently their catchability to several fishing gears, particularly those like live bait boat. In addition to the large scale, small scale effects, like topographic effects of the seamounts may have effects on the abundance and distribution of the species. For example, it has been suggested that seamounts hold higher abundances of some 'visiting' animals, such as tuna, sharks, billfishes, marine mammals, sea-turtles and even seabirds. Results of a study from the Azores area indicate that some of these marine predators (skipjack *Katsuwonus pelamis* and bigeye tuna *Thunnus obesus*, common dolphin *Delphinus delphis* and Cory's shearwater *Calonectris diomedea borealis*) were significantly more abundant in the vicinity of some shallow water seamount summits (Morato *et al.*, 2008b,c). However, for some species any association was demonstrated particularly for bottlenose dolphins *Tursiops truncatus*, spotted dolphin *Stenella frontalis*, sperm whale *Physeter macrocephalus*, terns *Sterna hirundo* and *S. dougalli*, yellow-legged gull *Larus cachinnans atlantis* and loggerhead sea turtles *Caretta caretta*. Seamounts may act as feeding stations for some of these visitors. Not all seamounts, however, seemed to be equally important for these associations. Only seamounts shallower than 400m depth showed significant aggregation effects.

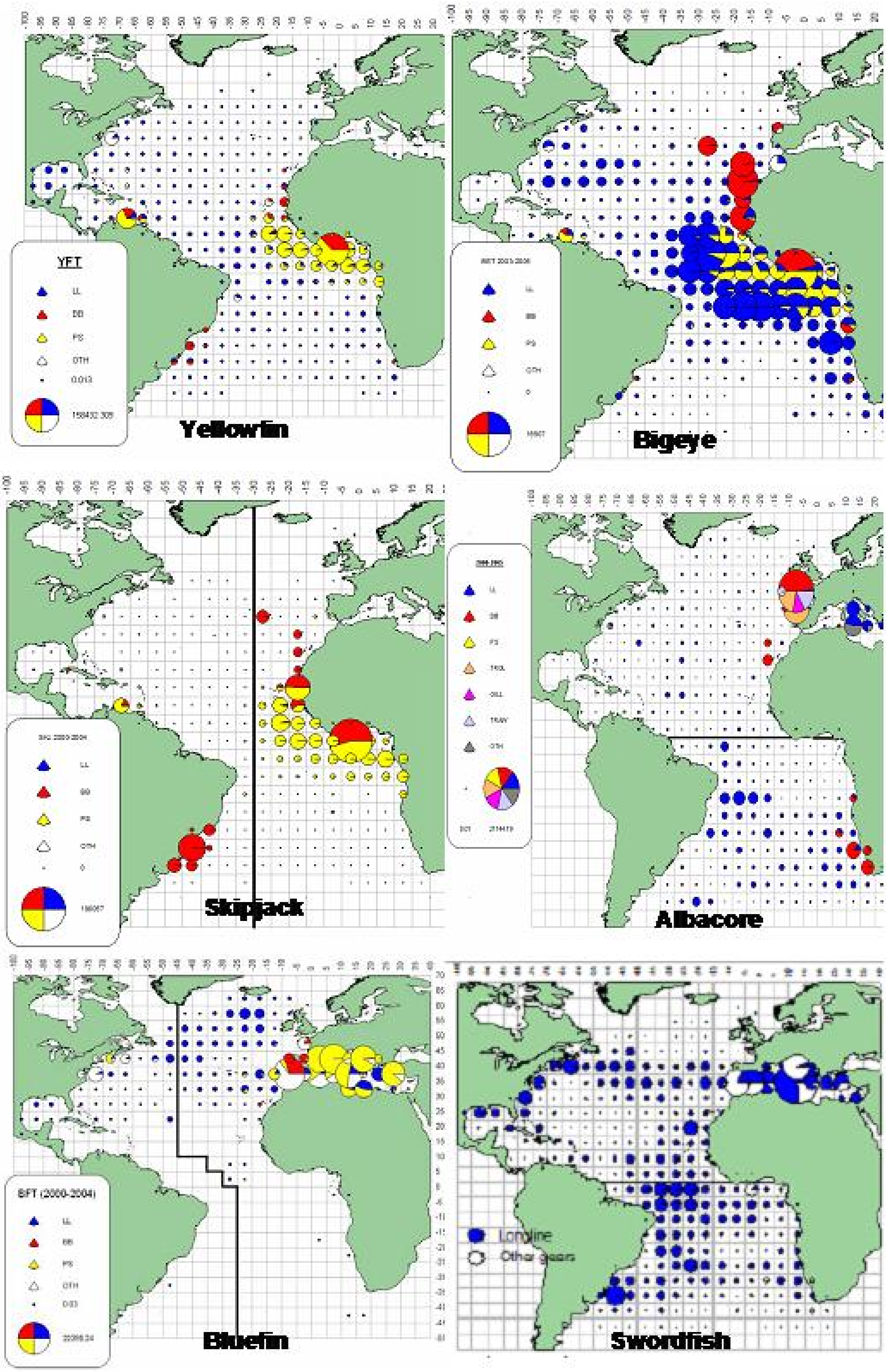


Figure 36. Geographic distribution of yellowfin (2000-2004), bigeye (2003-2005), skipjack (2000-2004), albacore (200-2005), bluefin tuna (2000-2004) and swordfish (2000-2004) catches of the recent years by gear. The line on the graph represents the boundary used for stock division. Source: ICCAT.

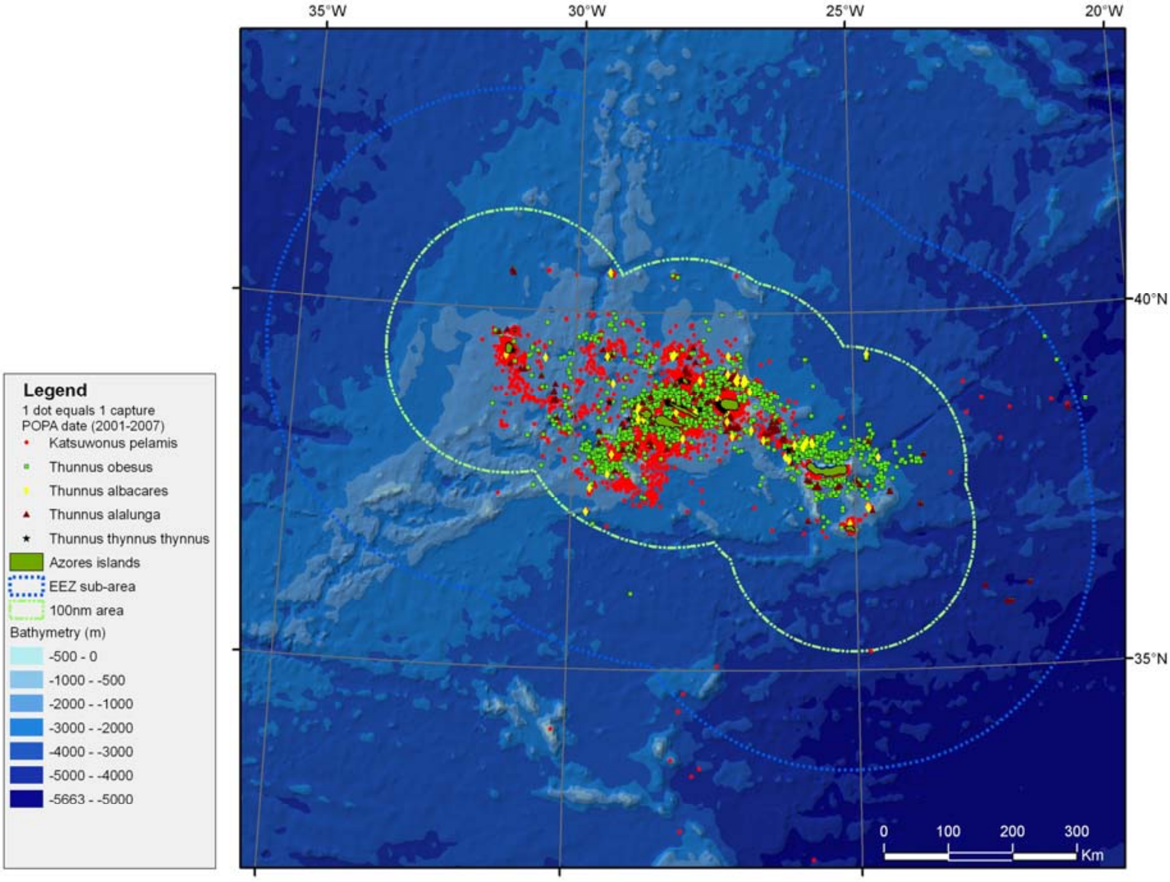


Figure 37. Distribution of the tuna catches by species from the Azorean bait boat for the period 2001-2007. EEZ and 100miles box is also represented on the graph. Data from POPA (Regional Tuna Observer Program).

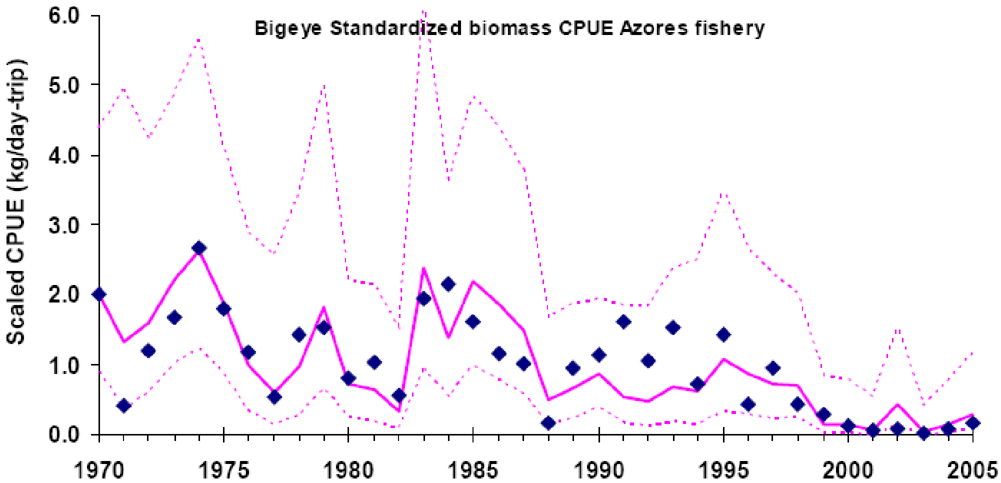


Figure 38. Standardised (rose line) and observed (squares) abundance index, with 95% confidence intervals (dashed line) of bigeye tuna (*Thunnus obesus*) from the Azorean bait boat fishery. From Pereira *et al.*, 2008.

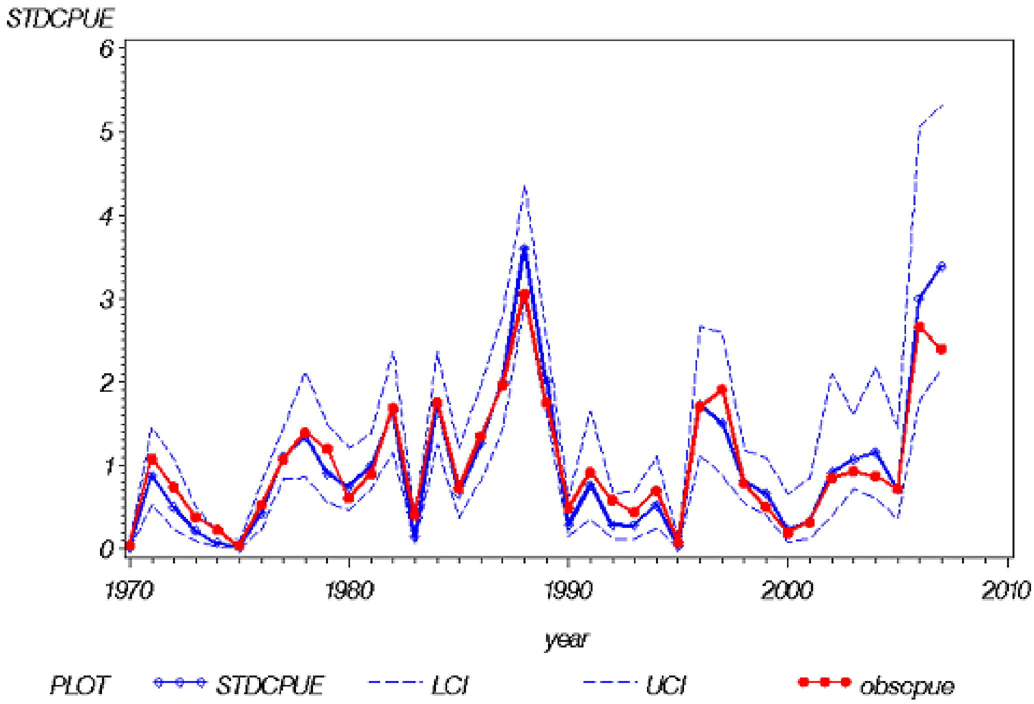


Figure 39. Standardised (blue line) and observed (red line) abundance index, with 95% confidence intervals (dashed lines) of skipjack tuna (*Katsuwonus pelamis*) from the Azorean bait boat fishery. Both series are scaled to a mean of 1.0 to facilitate comparison. From Shannon *et al.*, (2008).

The pelagic food web

The study of the trophic relationships in pelagic ecosystems is complicated by the large variability in diet of most species, which leads to unstructured food webs (Isaacs, 1973). Preferences in mesozooplankton feeding habits were studied in shelf waters off Santander using natural assemblages of mesozooplankton and natural assemblages of phytoplankton. The results suggest that the most abundant fractions of mesozooplankton (200-500 and 500-1000µm) graze mainly on nano and microphytoplankton cells. Grazing values of the larger fraction of mesozooplankton (>1000µm) showed neither a clear relationship with nano-microphytoplankton nor with picophytoplankton, suggesting feeding habits are not based exclusively on primary producers. A different approach to the study of plankton feeding habits was followed by Bode *et al.* (2003) in shelf waters off Galicia (NW boundary of the Bay of Biscay). These authors studied the gains of stable isotopes of C (^{13}C) and N (^{15}N) through the trophic chain from plankton to sardines and dolphins. Their main conclusions were: a) there are no more than four trophic levels in the studied pelagic ecosystem; b) the pelagic food web in the Galician upwelling area is more complex than expected due to the generalized onminvory in all organisms. Furthermore the obtained relationships between (^{15}N) and the size of organisms provide the basis for a quantitative analysis of changes in the trophic structure of the ecosystem.

On the other hand, pelagic fish species represent an important part of diet of the demersal fish community in the southern Bay of Biscay. Preciado *et al.* (2008) found that 39% (by volume) of the diet of demersal fish was composed by the following species: anchovy, blue whiting, horse mackerel, sardine, mackerel and *Gadiculus argenteus*, being the most important blue whiting and *Gadiculus argenteus*. They also found that the relevance of pelagic fish as prey increased with predator size (up to 60% of the diet by volume), although fish predators larger than 50cm depended less on pelagic fish (33% of the diet by volume).

Demersal fish populations

For most of the demersal deep-water stocks "management units" were defined, mainly based on the statistical ICES areas or fisheries occurring over the stock. The stock structure is unknown for almost all the demersal deep-water species from the oceanic regions (ICES, 2007a). The distribution of the majority of the species is broader than the Azores EEZ area (ICES area Xa2) and extended to north (Mid Atlantic Ridge) and south, to the CECAF (Fishery Committee for the Eastern Central Atlantic) statistical areas. Fisheries data resolution does not fit on the ecosystem type characterised by discontinuity and so suggesting potential metapopulations occurring on the different habitats (coastal areas, seamounts, abyssal plains). The dynamic associated to the probable areas interaction is not well understood (Pinho and Menezes, 2005). Genetic studies have not supported convincing evidence of population differentiation between seamounts and coastal areas of the Azorean EEZ for several important commercial species (Aboim *et al.*, 2005; Stocey *et al.*, 2005; Stefanni and Knutsen, 2007). Several projects were developed to address movements between areas (MAREFISH - http://www.horta.uac.pt/projectos/marefish/), looking for genetic differentiation (e.g. DEECON - http://www.imr.no/deecon/home) and examining the life history of the species from different habitats (e.g. ORPAM http://www.imr.no/deecon/home). The question over whether regional habitats are self recruiting or opening to external recruits is unresolved.

Stock assessment of demersal and deep-water species has been made under the ICES framework (ICES, 2008c). There is no valid assessment of these species from the Azores (ICES area Xa2) because data available do not catch the population dynamic of the species and the dynamic of the opportunistic fishery targeting different species depends on abundance, price or season. Abundance data from fisheries and survey, as well as size and age structure of the landings have been presented to ICES working group and are available at ICES WGDEEP and WGEF reports (see ICES, 2006b, 2006c, 2008c; Pinho and Menezes, 2005).

Deep-water community (>700m) are almost not caught because there is no commercial market for the species of these assemblages (*Mora moro, Aphanopus carbo*, deep water sharks, etc). Some low by-catch may occur on these species (Pinho and Menezes, 2005).

Iberian area

Demersal species comprise the majority of the fish species occurring in OSPAR Region IV. The species present are related to bottom topography and the adults and recruits usually have different areas of distribution. Some species are sedentary (e.g. sole, megrims, dogfish and skates), while others are migratory (e.g. hake, red seabream, blue whiting). Many deep-water species have an extensive geographical distribution owing to the small environmental variations in their habitat. Communities are described according to depth and to the main sectors of the continental shelf.

With regard to the eastern Bay of Biscay, a total of 191 species were recorded during the French groundfish surveys on the Armorican and Aquitaine shelves at depths of 15–600m. Abundance varied widely with around ten species making up over 80% of the total demersal catches. Six communities were identified in the Bay of Biscay; three located in the coastal area (15–60m), one on the muddy bottom of 'La Grande Vasière' (with hake as its main species), one over the outer shelf and one comprising deep-water species along the shelf edge.

The southern Bay of Biscay has a mixture of typically temperate fauna, with groups of boreal and subtropical affinity. Species richness and the distribution of fish populations are determined by the narrowness and topography of the continental shelf. This is very irregular with a reduced or even absent sediment cover in many areas. More than 80% of the demersal fish biomass is accounted for by seven species, in order of importance: blue whiting, horse mackerel, dogfish, hake, monkfish (*Lophius piscatorius*), silvery pout (*Gadiculus argenteus*) and megrim. Five communities characterise the area, corresponding to shallow coastal waters, the mid shelf, the outer shelf, and the shelf break and slope.

Important estuaries and coastal marshes at the mouths of large rivers draining into the Gulf of Cadiz further enhance the physiographical diversity of the region. Shallow muddy sediments off the mouth of the River Guadalquivir are characterised by fish of estuarine influence, similar to the coastal community of Sciaenidae at subtropical and tropical latitudes.

Gregarious and highly abundant species such as blue whiting and silvery pout, which serve as a food source for other species, occur between 100 and 300m. Predatory species of commercial interest are forced to occupy these areas in order to exploit an abundant food source and as a consequence this zone is the most intensively fished. Large predators such as hake, monkfish and sole, and the forage fish blue whiting, are particularly important in terms of the transfer of energy through the ecosystem.

The shelf break area appears to be the preferred region for hake spawning which is particularly intense during the first quarter of the year in the Bay of Biscay. Hake nursery grounds are located off northern Galicia, in the western Cantabrian Sea and Grande Vasiere, mainly in the range of 80–150m. A new cohort is present in these areas as early as May, following spawning and high numbers of age group 0 are found during autumn. Young hake remain in nursery grounds until spring, one year after spawning, and then scatter over the continental shelf.

Monkfish (both *L. piscatorius* and *L. budegassa*) are distributed throughout Region IV from shallow waters to waters of at least 800m depth. The smaller fish live in shallow waters moving to deeper waters as they grow. The spawning season is mainly between October and March and age at first maturity is estimated at over eight years.

The spatial aspects of the sole life cycle in the Bay of Biscay are well established. Spawning occurs in late winter and spring on the continental shelf (50–80m), with post-larvae and young juveniles arriving at coastal nurseries in May to June, where they remain for about two years. Blue whiting are distributed near the bottom, mainly between 200 and 500m. Fish length increases with depth and larger individuals (25cm) concentrate at 500 – 750m. At 200 to 400m, their distribution enters the oceanic zone in which they exhibit diurnal vertical migrations. Blue whiting are the main prey for large predators.

Available studies on the fish community structure (Sánchez, 1993, Sánchez and Serrano, 2003) in the Cantabrian Sea showed the existence of 5 groups (excluding slope):

- Coastal (<70m depth): typified by sparids (*Pagellus erythrinus*, juvenile *Pagellus bogaraveo*), flatfishes (*Solea lascaris*, *Buglossidium luteum*), *Trachinus draco*, and *Mullus surmuletus*.

- Inner shelf (70-120m): characterised by catshark *Scyliorhinus canicula*, hake *M. merluccius* classes 0 and 1, megrim *Lepidorhombus whiffiagonis* class 0, monkfish *Lophius budegassa* class 1 plus and *L. piscatorius* class 0.
- Middle shelf (120-200m): typified by blue whiting (*Micromesistius poutassou*), monkfish (*L. budegassa* class 0), *Conger conger*, megrim *Lepidorhombus boscii* class 0, *Helicolenus dactylopterus*, silvery pout (*Gadiculus argenteus*).
- Outer shelf (200-500m): typified by *Chimaera monstrosa*, *Bathysolea profundicola*, *Galeus melastomus, Phycis blennoides* and *Malacocephalus laevis*.
- Shelf break (>500m): community made up of species such as *Notacanthus bonapartei, Trachyrhynchus scabrus, Lepidion eques, Deania calceus, Etmopterus spinax* and *Lampanyctus crocodilus.*

The top predators of the demersal and benthic domains respectively, hake *M. merluccius* (class 2 plus) and monkfish *L. piscatorius* (class 1 plus) do not belong to any group, and are situated closer to the centroid, indicating their wide optimal environmental range, which increases their number of available preys (Sánchez, 1993).

Several studies have been carried out to determine the distribution, and seasonal variability of demersal fish assemblages in the area (Fariña *et al.,* 1997; Gomes *et al.,* 2001; Sousa *et al.,* 2005). Throughout the region, the demersal fish community is organised according to depth, bottom and latitude and is stable over time despite species abundance variations and trends (Souissi *et al.,* 2001; Poulard *et al.,* 2003; Gomes, *et al*., 2001; Sousa, *et al.,* 2005).

There are many elasmosbranch species in the region, including rays (*Raja clavata, R. montagui, and R. miraletus*) and catsharks, (*Scyliorhinus canicula and Galeus melastomus*) near the coast and on the slope and there are several deepwater sharks and chimaeroids. Widely migratory sharks also occur in the region such as blue shark (*Prionace glauca*), shortfin mako (*Isurus oxyrnchus*), porbeagle (*Lamna nasus*), tope (*Galeorhinus galeus*) and spurdog (*Squalus acanthias*). Some are taken in mixed demersal and pelagic (especially for tuna and swordfish) fisheries (ICES, 2006c).

The main Elasmobranch species in the region are the rays, *Raja clavata, R. montagui,* and *R. miraletus* and the catsharks, *Scyliorhinus canicula* and *Galeus melastomus* at the coast and on the inner and outer shelf respectively (Rodríguez-Cabello *et al.,* 2005). Several deepwater sharks and chimaeroids are also found (Sánchez and Serrano, 2003; Lorance *et al.,* 2000). Widely migratory sharks occur in this region such as blue shark (*Prionace glauca*), shortfin mako (*Isurus oxyrnchus*), porbeagle (*Lamna nasus*), tope (*Galeorhinus galeus*) and spurdog (*Squalus acanthias*). Some are taken in mixed demersal and pelagic (especially for tuna and swordfish) fisheries.

<u>Azores area</u>

Fish demersal community from the Azores is large and is mainly structured by depth assemblages (Pinho and Menezes, 2005; Menezes *et al.*, 2006,). Four large-scale fish assemblages following a depth structure have been defined: a shallow-shelf/shelf-break assemblage at depths < 200m, an upperslope assemblage at 200–600m, a mid-slope assemblage at 600–800m and a deep mid-slope assemblage at 800–1200m.

Within the main shallow assemblage, 4 small-scale fish assemblages may be defined: an inner-shelf-island assemblage, an outer-shelf-island assemblage, a seamount/islandshelf/ shelf-break assemblage and a transitional shelf/break assemblage (Menezes *et al.*, 2006).

The bathymetric delineation of the mid-slope assemblages coincides with the known distributions of the North Atlantic Central Water (NACW), Mediterranean Water (MW) and the upper influence of the intermediate waters in the region: the northern sub-polar waters (Subarctic Intermediate Water [SAIW], the Labrador Sea Water [LSW]) and the Antarctic Intermediate Water (AAIW). The delineation of the shallow small-scale fish assemblages appears to be determined by small-scale environmental factors (e.g. bottom characteristics, seamounts or island areas). The structure of these assemblages is similar in all habitat types like the coastal areas of the islands and seamounts. Despite the geographical effect similar assemblages are expected on north (MAR-Mid Atlantic Ridge) and south areas of the Azores EEZ. The distribution of the majority of these species is broader than the Azores EEZ or even the SSWRAC area (ICES, 2007a). Some are considered seamount aggregators like the alfonsinos (*Beryx* sp.) and for the majority the stock structure is not known. An incomplete but detailed list of demersal species observed on the Azores can be found in Menezes *et al.*, (2006) (www.int-res.com/articles/suppl/m324p241_app.pdf).

1.2.3.4 Marine mammals and reptiles

Marine mammals

Range and status

A large variety of marine mammals, both boreal and temperate, have been reported in the South Western Waters (SWW) region. Records of the presence of seven pinnipeds and thirty cetaceans (twenty-three odontoceti and seven mysticeti) have been documented from past whaling activities, strandings on coasts and systematic and opportunistic sightings at sea. However, some of these records correspond to vagrant individuals, outside their normal range (in particular some pinnipeds), and therefore cannot be considered part of the regional fauna. Information about some rare species is very scarce. A summary of the distribution and relative frequency of the most relevant species is provided in the Table 4.

The pinnipeds most commonly seen are the grey seal (*Halichoerus grypus*) and the harbour seal (*Phoca vitulina*). The southernmost breeding colony of grey seals is found in Brittany, with a permanent population. The presence of individuals in the Bay of Biscay and on the Atlantic Iberian coast is due to the dispersion of young individuals from breeding colonies on the British Isles. The harbour seals specimens found in this region are vagrants from the southernmost breeding groups along French Channel coasts. Monk seals (*Monachus monachus*) were once common in the southeastern North Atlantic, from the Azores Islands to near the equator, but at present only breeding colonies subsist on Madeira and Desertas Islands and around Cape Blanco on the Mauritanian coasts.

Table 4. Species found in the area.

Species Common English and *scientific* names	Main area of distribution in the region	Frequency
Grey seal *(Halíchoerus grypus)*	North of region	Permanent in Brittany
Harbour seal *(Phoca vitulina)*	North of region	Vagrants
Monk seal (*Monachus monachus)*	South of region	Locally extinct. Some isolated colonies. Endangered.
Minke whale *(Balaenoptera acutorostrata)*	Whole region	Common in northern part of the region
Sei whale *(Balaenoptera borealis)*	Whole region	Fairly common. Migrates through region

Blue whale *(Balaenoptera musculus)*	Whole region	Rare. Fairly common around the Azores. Migrates through region
Fin whale *(Balaenoptera physalus)*	Whole region	Most common. Migrates through region
Bryde's whale *(Balaenoptera edeni)*	South of region	Rare
Humpback whale (*Megaptera novaeangliae*)	Whole region	Rare. Migrates through region
Northern right whale (*Eubalaena glacialis*)	Mainly Bay of Biscay	Very rare. Occasional sightings. Extinct in region?
Northern bottlenose whale (*Hyperoodon ampullatus*)	North of 30º N. Slope, canyons and deep water	Fairly common
Sowerby's beaked whale (*Mesoplodon bidens*)	North of 30° N	Rare. Fairly common around the Azores Islands
Blainville's beaked whale (*Mesoplodon densirostris*)	South of region	Rare. Fairly common around the Azores Islands
Gervais' beaked whale (*Mesoplodon europaeus*)	South of region	Rare
True's beaked whale (*Mesoplodon mirus*)	South of region. Deep water	Rare
Cuvier's beaked whale *(Ziphius cavírostrís)*	Whole region. Slope, canyons and deep water	Fairly common. Small permanent numbers
Sperm whale *(Physeter macrocephalus)*	Whole region	Fairly common. Summer aggregations over continental slope
Pygmy sperm whale (*Kogia breviceps*)	Whole region	Rare
Dwarf sperm whale (*Kogia simus*)	South of 40° N	Rare
Short-beaked common dolphin *(Delphinus delphis)*	Whole region. Continental shelf, slope and oceanic waters	Most common. All year
Atlantic white-sided dolphin (*Lagenorhynchus acutus*)	North of region, oceanic waters	Fairly common
White beaked dolphin (*Lagenorhynchus albirostris*)	North of region, oceanic waters	Rare
Bottlenose dolphin *(Tursiops truncatus)*	Whole region. Coastal and oceanic waters	Common. All year
Striped dolphin *(Stenella coeruleoalba)*	Whole region, oceanic waters	Most common
Atlantic spotted dolphin (*Stenella frontalis*)	South of region	Fairly common
Melon-headed whale (*Peponecephala electra*)	South of region	Rare
Pigmy killer whale (*Feresa attenuata)*	South of region	Rare
False killer whale (*Pseudorca crassidens*)	Whole region	Fairly common to the south of 40° N
Killer whale *(Orcinus orca)*	Whole region. Oceanic and coastal groups	Rare
Risso's dolphin (*Grampus griseus*)	Whole region	Fairly common. All year
Short-finned pilot (*Globicephala maxcrorhynchus)*	Mostly south of 40° N	Common
Long-finned pilot *(Globicephala melas)*	Mostly north of 40° N	Common. Visits into coastal waters in summer
Harbour porpoise *(Phocoena phocoena)*	Whole region, mostly inshore	Fairly common locally. Probably decreasing.
Rough-toothed dolphin (*Steno bredanensis*)	South of region	Rare

Of the baleen whales, only fin whales (*Balaenoptera physalus*) are common through the entire region. During spring and summer fin whales approach the continental shelf for feeding, mainly on krill. Fin whales have also been found offshore Atlantic waters in winter. Genetic differences have been found between fin whales in these waters and other Atlantic areas. Sei whales (*B. borealis*) are very common in the Azores during spring and early summer. Although being less abundant than the previous species, blue whales (*B. musculus*) are also fairly common in the area during that period (Steiner *et al*., 2007). These species spend days to weeks foraging around the islands and seamounts.

The northern right whale (*Eubalaena glacialis*) that once was a common species along the northern and western Spanish coast has only been reported in these waters over the last 30 years on very exceptional occasions. Sperm whales (*Physeter macrocephalus*) tend to aggregate in summer over the continental slope, feeding on cephalopods. Males undertake large scale migrations while females and young animals remain all year round in tropical and temperate waters, at latitudes less than 50ºN. Some estimates suggest that food consumption (predominantly squid) around the Azores is about 67–374x103t of squid each year, which are four to twenty times the landings of fish on the islands.

Common dolphin (*Delphinus delphis*) is the species most frequently observed at sea and also represents about 50% of all strandings in the SWW region. In the Azores is the most abundant species during winter and early spring (Silva *et al*., 2003). Common dolphins found along the European Atlantic coasts may be part of the same population, as genetic differences between stocks have not been found (ICES, 2008b). They feed upon commercially important fish species such as blue whiting, sardine and horse mackerel.

The Atlantic spotted dolphin (*Stenella frontalis*) becomes the dominant species in the Azores between May and September (Silva *et al*., 2003). Bottlenose dolphins (*Tursiops truncatus*) are encountered around the coast of France, Spain, Portugal and the Macaronesian Archipelagos, occurring year round. Groups of bottlenose dolphins are resident in several inshore bays from Brittany to Portugal and in the Atlantic islands (Silva *et al*., 2008). The specimens from Azores and Madeira are not genetically different (Quérouil *et al*., 2007). The highest densities are found on the coastal waters of the Iberian Peninsula. The most important prey species are blue whiting and hake.

Harbour porpoise (*Phocoena phocoena*) was considered one of the most common species in the area, but now sightings and strandings are only common in western Galician and northern Portuguese coasts.

Population estimates

Sighting surveys carried out to estimate cetacean abundance in western European waters did not cover the full extension of the SWW region and therefore estimates of abundance for the most abundant species are only available for parts of this area.

The most comprehensive abundance estimate for fin whales in this region (Bay of Biscay and adjacent Atlantic area) was 17,904 (95% CI: 10,949-29,277) animals, obtained during the NASS-89 sighting survey (Buckland *et al*., 1992).

Porpoise density obtained during the SCANS II project (Figure 40) was lowest off the Atlantic coasts of France, Spain and Portugal (<0.1 animals/km^2). The estimated abundance of harbour porpoise in the Iberian shelf in the summer of 2005 was 2,646 (CV 0.02 - 0.80) (Table 5) (ICES, 2007b, 2008b).

Table 5. Abundance estimates for small cetaceans from the SCANS II

Species	Geographical Area	SCANS II Area	Abundance Estimate	CV
Harbour porpoise	France, Spain, Portugal coastal	W	2646	0.8
Common dolphin	Western Waters	N,O,P,Q,R,W	63400	0.46
Bottlenose dolphin	All areas		12700	0.27
White-beaked dolphin	All areas		22700	0.42

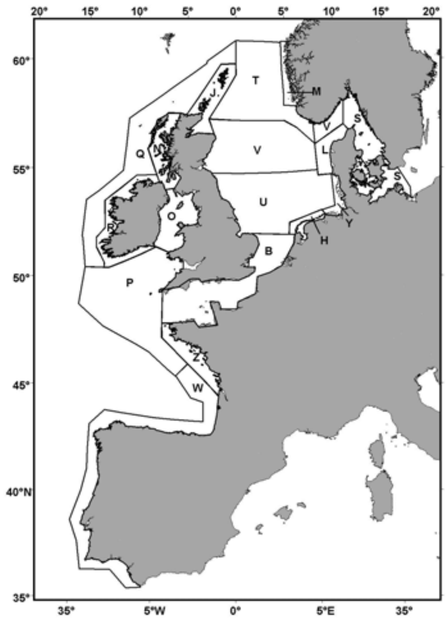


Figure 40. SCANS II survey areas.

For the area between NW Spain, W France and SW Ireland, the MICA survey (pink dashed lines in Figure 41) produced an estimation of common dolphin abundance of 61,888 (95% CI: 35,461 – 108,010) animals (Goujon *et al.,* 1993). The combined abundance estimation for common dolphin, for a defined management area (pelagic trawl fisheries in the NE Atlantic) (Figure 41), which coincides with ICES Areas VI, VII, & VIII, was 248,962 (CV=0.18; 95% CI 161,920 – 336,000) (Burt, 2007). Another estimation of abundance for common dolphin, obtained from SCANS II surveys (Figure 40) in the western continental shelf waters was 63,400 animals (Table 5). These estimates are specific for the summer, as seasonal changes in density in western European waters have been reported (ICES, 2005b).

The estimated number of striped dolphins in the MICA survey area was 73,843 (95% CI: 36,113 – 150,990) (Goujon *et al.,* 1993).

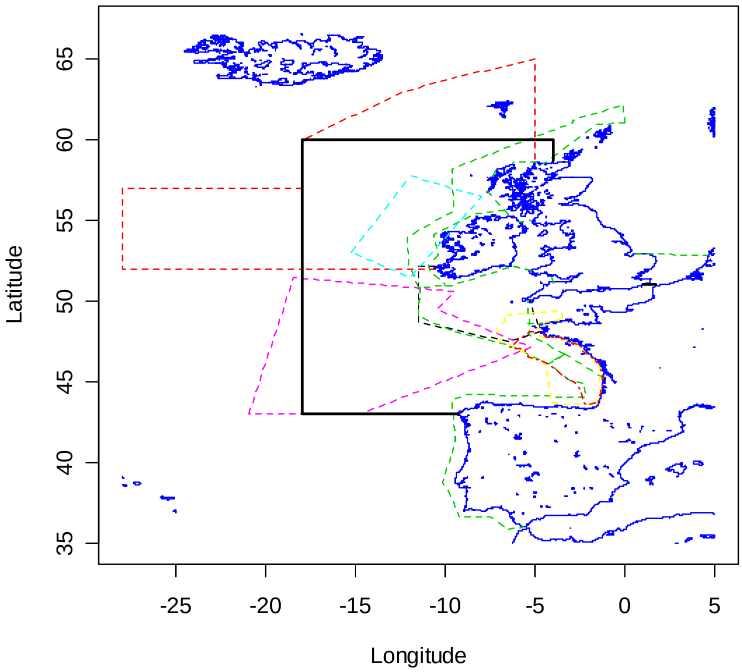


Figure 41. Areas covered by several surveys (dashed lines): MICA (pink), SCANS-94 (black), NASS-95 (red), SIAR (cyan), ATLANCET (yellow), PELGAS (red in Bay of Biscay) and SCANS-II (green) and the region for which an abundance estimate has been produced (solid black line).

Areas to the west of the SCANS 2 area were recently surveyed (July 2007), as part of the CODA project. Results from these surveys will provide new estimates of abundance for common and striped dolphins, pilot whales and fin whales inhabiting offshore SWW region.

Pressures and impacts

Concerns regarding conservation of cetacean populations are related to the impact of fisheries and other anthropogenic alterations of the ecosystem.

Incidental catches of cetaceans in the sea bass, tuna and herring pelagic trawl fisheries were observed in the northern part of the SWW region. The tuna fishery bycatch comprises bottlenose and common dolphins, while the other fisheries report common dolphins only (Morizur *et al*., 1999). Incidental takes of cetaceans are also known in other gears such as trawlers, gillnets, longlines and fish traps. The EU introduced a compulsory scheme to put observers onboard bottom gillnets and pelagic and high vertical opening trawls working in several ICES Divisions (VIII and IX) within this region.

Cetaceans can be chronically contaminated with PCBs and other persistent residues. Species with a predominant coastal habitat such as the bottlenose dolphin and the harbour porpoise are most exposed to pollution from land and other alterations of their habitats. The local prevalence of these impacts depends on the level of industrial activity and population density in the different coastal areas of this region. The ingestion of plastic debris can block the digestive tract and cause the death of the animal, as demonstrated by autopsies made to specimens stranded in French and Spanish coasts. There is also concern for the impact of underwater noise, produced by a variety of human activities such as seismic surveys and military exercises. Intense maritime traffic also generates noise and can result in collisions between ships and cetaceans in areas of high cetacean habitat use.

Whale watching is a very important activity in the Canary and Azores Islands and the Gibraltar Strait and may be the most important threat to the welfare of cetaceans in some of these areas. These activities are subject to regulations and codes of conduct to minimise the impact over affected individuals and populations but law enforcement can be improved in some areas. Short-term behavioural changes caused by whale-watching boats have been noted in sperm whales and bottlenose dolphins (Magalhães *et al*., 2002; Magalhães *et al*., 2007) but its consequences in the long run and at the population level remain unknown.

Turtles

Range and status

Of the 7 species of marine turtles in the world, 5 have been recorded in the South Western Waters region, mainly during their juvenile oceanic stage: the loggerhead turtle (*Caretta caretta*); the leatherback turtle (*Dermochelys coriacea*), mostly adults; the green turtle (*Chelonia mydas*); the hawksbill turtles (*Eretmochelys imbricata*) and Kemp's ridley (*Lepidochelys kempii*). Only the three first mentioned are regular visitors in the South Western Waters region.

Seasonal variations in abundance reported in the Bay of Biscay, Gibraltar Straits and the Macaronesian archipelagos (the Azores, together with the archipelagos of Madeira, the Canary Islands and the Cape Verde Islands, form the subtropical biogeographical region of Macaronesia) are related to a migration pattern that marine turtles undertake using the Gulf Stream (Carr, 1986; Camiñas and Valeiras, 2001; Santos *et al*., 1995a; ICES, 2008a). Santos et al. (2007) reported that seamounts occurring within the South Western Waters region might be critical habitats for oceanic stage loggerheads. Loggerhead and the leatherback occur year round in the southern part of the region. Leatherback turtles arrive every year between June and October to the Bay of Biscay. No turtles breed along the Western European margin. Genetic studies have linked the loggerhead turtles occurring off the Azores and Madeira with the populations that breed in Florida and the Caribbean, rather than those that breed in the Mediterranean and Brazil (Bolker *et al*., 2007; Bolten *et al*., 1998).

Pressures and impacts

Among a wide range of different human activities which threaten the survival of sea turtle populations worldwide, a major threat is the risk of incidental capture in commercial fisheries, mainly as bycatch of pelagic longline fleets (Bolten, 2003). The impact of longline fisheries on sea turtles has recently received attention by the scientific community (e.g. Long and Schroeder, 2004). In Azorean waters, the size classes of loggerheads being impacted by the swordfish fishery correspond to the largest size classes of loggerheads occurring in the area (Bolten, 2003; Ferreira *et al*., 2001). Crouse *et al*. (1987) reported that these size classes are the most important for the recovery of the North Atlantic loggerhead populations.

They are also vulnerable to injury through the ingestion of plastic debris accumulating along convergent fronts, as this resembles the gelatinous species on which they feed (Carr, 1987). Recent reports indicate a global epidemic of a form of non-cancerous tumour affecting most species of turtle. It is speculated that pollutants, by weakening the turtles' immune systems, make them more susceptible to viral infections (OSPAR, 2000).

1.2.3.5 Seabirds

Range and status

From the point of view of habitat use seabirds are grouped in coastal and pelagic species, with nesting or wintering populations in the SWW region. The nesting seabird community is very poor in comparison with other European Atlantic areas, both in terms of numbers and biomass. However the strategic geographical position of the Iberian Peninsula and the high biological production of coastal areas give rise to an important autumn migration and large wintering populations in the SWW region.

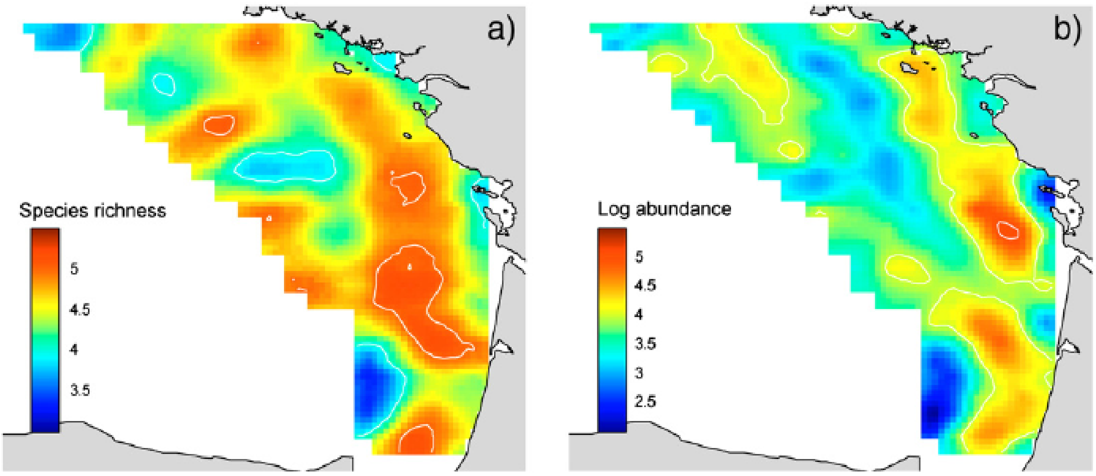


Figure 42. Spatial representation of the specific richness (the mean number of different species recorded during a 20km transect) and of the log abundance of seabirds (log number of seabirds counted within a 20km bin) in the French shelf.

Most important species in terms of abundance are the northern gannet (*Morus bassanus*), the *Larus* spp. gulls (7 species), the Manx (Balearic) shearwater (*Puffinus p. mauretanicus*), the sooty shearwater (*Puffinus griseus*), the Cory's shearwater (*Calonectris diomedea*), the razorbill (*Alca torda*) and the Atlantic puffin (*Fratercula arctica*).

The coastal nesting seabird community is dominated by the yellowlegged gull (*Larus cachinnans*), which until recently was considered the same species as the herring gull (*L. argentatus*). Its main food sources are fish discards and rubbish dumps which, together with the protection of their colonies, explains their strong demographic growth in recent decades. In Galicia (NW Spain) the population has grown five-fold since the end of the 1970s, accounting for up to 94% of total seabird numbers and 90% of biomass in the area. The very similar lesser blackbacked gull (*L. fuscus*) established itself in the 1970s in some Galician islands and in parts of the Basque Country coasts (inner Bay of Biscay). Other important nesting seabirds are the European shag (*Phalacrocorax aristotelis*), European storm petrel (*Hydrobates pelagicus*), kittiwake (*Rissa tridactyla*) and common guillemot (*Uria aalge*). The kittiwake and the guillemot both reach the southernmost points of their distribution on the northern Iberian Peninsula. More than 3000 pairs of little tern (*Sterna albifrons*) were counted in southern coastal Spanish areas and in the Gulf of Cadiz.

The scales at which seabird dispersion occurs in the Portuguese marine area render it quite difficult to define and characterise seabird densities. The possibility of identifying inshore coastal aggregations of some wintering species, such as Balearic shearwater and scoters, may lead to the classification of a small number of SPAs off continental Portugal.

Terrestrial seabird colonies that have a coastal component and are already classified might be extended into the sea to protect feeding, resting and/or rafting aggregations of birds. This may include important coastal feeding areas in the breeding season for species such as terns, and species-specific seasonal concentrations, such as "rafting" Manx and Cory's shearwaters during the breeding season. However, such seaward extensions could not integrate all foraging/staging grounds of most threatened seabird species or those Annex I species for which Portugal has highest responsibilities. In this sense, offshore areas hosting concentrations of seabirds are probably Portugal's main challenge for marine SPA designation. Data are currently being collected as truly pelagic species such as *Pterodroma madeira*, *Pterodroma feae*, *Pelagodroma marina* or *Oceanodroma castro* require large amounts of data and intense surveys to enable sensible proposals for future SPA classification. Their behaviour at sea is poorly known and the methodologies used to track them are still under development.

The Azores Archipelago represents an ornithological transition between tropics and temperate areas. The seabirds of the Azores Archipelago comprise six species of Procellariformes and four Charadriiformes, the regular breeders are: Bulwer's petrel *Bulweria bulwerii,* Cory's shearwater *Calonectris diomedea borealis*, Manx shearwater *Puffinus puffinus*, Little shearwater *Puffinus baroli* Madeiran Storm Petrel *Oceanodroma castro*, Monteiro's Petrel (*Oceanodroma monteiroi*, Common tern *Sterna hirundo* and Roseate tern *Sterna dougallii* and Yellow-legged gull *Larus michaellis* (Monteiro *et al.*, 1996b; Bolton *et al.*, 2008). Overall, the local seabird assemblage is similar to that from the southernmost Macaronesian archipelagos: Madeira, Salvages, Canary Islands and, to less extent, Cape Verde Islands (Monteiro *et al.*, 1996a) and has international conservation importance for some species, which have North Atlantic populations close to the thresholds of effective population size estimated for similar species (Monteiro *et al.,* 1999). The most distinctive features are the large tern populations, larger Cory's shearwaters population and population paucity or absence for the most tropical Procellariiformes- gadfly petrels *Pterodroma sp.*, white-faced storm petrel and Bulwer's petrel (Monteiro *et al.*, 1996a). The newly describe species *Oceanodroma monteiroi*, with a total breeding population estimate at between 250 and 300 pairs, is only known from the Azores islands and remains in the vicinity of the breeding grounds outside the breeding season (Bolton *et al.*, 2008).

More than 60% of Europe's roseate terns breed in the Azores (Tucker and Heath, 1994; OSPAR, 2000). The terns' distribution within the Azores is essentially concentrated within 5km offshore, with a wider spatial distribution in August (Amorim *et al.*, 2009).

Cory's shearwater, whose breeding is confined to the Mediterranean and the Northeast Atlantic (Granadeiro *et al.*, 2006) and whose population is highly dependent on Macaronesian seas during the breeding season, suffered a large decline between 1970 and 1990. Seamounts with associated upwellings are preferred summer foraging areas for some seabirds, especially for Cory's shearwaters, Yellow-legged Gull and Band-rumped Storm-petrel (Monteiro *et al.*, 1996b; Morato *et al.*, 2008b, c). Breeding birds in the Azores, employ a dual-foraging to exploit feeding areas up to 1800km from the nest, with core foraging areas over the MAR (mid-Atlantic ridge) north of the colony (Magalhães *et al.*, 2008).

About 25 species of seabirds are wintering or migrant along the northern Spanish coast. Among them the great cormorant (*Phalacrocorax carbo*) reaches significant numbers. Also important are the blackheaded gull (*Larus ridibundus*), common gull (*L. canus*), Mediterranean gull (*L. melanocephalus*), great blackbacked gull (*L. marinus*), razorbill, guillemot and Atlantic puffin. In the Gulf of Cadiz the wintering population of razorbill has been estimated at 4000 individuals, although it may actually be twice as high. Some species of sea ducks, such as the common scoter (*Melanitta nigra*), and different species of skua (*Catharacta skua* and *Stercorarius* spp.) and tern (*Sterna* spp.) are also abundant during winter (Valeiras, 2003; Valeiras *et al.*, 2007; OSPAR, 2000).

The deep offshore SWW are visited by non-breeding migrant birds, outside their breeding seasons. Few species are truly oceanic, although several are long-range migrants which regularly cross the region, such as the great shearwater (*Puffinus gravis*) and Arctic tern (*Sterna paradisaea*) (OSPAR, 2000). Most are Procellariformes and include northern fulmar (*Fulmarus glacialis*) from colonies around the North Atlantic and sooty (*P. griseus*) and great (*P. gravis*) shearwaters from the South Atlantic (ICES, 2008a). Other abundant species during migrations and in winter are Leach's petrel (*Oceanodroma leucorhoa*), gannet and yelkouan shearwater (*Puffinus p. yelkouan*).

Relationships with fishing fleets: The occurrence of 23 species of scavenger seabirds at fishing trawlers was studied off Galicia (Valeiras, 2003). The most common species were the yellow-legged and lesser black-backed gull (*Larus cachinnans* and *L. fuscus*), Sabine´s gull (*L. sabini*), the northern gannet (*Morus bassanus*), the great shearwater (*Puffinus gravis*), sooty shearwater (P. griseus), the Manx and Balearic shearwater (*P. puffinus* and *P. mauretanicus*), the great skua (*Catharacta skua*) and terns (mainly *Sterna hirundo* and *S. paradisaea*). Other species occurred in small numbers: Leach´s petrel (*Oceanodroma leucorhoa*), the storm petrel (*Hydrobates pelagicus*), the little shearwater (*Puffinus assimilis*), Cory´s shearwater (*Calonectris diomedea*), the parasitic skua (*Stercorarius parasiticus*), the pomarine skua (*S. pomarinus*), the black-headed gull (*Larus ridibundus*), the glaucous gull (*L. hyperboreus*), the kittiwake (*Rissa tridactyla*), the sandwich tern (*Sterna sandvicensis*), the black tern (*Chlidonias niger*), the guillemot (*Uria aalge*) and the little auk (*Alle alle*). The maximum number of seabirds recorded at a haul was 320. The maximum number of a particular species ranged from 120 great shearwaters to 250 yellow-legged/lesser black-backed gulls during a single haul. The differences in ship-follower species abundance are related to migratory movements but fisheries could also have a strong influence at a smaller scale on the distribution of seabirds off Galicia. The degree to which seabirds rely on fishery discards as food was not quantified, but may be important for several species.

Pressures and impacts

The main threats to most seabird species are the loss and degradation of their breeding sites, through coastal development and the introduction of non-indigenous plants and predators, the disruption of their food chains by overfishing, the incidental catch in longlines and other gears and their fatal attraction to lights at night (OSPAR, 2000).

Apart from having to come ashore to breed, many seabirds are totally dependent on marine food resources and so are essentially marine organisms. The majority feed near the surface, particularly at night when food is more abundant as a result of diel vertical migration. Daytime feeding relies on the detection of surface slicks, which normally occur along convergent fronts where suspended particles and plankton are concentrated. This renders them vulnerable to contamination by oil which also accumulates along these fronts, and resembles natural slicks. Once oil gets on their plumage it poisons them when they preen, preventing them from flying and breaking down their thermal insulation. Birds are more vulnerable when moulting (in eclipse), when many species become flightless and gather in rafts (OSPAR, 2000).

Fisheries have a considerable influence on the distribution of scavenging seabirds which feed on discards. The spatial distribution of scavengers is driven by fishing discards availability and the distribution of fishing boats. The most common species showed high frequencies of occurrence at trawlers, ranging from 71 to 95% of the hauls, in studies carried out in the Gulf of Cadiz (ICES IXaS), Galicia (ICES IXaN), and Cantabrian Sea (ICES VIIIc) (Valeiras *et al*., 2007) (ICES, 2008a). Diving species may become entangled in nets or hooked in longlines while predating in fishing gears, although this seems not to be a particularly significant problem in the SWW Region (OSPAR, 2000). Although long-lining has not been identified as a major problem for Cory's shearwaters around the breeding areas in the Atlantic, it is certainly a potential threat at their wintering areas (Granadeiro *et al.*, 2006).

Birds are probably better researched and monitored than any other group of organisms and are well placed to be used as indicators of the overall health of the environment.

1.2.3.6 Species subject of Community legislation or international agreements

In the area, it has been described the presence of several vulnerable species, following the OSPAR list of threatened and/or declining species and habitats (OSPAR, 2008): *Alosa alosa, Anguilla anguilla, Centroscymnus coelolepis, Centrophorus granulosus, Centrophorus squamosus, Cetorhinus maximus, Dipturus batis, Raja montagui, Hoplostethus atlanticus, Petromyzon marinus, Raja clavata, Squalus acanthias, Thunnus thynnus.*

In Le Danois Bank the presence of vulnerable species has been reported according to OSPAR: the shark *Centroscymnus coelolepis*, the skates *Dipturus batis* and *Raja clavata* and the orange roughy *Hoplostethus atlanticus*. Hotspots of diversity are also described (Sánchez *et al*., 2008). All these species together with *Centrophorus granulosus* are also present in the Galicia Bank (Piñeiro *et al*., 2001).

The large gastropod *Charonia lampas* has been declared as vulnerable, in the National Catalogue of Threatened Species, and in the Barcelona and Berna Convention. This species can be found in the northern Spanish inner shelf and coastal (0-200m), mostly in rocky and coarse sand habitats.

1.2.3.7 Exotic species

In the last years the number of new records of tropical affinity species has increased in the area (Arronte *et al*., 2004; Bañón, 2000, 2004; Bañón and Sande, 2008; Bañón *et al*, 2002, 2006, 2008; Punzón and Serrano, 1998). Two species related to this phenomenon were the grey triggerfish (*Balistes carolinensis)* and the flatfish (*Solea senegalensis*), previously unknown and now with a relevant biomass (ocean warming, changes in current patterns in the North Atlantic, bringing more southerly water into the northeast), but also increased exploration of deep-sea fish resources in recent years that has enhanced the discovery of new deepwater species northward of their known distribution area (Bañón *et al*, 2002).

About 55 marine taxa are listed as introduced in the Azores and four of the species are considered as invasive alien species (Cardigos *et al*., 2006).

1.2.4 Other features

The naturally favourable oceanographic conditions in this part of the North-east Atlantic, with its well-oxygenated coastal waters and strong hydrodynamic processes, positively influence the ecology of the region. Generally, the waters off the Atlantic coast of the Iberian Peninsula and in the Bay of Biscay are relatively unaffected by contamination.

Several fish stocks as sardine, hake, anglerfish, megrims and swordfish – are outside safe biological limits for sustainable fisheries, as a result of the combined effects of overfishing and the adverse effects of some natural processes on the recruitment and abundance of these resources.

A large proportion of shellfish farming areas are affected by some microbiological pollution, which implies that most of the shellfish must undergo depuration in an approved plant before they can be marketed.

Toxic algal blooms are widespread, with incidences of acute shellfish toxicity caused by amnesic toxins (ASP), diarrhetic toxins (DSP) and paralytic toxins (PSP).

Mariculture is mainly restricted to the cultivation of bivalve molluscs (usually mussels) on moored rafts or long lines. The impact of this type of mariculture is often minimal, but in some areas the deposition of organic detritus beneath suspended mussels has resulted in benthic enrichment; with a substantial increase in the organic content of the sediments, a dramatic decrease in faunal diversity and the predominance of opportunistic organisms.

Are there signals of regime shifts in this region? Considerable effort has been made in recent years in the region to answer to this question. Zooplankton and phytoplankton indices, catches and recruitment population indices of small pelagics were statistically tested as dependent of climate forcing indices at local and worldwide scales (ICES, 2007c). The main objectives were to provide a survey of large-scale, long-term changes throughout the ecosystems surrounding the Iberian peninsula and identify apparent synchronies (teleconnection patterns) with other regions of the north Atlantic or northern hemisphere; and finally to gain insight into the causes and mechanisms underlying the major ecosystem changes, e.g. identifying possible links of those changes in the ecosystems to climate variability. The main summary is as follows (ICES, 2007c):

1) Significant interannual trends in climatic, oceanographic and ecosystem variables integrated in the NW Iberia and Bay of Biscay region are indicative of a clear signal of global warming in the region since ca. 1950.

2) The regional decrease in copepods and planktivorous fish can be related to reduced upwelling and increasing stratification. In contrast, an increase in phytoplankton may be due to various mechanisms, such as the reduction in turbulence, the lack of coupling between phytoplankton and zooplankton and the increase in westward currents in the N Atlantic.

3) Besides the interannual trends, multiannual periods of relative positive and negative anomalies have been identified for all variable types. Quasi-decadal scales are characteristic

of climatic, oceanographic and fish abundance indices, while plankton indices display generally shorter periods.

4) A major shift affecting the succession patterns of positive and negative anomalies of all indices in late 1970s has been identified. The main changes were related to the periodicity and amplitude of the anomaly oscillations, and with the phasing of paired indices.

5) The mechanisms linking climatic to oceanographic and ecosystem variability can be summarized by a conceptual model leading to two alternative states. When boreal components dominate atmospheric climate over the North Atlantic, high upwelling and relatively turbulent surface ocean favours the growth of small copepods that are consumed efficiently by filter feeding sardines. When the climate is influenced by subtropical modes, reduced upwelling and stratification in the upper ocean causes a general reduction in plankton productivity and small copepods. In this situation, anchovies are able to increase their populations if large copepods are available.

1.2.4.1 Toxic contamination

In the last decades the input of contaminants in coastal waters resulted mainly from anthropogenic sources in land and accidents on sea. With the incorporation of new technologies in order to protect the environment and the habitats, the undesirable discharges tended to decrease. Diffuse sources emerged relevant for several contaminants. Sediments from harbours and urbanised estuarine systems retained contaminants from old and ongoing emissions and therefore dredging operations emerged as a new vehicle of contaminant transport. Dredged material is frequently disposed in adjacent coastal areas, the disposal site being selected taking into account the fishery commercial value of the area. According to the magnitude, repeated dredging operations in some areas result in an effective export of contaminants to the shelf (Vale *et al.*, 1998).

Metals

Heavy metals in this synthesis are considered the transition elements of the Periodic Table including the metalloids As and Se. Because of the abundant references on this topic a selection was done of the most relevant works for the purpose of this overview.

An extensive review of heavy metals in The Galician Rias until 2000 was published by Prego and Cobelo-Garcia (2003) on the basis of data existing in 40 papers. The studies were focused to 6 rias of socio-economic importance (Vigo, Pontevedra, Arosa, La Coruña, Ares-Betanzos and Ferrol) and 75% of the samples are related to sediments. The review states that the rias are not contaminated, although there is some evidence of important localised anthropogenically induced enrichments at the outflow of several rivers. Several works report the levels of metals in estuaries and coastal lagoons from Portugal. Works in offshore areas are fewer, most of them reporting sediment composition. Description of metal concentrations in water, suspended material, sediment and biota in Portuguese and Spanish estuarine and coastal areas is given in Table 6.

Table 6. Metal concentrations in water (µg L^{-1}), suspended particulate material (µg g^{-1} dw), sediment (ng g^{-1} dw) and biota (µg g^{-1} fw) from estuarine and coastal areas (see references for detailed description).

Location	Hg	Cd	Pb	Cu	Zn	Cr	Ni	Source
Galician coast								
Water		<0.5-118	0.77-907	<3-8094	15-13991			[1]
Sediments		nd-0.92	25-68	16-2097	97-5586	38-366	15-125	[2]
Biota (dw)	0.10-0.63	0.20-0.77	0.30-6.1	6.8-30	85-447	2.2-46	0.85-19	Beiras *et al*., 2003; Carballeira *et al*., 2000
Portuguese coast								
Water		0.0003-169		11-409	14-3517		31-239	Cotté-Krief et al., 2000; Caetano and Vale, 2003
SPM (ng g^{-1})		0.03-0.7		8-130	40-340			Caetano and Vale, 2003
Sediments			10-235	5-41	<14-175	10-179	<6-129	[3]
Biota (dw)	0.04-54	0.36-0.69	0.84-2.89	4.6-37	9-6700	0.46-1.01	0.22-3500	[4]
SW Spain								
Sediments (mg g^{-1})			43-601	28-534	123-1735	66-145	28-50	Machado *et al*., 2005
Biota				60-124	90-120			Arellano *et al*., 1999
Azores Islands								
Biota (µg g^{-1})	0.04-4.91	<0.11	<0.10					[5]
Estuaries								
Douro estuary								
Water	0.6-92							Ramalhosa *et al*., 2005
SPM	0.3-6.5							Ramalhosa *et al*., 2005
Sediments	0.06-0.18	0.05-1.8	0.25-192	1.0-229	6.2-457	1.2-120	1.3-186	[6]
Biota (dw)		0.5-0.6	100-125	30-50	150-200	35-45	15-20	Almeida *et al*., 2006a
Ria de Aveiro								
Water	1.0-275							Coelho *et al*., 2005; Ramalhosa *et al*., 2001
SPM	nd-50	0.1-1.6	20-55	20-40				[7]
Sediments	0.1-343	2.2-7.9	9.3-332		58-1764			[8]
Biota (dw)	0.02-0.23							[9]
Mondego estuary								
Sediments	nd-0.1	<0.01-0.32	36-437	12-85	7-349	2.8-133	22-90	[10]
Óbidos lagoon								
Sediments	<0.06-0.10	0.01-0.15	6-45	3.8-57	14-128	2.8-117	13-79	Carvalho *et al*., 2006
Tagus estuary								
Water	0.1-8.0							[11]
SPM	0.003-0.56(ng g^{-1})		30-250		100-650			[12]
Sediments	0.01-1.23 (ng g^{-1})	36-590 (ng g^{-1})	0.97-329000	18-89	41-1150	33-38 (ng g^{-1})	6.0-13 (ng g^{-1})	[13]
Biota (ng g^{-1} dw)		22-623	2.4-12	16-39	80-260			Caçador *et al*., 2000
Sado estuary								
Sediments	nd-1.4							[14]
Biota (dw)		4.6-40	<0.1-6.1	150-3110	4000-37400	0.2-3.7	0.2-6.0	Ferreira *et al*., 1990; Cortesão and Vale, 1995
Ria Formosa								
Sediments		0.04-0.52		10-149				Caetano *et al*., 2002
Biota (ng g^{-1})		0.02-0.27		1.3-3.6				Bebianno and Serafim, 2003
Guadiana estuary								
Sediments			4-60	4-64	41-290	12-125		Ruiz, 2001
Guadalquivir estuary								
Biota		0.003-2.4	0.02-3.12	0.5-384	4.4-5817		0.07-1.19	Blasco *et al*., 1999
Tinto-Odiel estuary								
Water (µg L^{-1})	0.0002-0.0008	4.1-23	1.5-27	11-2153	2.0-14		28-42	Elbaz-Poulichet *et al*., 2001
Sediments			11-4860	25-2990	58-3330	19-165		Ruiz, 2001
Guadalete estuary								
Sediments (ng g^{-1})		0.3-9	30-150	50-290	160-660		70-240	Campana *et al*., 2005
Cádiz Bay								
Sediments	<1.0	0.05-0.5	10-45		50-150			Ligero *et al*., 2002

[1] Beiras *et al*., 2003; Prego and Cobelo-Garcia, 2003; Prego and Cobelo-Garcia, 2004
[2] Prego *et al*., 1999; Beiras *et al*., 2003; Prego and Cobelo-Garcia, 2004
[3] Costa *et al*., 1999; Drago *et al*., 1999; Araújo *et al*., 2002; Madureira *et al*., 2003; Abrantes *et al*., 2005; Mil-Homens *et al*., 2006
[4] Machado *et al*., 1999; Araújo *et al*., 2003; Raimundo *et al*., 2004; Seixas *et al*., 2005; Morgado and Bebbiano, 2005; Cecílio *et al*., 2006
[5] Monteiro and Lopes, 1990; Andersen and Depledge, 1997; Branco *et al*., 2004; Afonso *et al*., 2006
[6] Mucha *et al*., 2003; Mucha *et al*., 2004; Mucha *et al*., 2005; ; Ramalhosa *et al*., 2005; Almeida *et al*., 2006a; Almeida *et al*., 2006b
[7] Abreu *et al*., 2000; Ramalhosa *et al*., 2001; Monterroso *et al*., 2003; Coelho *et al*., 2005
[8] Pereira *et al*., 1997; Pereira *et al*., 1998a; Ramalhosa *et al*., 2001; Coelho *et al*., 2005
[9] Abreu *et al*., 2000; Amaral *et al*., 2000; Ramalhosa *et al*., 2001; Coelho *et al*., 2005; Pereira *et al*., 2006; Ramalhosa *et al*., 2006
[10] Pereira *et al*., 2005; Vidinha *et al*., 2006; Vale *et al*., 2002
[11] Martin *et al.* 1982; Figuères *et al*., 1985; Canário, 2004
[12] Martin *et al.* 1982; Figuères *et al*., 1985; Vale, 1990; Canário, 2004
[13] Figuères *et al*., 1985; Caçador *et al*., 1996; Canário *et al*., 2003b; Vale *et al*., 2003; Canário, 2004; Canário *et al*., 2005; França *et al*., 2005; Sundby *et al*., 2005
[14] Cortesão and Vale, 1995; Belchior *et al*., 2000; Caeiro *et al*., 2005

Antifouling biocides

Antifouling paints have been applied to boats and ships to control the growth of fouling organisms. They constitute the major source of tributyltin (TBT) and triphenyltin (TPT) in aquatic ecosystems; organotin compounds, especially tributyltin (TBT) have been reported as highly toxic to a wide range of marine organisms, particularly to gastropods.

Several studies have been made on the organotin concentration on water, sediment and biota (Table 7).

Table 7. Organotin concentrations in water (ng Sn L^{-1}), sediment (ng Sn g^{-1} dw) and biota (ng Sn g^{-1} dw) from estuarine and coastal areas. (TBT – tributyltin, DBT - dibutyltin MBT – monobutyltin and TPT – triphenyltin).

Location	TBT	DBT	MBT	TPT	∑ BT	Source
Galician coast						
Water	<50-1150	23-580			1800-46800	Bermejo-Barrera *et al*., 1996
Biota	36-974	169-909	65-387	39-250		Ruiz *et al*., 1998
					186-2841	Barreiro *et al*., 2001
Portuguese coast						
Water						
Sediments	4-12				15-151	Diez *et al*., 2005
Biota	30-147	34-180	<23-77	12-21		Barroso and Moreira, 2002
	<20-1368	<34-721	<24-703	<10-256		Barroso *et al*., 2000
	<5.7-489	<2.5-18	<7.9-41		25-548	Diez *et al*., 2005
SW Spain						
Water	<0.5-31	nd-23				Gómez-Ariza *et al*., 2001
	<5-500	<5-100	<5-40			Gómez-Ariza *et al*., 1997
	nd-449	nd-117	nd-115			Gómez-Ariza *et al*., 1992
	nd-101	nd-38	nd-46			Gómez-Ariza *et al*., 1998
Sediments	<0.6-160					Gómez-Ariza *et al*., 2001
	1-600	1-500	1-130			Gómez-Ariza *et al*., 1997
	1.1-195	2.1-284	1.7-122			Gómez-Ariza *et al*., 1998
Biota	23-1500					Gómez-Ariza *et al*., 2001
	17-127	5-46	2-28			Gómez-Ariza *et al*., 1997
Estuarine data						
Oporto coast						
Biota	nd-124	50-159	34-251		84-410	Santos *et al*., 2004
Ria de Aveiro						
Water	9-42					Barroso *et al*., 2000
Sediments	<6-88				24-593	Barroso *et al*., 2000; Cortez *et al*., 1993
Tejo estuary						
Water	1.1-21	0.98-3.3	0.76-5.3			De Bettencourt *et al*., 1999
Sediments	5-35					Nogueira *et al*., 2003
	nd-1155	5.8-235	7.4-98			De Bettencourt *et al*., 1999
Sado estuary						
Sediments					21-12200	Quevauviller *et al*., 1989
	1-520	1-9600	4-2100		14-12220	Cortez *et al*., 1993
Biota					157-1044	Pessoa *et al*., 2001
	16-114	6-82	3.2-169		10-324	Quevauviller *et al*., 1989
Mira estuary						
Biota					183-203	Pessoa *et al*., 2001
Ria Formosa						
Water	<33.8					Coelho *et al*., 2002
Sediments	7-170	9-260				Coelho *et al*., 2002
Biota	nd-324	nd-430				Coelho *et al*., 2002

Polychlorinated biphenyls (PCBs)

Polychlorinated biphenyls are a group of 209 individual chlorinated compounds (known as congeners). There are no known natural sources of PCBs and manufactures were substantially reduced or ceased because of evidence of the fact that they build up in the environment and can cause harmful health effects. PCBs can still be released to the environment mainly from hazardous waste sites. PCBs do not readily break down in the environment and thus may remain there for very long periods of time. PCBs can travel long distances in the air and be deposited in areas far away from where they were released. In water, a small amount of PCBs may remain dissolved, but most stick to organic particles and bottom sediments. PCBs are taken up by small organisms and fish in water and accumulate in marine organisms, reaching levels that may be many thousands of times higher than in water. Detailed description of PCB concentrations and corresponding study is presented in Table 8.

Table 8. PCB concentrations in coastal waters (ng L^{-1}), suspended particulate matter (ng g^{-1}), sediments (ng g^{-1}) and biota (ng g^{-1} dw).

Location	Total PCB	Quantified as	Source
Portuguese coast [b]			
SPM	10-410	∑ of 18 PCB	Quental *et al*., 2003
Estuarine data			
Ria Vigo			
Biota	23-80	∑ of 10 PCB	Carro *et al*., 2004
	138 (ww)	Aroclor 1260	Piñeiro *et al*., 1996
Ria Pontevedra			
Biota	80	Aroclor 1260	Piñeiro *et al*., 1996
Ria Arosa			
Biota	98 (ww)	Aroclor 1260	Piñeiro *et al*., 1996
Ria Muros-Noya			
Biota	183	Aroclor 1260	Piñeiro *et al*., 1996
Douro estuary			
Biota	52-311	∑ of 18 PCB	Ferreira *et al*., 2004
Ria de Aveiro			
Water	4.9	∑ of 18 PCB	Antunes *et al*., 2001
SPM	10	∑ of 18 PCB	Antunes *et al*., 2001
Biota	7.9-13	∑ of 18 PCB	Antunes *et al*., 2001; Antunes and Gil, 2004
Mondego estuary			
Sediments	0.19-5.2	∑ of 19 PCB	Vale *et al*., 2002
Obidos lagoon			
Sediments	0.14-1.2	∑ of 18 PCB	Carvalho *et al*., 2006
Tejo estuary			
SPM	<100[a]	∑ of 19 PCB	Ferreira and Vale, 2000
Sado estuary			
Water	1-10	∑ of 16 PCB	Castro, 1997
SPM	5-20	∑ of 17 PCB	Ferreira and Vale, 1995
	<100	∑ of 16 PCB	Castro, 1997
Sediments	<114	∑ of 18 PCB	Gil and Vale, 2001
Biota	2-40	∑ of 17 PCB	Ferreira and Vale, 1998
	173-712	Aroclor 1260	Castro *et al*., 1990
	25-190	∑ of 17 PCB, lipids	Ferreira and Vale, 1995
Guadiana estuary			
SPM	0.4 – 10	∑ of 17 PCB	Ferreira *et al*., 2003a
Sediments	0.1-1.8		Ferreira *et al*., 2003a
Biota			
Ria Formosa			
SPM	5-12	∑ of 17 PCB	Ferreira and Vale, 1995
	4-20	∑ of 14 PCB	Ferreira, 1993
Biota	10-50	∑ of 17 PCB	Ferreira and Vale, 1998
	25-100	∑ of 17 PCB, lipids	Ferreira and Vale, 1995
Port of Huelva			
Sediments	2.0-2.3	∑ of 7 PCB	Casado-Martinez *et al*., 2006
Guadalquivir estuary			
Water	109-145	Aroclor 1260	Hernández *et al*., 1992
Port of Cádiz			
Sediments	<145	∑ of 7 PCB	Casado-Martinez *et al*., 2006
SW Spain			
Biota	0.96-24	∑ of 22 PCB	Bordajandi *et al*., 2006

[a] up to 1010 ng g^{-1} during occasional spills

[b] 1 mile

Hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) are a diverse group of organic planar compounds, containing two or more attached benzene rings. This group represents a relatively small percentage of petroleum constituents, but it constitutes important compounds to analyse when oil spills occur. Some PAHs are known by their toxicity and carcinogenicity to marine biota, due to their hydrofobicity and consequently adsorption onto sediments and organisms.

Table 9. Hydrocarbon concentrations in water (µg L-1), sediment (ng g-1 dw) and biota (ng g-1 dw) from estuarine and coastal areas.

Location	Total PAH	DAH	DDPAH	Quantified as	Source
General data					
Galician coast					
Water	–	0.1-0.7	0.2-408	DAH as carbazole; DDPAH as equivalents of chrysene	Doval *et al.*, 2006
	<1.4	–	–		Laffon *et al.*, 2006
Sediments	0.9-422	–	–	∑ of 13 PAH	Franco *et al.*, 2006
Biota	<3500	–	–	∑ of 35 PAH	Laffon *et al.*, 2006
Portuguese coast					
Sediments	30-1200	–	–	–	Salgado and Serra, 2001
Biota	<1600	–	–	equivalents of chrysene	Ferreira *et al.*, 2003b
	3700-17000	–	–	–	Salgado and Serra, 2001
Estuaries					
Tejo estuary					
Sediments	nd-3464	–	–	∑ of 16 PAH	IPIMAR, 2004

Pesticides

Pesticides are substances intended for mitigating living organisms that occur where they are not wanted or that causes damage to crops, humans or other animals. Among the chemical pesticides, organochlorine insecticides are the most common compounds analysed in aquatic systems. These compounds have been removed from the market due to their health and environmental effects and their persistence in ecosystems. Most of the studies of pesticides were performed in conjunction with the analysis of PCBs (Table 10).

Table 10. Pesticides concentrations in water column (ng g^{-1}), sediment (ng g^{-1} dw) and biota (ng g^{-1} dw) from estuarine and coastal areas.

Location	Total DDT	Quantified as	Source
Portuguese Coast			
SPM	<4-163	∑ p,p'-DDE, p,p'-DDD, p,p'-DDT	Quental *et al*., 2003
Biota	31030	∑ p,p'-DDE, p,p'-DDD, o,p'-DDT, p,p'-DDT, lipids	Borrell *et al*., 2006
SW Spain			
Biota	113950	∑ p,p'-DDE, p,p'-DDD, o,p'-DDT, p,p'-DDT, lipids	Borrell *et al*., 2006
Estuaries			
Ria Ferrol			
Biota	10-239	∑ p,p'-DDE, o,p'-DDT, p,p'-DDT	Carro *et al*., 2004
Ria Vigo			
Biota	1.1-50	∑ p,p'-DDE, o,p'-DDT, p,p'-DDT	Carro *et al*., 2004
Ria Aveiro			
Biota	5.4	∑ p,p'-DDE, p,p'-DDD, p,p'-DDT	Antunes and Gil, 2004
Douro estuary			
Biota	14-65	∑ p,p'-DDE, p,p'-DDD, p,p'-DDT	Antunes *et al*., 2004; Ferreira *et al*., 2004
Mondego estuary			
Sediments	0.01 – 1.7	∑ p,p'-DDE, p,p'-DDD, p,p'-DDT	Vale *et al*., 2002
Óbidos lagoon			
Sediments	0.06 - 155	∑ p,p'-DDE, p,p'-DDD, p,p'-DDT	Carvalho *et al*., 2006
Tejo estuary			
Sediments	0.07 – 9.6	p,p'-DDE	Gil and Vale, 1999
Sado estuary			
SPM	1-57	∑ p,p'-DDE, p,p'-DDD, p,p'-DDT	Ferreira and Vale, 1995
	1-46	∑ p,p'-DDE, p,p'-DDD, p,p'-DDT	Ferreira and Vale, 2001

Sediments	<1 – 4	∑ p,p'-DDE, p,p'-DDD, p,p'-DDT	Vale *et al*., 1993
	0.07 – 2.2	p,p'-DDE	Gil and Vale, 1999
Biota	5-220	∑ p,p'-DDE, p,p'-DDD, p,p'-DDT, lipids	Ferreira and Vale, 1995
	3-98	∑ p,p'-DDE, p,p'-DDD, p,p'-DDT	Castro *et al*., 1990
	0.1 – 2.1	p,p'-DDE, lipids	Vale *et al*., 1993
	1-100	∑ p,p'-DDE, p,p'-DDD, p,p'-DDT	Ferreira and Vale, 2001
Ria Formosa			
SPM	1-7	∑ p,p'-DDE, p,p'-DDD, p,p'-DDT	Ferreira and Vale, 1995
Sediments	0.07 – 0.96	p,p'-DDE	Gil and Vale, 1999
Biota	25-210	∑ p,p'-DDE, p,p'-DDD, p,p'-DDT, lipids	Ferreira and Vale, 1995

Biomarkers of exposure

Marine organisms accumulate contaminants from the environment where they live but levels did not provide accurate information about the effects on the organisms. Biomarkers are defined as quantitative measures of changes in the biological system that respond to either (or both) exposure to, and/or doses of substances that lead to biological effects and are potential tools for detecting either exposure to, or effects of, contaminants and give responses at different levels of biological organization: biochemical, physiological, organism and population (Lam and Gray, 2003). The aim of most published works on this topic is to investigate the sublethal effects of spiked sediments and contaminated solutions in selected species and conclude about the success of specific biomarkers. These numerous works are not included in this overview.

Fishing-environment interactions

The information of this topic is less abundant. The effect of systematic collection of benthic organisms in tidal flats of Ria Formosa on chemical disturbance of surface sediments and on phosphorous dynamics was investigated, and concluded that the estimated P-output from middle sediment decreased one or two orders of magnitude after sediment disturbance (Falcão *et al*., 2003; Falcão *et al*., 2006). A study of seawater nutrient concentrations during purse seine fishing for sardine showed release of nitrogen from excretion, probably stimulated from stress reactions, of phosphorous from skin mucus and scale loss, and nitrogen and phosphorous from forced evacuation of partly digested food or regurgitation (Stratoudakis *et al*., 2003).

Summary of the effects of pollution on the ecosystem

Within this section, an attempt was made to review the concentrations of the some of the most important inorganic and organic contaminants in water, sediments and biota between Finisterra Cape and Cadiz Bay which constitutes the West Iberian Sea. A summary of the comparative contamination reported for the western and southwestern Iberian estuarine systems and the most relevant contaminants is presented in Table 11.

- Contamination of estuarine and coastal systems

Most of the information available on the literature related to the distribution of contaminants in sediments and water and effects on organisms are focused in estuaries, rias and coastal lagoons. Ecosystems far from industries and cities are in general poorly characterised in terms of contaminants, and effects of agriculture and diffuse sources are less investigated. On the contrary, works have documented the levels of contamination in systems whose drainage basins are under anthropogenic pressures and potentially impacted.

Analysis of several contaminants pointed to the presence of multiple contaminants. Most of contaminants considered in this review are still originated from localised sources in land and resulted from accidents.

- Effects of river discharges

The effect of freshwater discharges into the adjoining coastal zones was better observed in river plumes of Douro and Tinto-Odiel. The impact of contaminants was recorded in water quality and suspended particulate matter of the Douro plume in winter periods, but the signal for Cd and Cu was still slightly present in other periods of lower river flows. Enhanced levels of Cd in octopus digestive gland from this area appear to be related with higher availability of metal probably resulting from river inputs. Changes on sediment quality was not observed presumably due to the highly dynamics of the coast. The Tinto-Odiel system was considered extremely contaminated by metals, which leads to a plume of metal-rich waters along the coast of Cadiz extending the effect through the Strait of Gibraltar. Runoff is an important vehicle to the transport of contaminants from land particularly in geographical areas of the Iberian Peninsula marked by prolonged dry season and river presenting a torrential regime. An example is the abrupt transport of lower chlorinated PCBs and DDTs during an episodic flood of Guadiana. Apparently flood episodes are registered in enhanced levels of DDTs and in change of PCB composition in sediment cores offshore the estuary. A similar effect on suspended particulate matter composition and on residues in oyster tissues was observed in Sado estuary and Ria Formosa.

- Accidental spills

According to the intensity, extension and biological value of the ecosystem, the impact and response of organisms have been studied after accidental spills. Among several accidents, the impact of two oil spills in the Galician coast with the tankers Aegean Sea and Prestige was studied. Besides the characterization of PAH levels in sediments, water and organisms, biomarkers of pollution exposure showed the biochemical response on target species. Results of extended monitoring programmes indicate that impact on species and ecosystem may persist for longer periods after the accident. In addition, these works were useful in identifying the suitable biomarkers to be used in environmental monitoring programmes in risk assessment studies. At least two estuaries were reportedly impacted by accidental spills of PCBs (Tagus) and of metals (Guadalquivir). Due to hydrodynamic conditions the effects were rapid and extended to larger areas, including the adjacent coast. In Guadalquivir, metal concentrations increased dramatically in water and tissues of several species of bivalves, crustaceans and fish. Enhancement of metallothioneins and histopathological lesions in clams were related to the spill. The levels of PCBs increased considerably in plankton samples and SPM collected in the Tagus estuary after the accident, and six months after various fish and mollusc species captured in the adjacent area exhibited enhanced levels of lower chlorinated CBs.

In short, this review point to areas relatively unaffected by contamination in parallel to potentially hotspots in highly-populated and industrialised zones around rias, estuaries and coastal lagoons. As a rule, most studies do not have a multi-disciplinary approach, namely the relationships between contaminant levels and biomarkers of exposure. Studies on accidental spills proved the importance of monitoring the presence of contaminants, bioaccumulation, and their effects on exposed organisms in extended time.

Table 11. Comparative contamination of the Western and Southwestern Iberian estuarine systems.

Site / Contaminant	Rias Galicia	Douro	Ria Aveiro	Tagus	Sado	Ria Formosa	Odiel-Tinto	Guadalquivir
Metals			Yes	Yes	Yes		Yes	Yes
Antifouling biocides	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
PCBs	Yes			Yes	Yes			Yes
Hydrocarbons (accidental)	Yes			Yes				
Pesticides								
Biomarkers of exposure	Yes	Yes	Yes			Yes	Yes	Yes

1.2.4.2 Non-toxic contamination

Litter

Litter is most abundant at river mouths, near urban centres, in tourist centres and along shipping lanes. The major constituents of litter are plastics, which represent 60-80% of all litter, depending on area. The most common items are plastic bags, bottles, and packaging. Glass and metal items may also be found in areas where litter collects, such as on beaches. Most items are slow to decompose. National cleaning operations do exist, particularly in the late spring/early summer.

Floating plastic litter is particularly harmful to cetaceans and sea turtles which can become entangled, and which can ingest large quantities of plastic. This may lead to death (OSPAR, 2000).

1.2.5 What constitutes "Good Ecological Status"?

1.2.5.1 Good environmental Status (GES)

The aim of the newly adopted MSFD is to achieve Good Environmental Status (GES) for each of the descriptors mentioned in Figure 43, by 2020. The Directive identifies marine regions for which "strategies" including detailed programmes of measures will need to be drawn up by Member States in close cooperation with one another and also with any third country sharing the same region.

ANNEX I

Qualitative descriptors for determining good environmental status

(Referred to in Articles 3(5), 9(1), 9(3) and 24)

(1) Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions.

(2) Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems.

(3) Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.

(4) All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.

(5) Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters.

(6) Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.

(7) Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.

(8) Concentrations of contaminants are at levels not giving rise to pollution effects.

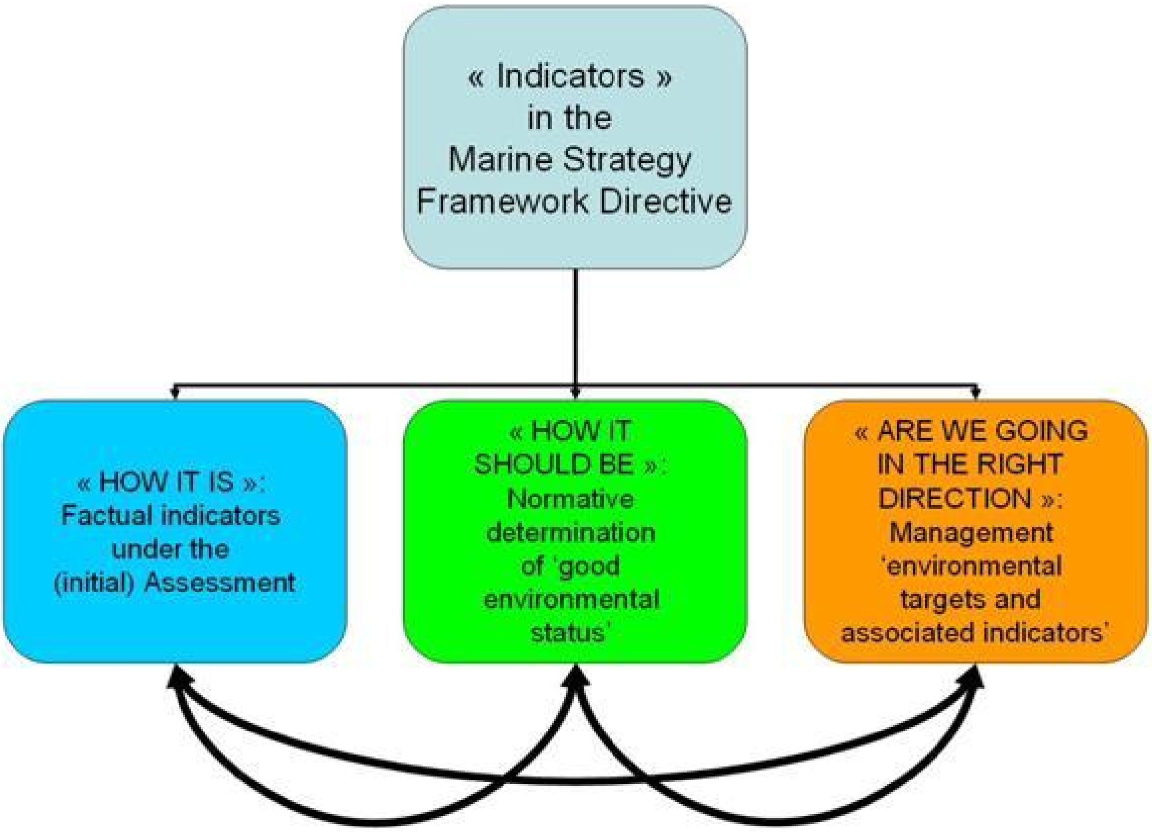
(9) Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards.

(10) Properties and quantities of marine litter do not cause harm to the coastal and marine environment.

(11) Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.

Figure 43. Qualitative descriptors for determining good environmental status.

The first three years of implementation will need to result in the first three elements of the strategy, described in articles 8-10, namely the initial assessment, determination of GES and the establishment of environmental targest and indicators (Figure 44). The preparatory phase will then be finalised with the definition of a coordinated monitoring programma. The formulation of a programme of measures and its entry into force in 2015-2016 should address (overcome) the gap between the existing and desired status. A six-yearly review of the strategy elements can be used to have a structures approach to “adaptive management”.



MSFD Article 8	MSFD Article 9	MSFD Article 10
+ Annex III of characteristics, pressures and impacts	+ Annex I on descriptors of 'good environmental status'	+ Annex IV on characteristics to be taken into account
FICTITIOUS EXAMPLE - RELATIONSHIPS		
o Indicator on levels and trends of TBT in sediment and biota	o Ecological quality objective on degree of biological effect (e.g. imposex) on snail populations	o Yearly indicator showing degree of compliance of ships with IMO AFS Convention and whether new TBT still enters the marine environment
RESPONDING TO:		
Annex III elements: "A description of the situation with regard to chemicals, including chemicals giving rise to concern, sediment contamination, hotspots, health issues and contamination of biota (especially biota meant for human consumption)" Introduction of synthetic compounds (e.g. priority substances under Directive 2000/60/EC which are relevant for the marine environment such as pesticides, antifoulants, pharmaceuticals, resulting, for example, from losses from diffuse sources, pollution by ships, atmospheric deposition and biologically active substances),	Annex I element: (8) Concentrations of contaminants are at levels not giving rise to pollution effects.	Annex IV element: (2) Need to set [...] (c) operational targets relating to concrete implementation measures to support their achievement.
DPSIR: S	DPSIR: S (Impact based)	DPSIR: R

Figure 44. The indicators in the MSFD and their relationship.

1.2.5.2 Generic approach to develop a framework that determines GES

GES is not arbitray and the methods by which it will be made operational under the MSFD should be "justifiable". To that end the task is to get from the very general descriptors, in the MSFD Annex 1, to a common understangind of what GEW is, and how it should be quantified. The aim is not to prescribe the boundaries between good and bad, but to agree on a generally applicable mechanism to get from observational data to a status assessment output. The key terms in these works are descriptors, criteria and methodological standards.

The MSFD Annex 1 contains 11 descriptors, and for each brief descriptions of the key aspects of GES.

The MSFD Article 1(6) defines criteria in very general terms as "distinctive technical features that are closely linked to qualitative descriptors". In our interpretation, the task is to make the descriptors more concrete and "quantifiable". This can be done by describing how a set of indicators of the marine ecosystem change with decreasing environmental status, taking into account:

- other relevant legislation/policies
- the relevant spatial scale (European/region/sub-region/specific habitats/other)
- identify the relevant characteristics/pressures/impacts from Annex III
- Policies

The outcome should be extended versions of each of the GES descriptors. This should provide a common conceptual framework applicable throughout Europe. For many of the descriptors, such conceptual frameworks are already available (e.g. eutrophication, fish stocks); here the task is to verify if there is a need for modifications to meet the MSFD requirements, and to check if there is a need for refinement at the sub-regional scale. For some descriptors (e.g. food web components) there is a need to start more or less from scratch.

Methodological standards are not defined in the MSFD; in our interpretation, the task is to agree on how to quantify the relevant indicators related to the (extended) descriptors (criteria). The outcome should be an agreement on what information/data is needed to quantify GES, as well as a generally applicable mechanism to progress from observational data to a status assessment output. It will be necessary to agree how to quantify the relevant aspects of the descriptor, and to identify minimum data requirements, also taking into account spatial and temporal variarbility. The methodological standards should be generally applicable (at EU level) wherever possible, but can be refined at sub-regional level if necessary.

1.2.5.3 Application of the framework

The Member States will contemporaneously make an assessment of the current status and define, within a common approach, a set of specific characteristics of what is GES (Article 9(3)) for their waters (in the sub-regional context).

The status assessment shall take into account the indicative lists of elements set out in Table 1 of Annex III and, in particular, physical and chemical features, habitat types, biological and hydromorphology features. But it shall also take into account the pressures or impacts of human activities in each marine region or sub-region, having regard to the indicative list set out in Table 2 of Annex III.

To determine GES, Member States shall consider each of the qualitative descriptors listed in Annex I in order to identify those descriptors which are to be used for their marine region or subregion. When a Member State considers that it si not appropriate to use one or more of those descriptors, it shall provide the Commission with a justification in the framework of the notification made pursual to Article 9(2).

1.3 Human activities

Europe's maritime spaces and its coasts are central to its well-being and prosperity; they are Europe's trade routes, climate regulator, sources of food, energy and resources, and a favoured site for its citizens' residence and recreation.

France

The main human activities in France include tourism, fishing and aquaculture, shipping, sand and gravel extraction, and new development of wave, tide and wind power generation. The coastal strip has an increasing high population density. Industries of various types, agriculture and land based activities are located along the coasts.

Human activities in the coastal areas also include aquaculture and farming. Population densities at the coastal edges of the Celtic-Biscay Shelf Large Marine Ecosystem are increasing. This fast population growth and socioeconomic development have resulted in environmental imbalances. Extra pressure was added through tourism, the new urbanization of coastal areas, transportation and recreational uses of beaches and shores.

Spain

The northern coast of Spain is divided in four Autonomous Communities (Galicia, Asturias, Cantabria and the Basque Country) with different human activities developing in each of them.

Galicia has a population of 2,720,369 habitants (2006), 6.2% of the Spanish population. Galician population experienced a light increment of 0.2% regarding the existent one in 2005. Galicia contributed 5.1% to the generation of the Spanish gross domestic product (GDP) in 2006, which means a *per capita* average income of 18,544€, below the Spanish average income per head (83.3%, Spanish average equivalent to 100).

The percentage structure of the GDP in 2006 was as follows: agriculture and fisheries represented 4.5%; energy, 13.4%; industry, 13.4%; construction, 12.1%; services, 54.5%; and net taxes, 10.9 %. The economic activities with a higher increment regarding the year 2005 were the construction (increment of 13.9 %) and the energy production (9.5%).

Asturias has a population of 1,057,897 habitants (2006), 2.4% of the Spanish population. The population experienced a slight decrease of 0.1% regarding the existent population in 2005. Asturias contributed 2.1% to the generation of the Spanish GDP in 2006, which means a *per capita* average income of 19,820€, below the Spanish average income per head (89.0%, Spanish average equivalent to 100).

The percentage structure of the GDP in 2006 was as follows: agriculture and fisheries represented 2.1%; energy, 4.1%; industry, 15.7%; construction, 12.7%; services, 54.5%; and net taxes, 10.9%. The economic activities with a bigger increment regarding the year 2005 were the construction (increment of 12.1 %) and the industry (8.2%).

Cantabria has a population of 560,190 habitants (2006), 1.3% of the Spanish population, experiencing a slight increment of 1.1% regarding the existent population in the 2005. Cantabria contributed 1.3% to the generation of the Spanish GDP in 2006, which means a *per capita* average income of 21.941€, lightly below the Spanish average income per head (98.6%, Spanish average equivalent to 100).

The percentage structure of the GDP in 2006 was as follows: agriculture and fisheries represented 3.0%; energy, 2.0%; industry, 16.2%; construction, 12.6%; services, 55.3%; and net taxes the 10.9%. The economic activities with a bigger increment regarding the year 2005 were the construction (increment of 14.1%) and the energy (7.1%).

The Basque Country has a population of 2,117,990 habitants (2006), 4.8% of the Spanish population. The population experienced a light increment of 0.5% regarding the existent population in the 2005. Euskadi contributed 6.2% to the generation of the Spanish GDP in 2006, which means a *per capita* average income of 28.731€, being one of the two regions - with Madrid - with a higher average income per head (129.1%, Spanish average equivalent to 100).

The percentage structure of the GDP in 2006 was as follows: agriculture and fisheries represent 1.1%; energy, 4.0%; industry, 22.7%; construction, 9.0%; services, 52.2%; and net taxes, 10.9%. The economic activities with a bigger increment regarding the year 2005 were the construction (increment of 13.7%) and industry (8.7%).

Portugal

The Portuguese Exclusive Economic Zone (EEZ) (Figure 45) has total surface of 1,700,000 Km^2, which makes almost half of the European's Union's EEZ. The Portuguese continent has a total area of 92,270 Km^2 with a coastal area of 976 km and a ZEE of 326,362 km^2. Madeira and Azores archipelagos, have total areas of 797 and 2,333 km^2 respectively with coastal areas extending 130 and 690 km and large ZEEs of 389,340 km^2 (Madeira) and 984,300 km^2 (Azores).

Atlantic continental coastal area is constituted by sand beaches (60.3%) rocky cliffs (35.9%), artificial coast (3.4%) and marshes (0.4%) (Andrade and Freitas, 2002). In the continent most of the human population are settled in the littoral being the demographic density in the littoral of 215 hab/ km^2 and the mean value for the total continental area of 125 hab/ km^2 (INE, 2008a).

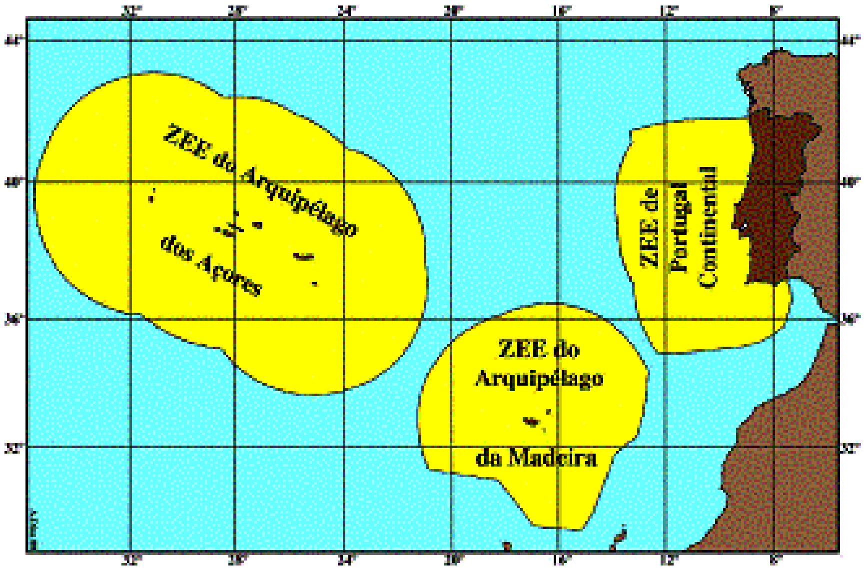


Figure 45. Portuguese Exclusive Economic Zone (EEZ).

Azores

The Azores archipelago is located over a moderately deep plateau, containing no extensive shelf areas (Figure 45). It is composed of nine islands spread among three major groups (western, central, and eastern) separated in total about 615km apart. Therefore, the islands correspond to the only land areas (and human population) existing on this oceanic region. As such, the Azores can be considered as a remote area away from the influence of large riverine outflows and major discharges of contaminants from land base sources. This oceanic region is currently used mainly for shipping, cable routes and fishing. Human impact has been much larger on the past, particularly during the Second World War, where several vessels were sunk and large quantities of munitions dumped in deep waters, particularly north the Azores area (OSPAR, 2000). Litter (including plastic, fishing floats, timber, polystyrene and tar balls) is still a common sight floating at the surface. So, human impacts within this region are mainly generated through the exploitation of resources (mainly fisheries, tourism and recreation) and from external sources via inflows like currents or the atmosphere.

1.3.1 What they are/Where they occur

Some of the busiest commercial routes in the world take place through the European seas, having a number of impacts on the marine environment. These can range from impacts on the coastal zone –resulting from the development and daily activities of large-scale port facilities- to the stirring up of contaminated sediments by dredgers, working to keep the shipping channels open (Frid *et al*., 2003).

This subchapter reviews the most important human activities occurring within the SWW RAC area, particularly, around French, Spanish, Portuguese and Azorean waters. Further, their main impacts upon the ecosystem are summarised.

1.3.1.1 Shipbuilding

While it does not seem to be a relevant human activity in other areas, detailed information regarding shipyard activity in Spanish ports has been reported.

Spain

There was a notable development of the shipbuilding in Galicia, which reached its heyday in the decade of the seventies. The crisis of the sector and the Asian competition also affected Galicia, but at the present time it is regaining the activity, with projects of technological quality, and the employment is increasing from the 6,200 jobs existing at the beginning of the decade. Only in the south of Galicia (Vigo, Marín) 78 ships are being constructed with an estimated cost of 3,500 million euros, and the order list reaches to 2012.

The evolution of the shipyards of Galicia is being positive in the last years, although with a certain delay, and they have guaranteed a very high level of activity and employment up to 2012 or 2015, both in public shipyards and in private ones.

Shipbuilding is an emblematic sector of the Asturian economy, because of its direct contribution and its auxiliary industry. According to the forecasts, between 2007 and 2010 the Asturian shipyards will build a total of 26 ships. Seven of them correspond to the shipyard "Naval Gijón" (four container vessels for the German ship owner Komrowski and three chemical tankers of 9,000 tons for the Italian company Finbeta) and eight correspond to the shipyard "Juliana" (six seismic research vessels with an average cost of 100 million euros per unit, an asphalt tanker and a chemical tanker, with a total work load of 2.5 million hours).

In 2007, the shipyards employed - in the group of factories composed by Juliana, Naval Gijón, Gondán and Armón – 1,700 workers. According to the managerial estimates, the growing activity of the shipbuilding in Asturias will generate more than 5,000 induced employments in the next years.

Cantabria has always been linked to the shipbuilding, and although currently only transformations and repairs of ships are made in the region, still exists an auxiliary industry.

Astilleros de Santander (Astander) is currently the only shipyard of Cantabria. It has a staff of 110 workers (having reached 700) and it repairs 200 ships per year. After its privatization in 1999 and the loss of the capacity of building ships, urged by the European Union and authorized by the Government of Spain, Astander only had the possibility of repairing and transforming ships. In 2007 the European Union and the Government of Spain gave Astander the juridical capacity to build ships again, activity that the company plans to take up.

The Basque marine sector is integrated by ship owners of merchant vessels and fishing vessels, shipyards, engineering, equipment and engine manufacturers and auxiliary industry. Shipbuilding companies represents 72% of the total, the marine-fishing sector represents 27%, and the port sector represents 3%.

The total billing of the sector in 2006 ascended to 1,350 million euros, 75% of which corresponds to sales to foreign countries, and it generated 10,000 employments. At the moment, the shipbuilding sector of Euskadi has an order list covered up to 2011, with about 38 ships.

Except for the main shipyards of the northern coast of Spain, there are also several large shipyards in the regions such as those of Nantes-Saint-Nazaire and Cadiz.

Pressures and impacts

As part of the coastal industry, the main impact of shipbuilding activity is coastal pollution (Table 12). Indeed, shipyards are identified as one of the major routes of TBT input to the coastal environment (OSPAR, 2000).

Table 12. Categories of pressures and impacts associated with shipbuilding and related activities.

Physical loss	Physical damage	Other physical disturbance	Interface with hydrological processes	Contamination with hazardous substances	Systematic and/or intentional releases of substances	Nutrient and organic matter enrichment	Biological disturbance
				X			

1.3.1.2 Ports and maritime transport

Port traffic along the Atlantic seaboard is about 180 x 10^6 t/yr. Ports handling more than 10 x 10^6 t/yr control nearly 82% of the port traffic in the Bay of Biscay and the Iberian Waters. Port activities are centred on twenty principal ports being Nantes-Saint-Nazaire, the most important French port. This port concentrates the transportation of hydrocarbons (Figure 46 and Figure 47).

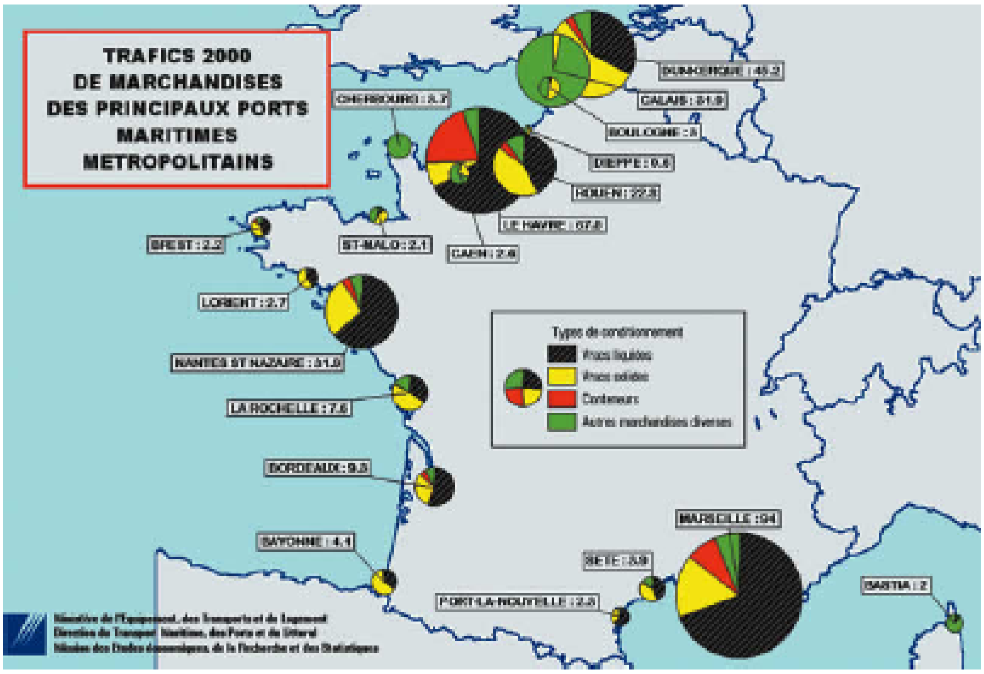


Figure 46. Main maritime metropolitan ports. Source: Ministère de l'équipement, des transports et du lodgement, 2000.

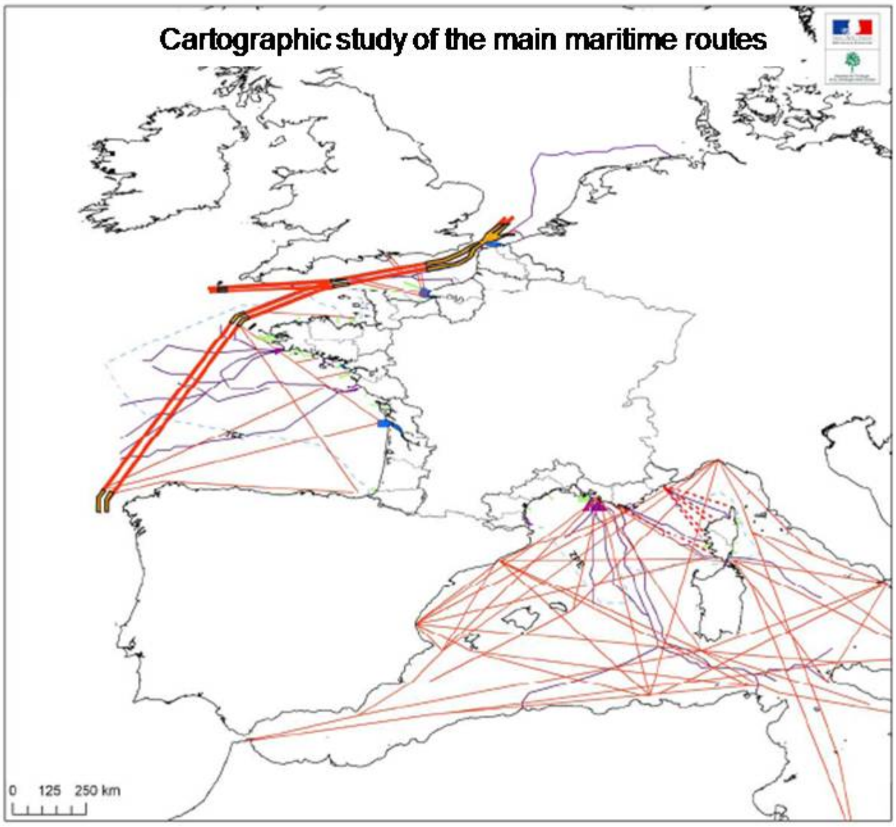


Figure 47. Map showing the main maritime routes.

Spain

In Spain, Galicia has a peripheral position in the geographical contour of the European Union, but it has a position focused in the transoceanic routes and the North of Europe routes.

The turnover rate in the five main Galician ports (Vigo, Marín, Vilagarcía, A Coruña and Ferrol) in the last years (2000-2006) was between 27.2 and 32.1 million tons. That represents between 7.28 and 8.19% of the Spanish total. This traffic includes both bulks and general merchandise, with a maximum in this last section of 237,311 TEUS in 2005, which is not a very high figure in relative terms. This result should be related with the weakness of the infrastructures of terrestrial transport in Galicia, and in particular with the connections inter-manners, very especially the connections ports - rail nets. The high-speed train, or the logistical platforms or dry ports are still in constructive phase or in project phase.

Galicia aspires to be located in a strong position in the Sea Freeway of the Western Europe, and offers an important knot for the big oceanic traffics.

The two more important Asturian ports are the Port of Avilés (Avilés) and the Port of *El Musel* (Gijón).

The port of *El Musel* has a Ro-Ro terminal belonging to the Atlantic Line Ro-Ro. It has terminals for solid bulks, containers, general cargo, steel products, liquid bulks and fishing. The marine traffic in 2004 was 16,767,000 tons.

The port of Avilés is located in the *Ría de Avilés* and it has fishing docks, terminal of containers, traffic of bulks and steel products. The marine traffic in 2004 was 5,085,641 tons, mainly of solid bulks (3 million tons).

Santander is the port with a more diversified activity of the North of Spain. The marine traffic is about 6 million tons per year, of goods like coal, iron, cereals, fishing or automobiles. It has traffics of ro-ro vessels, cruises, and ferries (with connections with the United Kingdom). There are sailing lines to France, Great Britain, Belgium, Germany or Finland.

The marine transport of short distance (Short Sea Shipping, SSS) is one of the firmest bets in the Port of Santander. The SSS is an immediate, profitable and ecological solution to the necessity of transferring goods from the European highways, over-saturated in many points.

The Port of Bilbao highlights in the sector of the marine transport, with 37.2 million tons in 2006. The main origin or destination countries are the United Kingdom, the rest of Spain and China. It contributes with 419 million euros to the Basque GDP and it generates 9,500 employments. The Port of Pasajes in Guipúzcoa is also important.

There exist 234 sailing lines across the world: 33 lines to the north of Europe, 55 lines to the Mediterranean, north of Africa and Near-Eastern, 17 lines to the Atlantic Africa, 18 lines to Africa, Indian Ocean and Asian Cost, 53 lines to the Atlantic Cost of USA, Canada and Cuba, 34 lines to South America and west coast of North America, and 24 lines to the Far East and Oceania.

Portugal

The large Portuguese EEZ is crossed by several obligatory routes for commercial maritime transport from South to North Atlantic and West to East (Figure 48). The maritime traffic is intense in the region. About 200 vessels per day carry more than 500 tons of merchandize, from which 40 vessels carry oil, (Dias, 2003). In continental Portugal the transportation of hydrocarbons is based in Sines whereas container shipping is largely controlled by Leixoes-Porto and Lisbon, (OSPAR, 2000).

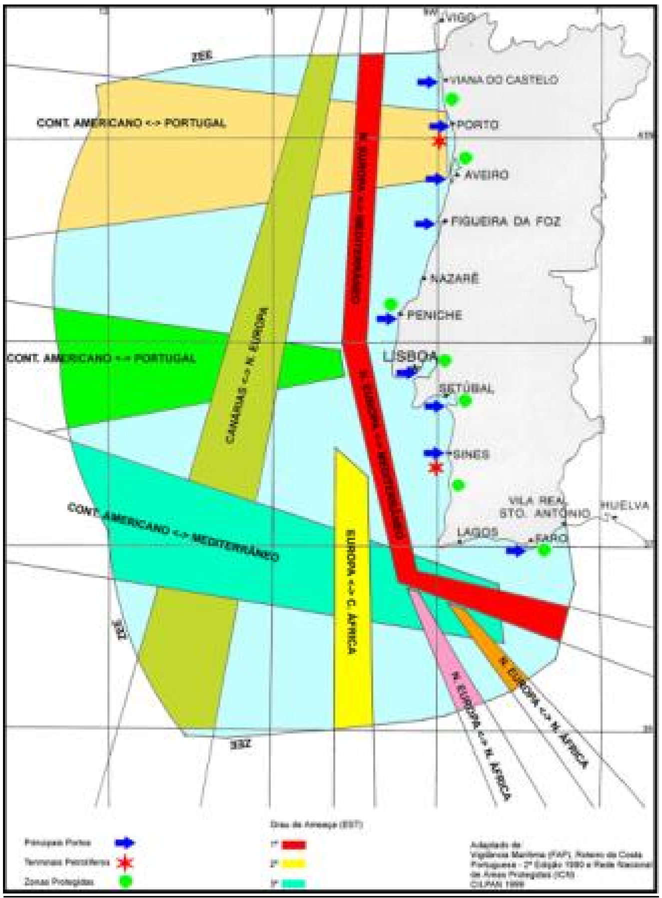


Figure 48. Routes for commercial maritime transport in continental Portuguese EEZ. (Source: CNADS, 2001).

<u>Azores</u>

Shipping is also an important human activity on the oceanic region (Azores) since this is one of the most important routes of commercial transport in the NE Atlantic. However, there is no information available of the potential impacts (crude pollution, noise, tank cleaning, introduction of non-indigenous species, litter, containers loss, etc.). With the abandonment of deep-sea dumping and the regulations imposed by MARPOL on ships at sea, inputs of most contaminants via direct discharges from vessels have been reduced (OSPAR, 2000).

Pressures and impacts

A list of shipping impacts include: contamination with hazardous substances, systematic or unintentional (accidents) release of chemical substances, nutrient enrichment and biological disturbance (Table 13).

Being a busy commercial route for ships, there is a high risk of accidents, which can be particularly serious if oils tankers are involved. In fact, there have been several dramatic oil spills off the northwest coast of Europe in recent years (Frid *et al*., 2003).

Oil spills have considerable effects on both biotic and abiotic factors of the affected area. For instance, after the Monte Urkiola oil spill (1976) the meiofauna on the beaches affected were totally eliminated. The main consequences of the Aegean Sea oil spill (1992) on the benthic macrofauna were a temporary reduction in amphipods and echinoderms, and a dramatic increase in opportunistic polychaetes. Because of high hydrocarbon concentrations mussel growth was reduced by three to forty times, and decreases in ingestion, absorption and assimilation rates were observed (OSPAR, 2000).

Concerning anthropogenic impacts on the ecosystem it is important to mention the "Prestige" oil spill off Galicia in November 2002. This event affected most of the northern Spanish coast and especially the northern part of Galicia.

From November 2002 to August 2003, 23000 birds (6000 alive and 17000 dead) were collected on French, Spanish and Portuguese coasts. More than 90 species were identified. The most affected species was the guillemot (51%), followed by the razorbill and the Atlantic puffin (*Fratercula arctica*). Other species found in significant numbers were the black-legged kittiwake, the little auk (*Alle alle*) and the great northern diver (*Gavia immer*). According to their relative abundance, the yellow-legged gull and the common scoter were the less impacted species. In general, more than 60% of the oily birds were females.

Three years after the Prestige oil spill, there has not been a clear effect of the event on the demersal and pelagic domains of the Iberian shelf. Although, based upon abundance indices and bottom trawl surveys, an initial abundance decrease of some primarily benthic species (e.g. four-spot megrim, Norway lobster and other benthic decapods crustaceans) was observed in 2003, it was followed by an increase in 2004 (Sanchez *et al*., 2006; Serrano *et al*., 2006b; Trujillo *et al*., 2005).

Oil spills have direct effect on organisms (mortality or morbidity), indirect effects (through alteration of lower trophic levels) or be associated to exposure to trace elements contained in oil (markers). An effect of the "Erika" oil spill was investigated by spatio-temporally comparing mortality, population structures, diets and concentrations of vanadium, nickel and phosphyrines in small delphinids, seals and otters from the French Atlantic coasts. These species differ in their vulnerability to oil. Changes in mortality and its demographic structures were within previously observed ranges. No measurable effect of the "Erika" oil spill was found in dolphins and seals (Ridoux *et al*., 2004).

Between 80,000 and 150,000 marine birds wintering in the Bay of Biscay were killed during the "Erika" oil spill. Three complementary studies were conducted to investigate the geographic origins of these birds. The common guillemot, *Uria aalge*, represented more than 80% of the oiled birds and these studies thus focused primarily on this species. The guillemots originated from a large geographic area, including colonies from across the Britsh Isles and the North Sea, along with more northern localities. However, the majority of individuals came from colonies located between western Scotland and the Celtic Sea. Overall, results indicate the large spatial scale of the oil spill's impact and underline the usefulness of combining multiple approaches to assess the local and regional effects of such accidents (Cadiou *et al*., 2004).

Table 13. Categories of pressures and impacts associated with ports and maritime transport.

Physical loss	Physical damage	Other physical disturbance	Interface with hydrological processes	Contamination with hazardous substances	Systematic and/or intentional releases of substances	Nutrient and organic matter enrichment	Biological disturbance
		X		X	X	X	X

Shipping is also source of biological disturbance in terms of noise, which interfere with marine species migrations, and has also impact on biodiversity through the water tank releases in the harbours bringing planktonic organisms *aloctenes* to the region, which may cause nutrient enrichment and eutrofication in the coastal areas (Borges *et al*., 2009).

Little is known on marine species introduction and invasions in the Azores. However, the potential for introduction is high, considering that the transatlantic leisure boat-traffic stopping over at the islands has significantly increased over the last decade.

Underwater noise (e.g. from shipping, underwater acoustic equipment) may be an important source of disturbance for cetaceans, however there is no information available from this area to quantify the importance of this type of impact.

MARPOL international regulations try to prevent chemical pollution, (e.g. the use of vessel painting containing hazardous chemicals). Portugal also signed Convention of MARPOL (73/78) by executive order nº 25/87, 10 July, 192/98. And in order to prevent long term direct impacts in marine habitats, surface waters, and underground waters there is also legislated in Portugal the Regulation for Accidents and Pollution Prevention and Control of Serious Accidents (DL 254/2007).

1.3.1.3 Fisheries

Fishing is a major activity, creating jobs for many coastal communities.

France

In the Bay of Biscay and the waters off the Iberian Peninsula, the fisheries area characterised by a large number of species of commercial interest, of which the following are of most importance: tuna and tuna-line species, hake, sardine, anchovy, mackerel and horse mackerel, and crustaceans and molluscs.

Traditionally the Bay of Biscay has been a region of intense fishing activity. Approximately 5,000 French and Spanish fishing boats are currently active in the Bay of Biscay.

Table 14 lists the main French métiers operating in the Bay of Biscay. The main species caught in this area are *Nephrops* (bottom trawl), sole (gillnet), and anchovy (pelagic trawl). Anglerfish and hake are mostly caught by French-flagged vessels based in the Basque Country. These vessels use gillnets.

The French fisheries take the largest proportion of elasmobranchs than any fleets in this region. Traditionally, the French fishery was limited to the continental shelf of the Celtic Sea, the Channel, and the Bay of Biscay, and only two species of sharks (*S. acanthias* and *S. canicula)* and one ray (*L. naevus)* were particularly important in the catches (about 60% to 70% of elasmobranch landings), with *L. naevus* accounting for about 30%.

Table 14. Fishing gears and target species per ICES area.

Area	Gear	Target species	By-catches
Divisions VIIIabd	Bottom trawls (mostly twin trawls)	*Nephrops*	Hake
Divisions VIIIabd	Bottom trawls	Mixed: sole, whiting, cuttlefish	Red-mullet, Pollack
Divisions VIIIabd+VII	Bottom trawls (mostly twin trawls)	Anglerfish	Megrim, rays
Divisions VIIIabde+VIIe+VIIIe+VII	Pelagic trawl small-mesh Pelagic trawl	Anchovy Bass, Albacore	
Divisions VIIIab	Purse-seine	Sardine, anchovy	
Divisions VIIIabd	Gillnets Gillnets large mesh	Hake Anglerfish	
Divisions VIIIabd	Miscellaneous	Crabs, bass, conger	

Spain

Fishing and aquaculture are important in Galicia, because of their direct contributions to the GDP or the number of employments and the added value along the productive and commercial chain. Galicia is a reference market of sea product and has a significant weight in the transformation.

Fishing and aquaculture represent 2.2% of the Galician GDP (2006), and generate 27,400 employments (50.8% of the Spanish fishing total employ). There are 5,216 fishinf vessels in Galicia (6% of the European Union total, although 9.1% of the total capacity, because of the ig average dimension of the Galician ships). This technical and human resource applies to different modalities, from the handmade fishinf or the shellfishing tot he big freezing stem trawlers which operate in distant fishing grounds. A total of 4,549 ships of less thatn 10 GRT compose the bajura fleet and operate fundamentally in interior waters (depending of the regional government) capturing octopus, whiting pout, conger, stout botail, spider crab and clams. The coast fleet is compsed of ships between 10 and 150 GRT: 168 purse seiners which capture vadigo, horse mackerel, Atlantic mackerel and sardine; 104 trawlers which capture hake, anglerfish, megrim, horse mackerel and Norway lobster; 28 longliners which capture hake; 34 “volanta” ships which caputer hake; and 62 surface longliners which capture swordfish. There are 49 trawlers and 64 longliners of more tha t100 GRT operating NEAFC waters and capturing hake, megrim, anglerfish and Norway lobster. In international Atlantic, Indian and Pacific waters there are 5 tune freezing vessels, 83 surface longliners, 23 NAFO trawlers, 7 cod tralwlers and 19 big freezing vessels. There are alos a big number of ports all along the coast. On the other hand, there are 10.800 employments in the processing industry.

The landings volume of fresh fishing in the Galician ports in 2007 was 172.249 tons, with a total economic value of 463.43 million euros, and an average price of 2.69 euros per kilogram. The main species in terms of volume were the horse mackerel (22,028 tons), the hake (21,857 tons), the Atlantic mackerel (17,048 tons), the sardine (16715 tons) and the vadigo (14,402 tons). In terms of value, the most important species were the hake (90.3 million euros), the anglerfish (27.3 million euros), the megrim (31.7 million euros) and the horse mackerel (17.6 million euros). The annual landings of frozen fishing surpass the 200,000 tons. The port of Vigo concentrates approximately half of the total Galician landings both of fresh and frozen fish.

The fish landings data in the Asturian ports in 2007 showed a bad result. The value of the auctioned fishing captures experienced a decrease of 9%, while the volume of the fish catches declined by 5.2%. The annual average fish price was 2.39 euros per kilogram, which means a decrease of 4%regarding 2006.

The total volume of fish landings in 2007 was of 17,228 tons. The most important species in terms of volume were the Atlantic mackerel (5,405 tons), the sardine (2,726 tons), the blue whiting (2,042 tons), the white tuna (1,727 tons), the hake (1,626 tons) and the rough shad (482 tons).

The total economic value of the landings was 41.02 million euros. The main species in terms of value were the hake (8.2 million euros), the white tuna (6.1 million euros), the anglerfish (3.2 million euros) and the blue whiting (2.1 million euros). In 2007 a geographical re-equilibrium took place in the fishing landings between the ports of Avilés and Gijón (in terms of value), as a consequence of the problems of the new rasher of Avilés which caused an important deviation of the more valued landings. In terms of weight, the port of Avilés still duplicates the landings data of Gijón.

The fishing in Cantabria is centered in species like: hake, red sea bream, anglerfish, anchovy, albacore, rough shad, sardine and Atlantic mackerel. The landings reach about 30,000 tons a year. Santoña habitually concentrates the biggest volume, with more than 10,000 tons, followed by the ports of Colindres and Santander (with some 5,000 tons each one), and those of San Vicente of the Barquera, Castro Urdiales and Suances. The annual economic value of the landings is about 30 million euros, being Santander the main port in this respect. The number of fishing ships reaches 180.

The evolution of the productive structure of the Basque fishing sector continues its descending trajectory performed along the whole last decade. The value of the production of the fishing sector descended 15% between 2005 and 2006, partly because of the increment of the fuel price, which is directly affecting the profitability of the sector. In addition to this cost, the continuous drop of the number of productive units generates smaller total productions. The total number of fishing vessels in 2006 was 300. That represents a net decrement of 6.25%, with 20 extractive units less. Only the tuna freezers gain one unit (from 23 to 24).

This reduction of the number of ships has also impact in the employment. The Basque fishing fleet had a total of 2,902 crew members in 2006, 182 less than in the year 2005, so there has been a descent of 5.9%.

The coastal fleet is composed of ships with less of 150 GRT (an average of 62.26 GRT). These ships operate near the coast using the following fishing techniques:

- Small Arts, denominated this way because of the small dimensions of this arts. They are used by ships of small length and power.
- *Cacea*, for the Atlantic mackerel and the white tuna fishing;
- Purse seine, for the capture of small pelagics, especially the anchovy;

- Alive bait, for the tuna fishing.

The coastal fleet is the sector with the higher number of units, 231 ships (77% of the fleet), with a drop of 5.33% regarding the year 2005. It also possess the highest number of fishermen, with 1,655 people (57% of the total), 4.61% less than in 2005.

The deep sea fleet had 69 units in 2006 (a reduction of 9.21% regarding the previous year) and 1,247 employees (7.56% less than in 2005). There are 6 cod vessels, with base port in Pasaia (2 ships and 54 fishermen less than in 2005); 24 tuna freezers with base port in Bermeo (1 ship and 33 fishermen more than in 2005), and 39 fresh fishing vessels mainly distributed among Ondarroa and Pasaia (6 ships and 81 fishermen less than in 2005). Since the year 2003 freezing trawlers does not exist in the Basque Country.

The captures volume of the coastal fleet in 2006 was 41.895 Tons, which represents a reduction of 18.5% regarding the year 2005, when 51.430 Tons were auctioned. The economic value of the landings was 78.1 million euros, a reduction of 2.8% compared with the revenues of 2005 (80.3 million euros). The average price of the fish was 1.9 euros/kg, 19.4% higher than in 2005 (1.6 euros/kg). The year 2006, for this coastal sub-sector, has been disastrous in reference to the anchovy campaign. The positive note is the good coastal campaign of the albacore.

Portugal

The number of trawlers has decreased since the early 1980s, resulting in a decreasing trend in the overall effort in the Portuguese and Spanish fleets. The number of boats in fleets operating with gillnets and longlines has also declined in recent years. Portuguese and Spanish boats using trawl, longline, and fixed nets have since 2005 been subjected to limitations on the number of fishing days per year.

Southern horse mackerel are mainly exploited by Spanish and Portuguese purse-seiners and by Portuguese trawlers. While the purse-seiners mainly catch juvenile fish, the catches taken by trawlers comprise also older fish. There is a significant bycatch of *Trachurus mediterraneus* and *Trachurus picturatus*, mainly in the trawl fishery.

For blue whiting most of the catches are taken in the directed pelagic trawl fishery in the spawning and post-spawning areas (Divisions Vb, VIa,b, and VIIb,c). Catches are also taken in a directed and a mixed fishery in Subarea IV and Division IIIa, and in the pelagic trawl fishery in Subareas I and II, and in Divisions Va and XIVa,b. These fisheries in the northern areas have taken 340,000–1,390,000 t per year in the last decade, while catches in the southern areas (Subareas VIII, IX, Divisions VIId,e and g–k) have been stable in the range of 25,000–34,000 t. In Division IXa blue whiting is mainly taken as a bycatch in the mixed trawl fishery, and in the case of the Portuguese trawl this bycatch was discarded at sea; however, since 2005 it has been landed in the Portuguese harbours by the Portuguese crustacean and fish trawlers, representing 36% and 17% of its landings, respectively.

Azores

Fisheries are the major human activity in the oceanic regions (Figure 49). Three broad categories of fishing can be identified:

a) Fisheries for large pelagic tuna and tuna-like fish. These occur mainly in the southern sector of the oceanic region (ICES areas VIII, IX and X) and CECAF areas including

Madeira and Canaries. ICCAT has responsibility for the international management of these fisheries (ICCAT, 2008);

b) Longline and trawl fisheries in deep waters on the Mid Atlantic Ridge (ICES area X) and south the Azores, CECAF area 2.0. These target species such as Alfonsinos (Beryx sp), grenadiers (*Coryphaenoides rupestris*) and various species of deep-water shark (ICES, 2008c);

c) Fisheries using traditional longline, handline and gillnet methods around the Azores and adjacent seamounts, targeting a great variety of species (ICES 2008e).

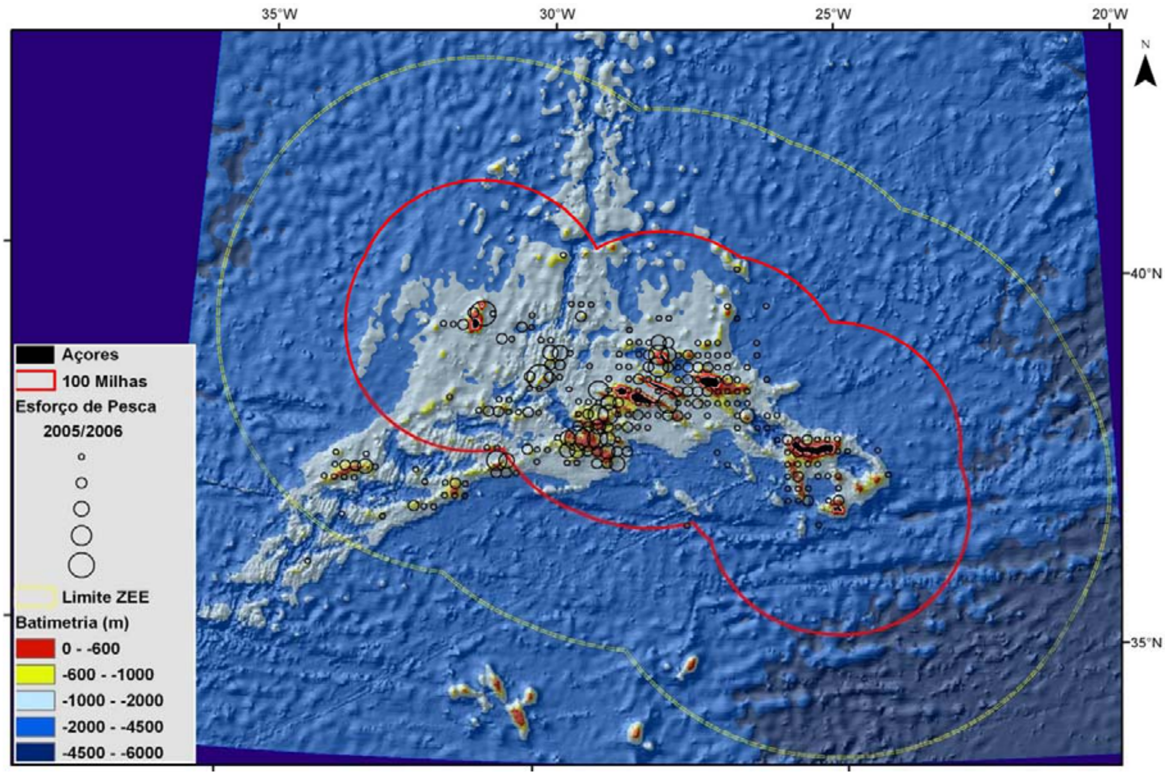


Figure 49. Effort of the fleet working with mixed demersal lines around Azores archipelago area.

Pressures and impacts

Fishing has many impacts on marine ecosystems (Table 15). On one hand, the large amount of catches of fish and shellfish and on the other hand the resulting changes associated with their removal from food chains. In this context, fishing can have effects on predator-prey relationships, which can lead to shifts in community structure. Moreover, fishing can alter the population size and body-size composition of species leading to a fauna composed of primarily small individual organisms (Kaiser *et al*., 2001). Additionally, fishing also impacts other marine animals, from non-target fish and invertebrates to seabirds and marine mammals that are incidentally caught in the fishing gear. There are also physical impacts on the bottom-living organisms and the seabed from bottom trawls (Frid *et al*., 2003). The disturbed sites are seen to have lower number of organisms, biomass, species richness and species diversity (Collie *et al*., 1997).

Commercial fishing on oceanic regions produces a biological disturbance on benthic and pelagic community. Exploitation levels for many of the tuna-like fishes are reported to be outside of biological safe limit (ICCAT, 2008). By-catch has been also reported from large pelagic fisheries, particularly from longliners. Some demersal and deep-water species have been also exploited in excess and since these are usually multispecies fisheries, by-catch (extraction of non target species) also occurs. Open ocean fishes, particularly those inhabiting deep waters tend to be vulnerable to overexploitation because they are at the end of the food chain, slow growing and having low fecundities. Overexploitation might have occurred in the past on some seamounts around Mid Atlantic Ridge. Presently, intensive pressure, with possible local depletions, may be occurring on some coastal areas and adjacent seamounts of the Azores EEZ (ICES, 2008c).

There is concern over the effect of marine organisms that ships can carry from one geographical area to another in their ballast water or attached to their hulls. If the non-native species are introduced to suitable conditions, they can sometimes out-compete the local marine life, potentially altering entire marine ecosystems.

It is possible that some abrasion impact on the seabed of commercial fishing, boating and anchoring occurs on the Azores area. The extend of this impact is not assessed but it has been considered low since only artesanal hook and line fisheries are used in the Azores area, although some deep-water gillnet were also used in the past (ICES, 2006c). Particularly vulnerable are those habitats such as the deep water corals and the seamounts. Fishing abrasion impacts may be important on the Mid Atlantic Ridge areas and offshore seamounts south of the Azores since international deep-water trawls operated there intensively (ICES, 2008c). The importance of seamounts to some large pelagic fish, marine mammals and seabirds is demonstrated (they may act as feeding stations for some species) (Morato, 2007) and thus any changes in their habitat may have indirect effects on them.

Table 15. Categories of pressures and impacts associated with fishing activity.

Physical loss	Physical damage	Other physical disturbance	Interface with hydrological processes	Contamination with hazardous substances	Systematic and/or intentional releases of substances	Nutrient and organic matter enrichment	Biological disturbance
X	X	X			X		X

The main source of marine litter on oceanic areas seems to be the fishing (plastics, floats, nets, lines, ropes, etc) mainly as a result of lost and discarded fishing gear. Impacts on seamounts from this kind of litter may be important. Litter discarded from vessels at sea (plastic bags, polystyrene fragments, pieces of rope and containers) may be also a problem. The accidental ingestion of some debris has been recorded in whales, turtles and some fish, often causing an obstruction in the digestive tract and occasionally death. This debris, particularly plastic and polystyrene, may be originated outside or far away from the Azores oceanic region (OSPAR, 2000) due to main mesoscale and large scale circulation patterns.

1.3.1.4 Offshore energy

They are not considered relevant activities or there is little information available regarding the development of offshore energy activity in France, Portugal and Azores. Thus, this section focuses on Spanish offshore energy extraction systems.

Spain

Galicia cannot present significant results in the use of marine resources for energy uses. But, on the other hand, possibilities of use of marine eolic energy or waves energy have been explored, being especially significant the Galician potential in the second case.

The energy is an interesting activity to develop economic and socially the Asturian coast, especially the renewable energy: eolic energy in the coast or in the sea (offshore), and marine energy (wave energy, tidal energy …). However, it is still an issue to develop in the future.

In Cantabria, there is a pilot plant of waves energy located four kilometres off the coast of Santoña, with a power of 40 kilowatts. It is supposed to be the first of a group of ten buoys (with a power of 150 Kw each one) that will settle in this point of the Cantabrian in the future. They will have a total power of 1.39 megawatts, and the annual generation of electricity would be equivalent to the consumption of 2.500 homes.

Undoubtedly, Basque Country is an important region in terms of offshore energy. The total energy demand in the Basque country is 7.7 Mtep, distributed as follows: solid fuels (6%), petroleum and by-products (41%), natural gas (42%), renewable energy (4%), electric power (7%) and other (1%).

a) Petroleum

The reference installation is the Petronor Refinery, with capacity to process 11 millions of annual tons of crude oil. It is located in the west area of the Bizkaia coast, in the municipality of Musquiz, in the vicinity of the Port of Bilbao.

This port is a key element in the supply of petroleum products. This is the entrance and exit point for the crude oil and the products processed in the refinery and for the fuels imported by independent operators by means of tankers. It has also facilities for the storage of fuels and other oil products and coal, and connection by pipelines with the refinery. The coal also enters through the port of Pasaia, mainly with destination to the thermal power station located in the same town.

The storage capacity of crude and oil products in Euskadi is 2,890,000 m^3; 31% corresponds to crude oil tanks in the Petronor refinery, 41% to petroleum products in the same refinery and 28% to the rest of operators.

b) Gas

Euskadi has a basic net of 3,700 km. for the transport and distribution of gas all along its territory. This net connects with the state net in the south, and with the Port of Bilbao in the north, by means of the re-gasification plant of Bahia Bizkaia Gas, terminal of importation of liquefied natural gas (LNG) which has a loading dock for gas tankers up to 140,000m^3, 2 storage tanks of 150,000m^3 each one and a capacity of re-gasification of 800,000 Nm^3/h.

The natural gas field “Gaviota”, discovered at the end of the decade of the 70s off the cost of Bermeo (Bizkaia), is now a deposit of strategic storage, with a total capacity of 2,480 millions of Nm^3 and a useful volume of 780 millions of Nm^3 of gas. This is the bigger State strategic reservoir of natural gas.

c) Renewable Energy

There is a tidal energy plant in Mutriku, which supplies green electricity to about 250 housings, with an average yield near the 300 kW. Its technology is based on the principle of the oscillatory water column (OWC). It will be able to produce 600,000 kW/h per year and it will avoid the emission of 600 tons of CO_2.

Pressures and impacts

The energy generation facilities and the energy transport systems cause different environmental impacts (Table 16), and they can affect other possible uses of the marine space. The management must contemplate these implications. In Galicia the risks of the oil transport are known. Other implications can appear if the locations for the generation of eolic energy or wave energy enter into conflict with other uses.

Table 16. Categories of pressures and impacts associated with offshore energy activity.

Physical loss	Physical damage	Other physical disturbance	Interface with hydrological processes	Contamination with hazardous substances	Systematic and/or intentional releases of substances	Nutrient and organic matter enrichment	Biological disturbance
X	X	X					X

The installation of offshore energy sources could suppose potential alteration of natural environments and diminution of habitats. Underwater support pilings, anchoring devices, scour-protection materials, and electromagnetic fields could cause a decrease in benthic communities, alter natural environments, and possibly affect migration patterns (U.S Department of Interior, 2006).

Besides potential collisions (bird strikes), it is possible that the birds would need to consume more energy to avoid collisions and maintain their orientation when navigating around the turbines. Tower illumination may also cause navigational disorientation for birds. Electromagnetic fields created by the electric cables running from the turbines and underwater noises and vibrations could affect orientation and navigational ability of endangered and threatened species. Moreover, noise impacts from rotating turbine blades can be generated (U.S Department of Interior, 2006).

1.3.1.5 Coastal and maritime tourism

France

In France, Brittany and Aquitaine are the two biggest tourist areas each processing 7% of the national accommodation available for visitors; although this capacity has more to do with the extended coastline in these regions that with a higher density of tourist. Of these regions Vendée and Charente Maritime head the list. In France the tourist season is focused on the two summer months, particularly from mid-July to mid-August. This seasonal tendency is becoming increasingly marked as the holiday period is shortening, and thus translating to an increase environmental pressure. During summer, the resident population is multiplied by a mean factor of 1.4 in Brittany, 3.2 in Aquitaine and 3.5 in the Loire and Charente. The maximum factor of 6.0 for Vendée (OSPAR, 2000).

Spain

The fishing infrastructure has now an incipient use in nautical sport, besides the specific endowments. There are approximately 25,000 cabin cruisers in Galicia (2004), which represents 10% of the Spanish total. But the most traditional leisure activity is the enjoyment of the beaches. In Galicia there are 459 beaches which constitute a good tourist attractiveness. There is also a significant and diverse cultural patrimony closely tied to the sea (museums, lighthouses, ports, etc.), besides singular places (very especially the *Parque Nacional de las Islas Atlánticas*).

Galicia is also very well located for the cruise tourism, as it is placed in the route from the north of Europe and the British Islands toward the south of the Peninsula, north of África and Canaries. A secondary alternative is the cruises of small dimension with nearer visits, and the local marine routes of cultural and landscape content.

The Government of Asturias (by means of the General Direction of Fishing) is participating together with the local councils of Gozón and Asaja and the Federation of Brotherhoods of Fishermen in an European project of fishing tourism, the *Sagital* project, which outlines this activity like a complement to the fishing activity, which could allow to use the same fishing ships to take tourists, when the conditions of the sea allow it, to fish or to show fishermen work in other crafts, to see the cliffs from the sea, to show marine wildlife, etc.

The tourism in the Cantabrian coast has experienced a recent growth which responds to a sensitisation for the environment. It is valued the rural and natural landscape of the coastal areas. In Cantabria, the coastal tourism concentrates on the villages of San Vicente de la Barquera, Santillana del Mar, Santoña, Laredo and Castro Urdiales, besides the capital.

Basque Country offers a wide variety of activities such as, nautical sports, surf, trekking along the coast... Beaches are important tourist attractions as well. Visiting coastal small fishing villages is another way of getting to know the fishing environment of the Basque Country. The increase of tourism in the last years has rise to a need of sustained development of the area.

Portugal

With reference to Portugal, about ¾ of the population inhabits the coastal zone, which houses most of the country's largest cities (Porto, Aveiro, Lisbon, Setúbal e Faro) (Figure 50). In 1997, the total income from tourism represented 4.2% of National Gross Domestic Product – and increased to 8% in 2000 (Andrade and Freitas, 2002). Currently tourism is responsible for 11 % of the Gross Domestic Product (GDP) of the country and approximately 10 % of total employment (EC, 2006).

At present the coastal tourism is the most important services of the Portuguese maritime activities. The coast attracts 90% of foreign tourists and employs a large number of persons. There are 38,894 jobs in coastal tourism and 2,480 jobs in recreational boating (EC, 2006).

Azores

Coastal and maritime tourism have been growing up in the Azores. Camping and bathing, yachting, recreational fishing, surfing, scuba diving and bird- and whale-watching are among the most popular activities. Recreational fishing, using rod and line and spear-fishing, exploits a variety of inshore fishes, few of which are caught commercially, but the popularity of underwater diving and spear-gun fishing has made necessary the introduction of regulations limiting the daily catch to five fish per person. Whale watching has expanded rapidly in recent years, and is now regulated in order to protect both visitors and whales (OSPAR, 2000).

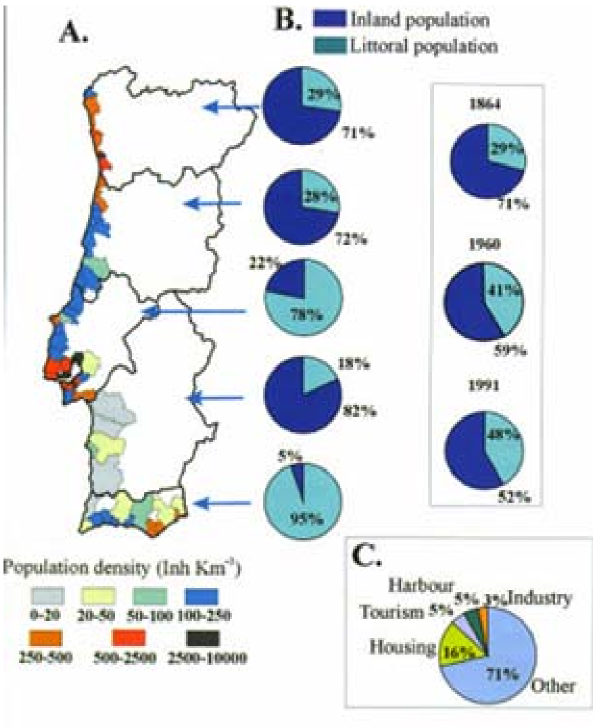


Figure 50. The Portuguese Coast: A- Population density of littoral municipalities. B- Inland population versus littoral population and its evolution since 1864. C- Occupation of the coast (SIAM, 2002).

Pressures and impacts

The increased use of the coast for tourism and recreational activities generates seasonal migrations to the littoral fringe creating adverse impacts on the coast (Andrade and Freitas, 2002). Recent studies indicate that approximately 30% of the Portuguese mainland coast is at present significantly altered by housing (urban settling and expansion, second habitation), urban and industrial facilities and tourism infrastructures, although the distribution of occupation patterns and density is quite variable along the shore (Turismo de Portugal, 2008a).

Table 17. Categories of pressures and impacts associated with coastal and maritime tourism.

Physical loss	Physical damage	Other physical disturbance	Interface with hydrological processes	Contamination with hazardous substances	Systematic and/or intentional releases of substances	Nutrient and organic matter enrichment	Biological disturbance
	X					X	

Tourism and recreation in coastal areas during summer are important social and economic activities along the Atlantic coast of France, Spain and Portugal. The additional services and infrastructures required can lead to a rapid degradation of coastal habitats and resources; however it is difficult to determine these impacts in detail due to poor data availability.

1.3.1.6 Exploitation of mineral resources

France

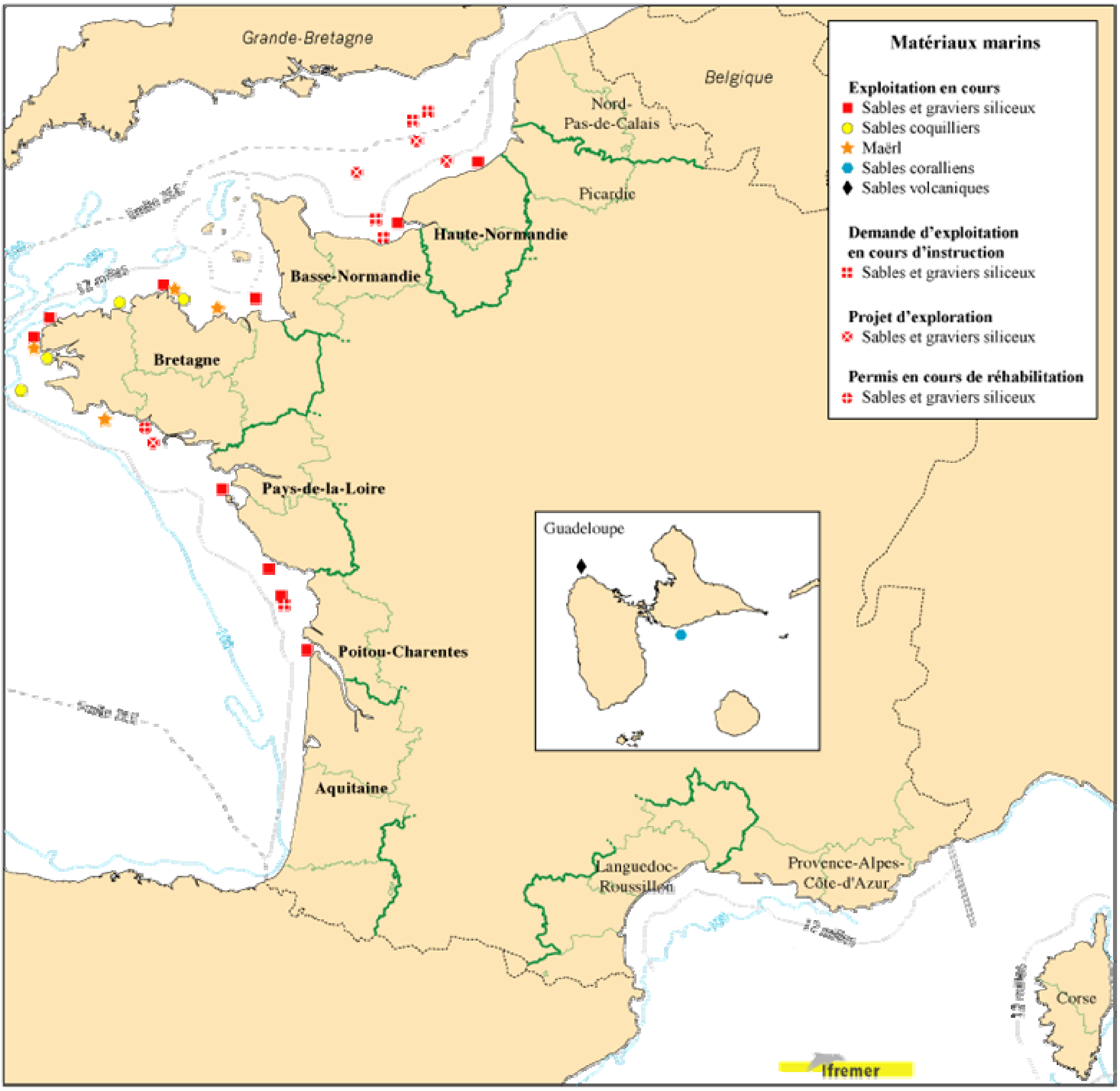


Figure 51. Sand extraction areas. (Source: http://www.ifremer.fr/drogm/Realisation/Miner/Sable/exploitation.htm).

In France, there are considerable sand and gravel resources along the Atlantic seaboard: 24 x 10^9 m^3 of siliceous sediments and 0.17 x 10^9 m^3 of calcareous sediments. The Loire Estuary is currently the largest producer of siliceous marine sediments in France with a production of 1.6 x 10^6 m^3/yr. The extraction of calcareous sediments is focused on Brittany and concerns conchiferous sands and Maërl (*Lithothamnion*) (Figure 51**¡Error! No se encuentra el origen de la referencia.**). Marine sediments extraction off the French

Atlantic seaboard represents 60% of national production. Marine aggregates are considered as ore products and so are subject to French mining regulations (OSPAR, 2000)

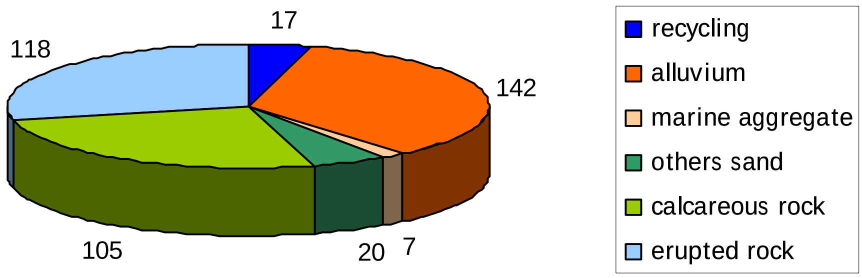


Figure 52. Parts of marine aggregate in the French consumption (in millions of tons). Source: UNICEM, 2007.

Spain

In Spain, the 1988 Law of Coasts prohibits the extraction of aggregates from the coast, expect for beach replenishment in which case it requires the effects to be assessed, both in terms of the site from which the aggregate will be extracted and the site where it will be deposited . The volume of sand extracted from the Peninsula coasts between 1983 and 1992, was 12 x 10^6 m^3. Of this total, 4.8 x 10^6 m^3 were extracted from the northern coast and 7.3 x 10^6 m^3 from the southern. Between 1993 and 1994 more than 3 x 10^6 m^3 were extracted and used to replenish eroded beaches (OSPAR, 2000).

Portugal

In Portugal a similar system is practised in which aggregates extracted from coastal areas must be used for beach replenishment. Despite recent legislation restricting the total amounts extracted, extraction from river beds, river margins, estuaries, navigation channels and coastal areas continues to occur at a relatively high rate. Total extraction is around 2000t/yr. The various governmental bodies with jurisdiction over the coastal areas have differing attitudes regarding management. Areas under the jurisdiction of the Institute for Nature Conservation are protected from sand extraction, whereas coastal areas under port jurisdiction (Figueira da Foz and Aveiro Ria, in particular) are subject to sand extraction (OSPAR, 2000).

Gravel and sand is extracted from estuaries and beaches for construction and other services. In 1995, legislation was enacted concerning the assessment and management of dredged material and dumping operations. Figure 53 indicates the main gravel and sand deposits in Portugal continental. Navigation channels and the reinforcement of dunes and sandy beaches aiming to help on the maritime circulation were performed by Institute of Nature Conservation at APPLE (Protected Landscape of Esposende Littoral Area) and PNRF (Ria Formosa Natural Park). The volume of sand dredged from these areas between 1994 and 1997 was 105 x 10^3 m^3 at APPLE and 958.5 x 10^3 m^3 at PNRF (OSPAR, 2000).

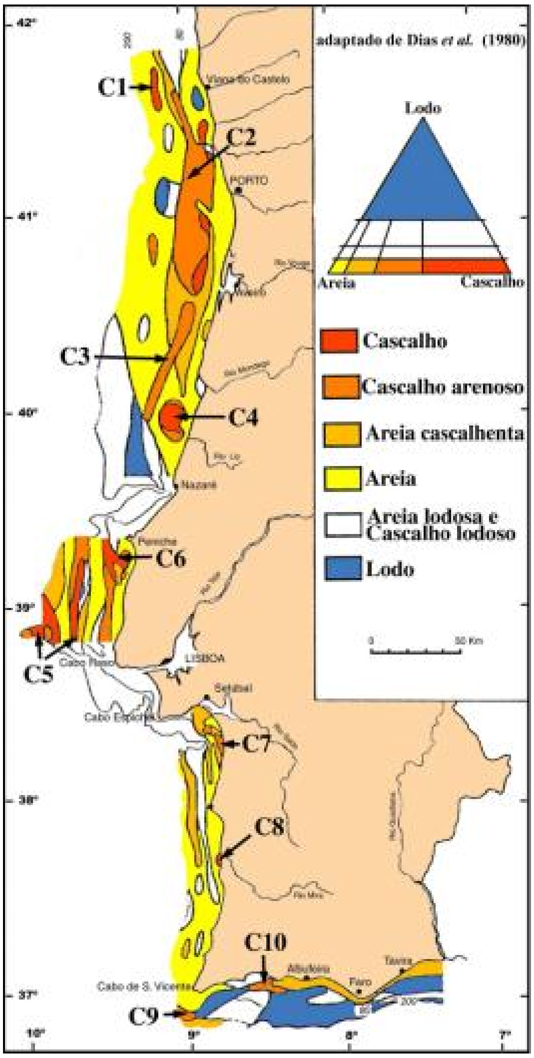


Figure 53. Main gravel and sand deposits from the continental Portuguese shelf.

Azores

Dredging is only conducted in the inshore waters of the Azores. However dredging is limited to sand, in islands inshore areas, licensed for annual extraction of about 140.000m^3. No potential mineral deposits for selective industrial exploration and exploitation were identified or referenced in the region.

Pressures and impacts

Sand and gravel extraction is an important activity along the French Atlantic coast, and the associated environmental impacts fall into three main categories: physical, chemical and biological (Table 18).

Table 18. Categories of pressures and impacts associated with explotation of mineral resources.

Physical loss	Physical damage	Other physical disturbance	Interface with hydrological processes	Contamination with hazardous substances	Systematic and/or intentional releases of substances	Nutrient and organic matter enrichment	Biological disturbance
X	X	X	X				X

Physical impacts include alterations to the seabed by sediment removal, increased turbidity and the deposition of the sediment load carried by currents. The type and extent of the impact varies according to the dredging method and its intensity, and the characteristics of the extraction site. The chemical impact is minor, reflecting the low organic matter and clay content of the material extracted. The biological impact varies according to the extent of the physical impact, and concerns the disturbance and removal of the benthic fauna and its recolonization potential. Species endangered by the extraction of marine sediments are those which use the seabed for spawning or feeding. Sand and gravel extraction may also limit access to traditional fisheries. However, these impacts are minimal along the French Atlantic seafront, since they only concern a few square kilometres directly or indirectly, a few dozen square kilometres (OSPAR, 2000).

1.3.1.7 Aquaculture

France

Marine aquaculture is spread widely along the Atlantic coast and concentrated in several well defined areas. In France, southern Britanny and the areas around Bourgneuf Bay, Ré Island, Marennes-Oléron and Arcachon Bay, are all major sites of aquaculture (OSPAR, 2000).

Spain

In Spain, aquaculture takes place along the greater part of the coastline, being particularly important in Galicia and on the north-west coast.

The Principality of Asturias is a territory not specially gifted neither for the marine aquaculture, because of the abrupt and not very preserved coast, nor for the continental aquaculture, because of the stationary regime of its rivers, with short courses.

The continental aquaculture production is specialised in trout, and the marine one is represented by two species: the oyster and the turbot. The number of people employed in the aquaculture sector in Asturias is 84.

The aquaculture production in Cantabria in 2006 was 616.6 tons, with a total value of 2,095,000 euros. The productive process of autochthonous species is developed in certain zones of the intertidal area, and directed by cooperatives of shellfishers, farmers and Brotherhoods of Fishermen. Cantabria is the Spanish first producer of alevins in hatcheries, reaching a production of 118,900,000 units, whose value ascends to 6,492,657 euros. The aquaculture companies generate 180 employments.

The aquaculture in the Basque Country is a minority activity with a reduced development, marked by the strong competition of uses in the coast (conservation, tourism, beaches, urbanism, etc.), the low availability of floor in the coast and the meteorological conditions, which constrain the aquaculture in the open sea.

The regional production in 2006 was 775.7 tons and 3,858,000 euros, distributed among the turbot production, with 393.2 tons, and the rainbow trout production, with 382.5 tons. The aquaculture companies generate 46 employments.

Portugal

In Portugal, marine aquaculture occurs along the western and southern coasts, particularly in some of the more important estuaries. The Ria Formosa lagoon is important for mollusc culture.

Aquaculture in Portugal has maintained since 2001 a production of 8000 tons (Figure 54). Marine culture was initiated in 1984.

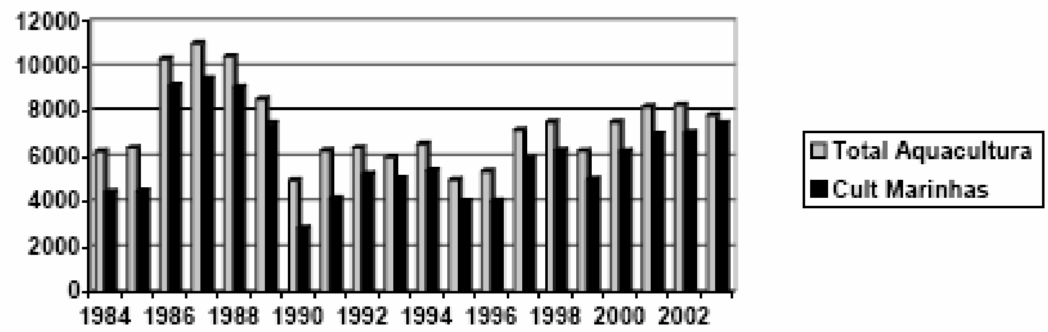


Figure 54. Aquaculture evolution 1984-2003. Grey-Total Aquaculture; Black-Marine Culture. Adapted from Pessoa, M.F. pers. Com.

In 2006 there were 1,541 aquiculture units in Portugal (including those of reproduction and fattening). Aquaculture production reached 7,893 tonnes, corresponding to a value of 43,238 thousand euros. The region of Algarve has 50% of the total weight in national aquaculture production. In 2006, amounted 3,790 tons corresponding to 25,145 thousand euros.

In 2006, a total of 5,843 tons cultivated fish had a value of 38,228 thousand euros. These were constituted, by decreasing order of quantity produced in tons, as follows:

1) Clams (*Ruditapes decussatus*) 2,246 tons corresponding to a value of 20,010 thousand euros,

2) European sea bass (*Dicentrarchus labrax*) 1,259 tons (6,607 thousand euros),

3) Gilthead sea bream (*Sparus aurata*) 1,158 tons (6,164 thousand euros),

4) Golden trout (*Oncorhynchus aguabonita*) 741 tons (1,611 thousand euros) and,

5) Turbot (*Psetta maxima*) 292 tons (2,188 thousand euros).

Bivalve mollusc species are the species most cultivated and its production amounts to 46,5% of the total aquaculture production including all species and regions. (INE, 2008b).

Pressures and impacts

The aquaculture impacts are the chemical release and the antibiotics used to control fish pathologies and the coastal physical damage in consequence of the infrastructures (Table 19).

Table 19. Categories of pressures and impacts associated with aquaculture.

Physical loss	Physical damage	Other physical disturbance	Interface with hydrological processes	Contamination with hazardous substances	Systematic and/or intentional releases of substances	Nutrient and organic matter enrichment	Biological disturbance
	X			X	X	X	X

Aquaculture is mainly restricted to the cultivation of oysters and mussels on moored rafts and long lines. These are usually located in semi-enclosed bays such as Arcachon, Marennes-Oléron, Bourgneuf, Vilaine and Morbihan, and rias such as Arosa and Pontevedra. At such sites the deposit of organic detritus beneath suspended mussels has increased the organic content of the sediment and changes the sediment structure. In some areas the rate of sedimentation is up to several centimeters per year. These changes may cause alterations at the ecosystem level (OSPAR, 2000).

Importing non-indigenous species for cultivation has introduced parasites and disease. Such parasites include: *Bonamia ostra* and *Marteilia refrigens* in oysters, and *Perkinsus marinus*, *Minchinia* (*Haplisporidium*) *tapetis* and *Vitorio tapetis* in clams (OSPAR, 2000).

1.3.1.8 Recreational, aesthetic and cultural uses

Many cities and towns are located close to the coast. Tourism and recreational activities area growing sources of disturbance in coastal areas, particularly as they often prefer areas that are also of importance to the local flora and fauna. This activity has only been reported for Spain whereas no information regarding France, Portugal and Azores has been found.

Spain

In Spain, the Galician patrimony is quite extensive (mainly ports, lighthouses and crafts, but also facilities, in different state of conservation, of fish salting or drying, riverside carpentries, saline, sea mills, warehouses for diverse uses, ramps or shipyards, old ports, etc). The main features are:

a) Galicia possesses a very diverse and quite singular Maritime Culture;

b) An important part of this patrimony has industrial or artisanal character, tied to characteristic occupations;

c) The applied protection measures have been minimum and the cataloguing initiatives have been discontinuous.

There exist possibilities of value creation starting from this "cultural capital." Mainly, an active tourism which attracts visitors and rents. Some performance lines: traditional sailing; marine routes (if possible in traditional ships); active tourism of fishing and shellfishing; rehabilitation of properties for innkeepers or nautical uses; net of museums. Almost all these activities also allow integrating the fishing communities, in an exercise of socioeconomic diversification.

In the case of Galicia, the endowment and use of resources, on one hand, and the marine communication ways, on the other, marked the development of the marine culture.

This historical interaction of the Galicians with the sea and with other towns thanks to the sea generated a group of traditions, empiric or experimental knowledge, and also the corresponding material expressions, with a wide cultural and patrimonial baggage.

Galicia has a wide mark of juridical reference on the cultural patrimony. But the Galician specificities as a marine country are not picked up in the typology of Goods of Cultural Interest, although there are many goods classified for their singularity.

The current normative mark makes the administration the backer of the patrimony and the propeller of almost all the initiatives in this field. But certain dispersion exists in the competitions in this sense. On the other hand, it is not very developed the paper of the cultural institutions and of the private initiative.

Pressures and impacts

Pressures and impacts of recreational, aesthetic and cultural uses are believed to be similar to coastal tourism impacts (Table 17 and Table 20).

Table 20. Categories of pressures and impacts associated with recreational, aesthetic and cultural uses.

Physical loss	Physical damage	Other physical disturbance	Interface with hydrological processes	Contamination with hazardous substances	Systematic and/or intentional releases of substances	Nutrient and organic matter enrichment	Biological disturbance
	X					X	

1.3.2 The intensity of those activities

Bay of Biscay and the Iberian coast has traditionally been an area of intensive fishing activity (Figure 55), particularly with the expansion of engine-powered vessels and trawling over recent decades. The region has a wider variety of fish, shellfish and molluscs of commercial interest than more northern areas and thus fishing and aquaculture are described as activities of high importance (OSPAR, 2000).

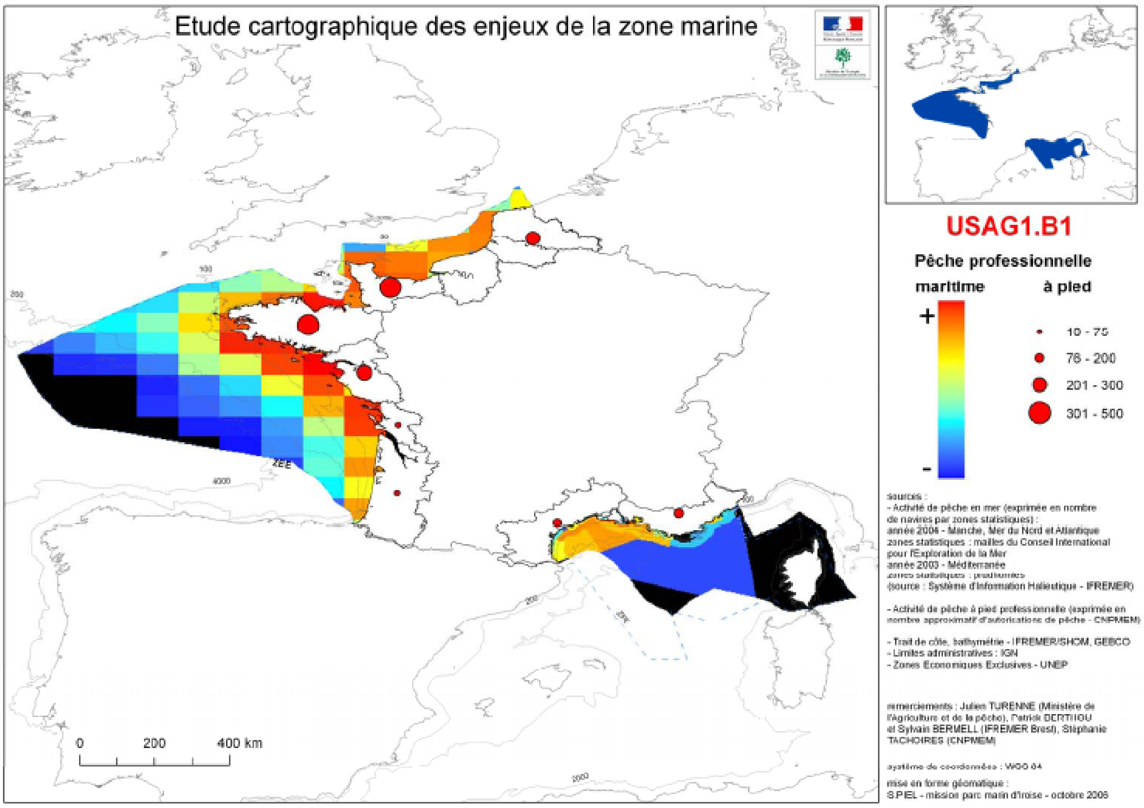


Figure 55. Intensity of fishing activities (boating and fishing on foot).

The human population is concentrated in coastal areas, creating increasing conflict between the exploitation of natural resources and the consequent development and the need for nature conservation.

Sediments are currently dredged in harbour areas, estuaries and navigation channels. In terms of the French coastal and estuarine areas of the Bay of Biscay large harbours such as Nantes and Bordeaux account for 94% of the annual input. Dredging operations in Portugal have increased over the last five years.

Maritime transport is another important human activity. Several shipping routes take place within the European northeastern waters (Figure 56**¡Error! No se encuentra el origen de la referencia.**) being the sources of TBT input to coastal environment and increasing the risk of the introduction of non-indigenous species in ballast waters.

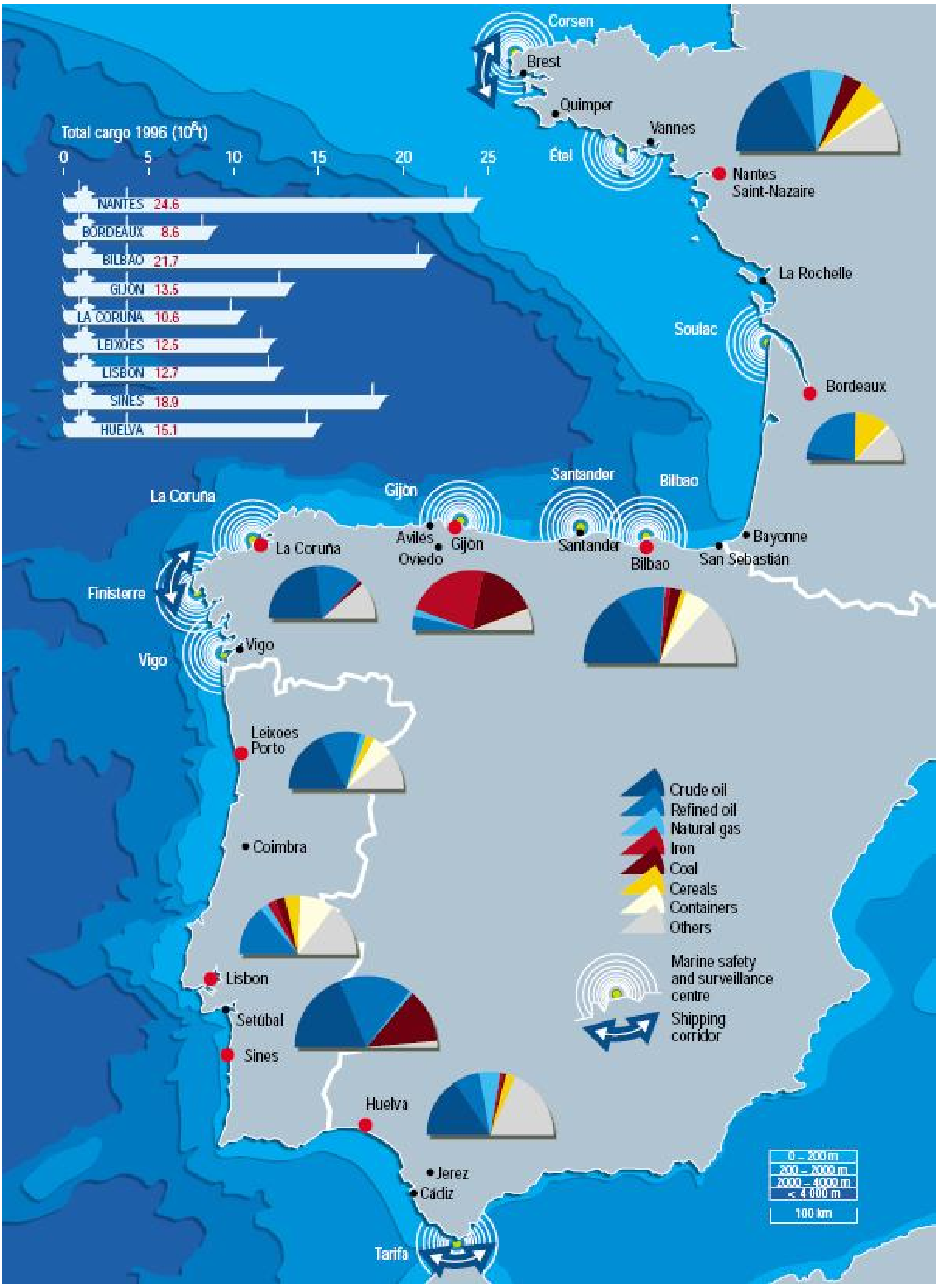


Figure 56. Shipping activity 1996. (Source: OSPAR, 2000)

In Azores, in general there are very few studies assessing the impacts from the different human activities on this oceanic region. Anthropogenic contaminants reach the sea either directly, via dumping and discharges, or indirectly via rivers and the atmosphere. Both inputs are considered low and on balance indirect inputs, far away from the region (via atmosphere or ocean transport), may be considered higher than direct ones.

Shipping and coastal maritime tourism are other relevant activities in this oceanic region. Shipping on open ocean areas may be intense but the impacts are believed to be low due to the MARPOL regulations. Shipping movements on the Azores ports are considered low and it is expected to increase but at a moderate rate. Tourism has been increased in the Azores but is not a massive as the one observed in the Canaries and so impacts are also low.

Fishing is considered the activity with major impact. However, considering the artisanal characteristic of the Azorean fleet (small scale, 90% vessels<12m) and gears (hook and lines) and the effort regulations introduced by the EC and NEAFC on deep water species in the Mid Atlantic Ridge, these impacts are presently more related with biological disturbance and considered as moderate in the open areas and intense on the island coastal areas and adjacent seamounts of the Azores EEZ (ICES, 2008c).

The Azorean region is considered in good condition since low direct human impacts are observed on the ecosystem.

1.3.3 How the human activities are likely to develop

This section covers the future scenarios that above described human activities are likely to reach.

Trends in Shipping and Maritime Transports

On the French Atlantic littoral, maritime merchandize transportation is mostly an export/import activity. Trucking and railway transports are largely dominant for the exchanges inside France. Shipping activity is mainly dominated by Nantes and Bordeaux harbours. A project of motorway of the sea is studied to connect Nantes and La Rochelle with the Motorway of the Sea of Western Europe project. In 2008 the French Goverment developed a Shipping and Maritime transport plan to renew and to develop maritime activities. In this context, large maintenance and restoration works are programmed in Saint Nazaire, Nantes and La Rochelle harbours. Economical context of the ferries activity is unfavourable, and even if the orders increased for new liners these last years, uncertainties remain about risks of saturation in the cruise demand.

The Nantes-St Nazaire-Donges harbour complex is the 4th French harbour (30 millions tons), with a multispecific activity including food-processing, hydrocarbons, shipyards... The high investment dynamics and the policy to go with new industries, result in favourable trends of the shipping activity of this site for the next years. This is also the same trends in Bordeaux (6th French harbour, 9 millions tons), linked with 300 harbours in the world, by exchange shipping activity. The economical development of the harbour is accompanied by an environmental plan to restore and maintain the littoral and estuarine environment quality in the Gironde estuary.

In Portugal, maritime transport is the most utilised type in merchandize transportation. (IPTM, 2009)

It was approved by EU to develop a denominated *Motorway of the Sea of western Europe* (leading from Portugal and Spain via the Atlantic Arc to the North Sea and the Irish Sea) (by 2010). In order to facilitate the shipping maritime traffic flow, it is currently being developed a program of 2,5 Million Euros to serve the Maritime Mottor Ways, denominated *PORTMOS Integration of the Portuguese Port and Maritime System in the Motorways of the Sea*. The PORTMOS platform is planned to support door-to-door tracking, integrated transport chain management, online booking of inter modal services, transport chain monitoring and benchmarking, including Service Performance Indicators. Currently on its early steps of life, the PORTMOS platform is pioneering the creation of Motorways of the Sea in Europe by supporting the following services: Sines - La Spezia - Sines Service**;** and, Leixões - Tilbury - Rotterdam - Leixões Service (IPTM, 2007).

Legislation:

Communication from the Commission providing guidance on State aid complementary to Community funding for the launching of the motorways of the sea [OJ 2008 C317 p.10]

Article 12a of the TEN-T Guidelines of 29 April 2004 "TEN-T" [Official Journal L 167, 30/04/2004 P.0001 - 0038, COM (2004)884]

Shipping will continue to grow as world trade expands and so it is expected also an increase of transports in the oceanic regions such as Azores. However, it may be developed in a relatively efficient and environmentally friendly way due to the MARPOL regulations.

Trends in Fisheries Professional Courses

In France 12 secondary schools are specialised in fisheries vocational courses. The context of the demand in fisheries formation is stable. About 1600 young and 2000 adults follow the course every year.

There are some schools for fisheries that are responsible for this area of certification in Portugal. There is a growing tendency on the number of courses, and students. From 2005 to 2006 was observed a success tax of 87%, (INE, 2007).

Trends in Fisheries Fleet

The French fleet has been subjected to successive reductions, in the number of boats. Trend is in a decrease of the number and size of the boats and decreasing of the number of men onboard. The number of fishing boats decreased on 21.3% in the 1995-2007 years. The 12-24 meters boats are the less renewed category. This corresponds with a 17, 4% decrease in terms of power.

The Portuguese fleet has also been subjected to successive reductions, in the number of boats. POPIV indicates a prevalence of boats with a total length less than 12m, using fixed gears. Bottom trawlers are only used in the Continent (INE, 2007).

Trends in fisheries

Globally, the fishing effort in France is not reduced in the same rates as the number of boats, because of the progress in the fishing techniques. However many fisheries as the anchory fishery of the Bay of Biscay are drastically reduced because of the overfishing. About common sole management plan aims to renew the reproductive stock and further maintain and sustainable exploitation of the stock. Many initiatives are on the course linking professional associations and stakeholders (Association du Grand Littoral Atlantique - AGLIA), and research institutes (AGRO-Campus -Rennes, Ifremer...) to improve an inter-regional approach of the stocks exploitation under sustainable fishing effort and environmental conservation (PROCET program, selectivity of *Nephrops* trawling...).

Fisheries in the Azores EEZ are considered intense, particularly on coastal areas and adjacent seamounts. It is expected an increase on the catchability (fishing power) due to the fleet modernization under the Fishery Common Policy. Considering the limited size of the traditional demersal resources and limited size of potential areas for fishing it is expected an increase on the effort of the non-traditional deep-water species, like black scabbardfish (*Aphanopus carbo*). Hence, as a consequence of deeper fishing the by-catch will tend to be a problem in the future, particularly for deep water fisheries because of fish undersizing, damaging or because quotas shall be exceeded.

Fisheries outside the Azores EEZ are mainly directed to large pelagics and, considering the actual state of the stocks, it is unlikely that the effort increases. For deep-water species it is expected a reduction on the effort due to the low level of the stock sizes and EC and NEAFC regulations introduced to control and limit the effort and catches of most important commercial species like orange roughy and grenadiers (ICES, 2008).

Trends in Offshore energy

The exploitation of wave energy is a strong stake for the future along the French Bay of Biscay because of high potential offered by Atlantic swells. The installation of windmills generators in the sea is facilitated by the large continental platform, and many plans are in embryo, in the context of the Marine Strategy Directive of the UE, and the Marine Planning along the French Atlantic coasts. Projects in exploitation of the tidal currents are mainly focusing on the Iroise Sea and Channel coasts because of the strong currents are localised in these areas.

In Spain, Galicia has good conditions for eolic energy because of the winds regime, but there is an important difficulty for the installation of eolic generators in the sea, because the continental platform is very narrow. That should forces the facilities to be relatively close to the coast, with possible interferences with other uses.

Other sources do not offer good possibilities in Galicia. The use of the tidal energy has quite strong requirements on the magnitude of the tides. There are not conditions for the oceanic thermal energy. The only profitable possibility in Galicia is the ocean current energy, but it should imply the intervention in the entrance of the *rías*, incompatible with other uses in the current moment. The energy of the waves offers possibilities in Galicia, because the potential of the wave's energy in the Galician coasts is one of the highest ones in Europe, and there are already experimental projects in this direction. It is possible to think of an important use of this source of energy in the next decades.

The Consejería of Environment and Rural Development has remitted a proposal for the installation of marine eolic parks, to be included in the strategic study of the Central Government. The Government asks to enlarge the areas of exclusion of the offshore eolic platforms to a minimum width of six miles in the whole coast, except for the port areas of Gijón and Avilés, to safeguard the landscape value of the coastal area, as well as "to guarantee the whole safeguard of the ecological and fishing values of the protected marine areas, as the *Cañón de Avilés* or the *Cachucho*."

The study catchment area considered by the previous report of the Consejería of Environment, includes a coast band of approximately 24 nautical miles measured from the straight baseline, including the interior waters defined by the same baseline. The practical entirety of the regional coast is included in the category of “zones with environmental conditioning”. However, the only areas considered in principle as capable to shelter these facilities are in front of the town of Valdés, in the coastal fringe between Gijón and Colunga and in front of the costs of Ribadesella and Llanes.

The Basque Country is one of the areas with a bigger potential for the development of the marine eolic energy in Spain.

In Portugal, in 2007 a few enterprises started to explore the energetic and economic feasibility of installing offshore wind parks (Figure 57). Some research projects are being developed by Industry and Technology Research Governmental Laboratories related to offshore energy. Research in place is on the use of hydro storage as regulation for excess wind production and on remote control of wind park clusters, etc (Simões *et al.*, 2007).

Figure 57. Technological complex for wind farms in Viana do Castelo.

Trends in coastal and maritime tourism

Recreational nautical tourism is a very important activity along the French Atlantic coasts and this is expanding despite the unfavourable economical context. This includes sailing but also the non-professional fishing largely very developed along the French coasts, especially practised by retired people. From La Rochelle to North Biscay (South Brittany) sailing is largely developed and many international sailing races are organised. The numerous islands from Oleron in the south to the Glenan archipelago in the North are well-known destinations for marine leisure. The economical importance of coastal and maritime tourism along the Atlantic coast is increasing and trends are to develop tourism activity over a longer period than the two summer holiday months. In 2003 perspectives for the French coastal policy were developed by the "commission du littoral du Conseil national pour l'aménagement et le développement du territoire” (CNADT) and 10 proposals considered all the main features of the activities and occupation of space along the coasts to harmonise the tourism activities, the exploitation of marine resources, and the conservation of the littoral environment. Since this period, a concerned planning of the tourism activity facilitates a policy at the region scale. The application of the European directives facilitates creation of Marine Protected areas and the French Marine Protected Area Agency helps in the planning and the integrated management of the littoral and coastal sea. The Conservatoire du Littoral is a representative agency for the French State which buys the coastal areas for its conservation, and more than 880 kms, corresponding with 100 000 ha of the seashore, are definitely protected.

Among the new alternatives, a singular one is the seafaring tourism, combination of fishing and tourism with a plural objective: the fixation of population to carry out more polyvalent activities; alternation in the calendar with the fishing activity; appraisement of the attractiveness of the coast (landscape and culture); offer of products of the sea, impulse to the incorporation of women and young.

Another alternative is the recreational nautical tourism, with several possible objectives: important pull effects (construction and repair, equipment, rent, school, etc.); employment alternatives in ports and compatibility with fishing; valorisation of the good conditions of Galicia (almost 1,500 km of coast, many beaches and ports of refuge).

Based on the current analysis of the situation of the highly fishing dependent municipalities, the Basque Government adopts the global strategic goal of the reduction of the dependence that the coastal areas have upon the fishing extractive sector.

To this end, the Government intends to develop the green tourism pertaining to the own natural resources, and to areas of Euskadi with a great fishing tradition, where a fishing culture exists, as a vital factor for the economic reactivation of the coastal areas. This will be achieved by means of the following actions:

a. Developing the sea tourism; tourism of observation of the marine environment and ethnographic tourism pertaining to the fishing activity;

b. Fostering the nautical sports;

c. Fomenting the craft work;

d. Development of sportive ports;

e. Improving the image of the Basque Country products;

f. Supporting the local entities pertaining to these ambits, facing to the elaboration and proposal of plans and integral programs to improve the infrastructures and services of the fishing areas.

Portugal contributes considerably to the EU marine and coastal tourism, which is foreseen to grow by 3% per year during the period 2005–2009 (EC, 2006). The morphological diversity of the coast, combined with a mild climate, explain its advertisement as an attractive natural area in Europe and the exponential growth of second-housing and tourism activities since the 1950s.

In Portugal, tourists are particularly motivated to visit the zones in the coast. A recent study on tourism divided the motivations of the tourists by four groups: Sun and Sea; Sightseeing and cultural touring; Nature tourism; City Break. Visitors to Portugal, where particularly observed in Sun and Sea in Algarve (84%), (Turismo de Portugal, 2008a). The main regions of destination continued to be the Algarve, Lisbon and Madeira, concentrating around 74% of total overnight stays (INE, 2007).

Accordingly to Tourism Global Organization (OMT) and following Sustainable Development National Strategy (ENDS), one of the international Directives approved by Portugal in Agenda 21 (defined in Rio de Janeiro Conference Eco-92), sustainable tourism must assure that tourism activity respect sociocultural aspects of the communities. In this context, future development strategies adopted in Portugal, must always conciliate economic progress with biological/social environment preservation (Turismo de Portugal, 2008b).

Tourism is emerging in the Azores. However, it is predicted that it will increase at a low rate.

Trends in Marine Aggregate Extraction:

In France, extraction of marine aggregates is more and more controlled in order to limit the environmental impacts. Trends in maerl beds extraction are to stop progressively the exploitation of this calcareous alga.

The exploitation of superficial mineral deposits from the continental shelf is used as a supply of sediments for different activities (e.g., for beach nourishment, industrial and construction purposes) (SANDEX, 2009). This project represents an important alternative to the usual extractions performed in rivers and estuaries, namely due to its quality, availability and transport.

The pits left after dredging are not immutable in time. They tend to infill at a rate that is dictated by the dredged volume, the depth at which the extraction was made (distance to shore) and by the hydrodynamic conditions (mean and wave induced currents) prevailing at those sites. Under certain conditions, the infill process and modifications of the near shore wave conditions around the pit might have a negative impact in the coastal sediment budget, promoting erosion at the shore. Other local disturbances are likely to occur that will produce impacts on the fauna, flora and water quality.

Trends in Aquaculture

Aquaculture along the French Atlantic coasts is mainly mollusc culture for mussels and oysters, and these activities are globally stable, even if oyster farmers suffered these two last years strong oyster mortalities. Fish aquaculture is not developed.

The Portuguese coast has potential for aquaculture given its biological/geological climatic characteristics. Nevertheless this service has not developed to its potential probably because of insuffucuent investments. Moniz *et al.*, (2000) analysed the Portuguese aquaculture over the last 10 years and verified that the decrease of the total Portuguese catches in fisheries was not accompanied by an increase on aquaculture Portuguese production.

In Azores, aquaculture is expected to develop in the next years but at low rate.

1.4 Socio-economic environment

1.4.1 The Institutional Governance Setup of Fisheries Management in the South Western Waters

1.4.1.1 Introduction to the EU Institutional Setup for Fisheries Management

Providing a schematic overview of the institutional setup underlying the governance system of the Common Fisheries Policy (CFP) of the European Union (EU) is difficult. It runs the risk of either creating the illusion of a simple system or may further confuse what is already a complex system. Figure 58 is an attempt to provide a schematic overview of the system. . The model includes the main actors in CFP governance and streams between them of knowledge, legal processes and policy/management interventions.[1]

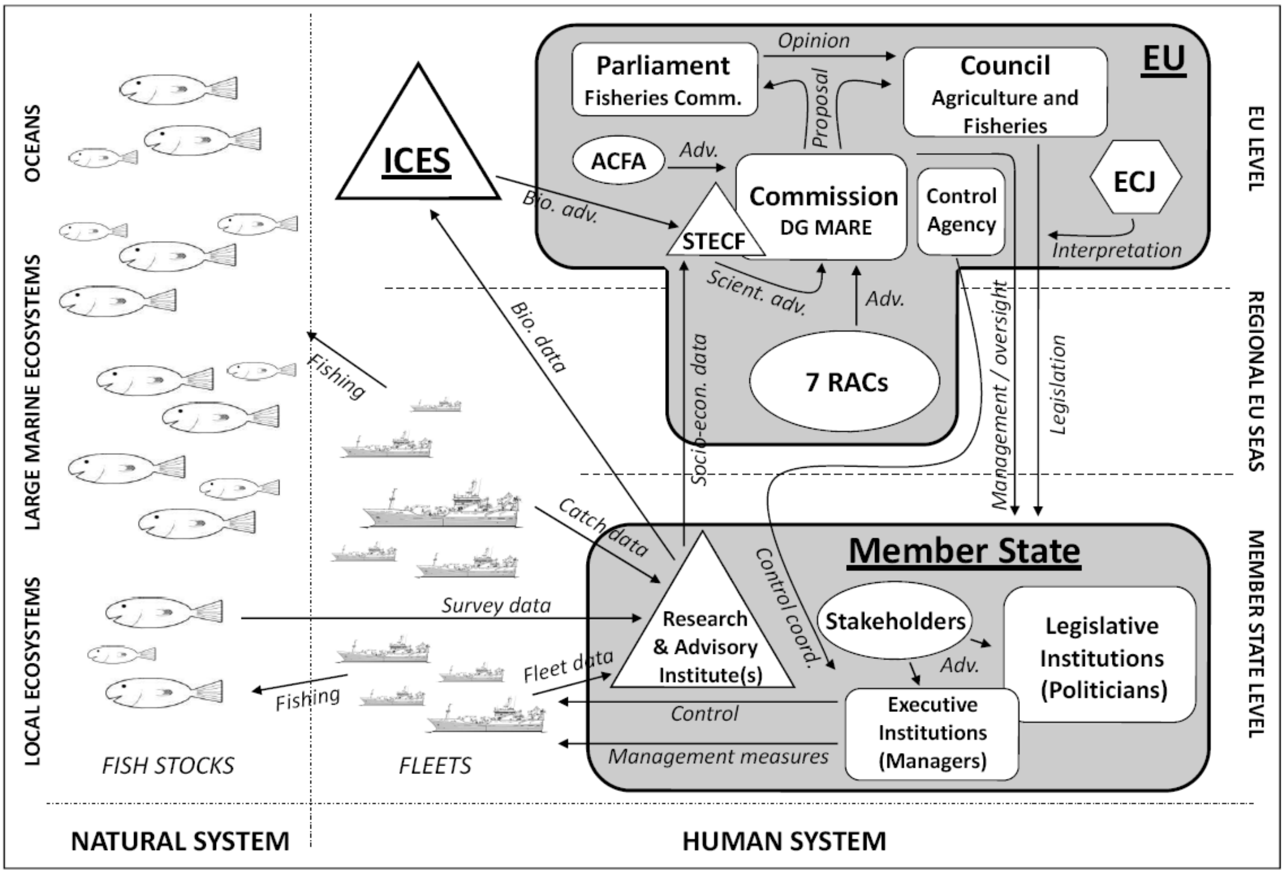


Figure 58: The Institutional Setup for Fisheries Management in the EU[2]

The scientific bodies are depicted as triangles, legal bodies as hexagons, stakeholder bodies as eclipses, and policy/management bodies as 'soft' rectangles.

Although the model in Figure 58 includes a multiplicity of actors and interactions, the model remains a simplified picture of the actual setting in which CFP governance unfolds. Other streams of interactions, as well as actors could have been added. The main institutional actors of the system are the EU and the member states. However, neither the EU nor the member states are unitary bodies, as it is evident from the model.

The human governance system can be understood as operating on several political levels. In this model, three levels have been included: EU supranational/intergovernmental level, EU regional seas level and EU member state level. However, above the EU level there is a global international level, on which the EU has signed a number of treaties, conventions and declarations dealing with fisheries policy and management among other issues. At the other end of the spectrum, there may be regional and/or local level governance considerations beneath the national level. Whilst this may not be particularly relevant for

[1] A number of publications from the last 10 years have dealt in depth with the knowledge, legal and policy/management systems related to the CFP. For an overview of the knowledge system underlying the CFP see Hegland (2006) and for a more in-depth analysis Wilson (Forthcoming); for legal aspects of the CFP see Berg (1999) and Long and Curran (2000); and for the management and policy issues, see for instance Sissenwine and Symes (2007), Lequesne (2004), Raakjær (2008), Gezelius and Raakjær (2008).

[2] Vessel illustrations from www.fiskerforum.dk.

countries such as Denmark where fisheries management is highly centralised (Hegland and Raakjær 2008), in countries such as Spain it is necessary to consider regional/local level governance issues when discussing fisheries policy and management.

The policy levels described above have counterparts to different ecological scales in marine systems. One such scale could start at a fjord or a bay, and move up to oceans and ultimately the global marine ecosystem. In between these levels, we have a relatively well-defined category of *large marine ecosystems* (LME)[3], of which the North Sea is one example. The ecologically defined scales of the natural system are not, however, necessarily reflected by corresponding levels of policy-making/management in the governance system.

1.4.1.2 History and Performance of the Common Fisheries Policy

The CFP is the fisheries policy framework of the EU. In its present, comprehensive form, it covers measures relating to markets, conservation, sector structures, external relations and control. It was first established in 1983 (Council 1983). Conservation of living aquatic resources (a main pillar under the CFP) is, as one of only a handful of policy areas, under the exclusive competence[4] of the EU. In this area it governs primarily by means of regulations that are binding and directly applicable at member state level. As such these legislative acts do not need to be transposed into national legislation. However, although the EU has exclusive competence, it is up to the member states to implement and operationalise the policy. This imbalance has made it extremely difficult to provide a level playing field for the industry across the EU.

The first acts relating to markets and fisheries sector structures were adopted as early as 1970 (Council 1970, 1970a). Since 1983, the policy has undergone reforms in 1992/93 (Council 1992) and 2002/03 (Council 2002). The next major reform is scheduled for 2012/13. Over the years the primary focus of the CFP has, alongside the general development in fisheries management worldwide, increasingly gone from being that of ensuring efficient fishing fleets and well functioning markets for fish products, towards conserving the resource base, which the sector ultimately stands and falls by (Gezelius et al. 2008). In practice, EU subsidies over the years have contributed to making the fleet more efficient, so, paradoxically, the success of the CFP in the area of developing an efficient fleet has contributed to its failure in relation to conserve fish stocks, as overcapacity is consistently mentioned as one of the fundamental reasons for the conservation failure. As a consequence, the focus of the policy has in part gone from that of developing the sector to that of conserving the stocks.

Although it has been argued that the mere adoption and maintenance of an EU fisheries policy under the prevailing circumstances must be considered an institutional success (Holden 1994; Nielsen and Holm 2006), the output that the CFP has delivered *vis-à-vis* indisputable core objectives of fisheries management has been far from impressive. At present the situation is according to Sissenwine and Symes (2007) characterised by:

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[3] The concept of a large marine ecosystem was pioneered by the National Oceanic and Atmospheric Administration, United States Department of Commerce, and a large marine ecosystem/LME is defined as an area *"of the ocean characterized by distinct bathymetry, hydrology, productivity and trophic interactions."* Information from http://www.publicaffairs.noaa.gov/worldsummit/lme.html (accessed 25 January 2009).

[4] Exclusive competence on behalf of the EU *"means that the member states cannot adopt their own legislation within the area* […] *unless that power has explicitly been given back to them"* (Hegland and Raakjær 2008: 164).

- a significant overcapacity in the EU member states' fleets compared to available resources;
- a poor profitability in large parts of the catch industry;
- overexploited stocks above what comparable regimes worldwide have been able to deliver;
- a lack of legitimacy of the management framework among industry stakeholders and conservationist non-governmental organisations (NGOs) alike;
- a continuation of environmentally destructive practices of fishing; and
- uneven and generally poor implementation and enforcement of conservationist fisheries legislation.

Consequently, although the CFP may possibly be considered an institutional success story, it is, we and many others would argue, a failure in terms of performance in nearly any other aspect. Paradoxically, the fact that the CFP can be regarded as an institutional success may in itself stand as an obstacle to decisive policy reforms since it is recognised that the fundamental political compromises that the CFP rests on, were long and hard in the making. One such compromise is the principle of *relative stability*, which stands as one of the fundamental features of the CFP. The relative stability, which was agreed in 1983, based on historical fishing patterns, outlines the fixed allocation keys to be used, after deciding on total allowable catches (TAC)[5] for individual fish stocks in specific sea areas, to distribute the fishing opportunities into national quotas to the member states (Hegland and Raakjær 2008a). This allocation key ensures relative stability in relation to fishing opportunities between member states, but it is at the same time a complicating factor in terms of reforming the CFP, as any proposal that directly or indirectly potentially impinges on the relative stability is *per se* highly contentious among the member states.

Although the magnitude of the failure cannot exclusively be blamed on the internal properties of the policy regime, which arguably in the EU is operating within a particularly complicated context of 'mixed and multi-everything'[6], there seems as of today to be a broad agreement on the fact that the policy regime seen in isolation has functioned far from optimally (e.g. Raakjær 2008; Sissenwine and Symes 2007; Gezelius and Raakjær 2008; Commission 2008; European Court of Auditors 2007).

In the following sections we will, with reference to Figure 58, briefly introduce the institutions and actors at the different levels as well as present their roles in the governance system. We will start at EU level and move downwards.

1.4.1.3 EU level Institutions and Actors

The formulation, adoption and implementation of EU fisheries legislation is, as it is evident from Figure 58, a process involving a multiplicity of actors and institutions operating on various levels in the political system. The standard procedure of EU fisheries policy-making involves that a unit within the Directorate General for Maritime Affairs and

[5] The overall TACs are ultimately set by the relevant ministers in the Council of the European Union acting on a proposal from the Commission; the decision is in short based on a combination of scientific advice on the state of the stocks and socio-economic considerations.
[6] The CFP have to stretch across more than 20 member states with very diverse fishing fleets; the fleets of the member states apply a multiplicity of fishing practices and gears; many of the important fisheries inside the EU are mixed fisheries (i.e. fisheries where multiple species are caught at the same time), a feature that is known to be a challenge for any fisheries management system as the fishermen are not able to control the composition of fish species in the catch.

Fisheries (DG MARE) (which is the relevant directorate-general within the Commission of the European Communities (Commission)), drafts the envisioned piece of legislation. In this process, DG MARE incorporates to varying extents, depending on the nature of the proposal, input from stakeholders and/or scientific bodies. Once the draft proposal has been agreed according to the internal procedures of the Commission, it is forwarded to the European Parliament (EP, Parliament), which under the consultation procedure[7] that covers fisheries issues, has the right to be heard on fisheries matters. Once adopted according to the internal rules of the Parliament, the resolution, usually in the form of suggestions for amendments, is forwarded to the Council of the European Union (Council). The Council receives the proposal from the Commission at the same time as the Parliament, and it is technically the Council that consults the Parliament. The Council is, however, not obliged to implement the Parliament's amendments. In the Council, the relevant ministers in the Agriculture and Fisheries Council discuss the proposal and vote on it. Once adopted (possibly in a revised form), it is passed on to the member states for implementation. Should disputes on the interpretation of EU fisheries legislation arise, it is ultimately up to the Court of Justice of the European Communities (ECJ) to make a ruling (Hegland 2004, Hegland and Raakjær 2008a).

In the following sections, we provide a brief overview of each of the institutions of relevance at EU level in the governance system as presented in Figure 58.

1.4.1.3.1 Commission

The Commission serves as the EU bureaucracy in the area of fisheries policy as in most other policy areas. However, compared to a traditional, national bureaucracy, the Commission has a considerable degree of authority and political power *vis-à-vis* the main decision-making body of the Council (see section 1.4.1.3.3). The Commission fulfils a number of other functions in the EU system, but in the following we will focus on the role of the Commission as the developer and proposer of legislation. However, as indicated in Figure 58, other important tasks of the Commission in the area of fisheries include carrying out direct management (e.g. by filling out Council legislation with more detailed or technical legislation) and overseeing that the member states fulfil their obligations, and if they are not take action possibly by referring disputes to the Court of Justice of the European Communities (see section 1.4.1.3.5).

It is the Commission that drafts and proposes new legislation in the area of the CFP. Furthermore, the Commission is also an active player in the negotiations with the Council, although without the right to vote. This means that it is not possible to draw a clear line between the political system and the bureaucracy/administration in the EU to the same degree as in national systems (Hegland and Raakjær 2008a).

In practice, a Commission proposal, communication, paper etc. relating to fisheries is drafted in the relevant office under the relevant Directorate under the Directorate General for Maritime Affairs and Fisheries (DG MARE).[8] In drafting the proposal DG MARE takes to a

[7] It should be mentioned that the Lisbon Treaty, which is currently under negotiation/adoption in the EU, entails that fisheries policy issues will in the future be dealt with under the co-decision procedure, which gives the EP considerably more power in the area.

[8] There is as of February 2009 six Directorates under DG MARE: Directorate A: Policy development and co-ordination; Directorate B: International affairs and markets; Directorate C: Atlantic outermost regions and Arctic; Directorate D: Mediterranean and Black Sea; Dirctorate E: Baltic Sea, North Sea and landlocked member states; Directorate F: resources (DG MARE administartion). Information from DG MARE's website: http://ec.europa.eu/dgs/fisheries/organi/oganig_en.pdf (accessed 18 February 2009).

varying extent, depending on the nature of the proposal, information from other relevant Directorate Generals, various committees, institutions and organisations into consideration. If scientific expertise is needed to draft the proposal, DG MARE is particularly dependent on information from other sources, as there is limited in-house scientific capacity (Commission 2003). The International Council for the Exploration of the Sea (ICES) (see section 1.4.1.3.6) and the Scientific, Technical and Economic Committee for Fisheries (STECF) (see section 1.4.1.3.1.1) are of particular importance in these instances. The Regional Advisory Councils (RACs) (see section 1.4.1.4.1) are now also consulted on a routine basis on most of the substantial initiatives from DG MARE.

Once DG MARE has received the information it has deemed necessary from the various sources, the responsible Directorate finishes drafting the proposal and passes it upwards through the Commission hierarchy. Ultimately, the proposal is dealt with in the College of Commissioners, which consists of 27 Commissioners, each appointed by a member state. However, the Commissioners are supposed to act on behalf of the EU and not on behalf of a member state, something which cannot, however, always be taken for granted in general or in fisheries in particular (see Hegland 2006: 223, footnote 2 for an illustrative example). The Commissioners can then accept the proposal (in that case it is passed on to the European Parliament and the Council), reject it, refer it back for re-drafting or decide not to take any decision whatsoever. The Commissioners decide by simple majority voting and individual votes as well as results of votes are confidential (Hegland 2006).

The Council and the Commission are, partly as a consequence of the blurred situation in relation to the lines between the political system and the bureaucracy/administration in the EU, engaged in a continuous negotiation over what the responsibilities of the two institutions should be. It is in the Commission's interest to frame issues as being administrative in nature (to gain control over them), and it is in the interest of the Council to frame issues as being political in nature (to keep control over them). Hegland and Raakjær (2008) describe the debate during the negotiations leading up to the 2002 reform on who should be in charge of setting the TAC once a multi-annual management plan for a specific species had been adopted by the Council as an example of a dispute of this kind. The Commission proposed that the question of the TAC for subsequent years should, by default, be dealt with by the Commission itself and only be referred to the Council if a Management Committee set up under the Commission and consisting of member states' representatives could not support it. This proposal was rejected by an almost united Council taking the stance that the setting of TACs is a politically issue even if subject to a multi-annual management plan.

Following Hegland (2004), the Commission is broadly perceived as being in favour of increased integration within the various policy areas. Consequently, increased integration can be said to be the institutional preference of the Commission bureaucracy. In the area of fisheries, increased integration has often been equated with stronger central powers on behalf of the Commission, as illustrated by the work of Holden (1994), a long-time high ranking Commission civil servant in the directorate general dealing with fisheries. Furthermore, according to Lequesne (2000), Commission officials view themselves as guardians of expertise, especially biological expertise, as opposed to governments, which are vulnerable to lobbying efforts from the industry.

1.4.1.3.1.1 Scientific, Technical and Economic Committee for Fisheries

The Scientific, Technical and Economic Committee for Fisheries (STECF) is the independent committee, appointed by the Commission that advises the Commission / DG

MARE on matters where scientific knowledge is vital. The committee consists primarily of scientists with a background in marine biology or ecology, fisheries science, nature conservation, population dynamics, statistics, fishing gear technology, aquaculture, or the economics of fisheries and aquaculture (Commission 2005). STECF forms internal sub-groups, which can include experts from outside the STECF (Commission 2003)

STECF and its sub-groups draw to a large extent on the same (limited) pool of expertise as the International Council for the Exploration of the Sea (see section 1.4.1.3.6), which according to the Commission (2003) has led to repetitive work on behalf of some of the STECF members, as one of the main tasks of the STECF is to review scientific advice emanating from ICES. Notably, besides reviewing advice and advising the Commission on its use, STECF contributes with economic calculations on potential effects of the predominantly biological conclusions on selected fleets. This work is carried out in the Subgroup on Economic Assessment and constitutes the sole source of systematic economic advice to DG MARE; a task of the STECF, which is considered increasingly important (Commission 2003, Hegland 2006).

According to Hegland (2006: 226) the wide overlap between the experts within ICES and the STECF should not conceal the fact that experts when working in STECF in some instances can come to different conclusions or recommendations than when working within the context of ICES:

> *"STECF tends to be able to provide advice on issues, and in a manner, which ICES is not - even on issues within its area of expertise. Part of the reason for this is that the same scientists accept different approaches, depending on whether they are working within or outside the ICES system. Within STECF the scientists are free to act more as consultants responding to whatever is required from the customer, DG Fisheries [now DG MARE], without having to consider, to the extent that ICES does, if the requests are reasonable or if answers can be misused."*

Besides this institutional reason, it should also be mentioned that the issues are discussed by another group of scientists and the conclusions may reflect that the balance between scientists of differing opinions and perspectives has changed.

1.4.1.3.1.2 Advisory Committee on Fisheries and Aquaculture

The Advisory Committee on Fisheries and Aquaculture (ACFA) is a consultative body set up in 1971 by the Commission to provide stakeholder input from European-level stakeholder groups and umbrella-organisations on fisheries matters (as opposed to the RACs, see section 1.4.1.4.1). The mandate of the committee is to issue opinions and resolutions on fisheries issues and proposals emanating from the Commission.

ACFA was reorganised in 1999 and 2004 and is currently organised with four working groups under it. The plenary committee consists of representatives of private ship-owners, cooperative ship-owners, employed fishermen, producer organisations, stock-breeders of fish, mollusc/shellfish stock-breeders, processors, traders, consumers, environmentalists, and development organisations. ACFA is numerically dominated by representatives of the fishing industry. ACFA's four working groups are: 1) Access to fisheries resources and management of fishing activities, 2) Aquaculture: fish, shellfish and molluscs, 3) Markets and Trade Policy and, finally, 4) General questions: economics and sector analysis (Commission 1999, 2004, Hegland 2006).

According to Lequesne (2000), the actual impact of ACFA on Commission proposals has over the years been limited. Consequently, he argues, "[t]*he core raison d'être of the Consultative Committee* [ACFA] *has been an exercise in mutual legitimization"* (Lequesne 2000: 353).

1.4.1.3.2 European Parliament

As described in section 1.4.1.3, the European Parliament (EP, Parliament), which consists of democratically elected parliamentarians from the 27 member states, has the right to be heard in relation to fisheries issues. The consultation procedure dictates that the Parliament has little decisive power in the area of fisheries, and as such the power of the Parliament lies mostly in the pressure it can exert by it being a democratically elected body and as such representing the voice of the EU citizens.

Most of the work towards fisheries resolutions is carried out in the standing Committee on Fisheries, which, after having discussed the issues based on a report drafted by one of its members, adopts a proposal for a resolution by a simple majority. This proposal for a resolution is subsequently dealt with by the Parliament in plenary, where each proposed amendment has to gather a majority of present parliamentarians. When the Parliament has arrived at a compromise in the form of an adopted resolution, this is forwarded to the Council, which is, as mentioned in section 1.4.1.3.3, not obliged to implement the Parliament's opinion under the consultation procedure. Although the Parliament is technically consulted by the Council and not by the Commission, the latter can choose to amend its proposal in light of the Parliament's opinion before the negotiations in the Council but, again, there is no obligation to do so (Hegland 2004, 2006).

Given its status in the consultative procedure, the power of the Parliament is, as mentioned above, limited. Nonetheless, stakeholders such as environmental non-governmental organisation (NGOs) and industry organisations alike, which have traditionally felt deprived of fair access to the EU fisheries policy-making process, have used the Parliament as a route for lobbying particularly the Commission through parliamentarians (Lequesne 2000). Anyway, it seems reasonable to expect that this kind of indirect lobbying has become less appealing to NGOs given the formalised role these groups now have through the RACs (see section 1.4.1.4.1). Notably, the Lisbon Treaty, which is currently under negotiation/adoption in the EU system, suggests that fisheries policy issues will in the future be dealt with under the co-decision procedure, which gives the EP considerably more power in this area.

1.4.1.3.3 Council of the European Union

In the Council of the European Union (Council), the member states are each represented by their minister responsible for fisheries issues. These ministers meet in the Agriculture and Fisheries Council, which acts as the primary decision-making body in relation to the CFP.

Fisheries policy issues in the Council are subject to qualified majority voting (QMV), which means that no single member state is in a position to block a proposal coming from the Commission. The member states hold different numbers votes in the Council; the largest member states have most votes but the smaller member states have more votes than the size of their populations would strictly suggest.[9] The total number of votes in the Council is 345, and a qualified majority is reached when there is 255 votes (73.9%) in favour, on the condition that 1) the votes in favour are cast by simple majority of member states (in some cases other than fisheries 2/3 of the member states) and 2) that the votes in favour represent at least 62% of the total population of the EU (this provision is only relevant is a few cases of alignment within the Council and it is only invoked on specific request from a member state). In practice abstentions under the QMV procedure count as negative votes and a blocking minority is thus constituted by 91 votes or abstentions (or a simple majority of member states or votes representing more than 38 percent of the EU population).[10]

The question of how often a member state finds itself in the favourable position to decide if a proposal is adopted or not depends, consequently, on its size (number of votes and size of population), and on the prevailing coalition patterns within the Council. Coalition building was particularly evident in connection with the 2002 reform where three different positions could be observed in the Council:

> *"The Commission, which does not have the right to vote, but nevertheless plays an important role in Council negotiations and the decision-making process in general, proposed a radical reform, which bore the marks of a conservationist world view. One position was assumed by a network of member states, which informally referred to themselves as the 'Friends of Fish' (FoF), composed of Germany, the UK, Sweden, the Netherlands, and Belgium - and to a lesser extent Finland, which had opposing views to the rest of the network on especially the question of structural aid. FoF were in favour of a comprehensive reform, but were less radical than the Commission in terms of conservationist focus. The network's nickname was chosen in response to the opposing group of member states who referred to themselves as 'Amis de la Pêche' (AdlP), or in English 'Friends of Fishing'. AdlP was composed of France, Spain, Ireland, Portugal, Italy and Greece and had been formed around December 2001 in response to the Green Paper and what they saw as an overly conservationist approach from the Commission. These member states, which to a large extent argued from a social / community perspective, engaged in an unprecedented level of coordination of strategies, meetings at high levels, publication of joint conclusions and counterproposals, etc."* (Hegland and Raakjær 2008: 153, drawing on Hegland 2004)

In practice, it is only a limited number of fisheries issues that actually reach the level of ministers. The Council is a hierarchical structure where proposals are initially scrutinised by member states' civil servants in one of the two working groups dealing with fisheries issues: the External Fisheries Working Group/Working Party on External Fisheries Policy deals with relations with third countries, and the Internal Fisheries Working Group/Working Party on Internal Fisheries Policy deals with conservation, markets and structures. The least contentious issues can be negotiated at this level where also the Commission can choose to amend its proposal if it encounters too much opposition and the Commission is not adamant about holding on to a specific position. Questions of a more contentious nature are passed on upwards to the higher ranking civil servants in the Permanent Representatives Committee (Coreper). Only the most politically sensitive issues are discussed in substance and subsequently decided on by the ministers in the Council; the Agriculture and Fisheries

[9] 29 votes: France, Germany, Italy, and United Kingdom; 27 votes: Spain and Poland; 14 votes: Romania; 13 votes: Netherlands; 12 votes: Belgium, Czech Republic, Greece, Hungary, and Portugal; 10 votes: Austria, Bulgaria, and Sweden; 7 votes: Denmark, Finland, Ireland, Lithuania, and Slovakia; 4 votes: Cyprus, Estonia, Latvia, Luxembourg, and Slovenia; and 3 votes: Malta.

[10] The information on the voting rules from the EU's website: http://europa.eu/institutions/inst/council/index_en.htm (accessed 18 February 2009).

Council meets approximately once a month in Brussels or Luxembourg. One of the issues, which are normally dealt with by the ministers themselves, is the yearly setting of TACs, which traditionally has taken place at a marathon meeting in Brussels in the second half of December (Hegland 2006). This is however, rapidly changing due to advice now being delivered earlier from ICES.

Although there is, as described above, a voting arrangement in the Council, networking and informal contacts and communication remain extremely important in Council negotiation processes on fisheries issues. The informal communication serves multiple purposes, e.g. leaking one's own and getting other countries' positions in order to explore possible compromises or gaining a better understanding of other member states' underlying motives (Hegland 2004).

1.4.1.3.4 Community Fisheries Control Agency

The recent establishment[11] of the independent Community Fisheries Control Agency (CFCA) is an integral element in the progressive implementation of the 2002/03 reform of the fisheries policy framework, and the objective of the CFCA is to strengthen the uniformity and effectiveness of enforcement across the EU territory. This should be done by assisting with the organisation of operational cooperation and coordination of monitoring and enforcement activities among member states (Council 2005).

The powers of the CFCA are highly limited and it is specifically stated in its legal foundation that the agency does not have the power to impose additional obligations on the member states besides those outlined in the basic regulation of the CFP. Neither does the agency have any powers to sanction member states (Council 2005). With its staff of 49 as of 2008 (Community Fisheries Control Agency Undated), the agency is amongst the seven smallest EU level agencies out of the 30 examined in Egeberg, Martens and Trondal (Undated). In practice the main task of the CFCA is to adopt 'joint deployment plans' (for specific stocks in specific sea areas) with the aim of coordinating the use of the different member states' human and material resources related to control and inspection as well as solving issues related to how and when control and enforcement activities of one member state may take place in waters under the sovereignty and jurisdiction of another member state, among other things. The relevant RACs should be involved in developing the plan (Council 2005, Community Fisheries Control Agency Undated a).

1.4.1.3.5 Court of Justice of the European Communities

The Court of Justice of the European Communities (ECJ, Court) is the legal body mandated to rule in disputes on the interpretation of EU law (including fisheries legislation) and thereby settle disputes between citizens and member states, between member states and EU institutions, as well as between EU institutions or between member states etc. In principle, the Court is a neutral actor in the governance system. However, as briefly mentioned in Hegland (2004), the Court has in some instances been accused of having engaged in 'judicial activism' to favour increased integration.

[11] Operational from 2007 in Brussels and physically set up in Vigo, Spain, in 2008.

1.4.1.3.6 International Council for the Exploration of the Sea12

The International Council for the Exploration of the Sea (ICES) is an international scientific organisation covering the North East Atlantic and is the predominant source of scientific input to the decision-making process relating to the CFP. The science is almost exclusively biological, and mainly in the form of stock assessments, which are essentially statistical interpretation of sampling programmes. However, it is important to note that ICES is not an EU institution and that ICES delivers advice to a range of clients besides the EU. Nevertheless, the EU is its largest client. ICES has 20 member states[13] and six affiliate states.[14] The basic units of ICES are individual marine scientists, primarily fisheries scientists, drawn from national scientific institutes or universities. The ICES network of scientists consists of approximately 1600 persons.

ICES' advice is based on data provided by national scientific institutes in either the shape of fisheries-independent data (e.g. from trawl surveys carried out by research vessels) or fisheries-dependent data (e.g. catch statistics from commercial vessels). Within the ICES system, the data from the various sources are analysed in a large system of working and study groups and turned into scientific advice for ICES clients'. Their clients include governments and international organisations with marine management responsibilities of which the EU is the single largest. Within the ICES system, it is the practice that the Advisory Committee formally formulates, adopts and submits advice to the clients.

The national institutes are funded by their national governments to attend meetings, but universities must procure their own funding. In respect to specifically EU member states, an increasing amount of work is funded by the Commission. The budget of ICES, with its staff of 47, does not cover more than coordination activities and ICES is as such mainly a secretariat bringing together scientists without the means to actually pay them. ICES is consequently highly dependent on the national institutes and universities having sufficient funding. That the EU is ICES' largest client means among other things that ICES is particularly responsive to the requirements and political signals coming from there (Hegland 2006).

1.4.1.4 Institutions and Actors at Regional EU Seas Level

There are relatively few institutions situated at regional levels (Figure 58). Common to all the regions discussed in MEFEPO are the presence of a Regional Advisory Council (RAC). MEFEPO is using this regional management unit for its research. Besides the RACs, there are a few additional institutions of particular relevance for individual regions. Both RACs and other regionally relevant institutions will be dealt with below. Initially we will discuss the RAC set-up from a generic point of view before introducing the specific RACs of the region in question. Given the strong link between the RACs and the MEFEPO project, we will go slightly more in detail with the RACs and other regional institutions than with other institutions.

1.4.1.4.1 Regional Advisory Councils

[12] This section builds in part on information from the ICES website: http://www.ices.dk/ (accessed 16 February 2009).
[13] The ICES member states are Belgium, Canada, Denmark, Estonia, Finland, France, Germany, Iceland, Ireland, Latvia, Lithuania, the Netherlands, Norway, Poland, Portugal, Russia, Spain, Sweden, the United Kingdom, and the United States of America.
[14] Australia, Chile, Greece, New Zealand, Peru, and South Africa

Seven Regional Advisory Councils (RACs) were set up under the CFP following the 2002 reform. These are stakeholder fora consisting predominantly of representatives of the fisheries sector, defined as *"the catching sub-sector, including shipowners, small-scale fishermen, employed fishermen, producer organisations as well as, amongst others, processors, traders and other market organisations and women's networks"* (Council 2004: art. 1), which according to the legal foundation should have 2/3 of the seats. The remaining 1/3 is to be filled with representatives of other interest groups, including *"amongst others, environmental organisations and groups, aquaculture producers, consumers and recreational or sport fishermen"* (Council 2004: art. 1). Other than the members, a number of people can be involved either as experts or active observers. These include Commission representatives, member state representatives, scientists, representatives from third countries etc. The RACs are primarily meant to function as advisory bodies towards the Commission but member states can also draw on the RACs for resolutions. The RACs are also mandated to issue resolutions on their own initiative (Council 2002). The Commission (or the member state authorities) is not obliged to follow a recommendation from a RAC and, therefore, in practice the advantage of following a recommendation from the RAC will always be weighed against other preferences of those receiving the recommendation. A critical discussion of the lack of formal powers of the RACs can be found in Gray and Hatchard (2003).

The RACs are either organised along specific sea areas roughly corresponding to large marine ecosystems / regional seas (five RACs[15]) or specific types of fisheries (two RACs[16]) (Council 2004). It is noteworthy that the introduction of RACs introduced a new political level in EU fisheries management which meant there was, for the first time, a close one-to-one match between a level of management in the governance system and a biological, ecological scale in the natural system (see Figure 58). Each RAC consists of a General Assembly (GA) and an Executive Committee (ExCom). The membership of particularly the GA is rather fluent from year to year, particularly for RACs with many smaller organisations in the GA. However, in practice most of the work on the resolutions is done in a number of specific working groups set up under each RAC. It is the ExCom that adopts recommendations, as far as possible, by consensus. However, if it is not possible to arrive at a compromise that is acceptable to all, then decisions can be taken by a majority vote but dissenting opinions should then be recorded in the resolution (Council 2004). However, it is clear that generally consensus resolutions have considerably more political clout in the decision-making process than resolutions including dissenting opinions; particularly if a broad selection of RAC members both from the sector and other interests has been active in the process of drafting the resolution.

Based on a study of the process of developing a long-term management plan for horse mackerel within the Pelagic RAC, Hegland and Wilson (2008) identified a number of challenges the Pelagic RAC faced in its work on the plan. In particular, as a general challenge to the RACs, the issue of the limited access to funding emerged. This is particularly a challenge for the conservation organisations, which have to cover the meetings of most or all of the RACs because they are dealing with cross-cutting issues. On top of this, the limited access to funding complicates a number of initiatives that the RACs could potentially engage in because they have difficulties for instance paying travel costs for invited experts. However, at the same time, the horse mackerel process also evidenced a considerable capacity of the Pelagic RAC to overcome these challenges.

[15] Baltic Sea RAC, North Sea RAC, South Western Waters RAC, North Western Waters RAC and Mediterranean RAC.
[16] Pelagic RAC and Distant Waters RAC.

1.4.1.4.1.1 South Western Waters RAC[17]

The South Western Waters RAC (SWW RAC) became operational in 2007 and covers the area of the Atlantic going from the point of Brittany in its north to the Straits of Gibraltar in its south as well as the regions of Madeira, Azores and the Canary Islands.

The SWW RAC is the largest of the RACs of relevance to MEFEPO. The SWW RAC has more than 100 organisations in the GA. Table 21 beneath outlines the membership of the SWW RAC in relation to both the GA and the ExCom.

Table 21: Membership of the SWW RAC as of February 2009[18]

Organisation	Country	Representing	GA	ExCom
EAA	Belgium	Other interests	X	X
SDVO	Belgium	Fisheries	X	X
SEAS AT RISK	Belgium	Other interests	X	X
ANASOL	Spain	Fisheries	X	
ANFACO	Spain	Fisheries	X	X
ARPESCO	Spain	Fisheries	X	
ARPOAN	Spain	Fisheries	X	
Asociación de Armadores de Buques de Pesca de Marí	Spain	Fisheries	X	
Asociacion de Armadores de Ribeira	Spain	Fisheries	X	
CERCO	Spain	Fisheries	X	
Cofradia de pescadores Virgen de las Mareas	Spain	Fisheries	X	
Confederación Española Pesca Marítima de Recreo	Spain	Other interests	X	X
Cooperativa del Mar Sta. Eugenia de Riveira	Spain	Fisheries	X	
F. Cof de Pescadores de Sta Cruz de Tenerife	Spain	Fisheries	X	
FECOPPAS	Spain	Fisheries	X	
Federación Española Organizaciones Pesqueras	Spain	Fisheries	X	
Federación Gallega de Cofradías de Pescadores	Spain	Fisheries	X	X
Fedracion de cofradias de pescadores de cantabria	Spain	Fisheries	X	
ONAPE	Spain	Fisheries	X	
OP LUGO	Spain	Fisheries	X	X
OPACAN	Spain	Fisheries	X	
OPECAN	Spain	Fisheries	X	
OPEGUI	Spain	Fisheries	X	X
OPESCAYA	Spain	Fisheries	X	
OPPA	Spain	Fisheries	X	
OPPAO	Spain	Fisheries	X	
OPROMAR	Spain	Fisheries	X	
ORPAGU	Spain	Fisheries	X	
ORPAL	Spain	Fisheries	X	
PESCAGALICIA-ARPEGA-OBARCO	Spain	Fisheries	X	X
Puerto de Celeiro	Spain	Fisheries	X	
ETF	Europe	Fisheries	X	X
WWF	Europe	Other interests	X	X
ADRHMF	France	Fisheries	X	
AIPCE	France	Fisheries	X	
ANOP	France	Fisheries	X	X
ARCA-COOP	France	Fisheries	X	
Association des professionnels du pélagiques	France	Fisheries	X	

[17] This section builds for the most on information from the SWW RAC's website: http://www.ccr-s.eu/EN/ (accessed 12 February 2009).
[18] Based on information from the SWW RAC's website and from its secretariat.

CLPMEM Bayonne	France	Fisheries	X	
CLPMEM du Guilvinec	France	Fisheries	X	
CLPMEM La TURBALLE	France	Fisheries	X	
CNPMEM	France	Fisheries	X	X
Comité local de St Gilles	France	Fisheries	X	
Coopérative Audierne Port	France	Fisheries	X	
CRPMEM Aquitaine	France	Fisheries	X	
CRPMEM Bretagne	France	Fisheries	X	
CRPMEM Pays de Loire	France	Fisheries	X	
CRPMEM Poitou-Charentes	France	Fisheries	X	
Fédération Internationale de la Pêche Sportive en	France	Other interests	X	
FEDOPA	France	Fisheries	X	X
FNE	France	Other interests	X	
FROM BRETAGNE	France	Fisheries	X	
FROM SUD OUEST	France	Fisheries	X	
ITSAS GEROA	France	Other interests	X	
OP CAP SUD	France	Fisheries	X	
OP Ile d'Yeu	France	Fisheries	X	
OP Vie Vendée	France	Fisheries	X	
OPOB	France	Fisheries	X	
OPPAN	France	Fisheries	X	
Organisation de producteurs du port de la Côtinièr	France	Fisheries	X	
Pêche et Développement	France	Other interests	X	X
PROMA	France	Fisheries	X	X
SO.CO.SA.MA.	France	Fisheries	X	
UAPF	France	Fisheries	X	
C.P.O. Oost-Ned. U.A.	Netherlands	Fisheries	X	
Dutch Fisheries Organisation	Netherlands	Fisheries	X	X
AAPABA	Portugal	Fisheries	X	
AAPAP	Portugal	Fisheries	X	
AAPLCLZO	Portugal	Fisheries	X	
AAPN	Portugal	Fisheries	X	
AAPSACV	Portugal	Fisheries	X	
ACPA	Portugal	Fisheries	X	
ADAPI	Portugal	Fisheries	X	X
AIB	Portugal	Fisheries	X	
ALIF	Portugal	Other interests	X	
AMAP	Portugal	Fisheries	X	X
ANICP	Portugal	Fisheries	X	
APASA	Portugal	Fisheries	X	
APEDA	Portugal	Fisheries	X	
APISJ	Portugal	Fisheries	X	
ARTESANALPESCA	Portugal	Fisheries	X	
Associaçao dos Pescadores Graciosenses	Portugal	Fisheries	X	
Associaçao Terceirense da Armadores (ATA)	Portugal	Fisheries	X	
Associçao dos Pescadores da Ilha de Santa Maria	Portugal	Fisheries	X	
Associçao dos Pescadores Florentinos	Portugal	Fisheries	X	
BARLAPESCAS	Portugal	Fisheries	X	
BIVALMAR	Portugal	Fisheries	X	
CENTRO LITORAL	Portugal	Fisheries	X	
Cooperativa E.S. Pescadores da Ribeira Quente	Portugal	Fisheries	X	
COOPESCAMADEIRA	Portugal	Fisheries	X	
DOCAPESCA, Portos e Lotas, S.A.	Portugal	Other interests	X	
EAFPA	Portugal	Other interests	X	X
Federaçao das Ass. Armad. e OPs da Reg. Sul	Portugal	Fisheries	X	
Federaçao das Pescas dos Açores	Portugal	Fisheries	X	X
Liga para a Protecçao da Natureza (SEAS AT RISK)	Portugal	Other interests	X	X
Mútua dos Pescadores	Portugal	Other interests	X	

OPCENTRO	Portugal	Fisheries	X	
PORTO DE ABRIGO-COOP.COMERCIAL-CRL	Portugal	Fisheries	X	
Quarpesca	Portugal	Fisheries	X	
QUERCUS	Portugal	Other interests	X	
Rede Portugesa das Mulheres da Pesca-AKTEA	Portugal	Other interests	X	X
SESIBAL	Portugal	Fisheries	X	
Sindicato Pescadores do ex-Distrito da Horta	Portugal	Fisheries	X	
UMAR Açores	Portugal	Other interests	X	
VIANAPESCA	Portugal	Fisheries	X	X

The SSW RAC has set up five working groups: Working Group: VIII & IX Zone, Working Group: Pelagic and ICCAT, Working Group: Insular Subdivision, Working Group: Deep-water species, and Working Group: Ad hoc - Traditional fisheries.

1.4.1.4.1.2 Pelagic RAC[19]

The Pelagic RAC became operational in 2005 and deals with issues related to four pelagic species in all EU waters: blue whiting, horse mackerel, mackerel and herring, and the Pelagic RAC is consequently also relevant for the South Western Waters.

The Pelagic RAC is according to Hegland and Wilson (2008) among the most active of the RACs and has during its short life *"developed a great deal of institutional momentum"* (Hegland and Wilson 2008: 6). Table 22 beneath outlines the membership of the Pelagic RAC in relation to both the GA and the ExCom.

Table 22: Membership of the Pelagic RAC as of February 2009[20]

Organisation	Country	Representing	GA	ExCom
Association Nationale des Organisations de Producteurs (ANOP)	France	Industry	X	
Comité National des Pêches Maritimes et des Elevages Marins (CNPMEM)	France	Industry	X	
Confederación Española de Pesca (Cepesca)	Spain	Industry	X	X
Coopóratives Maritimes Etaploises - Organisation de Producteurs (CME - OP)	Spain	Industry	X	
Danmarks Fiskemel- og Fiskeolieindustri	Denmark	Industry	X	
Danmarks Fiskeriforening	Denmark	Industry	X	
Danmarks Pelagiske Producentorganisation	Denmark	Industry	X	X
Danske Fiskeres Producent Organisation (Danish PO)	Denmark	Industry	X	
EU Fishmeal Association	International	Industry	X	X
European Association of Fishing Ports and Auctions (EAFPA)	International	Industry	X	X
European Anglers Alliance	International	Other interests	X	X
European Bureau for Conservation and Development (EBCD)	International	Other interests	X	X
European Transport Workers' Federation (ETF)	International	Industry	X	X
Federación de Cofradias de Pescadores de Bizkaia	Spain	Industry	X	
Federación de Cofradias de Pescadores de Guipuzcoa	Spain	Industry	X	
Federation Internationale de la Pêche Sportive en Mer (FIPS-M)	France	Industry	X	
Federation of National Organisations of Importers and Exporters of Fish (AIPCE-CEP)	International	Industry	X	X
Fonds Régional d'organisation du marché du poisson (FROM Nord)	France	Industry	X	
Herring Buyers Association Limited	International	Industry	X	
Irish Fish P.O.	Ireland	Industry	X	
Irish South & West Fish Producers Organisation Ltd.	Ireland	Industry	X	

[19] This section builds for the most on information from the Pelagic RAC's website: http://www.pelagic-rac.org/ (accessed 12 February 2009).
[20] Based on information from the Pelagic RAC's website and information from its secretariat.

Killybegs Fisherman's Organisation Ltd.	Ireland	Industry	X	X
National Federation of Fishermen's Organisations	UK	Industry	X	
North Atlantic Producers Organisation	Poland	Industry	X	X
Organizacion de Productores de Pesqueros de Lugo	Spain	Industry	X	
Pescagalicia-Arpega-Obarco	Spain	Industry	X	
Dutch pelagic freezer-trawler association (RVZ)	Netherlands	Industry	X	X
Scottish Fishermen's Federation	UK	Industry	X	
Scottish Fishermen's Organisation Ltd	UK	Industry	X	
Scottish Pelagic Fishermen's Association (SPFA) Ltd	UK	Industry	X	X
Seas at Risk	International	Other interests	X	X
Seefrostvertrieb GmbH	Germany	Industry	X	X
Shetland Fish Producers' Organisation	UK	Industry	X	
Shetland Fishermen's Association	UK	Industry	X	
Skagen Fiskernes Producent Organisation	Denmark	Industry	X	
Swedish Fishermen's Federation	Sweden	Industry	X	X
Union des Armateurs à la Peche de France (UAPF)	France	Industry	X	X
University of Copenhagen	International	Industry	X	
WWF European Policy Office	International	Other interests	X	X

The Pelagic RAC has set up two working groups: Working Group I dealing with herring and mackerel and Working Group II dealing with blue whiting and horse mackerel.

1.4.1.5 The Member State Level

Aside from Norway in the North Sea, the European countries of relevance in the MEFEPO regions are all EU member states. This means, as described earlier, that they are subject to the CFP framework. In the following sections we will initially provide a generic understanding of the role and responsibilities of the member states in the EU governance system. Subsequently, we will, based on features of selected EU member states, provide a brief account of convergence and divergence between national governance systems. Although there are significant similarities between the member states, there are also differences between them, e.g. in terms of how centralised or decentralised the national governance system is, or the extent to which user groups and other interest groups are involved in the national governance system.

1.4.1.5.1 The Role of the EU Member States in the CFP Governance System

Although the conservation of resources is a fundamental pillar of the CFP, and under the exclusive competence of the EU, this does not mean that member states are powerless to protect marine resources. Importantly, as described in section 1.4.1.3.3, the member states occupy a central role in the decision-making process through their membership of the Council. Though the Commission is also a powerful actor at the EU level (section 1.4.1.3.1**)**, it is ultimately the member states themselves that adopted the legislation of the CFP.

Moreover, it is the member states that are tasked with implementing CFP legislation nationally, although most of the legislation under the CFP is adopted in the shape of regulations that are directly binding on the member states. The power of implementation does allow the member states to take national considerations into account. As discussed in Gezelius et al. (2008), the Commission is only to a limited degree able to control and sanction member states that take these national considerations too far and engage in implementation practices that are problematic as seen from central EU perspective. This is particularly the case when unsustainable implementation practices are not outright against the rules but rather against the spirit of the rules.

In terms of the setup for governance it is particularly important to note that it is the member states themselves that are primarily responsible for control and enforcement in their own waters. The basic regulation (Council 2002) and more detailed legislation (e.g. Council 1993) provide details on how control and enforcement activities should take place but much is left to the discretion of the member states. Examples of other important areas where the member states have responsibilities for fisheries management decisions include allocation of fishing opportunities and adjustment of capacity. The issue of allocation of fishing opportunities deals with the question of how to allocate the national quotas within the national fleet. The member states vary significantly on this point but there is an increasing tendency to use market based approaches such as individual transferable quotas (ITQs). The issue of adjustment of capacity deals with the question of how to determine which vessels that are taken out of the fleet to allow for the entry of new vessels. Originally the EU set targets for capacity reduction, a practice that has now been abandoned in favour of a simpler exit/entry scheme where new additions to the national fleet presuppose that existing capacity is withdrawn from the fleet.

How the national institutional setup for fisheries management looks like in practice differs from member state to member state; something we will look more at in the following section. However, in Figure 58 we have outlined the basic elements of any national system: 1) Political institutions to legislate in the areas where the member states themselves are in charge, e.g. allocation of fishing rights. 2) Managerial institutions tasked with executing the decisions of the political system including the EU. 3) Stakeholders, often predominantly from industry but increasingly from conservationist NGOs, offering advice both to managers and politicians either through formal or informal channels. 4) National research and advisory institutes that monitor the state of fish stocks (as well as carry out other research activities related to fish and fisheries) and feed data and experts into ICES and STECF. Besides the institutions depicted in the figure, there is also a national legal system. And as mentioned earlier, if the state has delegated responsibilities to regional governments then the picture gets more complicated, see section beneath.

1.4.1.5.2 Variations of National Governance Approaches in Selected EU Member States[21]

The current fisheries governance landscape in Europe is diverse regarding the dominant forms of institutional design. Much of this variation is attributable to the varying political traditions across member states.

In Denmark the national governance system is largely influenced by the political environment in Scandinavia where ‘negotiation economies’ prevail (Hoel et al. 1997; Hersoug 2005; Christensen et al. 2007, and Hegland and Raakjær 2008), applying a centralised consultation of user-groups and stakeholders in the decision-making process. This tradition is rooted in the co-operative movement, which took off more than a century ago. Policy-making in Denmark fits the tradition of corporatist management, involving industry and user-groups in the decision-making through various types of advisory bodies. The system can be characterised as ‘centrally directed consultation’.

[21] This section draws intensively on Hoof et al. (2005).

France has a tradition of territorial management and this has created a strong focus on the state. In general, decision-making arrangements are dominated by political and institutional traditions with a sector-based corporatist structure. The state undertakes a systematic consultation process at the national level and decision-making power is delegated to the regional levels as well. In parallel to the rather structured official system (with a relatively clear division of responsibilities) there is a system based on informal agreements between the different groups, the administration and political bodies (such as the state and territorial communities).

The political philosophy in the Netherlands is based on 'subsidiarity' and 'sovereignty' having the implication that the government is willing to devolve responsibility to industry. In an organisational sense this is exemplified by corporatist institutions for inclusion of sector interest, including fisheries in the Dutch economy (since 1950). Here social organisations and their elite act as interest groups. Those interest groups take far-reaching decisions in consultative bodies without consulting the parliament (Hoefnagel 2002). Recently corporatist institutions have been weakened in terms of policy making and created a vacuum for policy mediation between government and sector interests. In Dutch fisheries co-management arrangements have largely filled this vacuum, but these are not yet properly institutionalised.

The Spanish system of organising the state into autonomous communities, which are delegated legislation authority to implement basic state legislation, has led to a high level of regional self-governance. This has resulted in a rather complex and complicated administrative framework, because new authorities and structures are constantly emerging. In the Spanish fisheries management model a tension exists between the different aims that are reflected by the present division of responsibilities between the various authorities and the move towards greater involvement of the fisheries sector in the decision-making process. However, the institutional set-up for participation has be accused for an imbalanced representation having an over-representation of the fishing industry in state and autonomous communities' consultative bodies providing limited space for other stakeholder groups. Furthermore, there is an overlap in resource management powers and responsibilities between the state and the autonomous communities and boundaries are not clearly defined, seemingly resulting in management objectives not being achieved.

The United Kingdom has applied an approach in which local institutional traditions are followed with a relative high degree of regionalisation of policy-making procedures. The UK institutional setting is very old with some remnants of the feudal era still in place. There is no written constitution and a rather powerful executive. Both the executive and civil service do not routinely consult before deciding policies, and citizens do not participate in decision-making, and the civil service does not yet have a culture of sharing information with citizens. Quango's (quasi autonomous government organisations) play an important role in day-to-day management. Accountability of these is considered to be rather low. Regional decentralisation and devolution is currently being introduced, manifested by the Scottish Parliament and Scottish Assembly, Welsh Assembly and Northern Ireland Assembly. Fisheries management has to a large extent been devolved. The fishing industry is divided in numerous organisations tied to a region or a specific fleet segment. The environmental organisations are immensely popular, with large membership that provides funding for lobbying, media campaigns and research in the areas of fisheries. The executive manages fisheries without duty to consult or negotiate with the industry. Lobbyism is well known, and the industry participation is very fragmented (Symes 1996).

1.4.1.6 Characteristics of the Common Fisheries Policy Governance System

The CFP can in many ways be argued to take the form of a classical intergovernmentalist, state-centric command-and-control, top-down management system, where member states' ministers in the Council exercise strong control over the fisheries management measures, which are developed and adopted[22] on the background of proposals from the Commission. The member states are responsible for the implementation of the rules and for monitoring compliance in relation to fishing activities taking place in waters under their jurisdiction, and they report back to the Commission, which is among other issues tasked with *"making sure that CFP rules are effectively implemented and that Member States set up and apply appropriate systems and rules to manage, control and enforce the limitations on fishing possibilities and fishing effort required by the CFP"* (DG MARE 2008).

Though situated at the top of the top-down structure together with the Council, the Commission has very weak powers in relation to direct control and monitoring of fishing activities compared to the member states. Gezelius et al. (2008) analyse with outset in the principal-agent approach the relationship between the EU (in that analysis treated as principal) and the member states (in that analysis treated as multiple agents) and document how the EU, represented by the Commission, is on crucial points in a weak position *vis-à-vis* the member states. One of the key findings of the analysis is the apparent inability of the EU to sanction member states whose implementation practices conflict with the intention of the rules or the with overall political goals *but are not directly against the rules* (in principal-agent terminology this can be referred to as *non-criminal agency drift*).[23] Usually non-criminal agency drift can be moderated by amending the framework that the agents operate under to change the incentive structure or make rules less open to interpretation. However, this has often not been possible under the CFP, which to a wide extent rests on sticky historical compromises. Moreover, the member states in the Council tend to be aligned in semi-permanent groups, each able to produce a blocking minority (Hegland 2004 and Raakjær 2008). Another key finding relates to the fact that the Commission largely relies on the member states themselves in the process of monitoring and overseeing their management efforts (although conservation NGOs can and do function as watchdogs). The Commission does not have the institutional capacity or legal mandate to genuinely monitor the member states and the member states in the Council are traditionally reluctant to transfer 'police-like' authorities to the Commission. Consequently, Gezelius et al. (2008: 217) conclude that *"it is hard to escape the fact that what seems to characterise the CFP from a principal-agent perspective seems to be strong incentives for the agents to drift away from conservation and weak powers on behalf of the principal to prevent this"*.

At the other end of the top-down process, Lequesne (2004) argues that although administrations of sub-national regions in some member states do have management tasks *vis-à-vis* fisheries there is little evidence that these administrations interact directly with supranational EU institutions with loss of central state control over the fisheries policy

[22] If necessary by means of qualified majority vote (QMV).

[23] One example could be that for the most fundamental conservation measures under the CFP, the TACs and quotas, there are few incentives for the member states to catch their quotas in a conservationist manner, i.e. reduce discards (fish thrown back dead or dying in the sea because they are too small or the vessel does not have a quota for them), at least if the stocks in question are shared with other member states. Whereas the benefits of being able to fish even with high discard rates are reaped by the individual member state, the negative impact of the non-conservationist behaviour is shared among all the member states, who will receive lower quotas in the following year. This is a typical example of the "tragedy of the commons" dynamic (Hardin 1968). The EU has so far been unsuccessful in putting an incentive structure in place to eliminate this problem (Gezelius et al 2008).

agenda as a result. Moreover, the fishermen as recipients of the management measures are weakly represented in the upstream policy formulation processes. The fishermen do not have any direct say in fisheries management at EU level. Though the Commission is in its preparatory work supported by input from various sources, incl. stakeholder fora (see Figure 58); it is not obliged to include stakeholder input in its proposals. Moreover, the pan-European organisation that organises the fishermen's organisations from the largest fishing nations in EU, Europêche, is weak due to limited institutional capacity and strong disagreements among its member organisations, and consequently its impact is limited. Instead the fishermen's organisations prefer to lobby their national administrations individually, which reinforces the member states' governments as central hubs in the process.

1.4.2 Selected Reforms of the Current EU Fisheries Governance System

1.4.2.1 Providing a Level Playing Field for the Industry across EU24

The CFP framework has for a long time been widely criticised for not being able to ensure efficient and uniform control and enforcement of its legislation. In response, the Commission is currently taking action to overhaul the control and enforcement system of the CFP as a core priority. The reformed framework is projected to enter into force from 2010.

1.4.2.1.1 Describing the Problem

Two reports published in 2007 summed up the shortcomings of the current system for control and enforcement. The European Court of Auditors (2007) provided an external analysis of the enforcement system of large fisheries nations in the EU: Denmark, Spain, France, the Netherlands, Italy and the United Kingdom (England and Wales). The report tested the national enforcement systems in terms of: 1) their ability to provide complete and reliable data, 2) the application of effective inspections and 3) the application of an effective penalty system. On these points the report drew devastating conclusions with implication for the entire framework of the CFP:

> *"The incompleteness and unreliability of catch data prevent the TAC and quota system, which is a cornerstone in the management of Community fisheries resources, from functioning properly. The regulatory framework and the procedures in force guarantee neither the exhaustiveness of data collection, nor the detection of inconsistencies during validation. Nor is the Commission in an overall position to identify errors and anomalies in the data forwarded by Member States, and, to take all the timely decisions required to protect the resource."* (European Court of Auditors 2007: 49)

> *"The inspection systems do not prevent infringements and do not ensure that they are effectively detected. The absence of general standards has resulted in the existence of divergent national systems that neither ensure adequate inspection pressure nor optimise inspection activities. Furthermore, it actually limits the scope and effect of the Commission's work of evaluating national arrangements, and as a consequence limits the latter's capacity to form an opinion as to the overall effectiveness of the national systems."* (European Court of Auditors 2007: 49f)

> *"The procedures for dealing with infringements found do not support the assertion that every infringement is followed up and even less that it is subject to penalty. Even when penalties are*

[24] [24] This section and subsections build for the most on information from the Commission's websites on the reform of the control and enforcement system:
http://ec.europa.eu/fisheries/cfp/control_enforcement/reform_control_en.htm (accessed 20 February 2009).

imposed, taken as a whole they prove to have very little deterrent effect. With regard to infringements of Community legislation by a Member State, the only instrument of proven effectiveness available to the Commission is an action before the Court of Justice for failure to fulfil an obligation. This however has certain features which limit its use and make it an insufficiently responsive instrument." (European Court of Auditors 2007: 50)

Although this was not an aim of the report, it nonetheless also indicated that there is a wide variation across the six selected member states in terms of how well the national systems of control and enforcement delivers in terms of the points above. There has been little attention to this fact, likely because the variation across member states on this point is a highly contentious issue. However, Hegland and Raakjær (2008a) made a simple count of critical comments (thus without discussing the severity of them) directed towards specific member states and found that Denmark and the Netherlands each received three remarks; Spain, Italy and the UK more than ten and France almost 20. However, although with some variation across member states, the picture that the report painted was that of a system generally not functioning properly.

The report, entitled *Report from the Commission to the Council and the European Parliament on the monitoring of the Member States' implementation of the Common Fisheries Policy*, was presented to the Council and the Parliament by the Commission (2007) itself and was, although positive developments were duly noted, not much more positive in its conclusions, which included among other things in the 'negative-department' that:

"many inspectors are not fully qualified for the work required", "[t]he recording of inspection activity is patchy and not harmonised in a way that would enable results to be compared between Member States", "[p]ort inspections are too often poorly organised, some of the basic catch registration documents are still not collected in many Member States", "[a] better use of well defined risk-based strategies could increase the efficiency of the control resources", and "[i]nfringing the rules of the CFP is a risk some individual fishermen may be prepared to take given the low chance of detection of infringements or the application of any dissuasive sanctions." (Commission 2007: 7-9)

According to the report, the above shortcomings have resulted in lack of compliance with key rules of the CFP in a number of fisheries. Importantly, compliance with TACs and quotas continues to be a problem, which is especially problematic in a situation where drastic reductions in fishing mortality are called for in relation to a number of stocks. Moreover, mis-reporting of (or failure to report altogether) landings undermines the management of TACs and quotas by forcing scientists to work with estimations of actual catches in cases where official figures are not considered reliable. Furthermore, the report noted that control of fishing effort often seemed to be organised in a way that caused the least effect on actual fishing activity, that satellite tracking systems had not effectively been used to monitor fishing effort and that significant amounts of undersized fish continued to be landed (Commission 2007).

Notably, the inability under the CFP of the member states to ensure - in practice by means of Commission oversight and actions - that other member states enforce regulation strictly on their own fishermen creates a 'Tragedy of the Commons' situation where no member state views it as being in its best interest to enforce strictly vis-à-vis own fishermen (Raakjær Nielsen 1992). On its website on reform of the control and enforcement system the Commission sums up the motivations behind taking action now in these words:

"The control system is now caught in a kind of vicious circle. Inadequate control undermines the reliability of the basic data on which scientific advice is formed. Fisheries policy decisions based on this scientific advice lead to unsustainable catch levels, which impact on the stocks even more. EU and Member State inspectors are currently unlikely to discover fraudulent practices. When they do, the penalties imposed are often much lower than the potential profits to be made from overfishing. When the Commission detects a serious problem in the performance of national control systems, a lack of legal tools hampers its ability to react quickly and effectively. At the same time, new technologies offer a potential that is not used to the full."[25]

1.4.2.1.2 Control Reform

In its preparations for a reform of the control and enforcement system of the CFP, the Commission considered various general options. As a result, impact assessments of four possible strategies were carried out: The *first option* considered was to continue within the current policy framework. This option had two sub-options: one where there was no policy change (basically a continuation of *status quo*, and another where focus was put on adopting a number of implementation regulations containing technical rules to fully implement the current control regulation. The *second option* involved a recasting of the control regulation and the addition of a Code of Conduct. The *third option* included the introduction of a reform package through a new regulatory instrument in the form of a binding regulation. The *fourth and final option* considered was to centralise control at EU level with significantly increased powers for the Commission and to the newly established Community Fisheries Control Agency (CFCA) as a result. However, no real impact assessment of the forth option was carried out as this approach was at an early stage deemed as being not feasible both technically (because of it requiring a reallocation of tasks exceeding what the Treaties provide for, as well as it being extremely costly at EU level) and politically (because the member states would be unlikely to accept giving up this much power) (Commission 2008b, 2008c).

As for the remaining three options, both sub-options under option one were found not to be able to bring about the desired change in the system. The 'activist' sub-option two might in fact further add to the complexity of the legal framework, which had been identified as one of the major shortcomings of the current set-up. Option two - recasting of control regulation and Code of Conduct - was found to be able to improve the situation in some member states but not to the required degree and it would not bring about a level playing field. Consequently, the impact assessment suggested that option three would be the best choice under the prevailing circumstances, and this is the strategy that the Commission has followed:

"A complete reform of the current fisheries control regime based on a binding Regulation as considered under option 3 would not only consolidate and simplify the existing legislation, currently spread over a number of different regulations. It would also allow us to develop a new, harmonised approach to inspection and control covering all aspects from 'net to plate', to develop a common culture of compliance and to ensure the effective application of CFP rules. The outcome would be a truly global and integrated control system able to restore the confidence of stakeholders in the CFP." (Commission 2008c: 5)

According to the Commission, the proposed reform along the lines of the third option, currently embodied by the Commission's proposal (Commission 2008a), aims in

[25] Cited from http://ec.europa.eu/fisheries/cfp/control_enforcement/why_reform_en.htm (accessed 20 February 2009).

general terms to: simplify the legal framework within the area; broaden the scope for control by including previously neglected fields and other areas where a need for control has emerged; establish a level playing field for control by harmonising inspection procedures and penalty systems; rationalise the approach to control and inspection by targeting on where the risk of infringements is highest; and reducing the administrative burden partly by using modern technologies; and, finally, ensure more effective application of CFP rules by increasing the focus on controlling and verifying the member states' implementation of the rules and giving the Commission and the Community Fisheries Control Agency (CFCA) new tools to react stronger and quicker when infringements are detected.

Under the new framework the mandate of the CFCA and its Community inspectors will be broadened. The CFCA will under the new framework as proposed by the Commission be in a position to carry out on-the-spot checks on the territory of member states, to set up emergency units with special powers and responsibilities when situations that pose a serious threat to the CFP arise. Furthermore the CFCA will be the responsible institution for coordination and exchange of data between other institutions and agencies of the EU (Commission 2008a, 2008d).

1.4.2.2 Making the Decision-Making Process more Participatory

The CFP has been criticised for being *"the most top-down command and control fisheries management regime in the developed world"* (Hegland and Wilson 2008:5). Only very recently the EU has taken steps towards a more participatory approach where a wide range of stakeholders are systematically invited to give advisory input to the decision-making process and where regional considerations are made when taking decisions. A continuation of this effort towards increased regionalisation and stakeholder involvement is likely to be an important part of the upcoming 2012 reform.

1.4.2.2.1 Describing the Problem

Stakeholders have traditionally had little direct say in the decision-making process relating to the CFP. Before the 2002 reform the primary source of direct input from stakeholders to the process was the Advisory Committee for Fisheries and Aquaculture (ACFA), which has seemingly exerted little real influence (section 1.4.1.3.1.2**)**. Most influential stakeholder input was consequently brought to the decision-making process in 'processed' form, indirectly by the member states' governments, which to varying extent engaged formally and informally with national interests groups in the domestic arena. It has been argued that this lack of direct, systematic and formal inclusion of stakeholders' input at EU level has contributed to the failure of the CFP[26] in at least two ways.

Firstly, the lack of inclusion of particularly industry stakeholders has been considered to have in part *contributed to the situation of widespread non-compliance with the CFP regulations*, which came to be in wide circles regarded as irrational, arbitrary decisions from a distant bureaucratic centre - the Commission - out of touch with the realities of the day-to-day situation of the sector. Although it is ultimately the member states

[26] However, it is worth mentioning that user and stakeholder consultation/representation in the CFP decision-making process is not new. Corporatist models have been widespread for decades in the various member states. At the EU level users and stakeholders have been consulted through the ACFA since the early 1970s. This is a clear indication that it is not without its challenges to develop structures for effective stakeholder involvement in relation to the CFP.

themselves that adopt CFP legislation on the background of Commission proposals, the member states have to some extent found it convenient not to take co-responsibility for unpopular decisions and instead to some extent support this somewhat biased picture of the Commission and the CFP. Hence, most member states have consistently used the annual setting of TACs as an opportunity to bring 'victories' over the Commission home from Brussels - notably victories that have involved semi-systematic setting of TACs above the scientific advice. For some member states the picture has been the same in relation to the continued practice of allowing financial support to modernise old and build new vessels. From a political perspective, the practices of inflated TACs and financial support to increase fishing capacity are - while in themselves highly problematic - likely the most significant explanations of why the CFP has continuously failed to effectively address the issue of fleet overcapacity, which increasingly is identified as the most fundamental reason to the failure of the CFP to conserve fish stocks.

Secondly, it was considered a problem for the technical quality of regulations that input from stakeholders was not directly fed into the process of developing legislation at EU level. Stakeholders, in particular from the industry, have insight in how technical legislation works in practice - and in many instances also on how it could be made more effective and more difficult to circumvent.[27] The failure to include it and give the industry a feeling of partial ownership over the rules presents the risk that this knowledge is not employed to improve legislation and make it more robust but rather to evade legislation with negative impact on its effectiveness.

That stakeholders did not feel sufficiently included was confirmed by the consultations in advance of the 2002 reform of the CFP, which showed that stakeholders felt excluded from influencing several important aspects of the CFP, for example in the provision of scientific advice (see section 1.4.2.3 beneath) and technical legislation from the Commission. Particularly industry stakeholders felt that their experience based knowledge was not taken into account, neither by managers or politicians nor by scientists.

Besides the failure to include stakeholders, the CFP has also been accused of being too centralised and lacking a consideration of the different situations in different marine areas of the EU. Besides the fact that the Mediterranean has for various reasons never been included fully in the CFP, the CFP framework has been largely applied as a 'one-size-fits-all' management system covering all EU waters; although there is, as an example, little resemblance between the fisheries taking place in the Baltic Sea and the fisheries taking place off the coast of Portugal. There has, at least in part due to the presence of a 'one-size-fits-all' approach, been considerable reluctance in the Council to experiment with regional distinct solutions due to a fear of these solutions subsequently being applied to regions, where they are not welcomed. In part as a consequence of a one-size-fits-all and exclusive competence of the EU, EU regulations include moreover an array of micro-management regulations as the example beneath illustrates:

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[27] This is supported by Raakjær (2008) who argue that it is critical to gain support from the fishers for imposed regulations in order to ensure compliance and to introduce more flexibility in the implementation of regulations. Dialogue with fishers is a precondition for this to happen. At the same time, however, users and stakeholders have vested interest in the process and there are several examples where industry representatives have advocate for regulations that protect the interests of fishermen at the expense of conservation concerns and society at large. As well as conservation NGO's have argued for more severe restrictions on fishing that can be justified by conservation concerns. This is a clear indication of the difficulties to separate technical and political decisions in practice.

"It is prohibited to carry on board or deploy any beam trawl of mesh size equal to or greater than 80 mm unless the entire upper half of the anterior part of such a net consists of a panel of netting material of which no individual mesh is of mesh size less than 180 mm attached:

- *directly to the headline, or*
- *to no more than three rows of netting material of any mesh size attached directly to the headline.*

The panel of netting shall extend towards the posterior of the net for at least the number of meshes determined by:

- *(i) dividing the length in metres of the beam of the net by 12;*
- *(ii) multiplying the result obtained in (i) by 5 400 and*
- *(iii) dividing the result obtained in (ii) by the mesh size in millimetres of the smallest mesh in the panel and*
- *(iv) ignoring any decimal or other fractions in the result obtained in (iii)."*

(Commission of the European Communities 2001: Art 5.3)

1.4.2.2.2 Regionalisation and Greater Involvement of Stakeholders

However, as described in section 1.4.1.4.1, following the 2002 reform a number of Regional Advisory Councils (RACs) have been set up to provide input from stakeholders on issues applying to specific fisheries or specific sea areas. The RACs constitute so far the most important response to the critique arguing that (particularly sub-EU level) stakeholders have not to a sufficient degree been included in the decision-making process at EU level, and that earlier and more consequent inclusion of these stakeholders could potentially lead to both better decisions, due to their expertise from the field, and a higher degree of compliance, due to a feeling of ownership over the rules on behalf of especially industry stakeholders (Hegland 2006).

RACs were, as discussed, proposed by the Commission as purely advisory bodies as a tentative step toward more stakeholder participation in developing EU fisheries policy; the idea being that the stakeholders on a RAC will seek a consensus about fisheries management and policy issues and thereby allow DG MARE to weigh the political advantages of following the RAC's consensus against any differences between the consensus and other preferences of DG MARE (Hegland and Wilson 2008). A description of the RACs' composition and mandate has been provided in section 1.4.1.4.1.

To what extent the role of the RACs and the RAC regions will be rethought in connection with the 2012 reform remains uncertain. However, it deserves mentioning that Sissenwine and Symes (2007) in their review of the CFP award special attention to the concept of regionalisation as an option in relation to future management under the CFP. Moreover, in the first official document from the Commission on the 2012 CFP reform, entitled *Reflections on further reform of the Common Fisheries Policy,* a move to greater use of *"regional management solutions"* (Commission 2008: 8) (possibly later than 2012) is also mentioned as a major, longer term reform possibility. However, the Commission does not in this paper specifically address the role of RACs in this respect.

According to Raakjær (2008) regionalisation of the CFP is not a new idea and is in line with the thinking that led to the creation of RACs as part of the 2002 reform. The move to ecosystem approaches in fisheries management is another factor that can support regionalisation of the CFP.

However, turning again to the way stakeholders are increasingly, directly involved in CFP decision-making, besides the increased focus on including stakeholders through the RACs, the Commission is also increasingly inviting stakeholder contributions to proposed initiatives by means of open consultations announced on its website. However, the extent to which these open and broad consultations actually have any impact on Commission policy is uncertain. As the example in Table 23 beneath shows, the open consultations attract contributions from a wide variety of stakeholders.

Table 23: Contributions received: open consultation on control reform (consultation closed 5 May 2008)[28]

Type of actor	Name of contributor
Advisory body	Baltic Sea RAC Long Distance RAC Advisory Committee on Fisheries and of Aquaculture (ACFA) North Western Waters RAC
Industry	Productschap Vis European Association of Fishing Ports & Auctions Deutscher Fischerei-Verband e. V. Asociación Nacional de Fabricantes de Conservas de Pescados y Mariscos Stowarzyszenia Armatorów Rybackich Comité National des Pêches Maritimes et des Elevages Marins CNES, CLS, DCNS, Thales (Alenia Space, Airborne Systems, Maritime Safety & Security) Association Nationale des Organisations de Producteurs (ANOP) et de l'Union des Armateurs à la Pêche de France (UAPF) Docapesca Portos e Lotas SA, Delegação do Sotavento Algarvio European Association of Fish Producers Organisations / Association Européenne des Organisations de Producteurs dans le secteur de la pêche Europêche/COGECA SHOAL: Shetland Oceans Alliance
NGOs	WWF Coalition for Fair Fisheries Arrangements Conference of Peripheral and Maritime Regions of Europe The Pew Charitable Trust's EU Marine Programme Birdlife International
Mixed membership associations	FishPopTrace Consortium
Public authorities	UK Statutory nature conservation agencies
Individuals	Prof. Corrado Piccinetti Johnny Woodlock,, http://ec.europa.eu/fisheries/cfp/governance/consultations/contributions111207/33_ligue_roc_fr.pdfSea Fisheries Advisory Group, Irish Seal Sanctuary

Generally, in terms of the involvement of industry stakeholders, the Commission document on the 2012 reform emphasises strongly the need to move past the present decoupling of rights and responsibilities so that it becomes increasingly up to those exploiting the common resource to document that this is happening in the way society has prescribed:

> *"Very little can be achieved if a reform does not include elements which will motivate the industry to support the objectives of the policy and take responsibility for effective implementation. Industry incentives need to be turned around from the present set-up, where it pays to be irresponsible, to a situation where fishermen would be made responsible and accountable for sustainable use of a public resource."* (Commission 2008: 8)

[28] From http://ec.europa.eu/fisheries/cfp/governance/consultations/consultation_280208_contributions_en.htm (accessed 23 February 2009).

> *"Results-based management, where the industry is made responsible for outcomes rather than means, would be a move in this direction. Results-based management will also relieve both the industry and the legislators of part of the burden of detailed management of technical issues, to which the industry tends to adapt with solutions that are economically ineffective and sometimes even counterproductive i.e. in relation to safety at sea and energy efficiency. Results-based management can be linked to a reversal of the burden of proof whereby it is up to the industry to demonstrate that it operates responsibly in order to get access. This would lead to simplification and reverse the present incentives where it pays to withhold information or even to provide false information."* (Commission 2008: 8)

Thus, the Commission suggests that it would in principle be possible to relieve the industry of much detailed management in return for the industry itself being responsible for documenting that its actions do not result in unwanted outcomes.

Although the 2002 reform of the CFP to some extent responded to the lack of stakeholder input into the CFP decision-making process, the CFP is still far from being a policy-framework characterised by stakeholder participation. Although stakeholders are increasingly consulted through RACs or in other ways, there is still little or no role for them in terms of actually taking decisions or having responsibility for management functions.

1.4.2.3 Restructuring the Scientific Advice System relating to the CFP

The system that feeds scientific advice to the CFP decision-making process has in later years been criticised on a number of points. In the following sections we will go through some of the main issues and subsequently take a brief look at what has happened in response to the demand for reform and restructuring.

1.4.2.3.1 Describing the Problem

One of the major issues in relation to the scientific advice system for EU fisheries management has been the imbalance between the status and amount of biological advice compared to advice based on other forms of science. As also indicated by Figure 58, which is the simplified picture of the institutional set-up, it is biological institutions that dominate that picture. STECF does include particularly economic expertise and there are also in most member states institutions or individuals that carry out economic or socio-economic analyses within the area of fisheries management. However, socio-economic or economic information is not systematically fed in to the CFP decision-making system, as is the case with biological information from ICES. If at all socio-economic aspects are being considered it is not at all socio (the whole development of the community and knock on effects in the long run are hardly taking on board when evaluating ex ante a proposed management measure) and if economic analysis is included it is mere addition of cost and earning data in a short term perspective than a long term societal cost benefit analysis.

In the few cases, where socio-economic aspects are being considered they do not address important social issues, such as community development, and the knock on effects in the long run are hardly considered when evaluating ex ante a proposed management measure. Economic analyses are often of a bio-economic nature or merely an addition of cost and earning data in a short term perspective. In general, the availability of comparable and quality checked data are considered higher concerning biological issues than economic or socio-economic.

Another issue has been the inability or lack of interest from the biological advice system to include fishermen's experience-based knowledge in their analysis, or at least give fishermen better access to observing how the biological advice system works. This critique mirrors the one raised in relation to the limited inclusion of stakeholders in the overall CFP decision-making process, see above. The lack of transparency and openness of the biological advice system has, according to the critics, contributed to the lack of legitimacy of the scientific process and the CFP as a whole. The CFP is a very science dependent policy framework and it has not been conducive for the general support of it that scientific processes, which are fundamental for CFP outcomes have been taking place behind closed doors. This system appears to many outsiders to be a black box, where catch data, sometimes of questionable quality, is inserted in one end and TACs come out in the other end.

A third issue relates to the timing of the scientific advice. A particular problem in relation to this has been that the advice from ICES has not been available until very late in the year. This has meant that there has been very little time to agree on the TACs, which have to be in place by 1 January. As a result of this, TACs have traditionally been set for most stocks at a marathon meeting of the ministers on the Agriculture and Fisheries Council in the end of December. Taking decisions in this compressed way is problematic and it complicates feeding in and considering input from other sources, e.g. stakeholders. Additionally, the fishing industry have for a long time been calling for the TACs to be set earlier so that they would know their fishing opportunities for the coming year more in advance.

1.4.2.3.2 Reforms of the Scientific Advice System

The scientific advice system has in later years been undergoing a number of changes. In response to the lack of comparable data the Data Collection Regulation (DCR) is progressively being implemented and amended to facilitate the change from single stock management to fisheries or fleet-based management and the eco-system approach to fisheries management. Although primarily concerned with biological data, the regulation also calls for the collection of a range of economic and socio-economic data to provide a better basis for carrying out impact assessments of new legislation and better monitoring of the performance of the EU fleet. This must be considered as a step towards making comparable data on other than biological issues available and thus conducive for a strengthening of the possibility to get advice originating from other relevant scientific disciplines than biology.

In response to the perception of ICES as a black box, ICES has now opened its meetings to include stakeholders as observers and in some cases participants. The establishment of RACs has also had impact on the science system and strengthened the role of stakeholders in that process. ICES now have a range of stakeholder institutions that it can interact with, which was not the case before. Moreover, ICES has reorganised its internal committee structure to facilitate the kind of integrated advice that will be needed for implementing EAFM.

In response to the timing issue ICES has streamlined its processes to make the advice available earlier - often referred to as ‘frontloading the advice’. This has, however, not been a straightforward process as the advice is dependent on an institutionalised rhythm of data gathering that is not easily changed (Wilson Forthcoming). Nevertheless, as from 2008 advice will come earlier and thereby allow more time to hear stakeholders and eventually also allow the industry to know its fishing opportunities earlier.

1.4.3 Management tools

The management tools used to control the fishery activity can be divided into three overarching groups; input and output management, as well as economic incentive mechanisms. In the following we present briefly some central tools withing these three groups of management, as a more detailed study will be carried out in WP 3:

Input management: These are measures aiming at controlling the input used in a fishery. One can restrict (control) the input used in a fishery in different dimensions; area restrictions, time restrictions, entrance restrictions, gear restrictions, bycatch reduction devices.

Area restrictions refer to the closure of some physical area in the ocean, permanently or for a limited time period, for all fishing activity or for some fishery/gear/vessel types.

Time restrictions refer to the limitation of time spent on fishing, be it individual time limitations, such as days at sea, or overall limitations such as seasonal closures with regard to a fishery, gear or vessel type.

Entrance restrictions usually apply to (types of) vessels. It is used to prevent certain types of vessels from taking part in specific fisheries or to regulate the number of vessels taking part in these fisheries. Typically this kind of restriction is formulated such that vessels need a permission or licence to take part in a fishery managed by entrance restrictions.

Gear restrictions are used to regulate the types of gears to be used in specific fisheries. It is also applied to regulate the properties or amount of gear, e.g. mesh size, number or size of gillnet, traps, etc.

There also exist regulations that impose bycatch reduction devices upon vessels taking part in specific fisheries. This is in order to reduce the catch of vulnerable and non targeted species in a specific fishery...

The most applied measures belonging to this group are gear restrictions such as mesh size, vessel size and engine capacity. Also time and entrance restrictions have long traditions within specific fisheries, whereas area restrictions have lastly become more relevant at least in EU-fisheries.

Input restrictions have long historic traditions and are very common in fisheries, and all the above may be present in one single fishery. Regulating what is taken out of a fishery, or output regulations, is more recent, but has been present in industrial fisheries for many decades.

Output management: These are measures aiming at controlling the output resulting from a fishery. The most prominent examples are TAC (total allowable catch), IQ (individual quotas), bycatch regulations, and minimum landing size.

TAC (total allowable catch) is a fundamental regulatory tool in the CFP, and it sets the upper limit for the total catches of each commercial species for the EU. The total catch is then divided between each member state according to specific distribution formula, and it is then up to each member state to perform a further distribution on vessel types, gear types or according to other criteria.

Individual quotas imply that the member states distribute their share of the total quota (TAC) or parts of it to vessels (i.e. their owners). Usually the vessels already active in a fishery are assigned quotas for free (grandfathering), and the allocation of these quotas to individual vessels (owners) is usually carried out based on historic catches and participation in a fishery. As the intention of quotas often is to limit or reduce the effort or participation in a fishery, new participants usually have to buy quotas.

Bycatch regulations involve rules for what type and/or age/size of bycatch species can be landed and/or the absolute or relative size of the bycatch

Minimum landing size implies that the fish or other catch which is landed must be above a specified minimum size.

Economic incentives: These are measures by means of which a manager tries to direct the behaviour of fishermen in specific directions. The most prominent examples are tradable quotas, taxes, subsidies…

Individual tradable quotas (ITQs) are individual quotas (see above) which can be bought and sold (or leased) in a market. This implies that when a vessel (owner) is assigned a quota he/she may sell the whole or part of the quota to other vessel owners, depending on the limitations set. Usually there will be restrictions with regard to whom the quota may be sold. Allocating quotas to individuals (vessels) based on historic catches does not take into consideration economic efficiency. With tradable quotas the idea is to develop a market for quotas such that the most efficient fishers (vessels) are those that appropriate the largest share of the TAC.

Tradable effort quotas are in principle similar to ITQs, only here the entities of trade are some input or effort limitation, most commonly days at sea. Here again the most efficient agents can pay the highest price, leading the more efficient fisheries.

Depending on how the quotas are set, the fishery may create so called resource rent, i.e. profits in excess of normal profits and remuneration of capital and labour, due to the fact that fish is a free input supplied by nature. Similar resource rent can be secured in an open access fishery where effort is limited by taxes or fees;

Taxes/fees: a tax on catch or inputs in the fishery reduces the effort exerted in an open access fishery, and the resource rent is appropriated through the tax. Likewise, a licence fee can function as a fixed tax lifting the start-up costs of fishing and thereby limiting effort.

Subsidies to fishery activities have been relatively widespread. Historically they have been applied both to harvests and to inputs. The most common subsidies today refer to ship building and buy-back or decommissioning schemes in order to reduce the number of vessels in a fishery. Some “green policy” subsidies have also been applied, in order to encourage less polluting or more environmentally friendly fishing technologies.

Table 24 gives an overview of the management tools applied by some selected EEA member states.

Table 24. Management tools and their dispersion in selected EEA member states.

	Portugal	*Spain*	*France*	*Netherlands*	*UK*	*Ireland*	*Denmark*	*Norway*
Input manage								
Area restr	X	X	X	X	X	X	X	X
Time restr	X	X	X	X	X	X	X	X
Entrance restr	X	X	X	X	X	X	X	X
Gear restr	X	X	X	X	X	X	X	X
Bycatch red dev		X	X	X	X	X	X	

Output manage								
TAC	X	X	X	X	X	X	X	X
IQ	X	X		X	De facto		X	X
Bycatch reg	X		X		X	X	X	X
Min landing size	X	X	X	X	X	X	X	
Economic incentives								
Tradable IQ	X	X		X	De facto		X	X
Taxes/fees			X	X	X			X
Tradable effort quotas	X	X		X	De facto			
Subsidies	X	X (CFP)	X	?	X (indir)	X		X (indir.)

Indir means that fishing vessels are exempted from ordinary fuel taxes

As can be seen, most countries combine a wide selection of management measures. As long as the fishery activity serve multiple aims and is subdued to several considerations, having access to a selection of measures increase the possibility for reaching efficient management solutions. Hence, the widespread use of different management measures may reflect that authorities try to reach efficient (not to say optimal) management regimes.

On the other hand, the combination of a series of management tools may be te result of trying to remedy failing effect from one tool by introducing a new tool or adding new tools when the first does not have the intended effects. Hence, a combination of very many tools does not necessarily imply a good management system.

The problem connected to pick selective measures for each specified aim or consideration is that the simultaneous use of two or more measures may lead to a low-power incentive scheme, which is the case when one measure revokes the effects of another measure. Also, with several regulations and measures the enforcement becomes a comprehensive task. If this implies that enforcement becomes less strict, the agents in the fishery sector may find it profitable to cheat as the probability for being caught is low. We will come back to this discussion in WP3.

1.4.4 Socio-economic considerations

The most basic socio-economic variables are production, as measured in nominal terms, and employment.

Production is often measured as sales value. The disadvantage with this measure is that it encompasses input produced elsewhere in the economy and thus not a part of the values generated by the specific sector activity, e.g. fishing or fish processing. As an alternative, value added may be used, as this variable expresses the contribution to the value of the product (e.g. fish) made by labour and capital. Gross value added is the (sales) value of the product when all input except for labour and capital (profits and capital depreciation) is deducted. Gross value added is the basic measure in the national accounts, and an international standard for how to calculate this variable secures comparability between countries.

Employment may also be measured in different ways. In most statistics it is measured as number of persons being (legally) employed or self-employed. However, as this may hide the fact that many of these persons work only part-time, it does not necessarily give a good picture of the total labour (measured in e.g. working hours) generated in the economy. An alternative measure is thus full time employment (FTE), which translates the work that people employed in a specific sector, e.g. fisheries, carry out into full time jobs. This translation is especially important in a sector like fisheries, as, due to input restrictions and other regulations, many of the persons employed in the sector do not work full time.

Table 25 and Table 26 present value added and employment, measured as FTE, in the fishery sector and in the economy as a total for selected European fishing nations (the partners in the MEFEPO-project). To get an impression of the relative importance of this sector to the national economy, we have measured value added and employment in the fishery sector relative to the total value added and employment in the economy.

Admittedly, the fisheries' relative share of total employment underestimates this sector's real importance for employment. The reason is that total employment in the economy is measured as number of employed persons and thus does not correct for part time working, whereas the fisheries employment is measured in full time equivalents.

Table 25. Gross domestic product (GDP) and value added in the fisheries in selected EEA countries (current prices in 2006).

	Gross value added in the economy (GDP), mln EUR	Gross value added in the fisheries, mln EUR	Gross value added in the fisheries in % of GDP
Denmark	218,341	261	0.1
France	1807,462	672	0.03
Ireland	177,268	126	0.07
Netherlands	539,929	149	0.02
Norway	268,363	875*	0.3
Portugal	155,446	124*	0.08
Spain	982,303	412*	0.04
UK	1938,979	354	0.02

* estimated, assumed to account for 60% of value of landings

Source: Preparation of Annual Economic Report (SGECA 08-02), Eurostat: National accounts

Table 26. Total employment and employment in the fisheries and in fish processing in selected EEA countries.

	Total employment, (1000 persons) 2006	Full time equivalent employment in the fisheries 2006	FTE employment in the fisheries in % of total employment, 2006	Employment in fish processing (# of persons) 2003	Employment in the fisheries and in fish processing in % of total employment
Denmark	2,805	2,667	0.1	8,948	0.4
France	25,173	13,462	0.05	21,676	0.14
Ireland	2,039	3,994	0.2	3,439	0.4
Netherlands	8,206	1,893	0.02	6,382	0.1
Norway	2,353	8,600	0.365	11,380	0.88
Portugal, incl Azores and Madeira	5,159	18,124	0.35	6,300	0.47
Spain (2004)	19,748	44,212	0.22	27,000	0.42
UK	28,931	7,973	0.03	18180	0.09

Source: Preparation of Annual Economic Report (SGECA 08-02), Employment in the fisheries sector: current situation (FISH/2004/4), Eurostat: Persons: income, employment and social conditions

The value added in the fishery sector as showed in Table 25 only encompasses catching the fish. No processing or transportation is included in these figures. Having this in mind, it is obvious that the fisheries do not constitute a substantial part of the national economy in any of the selected countries. Typically, it contributes to below 0.1% of total GDP. The exceptions are Denmark and Norway, where it contributes to 0.1 and 0.3 per cent of total GDP. On average the direct fishing activities counts for 0.0825% of GDP.

Employment in the fishing sector as percentage of total employment in the economy is below 0.5%, varying between 0.02% and 0.365% among countries and with an average equal to 0.17%. Due to different measures for employment these shares are underestimates, but still cannot hide the fact that the direct fishery related employment mean very little to the total national employment in all the selected countries. Including processing does not change the picture substantially, as it only increases the relative shares up to a maximum of 0.88%.

Comparing Table 25 and Table 26, it shows that in most countries the fisheries' share of total gross value added (GDP) corresponds to its share of employment. This implies that the (labour) productivity in the fishery sector is on the same level as in the economy as a whole (average labour productivity). Exceptions are Ireland, Portugal and Spain, where the fisheries' share of total employment is higher than the share of GDP. This implies that the (labour) productivity in the fisheries is lower compared to the average labour productivity in the economy. The fact that the fisheries' share of employment is an underestimate strengthens the argument that labour productivity in the fisheries is lower compared to the average labour productivity in the economy also in the other countries listed in such tables.

EU as a whole is a large net importer of fish, with a net import in 2006 reaching 13,680 mln EUR[29]. Measured in nominal values Norway, Denmark, Ireland and Netherlands were net exporters of fish products (Denmark, however, was a net importer when measured in tonnes), whereas the other countries were net importers of fish products. Table 27 shows that fish products constitute a more significant share of total exports compared to their share of GDP[30]. Though aquaculture is included in the export data, it is still likely that this conclusion holds also for harvested products as the export share at average equals 1.17% compared to the GDP share with an average of 0.08%. As can be seen from Table 27, for all countries the export share of fish products exceed their share of GDP. This indicates that fish products may be more important for the foreign trade of the member states (plus Norway) than for the national production (gross value added as expressed by GDP).

Table 27. Total exports and fish product exports for selected EEA countries (Current prices in 2006).

	Total exports, mln EUR	Exports of fish products, mln EUR	Export value of fish products in % of total export value
Denmark	113,484	3,082	2.7
France	484,545	1,360	0.3
Ireland	141,663	359	0.25

[29] For the 25 EU-member states total imports of fish products in 2006 amounted to EUR 17,195 mln, whereas total exports amounted to EUR 3,516 mln.

[30] The shares are not completely comparable as the figures for export include aquaculture whereas the figures for value added only encompass harvested products. However, in all countries aquaculture products constitute a minor share of total production of fish products when measured in tonnes.

Netherlands	394,396	2,344	0.6
Norway	124,573	4,403	3.5
Portugal	48,204	436	0.9
Spain	259,172	2,275	0.88
UK	552,101	1,405	0.25

Source: Eurostat: National accounts

How to evaluate the contribution of the fishing activities to the national economy depends on what we compare with. As fishing is a primary production sector for obvious reasons we compare with agriculture.

Table 28. Gross value added in the agricultural sector, farm labour force and productivity in the agricultural sector and the fishing sector in 2006.

	Gross value added in the agricultural sector in % of GDP	Total farm labour force in % of total employment	Productivity (gross value added per employee) in the agricultural sector, EUR per worker	Productivity (gross value added per employee) in the fishing sector, EUR per worker
Denmark	1.0	2.0	41,100	97,860
France	1.3	3.4	27,065	49,920
Ireland	1.0	7.5	12,150	31,545
Netherlands	1.6	2.1	48,570	78,710
Norway	0.3	2.5	14,120	101,745
Portugal	1.6	7.7	6,135	6,840
Spain	2.1	5.0	20,670	9,320
UK	0.4	1.2	23,235	44,400

Source: Eurostat: Yearbook 2008

Table 28 shows that the agricultural sector clearly contributes more significantly to the national economy, in terms of gross value added and employment, compared to the fishing sector. On the other hand, when it comes to labour productivity the fishing sector far surpasses the agricultural sector. This means that the contribution per worker to GDP is higher in the fishing sector compared to the agricultural sector. Taking into consideration the subsidisation of the sectors, this conclusion is strengthened.

Also, in all countries listed in the tables there are regions where the fisheries constitute an important sector of the economy and where a substantial part of the population works in the fisheries or fisheries related activities. An interesting, but not unexpected, characteristic is the tendency to a positive correlation between the share of the employment in the fisheries and fisheries related sectors and the efforts from the municipal government to maintain fisheries as a main industry in the community. As an example, in all communities with employment shares above 15% in the fisheries and fisheries related sectors there are investments in infrastructure to support the fisheries. These investments are mainly financed through municipal, state and EU-contributions.

When discussing the fisheries and their socio-economic importance it is necessary to make a balance between the insignificance of the sector in a national context and the big importance it has in some local communities.

The local importance of fisheries activities will be closer described in the narratives presented in connection with the matrix in section 2.

1.4.5 French fishing fleet

An important French bottom trawling fishery is taking place in the Bay of Biscay with 250 of these boats targeting nephrops. Within the Bay of Biscay, the nephrops fishery represents up to 15% of the number of fishing vessels (250 out of 1600 active vessels in the area). France holds 94% of the TAC in VIII a,b,d,e areas for nephrops. For example, in 2007, the TAC was of 4320 tonnes (AGLIA, 2007).

The *nephrops* fisheries in Divisions VIIIa,b have two Functional Units, which are assessed as one entity: a) Bay of Biscay North and b) Bay of Biscay South.

Development of this fishery has been high during the second half of the twentieth century, mainly through the advent of trawling. Landings peaked at about 6,000 tonnes per year during 80s and then decreased throughout the decade 1990 - 2000 (ICES, 2008e). Since the early 2000s, landings have been fluctuating between 3,000 and 4,000 tons per year according to the resource abundance (AGLIA, 2007).

Although the nephrops stock state within VIII a,b area is considered to be at a good level by ICES, substantial improvement could be obtained by reducing still significant fishing discards (AGLIA, 2007).

Scientific basis

The resource is scientifically surveyed since 1987 by Ifremer, while an ICES working group yearly carries out an assessment of the stock (AGLIA, 2007). The stock assessment is performed by XSA (eXtended Survivors Analysis) using catch-at-age data as inputs.

Information from the fishing industry

Discussions between the French fishing industry and scientists have been led aiming to come to an agreement on the information available for stock assessment. Industries have not provided any additional quantitative information that can be used in the assessment, but they supported information on landings and fishing effort compiled by the WG. The partnership commented the application of one tuning series involving in the northern part of the fishery and its extrapolation to the southern one. They underlined the heterogeneous feature of the whole area of the stock (in 2006, strong increase of LPUE in Area VIIIb compared with the stability in Area VIIIa; in 2007, relevant decrease of LPUE in Area VIIIb against stability in Area VIIIa). Thus, they emphasized the necessity of applying additional tuning information on the southern part of fishery. The perception of the stock trends by the industry generally encourages the signals given by the data used in this year assessment.

Professionals in the Bay of Biscay share this concern to protect the resource and have for several years demonstrated their involvement in this field. For them it is an approach that is often used everyday instinctively, because the abundance of waste is harmful to the effectiveness of gear and degrades the quality of the commercial catch (damaged goods, time spent lying on the deck). In addition, the awareness of the biological impact is real as evidenced by the massive involvement of professionals in programs on selectivity. Professionals have every interest in ensuring the decline of discharges (AGLIA, 2007).

The example of the nephrops fishery in the Bay of Biscay and the recent work undertaken since 2000 are original in more ways than one. The inter-professional initiative and the regional nature of the claim (10 harbours, 3 CRPMEM, 6 CLPMEM, 6 OP), the scope of the attempts and the study method, directly on board of professional ships, management and animation, close to the field, supported by direct communication *vis-à-vis* with the employers, are all factors of success of the approach (AGLIA, 2007).

Uncertainties in assessment and forecast

The assessment is considered uncertain for the most recent years. There is evidence of a retrospective pattern with consistent underestimation of fishing mortality (F) and over-estimation of spawning stock biomass (SSB), and especially over-estimation of recruitment. The effort data used in the assessment do not account for likely increases in catch efficiencies associated with the introduction of new gears and equipment in the fishery. This may be one cause for retrospective pattern. The assessment is considered reliable to indicate trends, but because of the retrospective pattern, particularly in recruitment, a short-term forecast is not considered reliable.

The estimates of discards are another important source of uncertainty. Prior to 2003 discards were only sampled in three years. Discards in years not sampled are estimated, but with greater uncertainty.

Species

The increase of biomass, after a fall in 90 years, began regularly in recent years (ICES, 2007a). The recruitment observed since 2004 are the highest of the last 20 years. However, the exact values remain to be confirmed for the most recent years (AGLIA, 2007).

Discards are one of the main problems for this fishery both in the nephrops landings themselves and as by catch. Due to the fishing technique and diversity in specific areas, individuals of small size (hake, nephrops) or non-target species (blue whiting, horse mackerel) are rejected after screening of the crew.

The main difficulty in this fishery, in addition to the rare geography (more than 700 km of coastline, 10 harbours, 250 ships from 10 to 22m), lies in the multispecies catches. If nephrop is the target species, a significant turnover of these vessels, is carried out on fish (hake, sole, etc ...). Any work of selectivity, whether intra-specific (limiting the release of nephrops) or inter-specific (limiting the release of hake, for example) will deal with this situation. The technical modifications in trawls must bring to reduce discards of small individuals of a particular species, but at the same time it must take care to limit the impact on diverse commercial catches. This precept is the guarantee of acceptance by professionals and therefore an effective and efficient implementation on the field (AGLIA, 2007).

Fleet and gears

This fleet is relatively specialised: about half of the vessels operating in this fishery accounts for more than 50% of their turnover on the nephrop. This specialization does not marginalise the multispecific character of this fishery, including its interactions with the stock of hake.

The nephrops is fished exclusively with bottom trawls, single or twin; trawlers are between 9.50 and 22.50m long. In the Bay of Biscay, a typical vessel targeting on nephrops is 15m long and has from 3 to 5 men on board.These vessels are mainly related to Guilvinec, Concarneau, Lorient, St. Nazaire and Marennes Oléron harbours. Nearly 70% of the vessels come from the southern ports of Brittany (AGLIA, 2007).

In the last 15 years, the fishery has known many technical changes that have altered the selectivity of trawlers: increase of mesh size to 2 times since 1990 (from 50mm to 70mm), changes in materials (nylon, polyethylene various ...), passage from the single to the twin trawl, increased mesh size in different parts of the trawlers...

Since 2005, fishermen have established a licence system to prevent the increasing number of vessels targeting nephrops in the Bay of Biscay.

Landings

Landings are concentrated between April and August. However, the seasonality of nephrops is less and less marked and spreads out henceforth until December. The duration of surveys varies from one port to another from 1 to 3 days. The proximity of fishing areas within the Bay makes short trips possible and thus it enables to market nephrops alive, in strong market value (represents the second species in terms of values).

Since the last published work, it is estimated that over 1,100 offshore jobs are concerned by the nephrops fishery, approximately 350 to 375 full time employments (FTE) by fishermen. In the port structures, approximately 320 to 330 FTE are directly related to this fishery (AGLIA, 2007).

The evolution of biomass and landings should be compared with simultaneous reduction of the fleet. An indicator of fishing effort on one of the most important areas (Guilvinec) shows that the number of hours of trawling was reduced by more than 80% over the period 1990-2000 (ICES, 2007a); the decline of the effort has continued since 2000 but in a more moderate way (AGLIA, 2007).

Since the SSB has been relative stable, the current landings can be maintained. ICES recommends not to increase landings in 2009 over the recent level of 3400 t (2005–2007 average) (Table 29).

Management and governance

Although the stock seems to have been relatively stable there is an opportunity to greatly increase the long-term yield from this fishery as well as the SSB. This can be achieved by lowering the fishing mortality and improving the selection pattern. Since the present fishing mortality is three times the fishing mortality related to high long-term yield, a management plan should be established to reduce fishing mortality and also to improve the selection pattern, in particular by reducing discards.

Table 29. ICES advice and recommended TAC values for the period 1987-2009.

Year	ICES advice	Recommended TAC	Agreed TAC	ICES landings (discards not included)
1987				5.5
1988				5.9
1989				5.2
1990				5.1
1991				4.8
1992		~6.8	6.8	5.7
1993		6.8	6.8	5.2
1994		6.8	6.8	4.1
1995		6.8	6.8	4.5
1996		6.8	6.8	4.1
1997		6.8	6.8	3.6
1998		4.2	5.5	3.3
1999		4.2	5.5	3.2
2000		4.2	4.44	3.1
2001		4.2	4.0	3.8
2002	*40% reduction of current exploitation rate*	2.0	3.2	3.7
2003	*50% reduction of current exploitation rate*	2.2	3.0	3.8
2004	*20% reduction of current exploitation rate*	3.3	3.15	3.3
2005	*20% reduction of current exploitation rate*	3.1	3.1	3.7
2006	*Maintain recent catch*	3.5	4.0	3.4
2007	*Maintain recent catch*	3.6	4.32	3.2
2008	*Maintain recent catch*	3.6	4.32	
2009	*Maintain recent catch (average 2005–2007)*	3.4		

Weights in thousand tonnes.

An important French bottom trawling fisheries takes place in the Bay of Biscay. However, the mesh size defined by the regulation does not prevent bycatch nor undersized fish catches. An improvement of the selectivity of bottom trawls operating in the Bay of Biscay is thus essential to reverse this situation, especially for hake whose stock was judged in such state that a rebuilding plan was designed in 2001, and the nephrops for which discard rates are important in spite of a good state of stock. In this context, the professionals are looking for a device able to reduce substantially undersized catches without decreasing in an unbearable way the commercial catches (AGLIA, 2007).

A very framed fishery

The fishery is controlled by several European common rules. First, the stock is managed through TAC. Catches of nephrops are landed almost exclusively by auction thereby control samples. The mesh is fixed at 70mm and additional rules were implemented in the management plan for hake.

Besides, professionals have wished to frame more the fishery: in 2003, a national Nephrops committee was created within the CNPMEM (**National Committee** *for Sea* **Fisheries** *and Aquaculture*) and it assemblies all the regional and local professional structures. The first decision of this committee was to establish a regime of authorizations of fishing, a quota of fishermen, by means of a license of fishing.

Based on the legal and statutory skills of the professional organization in well-balanced management of the resource, the system of frame regulates the access to the resource by the institution of a maximum national contingent of licenses.

In 2005, the allocation of license was conditioned in the compulsory use of a selective system for hake. In 2007, this last one was fixed to 250 so that the exploitation of the fishery is compatible with the available resource. The system contains limitations in terms of length of ships authorised to enter in the fishery area on one hand and conditions liking the anteriority on the other hand. Supplementary modalities of local management complete the global system, like ships stopping their activities during the weekend.

Selectivity

The selectivity of trawl nets is the subject of numerous scientific studies. In the context of multispecific fisheries, such as the nephrops fishery, measures of selectivity are more efficient or applicable to monospecific fisheries.

Three different systems are tested so far, only for nephrops selectivity which could fit to the different kind of vessels working in the Bay of Biscay. A new square mesh panel for nephrops, larger meshes in cod end (80mm instead of 70mm) and new design of flexible grids are used to reduce undersized nephrops (< 9cm, the French commercial size for area VIII a,b). Results are showing very interesting possibilities despite a potentially high variability due to the heterogeneity of the fleet (boats from 10 to 22m) (AGLIA, 2007).

For the Nephrops stock, the working group of ICES reported in 2005 that a marked improvement in the selectivity is nearly three times more effective than a drastic reduction in fishing mortality to sustainable exploitation stock (the improvement of selectivity can achieve the maximum sustainable yield more effectively than decreasing the effort (Fmax)).

Biological and anatomical features of this species make it difficult to improve selectivity (mainly because of spines of the shell, legs and claw). Moreover, the fact that this fleet fishes on several target species (multispecific activity) increases the difficulty to improve selectivity since every net modification may induce commercial losses on other species, especially on fish (hake, sole, etc…).

1.4.6 Spanish fishing fleet

1.4.6.1 Spanish purse seiner fishery

In 2006 a total of 346 vessels were registered as purse seiners. Changes in gear do not occur during the year except in summer, when part of the fleet switches to “curricán” (trolling lines) or “cebo vivo” (bait boat) for tuna fishing. This fishery behaves in two main ways, on one hand taking advantage of resources with a marked seasonal character such as anchovy, mackerel (in VIIIc East), sardine (in IXa North) or tuna (caught using curricán), and on the other a series of resources that are always present in the area, such as horse mackerel. Vessels must be over 21m in length, and so most of the effort and catches are registered in logbooks, and at most can only work 5 days a week, resting continuously for 48 hours per week. The gear has a maximum length of 600m excluding the purses, whose maximum size is 30m, with a maximum height of 130m and mesh size of 14mm.

Landings

The landings from this fleet were close to 59 thousand tons in 2006. Regarding the catch composition, the current purse seine landings show an increase of medium pelagic species (horse mackerel and mackerel) and a decrease of small pelagic species (sardine and anchovy). In the particular case of the decrease in the anchovy landings, it must be noted than this fishery was collapsed in 2005. As in the trawl fleets, the purse seine catches are mainly landed in the Galician ports, being distributed throughout a greater variety of ports.

Management and governance

Regarding on the fishery management, in general there are no specific regulations from EU (excepting the moratorium for anchovy fishery since 2006). Spanish government uses input control (area restrictions, entrance restrictions and gear regulation) and the regional governments implement output control for some species (maximum catches by fishing day in the sardine fishery).

Socioeconomic basic data

The value of landings from this fleet was close to 52 million euros in 2006, and most important costs are the crew share (by 56% of landing value) and fuel (20%). This gear employs between 6 and 8 crewmembers by vessel and generates 1,700 direct jobs (in FTE).

1.4.6.2 Spanish mixed demersal fishery

The Northern Spanish coastal trawl fleet is known to have undergone several technical changes through the last century, when the most significant industrial progress took place. Analysis from the period 1989-1993 showed that hake, the main target species in 70's, had fallen until 6% of total weight landed, while catches of other species such as blue whiting and horse mackerel had increased up to 47% and 18%, respectively (STECF, 2005). This increasing trend in landings of pelagic species can be followed exploring the 2003-2005 logbooks, where mackerel and horse mackerel catches raise up to 25%, while hake decreases to 4%.

At the end of 80's and early 90's this fleet included bottom otter trawlers (OTB) and bottom pair trawlers (PTB). In 2006 a total of 130 vessels were registered as trawlers in this waters (Bay of Cadiz is not included in that figure). Regarding the OTB fleet, it is known that this fleet has evolved in such a way that several kinds of trawl gears have been included in their fishing strategies through last years, being the most frequently used the "baca" and the "jurelera" gears. The first one, the traditional trawl gear used by targeting demersal species, has a cod-end mesh size of 65mm, a vertical opening of 1.2-1.5m and a wingspread of 22-25m. The more recent "jurelera" gear also uses a cod-end mesh size of 65mm, however is able to achieve a vertical opening of 5-5.5m and a wingspread of 18-20m, being suitable for targeting horse mackerel and other pelagic species. The "baca" trawl trips last from 1 to 10 days, with hauls of 1 to 8 hours depending on the weather condition, the species targeted or the area being fished, and employ between 3 and 9 crewmembers. The "jurelera" trawl trips are shorter, from 1 to 2 days, with hauls of 2 to 6 hours, and between 3 and 10 crewmembers.

The other group of bottom trawlers operating in the northern Spanish coastal waters, the PTB fleet, uses a specific gear with a cod-end mesh size of between 45-55mm, which is able to achieve a vertical opening of around 25m and a wingspread of 65m. Their trips last from 1 to 2 days, with hauls of 5 to 15 hours, and employ between 4 and 9 crewmembers. In relation to its fishing behaviour, this fleet has been always assumed to be very homogeneous, with most of the vessels targeting mainly blue whiting by using similar fishing techniques.

Landings

The total landings were estimated by 27 and 25 thousand tons, respectively, from otter and pair trawlers in 2006. Analysing the landings for the last years by both trawl fleets, it can be observed that OTB is mainly targeting horse mackerel and mackerel with the demersal species traditionally appreciated in the Spanish markets (hake, megrim, monk and Norway lobster). Regarding PTB, its fishing strategy is especially efficient targeting blue whiting (69%) but also produces important catches of hake. Under an administrative point of view, most of the both fleet's catches, OTB and PTB, are landed in Galician ports.

Management and governance

Regarding on the fishery management, the EU, within the framework of the Common Fisheries Policy, has regulated the fishery through TACs for hake, Norway lobster, megrim, anglerfish and blue whiting; and minimum catch sizes for hake since 1987. Besides, a recovery plan exists for hake and Norway lobster since 2006.

Spanish government and some regional governments implement input control (area restrictions, a closed list of vessels and gear regulation, and time restrictions).

Socioeconomic basic data

The value of landings from both fleets was close 90 million Euros in 2006, and most important costs are the crew share (by 37% of landing value) and fuel (24%). This fleet employ 1400 direct jobs (in FTE).

1.4.7 Portuguese fishing fleet

Fishing is an important source of income for coastal communities in this area, many of which are almost totally dependent on fisheries and related activities (Correia, 2002). The ecosystem has a high diversity of species, and there is demand for these species in local markets (Quadro comunitario de Apoio III 1999). Portugal has a high consumption levels of fish per capita (61.1 kg) (FAO, 2000a).

The Portuguese National Fisheries and Aquaculture Directorate (DGPA) has established four major fleet segments:

- The purse-seine fleet. Vessels with high engine power and autonomy. This fleet uses mainly seine nets and targets small pelagic species.
- The trawl fleet. Vessels with high engine power and autonomy. Use mainly bottom trawl nets. Target a great variety of benthic and demersal species including fish, cephalopods, and crustaceans.
- The small-scale regional fleet. Small vessels with reduced autonomy and with a high diversity of fishing gears (beam trawl, gill- and trammel nets, hooks

and longline, traps and pots) target mainly coastal and estuarine species. Gears and fishing activity may be very typical on a regional scale. In 2003–2005 a total of 3,484 vessels had operated, 25% with engine (35.5 of average HP) and 6.5m overall length.

- The artisanal/multi-gear (polyvalent) fleet. Vessels with higher engine power and autonomy compared to vessels of the small-scale regional segment. Use a great variety of fishing gears (gill- and trammelnets, hooks and longline, traps and pots). This fleet targets a great diversity of benthic, demersal, and pelagic species (fish, shellfish, cephalopods, and crustaceans).

The main gear types used by the Portuguese fleet in terms of numbers are fixed gears, while in terms of landings it is demersal/bottom trawling and purse seine. The many fixed gear types used include long line and various types of artisanal fixed gears that are used by small vessels (less than 12m in length). This polyvalent fleet use mainly hooks, gillnets and traps, and change between gear type according to the time of year and abundance of target species (Instituto Nacional de Estatística, 1998).

The Portuguese purse-seine fishery, the most important in landings volume, was in 2006 composed of 143 purse-seiners (Table 30). This fleet targets mainly sardine (*Sardina pilchardus*), which constitutes more than 80% of their landings, using a mesh size of 16mm. Other pelagic species landed are horse mackerel and Spanish mackerel (ICES, 2005c).

The trawl fleet is the second most important fleet in Portuguese waters and comprises two fleet components, i.e. the trawl fleet catching demersal fish (using 65mm mesh size) and the trawl fleet directed at crustaceans (70mm for Norway lobster and 55mm mesh size for other crustaceans. The trawl fleet targeting fish operates off the entire Portuguese coast mainly at depths between 100 and 200m, while the fleet targeting crustaceans operates mainly to the southwest and south of Portugal in deeper waters, from 100 to 750m (ICES, 2005c).

Table 30. The Portuguese fleet composition by number of vessels and power in 2006 (source: DGPA).

Gear	Number	Gross Tonnage	Power (kw)	% number	% GT	% Power
Artisanal <12m	7178	10076	112804	0.91	0.21	0.42
Artisanal >12m	439	19678	73857	0.06	0.42	0.27
Trawl	98	10324	49386	0.01	0.22	0.18
Purse seine	143	6928	34112	0.02	0.15	0.13
Total	7858	47006	270159	1	1	1

Portuguese landings

The main species caught are sardine (*Sardina pilchardus*), horse mackerel (*Trachurus trachurus*) caught by the purse seine fleets and hake (*Merluccius merluccius*), megrim (*Lepidorhombus whiffiagonis*), four-spot megrim (*L. boscii*), anglerfish (*Lophius piscatorius* and *L. budegassa*) and *Nephrops Norvegicus* targeted by the trawl fleet.

The most important species landed in Portugal are sardine and horse mackerel both in terms of weight and value. In 2006, 48 thousand tons of sardine (42.3 thousand tons caught by the purse seine fleet) and 14 thousand tons of horse mackerel (9.3 thousand tons by the trawl fleet) with a value of 26.28 mln euros and 16.47 mln euros respectively were landed. Hake is the most important demersal species, in 2006 2.22 thousand tons were landed (917 tons by the trawl fleet), with a value of 7.93 mln euros and for the crustacean trawlers the most important species is Norway lobster with 246 tons landed (214 tons caught by the trawl fleet) but with a value of 5.8 mln euros (Instituto Nacional de Estatística, 2004-2007).

Besides the mentioned species, small pelagic species as anchovy (*Engraulis encrasicolus*) and middle-size pelagic mackerel (*Scomber scombrus*) are also important fisheries in the area. Small pelagic fishes are generally caught by purse seiners, while a wider variety of gears are used to catch middle-sized pelagic fishes, e.g. handlines and trawl gears. Demersal elasmobranchs are also caught, mainly by coastal trawlers. Two species, lesser-spotted dogfish *Scyliorhinus canicula* and bull huss *S. stellaris* are landed in the major ports, and annual landings have increased in recent years. Skates and rays are landed as bycatches of trawl segments (and also artisanal gears) of the commercial fleet (ICES, 2005c).

Governance system and management tools

Portuguese fleet have been decreasing in size since the early 1980s due to restructuring and redimensioning, in order to adjust fishing capacity to available resources and to meet EU legislation (ICES, 2005c). Vessels have been renovated and modernised in order to improve on-board fish conservation methods, automate work systems and install electronic navigation and fish detection systems (FAO, 2000b).

Fisheries management in the region is in accordance with the objectives of the CFP. The present management system includes the establishment of annual TACs and quotas for certain species and fishing areas, the application of technical conservation measures and the limitation of fishing effort. There are four types of technical measures used in the Iberian Sea waters (EU regulations): minimum size/weight for fish caught, mesh sizes, the maximum percentage of by-catch and minimum percentage for target species catches and the restriction of fishing in certain areas, seasons and using certain gears.

TACs are set annually for individual species and fishing zones on the basis of ICES or other Regional Fisheries Organisation's advice, and are published in EU Council Regulations which also specify how they are to be allocated among Member States. The species subjected to TACs and quotas targeted by the Portuguese fleet are: megrims, whiting, European anchovy, horse mackerel, pollack, hake, mackerel, European plaice, anglerfishes, common sole, blue whiting, bluefin tuna, swordfish and Norway lobster. Further, measures may be needed for certain species which are at critically low levels, such as the recovery plans for southern hake and Norway lobster that are being developed.

Quotas can be allocated by the national fisheries authority to individual vessels or to groups of vessels. The latter is the case for the Portuguese purse-seine fishery, where sardine catch limits are attributed by Producers' Organisations. Individual vessel quotas may be transferable within the ship owner's companies to allow for flexible management and a maximum utilisation of these quotas. However, if Portugal does not use all its quota for certain species, they are traded with other EU Member States to ensure optimal use and achieve mutually beneficial equilibrium, without affecting relative stability (Organisation for Economic Co-operation and Development, 2005).

Socioeconomic description

The Portuguese mainland production (fresh and refrigerated fish) has been decreasing along the years and amounted to 164 mln euros, in 2006. The major part of the landings value for fresh and refrigerated fish involved the polyvalent fleet, bottom trawl fleet and the purse seiners (AER, 2008). However, taking into account the general results for the entire fleet there was an increase of 4% in the average income per vessel for 2006. In 2006, the average income per vessel was almost 80 thousands euros (AER, 2008) Moreover, the referred fleets are very important in terms of the social aspects of the fishing sector. In the period 2004-2007 these fleet (especially the polyvalent) on average gave work to more than 12,500 persons (as well as their families) which represent more than 80% of total number of fishermen (Table 31Table 31). The trawl and purse seine fleet provide work for less than 3,500 people but in landings value represent close to 50% of the total Portuguese fleet revenue (Table 32).

Table 31. Number of fishermen by fishing fleet (source: DGPA, 2004-2007).

Year	Trawl	Purse seine	Polyvalent	All gears
2004	1896	2194	10064	16648
2005	1812	2049	9226	15160
2006	1227	1875	9226	14337
2007	1078	1636	8907	13997

Table 32. Total landing value by fishing fleet (source: DGPA, 2004-2007).

Year	Trawl	Purse seine	All gears
2004	40593	37978	226810
2005	37069	34519	194536
2006	38040	28499	122076
2007	35961	40744	137822

1.4.8 Azorean fishing fleet

Production

Total production of fresh fish in the Azores presents a decrease pattern in weight from the end of the eighties (about 20 thousand tonnes) to the present (about 10-15 thousand tonnes in the last two years). This variability on the production is mostly a result of the high interannual variability of the tuna production. However, it presents a significant increase in value, increasing in the same period from 11 million euros to about 35 millions, due to the increase in price per kg in the auction first sale. Big pelagic fisheries, mainly tuna, are the most important fisheries in weight but demersal fishery is the most valuable one. Almost all landings of demersal fresh fish are exported to the European market. Most tuna production is sold to the industry (low prices) although a small proportion of the landings have started recently to be sold as fresh in the auctions. The other small fisheries have small values in weight however they have a very significant socio-economic importance for local subsistence of the fishing communities.

Fleet

Two major fleets can be identified: The polyvalent (mixed) and tuna fishery. The polyvalent fleet was composed in 2008 of about 765 boats (48.977 Kw), 85% of them less than 12m (the majority are open deck vessels) and representing 50% of the total power (Kilowatt) and 17% of the total TAB (INE, 2009). There are only about 20 active semi-industrial tuna live bait vessels but representing a significant proportion of the total fleet TAB (about 40%) and power (about 30%) (see INE, 2009; Silva and Goulding, 2003). However, there are about 2,700 fishing permits due to the multigear characteristic of the fishery (one vessel, several different gears) to give an opportunity to the vessels, particularly the open deck ones, to adjust its operational regime along the year to different species and gears according to abundance or prices. Close deck vessels are mostly divided by three islands: S. Miguel, Faial and Terceira, because the infrastructures available. S. Miguel Island concentrates the highest proportion of the fleet, fishermen and production due to the larger marked (about 60% of the total Azorean population are resident in this island). However, prices per kilo are lower in this island than the smaller ones (Ex: Faial, Pico, Graciosa and Flores).

In resume, the sector is highly dependent of an open deck fleet that represents a small proportion of the TAB and power but high value, particularly on the small islands. All the fleet presents high levels of inactivity, for example the tuna fleet operated seasonally (about 7 months). The most profit component of the fleet, based on the 2001 costs, is the median close deck mixed lines demersal vessel operating with hand lines.

Human resources

There are about 4000 thousand fishermen's registered in the Azores but with a decreasing trend along time and with a significant decrease during the last three years (about 50%). From the 4000 fishermen registered in 2001 about 21% had a complete time. A total of 2768 jobs (2.8% of total Azorean jobs) were estimated from fisheries. Part-time dominates the employment as a result of inactivity of high proportion of the Azorean fleet (INE, 2009; Silva and Goulding, 2003). This part-time result on employment also shows the plasticity of people movement between fisheries and other land activities (like agriculture and tourism), or even within fisheries like tuna and demersal.

Fisheries seem to represent on average about 2-3% of the employment in the Azores (Silva and Goulding, 2003). However, these ratios may change considerably by island or particular communities where the industry is installed, like Madalena on Pico Island and Ribeira Grande on S. Miguel island which the fisheries employment may represent between 10 and 13%. For example, tuna canned is an important source of woman employment. Auctions and fish commerce are other important employment areas under the fishery sector.

Industry

The canned industry (the main local industry) is dependent of imported tunas because there is not sufficient local annual production. It is also dependent of some external markets for export (like main land Portugal, Italy and USA).

Employment is based on women (75%) of low education without professional skills for the tasks and usually based on part time contract and so low salary.

Mixed demersal lines fishery

Fisheries in the Azores in general are defined as small-scale, meaning that the majority of the fleet are composed of small vessels (<12m) of limited autonomy, using artisanal gears and operating mainly inside the Azores EEZ (ICES, 2008c). This small-scale characteristic is an adaptation to the ecosystem, particular the benthic one (Pinho and Menezes, 2005). The main properties of this ecosystem are the deep water environment and the discontinuity on the stock/area relationship, having as predominant features the islands, seamounts and abyssal plains. Fisheries occur mainly on the former (islands and seamounts) applying necessary for small scale impact, since the ancient times (Silva and Pinho, 2007), due to the nature of the population dynamic of the resources inhabiting these ecosystems (Menezes *et al*., 2006; Pitcher *et al*., 2007).

Demersal fishery in the Azores is one of the most important along with the tuna fishery. Its importance has been growing up during the last decade, due to the overexploitation observed on the tuna fisheries and also due to the new markets for the fresh fish, increasing significantly the value of the product on the first sale. Actual landings in weight are around 4000 tonnes corresponding to about 22 million euros (values from the auctions first sale) (Figure 59). The demersal fleet represents about 83% of the total Azorean fleet (60% of total TAB and 70% of total KW) and so represents a significant proportion of total fishery employment and local community dependence (Silva and Goulding, 2003).

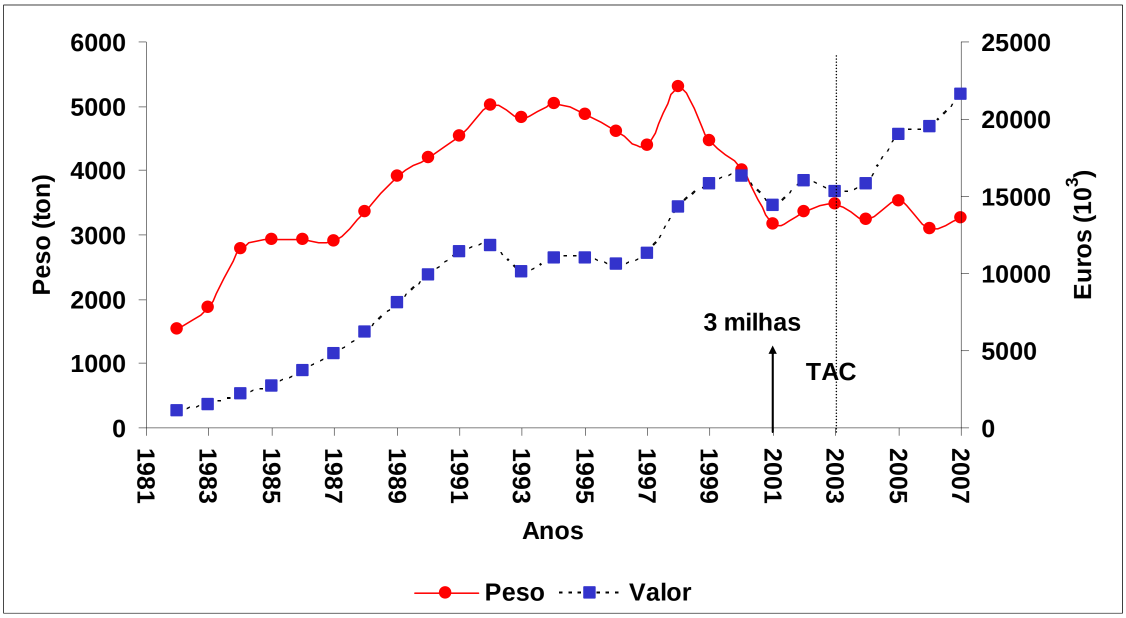

Figure 59. Historical landins in weight and value of the Azorean demersal fishery. Management measures adopted (TAC for some species and the 3miles box around islands) are also presented on the figure.

Species

The fishery is a multispecies and multigear one. About 104 species belonging to 49 families were caught and identified during the spring demersal longline surveys from 1995-2006 (Menezes *et al.*, 2006). This demersal community is structured by assemblages according depth (Pinho and Menezes, 2005; Menezes *et al.*, 2006). Three main assemblages can be defined according depth: Shallow (<200m), Intermediate (200-700) and Deep (>700). The key species of this fishery is Black spot seabream (*Pagellus bogaraveo*) and bluemouth (*Helicolenus dactylopterus*), both distributed from shallow to deep depth strata.

Fleet and gears

Three main components can be identified on the Azorean demersal fleet: (a) artisanal open-deck vessels, characterised by a mean length less than 12m and a gross registered tonnage (GRT) <50 tonnes, (b) artisanal closed-deck vessels, with mean lengths less than 18 m and a GRT <50 tonnes and (c), the industrial vessels with mean lengths greater than 18 m and a GRT >50 tonnes.

The operational regime of each vessel type varies considerably. Small open-deck vessels usually operate in areas near the coast, using mainly hand lines. They make daily trips and target mainly shallow (<200m) and intermediate (200–600m) depth species. On average this component makes between 70 to 150 fishing days per year, depending on the based island of the vessel. Some open-deck vessels (9–12m) based in St Miguel Island operates in a larger area including banks near the coast (to 50nm). These vessels make about 200 fishing days per year. Small closed-deck vessels are considered the main component of the fleet targeting deepwater species and cover almost all areas and depth strata (Figure 60). They use mainly deep longlines and hand lines, operating in coastal areas of the islands and in the main banks and seamounts. These vessels operate in all strata but preferentially target species from 200–600 m strata, making on average between three and seven fishing days per trip, with one set a day, though occasionally more, using from six to ten thousands hooks by set. On average they make about 200 fishing days per year. Industrial vessels operate mainly on banks and seamounts, inside or outside the EEZ, including the ICES and CECAF areas, using deep longlines. They usually fish in the intermediate and deepwater strata. These vessels make trips, on average of seven days, with one (or more) sets a day of about 14,000 hooks a set. They make on average 250 fishing days per year.

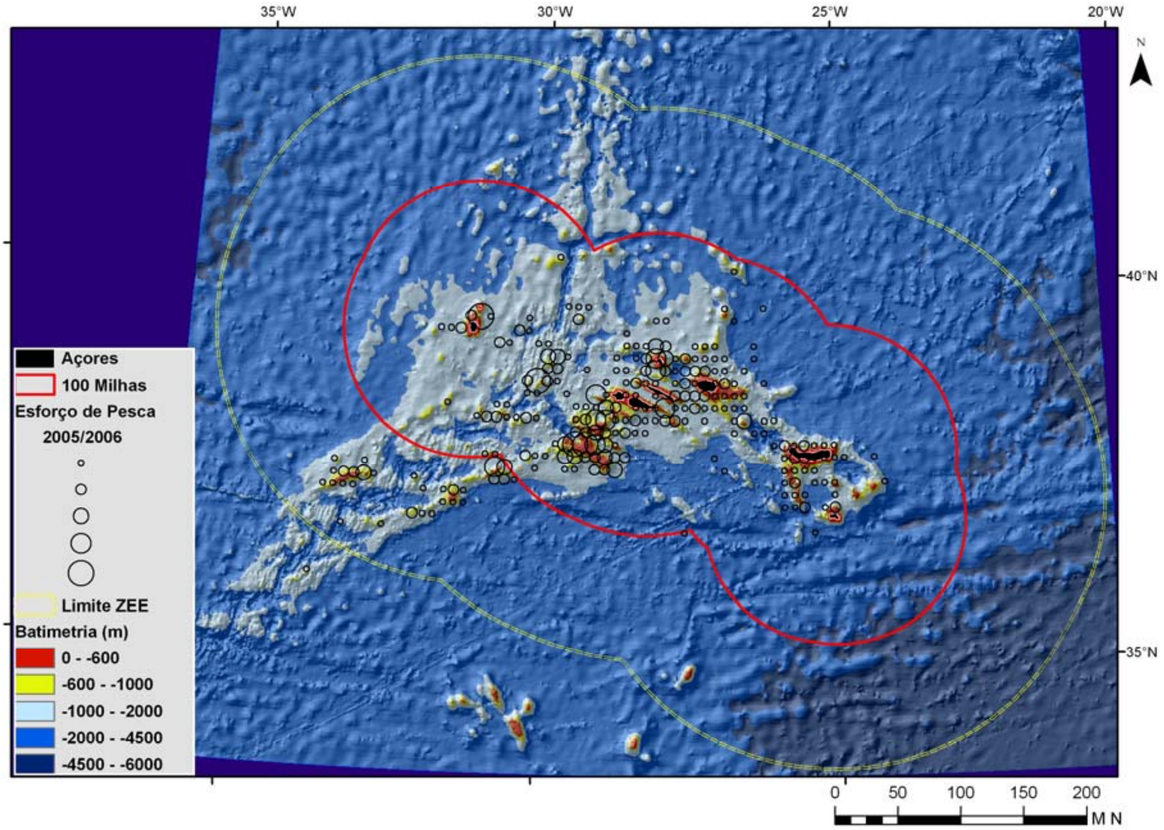

Figure 60. Distribution of the effort of the demersal mix lines fishery from the Azores. Limits of the 100miles box (red) and EEX (yellow) are also shown on the figure. Fishing areas available for the demersal mix lines fishery is also shown putting on evidence the 600m (red) and 1000m (yellow) depth strata.

The structure of this fleet is predominantly small-scale with the open deck component representing more than 70% of the total fleet. However, during the last decade the fleet has increased significantly the efficiency due to the incentives for new constructions targeting the small close deck vessels (8-12m).

Although the predominant gears are the demersal longline and hand lines, the fleet, particular the local open deck component, is very plastic and can operate opportunistically and on seasonal way to other species like crustaceans (using traps) or small pelagic (using nets) or tunas (live and bait) in function of the abundance and price. Each vessel has usually permits to use different gears.

Although the Azores EEZ is extent (about 1 million km^2) the total area available for the demersal fishery (limit depth of 100m) is very limited (Figure 60Figure 60).

Landings

Demersal fishery was historically the second fishery in weight, after the tuna fishery, except for the last decade due to the crisis of the tuna fishery. However, in value it was always much more important than the tuna fishery because the highest value of the demersal species on the first sale by contrast of the industry market for the tunas. Total demersal landings increased significantly until the end of the nineties and started decreasing thereafter (Figure 59). Landings in value increase almost linearly due to the increase of the mean price of fresh fish on first sale. A very significant increase was observed during the eighties and nineties due to the introduction of the longline, new markets, better transports, new vessels, etc (Menezes, 1996). However, during the last decade landings started decreasing as a consequence of intense fishing effort and so management measures, like area restriction (3miles box) and catch restriction (TAC), were introduced.

Total landings are dominated by few high commercial species. The ten top species from the landings in weight during the last decade were the blackspot seabream, bluemouth, conger eel, silver scabbardfish, wreckfish, alfonsinos, forkbeard, red porgy, common mora and rajas. Most of these species are from the intermedian habitat (200-700m) with exception of the forkbeard, red porgy and raja (mainly clavata) that are the key species on the shallow strata (inner shelf areas of the islands). The blackspot seabream is the objective species of the fishery, being far the most important species due to its very high price on first sale (Figure 61).

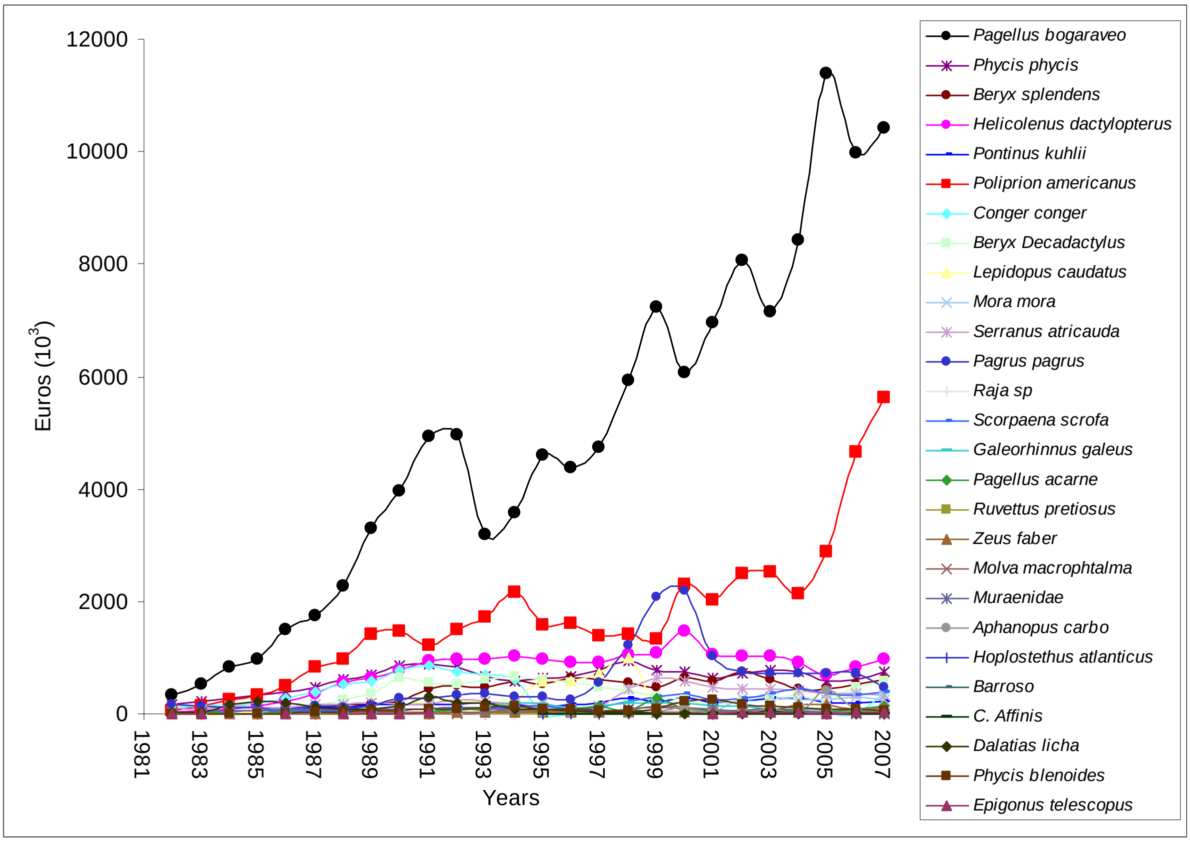

Figure 61. Historical landings in value, by species, from the Azorean mix demersal lines fishery.

Management and governance

The Azorean demersal fishery is a multispecies and multigear fishery. Although the blackspot seabream has been the objective species of the fishery the definition of a target species of the fishery has been a complicated scientific process for the assessment because the discontinuity of the Azorean ecosystem (suggesting meta populations), gear, vessel and area combination on the operational regime of the fleet (almost different metiers can be defined) and the unknown stock structure of most species (no precise management units are defined) (ICES, 2007). Management measures were sometimes difficult to implement or not implemented at all due to the governance structure where local government have no competence to produce valid regulations (e.g. TAC/Quota system or area restrictions). As a result the assessments are no analytical because models do not catch the dynamic of the population or the fishery, or there are no assessments at all due to a lack of information for the management unit defined, and so precautionary management measures have been introduced (ICES, 2006b). These measures include (local, national or EC regulations):

- Area restriction implemented by the Regional Government (3miles box for protection of island coastal assemblages, where only hand lines are permitted) and restrictions at the EC level (100miles box where only Azorean vessels can fish). Coastal Marine Protected Areas have been proposed and implemented under the E.U Natura 2000 network and offshore MPAs have been also proposed.
- Entrance restrictions. During 1998 and 2000 some technical measures were implemented, including restrictions on licences based on a minimum threshold landing in value. EC regulations limited also the effort for deep water species.
- Gear restriction. Hook size limit and fishing area restrictions by vessel size and gear type were implemented. Some gears like bottom trawl and bottom gillnets were forbidden in the Azores.
- By-catch control. Landings of some species are limited (through minimum size) or forbidden in a policy of bycatch regulation (e.g. deep-water sharks).
- TAC and Quotas for some deep water species (black scabbard fish, orange roughy, blackspot seabream, alfonsinos, and deep water sharks) were implemented under the EC Fisheries Common Policy.
- Minimum lengths are also in force for some species.
- Subsides have been implement under the EC FCP (new constructions, fuel, commercialization, etc).

2. Interactions between the ecosystem and fisheries case studies

2.2 Description of the fisheries case studies

Fishing is an important source of income for coastal communities in the SWW area, many of which are almost totally dependent on fisheries and related activities. The ecosystem has a high diversity of species, and there is demand for these species in local markets. The three countries involved in this area (France, Portugal and Spain) have high consumption levels of fish per capita (45-60 kg, depending on the country).

It is impossible to deal with all types of fisheries and gear types within the scope of this project. Therefore case studies are selected that include a mixture of gear types and trophic levels across the regions. In the South Western Waters RAC region, three fisheries are selected (Table 33) for their socio-economic importance and impact they have on the south western ecosystem. The fisheries are discussed separately and the rationality behind their selection will be commented on.

Table 33. The three case studies selected for the South Western Waters RAC region and their targeted species.

Case study	Target species
Purse seine fishery	Sardine (*Sardina pilchardus*) and other small pelagics
Mixed demersal trawl fishery	Hake (*Merluccius merluccius*) Nephrops (*Nephrops norvegicus*) Horse mackerel (*Trachurus trachurus*)
Azorean mixed demersal line fishery	Blackspot seabream (*Pagellus bogaraceo*) Bluemouth (*Helicolenus dactylopterus*) Wreckfish (*Polyprion americanus*)

2.2.1 Purse seine fishery

Purse seines are surrounding nest that catch the fish by surrounding them both from the sides and from underneath, thus preventing them from escaping in deep waters by diving downwards. Purse seines are characterised by the use of a purse line at the bottom of the net. A rope passes through all the rings, and when pulled, draws the rings close to one another, retaining all the fish caught (FAO, 1990). The purse seine is a preferred technique for capturing fish species which school, or aggregate close to the surface: such as sardines, mackerel, anchovies, herring…

The value of landings from this fleet was over 78 million euros in 2006, and employs 2294 people (in FTE).

The case study focuses mainly on the Spanish (see 1.4.4.1) and Portuguese (see 1.4.5) purse seiner fishery in SWW which, targets on small pelagic species such as, sardine, anchovy, mackerel and horse mackerel (Velasco *et al*., 2009).

In northern Spanish waters, sardine is taken by purse seiners (n=346, in 2006) ranging in size from 8 to 38m (mean vessel length=22m). Half of the purse seiners (51%) are licensed in Galicia, where most of the smaller boats are found since part of the fishing takes place inside the rias. Purse seiners from the Basque Country (27% of the fleet) and Cantabria (17%) are bigger (they generally take longer trips while fishing). The remaining 5% of the fleet is licensed in Asturias.

In the Gulf of Cadiz, purse seiners taking sardine are generally targeting anchovy (n=104) and range in size from 10.5 to 25m. In Portuguese waters, sardine is taken by purse seiners (n=121) ranging in size from 10.5 to 27m (ICES, 2007).

The Spanish purse seine fleet targeting anchovy in VIIIc ICES area is composed of about 200 boats that operate at the south-eastern corner of the Bay of Biscay, mainly in spring, when usually more than 80% of the Spanish annual catches occurred. With reference to the fishery in IXa, Portuguese and Spanish purse-seine landings accounted for 52% in 2006 (ICES, 2007).

Mackerel and horse mackerel are also target species for Spanish and Portuguese fleet. However, they are not only fished by purse seiners but also by demersal trawlers and artisanal boats.

2.2.2 Mixed demersal trawl fishery

The bottom trawl is a conical net bag with a mouth fitted with weights on the ground-rope and floats on the head-rope. They are closed by a bag or cod-end and extended at the opening by wings (FAO, 1990).

The value of landings from this fleet was over 119 million euros in 2006, and this gear generates 2261 direct jobs (in FTE).

The case study focuses mainly on the Spanish (see 1.4.4.2) and Portuguese (see 1.4.5) trawl fisheries targeting hake and horse mackerel, as well as the French Nephrops mixed trawl fishery (see 1.4.3) (Velasco *et al*., 2009).

The Spanish trawl fleet is quite homogeneous and uses mainly two gears, pair trawl and bottom trawl. The Portuguese trawl fleet comprises two distinct components, the trawl fleet catching demersal fish (70mm mesh size) and the trawl fleet targeting crustaceans (55mm mesh size). The fleet targeting fish species operates along the entire Portuguese coast at depths between 100 and 200m. The trawl fleet targeting crustaceans operates mainly in the southwest and south in deeper waters, from 100 to 750m (ICES, 2009a).

The largest Nephrops ground is called "la Grande Vasère". It is almost exclusively exploited by French trawlers, about 230 boats of typically 15m in length and three members as crew (ICES, 2009a).

2.2.3 Mixed demersal line fishery

The bottom longline and handline multispecific fishery is economically the most important fishery in the Azores. This fishery is considered in detail as it has most impact on marine communities. Besides blackspot seabream (*Pagellus bogaraceo*), the most significant catches consists of the bluemouth rockfish *Helicolenus dactylopterus dactylopterus*, the forkbeard *Phycis phycis* and *Phycis blennoides* and the conger eel *Conger conger*. Longlines are mostly used by open-deck boats with lengths over 9m and larger cabined boats. Smaller open-deck coats usually use handlines (Santos *et al*., 1995a) (see section 1.4.6 for more information).

The value of landings from this fleet was close 11 million euros in 2006, and this gear generates 1257 direct jobs (in FTE).

The case study focuses mainly on the Azorean demersal line fishery (see 1.4.6). Although it is a multispecies, multigear and multifleet fishery, black spot seabream is the most important species and seems to control the dynamic of the fishery. Other important commercial species, such as bluemouth (*Helicolenus dactylopterus*), wreckfish (*Polyprion americanus*) and alfonsinos (*Beryx* sp.) are also caught (Velasco *et al*., 2009).

Blackspot sea bream has been exploited in the Azores, at least, since the XVI century, as part of the demersal fishery, and is actually one of the most important Northeast Atlantic fisheries. Longliners are closed deck boats (>12m) that operate in all areas, including banks and seamounts (ICES, 2009b).

2.3 Description of the 'Social and Ecological Component by Pressure matrix '

A powerful way of providing data for management decision making is to combine the information from natural and socio-economic systems, rather than having two separate information sets and avenues (MEFEPO project meeting, October 2008). This allows for the simultaneous comparison of the effects of human activities on ecological components as well as socio-economic components and is what we tried to achieve with the development of the matrix.

2.3.1 Socio Economic variables in the Matrix

2.3.1.1 Background

A powerful way of providing data for management decision making is to combine the information from respectively the natural and socio-economic systems rather than having two separate information sets and avenues. This allows for the simultaneous comparison of the effects of the human activities on ecological components as wel as socio-economic components (MEFEPO WP1 Minutes).

This working paper provides a set of variables that can characterise the socio-economic impacts of specific fishing activities in the three selected EU regions in the MEFEPO project.

When choosing the variables, the following criteria have been used as guidance:

- It must be possible to justify the selection of variables from a professional (economic, social science) point of view
- The selection of variables should be supported by references (peer-reviewed literature, expert opinion, etc)
- There should be reliable and easily accessible data sources for operationalising the variables
- There should be comparable data on the variables in the three selected EU regions

Based on these criteria we have chosen a set of variables, describing the socio-economic impacts of selected EU fisheries. These are presented below. Ideally all the selected variables should fully live up to these criteria, but we recognise that this may not be the case in reality.

2.3.1.2 Socio-economic variables

The variables selected can be divided into three groups (numbers in brackets refer to the variables listed in appendix 1):

(i) Catches measured in physical terms (1-6)

(ii) The economic value of the catches (7-13)

(iii) Employment and productivity (14-21)

Catch is the basic fishery statistics variable and describes the output of the fishery activity in physical terms. Combined with unit price of each species caught, data on catches gives the economic value of the catches, i.e. how society values the harvested resource. This is an expression of the fishery's income generation and a basic economic variable. Whereas catch and price describes income, employment also contributes to determining the cost of the fishery activity. Combined with catches measured in physical units it also expresses the productivity in the specific fisheries.

These three main groups of data are also among the core variables presented in the EU report "Employment in the fisheries sector: current situation" (European Commission, FISH 2004/4), and in the Annual Economic Report (AER).

How the variables are operationalised will differ between the three groups:

Catches measured in physical terms

The ICES database on catches contains catches distributed on country, catch area and species. By the use of the software system FishPLus anybody can extract catch data for the period 1973-2007, and one is free to decide the aggregation level for the variables fishing area, country, and species.

For single species fisheries it is easy to get data on total catches (all countries) of the selected species in the selected sea areas. For multispecies fisheries we correspondingly can get total catches (all countries) of all the species in the fishery in the selected sea areas.

It might be the case that two or more fisheries in one sea overlap with respect to which species they include. Measuring actual catch in tonnes for each case, such an overlap does not necessarily constitute a problem. However, if we want to assess the relative importance of the fisheries in the sea under consideration there is a problem with such overlapping cases. Hence, when selecting fisheries they should be defined in a way that ensures that they are mutually exclusive (do not include any common species). For later use, we will for multispecies fisheries construct an index consisting of the share of each species in the total catch. Such an index will most likely vary over time.

In addition to data on catches, the ICES statistical office also provides data on TACs for the current year (2008), at the same disaggregated level.

The economic value of catches

The AER provides data on fish prices both on EU and on member state level.

For most fisheries several countries take part in the fishery. Data on prices per species measured in Euro/kg are given in AER, and these reflect the fact that the price of the same species can vary between countries. One possibility is to apply the price achieved in the country which has the dominating catch of the specific species, but this may be confusing and also give a biased estimate in cases where more than one country has a substantial catch of the species. As an alternative we have chosen to construct price indices. This must be done at two levels.

1) Single species fisheries: The price index consists of the first hand price, measured in Euro/kg, for the species in each country taking part in that fishery. A weighted average of these prices, where the country's share of the total catch in that fishery in each of the three selected sea areas is used as weight.

2) Multi species fisheries: First a price index for single species fisheries is constructed as above. Next, a weighted average of the price indices over all species encompassed is calculated, where the weights are the relative share of each species in the total catch of that fishery.

Finally, we make a price index for all species in each of the regional seas. This is a weighted average of the first hand price of each species in the countries that most actively take part in the fishery, where the relative proportion of each species in the total catch are the weights.

First hand prices measured in Euro/kg for all important species harvested in the European waters are given in the AER. However, the most up to date numbers here are for the year 2006.

Employment and productivity

To get an idea of the significance of the fisheries for society, employment is a crucial indicator. Fishery based employment encompasses both the fishers (fleet) and processing labour (land plants).

There is no annually updated statistical report or database providing these employment data on species and fishing area level, as demanded for the use in the matrix. Data are not readily available for processing labour, but do exist for the fleet data but require manipulation. Hence, we suggest the division of the employment indicator into two components; fleet and land plants.

Fleet

AER provides data on employment on a member state (MS) level, and they are also distributed on gear- and vessel types within each country. However, they are not distributed on fishing area or species, which are the two categories prevalent in the matrix. Thus, we have to process the existing employment data into catch-area and species specific employment data.

The employment indicator for the fleet is constructed as follows:

In the AER there are data on employment and catch for the most important fleet segments in each country. In the matrix the cases are specified as species. Through the use of expert knowledge about which gear and vessel type catch the case species, we pin down 1-3 main gear and vessel types for each case in the countries most important for the catch in this case. Then we calculate a productivity indicator for each gear and vessel type. This is also done for the most active countries participating in the fishery. Next, a weighted average is made of the productivity indicators above, and where the weights are the relative share caught by the nation-gear/vessel types in the fishery under consideration. This provides a case-specific productivity indicator.

As long as we do not expect significant changes in the productivity, annual employment for each case (fishery) can be found by multiplying the total catch in the respective fishery (defined as species and catch area) with the productivity indicator.

Land plants

Data on the land based fishery activities are scarce. There is a report, prepared on behalf of and financed by the European Commission, called “Employment in the fisheries sector: current situation” (FISH/2004/4). This report presents highly disaggregated data on the employment within the fisheries, encompassing fleet, land plants and aquaculture. The data are presented on NUTS-2 level (geography) and NACE-3 level (industrial sector). Data on such disaggregated levels are hardly publicly available. These reports are not updated, as the most recent numbers are from 2004, and the data most relevant for our purpose is from 2002-2003.

However, as this is the only easily accessible source we have for data on land based fishery activity, we will use these data as an indication of the size of land-based fishery related employment. As an example, for the North Sea countries (fishing in the North Sea), land-based employment exceeds fleet employment by more than two times (35000 vs 15000). This indicates the importance of land-based fishery employment.

On the other hand, it is important to be aware that this employment cannot, in its whole, be connected to the fisheries in the adjacent seas. Many MS import raw materials to the fish processing industry, which means that industrial employment is based on fishing activities in other seas. Also, fishing activity in one sea, e.g. the North Sea, may lay the foundation for industrial activity in an adjacent sea, e.g. the Northwestern Waters or Southwestern Waters. The land based fishery employment obviously must be a function of access to raw materials. Due to economic and political circumstances, the amount of fish imported for processing may vary significantly over time, and this will thus also be the case for land based fishery employment. Also, as the numbers in the mentioned report are quite old, there may have been increases in productivity, which would imply that for the same size of catch/raw material the land based fishery employment will be lower.

2.3.1.3 Background variables and variable correlations

Fuel is the single most important economic input in most fisheries, disregarding capital and labour. Hence, changes in fuel price have severe consequences for the profitability of fisheries. This variable (fuel costs or fuel consumption) is included in the AER and there is often a special section in the report treating fuel prices and how they affect the profitability of the fisheries. Hence, it is a relevant variable to include in the matrix.

However, fuel consumption is a variable that is highly correlated with other decision variables in the fishery, and may vary significantly over time. This may cause some problems with the calculation and presentation of this variable, as explained below.

The socio-economic variables presented in the matrix are usually not given for fisheries, but rather for countries, and divided on species and gear type within a country. Thus, when presenting these variables on fishery level they are composed from average country specific indicators, which make them less exact compared to data, which are taken directly from databases. Only data on catches is available to take directly from an existing database (ICES), and thus need no further computing. Catches is therefore used as a basic variable, which also contribute in the composition of the two other variable groups (value of catches and employment).

This problem implies that when choosing variables for the matrix they should be as de-composed as possible, i.e. not derived from other variables (than catches) and with as little dependency on other variables as possible.

The value of catches and employment are two such variables. The value of the catches, which is the gross income to the fishers or shipping companies, is supposed to cover all costs, including fuel costs, crew costs, and maintenance of gear and vessel. Assuming that all fishers are profit maximising, the relative input-output price (price on a specific input relative to the price in the market for the species under consideration) will be decisive for the composition of the input. Hence, there will be interdependencies between the price of a species, the value of the landings, and the use of specific input, such as fuel and crew. When not knowing the exact nature of such interdependencies, we have little control over the variables “deeper down” in the chain. Hence, it has been a guideline through the work of developing the socio-economic variables to choose variables which are as independent as possible, i.e. variables high up in the chain.

In this respect, fuel consumption is a "dependent" variable, and one must be aware of the interdependencies between this and other economic variables. Also, fuel consumption stemming for the fishery activities does not impact society directly, in the way employment does, for example. As such, it cannot be regarded as a good representative for describing socio-economic conditions.

Matrix variables and background variables

Many of the socio-economic variables for the matrix, described above, have to be constructed. During the construction process, underlying and preliminary variables are developed. Some of these variables may be of interest in themselves. Hence, when developing and operationalising the matrix variables, we also have underlying tables with so-called background variables. The background variables are variables, necessary to calculate and estimate the matrix variables. In appendix 1 there is a list of each of the single socio-economic variables to be developed in order to complete the socio-economic part of the matrix. It is indicated whether the variable is a background (underlying) variable or a matrix-variable.

2.3.2 Biological variables in the Matrix

The biological variables in the matrix were assessed in terms of whether the specific pressure (rows) exerted by the case-study fishery had an effect on the ecological components (columns). The list of ecological components was taken from the Marine Strategy Framework Directive (MSFD; Annex III) and the pressures from the MSFD (Annex III) and OSPAR. Such effects will exist on a continuum from no effect through to a catastrophic effect (i.e. extirpation of a species). For the purpose of informing managers, the interaction strength was mapped onto a three point scale. A three point scale was used as this requires assessment of the impact against only two break points and so is able to cope with high levels of data uncertainty. The first breakpoint separates situations where there is no interaction from situations where there is an impact. The second breakpoint seeks to capture the shift from the situation where there is an impact but on its own it is not 'ecologically significant' from situations where the scale of the impact results in a significant ecological effect. The latter are likely to warrant some form of management action, either a direct response or a monitoring scheme, while the former need to be considered in relation to their possible interaction with other pressure components. Given the lack of a formal definition/test of 'ecological significance' this was assessed by means of expert judgement from the scientific team within the project and using expertise and experience gained with OSPAR and ICES working groups. Where scientific evidence was available from experimental studies, meta-analyses or field comparisons this was used to inform this judgement. Expert scientific judgement was used where information was not available. The information base used to make the assessments is detailed below.

- Where there was no interaction the cell was left blank.
- Where there was an interaction of the pressure component and the ecological component the cell was light blue. Those cases where the effect was considered as trivial were marked with an asterisk.

- Where the interaction was deemed ecologically significant the cell was coloured dark blue.

2.3.3 Reading the SECPM

For each fishery the SECPM (social and ecological component by pressure matrix) provides an overview of the interactions between the fishery and various component of the fishery system, ecological and socio-economic. In developing management procedures for a fishery the first area of concern should be those areas where cells are shaded deep blue. These are areas where interactions are significant and might need addressing in the management plan. Some of these interactions will be positive other negative i.e. positive employment potential but negative effects through high fuel consumption (carbon footprint is high).

Cells shaded light blue indicate areas where the review needs consider possible interactions and cumulative effects. The mechanisms for dealing with such multiple pressures on ecological components is in its infancy (Hegmann *et al*., 1999; James *et al*., 2003; Halpern *et al*., 2007; Foden *et al*., 2008; ICES, 2008e) and linking these to socio-economic interactions remains a challenge (Foden *et al*., 2008).

2.4 Social and Ecological Component by Pressure matrix

2.4.1 Purse seine fishery

	Ecological components										
	habitats			plants		invertebrates		vertebrates			Other groups
Impact Type (MSD & OSPAR)	seafloor	watercolumn	protected habitats	phytoplankton	macroalgae	Zooplankton	benthos	fish	mammals & reptiles	seabirds	non-indigenous & invasive
Barrier to species movement											
Community structure or species dynamics changes											
Death or injury by collision											
Introduction [spread] of non-indigenous species & translocations											
Introduction of microbial pathogens											
Removal of non-target species											
Removal of target species											
Heavy metal contamination											
Hydrocarbon contamination											
Radionuclide contamination											
Synthetic compound contamination											
Emergence regime changes (inc. desiccation) - local											
Emergence regime changes (inc. desiccation) (sea-level rise) - regional/national											
pH changes											
Salinity changes - local											
Salinity changes (rainfall; arctic ice melt) - regional/national											
Temperature changes - local											
Temperature changes - regional/national											
Water flow (tidal & ocean currents) rate changes - local											
Water flow (tidal & ocean currents) rate changes - regional/national											
Water flow (tidal currents) rate changes - local											
Wave exposure changes - local											
Changes in species or community distribution, size/extent or condition											
De-oxygenation											
Input of nitrogen & phosphorus											
Electromagnetic changes											
Litter											
Noise and visual disturbance											
Noise disturbance											
Visual disturbance											
Habitat structure changes											
Habitat structure changes - abrasion											
Siltation (turbidity) changes											
Habitat loss (to land)											
Habitat transformation (by smothering or sealing)											

2.4.2 Mixed demersal trawl fishery

	Ecological components										
	habitats			plants		invertebrates		vertebrates			Other groups
Impact Type (MSD & OSPAR)	seafloor	watercolumn	protected habitats	phytoplankton	macroalgae	Zooplankton	benthos	fish	mammals & reptiles	seabirds	non-indigenous & invasive
Barrier to species movement											
Community structure or species dynamics changes				*?		*?					
Death or injury by collision											
Introduction [spread] of non-indigenous species & translocations											
Introduction of microbial pathogens											
Removal of non-target species											
Removal of target species											
Heavy metal contamination											
Hydrocarbon contamination											
Radionuclide contamination											
Synthetic compound contamination											
Emergence regime changes (inc. desiccation) - local											
Emergence regime changes (inc. desiccation) (sea-level rise) - regional/national											
pH changes											
Salinity changes - local											
Salinity changes (rainfall; arctic ice melt) - regional/national											
Temperature changes - local											
Temperature changes - regional/national											
Water flow (tidal & ocean currents) rate changes - local											
Water flow (tidal & ocean currents) rate changes - regional/national											
Water flow (tidal currents) rate changes - local											
Wave exposure changes - local											
Changes in species or community distribution, size/extent or condition				*?		*?					
De-oxygenation											
Input of nitrogen & phosphorus											
Electromagnetic changes		*									
Litter		*		*?				*			
Noise and visual disturbance		*						*			
Noise disturbance		*						*			
Visual disturbance								*			
Habitat structure changes											
Habitat structure changes - abrasion											
Siltation (turbidity) changes							*	*			
Habitat loss (to land)											
Habitat transformation (by smothering or sealing)											

2.4.3 Mixed demersal line fishery

	Ecological components										
	habitats			plants		invertebrates		vertebrates			Other groups
Impact Type (MSD & OSPAR)	seafloor	watercolumn	protected habitats	phytoplankton	macroalgae	Zooplankton	benthos	fish	mammals & reptiles	seabirds	non-indigenous & invasive
Barrier to species movement											
Community structure or species dynamics changes											
Death or injury by collision											
Introduction [spread] of non-indigenous species & translocations											
Introduction of microbial pathogens											
Removal of non-target species											
Removal of target species											
Heavy metal contamination											
Hydrocarbon contamination											
Radionuclide contamination											
Synthetic compound contamination											
Emergence regime changes (inc. desiccation) - local											
Emergence regime changes (inc. desiccation) (sea-level rise) - regional/national											
pH changes											
Salinity changes - local											
Salinity changes (rainfall; arctic ice melt) - regional/national											
Temperature changes - local											
Temperature changes - regional/national											
Water flow (tidal & ocean currents) rate changes - local											
Water flow (tidal & ocean currents) rate changes - regional/national											
Water flow (tidal currents) rate changes - local											
Wave exposure changes - local											
Changes in species or community distribution, size/extent or condition											
De-oxygenation											
Input of nitrogen & phosphorus											
Electromagnetic changes											
Litter											
Noise and visual disturbance											
Noise disturbance											
Visual disturbance											
Habitat structure changes											
Habitat structure changes - abrasion											
Siltation (turbidity) changes											
Habitat loss (to land)											
Habitat transformation (by smothering or sealing)											

2.5 Ecological Matrix elements supporting evidence

2.5.1 Purse seine fishery

2.5.1.1 Habitats

Since purse seine fisheries operate in pelagic habitats they are unlikely to have any effect on seabed habitats. Besides, no effect on water column or protected habitats is known.

2.5.1.2 Plants

Purse seines are unlikely to have any influence on phytoplankton or macroalgae community, except for indirect effects through the food web.

2.5.1.3 Invertebrates

2.5.1.3.1 Zooplankton

Community structure or species dynamic changes

Small pelagic fish exert a major control on the trophic dynamics of upwelling ecosystems and constitute midtrophic-level "wasp-waist" populations (Cury *et al.*, 2000). Since overfishing can alter the abundance, composition, and distribution in pelagic communities, any increase/decrease in small pelagic population would result in abundance changes on their prey, that is to say, zooplankton community.

2.5.1.3.2 Benthos

Provided that purse seines operate in pelagic habitats they are unlikely to have any effect on benthos.

2.5.1.4 Vertebrates

2.5.1.4.1 Fish

Community structure or species dynamic changes

The most obvious impact of fishing on the marine environment is that it causes mortality on both target species and on other species taken as by-catch. Moreover, in the longer term the direct impacts give rise to indirect impacts, such as changes in trophic interactions (Gislason, 1994). Sanchéz and Olaso (2004) concluded that the Cantabrian Sea purse seine has a negative impact on small and medium planktivorous fish that are important as forage fish for diverse trophic groups. Thus, this fishery has a negative effect on the other fisheries. In general, in the Bay of Biscay fisheries have a major effect on the structure and dynamics of the ecosystem; some key compartments are highly exploited and consequently, some structuring and trophic interactions of the ecosystem are highly impacted by fisheries (Lobry *et al.*, 2008).

Removal of non-target species

In pelagic fisheries discarding occurs in a sporadic way compared to demersal fisheries. This is because the nature of pelagic fishing is to pursue schooling fish, creating hauls with low diversity of species and sizes and consequently often extreme fluctuation in discard rates (100% or null discards).

Discard percentages of pelagic species from pelagic fisheries were estimated between 3% and 17% (Pierce *et al*., 2002; Hofstede and Dickey-Collas, 2006; Dickey-Collas and van Helmond, 2007; Ulleweit and Panten, 2007).

Sometimes the target species is discarded especially during slippage events, when the entire catch is released. Mean reasons for slipping are daily or total quota limitations, illegal size and mixture with unmarketable bycatch. Slipping estimates has only been published for the Portuguese purse seine fishery targeting sardine, with values at around 70% of the total catch (Stratoudakis et al., 2002), mostly in years with high recruitment and in northern Portugal (ICES, 2007d). No information is available for other fisheries.

In the case of anchovy, preliminary discard estimates for purse seine vessels show that 10.1% of anchovy catch in numbers and 10.7% in weight is discarded in the Gulf of Cadiz. There are no recent estimates of discards in the French and Spanish anchovy fishery in the Bay of Biscay (ICES, 2007d).

<u>Removal of target species</u>

The main target species of purse seines selected for this case study are small pelagic species like sardine and anchovy, but also mackerel and horse mackerel. Such species were assessed within ICES by the Working Group on the Assessment of Mackerel, Horse Mackerel, Sardine and Anchovy (WGMHSA). Such working group has been dissolved in 2008.

Figure 62 shows sardine landings time series from 1940 till 2005. Although high fluctuations are registered over the time series landings have decreased considerably in the last decade.

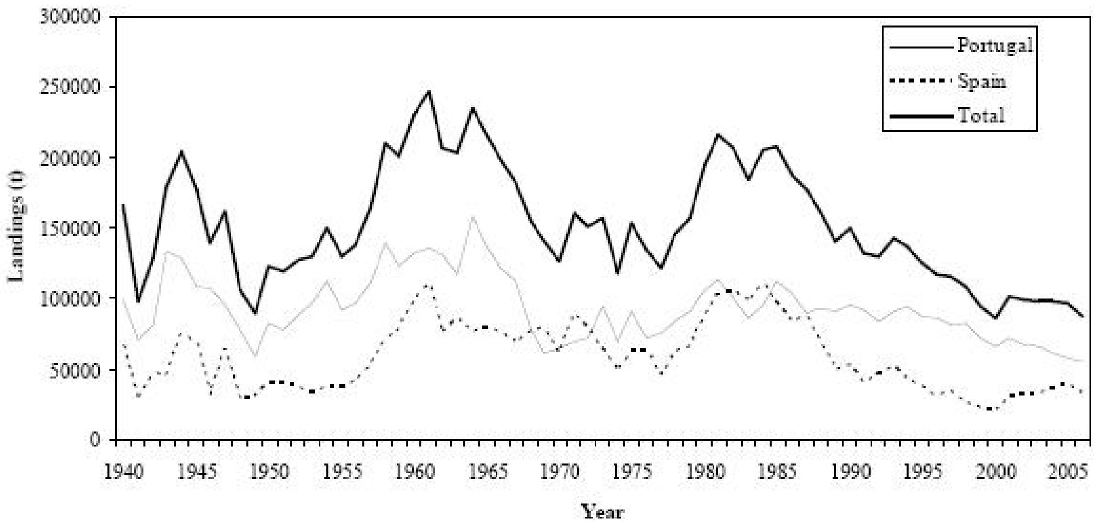

Figure 62. Historical series of Spanish and Portuguese sardine landings (source: ICES).

Regarding anchovy, Figure 63 illustrates the highly variable evolution of the French and Spanish landings during the same period. In 2005, there was a failure of the commercial fishery for the Bay of Biscay anchovy and the fishery has remained closed since then.

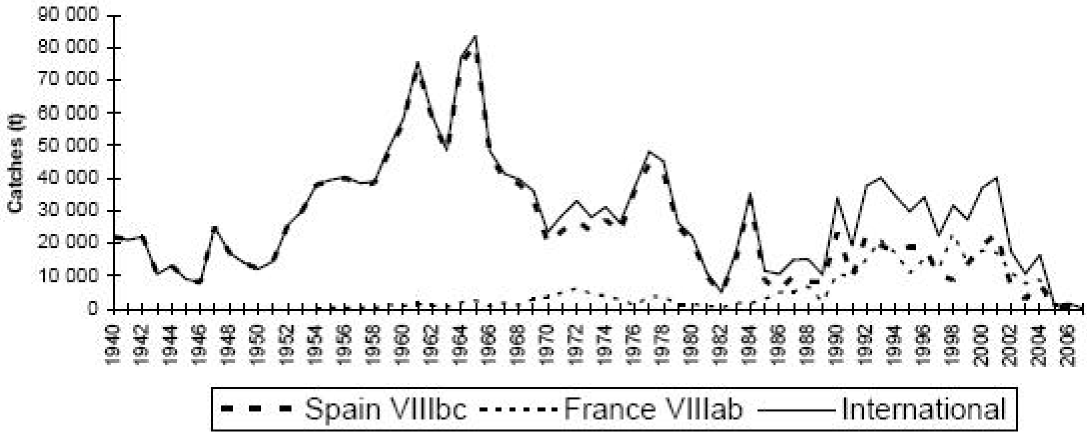

Figure 63. Historical series of Spanish (in VIIIbc) and French (in VIIIab) anchovy landings in comparison to international landings (source: ICES).

Additionally, anchovy landings over the western Iberian coast fluctuated largely showing the lowest landing values in the 1970s and 1980s (Figure 64).

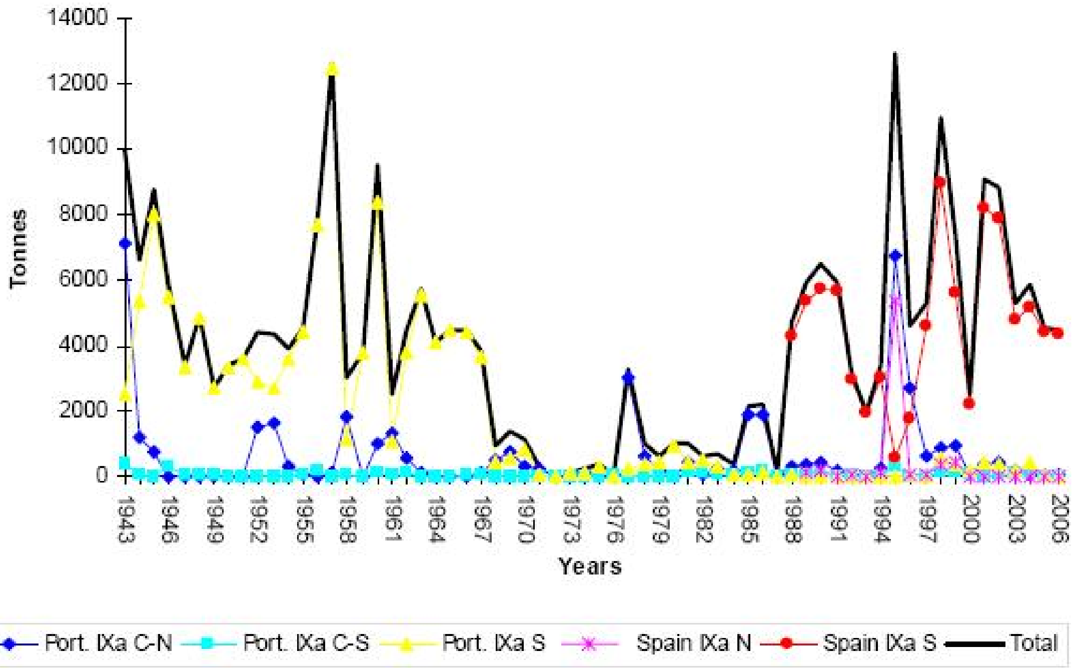

Figure 64. Historical series of Portuguese and Spanish anchovy landings in Division IXa (1943-2006) (source: ICES).

<u>Noise and visual disturbance/Noise disturbance/Visual disturbance</u>

Noise and visual disturbance caused by pelagic fisheries can result in an avoidance reaction and stress. This can make fish more susceptible to predation and possibly pathogens.

2.5.1.4.2 Mammals & reptiles

Death or injury by collision

In a study undertaken in the northern Iberian coast, pelagic purse seines and trawls were the main fishing gears causing by-catches of cetaceans. Common dolphin (*Delphinus delphis*) is the species that suffers more interactions with fishing activities (CEMMA, 2007).

Removal of non-target species

Dolphins and turtles are often accidentally caught by fishing nets. In a study undertaken over the north and northeast of the Spanish coast, between 1990 and 2005, the 18% of the total marine turtles recorded (518) was caught accidentally (Cermeño *et al*., 2006).

Litter

Within this section litter thrown from the vessels as well as lost fishing gears can be considered. Both factors could have detrimental effects on marine mammals and reptiles either by the ingestion of plastic bags or by getting trapped by lost fishing nets.

In spite of the known likely effects, further research is needed in order to quantify annual death or injuries caused by litter coming from fishing vessels.

Noise and visual disturbance/Noise disturbance/Visual disturbance

Fishing vessel engines can influence species distribution and behavioural aspects. The engine power and autonomy that characterises this fleet can cause stress for example to the dolphin estuarine communities.

It has been suggested that anthropogenic sounds could have some negative effects on cetaceans such as whales, in terms of sound propagation and acoustic exposure during specific stranding events (Cox *et al*., 2006). However, it is an issue that still needs to be investigated.

2.5.1.4.3 Seabirds

Community structure or species dynamic changes

See “Changes in species or community distribution, size/extent or condition” section.

Death or injury by collision

Seabirds may be injured or killed by getting caught in the purse seine net as they attempt to feed on fish during the hauling.

Changes in species or community distribution, size/extent or condition

Fisheries have a considerable influence at different levels on the distribution of seabirds at sea due to the supply of discards that are used as food for scavenging species.

The seabird community is dominated by the yellow-legged gull (*Larus cachinnans*) which makes up 70% of the total number of seabirds with predominately coastal and fishing ground distribution. It is a littoral species and its main food sources are fish discards and rubbish dumps which, together with the protection of their colonies, explains their strong demographic growth in recent decades in the Portuguese coastal waters (OSPAR, 2000).

Litter

See 2.4.1.4.2 on litter impacts on Marine mammals and reptiles.

2.5.1.5 Other groups

2.5.1.5.1 Non-indigenous & invasive

There is no evidence of any effect of the purse seine fishery on non-indigenous or invasive species.

2.5.2 Mixed demersal trawl fishery

2.5.2.1 Habitats

2.5.2.1.1 Seafloor

Heavy metal, hydrocarbon and synthetic compound contamination

Sediment resuspension derived from trawling may result in increased levels of contaminants in the seafloor that have previously been stabilised in the sediment (ICES, 2006d; 2008). Thus, the effect of trawls on the seafloor is considered to be ecologically significant.

Salinity changes – local

Sediment resuspension derived from trawling may result in small local salinity changes in the seafloor, thus there may be an interaction of the pressure component and the ecological component.

De-oxigenation

The large increase in nutrient caused by the trawl gears (see "Input of nitrogen & phosphorus") can lead to de-oxygenation as the oxygen requirements of the bacteria degrading the organic matter may deplete oxygen from the bottom waters (Brockmann *et al.*, 1988), and cause anoxia. A study undertaken in North Carolina showed how habitat degradation through fishery disturbance enhanced impacts of hypoxia on oyster reefs (Lenihan and Peterson, 1998). Although no comparable study is known for trawled habitats in the Bay of Biscay, similar hypoxia/anoxia conditions could occur in the Grande Vasière for instance.

Input of nitrogen & phosphorus

Sediment resuspension derived from trawling may result in increased levels of nitrogen and phosphorus that have previously been stabilised in the sediment. Trawl activity can determine whether the seabed acts as a source or a sink of nitrogen nutrients (Olsgard *et al.*, 2008).

Litter

The most abundant debris in European seafloor is plastic (mainly bags and bottles) that account for a very high percentage (more than 70%) of total number of debris, and accumulation of specific debris, such as fishing gears. In some European areas, some amounts of debris were collected on the continental shelf, mostly in canyons descending from the continental slope and in the bathyal plain where high amounts were found down to more than 500m. Particularly in the Bay of Biscay, the mean amount of litter was quantified as 142 pieces of debris/km^2 (Galgani *et al.*, 2000). The litter coming from the trawl fishing vessels is not the most important source of this material, but nevertheless it has some effect on the concentration of litter lying on the seafloor.

Habitat structure changes – abrasion

Demersal trawlers consist of heavy metal frames with nets and rubber wheels that roll along the ocean floor, scooping up or crushing down everything in their path. Bottom and demersal trawl fishing gears are well known to be responsible for the destruction of the sea bed structures and specific habitats. For such reason, they are considered to cause ecologically significant physical damages on the seafloor.

The effects of demersal trawlers on habitat structure changes have been widely studied, but most of the available literature is not from the SWW region.

Siltation (turbidity) changes

The demersal trawl gears have effects on the turbidity conditions of the seafloor through the sediment and debris resuspension.

Habitat transformation (by smothering or sealing)

Trawling may have some impact on the sediment compound. The sediment compound of a large area of sedimentary bottom know as "Grande Vasiere" and trawled for Nephrops, to the south west of Brittany, appeared to have changed over the last 30 years. The proportion of mud decreased and the change may be due to sediment remobilization by storms and trawling (Bourillet *et al*., 2004).

2.5.2.1.2 Water column habitats

Electromagnetic changes/Noise and visual disturbance/Noise disturbance

Fishing vessel engines could cause electromagnetic changes and noise disturbance alone or both, noise and visual disturbance on the water column habitats, thus it is considered that some interaction could occur between the pressure component and the ecological component though it would have a trivial effect.

2.5.2.1.3 Protected habitats

Community structure or species dynamic changes

Protected habitats include special areas of conservation or special protection areas. The purpose of these protected areas is to promote the well-being of certain communities of living organisms. In theory, the demersal trawl fishery activity should not have a direct impact in these special areas. Nevertheless, because bottom trawling sometimes occurs immediately adjacent to the closed areas, there could be an adaptive migration of some species with contiguous distribution and whose seabed habitat was damaged by the bottom trawl fishing gears. The relocation of these individuals could have consequences in the diversity and stability of the ecological communities within these protected areas.

Changes in species or community distribution, size/extent or condition

See "Community structure or species dynamic changes" section.

2.5.2.2 Plants

2.5.2.2.1 Phytoplankton

Since phytoplankton species only exist in the photic zone of the water column the demersal bottom trawl fishery does not have a direct effect on phytoplankton communities. Nevertheless, there could be some trivial effects by means of the indirect effect through the food web.

Community structure or species dynamics changes/Changes in species or community distribution, size/extent or condition

Some demersal species have a juvenile pelagic phase in their life history. Thus demersal bottom trawl fishery could have an indirect effect on adult individuals as a result of the direct effect on their juvenile planktivores fish concentration. Planktivores fish concentration could have some control on the concentration of several phytoplankton species through a top-down effect (Scheffer *et al*., 2000).

Vessel engines stir up the ocean waters and help absorption of nutrients by the phytoplankton.

Litter

Some of the debris or litter thrown overboard by fishing vessels can induce small bloom patches in some phytoplankton species.

2.5.2.2.2 Macroalgae

Barrier to species movement/Community structure or species dynamics changes/Changes in species or community distribution, size/extent or condition

Fish grazing has a direct impact on macroalgal distribution and abundance. Fishing activities can disturb habitat and alter grazing pressure on algae. Trawling may directly affect deep water inter-reefal macroalgae (www.wwf.org).

The trawls impacting on seabed structures/substrate also indirectly affect algae allocation. The available habitat for algae becomes smaller or could fully disappear, with consequences in algae concentration and distribution.

Death or injury by collision

Macroalgae may be affected by demersal trawls if they are attached to hard substrates (e.g. rocks and cobbles) which are likely to be disturbed by trawls. As this type of substrate is likely to damage fishing gears or the catch, these areas are likely to be avoided.

Fish grazing has a direct impact on macroalgal distribution and abundance (see Community structure or species dynamics changes/barrier to species movement).

De-oxygenation

The large increase in nutrient caused by the resuspension due to the action of trawl gears can lead to de-oxygentaion as the oxygen requirements of the bacteria degrading the organic matter may deplete oxygen from the bottom waters (Brockmann *et al*., 1988) and cause anoxia.

Input of nitrogen & phosphorus

Sediment resuspension derived from trawling may result in increased levels of nitrogen and phosphorus that have previously been stabilised in the sediment.

Habitat structure changes – abrasion

Bottom and demersal trawl are responsible for the destruction of the seabed and algae populations that depend on a specific seabed habitat, thus they are strongly negatively affected. (See "Community structure or species dynamics changes/barrier to species movement").

2.5.2.3 Invertebrates

2.5.2.3.1 Zooplankton

Community structure or species dynamic changes/Changes in species or community distribution, size/extent or condition

The demersal trawl effect on the abundance of juvenile planktivores fish could have some control on the concentration of several zooplankton species through a top-down effect (see 2.4.2.2.1 Phytoplankton – Community structure or species dynamic changes). In contrast, it is also suggested that bottom disturbance may improve the feeding conditions for small, soft-bodied species which can be in turn, prey of commercial fish species (Hiddink *et al*., 2008). However, despite the existence of literature regarding closed areas such as the North Sea (Jennings *et al*., 1999; 2001), very little is known about the possible impacts on community structure of demersal trawl fisheries in the Iberian coast.

Habitat structure changes – abrasion

Bottom and demersal trawl are responsible for the destruction of the seabed. For example, seamounts are believed to be rich areas in terms of primary production, and thus, important for zooplankton. Consequently, the destruction of their habitat could have an impact in zooplankton abundance.

2.5.2.3.2 Benthos

Barrier to species movement

Demersal trawlers consist of heavy metal frames with nets and rubber wheels that roll along the ocean floor, scooping up or crushing down everything in their path. The trawls impacting on these habitat structures affect benthic communities. The habitat available for benthos depending on these structures becomes smaller and leads to barriers for the movement/migration of species and mixing of populations.

Community structure or species dynamic changes

Demersal trawling causes one of the most widespread physical and biological changes in marine shallow and shelf sedimentary habitats; actually, benthic trawling is believed to be a major source of disturbance for soft-bottom communities (Vergnon and Blanchard, 2006). Bottom and demersal trawl directly affects long-lived, attached and encrusting seafloor life, such as sponges, anemones and snails. Overall, diversity of seafloor life is significantly lower in the trawled areas due to removals of seafloor life. Sedentary invertebrates that live on the seafloor are those primarily affected by trawling. Highly mobile species, and those species that burrow into the seafloor are less affected (Rosenberg *et al*., 2003).

Demersal trawling decreases bottom habitat complexity and biodiversity, increases the abundance of opportunistic species, and benefits prey importance in the diet of some commercially valuable fish. At the Grande Vasiere, in the heavily exploited stations, the dominant species were opportunistic carnivorous species of minor or no commercial interest and there were no fragile invertebrates (Blanchard *et al*., 2004; Vergnon and Blanchard, 2006). As such, a great change has been seen since the 1960s in the Grande Vasière area. Sedimentary modifications due to several processes including the resuspension of the fine mud particles y bottom trawling are the main factor explaining the modifications observed in the macrobenthic fauna (Hily *et al*., 2008). In the Cantabrian Sea, parameters such as total biomass and species richness were sensitive to an experimental exclusion of trawling, results that highlighted the likely impact of trawling activity on species like seabreams, catsharks and skates, red mullets, gurnards and John Dory (Serrano *et al*., 2010).

Several studies suggest that trawling-related factors have important biological consequences and account for the different benthic communities observed between trawled and closed areas. Trawling affects benthic assemblages through resuspension of surface sediment and displacement to the surface of shallow-burrowing fauna (Brown *et al*., 2005).

Death or injury by collision

Demersal trawl nets and attached weights scrape the sediment surface. As a consequence, benthic animals are disturbed or killed.

Removal of non-target species

Diversity of seafloor life is significantly lower in the trawled areas due to removal of seafloor non-target benthic species.

Heavy metal contamination/Hydrocarbon contamination/Synthetic compound contamination

The resuspension of contaminated sediments by trawl gears has obvious impacts on the benthic biota. However, trends in the spatial distribution of benthic species are complex, as naturally occurring biological and environmental factors can influence the distribution of species, making it difficult the detection of impacts due to contaminants (Chariton *et al*., 2006).

Changes in species or community distribution, size/extent or condition

See "Community structure or species dynamic changes" section.

De-oxygenation

Sediment resuspension derived from trawling may result in increased levels of contaminants in the seafloor that have previously been stabilised in the sediment (ICES, 2006d; 2008). The marine environment is nutrient limited. Resuspension of nutrient-rich sediments will increase primary production which may have both positive and negative effects on the marine environment. An increase in the amount of organic matter sinking to the sea floor, as a result of increased primary production, will provide additional food for the benthos which will enhance secondary production. This enhanced secondary production will enhance the food availability of fish species. It will increase the carrying capacity of the system, being beneficial for the overall production. However, large increases in organic input can lead to the mortality of benthic fauna as the oxygen requirements of the bacteria degrading the organic matter may deplete oxygen from the bottom waters (Brockmann *et al*., 1988), and cause anoxia.

Input of nitrogen & phosphorus

The activity of the trawls can determine whether the seabed acts as a source or a sink of nitrogen nutrients. Intensive trawling, may affect the nutrient balance especially in continental shelf and coastal areas (Olsgard *et al*., 2008). The pressure that macroalgal blooms exert on other benthic organisms can be a direct or indirect consequence of changed water quality. Direct pressure comes from nutrient stimulation of macroalgal growth and indirect pressure from colonisation of space made available by the death of other organisms (Olsgard *et al*., 2008).

Litter

The deposition of litter by fishermen/vessel on the seafloor could result in increased aggregation of detritivores in retention areas generating small patches of benthic specific species.

Habitat structure changes – abrasion

Bottom and demersal trawl are responsible for the destruction of the seabed, and benthic communities that directly depend on a specific seabed habitat are negatively affected. The habitat available for benthic species depending on seabed structures/substrate becomes smaller or could fully disappear, with consequences in benthic biota abundance and distribution. Functional differences in the benthic communities were consistent with the observed differences in sedimentary characteristics caused by trawl activity (Brown *et al*., 2005).

Siltation (turbidity) changes

The bottom trawl gears have effects on the turbulence conditions of the seafloor through the resuspension of sediments and debris. Benthic communities are very dependant of some abiotic factors such as depth of water, temperature and turbidity. So fluctuations of turbidity can affect benthic communities but surely it is not the most important consequence of the demersal fishing activity.

2.5.2.4 Vertebrates

2.5.2.4.1 Fish

Barrier to species movement

The trawls impacting on habitat structures indirectly affect species movement. The habitat available for fish species depending on these structures becomes smaller, possibly resulting in larger distances between patches suitable for survival. Thus trawl could lead to barriers for the movement of species and mixing of populations (see “habitat structure changes”).

Community structure or species dynamic changes

The mortality in the trawl fleet is higher for larger demersal fish species, while pelagic and small specimens are much less impacted. This uneven fishing mortality will lead to changes in the size composition of the community. After an analysis using data sets from different world regions, Bianchi *et al*. (2000) documented changes in demersal fish community structure that may be related to fishing. Sometimes such modifications provoke changes in other trophic levels, due to the trophic cascade effect causing important alterations in the structure and dynamics of the marine ecosystem (Daskalov, 2002).

In the Bay of Biscay fisheries have a major effect on the structure and dynamics of the ecosystem; some key compartments are highly exploited and consequently, some structuring and trophic interactions of the ecosystem are highly impacted by fisheries (Lobry *et al*., 2008). In the Cantabrian Sea, in recent decades, the mean trophic level of the demersal and benthic fisheries declined. This is reflected in a gradual transition of landings from long-lived, high trophic level piscivorous groundfish (hake, anglerfish, megrim) towards lower trophic level planktivorous fish (blue whiting, horse mackerel). The mean trophic level was estimated to have declined from 4.10 in 1983 to 3.95 in 1993, then to have varied without clear trend (Sanchez and Olaso, 2004).

Fishing elevates variability in the abundance of exploited species. The increased variability is probably caused by fishery induced truncation of the age structure (fishing mainly directed at older individuals), which reduces the capacity of population to buffer environmental effects (Hsieh *et al.*, 2006). Smaller individuals may be more susceptible to environmental changes than older, larger individuals that can survive hard times better.

Fishing older individuals may affect demographic parameters, such as age of maturation and intensify the non linear nature of the processes involved in population dynamics; for example, through an increased population growth rate or by increasing non linear coupling of demographic parameters to environmental changes (Stenseth and Rouyer, 2008).

Intense and selective harvesting can alter the basic dynamics of exploited populations, and lead to unstable booms and busts that can precede systematic declines in stock levels (Anderson *et al*., 2008).

Evidence is accumulating that heavy exploitation of fish stocks causes genetic change to fish population causing less adaptation to the changing environment (Anderson *et al*., 2008).

In a study undertaken on the French coast of the Bay of Biscay, Blanchard *et al.* (2004) studied possible fishing effects on diversity, size and community structure of the benthic invertebrate and fish community. On one hand, they found that species diversity and largest body mass class of invertebrates were smaller in strongly exploited areas than in moderately exploited ones. Moreover, in the heavily exploited areas, the dominant species were opportunistic carnivorous species of minor or no commercial interest.

<u>Death or injury by collision</u>

Fishes tend to be injured by pressure changes during hauling, crushing and the abrasive action of other species spines or sales inside the trawls nets.

<u>Removal of non-target species</u>

Trawls remove non-target species, of which some are landed while others are discarded. For example, in the demersal trawl fleet, directed mainly at hake, there are restrictions on the landings weight of Norway lobster, and the opposite is also true; restrictions on hake landings caught by the bottom trawl fleet.

In relation to discards in the Bay of Biscay, bottom trawl reach the biggest rate of discards, due to the mixed species fishery. Among fishes, the main species discarded in number are the small fish snipe-fish (*Macrorramphosus scolopax*), silver pout (*Gadiculus argenteus*) and the medium sized blue whiting (*Micromesistius poutassou*) (ICES, 2008e). Olaso *et al*. (2002) studied the influence of discards on the feeding behaviour of some demersal fish species and they found that changes in trophic structure took place as a response to discards.

Hake discards in the Bay of Biscay Nephrops fishery are very important since Nephrops fishing grounds are on a hake nursery. Thus, the Bay of Biscay Nephrops fishery has a major impact on the northern stock of hake (ICES, 2009a). Additionally, in Iberian waters (ICES regions VIIIx and IXa), 21% of the weight of hake catches made by trawlers and 70% of the actual numbers are discarded due to their smaller than permitted size (OCEANA).

Off the Portuguese coast, the trawler fisheries of demersal fish and crustaceans manage to catch up to 192 and 177 different species (Pais *et al*., 2000), showing the low selectivity of these fisheries.

Removal of target species

The main species in Iberian waters caught by the demersal trawl fleet are hake (*Merluccius merluccius*), megrim (*Lepidorhombus whiffiagonis*), four-spot megrim (*L. boscii*), anglerfish (*Lophius piscatorius* and *L. budegassa*), and Nephrops spp. Targeted by the bottom trawl fleet (ICES, 2005c).

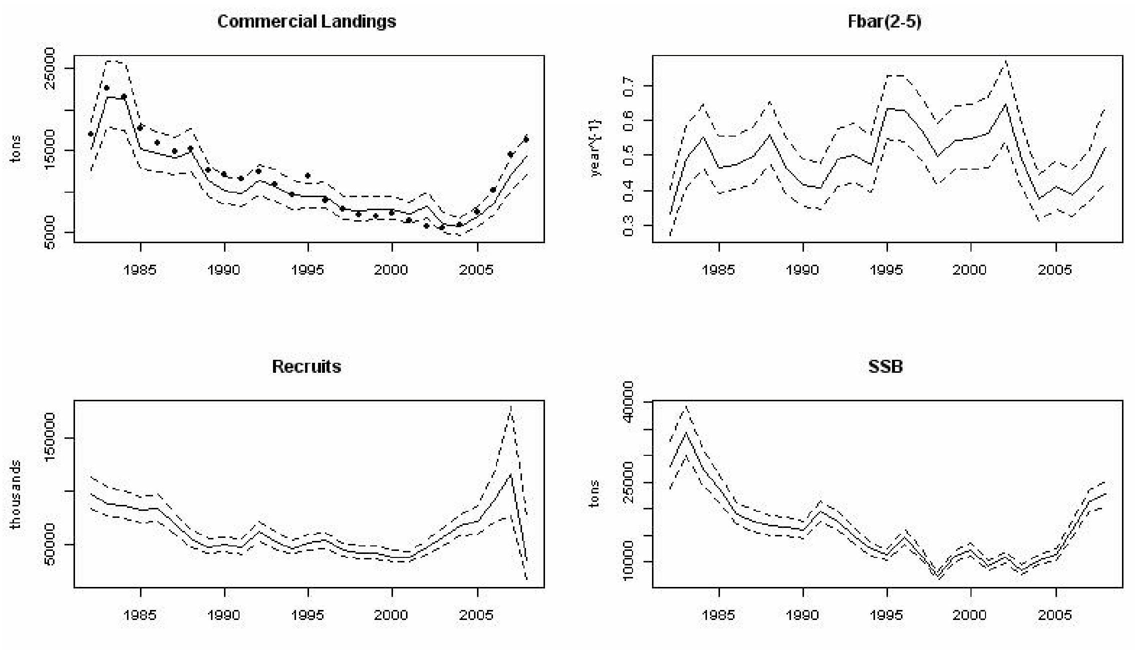

Figure 65. Southern hake stock landings, fishing mortality, recruit number and SSB fluctuations (source: ICES, 2009).

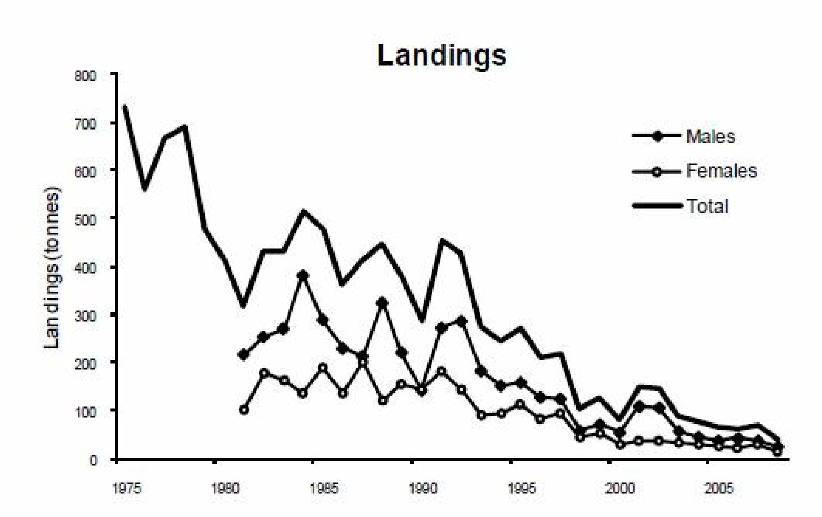

Figure 66. Nephrops landings in Division VIIIc (source: ICES, 2009).

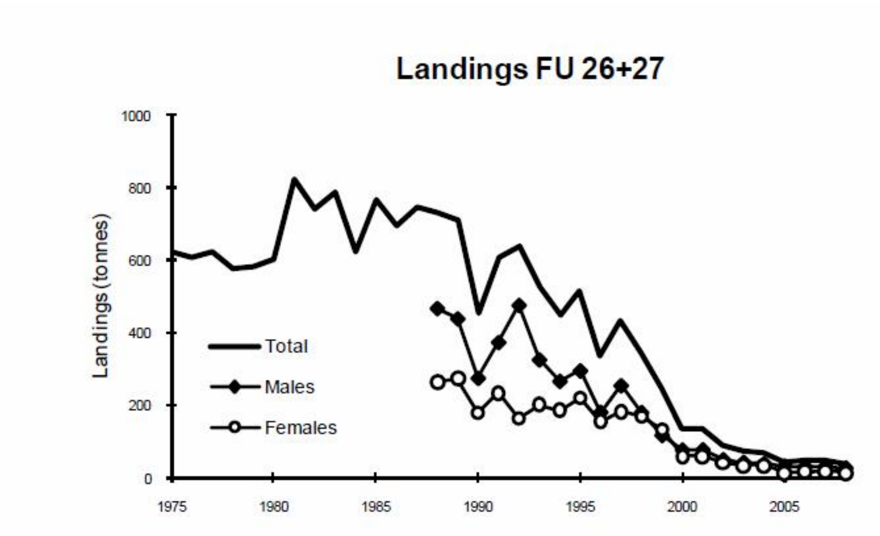

Figure 67. Nephrops landings in Division IXa (source: ICES, 2009).

Figure 65 illustrates southern hake evolution over time. It is clearly showed that after the highest values registered in early 1980s, commercial landings and SSB decreased considerably. However, it seems that recently the stock SSB is increasing although it has not yet reached the high values of the beginning of the series.

Figure 66 and Figure 67 clearly show the highly decreasing trend in Nephrops landins in both, ICES area VIIIc and IXa.

Heavy metal contamination/Hydrocarbon contamination/Synthetic compound contamination

Sediment resuspension derived from trawling may result in increased levels of contaminants in the seafloor that have previously been stabilised in the sediment (ICES, 2006d; 2008). The ecological effects of contaminants are often very difficult to assess, however some evidences have been found for the effect of contaminants on fish species.

Changes in species or community distribution, size/extent or condition

According to Olaso *et al*., (2002), discards seem to be a relatively important food source for some bottom fishes since predators and scavenger species such as *Pagellus acarne* and *P. bogaraveo* may move to areas disturbed by bottom trawling in order to prey on discarded or damaged material.

See also “Community structure or species dynamic changes” section.

De-oxigenation

See 2.4.2.3.2 Benthos, section “De-oxigenation”.

Input of nitrogen & phosphorus

See 2.4.2.3.2 Benthos, section “Input of phosphorus”.

Litter

Trawlers from demersal fishery, despite their high autonomy that allows them to be for long periods in the sea, have no mechanisms for trash/litter destruction. The deposition of litter on the seafloor could have some kind of effect on the distribution of fish communities on the seafloor.

On the other hand, fishing operations generate litter through the accidental loss of gears and by the dumping of damaged gear. In some cases these nets can continue to fish for some after being lost. Although, general information on ghost fishing impact could be found (IEEP, 2005), the amount of "ghost fishing" of trawl gears in the Atlantic region has not been highly quantified. Puente *et al*. (2001) made an attempt to characterise the loss of static fishing gears off the Spanish coast in the Bay of Biscay and estimate its consequences on benthic communities. They observed that catch composition in the lost nets evolved from being initially dominated by fish to being dominated by large crustaceans.

<u>Noise and visual disturbance/Noise disturbance/Visual disturbance</u>

The high engine power and autonomy that characterises this fleet has obvious noise and visual disturbance consequences on the ecosystem causing stress to fish communities.

<u>Habitat structure changes – abrasion</u>

Bottom and demersal trawl are responsible for the destruction of the seabed and populations that depend on a specific sea habitat are negatively affected. The habitat available for fish species depending on seabed structures/substrate becomes smaller or could fully disappear, with consequences in fish population abundance and distribution. Seamounts, for example, are believed to be an area of primary production of zooplankton, the first link in the marine food chain. Destruction of seamounts has an impact on fish since they depend on zooplankton either directly or indirectly.

<u>Siltation (turbidity) changes</u>

The vessel engines and gears have consequences on the turbulence conditions of the water column and seafloor with possible influences on species grouping, predation, stress conditions, etc.

2.5.2.4.2 Mammals & reptiles

<u>Barrier to species movement</u>

Mammals' predators can change distribution because potential preys tend to change their distribution also (see fish ecological component) and thus, could have bottom-up effect on mammals.

Concerns regarding the conservation of cetacean populations in this region are similar to those expressed for other regions, and relate to issues such as the alteration of ecosystem structure and the impact of fisheries (OSPAR, 2000).

<u>Community structure or species dynamic changes</u>

<u>Death or injury by collision</u>

Bottom trawlers can generate accidental catches of marine mammals but their impact seems to be lower than pelagic trawlers impact. Although, sea turtles and dolphins can get caught in the nets and get injuries from the engine propeller, there is very little available information on accidental catches of turtles by trawlers operating in European waters (OCEANA).

<u>Changes in species or community distribution, size/extent or condition</u>

Mammals' predators can change distribution because potential preys tend to change their distribution also (see fish ecological component) and thus, could have bottom-up effect on mammals.

Electromagnetic changes

Noise or electromagnetic changes caused by fishing vessel engines can influence species distribution and migration routes.

Litter

Trawlers from demersal fishery, despite their high autonomy that allows them to be for long periods in the sea, have no mechanisms for trash/litter destruction. The most common example is plastic bags that in the water can be mistaken for jellyfish. This makes plastic bag pollution in marine environments particularly dangerous, as birds, whales, seals and turtles ingest the bags with the consequent death due to intestinal blockages. Disturbingly, it is claimed that plastic bags are the most common man-made item seen by sailors at sea (www.wwf.org).

See also 2.4.1.4.2 section on litter.

Noise and visual disturbance/Noise disturbance/Visual disturbance

See 2.4.1.4.2 section on noise and visual disturbance of purse seines.

2.5.2.4.3 Seabirds

Community structure or species dynamic changes

See "Changes in species or community distribution, size/extent or condition" section.

Death or injury by collision

Seabirds may be injured or killed by either encountering the warp wire of the trawlers or by getting caught in the net as they attempt to feed on fish inside the net during hauling.

Changes in species or community distribution, size/extent or condition

Fisheries have a considerable influence at different levels on the distribution of seabirds at sea due to the supply of discards that are used as food for scavenging species (Figure 68).

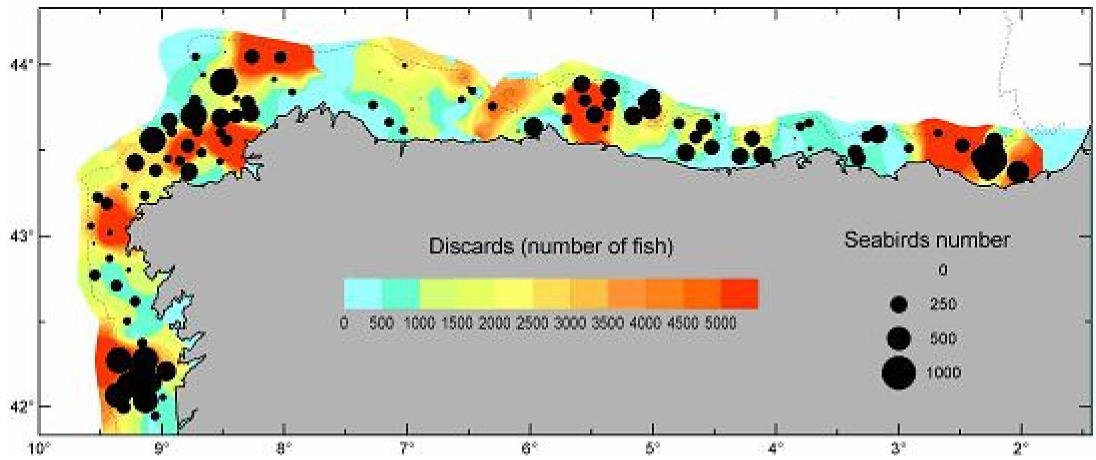

Figure 68. Abundance of fish discards and total number of seabirds attending trawling fishing operations at Galician and Cantabrian continental shelf. Northern Spanish Shelf Bottom Trawl Survey 2006 (source: Velasco *et al*., 2009).

The seabird community is dominated by the yellow-legged gull (*Larus cachinnans*) which makes up 70% of the total number of seabirds with predominately coastal and fishing ground distribution. It is a littoral species and its main food sources are fish discards and rubbish dumps which, together with the protection of their colonies, explains their strong demographic growth in recent decades in the Portuguese coastal waters (OSPAR, 2000).

Foraging seabirds are attracted to the stern of trawlers as nets containing fish are being hauled on board and as fish waste and offal are discarded during fish processing. The opportunistic and competitive nature of seabirds can lead to very large numbers of seabirds surrounding trawl vessels as they learn that there is a free and easy meal available. Except for migratory movements, Valeiras (2003) suggested that fisheries also have a strong influence at a smaller scale on the distribution of seabirds off Galicia; they found up to 320 seabirds at a haul. Another work observed 1004 individuals at a trawl undertaken in the Cantabrian Sea and they concluded that the influence of fisheries upon the abundance and distribution of scavenger seabird species could be of critical importance in Cantabrian and Galician waters (Valeiras *et al*., 2009).

<u>Litter</u>

See Mammals and reptiles ecological component.

2.5.2.5 Other groups

2.5.2.5.1 Non-indigenous & invasive

There is no evidence of any effect of the demersal trawl fishery on non-indigenous or invasive species.

2.5.3 <u>Mixed demersal line fishery</u>

Despite longline fishing often is regarded as an environmentally friendly fishing method, with no destructive impact on bottom habitats, good selectivity and low fuel consumption, a disadvantage is that incidental catches and thus killing of seabirds might occur, particularly during setting of the line (FAO, 1999).

2.5.3.1 Habitats

2.5.3.1.1 Seafloor

<u>Habitat structure changes – abrasion</u>

The effect of longliners on habitat structure are not yet demonstrated. However there are concerns since the area available for fishing on seamounts is very small. Gear loss and abrasion concentrated on a small area may have some impact on the essential habitat available for fish species depending on these structures.

2.5.3.2 Plants

Mixed demersal line fishery is unlikely to have any influence on phytoplankton or macroalgae community, except for indirect effects through the food web.

2.5.3.3 Invertebrates

Mixed demersal line fishery is unlikely to have any effect on zooplankton or benthos.

2.5.3.4 Vertebrates

2.5.3.4.1 Fish

Barrier to species movement

The hook and lines may have some small impact on habitat structures, particularly on the seamounts. Considering that most stocks are composed of several metapopulations it is probable that some indirectly effects on the fish species movement occurs due to the interaction of the different metapopulations. However, no evidence was found until now of any negative effects on the populations.

Community structure or species dynamic changes

There is no evidence of any significant change on the community structure of the demersal/deep water resources from the Azores (Menezes *et al*., 2006). However, some species are intensively exploited, particularly species from the assemblage of the intermediate depth (200-600m), and so changes on the size composition of the community are expected as a result of declines in the abundance of large fish. However, for the case of the Azores this interpretation is not simple. For example, significant interannual variability on the abundance of some species has been reported and not very well understood (Pinho and Menezes, 2005). The amplitude of this variability can not be explained only by the fishing effects (Pinho, 2003). It seems also that the rate of recruitment of some seamounts for some high mobile species may be very high (Silva and Menezes, 1996). Results from the surveys shows a high degree of stability in those indicators (length, abundance trend, community structure), suggesting that bias may be occurring due to the complexity of the ecosystem and low resolution of the information to assess this impacts at a seamount scale.

Some changes have also been reported on the reproduction and growth dynamic of some target species of the fishery, like black spot seabream (*Pagellus bogaraveo*) (Krug, 1998). It is suggested that the observed reduction on the age of first maturity may be an effect of fishing pressure. It is also suggested a density dependence of the growth rate.

Death or injury by collision

Fish disturbed by hook and line fishing in general is not very well documented and for the Azores case almost there are no studies. However, from hook and line gears fishes tend to be injured by pressure changes during hauling, particularly the deep-water species. Death may occur also through discards (Catarino, 2006; Technical report, 2007).

Removal of non-target species

Hook and line gears may remove non-target species of which some are landed while others are discarded (Pinho and Menezes, 2005; Catarino, 2006; Technical report, 2007). However, the Azorean demersal fishery is generally considered a “clean” fishery with little discard species (Catarino, 2006). The by-catch, when exist, is composed of the undersized or non-commercial species. The discards consists of undersized landed species, high graded species (species that can be landed, but are discard because of low value or low TAC) and non-commercial fish.

An incomplete list of species landed by this fishery is listed on Table 34. Definition of target species is difficult due to the multigear, multiespecies and multiarea character of the fishery. Usually the fishery targets a species assemblage or even species from all depth assemblages (Shallow, intermediate and deep). It is possible to target a particular species, most common with the hand lines component of the fishery, but the landings very rarely are mono-species, suggesting an opportunistic regime of operation in function of area, species abundance, price, etc. So, we will consider as by-catch the deep water elasmobranches, others than kitefin (*Dalatias licha*) because a target fishery was developed on the past for this species. Several elasmobranch species are caught by the Azorean mix demersal lines fishery (Figure 69). The most abundant species caught by this gear are the species from the genera *Etmopterus sp.* and *Deania sp*. These species are assessed by the ICES Working Group on Elasmobranch Fishes (WGEF). However, very little is known about the stock structure and population dynamics of these stocks and most of them are classified by the Working group as "Other species". There is no assessment of these species and no management objectives have been adopted. An EC Action Plan on elasmobranches is being developed (ICES, 2008d). A zero TAC was proposed for the deep-water elasmobranchs on ICES area X for the year 2010 (Reg. EC nº 1359/2008).

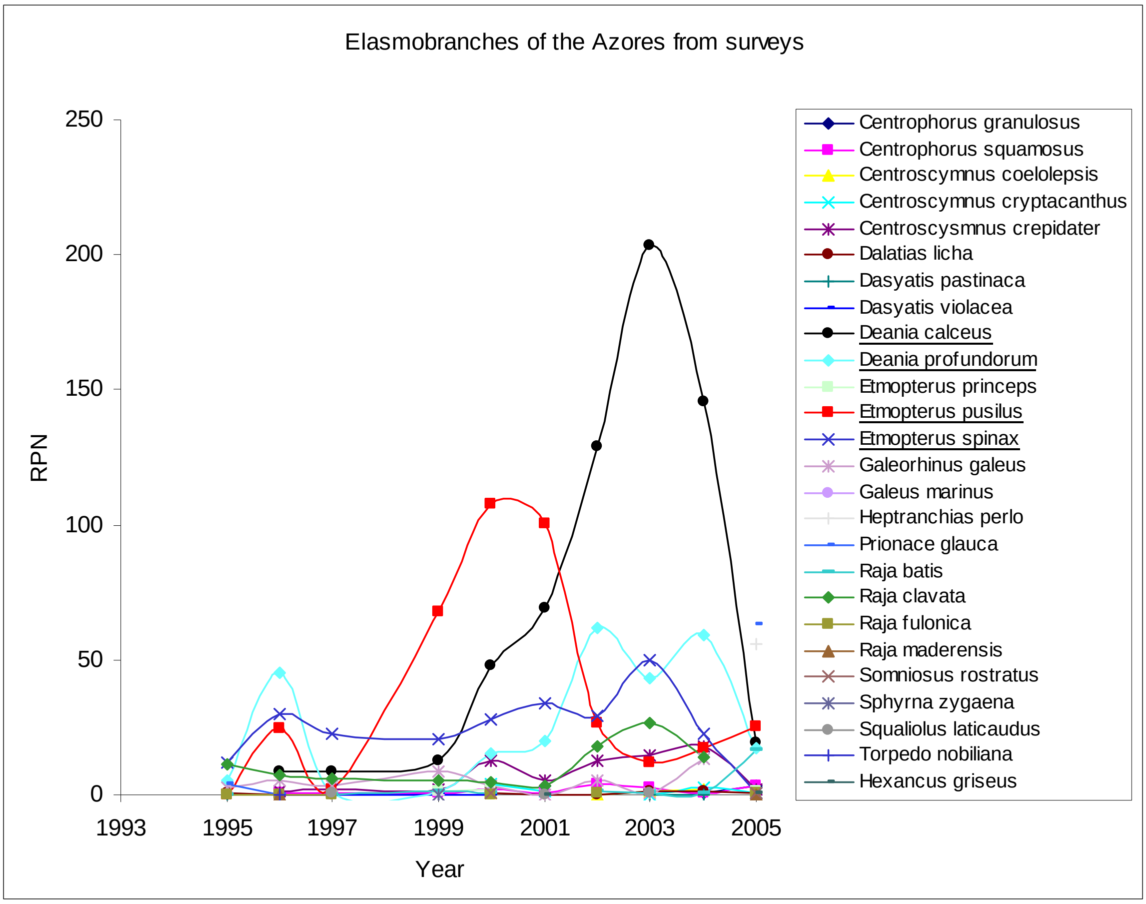

Figure 69. Elasmobrach species caught during the Azorean Spring Demersal Longline Survey (source: Pinho, 2006). RPN-Relative Population Number.

Table 34. Species caught by the Azorean demersal mix lines. Table is organized by general depth assemblages of the demersal fish community. Very uncommon species were not included.

Scientific name	Portuguese	English	HABITAT
Serranus atricauda	GAROUPA	Blacktail comber	Shallow
Phycis phycis	ABRÓTEA	Forkbeard	Shallow
Mycteroperca fusca	BADEJO	Island Grouper	Shallow
Epinephelus marginatus	MERO, GAROUPA BRASIL	Dusky Grouper	Shallow
Aspitrigla cuculus	CABRA RUIVO	East Atlantic red gurnard	Shallow
Zeus faber	PEIXE GALO	John Dory	Shallow
Zenopsis conchifer	PEIXE GALO BRANCO	Silvery John dory	Shallow
Gymnothorax unicolor	MOREÃO	Brown Moray	Shallow
Muraenidae	MOREIA PINTADA		Shallow
Muraena augusti	MOREIA PRETA VIÚVA	Mediterranean moray	Shallow
Kyphosus spp.	PATRUÇA		Shallow
Gaidropsaurus guttatus	VIÚVA	Rockings	Shallow
Pagrus pagrus	PARGO, PARGUETE	Red Porgy or Common Seabream	Shallow
Scorpaena scrofa	ROCAZ	Large-Scaled Scorpionfish or Red Scorpionfish	Shallow
Pagellus acarne	BESUGO	Axillary Seabream	Shallow
Raja clavata	RAIA	Thornback Ray	Shallow
Sphyrna zygaena	CORNUDA, TUB MARTELO	Smooth Hammerhead	Shallow
Diplodus sargus cadenati	SARGO SARGUETE	Sargo or White Sea bream	Shallow
Ballistes carolinensis	PEIXE PORCO	Grey Triggerfish	Shallow
Pseudolepidaplois scrofa	PEIXE CÃO, GAIO	Barred hogfish	Shallow
Labrus bimaculatus	PEIXE REI DO ALTO	Cuckoo wrasse	Shallow
Serranus cabrilla	GAROUPA DO ALTO	Comber	Shallow
Schedophilus ovalis	CHOUPA	Imperial Blackfish	Intermedian
Lophius piscatorius	TAMBORIL	Angler	Intermedian
Heptranchias perlo	BICO DOCE	Sharpnose sevengill shark	Intermedian
Pontinus kuhlii	CÂNTARO, BAGRE	Offshore rockfish	Intermedian
Hexanchus griseus	ALBAFAR	Bluntnose sixgill shark	Intermedian
Berix splendens	ALFONSIM	Golden eye perch	Intermedian
Helicolenus dactylopterus	BOCA NEGRA	Bluemouth	Intermedian
Polyprion americanus	CHERNE, CHERNOTE	Wreckfish	Intermedian
Conger conger	CONGRO, SAFIO	Conger eel	Intermedian
Pagellus bogaraveo	GORAZ, PEIXÃO,CARAPAU	Blackspot Seabream or Red Seabream	Intermedian
Beryx decadactylus	IMPERADOR	Alfonsino	Intermedian
Lepidopus caudatus	PEIXE ESPADA BRANCO	Silver scabbardfish	Intermedian
Phycis blennoides	JULIANA, ABRÓTEA ALTO	Greater Forkbeard	Intermedian
Centrophorus granulosus	BARROSO	Gulper shark	Deep
Dalatias licha	GATA LIXA	Kitefin shark	Deep
Centrophorus lusitanicus	BARROSO-LISITÂNICO	Lowfin gulper shark	Deep
Centroscymnus coelolepsis	CAROCHO	Portuguese dogfish	Deep
Epigonus telescopus	ESCAMUDA, JORDÃO	Cardinalfish or Bulis-Eye or Big Eye	Deep
Etmopterus spp.	LIXINHAS-DA-FUNDURA	Lanternsharks nei	Deep
Mora moro	MELGA	Deepsea Cod or Ribaldo or Common mora	Deep
Aphanopus carbo	PEIXE ESPADA PRETO	Black Scabbardfish	Deep
Coryphaenoides rupestris	PEIXE RATO	Roundnose grenadier	Deep
Molva macrophthalma	PESCADA DOS AÇORES		Deep
Centroscymnus crepidater	SAPATA-PRETA	Longnose velvet dogfish	Deep
Deania spp.	SAPATAS		Deep

Removal of target species

Only part of the species from Table 34 is reported to the ICES working groups, mainly the Working Group on the Biology and Assessment of Deep-Sea Fisheries Resources (WGDEEP). The key species of the fishery are considered those from the intermediate depth assemblage, which represents about 60-70% of the total demersal/deep water landings. From these only the black spot sea bream has been assessed because there is reliable data available. Results show a relatively stability on stock indicators. However, the assessment is uncertain with stock estimates being underestimated and without convergence back on time (Figure 70).

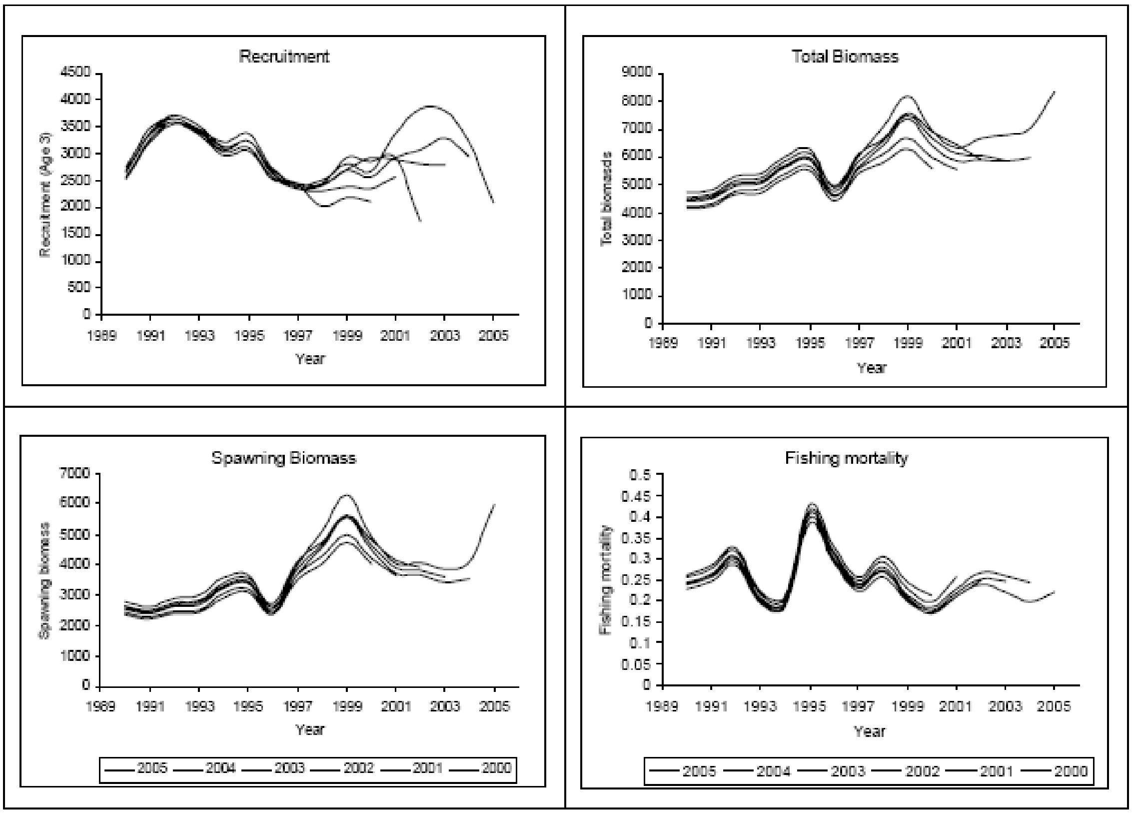

Figure 70. Retrospective analysis of estimates of recruitment, total stock bimass, total spawning biomass and fishing mortality from XSA. Source: ICES, 2006d

Results from the Azorean spring demersal surveys show also some relatively stability on the abundance index of the most important commercial species, with increasing or a stable trend for almost all species (Figure 71). However, the survey may be not designed for some of the species and it is observed high inter annual variability (Pinho *et al.,* 2009). For some species it is observed a conflicting trend between landings and survey index as a result of low survey resolution or target effect of the fishery.

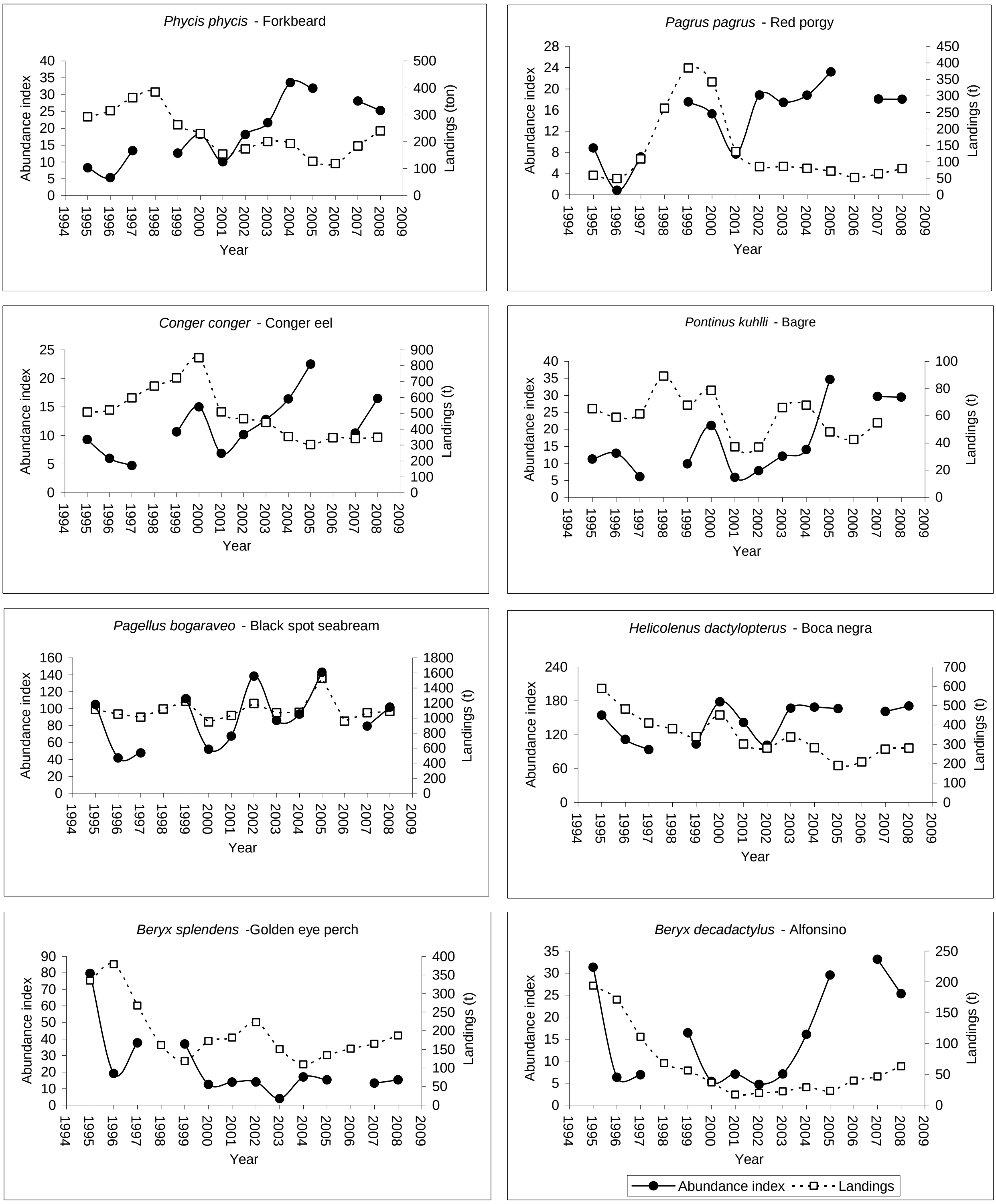

Figure 71. Abundance index for some selected demersal/deep water species from the Azorean spring demersal surveys. Landings data are shown on the figures. Adapted from Pinho *et al.*, 2009.

Kitefin shark (*Dalatias licha*) was on the past a target fishery (Heessen, 2003). Assessment of the resource during 2003 considered the stock as overexploited (Figure 72) (ICES, 2003). However, the assessment must be considered preliminary and further analysis is required to better understand the status of the stock, particularly analysing the effect of liver oil prices on the fishery.

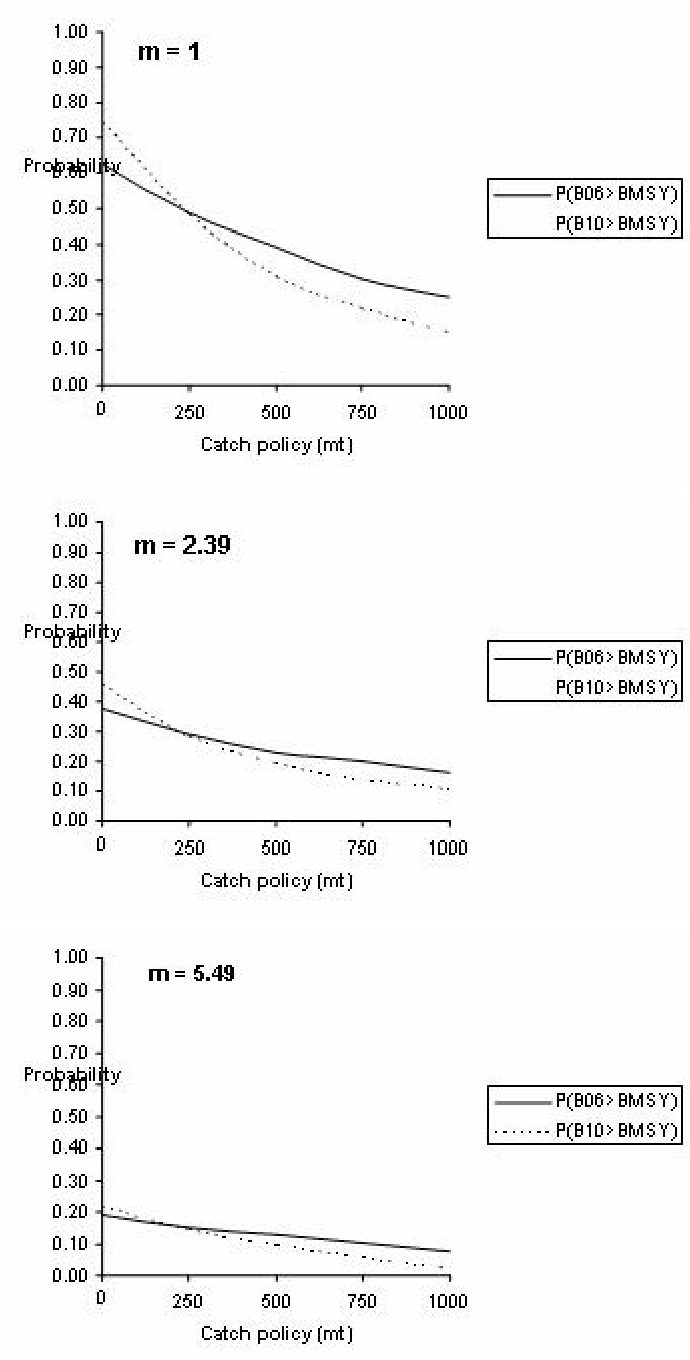

Figure 72. Risk curves from Bayesian production models expressing the probability that the biomass (*B_{2006}* and *B_{2010}*) will exceed *B_{MSy}*. Source: ICES, 2003.

2.5.3.4.2 Mammals & reptiles

There is no evidence of any effect of the demersal trawl fishery on mammals and reptiles.

2.5.3.4.3 Seabirds

Removal of non-target species

Certain longline fisheries result in large numbers of seabirds being hooked on setting lines (FAO, 1999). The major problems are registered for the demersal fisheries of the Northeast Pacific, North Atlantic, Southern Ocean and the Atlantic coast of South America (FAO, 1999). However, data on the incidental catch of seabirds are lacking for the Azorean mixed demersal line fisheries.

2.5.3.5 Other groups

2.5.3.5.1 Non-indigenous & invasive

There is no evidence of any effect of the demersal trawl fishery on non-indigenous or invasive species.

2.6 Synergetic effects of the case study fisheries with other human activities

Human activities on land and sea will indefinitely have an effect/impact on the ecosystem. This is what we have to accept and what we have to deal with. Improper use however can lead to transformations in the system, that can range from smaller reversible changes to large scale "catastrophic" shifts (Scheffer *et al*., 2001; Scheffer and van Nes, 2004). Here, you can think of fishing through (Essington *et al*., 2006) or down the food web (Pauly *et al*., 1998), the slippery slope to slime (e.g. increase of jelly fish, related to overfishing, eutrophication, climate change, translocation and habitat modification) (Richardson *et al*., 2009), ecological changes due to oil spills (Teal and Howarth, 1984; Peterson *et al*., 2003) or other pollutions (De Metrio *et al*., 2003; Porte *et al*., 2006).

Effects of single activities could be managed in relation to their impact on the environment, but their synergistic effects with other anthropogenic or even non-anthropogenic impact could still lead to disasters. Synergistic effects of habitat destruction, overfishing, introduced species, warming, acidification, toxins, and massive runoff of nutrients are transforming once complex ecosystems like coral reefs and kelp forests into monotonous bare bottoms, transforming productive coastal seas into anoxic dead zones, and transforming complex food webs topped by big animals into simplified, microbially dominated ecosystems with boom and bust cycles of toxic dinoflagellate, jellyfish, and disease (Jackson, 2008).

Therefore management should at least have an idea of and consider the synergistic effects of the various anthropogenic activities in the marine environment. But also the relation with non-anthropogenic forcing factors, e.g. climate, needs to be considered. For example: fish stocks which are depleted (by fishing) are at higher risk of collapse due to small changes in their environment (Brander, 2005). The synergistic effects of climate change are threats for all anthropogenic activities.

Here, we will focus on the synergistic effects of the fisheries case studies with other human activities. It should be realized that most if not all of the synergistic effects with fisheries will result in a further decrease in the target fish stocks or other biological components. Therefore, not a full description of what would be the result of the synergistic effects is given, rather a overview of threats is presented. The intention is not to give an extensive overview of possibilities and what ifs, but to point at serious threats. Management should consider these threats and manage each anthropogenic effect in such a way that even the synergistic effect will not cause the ecosystem aspects to exceed the sustainable reference points.

2.6.1 Purse seine fishery

The effects in relation to the purse seine fisheries concern mainly the pelagic fish stocks (anchovy and sardine, mainly) and other communities such as mammals, reptiles and seabirds (see Norse matrix). All other impacts affecting these ecosystem aspects could potentially have synergistic effects with the purse seine fishery.

- One clear example could be the case of the Prestige oil spill that contaminated some of the grounds and areas fished within the VIIIc and IXa North, and also produced some temporal closures on almost all fisheries in the area.

2.6.2 Mixed demersal trawl fishery

The effects in relation to the mixed demersal trawl fisheries concern mainly the demersal stocks (hake, horse mackerel and nephrops), benthic habitats and communities and other biological components such as mammals, reptiles and seabirds (see Norse matrix). All other impacts affecting these ecosystem aspects could potentially have synergistic effects with the purse seine fishery.

- Except for the pelagic community, the demersal domain also has been affected by the Prestige oil spill. In fact, significant reductions in the abundance of Norway lobster were found in the most impacted area over the Galician shelf (Sánchez *et al*., 2006).
- Nephrops fishery is close to collapse, or at least going on recovery plans in several units in areas not clearly related between them. This suggests that other factors than fishing could be affecting these fisheries, and the usual suspect nowadays, global warming, has come in some comments, but it still needs to be investigated.

2.6.3 Mixed demersal line fishery

The effects in relation to the mixed demersal line fisheries concern mainly the demersal stocks (particularly, blackspot seabream), indirectly other biological components such as mammals, reptiles and seabirds (see Norse matrix). All other impacts affecting these ecosystem aspects could potentially have synergistic effects with the purse seine fishery.

2.7 Models of fishing effects on the ecosystem

Previously, in the matrix above showed (section 2.3.), interactions between fisheries and the ecological components have been stated. In this regard, an attempt to describe the different case studies impacts on habitats, plants, invertebrates and vertebrates have been made. In order to discuss and assess fisheries effects quantitatively, model simulations are carried out.

Within the Bay of Biscay, the Cantabrian Sea shelf ecosystem was described using a mass-balance model of trophic interactions, so as to understand the effects of the different fisheries that operate in this area (Sanchez and Olaso, 2004). With the aim of producing a balanced steady-state description of the Cantabrian Sea shelf ecosystem, the Ecopath model was used.

They found that strong relationships existed between the pelagic, demersal and benthic domains due to the key groups that transfer production from primary production to the upper trophic level. The level of fisheries impacts in the Cantabrian Sea was comparable to the most intensively exploited temperate shelf ecosystems which showed that landings are expected to decrease with the current fishing pressure. With regard to the different fishing gears studied, the negative trophic impact of trawling on the different groups of the system was seen to be high and much stronger than for other gears. In contrast, longlining produced the most positive impact in the ecosystem. Besides, all fishing gears, except the purse seine, were found to impact negatively on piscivorous fish and elasmobranchs (Sanchez and Olaso, 2004).

Additionally, the study has been extended in order to perform some time-spatial simulations of the consequences of some management measurements such as fishery closed areas (Sánchez et al., 2004). They observed that species like rays, catsharks, anglerfish, megrim, hake benthic cephalopods and large demersal fish increased their biomass when trawl fishing decreased. Contrarily, horse mackerel, small demersal fish, sardine and anchovy were not affected.

Appart from the Cantabrian Sea case, an ecopath modelling approach has also been applied to the Azores ecosystem (Guénette and Morato, 2001), but no impacts were assessed.

3. What people think

This section summarises perceptions of stakeholders involved in the SWW RAC region and their viewpoints are presented in the following order: France, Spain, Portugal and Azores.

3.2 What consultations have been done in the regions

France

Stakeholders in France are organized in a hierarchic structure: Local, Regional and National Fisheries Councils (Comités locaux, Régionaux, National des Pêches maritimes CL-, CR-, CNPM). Perception about the environmental, socioeconomic and management situation of the fishery is then discussed and given through these organisations. Advices of stakeholders are synthetized generally at the regional level or directly at the national level. The "Assises de la pêche" in 2009 is the more recent process which gave a good overall picture of the situation and the perception of the professionals on the situation of the fisheries in France. At the regional scale forums and debates were organised and reports were finalised to give a global advice, particularly about the proposals given in the EU Green Book in the context of the RAC's and CFP.

Spain

Stakeholders in the autonomous communities of the Spanish Cantabrian Cornice (Galicia, Asturias, Cantabria and the Basque Country) are a total of 115 fishing communities and 9 producer organizations. They were sent a total of 124 questionnaires (see Appendix 2) which were oriented to three fleet segments: coast bottom trawlers, coast long liners and sardine purse seiners.

Such questionnaires mainly cover the perceptions of the sector on three main areas: environmental situation in the fishery, socioeconomic situation in the fishery and management of the fishery. Each area includes a number of sections, which must be rated in a rating scale from 1 to 5 according to intensity (worst-better, low-high).

The first area, environmental situation in the fishery, includes the following 9 sections: state of the exploitation, variability in the recruitment, collapse range, size of the captures inferior to sexual maturity size, % of accidental captures (by-catch), % of discards, degree of marine environment pollution, polluting effects of the transport (of hydrocarbons, tourism,…) on the marine environment and effects of the fishing tackle on the sea bottom and the benthonic species.

The second area, socioeconomic situation in the fishery, includes the following 8 sections: new incoming members in the fishery, fishermen's educational level, state of conflicts, evolution of the number of employments, average wage, profitability, commercial situation, and level of efficiency (reduction of costs).

The third area, management of the fishery, includes the following 5 sections: current management of the fishery (on the part of the European Union, the Spanish Government and the Autonomous Communities Governments), participation of the fishing sector in the design of management measures implemented by EU, Spanish Government and Autonomous Communities Governments, participation of other agents (ecologist associations, consumer associations,...) in the design of management measures implemented by EU, Spanish Government and Autonomous Communities Governments, effectiveness of the current management measures in the fishery (including closed seasons, TACs, total effort, weekly rest, regulation of the fishing equipment and daily catch limits) and effectiveness of possible instruments to apply in the future (individual transferable quotas, total allowable catches).

Portugal

In the case of Portugal, three main consultations took place in Portugal Continental during the last ten years (MARHE, 2000; PECOSUD, 2002 and Comunidades Azuis, 2004).

MARHE project was a multidisciplinary approach on Employment and Human Resources in the Fishery Socio-economic System involving players in the area of fisheries, biology, economics, sociology, demography, geography and robotic engineering. It also brought together both academic researchers and the different social actors, unions, employers and local authorities, involved in the socio-economic fishery system (Moniz, *et al*., 2000).

PECOSUD (*Caractéristics des petites pêches côtières et estuariennes de la côte atlantique du sud de l'Europe*) was a European partnership in which Portugal was represented by IPIMAR. The aim of the project was to access the southern European inshore and estuarine fisheries. PECOSUDE Portuguese report made a description of the artisanal national fleet, approaching fisheries interactions and analysing socioeconomic aspects of the activity. These aspects related with production factors, fishing fleet characteristics, capital evaluation, and factor cost (Pestana *et al*., 2002).

The third, denominated *Comunidades Azuis* project is a social study about the characteristics and perspectives of the Portuguese artisanal fisheries fleet. The project described factors for the quality of life, such as fisherman community housing, fleet local infrastructure, community social bounds, and work environment, (Moreira, 2004).

Azores

Three main studies characterise the Azorean fishing population (Silva and Goulding, 2003; Tomaz and Medeiros, 2006; Sempere and Sousa, 2008). The first one is basically an economic study and the others social ones. The last one characterises the woman participation on the fishing.

There are no formal consultation done until now to know the perception of the sector about the environmental, socioeconomic and management situation of the fishery. However, there is some information available from few social and economic studies and reports of the fisheries week conferences and other local events from which we can infer some local sector thinking. We will focus here on demersal mixed lines fishery.

3.3 Stakeholder impressions

France

Regarding marine environment impression stakeholders underline the necessity to have a better evaluation of the global quality of coastal waters as pollution and non-professional fishery. They wish to have stronger links between scientific and fisher's organisations through collaborating programs as the PELGA program developing a guarding fishery on the anchovy in the Bay of Biscay. About the objectives to reduce the rate of by-catch and discard, they wish to be more integrated in the process defining technical modifications and new regulations. One of the strong impression is that the application of rules and quota must be equivalent for all the fishers communities (state members) in one fishery; the example of the hake fishery in Bay of Biscay. Such differences in application of controls create an unfairness impression in many cases.

Spain

As abovementioned, Spanish consultations were oriented to three fleet segments and thus, the results of the questionnaires are presented for such three fleet segments.

Regarding marine environment impression, in the case of the trawling segment, stakeholders show a very poor evaluation rating of the marine environment, with an average of 1 in the rating scale for all the sections. In the case of the long line segment, the rating is a bit better, reaching 2 for 5 sections: size of the captures inferior to sexual maturity size, % of accidental captures (by-catch), % of discards, effects of the transport on the marine environment and effects of the fishing tackle on the sea bottom and the benthonic species. The purse seine segment is the best valuated, with an average of 4 for 2 sections (state of the exploitation and collapse range), 2.5 for variability in the recruitment, and 2 for the rest of the sections.

The socioeconomic situation in the fishery is perceived in a quite similar way in the trawling and the long line segments, with an average of 3 for state of conflicts, and 1 for the rest of the sections. In the case of the purse seiner segment, the average rating was 2 for 4 sections (new incoming members in the fishery, fishermen's educational level, state of conflicts and level of efficiency), and 1.5 for the other 4 sections.

The governance issues are perceived in a negative way for the trawling segment, with an average of 1 in all the sections except one (participation of the fishing sector in the design of management measures implemented by Autonomous Communities Governments), rated with 3. The effectiveness of the current management measures in the fishery was evaluated as follows: closed seasons, 3; TACs, 1; total effort, 1; weekly rest, 3; and regulation of the fishing equipment, 3. The effectiveness of possible instruments to apply in the future (individual transferable quotas) was rated with 1.

For the long line segment, current management of the fishery is valuated with an average of 2 in all the 3 subsections (by EU, Spanish Government and Autonomous Communities Governments); participation of the fishing sector in the design of management measures implemented by EU and Spanish Government is rated with 1, but in the case of the Autonomous Communities Governments, the evaluation reaches 3; and participation of other agents is rated with 1 in all cases. The effectiveness of the current management measures in the fishery was evaluated as follows: closed seasons, 3; TACs, 1; total effort, 1; weekly rest, 3; and regulation of the fishing equipment, 3. The effectiveness of possible instruments to apply in the future (ITQs) was rated with 1.

In the case of the purse seine segment, current management of the fishery is valuated with 2.5 in all the 3 subsections, participation of the fishing sector in the design of management measures is rated with 1.5 for EU and Spanish Government, and with 3 for the Autonomous Communities Governments, and participation of other agents is rated with 1 in all cases. The effectiveness of the current management measures in the fishery was evaluated as follows: closed seasons, 3; daily catch limits, 3.5; weekly rest, 4; and regulation of the fishing equipment, 3. The effectiveness of possible instruments to apply in the future was: TACs, 2.5; ITQs, 1.5.

Portugal

The evolution in fisheries in Portugal over recent decades has been the result of a wide range of factors, particularly the strategies of the main domestic actors, but also a reflection of the changes in international laws and policies regulating access to fishing areas (Moniz *et al.*, 2000).

The main social characteristics of the local fisher population are of an aged population mostly masculine, with Portuguese nationality with a particularly low level of school instruction. Their individualistic attitudes sometimes question the possibility of an involvement in extra community affairs. The fishers' associations and the producer's organizations are very important in these communities and help them in several matters (Moreira, 2004).

Azores

In the Azores, conclusions are very similar to the national results, 80% of the community are males, with low level of instruction with women more involved on industry and coordinating land activities of the fishing process. Fisheries are small-scale and so no organised accountability is available, predominating family organizations.

3.4 Stakeholder preferred management tools and regimes

France

French stakeholders have a preference for a strengthening of the role played by the Producers Organisations (OP) at the local/regional scale. They underline the weak political will of the CFP and are frightened that CEE administration became the main decisionmaker in the CFP. However they hope that the Lisbonne Treaty will be a help in this problem. They prefer that fishery administration remains collective as in the OP, and are not satisfied by the proposals of a transfer of fishery rights, as given in the Green Book to reach the MSY. They should like that management tools and regime should be established and adapted from the results of collaborating programs between fisher's councils and scientific institutions at the level of each CEE state member. This collaboration should be more institutionalized. Fisher councils propose to maintain the distribution of TAC's into national quotas which suppose that each state manages these quota in the better manner. This proposal is based on the assertion that a collective management of quotas at this scale makes more responsible members of the fishery channels because they are close to the field. The stakeholders prefer the maintenance of the management of territorial waters of one state under the control of this state, which allows a better management, particularly to minimize conflicts between industrial and coastal fleets in the coastal waters.

Spain

Spanish stakeholders show a medium valuation of the current management of the fishery (3) in the case of the purse seine segment, a low valuation (2) for the long line segment, and a very low valuation (1) in the case of the trawling segment. That evaluation rating is homogeneous inside each segment, with no distinction between the management levels (European Union, Spanish Government and Autonomous Communities Governments).

However, they show a marked preference for the Autonomous Communities management when they are asked about the participation of the fishing sector in the design of management measures. The participation in those implemented by the Autonomous Communities Governments is rated with 3, while in the rest of the cases, the rate is 1.

The preferred current management tools (from 3 to 4) are the weekly rest, the daily catch limits (for the purse seine segment), the regulation of the fishing equipment, and the closed seasons. TACs (for long line and trawling segments) and total effort measures have a very low valuation (1). In the case of possible instruments to apply in the future, however, TACs for purse seine segment have a medium valuation (2.5), and ITQs have a low valuation (1.5) for all the segments.

Portugal

In Portugal, in the last ten years there is an attitude generally more receptive to a new type of governance than struggling with a segmented policy-making (Moniz, 1998). This mindset is being observed in new ways of business organisation and pro-active consumer behaviour (Moniz *et al*., 2000).

Some of the recommendations from MARHE project (27 in total) relied on: proposals for a co-management compatible with Portuguese system; more participation of fishers on the local management; new mechanisms in professional education; and, the establishment of advisory councils for the improvement of the education in fisheries.

The Socioeconomic National Observatory for Fisheries Analysis and the establishment of an Economical and Social Council for Fisheries represent efforts in the enhancement of social objectives in the Portuguese political framework and in recovering fisheries management policies.

Azores

In the Azores there are no studies describing the stakeholders preferred management tools. There is a general perception that valuation may be low at the European and National level and moderate at regional level because participation at the regional level is more active. However, it has been proposed a co-management system by island, meaning more involvement of fishers on the local management process. Area restriction by vessel size and gear type, to control the demersal deep/water fishery effort, is the most acceptable technical measure. Other technical measures implemented are the minimum size, hook size, TACs and closed areas. From these the TACs and quota system are less acceptable, at least on the actual format.

About 50% of the fishermen's in the Azores are linked to the local (island) fisheries associations. Consultation conducted to this population identify as major class problems the inadequate regulations applied to the region (35%), low abundance of resources (30%), and low income from fisheries associated to the markets and commercialisation process (15%) (Tomaz and Medeiros, 2006).

Although there are no specific consultations addressing these issues directly, results from the reports of Fisheries week conferences in the Azores show that environment preservation is a constant concern of the stakeholders, including fishers. Other issues of concerned are governance and control. Stakeholders in general do not understand very well the institutional setup for governance relating fisheries management. They have difficulties to link the different scales of management (Regional, National and European Union) and assume that environment is not preserved because the actual "bottom-up" governance structure. A common critic point among stakeholders is surveillance of the Azorean EEZ and adjacent areas that does not exist or is not efficient.

3.5 Linkages between the ecological, economic and social perspectives on the system

France

If the principle that strong links between the ecological, economic and social perspectives are essential for further sustainable fishery activities is largely accepted by stakeholders, these links remain to be strenghtened into concrete actions. The process of creation of Marine Protected Areas on the areas of fisheries must better integrate the fisher councils and better consider the social impacts of the MPA's. The objectives of the MPA's remain unclear, and consequently it remains a problem to better link ecological and economic perspectives. In this context also it is considered as essential that a social field must be integrated in the CFP. Territorial communities should be included in the RAC council, and the CCE should give funds and opportunities to the RAC's organisation to propose and develop specific studies which could integrate the three perspectives.

Spain

There are important linkages between the three perspectives on the system, as the ecological health of the marine environment is the first step for a sustainable economic exploitation, and only a sustainable activity can generate economic and social benefits for the future. An ecological damage generates economic and social problems.

The governance institutions are a part of that linkage. The European Union tries to coordinate the three perspectives in the Common Fishing Policy. In Spain, the *Ministerio de Medio Ambiente y Medio Rural y Marino* also integrates the environmental, socio-economic and governance issues as a whole.

Portugal

In Portugal, the MARHE project was pioneer, since research developed to support forecasting was until then only based on bio-and econometric methodologies in fisheries research.

There is a clear perception of what represent the value of a broader conceptualisation in the treatment of fisheries and that approaches cannot remain isolated in the e.g. economic activity (centred only on the harvesting process). The sociological investigation of fisheries represents an important challenge to the sector and for the subject itself, not only by reason of the new problems that may be defined, but also more importantly by reason of the results which may be obtained (Moniz, 1998).

Azores

In the case of Azores, there is a perception that the ecological system is the most important pillar and that better link with the others, i.e. the social and economic perspective is a function of the ecological health of the marine environment. However, there are difficulties on understanding the formal governance link between the three perspectives at the different scales (Regional, National and European).

4. Conclusions

The South Western Waters region is overviewed in all its aspects, which makes it difficult to give a single classification of its state. The main difficulty lies on both the highly extensive area of the region and the highly diverse habitats that can be found within SWW region. Apart from spatial variability of the study area, temporal trends and seasonal variations of the ecological environment are of critical importance.

In addition to natural fluctuations in marine populations and ecosystems, human activities cause an additional variability that should be also taken into account when setting management measures. Although we can conclude that various issues affect the state of different aspects of the ecosystem, one of the main issues are human activities, specifically the fisheries case studies described in more detail. It has been relatively easy to find information about human activities that occur in the SWW region. However, information is missing regarding the main impacts that such activities have caused or could cause on the marine environment (habitat and biota). Additionally, the non existence of bibliography regarding the impacts of different fisheries working within the study area made it difficult the compilation of the Norse matrix. Although the impacts of some gears could be known or expected beforehand due to similarities with other areas, there are no or few specific impact studies within the SWW region in particular. For instance, in spite of the fact that the effects of fishing trawl on sediment and habitat structures have been subject to much investigation in other areas, it is considerably difficult to find impact studies regarding the SWW region. Fishing affects seabed habitats worldwide, however, these impacts are not uniform and are affected by the spatial and temporal distribution of fishing effort, and vary with the habitat type and environment in which they occur (Kaiser *et al*., 2001). Therefore, further research is required on specific regional activities and on their impact upon local habitat and biota. Furthermore, there is very little information available on the true impact of trawling on the seabed as there are hardly any virgin areas that have not been affected by the repercussions of this fishing technique to serve as a point of reference (OCEANA).

Besides, fisheries effects should not be evaluated separately, but rather in conjunction with other human activities that may also have an effect, so that an overall view of the impacts and thus, a list of actions can be obtained. It should be noted that human activities together with fisheries impacts on the marine ecosystem, could cause synergistic effects which should be taken into account when assessing the different management tools. Additionally, climate change influence on marine environment, and particularly, on fisheries, is another outstanding issue. However, there is a considerable lack of bibliographic documentation covering synergistic effects between fisheries, climate change and human activities; consequently, it is difficult to draw any clear conclusion except for the need of more studies in this field.

This comprehensive review is a valuable document for further work in the project MEFEPO and in developing and implementing an operational FEP for the South Western Waters region. The data presented in this document are building blocks for such an FEP and identify gaps that need attention to successfully develop it. The knowledge gaps of the ecosystem as well as the human activities lie mainly in the area of spatial and temporal resolution of the data. The features and activities are known, but for successful management, the spatial and temporal aspects are of major importance. This is a gap we have to accept in this project, but it is advised to put effort into this to minimise this gap and improve the success of FEPs.

In order to know which tools apply for a successful ecosystem-based management of the marine habitats and populations, fully characterised information is required. This could be relatively easy in deeply studied semi-enclosed areas such as the North Sea whereas it is more difficult for open, extensive and diverse areas such as the SWW area.

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Appendix 1: Socio-economic variables

G1 Catches measured in physical terms

1) Catch of species j by country k in sea l (background)

$$x_{jkl} \tag{1}$$

x_{jkl} = catch measured in tonnes of species j by country k in sea l

l – refers to sea, l = (North Sea, NWW, SWW)

The North Sea encompasses the following sea areas: ICES: IIIa, IVa, IVb, IVc, VIId

Northwestern waters (NWW) encompass the following sea areas: ICES: VIa, VIb, VIIa, VIIb, VIIc, VIIe, VIIf, Viig, VIIh, VIIj, VIIk, XII

Southwestern waters (SWW) encompass the following sea areas: VIIIa, VIIIb, VIIIc, VIIId, VIIIe, IXa, IXb, X and CECAF: 1.11, 1.12, 1.13, 1.2, 2.0

k – refers to country

j – refers to species

For each sea 3-4 cases (fisheries) are specified. Some of these cases are single species fisheries, and then the species referred to by j coincides with the case (fishery) Some of the cases are multispecies fisheries, and then the case will consist of all the species j defined as belonging to the specific case (fishery).

North Sea cases: i) Flatfish-beam trawl, ii) Herring-pelagic trawl, iii) Sandeel - trawl, iv) Whitefish-demersal trawl

NWW cases: i) Nephrops (Lobsters), scallops-dredge, ii) Western Mackerel, Hake, Monk, Megrim - Mixed trawl fish

SWW cases: i) Hake, nephrops, horse mackerel - Mixed demersal trawl, ii) sardines-purse seine, iii) mixed demersal lines, iv) *Nephrops norvegicus* – North Biscay.

2) Total catch of species belonging to case h in sea l by country k (background)

$$X_{hkl} = \sum_{j=j(h(l))} x_{jkl} \tag{2}$$

Xhkl = total catch measured in tonnes of species belonging to case h in sea l by country k

h(l) – refers to case (fishery) h in sea l, h(North Sea) = (Herring, sandeel, whitefish, flatfish), h(NWW) = (Nephrops, Scallop, Mixed trawl fish), h(SWW) = (sardines, mixed demersal trawl fish, mixed demersal line fish)

j(h(l)) – defines all species belonging to case (fishery) h in sea l

In the case of single species fisheries $X_{hkl} = x_{jkl}$

3) Total catch of species belonging to case h in sea l (background)

$$X_{hl} = \sum_{j=j(h(l))} \sum_{k} x_{jkl} \tag{3}$$

X_{hl} = total catch measured in tonnes of species belonging to case h in sea l (background)

4) The aggregated catch of all species for country k

$$X_k = \sum_{j} \sum_{l} x_{jkl} \tag{4}$$

X_k – total catch measured in tonnes of all species and in all seas for country k

5) Total catch in sea l

$$X_l = \sum_j \sum_k x_{jkl} \qquad (5)$$

X_l = total catch in sea l measured in tonnes

6) Relative size of case h in sea l (matrix)

$$r_{h(l)} = \frac{X_{hl}}{X_l} \qquad (6)$$

rh(l) = total catch in case h in sea l relative to total catches in sea l

G2 The economic value of the catches

As there is no continually registration of sea area specific prices, the price indices have to be country specific.

In single species fisheries we only need to take the average over country-specific prices for the countries that (most actively) takes part in the fishery (case). We take a weighted average where the countries relative share of the total catch of the species under consideration serves as weight. In multi species fisheries we have to take the average both over country specific prices per species and over species.

7) Average price of fish caught in single species cases (background)

$$P^S{}_j = \frac{\left(\sum_{k=k(h(l))} P_{jk} * x_{jk} \right)}{X_{jk(h(l))}} \qquad (7)$$

k(h(l)) – defines the most active countries taking part in the fishery defined in case h in sea l, e.g. k(herring(North Sea)) = (Denmark, Norway, UK, Netherlands)

Pjk - price on species j in country k

xjk – total catch of species j by country k

Xjk(h(l)) = aggregated catch of species j (the species in case h in sea l) by the most active countries taking part in the fishery defined by case h in sea l

PSj = weighted average price of species j measured in Euro/kg

8) Average price for fish caught in multi species cases (background)

$$P^M{}_h = \frac{\sum_{j=j(h(l))} \sum_{k=k(h(l))} P_{jk} * x_{jk}}{X_{hk(h(l))}} \qquad (8)$$

j(h(l)) – defines the main species belonging to case (fishery) h in sea l

Xhk(h(l)) = aggregated catch of species in case h by the most active countries taking part in the fishery defined by case h in sea l

$P^M{}_h$ = weighted average price on species in case h measured in Euro/kg

9) Weighted average price of all species caught by country k

$$P_k = \frac{\sum_j P_{jk} * x_{jk}}{X_k} \qquad (9)$$

Pk(h(l)) = weighted average price of all species caught by country k

X_k – total catch by country k measured in Euro/kg

10) Weighted average price of all species caught by the countries most actively taking part in the fisheries defined by case h in sea l

$$P_l = \frac{\sum_j \sum_{k=k(h(l))} P_{jk} * x_{jk}}{X_{lk(h(l))}} \qquad (10)$$

Xlk(h(l)) = aggregated catch of all species in sea l by the most active countries taking part in the specified cases (fisheries) in this sea

Pl = weighted average price measured in Euro/kg of all species by the most active countries taking part in the fishery in case h, where case h belong to sea l

11) Value of total catches in sea l

$$V_l = (P_l * X_l) * 1000 \qquad (11)$$

Vl = total value of all catches in sea l

12) Value of catches in case h in sea l

$$V^S{}_{hl} = (P^S{}_j * X_{hl}) * 1000 \quad \text{when case h is a single species fishery} \qquad (12a)$$

$$V^M{}_{hl} = (P^M{}_h * X_{hl}) * 1000 \quad \text{when case h is a multi species fishery} \qquad (12b)$$

Vthl = total value of total catches in case h in sea l, t=S, M

13) Relative size of case h in sea l, when measured in nominal values (matrix)

$$Q^S{}_{hl} = \frac{V^S{}_{hl}}{V_l} \quad \text{when case h is a single species fishery} \qquad (13a)$$

$$Q^M{}_{hl} = \frac{V^M{}_{hl}}{V_l} \quad \text{when case h is a multi species fishery} \qquad (13b)$$

G3 Employment and productivity

As for values of catches, there are no sea-specific data on employment. Data on employment are mainly given on country-level, but within each country employment measured as full time equivalents are given for specific gear and vessel types. Hence, we construct productivity indices, both country specific, encompassing all gear and vessel types, and fishery (case) specific, encompassing the most important gear and vessel types participating in the fishery (case) under consideration.

14) Productivity indicator for gear/vessel type g in country k (background)

$$Z_{gk} = \frac{EMPL^{dir}{}_{gk}}{X_{gk}} \qquad (14)$$

Xgk = total catch for gear/vessels type g in country k

EMPLdirgk = total fleet employment for gear/vessel type g in country k

Zgk = number of full time equivalent employment (FTE) per 1000 tonnes catch for gear/vessel type g in country k

15) Productivity indicator for case h in sea l

$$Z_{lh} = \frac{\sum_{k=k(h(l))} \sum_{g=g(h(l))} EMPL^{dir}{}_{gk}}{\sum_{k=k(h(l))} \sum_{g=g(h(l))} X_{gk}} \qquad (15)$$

g(h(l)) – defines the gear/vessel types that counts for the largest share of total catches in case (fishery) h in sea l

Zlh = weighted average of FTE per 1000 tonnes catch for the (most active) gear/vessel types and countries taking part in fishery (case) h in sea l

16) Productivity indicator for country k

$$Z_{k} = \frac{\sum_{g} EMPL^{dir}{}_{gk}}{X_{k}} \qquad (16)$$

Z_k = employment measured in FTE per 1000 tonnes catch for country k

17) Productivity indicator for sea l

$$Z_{l} = \frac{\sum_{g} \sum_{k=k(h(l))} EMPL^{dir}{}_{gk}}{X_{l}} \qquad (17)$$

Z_l = weighted average of employment measured in FTE per 1000 tonnes catch in sea l and where the most actively participating countries in the fisheries (cases) in sea l are used as weights

18) Total direct employment in the fisheries in sea l

$$EMPL^{dir}{}_{l} = (Z_l * X_l)/1000 \qquad (18)$$

$EMPL^{dir}{}_l$ = total direct employment, measured in FTE, in the fisheries in sea l

19) Total direct employment (fleet) in case h in sea l (background)

$$EMPL^{dir}{}_{lh} = (Z_{hl} * X_{hl})/1000 \tag{19}$$

$EMPL^{dir}{}_{hl}$ = direct employment, measured in full time equivalent, in fishery (case) h in sea l

20) relative importance of a fishery according to employment (FTE)

$$s_{hl} = \frac{EMPL^{dir}{}_{hl}}{EMPL^{dir}{}_{l}} \tag{20}$$

s_{hl} = direct employment in fishery (case) h in sea l relative to total direct employment in all fisheries in sea l

For each country participating in the fishery (case) the vessel/gear types catching the major share of total catches for that fishery are included

21) Total indirect employment in the selected sea areas

$$EMPL^{ind}{}_{l} = \sum_{kr=kr(l)} PRO_{krl} \tag{21}$$

PRO_{krl} = number of persons working in fish processing in country-region kr (NUTS-2 level) bordering sea l

kr(l) – refers to country-region kr bordering to sea l

Fuel consumption and fuel costs

22) Fuel indicator for gear/vessel type g in country k (background)

$$F_{gk} = \frac{FCosts_{gk}}{X_{gk}} \tag{22}$$

X_{gk} = total catch for gear/vessels type g in country k

$FCosts_{gk}$ = total fuel costs for gear/vessel type g in country k

F_{gk} = fuel costs per 1000 tonnes catch for gear/vessel type g in country k

23) Fuel indicator for case h in sea l

$$F_{lh} = \frac{\sum_{k=k(h(l))} \sum_{g=g(h(l))} FCosts_{gk}}{\sum_{k=k(h(l))} \sum_{g=g(h(l))} X_{gk}} \tag{23}$$

g(h(l)) – defines the gear/vessel types that counts for the largest share of total catches in case (fishery) h in sea l

Flh = weighted average of fuel costs per 1000 tonnes catch for the (most active) gear/vessel types and countries taking part in fishery (case) h in sea l

24) Fuel indicator for country k

$$F_{k} = \frac{\sum_{g} FCosts_{gk}}{X_{k}} \tag{24}$$

Zk = employment measured in FTE per 1000 tonnes catch for country k

25) Productivity indicator for sea l

$$F_l = \frac{\sum_g \sum_{k=k(h(l))} FCosts_{gk}}{X_l} \tag{25}$$

Fl = weighted average of fuel costs measured as million Euros fuel costs per 1000 tonnes catch in sea l and where the most actively participating countries in the fisheries (cases) in sea l are used as weights

26) Total fuel costs in the fisheries in sea l

$$FCosts_l = (F_l * X_l)/1000 \tag{26}$$

$FCosts_l$ = total fuel costs, measured in million Euros, in the fisheries in sea l

27) Total fuel costs in case h in sea l (background)

$$FCosts_{lh} = (F_{hl} * X_{hl})/1000 \tag{27}$$

$FCosts_{lh}$= direct employment, measured in full time equivalent, in fishery (case) h in sea l

28) relative importance of a fishery according to employment (FTE)

$$f_{hl} = \frac{FCosts_{hl}}{FCosts_l} \tag{28}$$

f_{hl} = direct employment in fishery (case) h in sea l relative to total direct employment in all fisheries in sea l

For each country participating in the fishery (case) the vessel/gear types catching the major share of total catches for that fishery are included

Variables

The main idea behind the selected variables is to give a picture of the relative importance of each of the selected fisheries (cases) in the three sea areas. Because there is a difference between the biological and the economic aspects of the fisheries, we choose to show the relative importance of each fishery measured in quantities (tonnes), nominal values and employment. In order to avoid giving a non-representative image of the relative importance of the selected fisheries, data should be given for three subsequent years. This at least reduces the probability for showing a-typical situations with regard to the fisheries in the three sea areas.

Seen from a local community point of view the fishing activity may have spill over effects to other sectors. When this is the case the importance of a fishery to the local community is larger than just the size of the fishery activities, and a reduction in the fishery activity may have effects on the local community which are far more comprehensive than is predicted. An important concept here is threshold levels, which points to the fact that when the fishing activity drops below a (lower) level many other related activities will loose their justification or economic foundation. We do not take such circumstances into consideration.

Data

The basic data sources for the selected variables are ICES Fishery data base and Annual Economic Report (AER) from DG Mare. ICES data base provides numbers on catches divided on country, fishing area and species. These are sufficient to calculate the variables 1-3.

The annual report from DG Mare provides a selection of nominal measures, including income (value of landings), gross value added, and also data on employment and number of vessels taking part in the specific fisheries. However, these data are not distributed on species, but rather on type of fleet. They are presented for each MS, but not on a sea area level, such as North Sea, NWW or SWW.

Finally, when it comes to a more comprehensive overview of the fishery employment the only existing source (on EU level or above) is the report "Employment in the fisheries sector: current situation" (FISH/2004/04), which is funded by the European Commission. Unfortunately, this is not a report that is processed on a regular basis, and thus we have data only for 2002-2003 on indirect employment.

AER presents data based on national statistics, which have been collected through samples, surveys and estimations. Hence, these data may give a more uncertain picture of the actual situation than does the ICES database.

Appendix 2: QUESTIONNAIRE POs` PERCEPTIONS (Spanish model)

MAKING THE EUROPEAN FISHERIES ECOSYSTEM PLAN OPERATIONAL (MEFEPO)
FP7-KBBE-2007-1-212881

Valuation 1 to 5 (1: worst/low – 5: best/high)

	Demersal trawl	**Longlines**	**Purse seine**
Perceptions on environmental situation in the fishery			
Exploitation state			
Variability in the recruitment			
Collapse level			
Catches size inferior to sexual maturity size			
% Bycatch			
% Discards			
Pollution level in marine environment			
Pollution effects on the marine environment from transport (hydrocarbons, tourism, …)			
Effects on sea bottom and benthonic species from gears			
Perceptions on socioeconomic situation in the fishery			
New enters in the fishery			
Education level of the fishermen			
Conflict level			
Number of jobs evolution			
Average wage			
Profitability			
Market situation			
Efficiency level			
Perceptions on the management of the fishery			
Current management from:			

European Union														
Central Government														
Regional Governments														
Implication of the fishing sector in the management measures implemented by:														
European Union														
Central Government														
Regional Governments														
Implication of the other agents (ecological associations, consumer associations, …) in the management measures implemented by:														
European Union														
Central Government														
Regional Governments														
Effectiveness of current management in the fishery	Closures	TAC	Effort Total	Weekly rest	Gear regulation	Closures	TAC	Effort Total	Weekly rest	Gear regulation	Closures	Daily catches	Weekly rest	Gear regulation
Effectiveness of other possible instruments (for applying in the future)	ITQ					ITQ					TAC		ITQ	

Valuation 1 to 5 (1: worst/low – 5: best/high)

COMMENTS: