chapter 3

Human activities

3.1 Introduction

Region V is very different in character from the other OSPAR regions. It is predominantly deep-water and contains no extensive areas of shelf seas. Its only areas of land are the islands of the Azores Archipelago and the tiny rock outcrop on Rockall Bank. Hence it is remote from the influence of large riverine outflows and major discharges of contaminants from land-based sources. The region is currently used directly for shipping, cable routes, the extraction of hydrocarbons and fishing. Fishing is expanding into the deep water regions as fishing technologies improve, new stocks are discovered and as shallow water stocks are depleted or cease to be available to some fishermen because of quotas. There is also intensive fishing activity in the shallow waters surrounding the islands and seamounts of the Azores. Anthropogenic inputs have been much larger in the past. For example, during the Second World War numerous vessels were sunk in the region, and post-war large quantities of redundant munitions were dumped in deep water. The seabed is littered with large accumulations of clinker from the boilers of the old coal-fired vessels along the old shipping routes (Huggett and Kidd, 1983/4). Licensed disposal of industrial and radioactive waste continued until 1982. However, litter (including plastic, fishing floats, timber, polystyrene and tar balls) is still a common sight floating at the surface, particularly along convergent fronts. Industrial development is just beginning to impinge on the region with the beginning of the exploitation of hydrocarbon reserves along the continental slopes in the north-east. The only human population in the region is on the Azores.

Human impacts are generated within the region through the exploitation of resources, and from external sources via the inflows, i.e. ocean currents or the atmosphere. Similarly, some contaminants are exported from the region in the outflows. An example of an external impact that has just been identified is the reduction in the freshwater inputs into the Eastern Mediterranean from the construction of the Aswan Dam in Egypt, which has caused changes in the physical oceanography of the basin. These changes are currently being transmitted through the Strait of Sicily into the Western Mediterranean and are expected to change the characteristics of the Mediterranean outflow waters, and hence may perturb the thermohaline circulation of the North-east Atlantic (de Lange *et al*., 1999).

3.1.1 Boundaries

Much of Region V lies outside national Exclusive Economic Zones (EEZs) and so represents 'Global Commons'. The exceptions are the substantial area (938 000 km^2) of the territorial seas and EEZ surrounding the Azores, designated as sub-area 3 of the Portuguese EEZ, and in the north-east where the outer fringes of the EEZs of France, Ireland, the UK and the Faroe Islands just impinge on the region. Region V also skirts the Icelandic EEZ in the north and the EEZ of Greenland in the north-west. There is a lack of formal agreement over the precise alignment of some of these boundaries, although several issues were resolved when the United Nations Convention on the Law of the Sea (UNCLOS) entered into force. For example, the outcrop on Rockall Bank is exemplified as a rock in the text of UNCLOS and so any claims based on it being an island are no longer valid. These legal boundaries are important in defining which country has the right to exploit particular resources and also carries the responsibility for managing the resources within the various zones.

3.2 Demography

The only population in the region occurs on the Azores Archipelago ***(Figure 3.1)***. The 1997 census data (from the Direcçåo Regional de Estatìstica e Planeamento dos Açores) indicate there are just over 241 000 residents in the Azores ***(Table 3.1)***, over half of whom live on the largest of the islands, São Miguel. However, during summer the influx of tourists doubles the population.

The islands' population, which had been declining, increased during the latter half of the 1990s as economic conditions and the infrastructure improved with the help of EU funding; 73% of houses are now connected to electricity supplies, 61% to water and 69% to sewage treatment systems. In 1994–5 the population increased by 970 (0.4%).

Table 3.1 Population and surface areas of the inhabited islands of the Azores, 1997.

	Population	Surface area (km^2)	Density (inh/km^2)
Santa Maria	5 990	97	61.7
São Miguel	129 160	747	172.9
Terceira	56 540	402	140.6
Graciosa	5 010	61	82.1
São Jorge	10 280	246	41.8
Pico	14 990	448	33.5
Faial	14 770	173	85.4
Flores	4 430	142	31.2
Corvo	320	17	18.8
TOTAL	241 490	2 333	103.5

3.3 Conservation

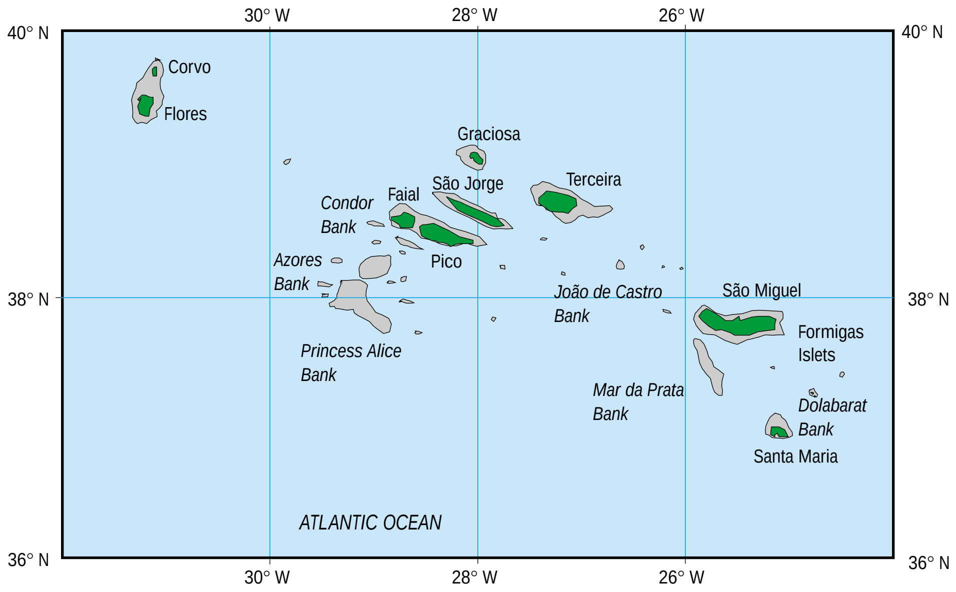
3.3.1 Ecological conservation

Habitats and species

All species of whales and dolphins, turtles and some bird species are protected to some extent under various international conventions. However, the conservation measures banning the exploitation of whales and dolphins under the International Whaling Convention have not been agreed to by all European countries. Nor are such measures effective in limiting by-catches of dolphins and small whales or turtles during fishing. Locally in the Azores, conservation legislation affords some protection to a range of species. There are no protected oceanic habitats in Region V, other than the Formigas Islets and the Dolabarat Bank, which lie within the EEZ of the Azores and are protected under national legislation.

There are nine protected marine areas in the Azores that are managed by the Environment Department, according to Portuguese law ***(Table 3.2)***. In addition there are fourteen Special Protected Areas designated under the EC Wild Birds Directive (79/409/EEC) to protect important breeding colonies of Bulwer's shearwater (*Bulweria bulwerii*), Cory's shearwater (*Calonectris diomedea*), Manx shearwater (*Puffinus puffinus*), little shearwater (*Puffinus assimilis baroli*), Madeiran storm petrel (*Oceanodroma castro*), common tern (*Sterna hirundo*) and roseate terns (*Sterna dougallii*). To comply with the EC Habitats Directive (92/43/EEC) a list of seventeen sites important for European conservation has been prepared, nineteen of which are either coastal or marine, and under this Directive all whales and turtles are fully protected.

Figure 3.1 **Islands and banks of the Azores Archipelago. Source: Santos *et al*. (1995).**



Biodiversity

Biodiversity of most oceanic ecosystems is poorly understood. Nearly all phyla have representatives in the bottom-living communities (the benthos), which is almost twice as many as are found in terrestrial and pelagic communities (Ormond *et al*., 1997). Large plants, however, only occur in shallow coastal waters, whereas the microflora is highly diverse. This lack of large plants may be one reason why the rich variety in animal phyla is not reflected in a correspondingly rich variety of species. Pelagic communities are locally rich in species, but because the species are very widely distributed, the global inventory of known oceanic species is very much smaller than that of terrestrial and even shelf-sea ecosystems (Ormond *et al*., 1997). Since the scales of the distributional patterns are much coarser, the classical species/area relationships established for island faunas (Huston, 1994) do not appear to apply in open ocean pelagic ecosystems.

There is a steep north/south gradient in the numbers of species, which is stepped at 40º N. Species richness reaches a maximum at depths of about 1 km, both in the

Table 3.2 Designated marine protected areas in the Azores.

Site	Conservation value	Usage
Santa Maria		
Baía da Maia	representative littoral habitats	recreational
Baía da São Lourenco	representative littoral habitats	recreational
Baía da Anjos	representative littoral habitats	recreational
Baía da Praia	representative littoral habitats	recreational
Formigas Islets	littoral and sublittoral rocky habitats	some fishing allowed
São Miguel		
Ilhéu de Vila Franca	volcanic crater; nesting site for Cory's shearwater	recreational
São Jorge		
Ilhéu do Topo	botanical and ornithological	
Lagoa do Santo Cristo	protection of clam (*Ruditapes decussatus*)	coastal lagoon
Faial		
Monte da Guia	volcanic crater	protected landscape

water and on the seabed. Estimates of the global numbers of species in benthic ecosystems range from half a million (Gage and May, 1993), to ten million (Grassle and Maciolek, 1992) or even hundreds of millions (Bouchet and Lambshead, 1995). Recent investigations of sediment communities inhabiting the continental slope to the west of Scotland, carried out as part of Environmental Impact Assessments (EIAs) prior to the development of deep-water hydrocarbon reserves, have shown that locally species richness is extremely high. However, extrapolating these data to estimate the size of benthic faunas globally is very misleading. Inventories of the known species of the large organisms are surprisingly small considering the wide geographic areas they occupy (for data on fish see Section 5.2.8). Knowledge of the faunas of the smaller species (macrofauna and meiofauna) will, for the foreseeable future, remain too sparse to derive believable estimates of the numbers of benthic species in Region V (and the global ocean). Thus management measures to conserve the biodiversity of Region V will have to remain precautionary.

3.3.2 Archaeological conservation

Ever since their discovery and colonisation in the Fifteenth Century, the Azores have been an important staging post for ocean travel. During the era of sail, the islands provided facilities to effect repairs and to obtain fresh water and food, and so numerous Portuguese, Spanish, English and French vessels foundered there. In all at least 517 wrecks *(Table 3.3)* have been registered and are protected against ‘treasure’ hunters.

Table 3.3 Registered wrecks around various islands of the Azores.

Formigas Islets	1
Santa Maria	9
Graciosa	14
Corvo	15
Pico	25
Flores	32
São Jorge	43
Faial	83
São Miguel	138
Terceira	157
TOTAL	517

3.4 Tourism and recreation

3.4.1 Tourism

Tourism has been growing steadily in the Azores since 1980, with lodging capacity increasing by 83.5%. The strongest growth, averaging 7.9% per annum, was from

Figure 3.2 **Whalewatching near the Azores (F. Cardigos © *imag*DOP).**

1988 to 1995. Most tourists come from the Portuguese mainland, but large contingents come from Germany and the UK, attracted by the clean environment and opportunities for outdoor pursuits.

Some tourist activities are controlled. Recreational fishing, using rod and line and spear-fishing, exploits a variety of inshore fishes, few of which are caught commercially, but the popularity of underwater diving and spear-gun fishing has necessitated the introduction of regulations limiting the daily catch to five fish per person. Whalewatching has expanded rapidly in recent years, and is now regulated in order to protect both visitors and whales *(Figure 3.2)*.

3.4.2 Cruise industry

Worldwide there are over 240 ocean-going cruise ships with a total gross tonnage of over 5 million t and a passenger carrying capacity of about 160 000 (Seatrade Cruise Review, 1997). About half these vessels operate at times in the North-east Atlantic, although most cruise destinations are outside Region V. The number of ships and their passenger carrying capacity have been expanding rapidly. In spring 1997, 27 new cruise ships were on order, increasing the tonnage by 1.88 million and the passenger capacity by nearly 30%. Two of the latest vessels to have been built have gross tonnages of 130 000 t and carry about 3000 passengers (and similar numbers of crew). The operation of such large vessels must place considerable strain on local port facilities.

3.4.3 Ocean yachting

Ocean yachting is a small but growing recreational activity. In 1995, 1783 boats carrying 6718 people visited the Azores *(Figure 3.3)*. This growing activity poses local environmental problems such as the risk of introducing non-indigenous species and of pollution from antifouling

Figure 3.3 **Horta on Faial and its yacht harbour (R. Patzner © *imag*DOP).**

paints, particularly those containing TBT (see Section 4.5.1).

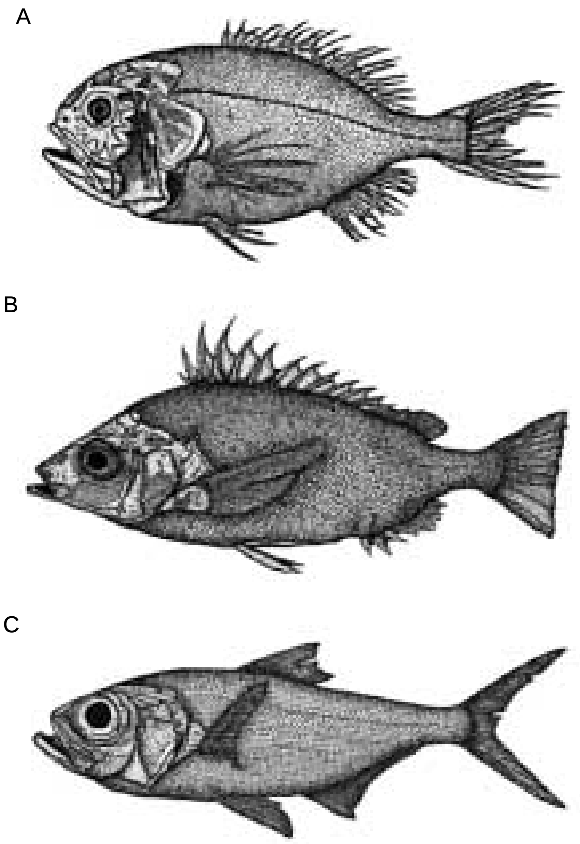
3.5 Fishing

There are four broad categories of fishing in Region V:

a. fisheries for large pelagic tuna and tuna-like fish. These occur mainly in the southern sector. ICCAT has responsibility for the international management of these fisheries;
b. longline and trawl fisheries in deep waters on the continental slopes *(Figure 3.4)*. These target species such as ling (*Molva molva*), tusk (*Brosme brosme*), argentine (*Argentina sphyraena*), grenadiers (*Macrourus berglax* and *Coryphaenoides rupestris*) and various species of deep-water shark;
c. fisheries for demersal and pelagic stocks (other than tunas and related species). These have developed recently and are rapidly expanding; and
d. fisheries using traditional longline, handline and gillnet methods around the Azores and adjacent seamounts.

For several reasons, only general and non-specific statements can be made on the basis of reported catch data. There is little correspondence between Region V and the areas adopted for reporting catches to ICES and ICCAT. This makes it difficult to use catch data to develop a coherent management strategy. All these fisheries are multi-species. Hence not only are they difficult to manage sustainably, but they also result in considerable quantities of by-catch. Many of the data on landings are of questionable value, one of the reasons being the uncertainties of many of the species' identifications. Moreover, with few monitoring programmes and only sporadic participation by many fleets, reported catches are highly suspect for many target and minor species. Nor do the data on landings reflect the overall impacts on the non-target stocks or the extent of damage inflicted on some deep-sea habitats. Fishing effort in the deeper waters tends to be unpredictable, since it waxes and wanes according to the fluctuations experienced by fishermen as their access to other stocks is limited by regulation or overfishing.

Figure 3.4 **Deep-living fishes exploited commercially over seamounts and continental slopes. A: orange roughy (*Hoplostethus atlanticus*); B: armourhead (*Pseudopentaceros wheeleri*); C: alfonsin (*Beryx splendens*). Source: Rogers (1994).**



3.5.1 Fisheries for large pelagic species

The management areas adopted by ICCAT match neither the OSPAR regions or the ICES statistical areas, nor the ranges of these highly migratory fish. Hence none of the derived data on stock sizes and landings are specific to Region V. The species caught in Region V are listed in *Table 3.4*. The problems of regulating the stocks of species such as Atlantic bluefin tuna (*Thunnus thynnus*) and bigeye tuna (*T. obesus*) to ensure there is no overexploitation remain unresolved. Fishing boats from many nations, including many from non-OSPAR countries, operate in the region. For example in 1996, 282 Japanese longliners operated in the Atlantic Ocean, some fishing as

Table 3.4 Deep-living species fished commercially or regularly occurring as by-catch in commercial fisheries.

		ICES Fishing Areas targeted (or by-catch)			ICES Fishing Areas targeted (or by-catch)
	Teleosts				
+	Baird's smooth-head				
	Atlantic wolf-fish			longfin hake	
+	black scabbardfish	(V), VI, VII, IX, XII		forkbeard	(VIII)
+	argentine/great silver smelt	II, III, (IV), (V), (VI), (VII)	+	greater forkbeard	(V), VIII, (IX)
+	golden-eye perch	(VIII), X, XII		saithe or colley	
+	red bream/alfonsino	X	+	wreckfish	(VIII), X, XII
+	tusk	IV, V	+	Greenland halibut	II, IV, V, XIV
+	rabbitfish	(V), (VI), (VII)	+	redfish	
+	conger eel	(IX), X	+	roughnose grenadier	
+	round-nose grenadier	II, (III), (V), VI, VII, XII, (XIV)			
+	big-eye/deep-water cardinal fish	(V), (VI), (VII), XII		Elasmobranchs	
	witch			gulper shark	(IX)
+	blue-mouth	(V), (VIII), (IX), X		leaf-scale gulper shark	VI, VII, VIII, (IX)
	Atlantic halibut			black dogfish	
	American plaice			Portuguese dogfish	
+	orange roughy	V, VI, VII, XII		longnose velvet dogfish	VI, VII, VIII
+	silver roughy			kitefin shark	X
+	silver scabbardfish			birdbeak dogfish	
+	megrim	VIII		deepsea cat shark	
+	anglerfish or monkfish	IV, V, VIII		great lantern shark	
	eelpouts			velvet belly	
+	rough-head grenadier	II, (IV), (V), (XIV)		black-mouthed dogfish	(IX)
	capelin			Greenland shark	
	haddock			knifetooth dogfish	
+	hake	VIII		six-gill shark	
+	blue whiting			skates	
	lemon sole				
+	ling	IV, V, (VIII)		Decapods	
+	blue ling	V, VI, (VIII)	+	deepwater red crab	V
+	mora	(V), (VI), (VII), VIII		deep-sea shrimp	II, III
+	red/blackspot sea bream	(VIII), IX, X	+	giant red shrimp	IX

+ the most important deep-water species according to ICES (1998).

far north as 60º N (ICCAT, 1997), and caught > 50 000 t; 65% being bigeye tuna. A variety of fishing methods are used; longlining, purse-seining, baitboats (with and without artificial floating objects), harpoons, driftnets and gillnets *(Figure 3.5)*. ICCAT evaluations indicate that stocks of most species are currently being exploited in excess of their replacement potential.

For example, Atlantic bluefin tuna is being caught in an area stretching from the Gulf of Mexico to Newfoundland in the western Atlantic, and from the Canary Islands to the south of Iceland in the eastern Atlantic, as well as throughout the Mediterranean Sea. The vessels taking part in the fishery range from local recreational and artisanal boats to large vessels with the ability to operate in any ocean. Annual catches in the Atlantic are around 40 000 million t, exceeding the rate estimated to be sustainable by over 25%. In 1974, an ICCAT Committee recommended that the fishing mortality of bluefin tuna throughout the Atlantic and the Mediterranean should not increase. Although this recommendation came into force in 1975, it has been neither respected nor enforced in the subsequent twenty-five years.

The impacts of overfishing are being exacerbated by the general disregard of size restrictions on the fish that may be landed. In 1980, a minimum size limit of 3.2 kg was adopted for both bigeye and yellowfin tunas (*Thunnus albacares*). In 1994, the proportion of undersized small yellowfin tuna landed from the Atlantic fell to a low of 31.4%, but reverted to 49.7% in 1995, which is close to the 20-year mean of 48%. The problem arises because the young and full-sized tuna form mixed-species schools near the surface, often associated with

Figure 3.5 **Fishing for tuna off the Azores (I. Morató © *imag*DOP).**

drifting objects, whale-sharks (*Rhincodon typus)* or seamounts. So vessels targeting legal-sized fish inevitably take a heavy by-catch of undersized fish. Large quantities of undersized bigeye tuna continue to be captured and landed, mostly by the equatorial surface fleets; in 1996 the proportion of undersized fish landed increased to 70%.

The northern stock of albacore (*Thunnus alalunga*) is exploited by surface and longline techniques. Spanish fishermen troll at the surface in the Bay of Biscay and adjacent waters, and Spanish and Portuguese baitboats operate there and near the Azores. The albacore are now exploited at their maximum sustainable level and the fishery is taking considerable by-catches of otherwise protected species (see Section 5.3.2).

In 1996, the reported landings of blue marlin (*Makaira nigricans*), 1870 million t, were the second highest landings for more than 30 years. Reported landings alone exceed the replacement yield and so the status of the stock is likely to decline. Similarly, landings of swordfish (*Xiphias gladius*), a species that ranges widely throughout Region V and is taken mainly as a by-catch during longlining, were consistently around 1600 million t during the 1990s. Such a rate is unsustainable and can be expected to deplete the stocks. In addition, fisheries targeting swordfish take extensive amounts of by-catch; only 10% of the fish landed belong to the target species (see Section 5.3.2).

3.5.2 Continental slope fisheries

Deep-living demersal species targeted commercially or regularly taken as by-catch are listed in *Table 3.4*. Several of these species have considerable longevity and take many years to reach maturity. For example, the deepwater redfish (*Sebastes mentella*) lives 70 – 75 yr (Campana *et al.*, 1990) and the orange roughy lives for > 100 yr (Fenton *et al*., 1991) and in the Atlantic takes 30 – 35 yr to reach maturity. Analysis of the age structure of an argentine stock fished experimentally off Ireland showed that 40% were > 20 yr old (McCormick, 1994). Such stocks can sustain only very low exploitation rates, yet these deep-sea fisheries are expanding very rapidly. Biological and assessment information is sparse and ageing techniques have been validated for only three of the 340 deep-living species of bony fishes (teleosts) recorded in the North Atlantic (Haedrich and Merrett, 1988), and for only one of the 40 species of shark (Bergstad, 1994).

Species richness of deep-sea fish assemblages increases with depth to depths of 1000 m. So as one species is fished out, the temptation is to target another species, thus maintaining the fishing pressure on the original target species. For example, to the west of Ireland and France the fishery for hake (*Merluccius merluccius*) and/or red sea bream (*Pagellus bogaraveo*) has shifted to the exploitation of some of the deep-living sharks (*Deania calceus, Somniosus rostratus, Centrophorus granulosus, Centroscymnus coelolepis*). Only the livers of these sharks have significant economic value, so the liver is removed (20 – 30% of weight) and the rest discarded. Because the oil (70 – 80% of the liver's weight) is extracted, converting the landings to meaningful fishery statistics is a major problem (Iglesias and Paz, 1995).

3.5.3 Demersal and pelagic fisheries

Knowledge of the biology of most target species is inadequate, but all the indications are that most, if not all, stocks can only sustain low rates of exploitation. These fishes tend to be long-lived, slow to mature and to have low fecundities. Hence they do not have the resilience to recover rapidly from overexploitation. In the north, the primary fishery is trawling for redfish (*Sebastes marinus*) and deepwater redfish. Redfish stocks include a genetically distinct component, *S. marinus ëgiantí,* and deepwater redfish stocks include separate deep-sea and oceanic stocks. Thirteen national fleets participate in this fishery, the major ones being from Russia, Germany, Iceland and Norway. Redfish catches in Region V peaked in 1994 and 1995, at 94 000 t and 127 000 t respectively, when the areas and the depths being exploited were extended. The most recent assessments of deep-sea redfish, although being highly uncertain, indicate that the decline in biomass throughout the 1990s is nearly equivalent to the total biomass of fish that has been removed. This implies that the accumulated stock of old fish is overexploited rather than harvested sustainably. As the redfish stocks have declined, other species are now being targeted. Along the Mid-Atlantic Ridge these include the golden-eye perch (*Beryx splendens*), orange roughy, black scabbardfish (*Aphanopus carbo*) and wreckfish (*Polyprion americanus*). Catch per unit effort (CPUE), normally a useful management index, is not an informative measure of the status of these stocks. These fisheries have been expanding rapidly, but only in very few have by-catch and discard rates been studied. In those that have, the weights of discards often equal the weights of fish landed. Generally these fisheries are environmentally damaging and unsustainable.

3.5.4 Azorean and seamount fisheries

These fisheries target a great variety of species, including red sea bream, wreckfish, conger eel (*Conger conger*), forkbeards (*Phycis blennoides* and *P. phycis*), blue-mouth (*Helicolenus dactylopterus*), golden-eye perch, alfonsine (*Beryx decadactylus*), kitefin shark (*Dalatias licha*) and gulper shark (*Centrophorus granulosus*), using a variety of methods. Landings in recent years have been < 5000 t/yr, and so exploratory surveys are being carried out to evaluate other stocks. There are three categories of fishing (Santos *et al*., 1995). One targets young horse mackerel (*Trachurus picturatus*) and chub mackerel (*Scomber japonicus*) using seine nets, dipnets and liftnets from small boats < 12.5 m. Secondly, there is a seasonal pole and line fishery for tuna during March to October, and a bottom longline and handline multi-species fishery. Thirdly there is a demersal fishery, which probably has the greatest impact on the marine communities, in which the most important species are red sea bream, blue-mouth, forkbeards and conger eel. These fisheries are all inter-related; for example, mackerel and juveniles of the red sea bream are used as bait for the tuna longlining and so do not get reported in the landing statistics.

Landings of these species increased after the replacement of the traditional open-decked boats with more efficient close-decked boats. However, the CPUE for red sea bream has declined by 50%; possibly because large, and unreported, numbers of juveniles are being taken for bait. As fishing activity moves progressively offshore, at least 50 other species of fish are now taken regularly.

The exploitation of a number of invertebrates in inshore waters is now regulated, but there are two problems. Firstly, how to enforce regulations in artisanal fisheries, and secondly, what catch rates can most of these invertebrates sustain.

3.6 **Aquaculture**

Aquaculture is presently restricted to inshore waters. There have been two experimental aquaculture projects in the Azores. The first was to farm red sea bream and was unsuccessful. The second, currently being promoted by the Regional Government, is to produce live *Haliotis discus hannai* for human consumption.

3.7 **Coastal protection and land reclamation**

3.7.1 Coastal protection

The steep coastlines of the Azores are composed of volcanic rocks and so are resistant to erosion and unsuitable for land reclamation. Further expansion of the cruise industry may necessitate the further development of port facilities.

3.7.2 Energy

At present no energy is being extracted directly from the ocean. The region is unsuitable for Ocean Thermal Energy Conversion (OTEC), which to be effective requires there to be a temperature difference of 20 ºC between the water at the surface and at a depth of 1000 m. The outflow water from the Strait of Gibraltar *(Figure 2.10)* keeps the deep-water temperatures abnormally high. Maximum wave energy occurs in the vicinity of the shelf-break, but the technology for extracting energy from waves in shallow water, let alone the open ocean, remains undeveloped. A small experimental wave energy generator is now being constructed on the island of Pico on the Azores. Open ocean culturing of macroalgae to provide biomass has been discussed, but no commercial technology has been developed.

Small wind farms now operate on the islands of Santa Maria, São Jorge and Graciosa. The sixteen generators produce between 5.1 and 8.8% of the power demand on each of these islands. These installations are to be extended and new ones constructed on other islands. There is also extraction of geothermal power on the Azores.

3.8 **Sand and gravel extraction**

Some sand is extracted from the inshore waters of the Azores, around the islands of Santa Maria, São Miguel and Terceira, mostly by dredging. Licences have been approved for the annual extraction of 140 000 m^3. However, since the Azores are volcanic the exploitable reserves are limited. Similarly, no potential seabed mineral resources have yet been identified within the area. However, metal-rich crusts are being deposited on the Mid-Atlantic Ridge in association with hydrothermal vent activity (see Section 2.4.2), so it is feasible that in the future commercially viable deposits may be discovered.

3.9 **Dredging, dumping and discharges**

Dredging is only conducted in the inshore waters of the Azores. In the past ocean dumping of sewage sludge, industrial residues, radioactive wastes and redundant munitions was conducted at a range of licensed deep-

Table 3.5 **Permits issued for the disposal of wastes into the North Atlantic in 1978–86. Source of data: London Dumping Convention circulars.**

		Waste type	t
1976	Denmark	industrial liquids	22 400
	UK	industrial liquids	95
		industrial solids	2 035
		industrial sludges	365
1977	Denmark	industrial liquids	31 000
	Netherlands	industrial solids	3 000
		munitions	73
	Canada	radioactive tracer	0.002
	UK	industrial solids	2 670
		industrial sludges	70
1978	Denmark	industrial liquids	31 000
	France	dredged spoils	14 600 000
	Ireland	caustic liquids	1 100
	UK	ammunition	20
		pipes	150
		seal carcasses	3 000
		industrial sludges	170
		industrial solids	2 235
1979	Denmark	industrial liquids	34 000
	France	dredged spoils	1 430 000
	Netherlands	radioactivity	3 431
	UK	industrial sludges	770
		industrial solids	95
		radioactivity	2 300
1980	Denmark	industrial liquids	34 000
	France	dredged spoils	4 380 000
	Germany	sewage sludge	172 000
	UK	arsenic sulphide	70
		contaminated iron oxide	70
		antimony chloride residues	45
1981	Denmark	industrial liquids	34 000
	Germany	sewage sludge	607 000
1982	Germany	sewage sludge	31 000
	UK	arsenic sulphide	180
		antimony chloride	45
		contaminated iron oxide	140
		aqueous waste containing organohalogens	8 800
1983	Denmark	pharmaceutical	34
	UK	concrete in steel drums	200
		arsenic sulphide	50
1984	UK	industrial sludges	50
		inert ammunition	20
	Spain	sand contaminated with cyanide	30
1985	UK	arsenic sulphide*	
1986	UK	industrial sludges	50

It is not known whether these licences were fully taken up in every case.
* 51 m^3.

water sites *(Table 3.5)*. Discharges from surface vessels and oil platforms are currently making a relatively small contribution (*c*. 13%; IWCO, 1998) to the overall input of contaminants.

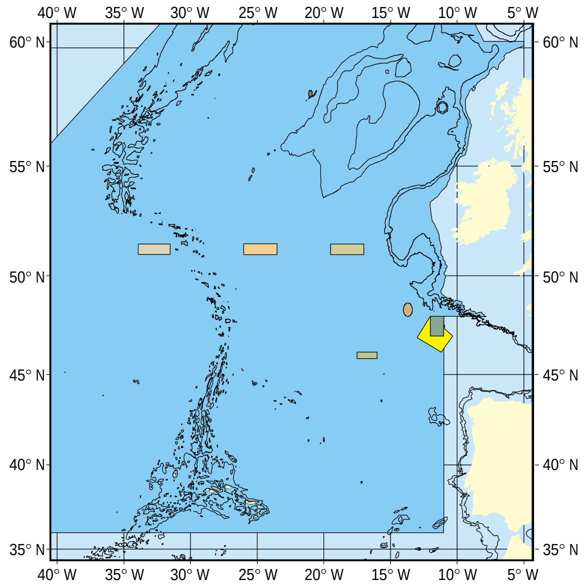
3.9.1 Industrial waste

In the past, licences were issued permitting the disposal of industrial materials at a number of designated dump sites, most of these were inshore but there were a few in Region V *(Figure 3.6)*. The issuing of a licence did not necessarily mean that the waste was actually dumped. Disposal was usually by directly discharging material at the sea surface, either by pumping slurries or by dropping the waste packaged in sealed containers. The wastes disposed of were generally those which at the time were difficult and expensive to reprocess or detoxify. Records of the licences granted are to be found in the OSPAR annual reports, but precise information on the exact quantities and types of substances disposed of, is often incomplete.

3.9.2 Radioactive waste

In the early years, sea disposal of radioactive wastes was uncoordinated and a number of shallow sites were used for the disposal of relatively small amounts of wastes. After 1967, disposal was coordinated by the Nuclear Energy Agency (NEA/OECD). By 1985 twenty-one countries were party to the NEA (Belgium, Canada, Denmark, Finland, France, the Federal Republic of

Figure 3.6 **Location of sites licensed for the dumping of industrial wastes until 1986.**



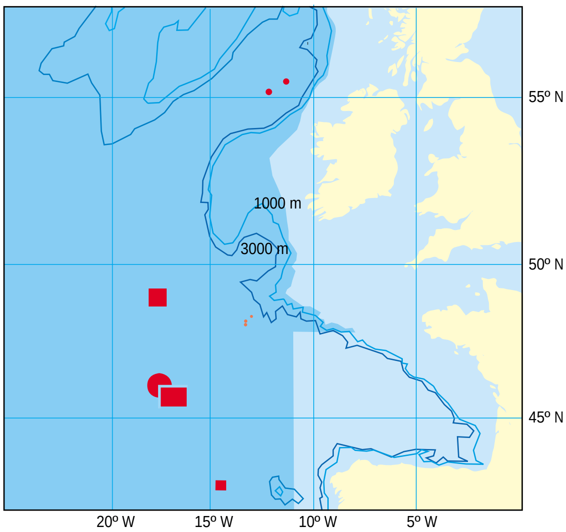
Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the UK and the USA). The dumping of nuclear waste was regulated under the provisions of the London Dumping Convention (details and site selection criteria are to be found in OECD (1985)). Four main sites were used in Region V *(Figure 3.7)*:

a. in 1967 a 50 km square centred on 42º 30' N, 14º 30' W;
b. in 1969 a 50 nm square centred on 49º 05' N, 17º 05' W;
c. in 1971–6 a circle of radius 35 nm centred on 46º 15' N, 17º 25' W; and
d. in 1977–82, the 'NEA site', a rectangle bounded by 45º 50' N and 46º 10' N and 16º 00' W and 17º 30' W. This site, with an area of 4250 km^2, is in the foothills of the Mid-Atlantic Ridge and its nearest points are 741 and 627 km from the Irish and Spanish coasts respectively.

The wastes dumped mostly comprised low-level materials from nuclear plant operations, fuel fabrication and reprocessing, radionuclide use in medicine, research and industry, and decontamination of redundant plant and equipment. The α-active wastes were mostly from nuclear fuel processing and the production and use of specific radionuclides (e.g. ^{241}Am used in smoke detectors, ^{226}Ra in medicine). The β- and γ-activity wastes came from the production of ^{241}Pu in fuel reprocessing, fission products produced in routine nuclear power plant operations (e.g. ^{90}Sr and ^{137}Cs), activation products (e.g. ^{55}Fe, ^{58}Co and ^{60}Co), the production of specific nuclides (e.g. ^{14}C and ^{125}I), the products of decontamination, and tritium (generated during production and use of labelled compounds for medical, research and industrial applications). Plutonium and americium accounted for > 96% of the α-activity dumped, and tritium and plutonium-241 for > 87% of the β-activity dumped. The remainder of the β/γ activity was mostly ^{90}Sr, ^{137}Cs and ^{60}Co. There has been leakage from drums of material that were dumped *(Figure 3.8)*. However, the results achieved under the Coordinated Research and Environmental Surveillance Programme of the NEA (OECD, 1990) concluded that the radiological impacts on human and oceanic populations emanating from these dump sites remain, and are likely to remain, exceedingly small compared to the natural background levels. These conclusions have recently been validated by some *in situ* labelling experiments conducted on the grenadier *Coryphaenoides armatus* and the deep-sea amphipod *Eurythenes armatus* (Charmasson, 1998).

Loss during transportation is another mechanism whereby radionuclides may reach the deep ocean. For example in November 1997, a section of the container ship Carla sank at 40º 03' N, 22º 50' W. Three of the containers contained radioactive sources of 65, 65 and 200 TBq ^{137}Cs respectively, and now lie at a depth of about 3000 m. They had been sealed according to the international procedures for the transportation of radioactive materials, and so the risk of serious environmental contamination is considered to be small.

Figure 3.7 **Location of sites used for the disposal of radioactive wastes until 1983.**

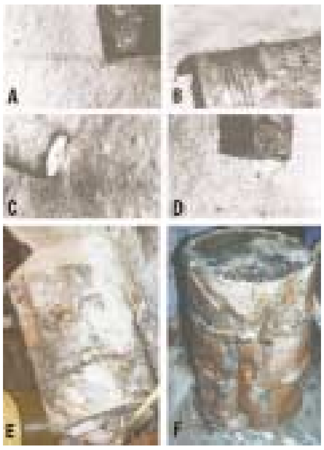


3.9.3 Munitions

At the end of the Second World War considerable quantities of arms and munitions were dumped at sea, which included considerable quantities of chemical warfare materials. The latter consisted mainly of tear gases, nerve gases and other agents. The majority was dumped in areas which at the time were considered deep enough to be safe because they were not being, nor expected to be, exploited for fishing. Most were dumped in the Baltic and the Skagerrak, but 69 000 grenades containing the nerve gas tabun (hydrocyanic acid mixed with 20% chlorobenzene) were subsequently retrieved embedded in concrete and sunk in the Bay of Biscay (NATO, 1995). Tests on three grenades showed that their toxic contents had largely decomposed. Between 1946 and 1949, twelve redundant vessels loaded with confiscated German munitions, including chemical munitions, were scuttled at depths ranging from 500 to 4200 m in the Southwest Approaches. A further twelve were scuttled in the Rockall Trough between 1945 and 1957 (ACOPS, 1988), at depths ranging from 800 to 2500 m *(Figure 3.9)*. No reports on monitoring of these vessels have been published.

Quantities of munitions lost during military actions in the war (shells and bombs which failed to explode, and

Figure 3.8 **Drums photographed *in situ* at the NEA radioactive waste dump site showing benthic organisms in close association (a–d). Source: M. Sibuet, IFREMER. Two corroded and leaking drums recovered from the dump site in 1991 (e–f). Source: M. Vobach, German Federal Fisheries Research Centre.**



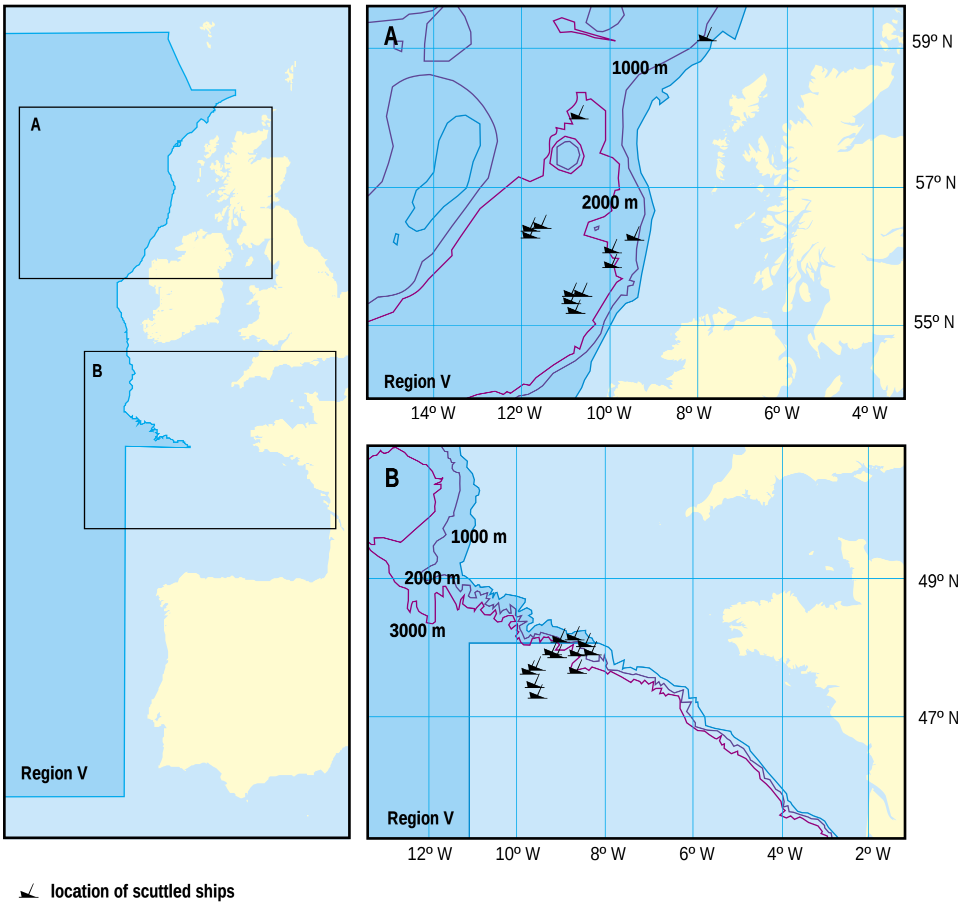
in cargoes and magazines of sunken military and merchant ships) far exceeded those ultimately disposed of in deep water.

Disposal of redundant munitions by various Western European countries has continued intermittently, mostly in coastal seas. The most recent incident was in 1994 when Portugal scuttled a redundant ship loaded with > 2000 t of unstable ammunitions 215 nm from the Portuguese coast at the edge of their EEZ in > 4000 m of water (OSPAR, 1995).

3.9.4 Carbon dioxide

The oceans have taken up about 30 – 40% of the carbon dioxide emitted since the onset of the industrial revolution. This has resulted in the pool of dissolved inorganic carbon in the deep ocean having increased from 38 to 38.1 x 10^{12} t since the start of the industrial revolution (Siegenthaler and Sarmiento, 1993) and the pH of the upper ocean has probably been reduced by about 0.1 units. The impacts are discussed in Section 4.10.

Figure 3.9 **Locations at which redundant vessels loaded with munitions, including chemical warfare weapons, were scuttled between 1945 and 1957.**



3.10 Oil and gas industry

Offshore exploration for hydrocarbons is at an early stage of development in Region V. Areas have been licensed for exploration in the north-east of the region in the EEZs of the UK and Ireland, in the Rockall Trough, the margins of the Rockall and Porcupine Banks and in the Southwest Approaches. Exploration and development do have some impacts. The use of seismics in exploration (and scientific research) is thought to affect certain biota, especially whales (see Section 5.3.3), and operational activities inevitably result in some discharges into the marine environment. The high economic cost of offshore exploitation and the relatively low returns are stalling development of some of these deep-water reserves. In a global context, the deep offshore reserves in the North Atlantic are small compared to those of the Middle East and Azerbaijan, but nationally they are of considerable economic importance.

3.11 Shipping and other commercial activities

3.11.1 Shipping

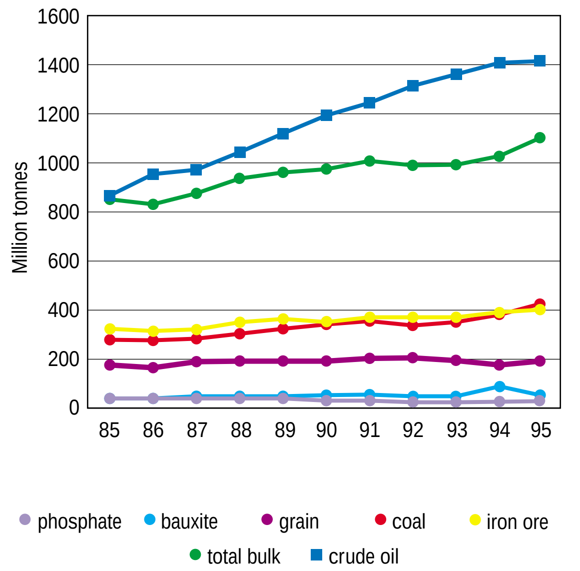
Ocean transportation continues to grow as world trade expands *(Figure 3.10)*. Large bulk carriers continue to convey increasing quantities of raw materials in a relatively efficient and environmentally friendly manner. However, the increasing size of the vessels does mean that accidents when they do occur have greater impacts, although the majority of sinkings occur in inshore waters. The transportation of crude oil increased 5% per annum in 1985–95, resulting in a total increase of 61% in the tonnage carried and 86% in the tonne-miles. Of the total 1415 million t of crude oil transported by sea about 374 million t (26.4%) were either destined for, or came from North-western Europe. Seaborne trade in iron ore, coal, grain, bauxite and alumina, and phosphates also increased by an average of 2.6% per annum over the same period. Of the 402 million t of iron ore carried, about 125 million t (31.3%) passed through the OSPAR area. There was an increase of 59% in coal shipments as a result of strong demands for thermal coal (see Section 4.10), which in the context of the carbon dioxide problem is of concern.

MARPOL-regulated operational discharges from tank cleaning at sea and other legal operational discharges continue to introduce small quantities of contaminants into the region, but there is no evidence, nor does it seem at all likely, that these present any significant environmental risk. Ships under ballast exchange ballast waters in open ocean areas as a way of reducing the risks of introducing non-indigenous species to inshore environments. There are no known examples of such introductions occurring in any open ocean environments. The risk of non-indigenous species becoming established in the shallow waters around the Azores is considered to be small because the islands are not currently being used by bulk carriers.

Litter discarded from vessels at sea continues to be a chronic, albeit relatively small, problem in Region V. The litter ranges from plastic bags, containers and polystyrene fragments, to baulks of timber and pieces of rope. Tar balls, presumably from tank cleaning, are still abundant at the surface and tend to accumulate along fronts. Lost and discarded fishing gear, floats, nets and lines are also frequently encountered, particularly close to fishing grounds. On-board incineration of combustible refuse from shipping and the availability of waste facilities in many ports has lead to a marked reduction in the quantities of litter in the open ocean. However, less scrupulous ship operators may still be illegally discharging at sea either through ignorance or in order to avoid paying the charges levied by port operators for waste and refuse disposal.

Together with the increase in bulk transport has been the growth of container traffic carrying manufactured goods, and this is likely to continue, for example forecasts are that by 2020 the port of Rotterdam will be handling 20 million containers annually. The maximum size of container carriers continues to increase; currently the largest vessels are capable of carrying 7000 containers. Losses of containers in bad weather are quite frequent, and not all containers have their contents well documented. Even so, recovery of dangerous cargoes from deep water is often impossible (see Section 3.9.3).

Figure 3.10 **Growth in world transportation of bulk commodities by sea from 1985 to 1995. Source of data: Fearnresearch (1996).**



However, accidents in the open ocean are less frequent and the subsequent ecological impacts smaller than those resulting from similar accidents nearer shore.

3.11.2 Communications

Despite the enormous expansion of satellite use for communications, transocean cables are still in high demand because of the need for security. Computer networks and communications are expanding exponentially, and technically cables are better (and cheaper) for such links. The development of fibre-optic technology has enabled much more efficient use of cables. Consequently, there is an expansion of cable laying activities in the North Atlantic *(Figure 3.11)*. Cables have a minimum impact on the environment, but do restrict deep trawling and some scientific activities.

3.12 Coastal industries

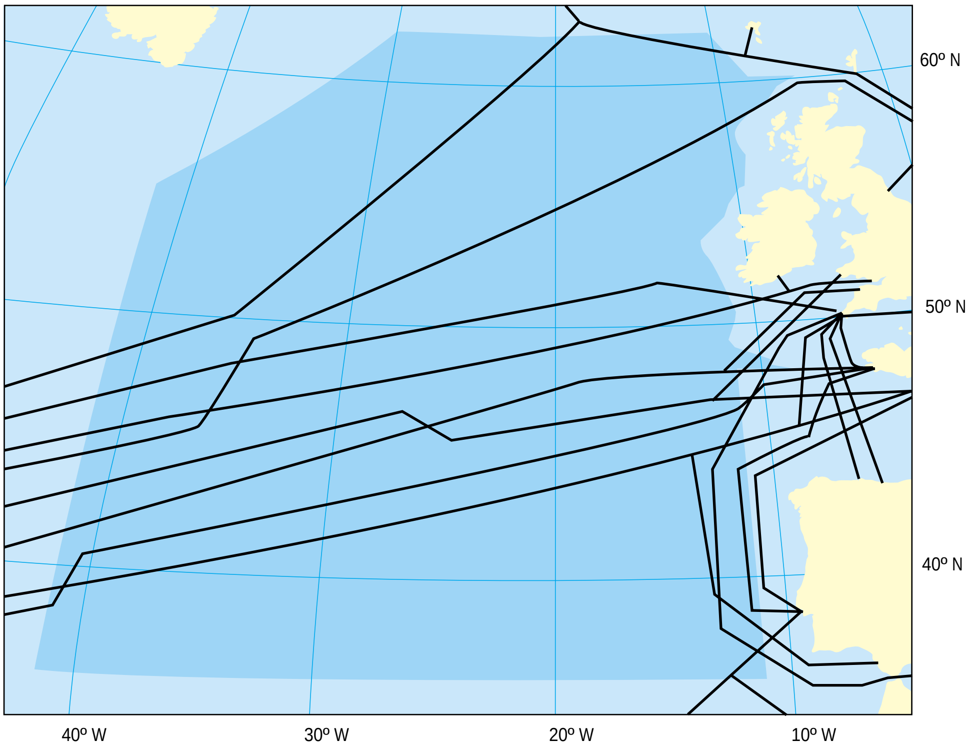
There are a few coastal industries in the Azores but their impact, even locally, is quite trivial and unlikely to grow to any serious proportions.

3.13 Military activities

Wars and their associated military activities have left a legacy throughout the region. During the Second World War some 20 million t of shipping were sunk in the Atlantic. Post-war, military authorities faced with the problem of how to deal with dangerous munitions scuttled numerous redundant vessels loaded with such materials (see Section 3.9.4). Throughout the Cold War, there was intense military activity, including naval exercises and patrolling, aimed at monitoring the movements of Soviet submarines passing through the channels in the ridges between Scotland, the Faroe Islands and Iceland. There were constant overflights by military aircraft from both sides probing air defences, and a nuclear strike force was constantly maintained airborne as a deterrent. Inevitably there were accidents and the seabed is now littered with artefacts resulting from these activities. This litter ranges from sunken vessels, some having been nuclear powered or armed with nuclear devices, to munitions and pyrotechnics used in exercises, to hydrophone arrays (still operational) deployed along the western margins of the European continental margin.

Despite the ending of the Cold War, some military activity continues. This is needed to maintain a body of

Figure 3.11 **Routes of deep sea fibre-optic cables across Region V. Source: France Télécom.**



trained personnel and adequate weaponry, necessary to protect national interests and to support international peacekeeping, particularly to deal with regional conflicts. These missions often require a rapid response capability; hence the continuing need for bases in mid-ocean, such as on the Azores, to act as staging posts for the transportation of personnel and equipment to centres of conflict.

Many national military forces are developing a responsible ethos of environmental compliance alongside their primary mission. The updating of hydrographic and bathymetric surveys and the maintenance of satellite navigation networks, which are vital for the safety of marine operations, are conducted by agencies that are predominantly funded by navies, so not all the information reaches the public domain.

3.14 Land-based activities

Land-based activities have a relatively small impact on Region V, except as sources of atmospheric contaminant inputs. Fluxes entering the oceans via the atmosphere are generally poorly quantified, but become increasingly important with distance from land. For many persistent organic contaminants, some heavy metals and nitrogenous compounds entering oligotrophic ocean regions, the atmospheric inputs are non-trivial (see Chapter 4).

3.15 Agriculture

Agricultural activities in the Azores have little impact on Region V. However, agricultural activities in Europe and America constitute sources of atmospheric inputs to the deep ocean, particularly for nitrogenous compounds and biocides.

3.16 Regulatory measures and future developments

There are four Conventions, three of these global, that offer some protection specifically to deep-sea environments (Sand, 1992):

a. the Convention for the Protection of the Marine Environment of the North East Atlantic, 1992 (OSPAR Convention);
b. the UN Convention on the Law of the Sea, 1982 (UNCLOS);
c. the Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter, 1972 (London Convention or LC); and
d. the Convention for the Prevention of Pollution from Ships, as modified by the protocol of 1978 relating thereto (MARPOL 1973/78).

The OSPAR Convention stipulates that Contracting Parties shall take all possible steps to prevent and eliminate pollution and shall take the necessary measures to protect the maritime area against the adverse effects of human activities so as to safeguard human health and to conserve marine ecosystems and, when practicable, restore marine areas which have been adversely affected. The Convention addresses the prevention and elimination of pollution from land-based and offshore sources. It prohibits incineration and dumping at sea, the latter with certain exceptions (e.g. dredged material). It also provides for the assessment of the quality of the marine environment and the protection and conservation of the ecosystems and biological diversity of the maritime area.

UNCLOS has been ratified by 122 States (December 1997). It has amongst its objectives the promotion of ‘peaceful uses of the seas and oceans, the equitable and efficient utilisation of their resources, the conservation of their living resources, and the study, protection and preservation of the marine environment’. It confirms the sovereign rights that States have to exploit their natural resources, but balances this against the duty to protect the marine environment. It provides States with the international basis upon which they must pursue the protection and sustainable development of resources in marine and coastal environments, both within their own EEZs and on the high seas (see parts V, VI, VII, IX and IX). Any activities by a State must cause no significant adverse changes in either the living or non-living components of the marine and atmospheric environment. Moreover these activities must not cause significant adverse effects on ecosystem diversity, productivity and the stability of biological communities. Nor should any activity cause unreasonable loss of scientific or economic value of marine resources relative to the benefits otherwise being derived from the activity in question.

In September 1997, the London Convention had been ratified by just 77 States. In 1996 it adopted a protocol which specifically states that ‘the disposal (or storage) of wastes or other matter directly arising from, or related to exploration, exploitation and associated offshore processing of seabed mineral resources is not covered by the provisions of the Convention’ (IMO, 1997). However, disposal of industrial wastes is now banned under the Convention. MARPOL specifically deals with discharges from ships and platforms (but not via pipelines) and has currently been ratified by 102 States.

There is a multiplicity of organisations involved in the management of fish stocks in the Northeast Atlantic – the Northeast Atlantic Fisheries Commission, the North

Atlantic Salmon Conservation Organization, ICCAT, ICES and the European Community with its Common Fisheries Policy. The UN Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks is addressing the ways in which States are required to cooperate to conserve and promote the optimum utilisation of these stocks. Turtles and seabirds are afforded some measure of protection under international agreements. The situation in respect of whales is particularly confused. Under the International Convention for the Regulation of Whaling (ICRW) and UNCLOS, States are free to take living resources from the High Seas as long as their exploitation is carried out in a sustainable manner. The International Whaling Commission (IWC), with considerable international support, is trying to impose a moratorium on all whaling. However, not all OSPAR countries support this moratorium, and they point out that there are contradictions between the provisions of ICRW and the actions of IWC. The North Atlantic Marine Mammal Commission (NAMMCO) is a regional organisation which has been established by those countries that consider that sustainable exploitation of whales is justified.

The adoption of Annex V to the OSPAR Convention is a relatively recent development in providing protection for biodiversity and specified species and habitats, but it is yet to be seen how this Annex will be implemented in offshore waters. National Portuguese legislation has been introduced to implement the EC Habitat Directive (92/43/EEC) in the coastal and EEZ waters around the Azores, otherwise EC Directives do not apply to Region V. The provisions of the Conventions on Sustainable Development and Biodiversity should be applicable to Region V, but so far the focus has mainly been on terrestrial and inshore habitats and species.