chapter 5

Biology

5.1 Introduction

Within the context of the general ecosystem structure, which results from the major climatic, topographical and evolutionary characteristics of the oceans and continental land masses, biogeographic areas and subareas with common biotic and abiotic features can be defined according to the patterns of the composite flora and fauna. For example, on the European continental margin of the Atlantic Ocean, there is a sharp north to south temperature gradient, which restricts the distribution of many species and leads to a biogeographic subdivision of the eastern Atlantic into two provinces: the boreal Atlantic province and the subtropical Lusitanian province *(Figure 5.1)*.

Region IV corresponds to the Lusitanian province, which extends from the western coasts of the Iberian Peninsula to Brittany. Owing to major differences in the climatic characteristics and communities of animal and plant species, the Lusitanian province has been subdivided into the subtropical subprovince (Strait of Gibraltar to Finisterre) and the subtropical/boreal transition subprovince (Finisterre to Brittany).

Within the subtropical area, the coastline open to the ocean (Finisterre to Cape San Vicente) can be distinguished from the subregion of the Gulf of Cádiz, which represents an area of transition between the Mediterranean Sea and the Atlantic Ocean.

In the subtropical/boreal transition subprovince the fauna are mixed, with groups of boreal and subtropical origin. This area may also be subdivided into the eastern subregion, which exhibits the oceanographic characteristics of the Bay of Biscay, and the Atlantic-influenced subregion (Cape Finisterre to Cape Estaca de Bares and then to the south of Brittany). The characteristic fauna and flora of the latter result in part from the position occupied by the Iberian Peninsula at the beginning of the Tertiary Period, i.e. folded in towards France, with the Bay of Biscay practically closed, in such a way that Galicia and Brittany were very close together.

In addition to biogeographical affinities, the communities in a given area reflect the nature of substrate. In this respect Region IV is highly diverse, having many different types of coastal habitat, such as rocky cliffs, shingle, rocky shores, sandy and muddy shores, coastal lagoons and estuaries.

5.2 **Overview of the ecosystem**

5.2.1 Bacteria

The abundance of benthic bacteria reflects the concentration of organic matter in the sediments. On the Galician shelf the highest numbers occur in regions close to areas with high population densities and with high levels of organic matter in the sediments. In continental shelf sediments from Cape Finisterre to the River Minho, bacterial abundance increases southwards along the Galician coast with the highest numbers occurring in sediments off the Rías Bajas, mainly off the Ría of Vigo (2 – 32 x 10^8 cells/g dw). The number of bacteria decreases offshore where less organic matter is present in the sediment.

The abundance of pelagic bacteria varies in relation to river inputs, site, depth and seasonality. Vertical profiles of heterobacteria and cyanobacteria on the continental shelf of the Cantabrian Sea during periods of upwelling, show that cyanobacterial abundance is associated with the chlorophyll maximum. In Santander Bay, the annual abundance of pelagic bacteria varies between 7.3 and 24.6 x 10^8 cells/l, with cyanobacteria ranging from 1.2 to 46 x 10^6 cells/l and autotrophic nanoflagellates from 3.8 to 19.7 10^6 cells/l.

In the Ría of Arosa with its intensive mussel culture, the annual numbers of planktonic bacteria vary between 4.5 and 20.8 x 10^8 cells/l. These numbers are a consequence of the organic matter released from mussel rafts. After an upwelling event, abundance varies over depth and time, ranging from 2.5 to 12 x 10^8 cells/l. In the neighbouring Ría of Vigo (which has a high population density), abundance ranges from 5.3 to 35.2 x 10^8 cells/l, with cyanobacteria ranging between 0.4 and 102.1 x 10^6 cells/l, autotrophic nanoflagellates between 0.5 and 15.2 x 10^6 cells/l and heterotrophic nanoflagellates between 0.8 and 2.6 x 10^6 cells/l.

5.2.2 Phytoplankton

At least 1000 species of phytoplankton have been identified in Region IV *(Table 5.1)*. For most of the year diatoms dominate the phytoplankton community, particularly during periods of upwelling, while coccolithophorids dominate during winter. Small dinoflagellates dominate warmer stratified waters offshore. In the northern and eastern waters of the Bay of Biscay, the influence of upwelling events is weaker and a predominance of dinoflagellates is likely in summer. In the coastal area between the Loire and Gironde estuaries, *Rhizosolenia*

Table 5.1 Numbers and types of phytoplankton identified in Region IV.

	No. species
Bacillariophyceae (diatoms)	533
Dinophyceae (dinoflagellates)	315
Prymnesiophyceae (coccolithophorids)	86
Raphidophyceae	3
Euglenophyceae	9
Chlorophyceae	27
Prasinophyceae	15
Crysophyceae	4
Dictyochophyceae	9
Cryptophyceae	10
Cyanophyceae	6
Ebriideae	1

Figure 5.1 **Biogeographical subdivisions of Region IV.**

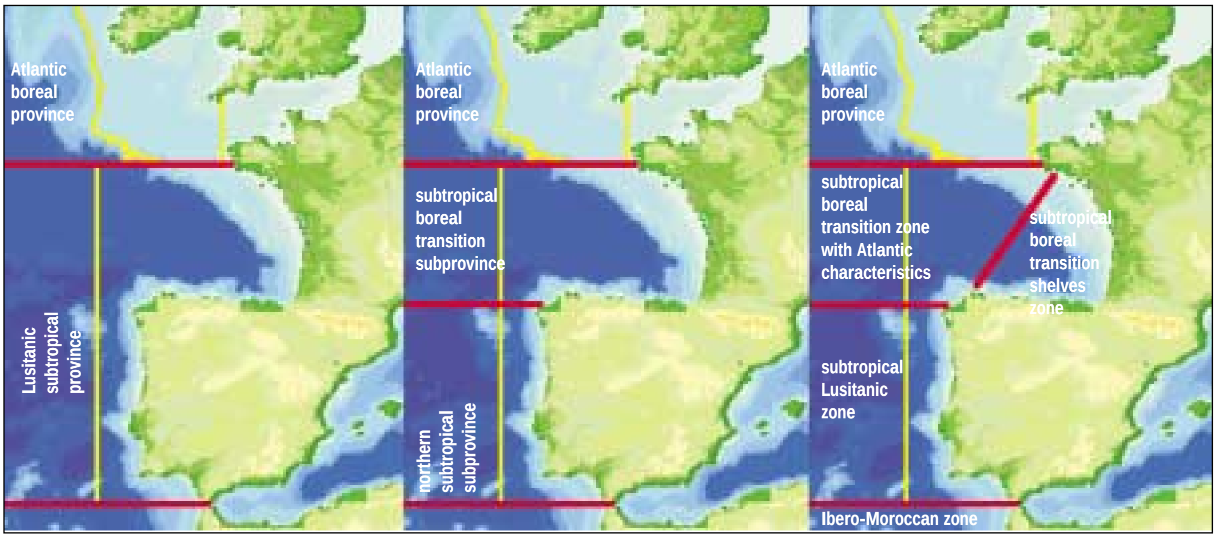


Table 5.2 Dominant phytoplankton species at a coastal site near A Coruña on the Galician coast.

Stage	Species	Comments
Blooms	*Chaetoceros socialis* *Lauderia borealis* *Thalassiosira fallax* *Schroederella delicatula* *Chaetoceros dydimus* *Rhizosolenia setigera*	Microflagellates, chain-forming and large diatoms
Stratification	*Leptocylindrus danicus* *Chaetoceros affinis* *Dinophysis acuminata* *Dinophysis acuta* *Rhizosolenia delicatula* *Gyrodinium spirale* *Protoperidinium bipes*	Microflagellates, small and large diatoms and dinoflagellates
Summer upwelling	*Chaetoceros socialis* *Rhizosolenia fragilissima* *Pseudo-nitzschia* spp.	Small chain-forming diatoms
Winter mixing	*Skeletonema costatum* *Nitzschia longissima* *Pseudo-nitzschia* spp. *Distephanus speculum* *Solenicola setigera* *Gyrodinium glaucum* *Gyrodinium spirale* *Paralia sulcata*	Perennial species, small diatoms, dinoflagellates and microflagellates Resuspended phytobenthos

and *Skeletonema* are ecological dominants in spring; *Navicula* in spring, summer and autumn; *Coscinodiscus* and *Leptocylindrus* in summer, autumn and winter; *Fragilaria* in winter and *Melosira* and *Paralia* throughout the year. The dominant phytoplankton species occurring in the Galician area during the main oceanographic stages are listed in *Table 5.2*. Species composition is similar in the Cantabrian Sea, even though the importance of dinoflagellates increases during summer, especially in the eastern Bay of Biscay.

The annual phytoplankton cycle in Region IV 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. Phytoplankton biomass within Spanish coastal waters under various oceanographic conditions is given in *Table 5.3*.

Rivers discharge large volumes of freshwater into the sea forming river plumes. The continuous input of nutrients from the run-off of large rivers (such as the Loire, Gironde, Minho, Tejo and Douro) enhances and maintains 'new' primary production. Owing to the haline stratification which maintains phytoplankton cells in a very thin layer of water, phytoplankton production can start very early in the less turbid part of the plumes. These winter blooms are relatively short-lived however, as they soon become phosphorous-limited. Lower river run-off and a much narrower continental shelf off the northern Iberian Peninsula together make buoyant plumes much less persistent along the Cantabrian coast. 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,

Table 5.3 Mean (± 1 standard deviation) of chlorophyll concentrations for the main oceanographic stages within Spanish estuaries, rías and coastal waters.

	Bloom	Stratification	Upwelling	Winter
Estuaries and rias on the Spanish coast*				
Zarauz-Fuenterrabía	2.51 ± 1.85	0.89 ± 0.54	-	0.50 ± 0.27
Deva-Zumaya	1.85 ± 0.97	0.23 ± 0.12	-	0.48 ± 0.23
Ría of Ferrol	3.83 ± 1.11	-	3.03 ± 0.59	0.52 ± 0.12
Ría of Ares-Betanzos	3.30 ± 1.20	1.75 ± 0.75	2.05 ± 0.85	0.42 ± 0.09
Ría of A Coruña	2.51 ± 1.55	1.70 ± 0.71	2.15 ± 0.15	0.68 ± 0.30
Ría of Corme-Laxe	2.23 ± 1.12	1.03 ± 0.15	1.66 ± 0.20	0.32 ± 0.15
Ría of Camariñas	1.20 ± 0.05	0.50 ± 0.05	-	-
Ría of Muros-Noya	2.83 ± 0.54	1.71 ± 0.72	1.71 ± 0.72	0.35 ± 0.05
Ría of Arousa	2.85 ± 0.89	1.57 ± 0.85	4.52 ± 1.56	0.52 ± 0.29
Ría of Pontevedra	2.01 ± 0.70	1.05 ± 0.61	2.65 ± 1.31	0.38 ± 0.02
Ría of Vigo	2.70 ± 0.72	1.74 ± 0.84	2.60 ± 0.81	0.35 ± 0.04
Ria of Huelva	3.41 ± 3.35	2.01 ± 1.62	-	2.72 ± 2.15
Continental shelf close to the Galician and Asturian coast†				
Asturias	49.33 ± 19.29	25.33 ± 10.85	40.72 ± 14.32	15.64 ± 7.52
Rias Altas	67.68 ± 49.49	37.55 ± 24.44	57.84 ± 41.86	15.64 ± 3.80
Rias Bajas	32.84 ± 10.50	35.53 ± 20.45	87.11 ± 34.04	–
coastal	43.13 ± 21.23	33.21 ± 21.26	62.36 ± 36.40	15.33 ± 8.79
mid-shelf	82.70 ± 52.23	32.25 ± 19.39	65.09 ± 55.29	15.17 ± 4.19
outer-shelf	37.35 ± 12.33	28.66 ± 16.04	60.76 ± 19.30	18.03 ± 6.10

* mg Chla/m^2; † mg Chla/m^2, integrated over the euphotic zone (25 – 40 m); – no information.

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 is 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 25 km of coastal water are about ten times more productive than offshore waters, and upwelling centres approximately twenty times more productive. Along the Landes coast, mainly in summer, weak upwelling events are induced by northerly winds. Their effects on plankton production are unknown.

Toxic dinoflagellates and diatoms are regular components of the marine phytoplankton community and can render shellfish toxic at concentrations as low as 10^2 – 10^3 cells/l, well below those causing water coloration (i.e. > 10^6 cells/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. *Table 5.4* lists the phytoplankton species that have been associated with toxic outbreaks on the Galician and Portuguese coast and their associated toxins.

5.2.3 Zooplankton

The zooplankton community of Region IV is very rich in terms of taxonomic groups and species. The main holoplanktonic and meroplanktonic groups and their relative abundance are shown in *Figure 5.2*. 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 Region IV since 1967. Nevertheless, despite this diversity only seven species of copepod characterise the region, accounting for 90% of the total abundance *(Figure 5.2)*.

Table 5.4 Species associated with shellfish toxicity on the Galician and Portuguese coasts.

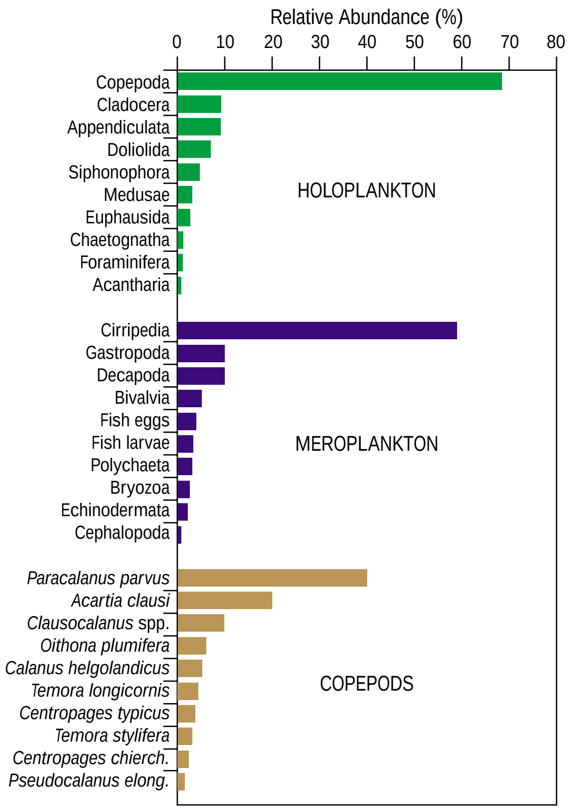
	Rías Altas	Rías Bajas	Portuguese coast
Paralytic Shellfish Poisoning			
Gymnodinium catenatum	-	+	+
Alexandrium minutum (=lusitanicum)	+	+	+
Diarrhetic Shellfish Poisoning			
Dinophysis sacculus	+	-	-
D. acuminata complex	+	+	+
D. acuta	-	+	+
D. caudata + *D. tripos*	+	+	+
Amnesic Shellfish Poisoning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

Nyctiphanes cochii and *Meganyctiphanes norvegica* are the most abundant euphausiids. Seven of the nine species of marine cladoceran are found in 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 Region IV.

Figure 5.2 **The relative abundance of the ten major groups and species of holoplankton, meroplankton and copepods.**



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.

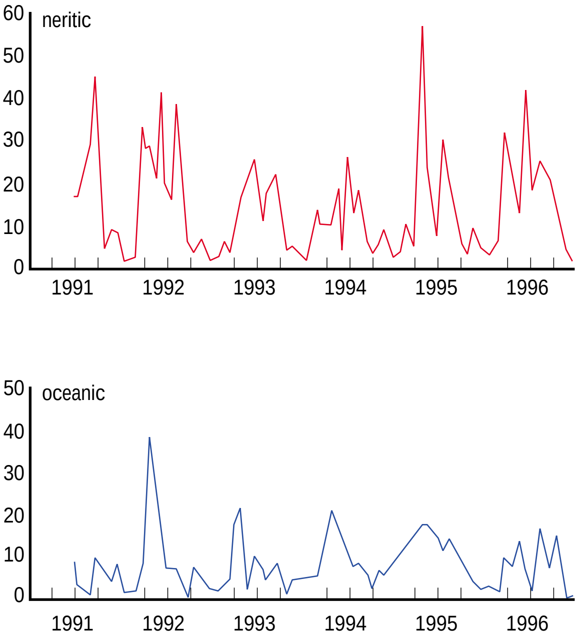
Zooplankton composition, abundance and distribution is highly variable spatially, varying across the shelf with respect to latitude and coastal topography. For example, in terms of variations with latitude 95 species of copepod have been identified in the southern Bay of Biscay (accounting for 71.9% 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 are more abundant over the mid-continental shelf.

There are two peaks in the annual cycle of zooplankton abundance and biomass in 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 Region IV 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 *(Figure 5.3)*.

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.

Figure 5.3 **Zooplankton biomass (dry weight, mg/m^3) at neritic and oceanic sampling stations off Santander, 1991–6. Source: after Valdés and Moral (1998).**



5.2.4 Benthos

Macrophytobenthos

Marine plants include algae and some flowering plants. Algae live on rocky substrates extending from the coastline to depths of up to 20 – 30 m. 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 *(Table 5.5)*. 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 – 15 m deep, and which have been subject to industrial exploitation since the 1950s *(Figure 5.4)*. 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

Table 5.5 Main seaweed species in Region IV.

	Species	Comments
Southern Brittany	*Laminaria digitata, Alaria esculenta, Phycodrys rubens, L. saccharina, Himanthalia elongata, Palmaria palmata.*	Southern limit of cold water populations
Cantabrian zone		
Basque country	*Caulacanthus ustulatus, Corallina elongata, Gelidium latifolium.*	Rocky littoral with communities of a caespitose habit
	Stypocaulon, Cladostephus, Dictyota.	Protected and sandy areas
	Cystoseira, Sargassum flavifolium.	Infralittoral
eastern Cantabria – Asturias	*L. ochroleuca, S. polyschides.*	Transition towards more northern communities
	G. sesquipedale, Cystoseira baccata, Halidris siliquosa, Laminaria spp.	Infralittoral
Atlantic zone		
western Asturias – northern	*Fucus serratus, Chondrus crispus* (var. *filiformis).*	Mixture of southern and northern species
Galicia	*G. sesquipedale, Cy. baccata*	Infralittoral. Substituted towards the west by others (e.g. *L. hyperborea*)
Cape Ortegal – River Minho	*L. saccharina, S. polyschides, H. elongata, Ascophyllum nodosum.*	Settlement of northern species favoured by seasonal upwelling of cold water
	S. muticum, Undaria pinnatifida.	Non-indigenous species in the inner part of the Rias Bajas
Portugal	*L. saccharina, L. hyperborea, F. serratus, Pelvetia canaliculata, A. nodosum, H. elongata, Ch. crispus, P. palmata, Ceramium shuttleworthianum.*	Most southern European distribution in Portugal
	Cy. barbata, Zonaria tournefortii, Amphiroa beauvoisii, Griffithsia opuntioides, Ulva linearis, Valonia utricularis.	Meridional and Mediterranean species with their northern limit in Portugal
Gulf of Cadiz	*Ca. ustulatus, Gelidium spathulatum, G. microdon, Chondracanthus acicularis, Ce. ciliatum, Co. elongata.*	Abundant caespitose plurispecific communities
	Phyllophora heredia, G. sesquipedale, Caliblepharis ciliata.	Infralittoral
	Cy. tamariscifolia, Cy. baccata, S. flavifolium.	Laminarians very scarce
	F. spiralis limitaneus, F. vesiculosus.	Fucales representative of large estuaries
	Sphacelariaceae, Dictyotaceae, *Halopitys incurvus, Cryptonemia lomation.*	Protected sandy areas

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

Figure 5.4 ***Gelidium sesquipedale* is an important natural resource for the local economy of northern Spain.**

waters, and the northern limits of more than twenty southern and Mediterranean species occur primarily along the Algarve coast.

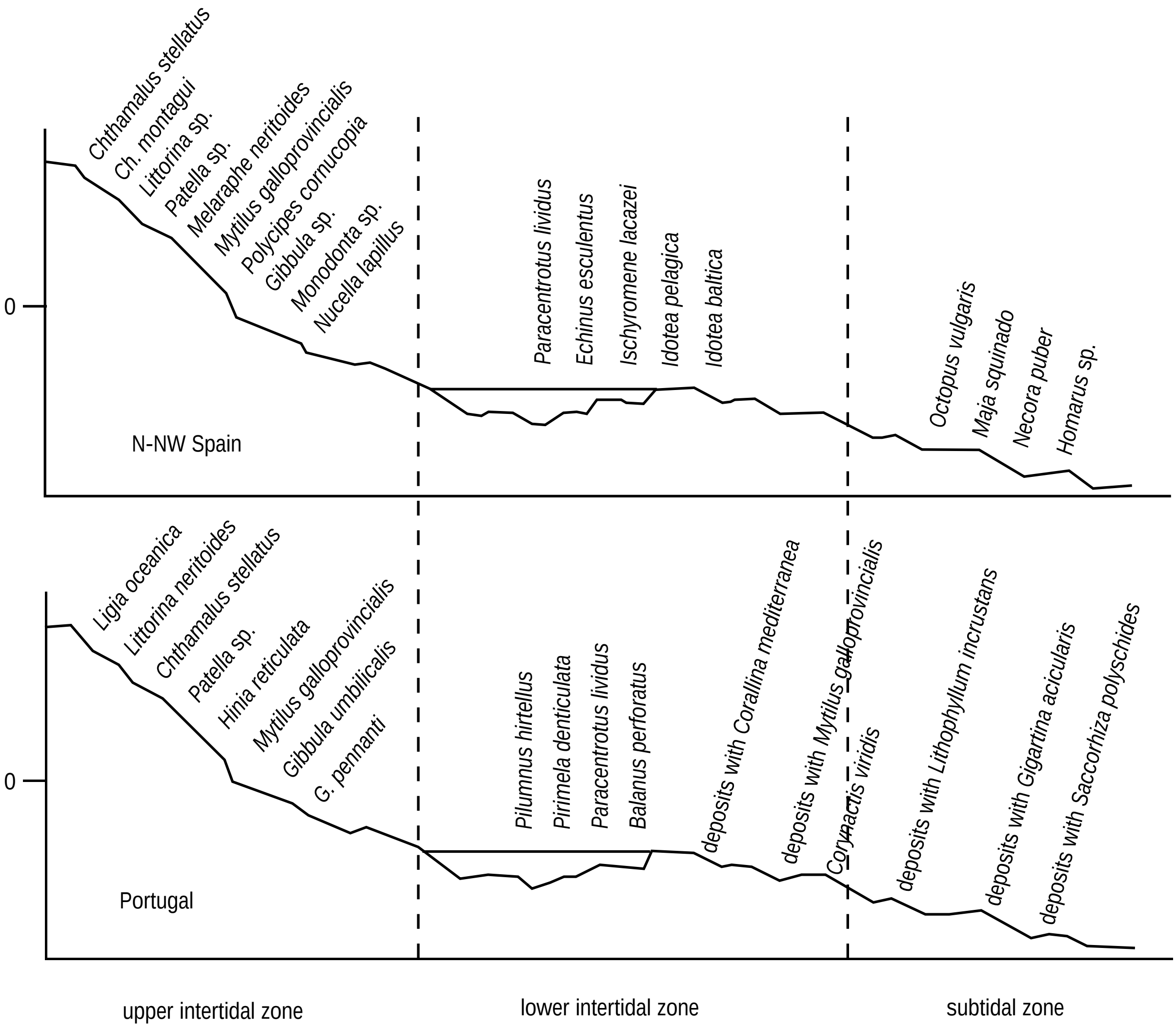
Algae in the Gulf of Cádiz are very similar to those of the Basque country. Caespitose plurispecific communities occur in the littoral zone, Laminarians are very scarce, and the Fucales are represented by *Fucus spiralis limitaneus* and forms of *F. vesiculosus* in the large estuaries *(Table 5.5)*.

Macrofauna on hard substrates

Intertidal and shallow subtidal macrofauna (> 1 mm 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 5.5)*. 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

Figure 5.5 **The main macrofaunal species on the rocky shores along the north and north-western coasts of Spain and Portugal.**



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 *(Figure 5.5)*. 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 *Corallina mediterranea* occurs between the surface and 2 m followed by a facies of Mediterranean mussel (2 – 12 m). 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 42 m 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 4500 m. 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*.

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). Species composition and abundance for both communities are given in *Figures 5.6* and *5.7*.

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 (*Figures 5.6* and *5.7*).

Figure 5.6 **Relative abundance of the main species occurring in muddy sediment communities. Source: Lopez-Jamar *et al*. (1995); Tenore et al. (1984); Viéitez (1976).**

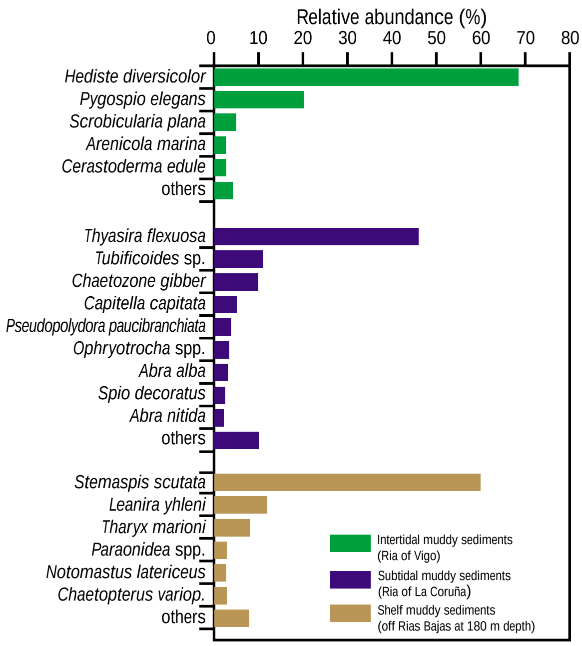
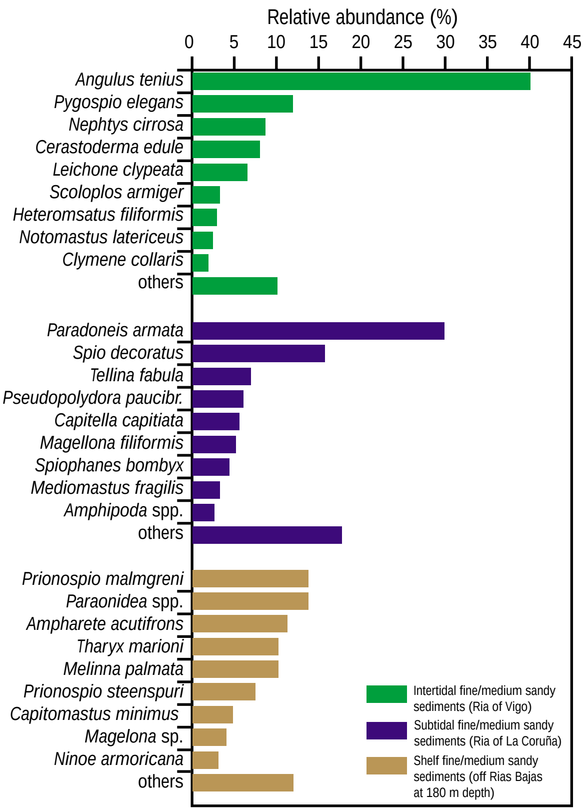


Figure 5.7 **Relative abundance of the main species occurring in fine/medium sandy sediment communities. Source: Lopez-Jamar *et al*. (1995); Tenore *et al*. (1984); Viéitez (1976).**



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 (*Figures 5.6* and *5.7*). Polychaetes, molluscs, cnidarians, echinoderms and crustaceans are the most abundant groups on the Cantabrian shelf and slope (31 – 1400 m).

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. The main species are listed in *Table 5.6*. In the subtidal zone (about 30 m 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 200 m, 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. Other communities corresponding to mixed sediments, silt sediment and muddy bottoms are shown in *Table 5.6*.

Soft substrates predominate in the Gulf of Cádiz. Large macrofauna communities are related to depth and sediment type *(Table 5.6)*: shallow muddy bottoms off the River Guadalquivir (15 – 30 m) are characterised by prawns, mantis shrimp, crabs, and common cuttlefish; the middle continental shelf (31 – 100 m) is characterised by bivalve molluscs, gastropods, cephalopods and crustaceans; the outer continental shelf (101 – 200 m) is characterised by a high abundance of the prawn *Parapenaeus longirostris*; the upper portion of the slope (201 – 500 m) is dominated by shrimps and crabs; areas deeper than 300 m 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 molluscs (surf clam, razor clam, wedge shell, carpet shell, mussel, cockle, octopus and cuttlefish).

Meiofauna

Meiofauna are those 1 – 0.06 mm 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 4400 m 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 5300 m 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 1500 m. Between 2000 and 4000 m the decrease in density is not significant. The dominant groups are nematodes (up to 92%), followed by copepods and nauplii (up to 8%).

5.2.5 Fish

The fish of Region IV are well known from a descriptive point of view. Of the 1098 species described for the North-east Atlantic and the Mediterranean, around 700 occur in Region IV. In terms of biogeography, many species reach their southern or northern limits of distribution in the Bay of Biscay. The boundary for the cold temperate species is around 47° N *(Table 5.7)*. The shelf break in the Bay of Biscay is a major spawning area for species with a wide

Table 5.6 Main species of benthic macrofauna in soft substrates along the Portuguese coast and in the Gulf of Cadiz.

Portuguese coast	Species	Gulf of Cadiz	Species
Intertidal	*Talitrus saltator*	River mud (15 – 30 m)	*Penaeus kerathurus*
sand	*Tylos europeus*		*Squilla mantis*
	Eurydice pulchra		*Medorippe lanata*
	Spio filicornis		*Calappa granulata*
	Nephtys cirrosa		*Sepia officinalis*
	Haustorius arenarius		
	Urothoe brevicornis	Littoral mud and mud-sand	*Chamaelea gallina*
	Bathyporeia guilliamsoniana		*Donax* sp.
	Pontocrates arenarius		*Tapes* sp.
	Donax trunculus		*Venerupis* sp.
	Tellina tenuis		
		Middle shelf (30 – 100 m)	*Atrina pectinata*
Subtidal			*Circomphalus cassinus*
fine sand	*Chamelea striatula*		*Cymbium olla*
coarse sand	*Dosinia exoleta*		*Loligo vulgaris*
	Spisula solida		*Alloteuthis* sp.
gravel	*Amphioxus lanceolatus*		*Sepia* sp.
			Octopus vulgaris
Infralittoral			*Eledone moschata*
up to 10% fines	*Jasmineira caudata*		*Alpheus glaber*
	Eunice pennata		*Pontocaris* sp.
	Pista cristata		*Liocarcinus depurator*
	Corbula gibba		*Goneplax rhomboides*
	Maera othonis		*Dardanus arrosor*
	Liocarcinus pusillus		
	Aspidosiphon muelleri	Outer shelf (100 – 200 m)	*Parapenaeus longirostris*
			Plesionika heterocarpus
mixed sediment	*Calappa granulata*		*Dardanus arrosor*
	Thyone inermis		*Homola barbata*
	Labidoplax digitata		*Inachus* sp.
	Petrosia ficiformis		*Macropodia*
	Chloeia venusta,		*Eledone cirrhosa*
	Eunice vittata		*Sepia elegans*
	Eunice harassii		*Illex coindetii*
	Euthalenessa dendrolepis		
		Upper slope (200 – 500 m)	*Solenocera membranacea*
25 – 50% silt	*Dasybranchus caducus*		*Chlorotoccus crassicornis*
	Aglaophamus malmgrenis		*Plesionika* sp.
	Mysta picta		*Pasiphaea* sp.
	Glycera rouxi		*Processa* sp.
	Leanira yhleni		*Munida intermedia*
	Lumbrineris impatiens		*Macropipus tuberculatus*
	Sternaspis scutata		
		Bottom > 300 m	*Nephrops norvegicus*
deep mud	*Dentalium agile*		Sepiolidae
	Siphonodentalium quinquangulata		
	Abra longicallus	Deep samples (500 – 700 m)	*Aristeomorpha foliacea*
	Sternaspis scutata		*Aristeus antennatus*
	Ampharetidae		*Plesionika martia*
	Terebellidae		*Bathynectes superbus*
	Glyceridae		*Nephrops norvegicus*

geographical distribution (e.g. blue whiting (*Micromesistius poutassou*), mackerel, horse mackerel and hake).

Pelagic fish

Although fifteen pelagic species are common in Region IV, only sardine, anchovy, mackerel, horse mackerel, albacore and bluefin tuna (*Thunnus thynnus*) are important in terms of abundance and commercial interest. *Figure 5.8* shows the distribution of the small and medium-sized pelagic species over the French continental shelf.

The sardine has a wide geographic distribution, from Mauritania to the British Isles. The Ibero-Atlantic and Bay of Biscay populations coexist in 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 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.

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.

Demersal fish

Demersal species comprise the majority of the fish species occurring in 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 – 600 m. Abundance varied widely with around ten species *(Table 5.8)* 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 – 60 m), 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 *(Table 5.9)*.

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 *(Table 5.9)*.

Table 5.7 Cold temperate and warm temperate fish species with their southern and northern limits of distribution on the French shelf of the Bay of Biscay. Source: Quéro *et al*. (1989).

Cold temperate species	Warm temperate species
Butterfish	Axillary sea bream
Cod	Bogue (*Boops boops*)
Dab	Bogue (*Sarpa salpa*)
Echiodon drummondi	Couch's sea bream
Great silver smelt	Drum (*Umbrina canariensis*)
Greater sandeel	Gilt-head sea bream
Haddock	Long-finned gurnard
Herring	Mediterranean horse mackerel
Lemon sole	Scorpionfish (*Scorpaena loppei*)
Nilsson's pipefish	Sea spotted bass
Norway pout	Seahorse
Norwegian topknot	Spanish mackerel
Saithe	Spanish sea bream
	Thickback sole

Data obtained in autumn 1973 and spring 1976.

Figure 5.8 **Distribution of the main pelagic fish species on the continental shelf to the east of the Bay of Biscay. Source: after Massé (1996).**

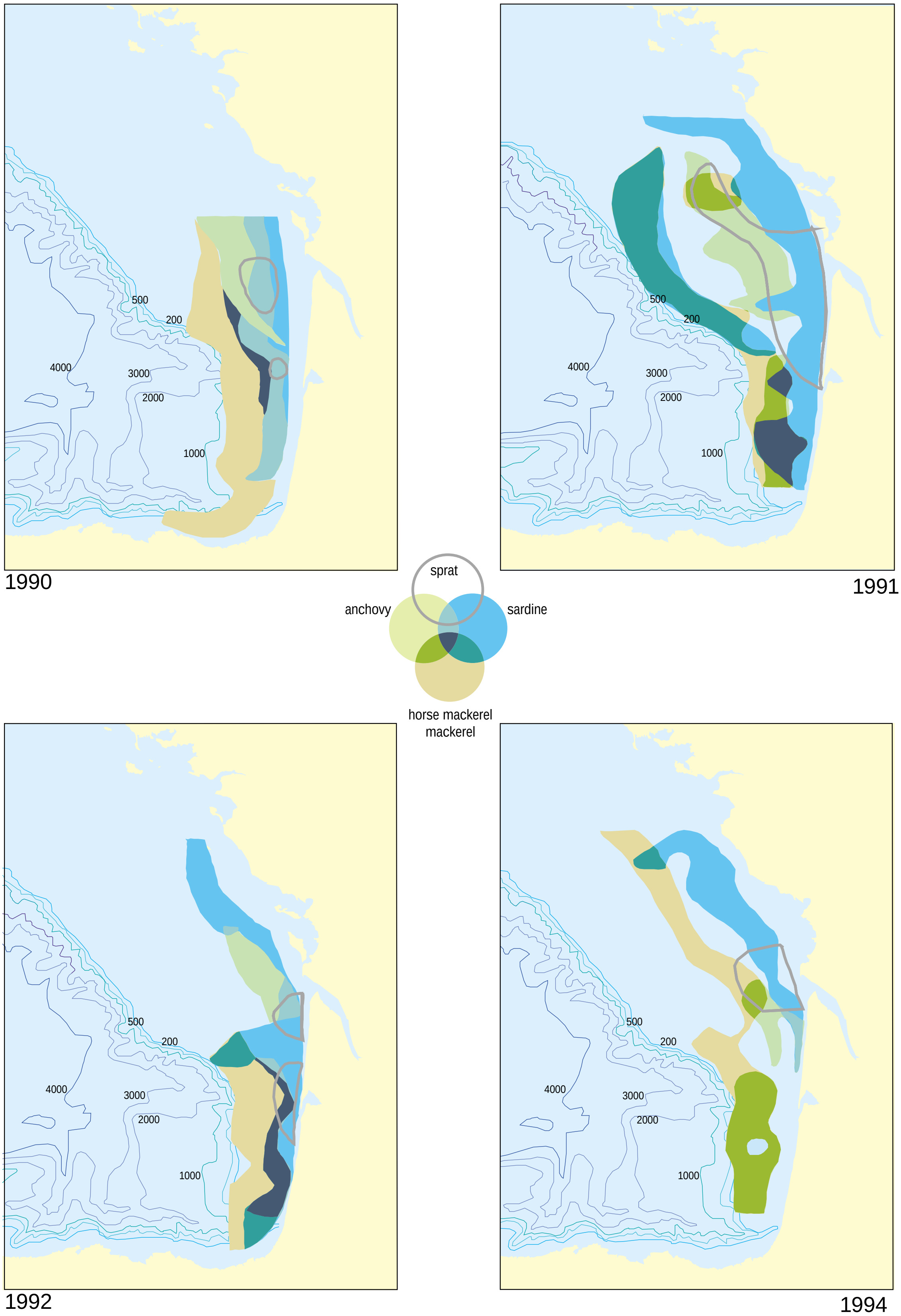


Table 5.8 The most abundant fish species in the Bay of Biscay, 1987–95.

Demersal species	Relative abundance in demersal catches (%)	Pelagic species	Relative abundance in pelagic catches (%)
Poor cod	27	Horse mackerel	56
Boar fish	17	Blue whiting	30
Bib	13	Greater argentine	2
Hake	12	Mackerel	2
Lesser spotted dogfish	4	Mediterranean horse mackerel	2
Anglerfish	3	Pilchard	2
Thornback ray	2	Sprat	2
Whiting	2	European anchovy	1
Spurdog	2	Common ling	1
Cuckoo ray	2		
Red gurnard	2		
Megrim	2		

The top ten species within Portuguese waters are snipefish (*Macroramphosus scolopax*), boarfish (*Capros aper*), blue whiting, horse mackerel, mackerel, axillary seabream (*Pagellus acarne*), hake, jack mackerel (*Trachurus picturatus*), chub mackerel (*Scomber japonicus*) and dogfish. These account for 75% of total biomass *(Table 5.9)*.

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. Species groups are shown in *Table 5.9*.

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 300 m. 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 – 150 m. A new cohort is present in these areas as early as the 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 800 m 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 – 80 m), 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 500 m. Fish length increases with depth and larger individuals (> 25 cm) concentrate at 500 – 750 m. At 200 to 400 m, their distribution enters the oceanic zone in which they exhibit diurnal vertical migrations. Blue whiting are the main prey for large predators.

5.2.6 Birds

The Iberian Peninsula is at a strategic geographical position regarding the migratory behaviour of seabirds and, together with the high biological production of coastal areas in the Gulf of Cádiz and along the Galician coast, gives rise to large seabird populations. Seabirds are grouped in terms of pelagic species (e.g. yelkouan shearwater (*Puffinus yelkouan*), Leach's petrel (*Oceanodroma leucorhoa*), northern gannet (*Morus bassanus*) and razorbill (*Alca torda*)), coastal species (e.g. shag (*Phalacrocorax aristotelis*), terns (*Sterna* spp.) and common scoter (*Melanitta nigra*)) and gulls, with coastal or fishing ground distribution. For descriptive purposes, seabird populations are divided in terms of nesting and wintering populations.

The seabird community is dominated by the yellow-legged gull (*Larus cachinnans*), which until recently was considered the same species as the herring gull (*L. argentatus*), and which makes up 70% of the total

Table 5.9 Main demersal fish species in Region IV.

Eastern Bay of Biscay		Southern Bay of Biscay		Portugal		Gulf of Cadiz	
15 – 60 m	greater weaver	35 – 90 m	common sole	< 100 m	scad	15 – 30 m	meagre
	sandeel		greater weaver		black sea bream		*Umbrina canariensis*
	black sea bream		axillary sea bream		common two-banded sea bream		*Spicara flexuosa*
	sprat		Spanish sea bream		greater weaver		transparent goby
	whiting		red mullet		Spanish sea bream		*Halobatrachus didactylus*
	sand goby		tub gunard		striped mullet		thick-back sole
	bib		Atlantic John Dory		axillary sea bream		*Dentex* sp.
	thin-lip grey mullet		solenette		brown comber		*Pagrus* sp.
	red mullet				little scorpionfish		*Diplodus* sp.
	common sole	90 – 150 m	bib				*Pagellus* sp.
	bogue (*Boops boops*)		boarfish	100 – 200 m	snipefish		
			hake		large-scaled gurnard	30 – 100 m	brown comber
60 – 120 m	*Lesueriogobius friesii*		anglerfish		boarfish		little scorpionfish
	hake		megrim		chub mackerel		long-finned gurnard
	red bandfish		dragonet		hake		*Mullus* sp.
	scaldfish		dogfish		bib		*Leseurigobius sanzoi*
	wedge sole				scad		scaldfish
	Enchelyopopus cimbrius	150 – 250 m	four-spot megrim		dogfish		wedge sole
	Maurolicus muelleri		black-bellied angler		bogue (*Boops boops*)		*Citharus linguatula*
			blue whiting		Couch’s sea bream		
120 – 250 m	blue whiting		wedge sole			100 – 200 m	boarfish
	silver pout		silver pout	200 – 600 m	blue whiting		snipefish
	lesser silver smelt				blue-mouth		dogfish
	spotted dragonet	250 – 400 m	*Malacocephalus laevis*		four-spot megrim		
	dogfish		*Bathysolea profundicola*		greater forkbeard	200 – 500 m	silver pout
	megrim		ratfish		silver pout		blue whiting
	boarfish		black-mouthed dogfish		anglerfish		greater forkbeard
			greater forkbeard		black-mouthed dogfish		hake
250 – 600 m	black-mouthed dogfish		*Antonogadus macrophthalmus*		black-bellied angler		*Antonogadus megalokinodon*
	greater forkbeard				velvet belly		black-spot grenadier
	ratfish	400 – 600 m	*Notacanthus bonapartei*		hake		*Malacocephalus laevis*
	four-spot megrim		*Deania calceus*		*Benthodesmus elongatus*		
	greater silver smelt		velvet belly		European conger	500 – 700 m	ratfish
	Malacocephalus laevis		*Trachyrhynchus trachyrhynchus*		scabbardfish		*Deania calceus*
	Notoscopelus kroeyerii		*Lepidion eques*		*Nezumia sclerorhynchus*		gulper shark
					dogfish		velvet belly
							black-mouthed dogfish

number of seabirds. 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 Galicia, the population has grown fivefold since the end of the 1970s, and the 46 000 nesting pairs account for up to 94% of total seabird numbers and 90% of biomass in the area. In the Cantabrian Sea and the Gulf of Cádiz there are estimated to be 10 000 and 1800 breeding pairs respectively. The very similar lesser black-backed gull (*L. fuscus*) established itself in the 1970s and there are now some 300 pairs in Sisargas, with many more in Cíes and parts of Vizcaya and Guipúzcoa.

Other nesting seabirds of importance are the shag (2200 pairs), European storm-petrel (*Hydrobates pelagicus*, 1300 pairs), kittiwake (*Rissa tridactyla*, 185 pairs) and guillemot (*Uria aalge*, < 15 pairs). The kittiwake and the guillemot both reach the southernmost points of their distribution on the northern Iberian Peninsula. Up to 3000 pairs of little tern (*Sterna albifrons*) were counted in the coastal area of the Odiel marshes in 1993 and more than 200 in the Gulf of Cádiz.

The nesting seabird community is very poor in comparison with other European Atlantic areas, both in terms of numbers and biomass. Nevertheless, it improves appreciably during migrations and in winter. Of particular importance is the autumn passage, visible from coastal points such as the Cape Estaca de Bares and Cape Peñas, where large numbers of common scoter, Cory's shearwater (*Calonectris diomedea*), sooty shearwater (*Puffinus griseus*), Balearic shearwater (*Puffinus mauretanicus*), northern gannet and different species of skua (*Catharacta skua* and *Stercorarius* spp.) and tern (*Sterna* spp.) are seen. Among the wintering populations the great cormorant (*Phalacrocorax carbo*) reaches significant numbers (2500 individuals in the Rías Bajas). Also important is the black-headed gull (*Larus ridibundus*), common gull (*L. canus*), Mediterranean gull (*L. melanocephalus*), great black-backed gull (*L. marinus*), razorbill, guillemot and Atlantic puffin (*Fratercula artica*).

In the Gulf of Cádiz the greatest number of species and individuals occurs during winter and in migratory periods. The wintering population of razorbill has been estimated at 4000 individuals for the coasts of Cádiz and Huelva, although it may actually be twice as high. In Atlantic waters, Leach's petrel is an abundant wintering species (as shown by the large number of dead specimens which occur along the coast following storms), other abundant species during migrations and winter are gannet and yelkouan shearwater. Some species of seaduck and tern are also abundant in the Gulf of Cádiz during winter.

5.2.7 Marine mammals

Information on the presence of marine mammals is based on past whaling activities, strandings on coasts and systematic and opportunistic sightings. A large variety of species, both boreal and temperate, have been reported in the Bay of Biscay and Iberian Atlantic waters, including seven species of mysticeti, twenty-three species of odontoceti and seven species of pinnipeds. The main habitats and status of these species is summarised in *Table 5.10*. Detailed information on distribution and migratory patterns is restricted to the most common species.

Cetaceans

Of the baleen whales, which are all migratory, only fin whales (*Balaenoptera physalus*) are common within Region IV. The northern right whale (*Eubalaena glacialis*) was a common species along the northern and western Spanish coast during the Middle Ages, supporting a seasonal coastal fishery for more than 500 years, but over the last 30 years has only been reported on very exceptional occasions.

Sperm whales (*Physeter macrocephalus*) are a common feature of the cetacean fauna of Region IV. They tend to aggregate in summer over the continental slope, feeding on cephalopods. The common dolphin (*Delphinus delphis*) is the species most frequently observed at sea *(Figure 5.9)* and also represents about 50% of all strandings in the area. Groups of bottle-nose dolphins (*Tursiops truncatus*) are resident in several inshore bays from Brittany to Portugal. Harbour porpoise (*Phocoena phocoena*) was considered one of the most common species in the area, but sightings and strandings are now common only in certain areas, for example the western Galician and northern Portuguese coasts.

Concerns regarding the conservation of cetacean populations in Region IV are similar to those expressed for other regions, and relate to issues such as the alteration of ecosystem structure and the impact of fisheries.

Figure 5.9 **The common dolphin is the most abundant cetacean within Region IV.**

Table 5.10 Status of marine mammal species in the Bay of Biscay and Atlantic Iberian waters.

	Habitat	Status*
Mysticeti		
minke whale	pelagic, continental shelf	rare, frequent
sei whale	pelagic	exceptional
fin whale	pelagic	frequent
blue whale	pelagic	exceptional
Bryde's whale	pelagic	exceptional
humpback whale	pelagic	rare
northern right whale	pelagic	exceptional
Odontoceti		
rough-toothed dolphin	pelagic	exceptional
bottlenose dolphin	coastal, continental shelf	frequent
striped dolphin	pelagic	frequent
Atlantic spotted dolphin	pelagic	rare
common dolphin	pelagic, continental shelf	frequent
white-beaked dolphin	continental shelf	exceptional
Atlantic white-sided dolphin	continental shelf	exceptional
Risso's dolphin	pelagic, continental shelf	frequent
false killer whale	pelagic	exceptional
long-finned pilot whale	pelagic, continental shelf	frequent
short-finned pilot whale	pelagic, continental shelf	exceptional
killer whale	pelagic	rare
harbour porpoise	coastal	rare, frequent
white whale (beluga)	continental shelf	exceptional
sperm whale	pelagic	frequent
pygmy sperm whale	pelagic	exceptional
dwarf sperm whale	pelagic	exceptional
Cuvier's beaked whale	pelagic	rare
northern bottlenose whale	pelagic	exceptional
True's beaked whale	pelagic	exceptional
Gervais' beaked whale	pelagic	exceptional
Sowerby's beaked whale	pelagic	exceptional
Blainville's beaked whale	pelagic	exceptional
Pinnipeda		
walrus	coastal	exceptional
harbour seal	coastal	exceptional
ringed seal	coastal	exceptional
harp seal	coastal	exceptional
grey seal	coastal	rare
bearded seal	coastal	exceptional
hooded seal	coastal	exceptional

* 'frequent' implies a species considered to be abundant or frequently sighted within the area; 'rare' implies a species within its main area of distribution but which is not abundant; 'exceptional' implies a species that has been observed in the area but which is outside its distribution range or is within its supposed range of distribution but which is extremely scarce.

Pinnipeds

Pinnipeds cannot be considered part of the fauna of Region IV, although specimens appear regularly in the Bay of Biscay and on the Atlantic Iberian coast. The species most commonly seen are the grey seal (*Halichoerus grypus*) and the harbour seal (*Phoca vitulina*) *(Table 5.10)*. The presence of the grey seal is related to the dispersion of young individuals from breeding colonies on the British Isles.

5.2.8 Turtles

Sea turtles are mostly tropical or subtropical, although some species undertake long migrations using the Gulf

Stream. A few vagrants therefore arrive in Region IV each year. The majority are leatherback turtles (*Dermochelys coriacea*) and loggerhead turtles (*Caretta caretta*), but green sea turtles (*Chelonia mydas*), hawksbill sea turtles (*Eretmochelys imbricata*) and Kemp's ridley turtles (*Lepidochelys kempii*) are also seen.

5.2.9 Ecosystem functioning

Region IV corresponds to a temperate sea whose dynamics are governed by climate and tides. As is the case for the entire North-east Atlantic, Region IV undergoes a seasonal climatic rhythm resulting from changes in sunlight, heat input and mechanical forcing on the water surface due to wind. These produce a regular pattern in hydrographic conditions throughout the year characterised by winter mixing and summer stratification, with phytoplankton blooms occurring during the transition periods. The spring bloom, generally March to early April, occurs when sunlight exposure is intense and long enough for net photosynthesis. This seasonal pattern has a significant effect on the dynamics of the pelagic ecosystem.

Temporal variability is manifest at the seasonal, inter-annual and decadal scale. Spatial variability reflects vertical and horizontal water movements, which are particularly diverse in Region IV and include coastal run-off and river plumes, internal waves and tidal fronts, coastal upwelling, shelf break currents, cyclonic and anticyclonic gyres, jet filaments, fronts and large scale low frequency oscillations. Most of these are mesoscale processes, which are typically the most energetic. They represent major perturbations of the system and have a dramatic impact on ecosystem productivity and the transport and fluxes of biological material.

There are no regional budgets for matter or energy, or any trophic models for the ecosystems of the area as a whole. However, a preliminary comparison between the Galician shelf, which is subject to strong upwelling, and the Cantabrian Sea, where upwelling on the shelf is of lesser significance, indicates higher phytoplankton biomass on the Galician shelf compared to the Cantabrian Sea, attributed to export from the rías, while primary production levels are the same in both areas.

The average value of annual primary production for the Galician shelf is 410 g C/m^2/yr, while that of the Cantabrian Sea is 428 g C/m^2/yr. Annual carbon budgets computed from the values in ***Table 5.11*** and export production rates indicate that a large fraction of primary production in Galicia is exported to the bottom as particulate organic matter ***(Figure 5.10)***. Total primary production values were increased by 30% to account for the production of dissolved organic matter by phytoplankton. The contribution of zooplankton to export is relatively small in both areas, although its relative importance is higher in the Cantabrian Sea. About 65% of primary production is available for export in Galicia, while in the Cantabrian Sea export is only 17% of production.

The pelagic ecosystem in the Cantabrian Sea is more dependent on recycled nutrients than that on the Galician shelf. This mostly occurs within the water column, as indicated by the higher availability of primary production to bacteria, and supports the results from studies on oxygen consumption. The large amount of export production on the Galician shelf is important to the benthic ecosystems and the demersal fish. The proportion of primary production available to pelagic fish is similar in both areas, at 3% in the Cantabrian Sea and 4% on the Galician shelf.

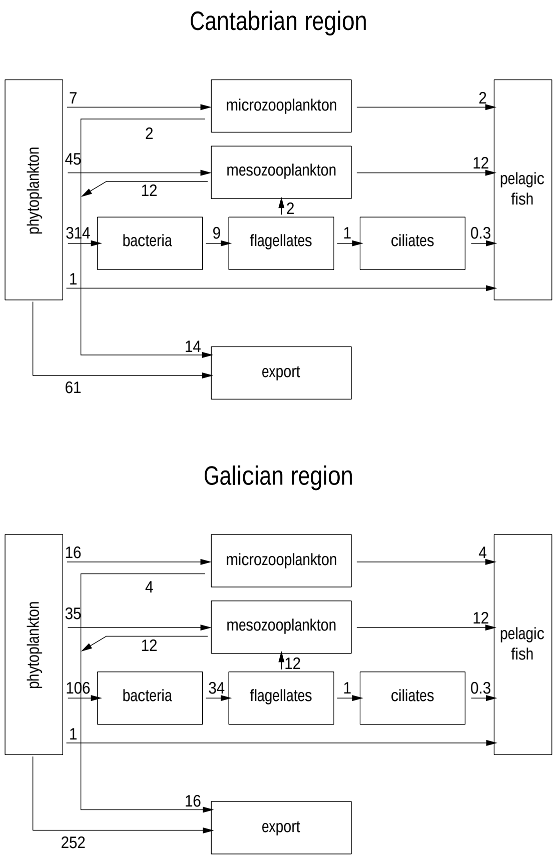
Trophic studies on the role of invertebrate megabenthos in the diet of demersal fish indicate that decapod crustaceans are the main food items for the juveniles. Molluscs and echinoderms are accidental prey items or are selected by specialist predators. Benthic fish are more selective than demersal fish in terms of their prey items. Demersal fish have a more general diet. When the predator populations reach a certain size, the benthic fauna are not sufficient to satisfy their food requirements and the diet must be supplemented by catching nektonic organisms.

Table 5.11 Mean biomass (mg C/m^2) and daily production rates (mg C/m^2/d) for the main compartments of the Cantabrian and Galician pelagic shelf ecosystems.

	Cantabrian shelf		Galician shelf	
	biomass	production	biomass	production
Phytoplankton	1638*	903*	2714*†	863*†
Bacteria	753‡	631‡	652†§	701⊥
Heterotrophic flagellates	3¶	9⊥	11§	33⊥
Ciliates	2¶	0.7⊥	2§	0.7⊥
Microzooplankton	53¶	5⊥	105**	11⊥
Mesozooplankton	315¶	32⊥	319**	32⊥

* averaged from data in Bode *et al*. (1996); † averaged from data in Tenore *et al*. (1995); ‡ data from Barquero et al. (1998); § based on unpublished data; ⊥ computed using formulae in Bode and Varela (1994); ¶ averaged from data in Bode (1995); ** averaged from data in Valdés *et al*. (1991).

Figure 5.10 **Carbon fluxes (g C/m²/yr) from the phytoplankton to the pelagic fishes in the Cantabrian and Galician regions of the Bay of Biscay.**



5.2.10 Key habitats

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.

Coastal plain estuaries

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 7 m in many places. In the lower estuary the period of active growth by the phytoplankton may be more prolonged than in adjacent coastal waters due to the supply of riverine nutrients. The main habitat types, in addition to the pelagic system, are marshes and intertidal and subtidal mudflats and sandflats. Many of the marshes on the northern estuaries, such as those of Santoña and Urdaibai, are important wintering areas for birds. Several of these estuaries have been severely threatened by pollution, dredging and land reclamation. Aquaculture sites are located in some, mainly producing shellfish and turbot.

Rías

Rías, located on the north-western Iberian Peninsula, formed in river valleys affected by both tectonic land subsidence and a rise in sea level. 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. Intertidal and subtidal fauna, which are largely dependent on planktonic productivity, play a major role in the productivity of rías. In addition to turbot, aquaculture within Galician rías produces significant quantities of shellfish, mainly mussels, oysters and several species of clam.

Bar-built estuaries

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.

5.2.11 Key species

The accurate selection of key species for a given area depends on a good understanding of the ecosystem. There are two main sources of environmental change:

effects derived from global warming and effects due to fishing activities. On this basis, a pelagic invertebrate and several demersal vertebrates are proposed as key species for Region IV.

Over the last fifteen years the pelagic copepod *Temora stylifera* has shown a clear increase in spatial coverage, abundance and persistence in Region IV. This species is subtropical, highly abundant in southern waters and because of its strong relationship with surface water temperature and its accurate identification, it is proposed as a key species for monitoring oceanographic change within the Bay of Biscay.

The warming trend indicated by *Temora stylifera* is also likely to be responsible for the appearance of tropical fish species throughout Region IV; temperatures were observed to increase by about 2 °C from 1972 to 1992 in the northward slope current and by 1.4 °C from 1972 to 1993 in surface waters on the southern Bay of Biscay shelf. The first recorded observations of tropical fish in Region IV were along southern Portugal in 1963 and in the Bay of Biscay in 1968 for *Cynopsis roseus*, in 1970 for American John Dory (*Zenopsis conchifer*) and in 1980 for *Sphoeroides pachygaster* ***(Figure 5.11)***.

As with the common European skate (*Raja batis*), which is negatively affected by fishing activities in the North Sea and Irish Sea, the thornback ray (*Raja clavata*) has decreased since 1995 along the north and northwestern coasts of Spain ***(Figure 5.12)***.

Dogfish may be a good indicator species for monitoring change in exploited systems, as its natural diet is modified by discards from fishing activities. It also shows a high survival rate (of up to 90%) when discarded. Both factors are responsible for its increasing abundance since 1995 ***(Figure 5.12)***.

5.3 Impact of non-indigenous species and harmful algal blooms

5.3.1 Non-indigenous species

The introduction of non-indigenous species carries the risk of introducing pests and disease. Non-indigenous species may arrive as a result of both natural processes (e.g. ocean currents) and anthropogenic activities (e.g. ballast water or the transport of fish and shellfish). The most significant ecological effects of non-indigenous species are pathogenic effects and competition with indigenous and/or commercially important species for food, space or light. By 1996, around a hundred non-indigenous species of great taxonomic diversity (phytoplankton, macroalgae and benthos) had been recorded in the OSPAR Maritime area.

There are at least twelve non-indigenous macroalgae in Region IV, several of which may have deleterious environmental effects. For example Japanese seaweed, which

Figure 5.11 **Distribution of *Zenopsis conchifer* and *Cynopsis roseus* catches along the Atlantic coast. Source: after Quéro *et al*. (1998).**

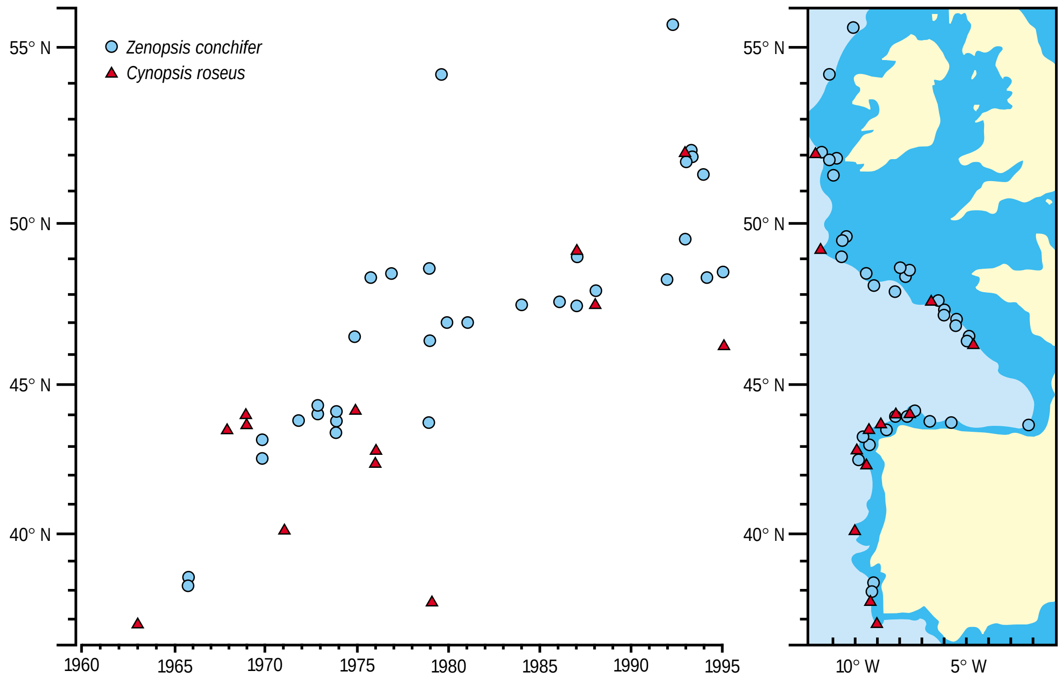
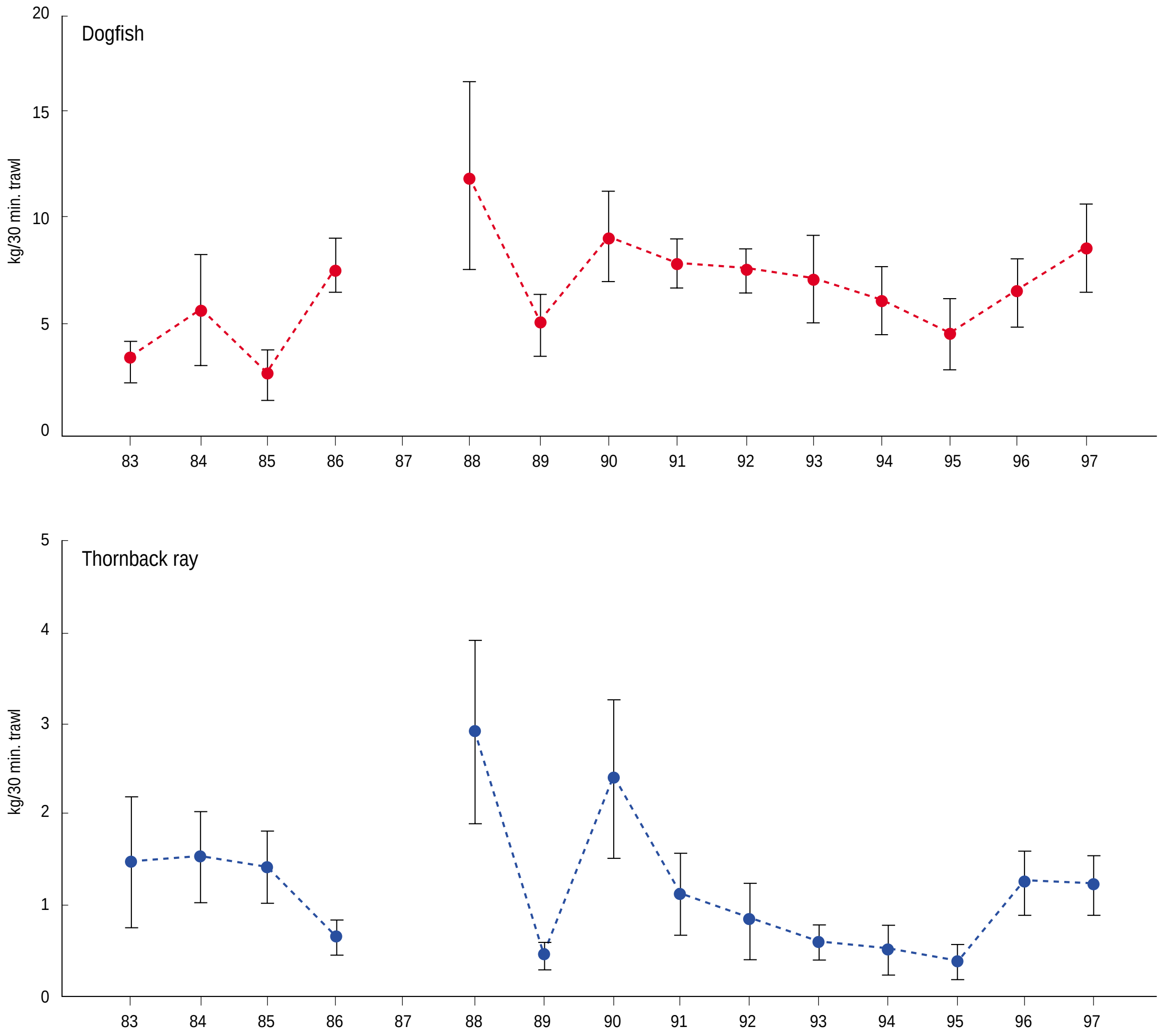


Figure 5.12 **Variations in the biomass of dogfish and thornback ray in the Cantabrian Sea, 1983–97. Source: after Sánchez (1993).**



was imported via shipments of the Japanese oyster to France in 1969 *(Figure 5.13)*, often clogs bays and harbours and competes with other seaweeds for space. Another example is *Undaria pinnatifida* which was introduced to Europe in 1983, subsequently escaping from farms and spreading throughout the environment.

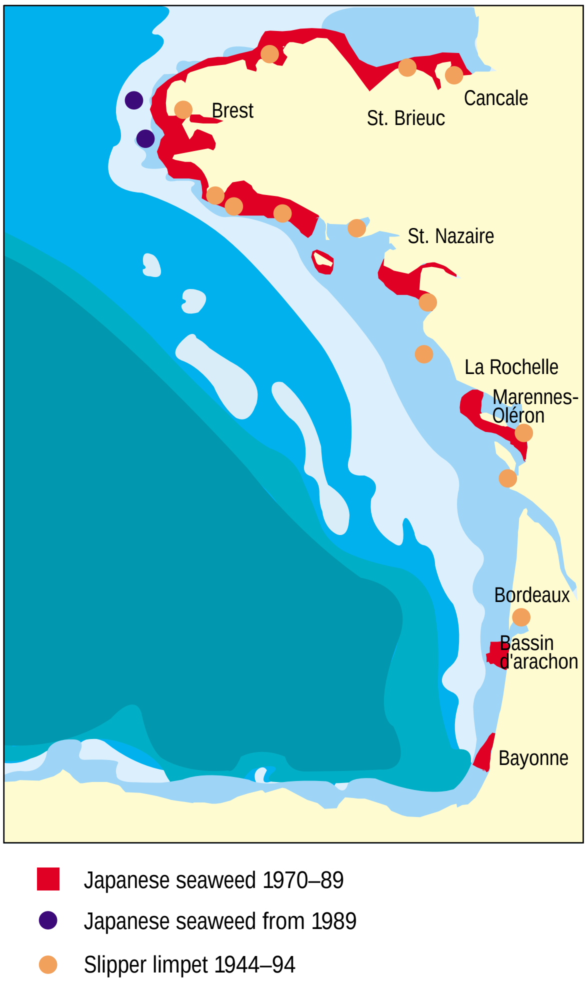
In terms of the macrofauna, the crab *Hemigrapsus penicillatus* found at La Rochelle in 1995 is a recent example of an accidental introduction. It arrived from the Far East due to fouling and has now spread over 700 km of coastline from the Vendée to the Basque Country. The slipper limpet (*Crepidula fornicata*) is thought to have negative impacts on scallop and other shellfish culture *(Figure 5.13)*, while the barnacle *Elminius modestus*, which was introduced from Australia, may compete for space with the indigenous barnacles *Balanus* and *Cthamalus*. Large populations of Japanese oyster compete with other filter-feeding molluscs.

5.3.2 Harmful algal blooms

Some phytoplankton species produce toxins that can be harmful to both human and marine life. Their presence in high concentrations in sea water is therefore a cause for concern. Some toxic algae affect fish directly, while others produce potent neurotoxins that accumulate in filter-feeding shellfish. The consumption of such shellfish may result in fatal poisoning.

Region IV is subject to recurrent shellfish toxicity outbreaks. These are due to Amnesic Shellfish Poisoning (ASP), caused by domoic acid, Diarrhetic Shellfish Poisoning (DSP), caused by okadaic acid and its derivatives, and Paralytic Shellfish Poisoning (PSP), caused by saxitoxin-related toxins. Although there appears to have been an increase in harmful algal blooms over recent decades this is not supported by scientific studies and may just reflect the increased use of coastal waters, together with a greater public awareness of the problem and more comprehensive monitoring activities. Also,

Figure 5.13 **Distribution of the Japanese seaweed and the slipper limpet on the French Atlantic coast.**



greater economic use of coastal resources has focused interest on ecological matters, which had previously received little attention except during particularly acute toxic/noxious events.

Some toxic phytoplankton species have been introduced to Region IV via cysts in ships' ballast water, these include *Gymnodinium catenatum*, *G. chrorophorum* and *Alexandrium minutum*, which often cause PSP, and *Pseudo-nitzschia australis* which is associated with ASP.

5.4 Impact of microbiological contaminants

Sewage discharges are responsible for pathogenic bacterial and viral inputs to the sea. They pose significant human health threats via the ingestion of contaminated shellfish or exposure to contaminated water. Community Directives for bathing water quality (76/161/EEC) and for the production and marketing of live shellfish (91/492/EEC) state permissible levels of bacteria in water and shellfish.

Table 5.12 Classification of shellfish production areas in 1997 with respect to Community Directive 91/492/EEC.

	Category (%)		
	A	B	C+D
France	43.7	44.4	11.9
Spain	19.3	63.9	16.8
Portugal	25		75*

A can be sold immediately; B requires purification in an approved plant for at least 48 hours; C requires treatment in clean water for an extended period of time; D the area is forbidden for shellfish farming. * categories B+C+D.

5.4.1 Bathing water quality

The microbiological quality of bathing water has been monitored for many years in France, Spain and Portugal. In 1997 the vast majority of bathing water in Region IV was of good or fair quality; 95% in France and Spain and 87% in Portugal.

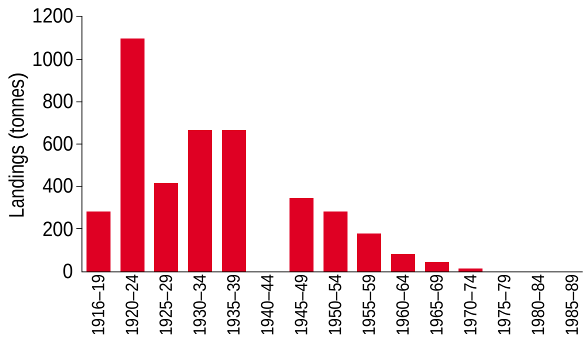
5.4.2 Shellfish quality

There are three categories of shellfish marketed for human consumption. These are based on the *Escherichia coli* and faecal coliform content; those that can be sold immediately (Category A), those that must first undergo purification in an approved plant for at least 48 hours (Category B) and those requiring treatment in clean water for an extended period of time (Category C). *Table 5.12* shows the percentage distribution for the three categories in 1997.

5.5 Impact of fisheries

Region IV includes ICES Fishing Areas VIII and IX and has traditionally been an area of intensive fishing activity, particularly with the expansion of engine-powered vessels

Figure 5.14 **Average landings of skates and rays for five-year periods at Arcachon, 1916–89. Source: after Quéro and Cendrero (1996).**



and trawling over recent decades. The region has a wider variety of fish and shellfish species of commercial interest than more northern areas and given the wider range in size and behaviour of these species, a large array of towed or fixed fishing gear must be used (see Section 3.5). Few of the fisheries target single species. Most are mixed fisheries catching several species simultaneously during each fishing operation. This creates difficulties for the management of the fisheries.

Data required for fisheries assessments on a regional scale are often sparse or deficient. Although acceptable data are available for some stocks of commercial importance internationally, they are often lacking for small-scale inshore fisheries. The effects of fishing are usually classified as direct (or short-term) and indirect (or long-term). The direct effects include the mortality of target and by-catch species of fish, shellfish, birds and marine mammals, the dumping of discards or offal, physical changes to the seabed by fishing gear, ghost fishing by lost gear and litter dumped from fishing vessels. The indirect effects include trophic changes in predator-prey relationships and energy flows, habitat alterations and genetic changes (e.g. decreased diversity).

Region IV is also an important nursery ground for hake, sardine, horse mackerel and blue whiting and therefore catches by fleets operating with gear of low selectivity often contain significant quantities of juveniles. Discards are thus a big problem as undersized fish must be returned. Quantification of discards is very difficult.

Large pelagic species such as tuna or swordfish (*Xiphias gladius*) have a very wide distribution, which includes Region IV. In the case of bluefin tuna and albacore, Region IV is a feeding area for juveniles in summer, and a traditional fishery using bait-boat and troll has developed. In 1987 pelagic trawl and drift nets began to fish this component of the stock. The swordfish fishery occurs partly in the Iberian region and is conducted with long lines.

5.5.1 Mortality in fish populations

Fisheries cause mortality. Their main effect is therefore to reduce the abundance and alter the productivity of the resources targetted. Fishing also reduces average age and length in stocks, since higher mortality means a lower probability of any individual reaching old age. This shift can be monitored by surveys at sea or by sampling catches and is a good reflection of fishing pressure. Depending on gear and fishing location, some fisheries tend to target the juvenile component of the stocks, as in the hake fishery where 75% of the catch are juveniles. When excessive, catches of immature fish may deplete the spawning stock to a point at which the sustainability of the resource is threatened. This is particularly the case for species with late maturity or low fecundity. For example, several low fecundity elasmobranches which were previously common are now virtually extinct in the southern Bay of Biscay ***(Figure 5.14)***.

Several stocks in Region IV are considered to be outside safe biological limits, meaning they have a dangerously low spawning stock biomass and are probably being exploited at an unsustainable fishing mortality rate. This is the case for hake, megrims, anglerfish, sardine and swordfish in the Iberian area, and hake in the northern part of Region IV has begun to show the same trend. Other species, such as anglerfish and megrim in the northern part, and anchovy, horse mackerel, mackerel, Norway lobster and albacore are considered to be within safe biological limits.

As shown in Section 3.5, the number of trawlers in Portugal and Spain has decreased since the early 1980s, resulting in a fall in overall fishing effort. The number of fleets operating gillnets and long lines has also declined in recent years. However, this decrease in overall fishing effort has not been reflected in fishing mortality, since this fluctuates with no apparent trend in most demersal stocks in the Iberian region ***(Table 5.13)***.

Table 5.13 Fishing mortality in 1985–7 and 1995–7.

Stock	Mean (1985–7)	Mean (1995–7)
Hake*	0.22	0.27
Anglerfish*	0.20	0.22
Megrim*	0.21	0.32
Hake†	0.45	0.37
Megrim†	0.32	0.33
Anglerfish†	ni	ni
Horse mackerel†	0.21	0.18
Sardine	0.37	0.51
Anchovy	0.57	0.81

* northern; † southern; ni no information.

5.5.2 Discards

There are other aspects of fishing mortality which are much more difficult to assess, such as death or injury due to contact with the gear or escape through the mesh, ghost fishing by lost gear (such as gillnets) and discards.

Effects of discarding on fish stocks can be assessed using models, but are much less clear for the other components of the ecosystem. Discards may enhance the provision of food for birds, demersal fish or benthic scavengers such as crustaceans and starfish. This may alter the structure of benthic communities in favour of the benthic scavengers or, in localised areas, may result in anoxia. Discards are estimated through specially designed sampling programmes.

Within ICES Divisions VIIIc and IXa, bottom trawls generate the highest levels of discards, due to the mixed species fishery and the low selectivity of the gear. Most

Table 5.14 Spanish discard data according to gear type. Source: based on Pérez *et al*. (1996).

	Year	ICES Divisions	Quarters 1	2	3	4	Mean (%)
Trawl	1994	VIIIab	36.6	40.2	55.5	56.5	48.9
		VIIIc	40.5	32.7	30.1	34.9	34.7
		IXa	28.7	67.3	73.8	54.9	59.2
		TOTAL	35.3	46.7	53.1	48.8	47.6
Long line	1994	VIIIab	2.4	21.1	0.1	12.7	12.5
		VIIIc	36.7	10.3	4.5	16.3	18.7
		TOTAL	19.6	15.7	2.3	14.5	15.6
Gillnet	1994	VIIIc	11.0	9.3	47.9	39.3	25.3
Purse seine	1994	VIIIbc east	2.8	24.0	32.5	ni	26.7
	1995		10.6	6.2	ni	ni	7.6
	1994	VIIIc west	2.0	1.4	6.3	10.1	6.4
		IXa north	0.0	0.2	0.8	2.1	0.9
		TOTAL	3.9	8.0	13.2	6.1	10.4

ni no information.

species caught in this fishery are discarded to some extent, in some cases due to their low or zero commercial value, in others because the fish are undersized or damaged (*Tables 5.14* and *5.15*). Pelagic trawl fisheries are mainly conducted by the French fleet. Although the target species (anchovy, sardine and tuna) usually comprise a high proportion of the catch, discard rates are consistently high (up to 100%) for horse mackerel.

Gillnets result in the highest proportion of damaged specimens or fish partly eaten by small crustaceans. This is because the fish may remain entangled in the nets for long periods, particularly in bad weather when the nets are left in the water. Bottom long line fisheries directed at demersal species and purse seine fisheries directed at small pelagic species have low discard rates *(Table 5.14)*.

The main fish species discarded in Region IV are the small fish silvery pout, with the medium-sized blue whiting second in importance, representing 33% of the total weight caught and 22% of the total discarded. Both species are dead when discarded. Lesser-spotted dogfish (which comprises 3.6% of total catch) is not a commercial species and so is almost totally discarded when caught. This species has a high survival rate.

Table 5.15 Portuguese discard data according to gear type. Source: Borges *et al*. (1998).

	Mean (%)	Range (%)
Crustacean trawl	83	36 – 91
Fish trawl	79	59 – 91
Pelagic purse seine	60	1 – 94
Demersal purse seine	35	1 – 86
Bottom trammel	9	2 – 92

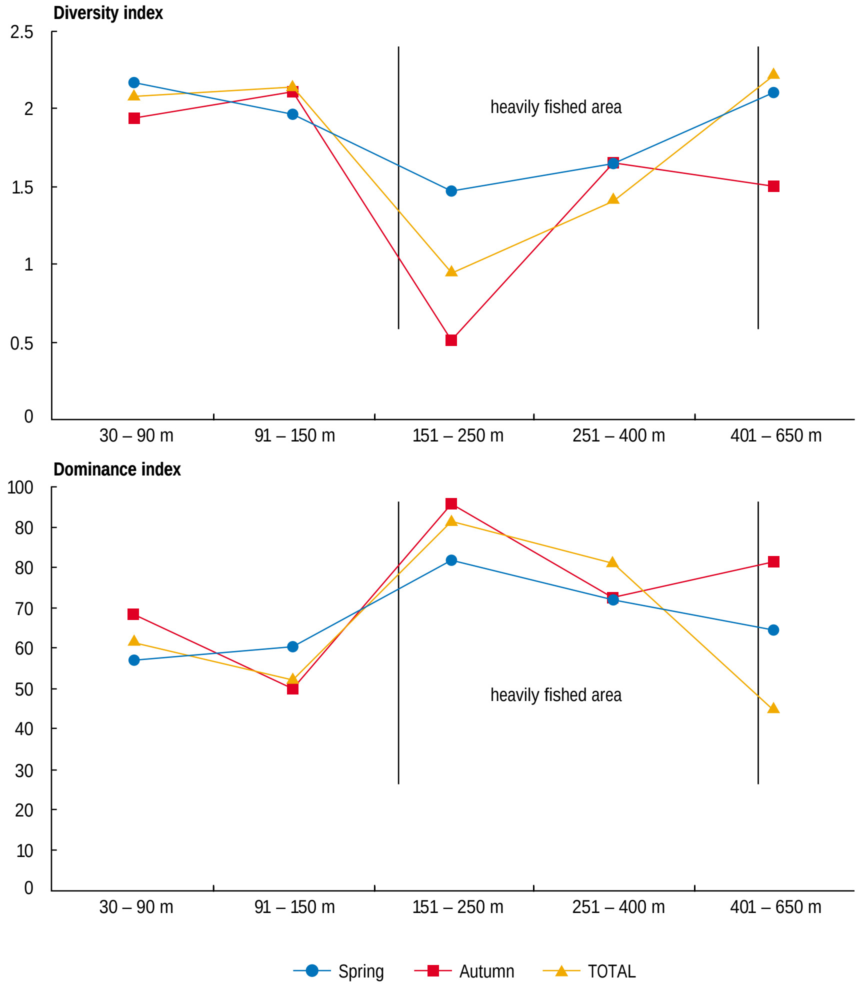
5.5.3 Effects on ecosystem diversity

The diversity of fish communities decreases in heavily fished areas *(Figure 5.15)*. In communities with a high dominance index, the dominant species are small gregarious species with high growth rates (such as blue whiting and silvery pout). Such species are the main food source for predatory demersal fish (such as hake and monkfish) which constitute the target species of the fishery. This could be interpreted as fishing intensity causing a reduction in diversity through the elimination of specialist species with low birth rates, thus altering the balance between predators and prey.

5.5.4 Effects on benthic communities

The impact on the benthic community is essentially due to the physical disturbance by fishing gear. All gear types are likely to damage the epifauna. Towed gear types can displace sediment and boulders and, depending on their weight and on the nature of the seabed, the extent to which they affect the infauna varies. Other types of trawl are also used extensively, the doors of which trench into soft bottoms. Their cumulative effects can be important. However, there have been few field studies on quantifying these effects due to their cost and difficulty.

Figure 5.15 **Diversity and dominance indices for fish communities in the Cantabrian Sea. Source: after Sánchez (1993).**



5.5.5 Effects on birds

Seabirds may benefit from fishing activities, particularly scavenging species which feed on discards. However, diving species may drown after becoming entangled in nets, although this is not a particularly significant problem in Region IV.

5.5.6 Effects on marine mammals

By-catches of cetaceans are a controversial issue concerning the gillnet fishery for albacore tuna in summer. In 1992 and 1993 (when most vessels were still allowed to fish with 5 km nets), an average by-catch of eight dolphins was estimated per 100 km of net and per day of fishing. By-catches in gillnets have been reported for several decades in the Bay of Biscay and off the Iberian coast. Cetaceans were observed as by-catches in the French tuna and sea bass pelagic trawl fisheries. Small numbers of cetaceans are known to be caught by trawlers, longlines and fish traps. The tuna fishery by-catch comprises bottle-nose and common dolphins, while the other fisheries report common dolphins only. A comparatively small by-catch of common dolphin has been reported for trawls (probably pelagic trawls) deployed in Region IV. Minke whales (*Balaenoptera acutorostrata*) occasionally become entangled in fishing trap leader-lines.

5.5.7 Feeding interactions

The most abundant species discarded in Region IV (silvery pout and blue whiting) play a significant role in the diet of fish and cetacean communities. The stomach contents of the 28 main demersal fish species showed that nineteen prey on blue whiting (eight being active predators and eleven opportunists), probably on dying, dead or decomposed individuals.

5.6 Impact of aquaculture

Aquaculture in Region IV is mainly restricted to the cultivation of oysters and mussels on moored rafts and long lines (see Section 3.6). These are usually located in semi-enclosed bays such as Arcachon, Marennes-Oléron, Bourgneuf, Vilaine and Morbihan, and rías 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 changed the sediment structure. In some areas the rate of sedimentation is up to several centimetres per year. These changes may cause alterations at the ecosystem level.

Importing non-indigenous species for cultivation (see Section 5.3.1) has introduced parasites and disease. Such parasites include: *Bonamia ostrea* and *Marteilia refrigens* in oysters, and *Perkinsus marinus, Minchinia (Haplosporidium) tapetis* and *Vitorio tapetis* in clams.

5.7 Impact of eutrophication

Eutrophication results from anthropogenically-induced increases in nutrient concentration. The effects of eutrophication include increased phytoplankton production and biomass, changes in species composition (including the occurrence of harmful algae), and increased oxygen consumption in the water and sediments. According to available nutrient data (see Section 4.8.1) there is no eutrophication in the open waters of the Bay of Biscay and the Iberian Peninsula. However, high concentrations of nutrients in some estuaries (e.g. the Ría of Huelva) and the growth and accumulation of macroalgae in very shallow waters along the southern coast of Brittany may be associated with eutrophication. Although oxygen concentrations have decreased in some areas, it is only in the Bay of Vilaine that deoxygenation of the bottom water occurs each summer following the phytoplankton blooms. In some estuaries of the Cantabrian Sea and in some Galician Rías low oxygen levels near the sediment are caused by organic matter inputs from land or mussel rafts (see Section 5.6).

5.8 Impact of tourism and recreation

Tourism and recreation in coastal areas during summer are important social and economic activities along the Atlantic coast of France and Portugal. The additional services and infrastructure 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.

5.9 Impact of sand and gravel extraction

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. 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.

5.10 Impact of dredging

Dredging occurs to enable new construction or is for the maintenance of existing channels. The material dredged is normally sand, silt or gravel. Dredged material associated with new construction only usually generates adverse effects as a result of physical and sedimentological changes. However, maintenance dredging often involves the removal of sediment that has been dumped in the relevant river, harbour, estuary or coastal region. To minimise the adverse effects of any associated contaminants, national authorities require a full description of the dredged material relative to the potential environmental impacts, and the disposal site selected must be appropriate to the composition of the material dredged. The dumping of dredged material may also affect the concentrations of suspended particulate matter and the nutrient dynamics at or near the dumpsites, particularly those in estuarine systems. The risks of contamination due to dredging are more limited in open areas than in navigation channels within estuaries. Within estuaries the tides result in the periodic resuspension/deposition of sediments, which in turn results in the metals and organic matter within the sediments being redissolved.

5.11 Impact of coastal protection and land reclamation

Coastal areas are prone to erosion. They are also the areas most likely to be affected by the consequences of climate change, particularly by rises in sea level. To protect the coast from erosion, various types of sea defences have been constructed, however to date these have been deployed regardless of any associated prediction of environmental impact (see Section 3.7). The construction of dams in rivers has also altered the hydrological pattern, resulting in a reduction in freshwater flow and sediment load, and an increase in coastal erosion. Such was the case in the Vilaine Estuary and Guadiana River in the Gulf of Cádiz (see Section 2.6.1). The potential effects of sea level rise must be addressed in future so as to ensure coastal protection for sustainable development.

5.12 Impact of offshore activities

There is no evidence that offshore activities in Region IV (see Section 3.11) have any deleterious impact on the marine environment.

5.13 Impact of shipping

Two major accidents to the north of Spain have generated public concern; the supertanker 'Monte Urkiola' was wrecked in 1976 spilling 30 000 t of oil in shallow waters (< 50 m) and the oil tanker 'Aegean Sea' was wrecked in 1992 covering the rías of A Coruña, Betanzos, Pontedeume and Ferrol with 80 000 t of oil. The effects of the Monte Urkiola oil spill were considerable, and the meiofauna on the beaches affected were totally eliminated. The abundance and diversity of the meiofauna took a year to recover *(Figure 5.16)*. The main consequences of the Aegean Sea oil spill on the benthic macrofauna were a temporary reduction in amphipods and echinoderms, and a dramatic increase in opportunist polychaetes (mainly *Pseudopolydora paucibranchiata* and *Capitella capitata*) which coincided with the period of higher hydrocarbon concentrations *(Figure 5.17)*. Cultivated mussels from 125 rafts were also affected and had to be removed. Field experiments showed that mussel growth was reduced by three to forty times, depending on the hydrocarbon concentration (i.e. high or medium) and the period of exposure (i.e. days, weeks or months). Decreases in ingestion, absorption and assimilation rates were observed, and these appear to have been a consequence of malfunctions at the cytological level in the digestive gland. Mussel cultivation resumed sixteen months after the oil spill.

Figure 5.16 **Nematode abundance on the Galician coast before (1976) and after (1977) the Monte Urkiola oil spill.**

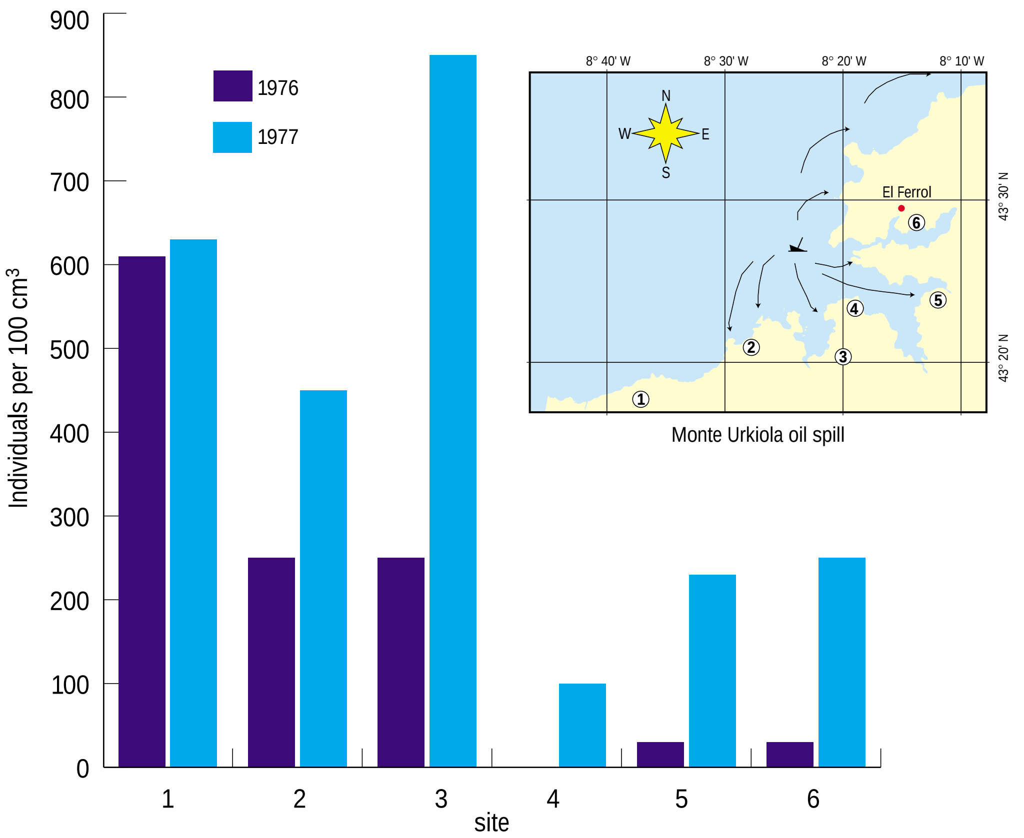
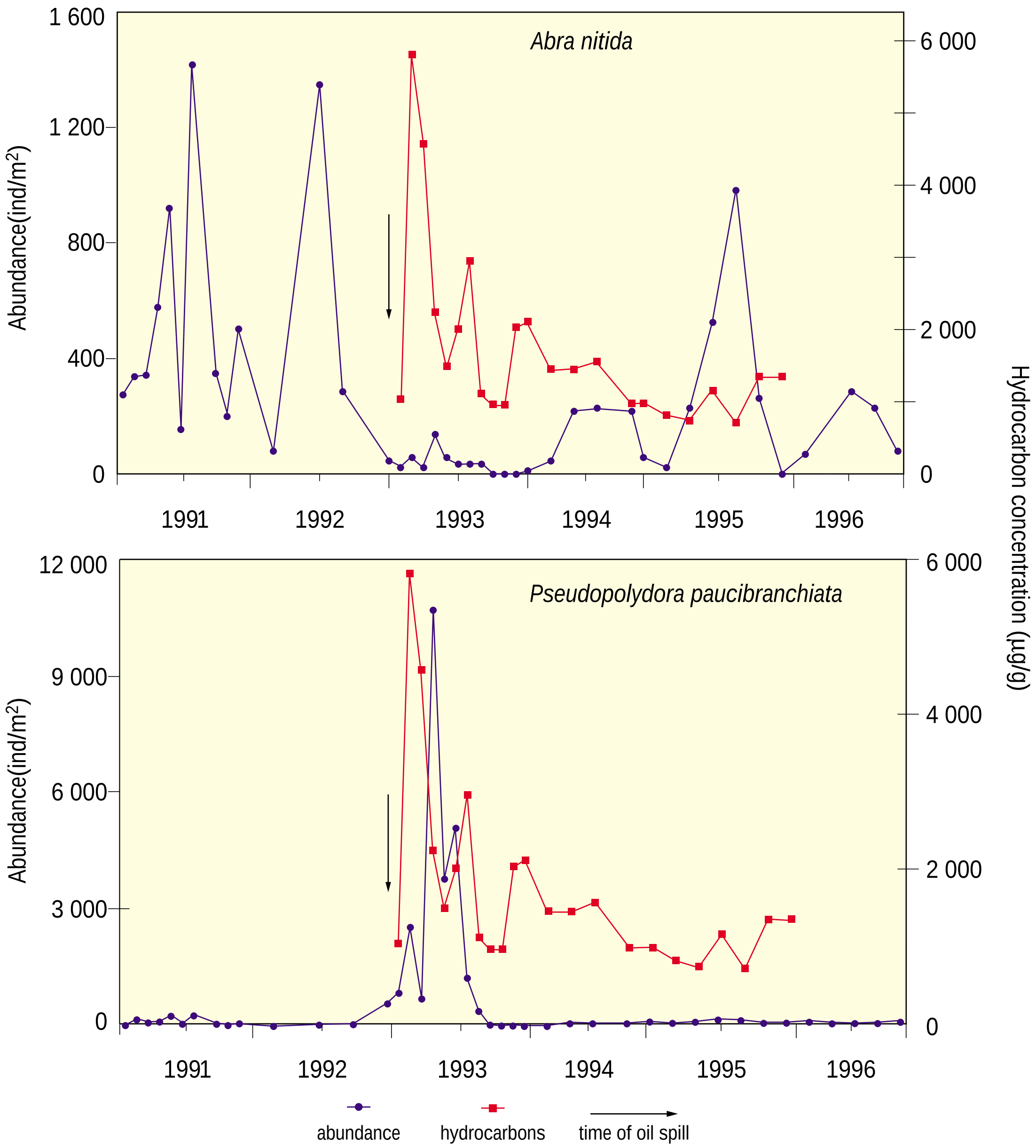


Figure 5.17 **Changes in the abundance of *Abra nitida* and colonisation of the substrate by the opportunistic polychaete *Pseudopolydora paucibranchiata* after the Aegean Sea oil spill. Source: after Parra and López-Jamar (1997).**



5.14 Impact of contaminants

The effects of contaminants at the ecosystem level are difficult to assess. Except for a few organic compounds there are no data on the direct cause/effect of individual compounds or elements in the Bay of Biscay or along the Iberian coast. Thus, BRCs and EACs (see Section 4.2) are used for assessment. Owing to the need for a standardisation of methodology, co-ordination and data interpretation, OSPAR established a Joint Assessment and Monitoring Programme for its entire maritime area.

However, data reported for the Bay of Biscay and the Iberian coast in association with the JAMP are too sparse to enable any meaningful assessment of Region IV. Thus, care should be taken when comparing levels from different areas directly, since the data provided for this report are from various national monitoring programmes or research studies carried out independently by France, Spain and Portugal and, with the exception of the JAMP data, have been used without reference to their quality assurance. With the exception of the baseline data on contaminants in sediments carried out by Spain in 1996, no other monitoring activities have been undertaken specifically for the present assessment.

5.14.1 Heavy metals

This report focuses on the small group of heavy metals included in the JAMP: mercury, cadmium, copper and lead. Data on their distribution and temporal trends are summarised in Section 4.3 and indicate that the concentrations in water, surface sediments and biota from the coastal areas are generally below those likely to be harmful to marine life. Nevertheless, for a number of metals the EACs are exceeded at sites close to densely populated and industrialised areas situated mainly in bays and estuaries.

5.14.2 Organic contaminants

The information available on organic contaminants is reviewed in Section 4.4. This includes information on PCBs, organochlorine pesticides and PAHs. Although limited the information shows low concentrations of organic contaminants in molluscs and sediments, with a few localised exceptions at sites close to highly populated and industrialised areas, mainly in bays and estuaries, where EACs are exceeded.

Various organic contaminants may induce production of the enzyme ethoxyresorufin-*O*-deethylase (EROD) in fish liver and the extent of activity can be used to measure the degree of exposure to a range of compounds, including PCBs and PAHs. EROD activity measured in dragonet (*Callionymus lyra*) and sole from coastal areas within the Bay of Biscay shows no indication of deleterious effects. However, studies in the Loire, Gironde and Vilaine estuaries indicate significant variations in EROD activity that could be caused by diffuse contamination.

The *Crassostrea gigas* embryo-larval bioassay, which was used to assess water quality in tributaries draining into an oyster farming area in Arcachon Bay, showed the percentage of normally developed larvae to vary considerably depending on the location of the sampling station. The tributaries on the southern shore of the bay (particularly the inner sites) showed enhanced toxicity, whereas only one polluted site occurred on the north-eastern shore.

Exposure to TBT (derived predominantly from antifouling paints) produces distinctive responses in various organisms, notably oysters and dogwhelks; female oysters develop male sexual characteristics, which in severe cases can lead to sterility and detrimental effects at the population level. Imposex was first observed in the Bay of Arcachon in 1975 when oyster production was significantly affected by a progressive decline in reproduction and juvenile recruitment, together with a general outbreak of shell calcification anomalies in adult oysters. Between 1975 and 1982, spatfall in the Bay of Arcachon was very low or even non-existent in certain sectors, while remaining normal outside the bay. Although TBT concentrations in the marine environment have decreased since their ban in antifouling paints in 1982, a survey in 1994 showed that concentrations in the water and sediments of sailing harbours are still high compared to concentrations in the rest of the bay.

A 1996 survey of TBT effects in dogwhelk from coastal areas off north-western Spain showed that the industrial bays and estuaries investigated had significant levels of imposex in dogwhelks. Female sterility was found in almost all the samples, although the population was not at risk of extinction. Significant levels of imposex in dogwhelk have also been reported in northern Portugal, but without female sterility.

5.15 Impact of marine litter

Marine litter has been observed at sea for many years. However, owing to the increased use of plastic packaging it is now considered a significant form of pollution. Nevertheless, its impact on vertebrate fauna has only been highlighted fairly recently. Marine litter is a worldwide problem.

Most data concern floating debris or litter washed up along the coast, particularly on beaches, where it is abundant. Marine litter comprises a range of material, including glass, plastics, metal, paper, bottles, clothing, foodstuffs, wood, rubber, packaging materials, remnants of trawl nets and other fishing gear. Plastics tend to represent around 85% of the debris owing to their poor degradability.

Plastics enter the marine environment via the recreational use of beaches, from ships, sewers, coastal run-off and from the atmosphere. Although freshly introduced plastics are buoyant, they can associate with other materials and sink to the bottom. They affect living organisms through ingestion or entanglement, and by their accumulation on the seabed where they provide a habitat for opportunistic species, thus altering the natural composition of benthic communities.

Regional information is scarce and restricted to a few areas of the Bay of Biscay. A large-scale survey of debris on the seabed of the northern section of the continental shelf *(Figure 3.8)* shows that densities vary throughout the year and are particularly high during late autumn and winter in an area offshore of the Gironde Estuary. Regional-scale studies indicate the presence of debris along the coasts of Spain and France. A particular problem exists for the French Basque Country which, owing to the general pattern of circulation, receives debris from Spain in winter and the Portugal current from late autumn to late winter. During summer the debris is from the northern part of the Bay of Biscay and from local rivers *(Figure 3.8)*.

In September 1996, around 70 000 t of debris from an urban rubbish dump fell into the sea near A Coruña. Most of the debris dissolved or sank to the bottom. Around 25 – 30% of that entering the sea was recovered. It was estimated that 5 – 10% of the debris remained at the sea surface; of which around 80% was plastics. There was no evidence of any effects on the marine fauna as a result of this accident.

The effects of litter on marine organisms, including entanglement, have been documented for the Bay of Biscay. Leatherback turtles arrive every year between June and October and autopsies on 53 from the French section between 1988 and 1998 showed that 58.4% had ingested plastic waste. Loggerhead turtles are also affected, although to a lesser extent; 27 autopsies indicated that plastic had been ingested by three individuals only.

The ingestion of large quantities of floating plastic by the mysticeti can also result in death, as demonstrated by the autopsy of a fin whale stranded on a Cantabrian beach in November 1997.

In odontoceti cetaceans the presence of plastic debris in the digestive tract is exceptional. No plastic debris was found in several hundred autopsies of Delphinidae, only once in a long-finned pilot whale (*Globicephala malaena*), and once in a pygmy sperm whale (*Kogia breviceps*). In both cases, the species feed on cephalopods and could have mistaken plastic bags for their prey.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