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ASSESSMENT OF THE PRESENT STATE OF POLLUTION BY PETROLEUM HYDROCARBONS IN THE MEDITERRANEAN SEA

In Co-operation with

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PREFACE

The purpose of this document is to summarize information on the sources of inputs and observations of petroleum hydrocarbon levels in the Mediterranean, on the biological effects of the contamination and on existing legal, administrative and technical arrangements for the protection of the Mediterranean from petroleum hydrocarbon pollution.

The combination of the scientific, technical and legal aspects will provide a good basis for the development of proposals for control measures.

It is recognized that there are considerable differences in scientific basis and operational framework for the scientific aspects on the one hand and the legal and technical control aspects on the other hand. Several Conventions exist, including the Barcelona Convention, relevant to the latter aspects, while the scientific and observational basis is provided through individual research and through the monitoring and research component of the MED POL.

In view of these differences and in order to facilitate the further development, the document is divided into two separate parts:

- the present state of pollution of the Mediterranean Sea by petroleum hydrocarbons (Part A), and,

- legal, administrative and technical arrangements for the protection of the Mediterranean Sea from petroleum hydrocarbon pollution (Part B).

It is clear, however, that both parts need to be considered in the further development of best possible measures for control, protection and prevention, which is the ultimate goal of this work.

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P A R T A

THE PRESENT STATE OF POLLUTION OF THE MEDITERRANEAN SEA BY PETROLEUM HYDROCARBONS

EXECUTIVE SUMMARY

The present information about the inputs of petroleum hydrocarbons and pollution sources to the Mediterranean is still limited. The overall estimates of sources and inputs converge on input of 0.6 million tonnes of petroleum hydrocarbons per year to the Mediterranean.

An assessment of the fluxes and fates of petroleum hydrocarbons is carried out on the basis of the estimated inputs, although detailed information about some of the main components, especially the biological fate (biodegradation, etc.) in the area, is lacking.

Data on concentration levels of petroleum hydrocarbons in the Mediterranean ecosystem have increased during the last years, especially with regards to concentrations in water and on beaches. The amounts of petroleum hydrocarbons in marine organisms and sediments in the area are still poorly known however. The available data covers mainly the coastal zone and thus the contamination of the open waters is less well known.

In order to gain uniformity in reported data on concentrations of hydrocarbons in sediment, biota and water, several intercalibration exercises have been carried out covering sampling and analytical techniques and advances within this field are clearly demonstrated.

The results show that concentrations of dissolved/dispersed hydrocarbons in water varies considerably through the entire area presumably due to the distribution of the various sources. Concentrations vary generally between 0 ug/l and 5 ug/l, although a small number of values exceed 10 ug/l.

The observations over the period 1969-1985 of tar in the Mediterranean Sea show mean concentrations of pelagic tar in the area from 0.6 to 130 mg/m^2 and mean quantities of tar on beaches from 0.2 to 4388 g/m. Thus a considerable variation has been observed. However, measurements of pelagic and beach tar conducted after 1980 suggest a decrease in tar quantity within the last few years, especially in the areas of the Eastern Mediterranean.

Petroleum hydrocarbons have been measured in the Mediterranean Sea at several occasions within the last years. However, there is a great need for further data especially in the Eastern Mediterranean. The results show an increased level of petroleum hydrocarbons in the sediments compared to the concentrations in the water. This suggests that the sediments in certain areas of the Mediterranean Sea accumulate petroleum hydrocarbons.

Few studies have been carried out on the uptake and levels of petroleum hydrocarbons in marine organisms from the Mediterranean Sea. These results therefore do not provide sufficient information about the pollution state of the ecosystem of the Mediterranean Sea as a whole.

On the basis of the available data on the distribution of petroleum hydrocarbons in the different environmental compartments a mass balance is estimated. The very preliminary estimate suggests a total amount of petroleum hydrocarbons of approximately 716 x 10^3 tonnes/year. This amount should be compared with the estimated yearly input of 635 x 10^3 tonnes/year which may indicate a possible accumulation of hydrocarbons in the Mediterranean ecosystem. However, the uncertainly of the mass balance is such that no firm conclusions can be drawn, but to state there is a clear need for more data so as to improve the mass balance.

Practically no observations exist on effects of petroleum hydrocarbons on marine organisms in the Mediterranean and no conclusions can be made on the effects of oil pollution in this area.

The major gaps of information are on inputs and levels of petroleum hydrocarbons along certain parts of the Southern shore. Information is also sparse on levels in the deep-sea sediments and in the open waters especially in the Eastern Mediterranean and finally there is a great need for information in the entire area on the effects on marine organisms of long-term input of low level contaminants.

INTRODUCTION

The Mediterranean, a semi-enclosed sea, with a surface area of 2.96 million km^2, is surrounded by mountains except on the southeastern desert coast. The coastal plains are small and narrow compared to the general feature along the Atlantic Ocean. Large alluvial plains are situated in the deltas of great rivers such as the Ebro, Rhone and Po. In addition, the Nile delta is an essential part of the Eastern Mediterranean environment, although its hydrographical significance has changed with the construction of the Assuan dam. Figure I shows the Mediterranean and its regional seas.

The average depth of the Mediterranean is 1500 m with maxima of 5000 m. The sea has a volume of 3.7 million km^3 and a renewal period of 80 years for its water. There are three important sills in the Mediterranean: the Straits of Gibraltar (365 m depth), the Sicilian Channel (350 m) and the Dardanelles (100 m). The first one, with a width of 15 km separates the Mediterranean from the Atlantic Ocean and makes it an almost enclosed sea; the second divides it into a western and an eastern basin, the third separates it from the Sea of Marmara and the Black Sea.

The evaporation rate is extremely high, so that surface circulation result in a net influx of surface waters from the North Atlantic and Black Sea. The rate varies over the entire area. In the Agean Sea, the Adriatic Sea and the Ligurian Sea (Fig. 1), the evaporation balance is zero whereas a high evaporation rate is found in the Eastern Mediterranean, the Golf of Sirte and in the Central Western Mediterranean. The average salinity of the Mediterranean is 38°/oo against 35°/oo in the Atlantic Ocean.The Mediterranean is surrounded by 18 countries, some of which are among the most industrialized countries in the world.Over 200 million people live along its coasts and in areas which contribute to river run-off into this sea.

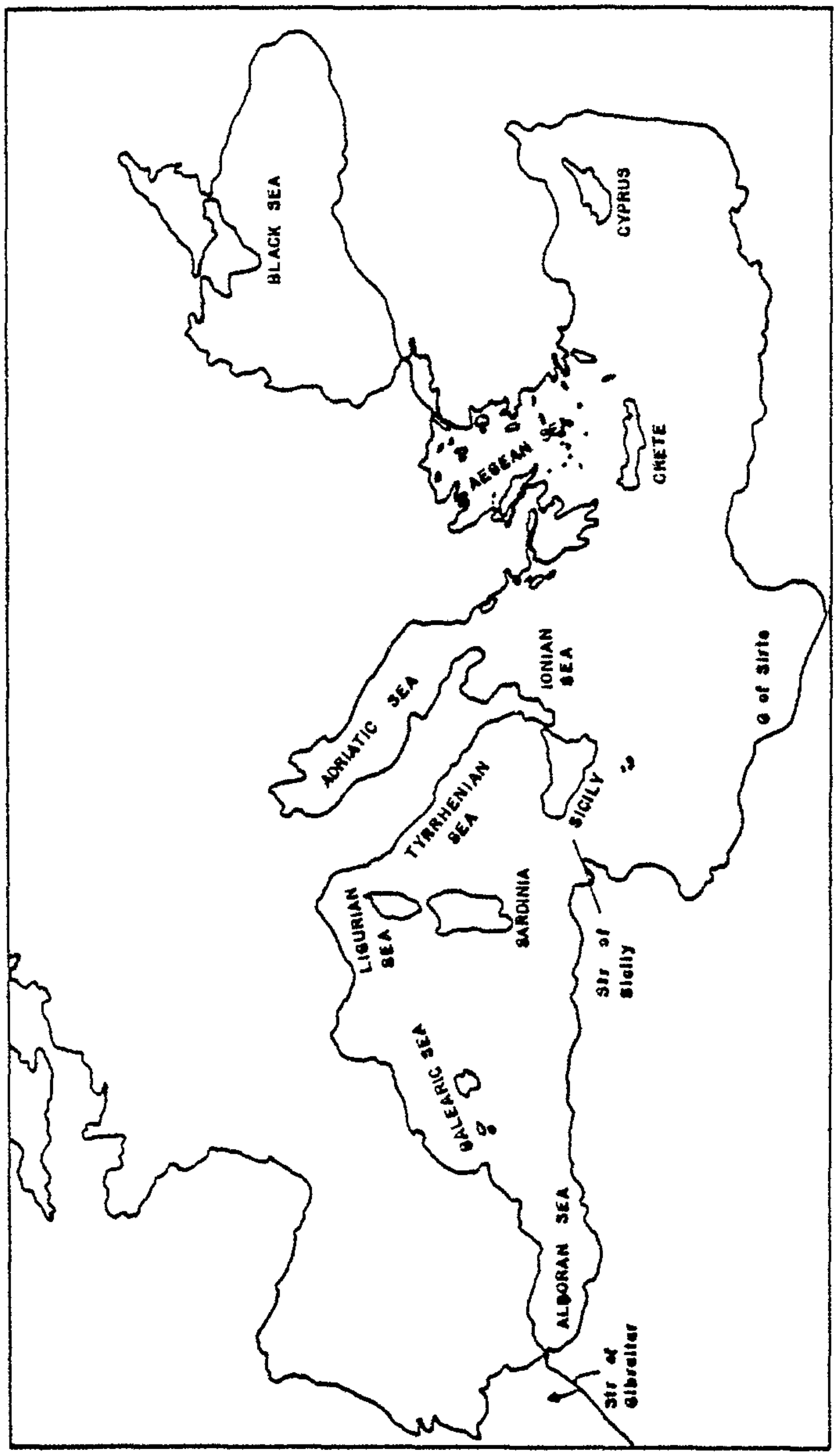

Figure I : The Mediterranean Sea and its regional seas

Oil pollution is not a new phenomenon in the Mediterranean. Natural seeps have existed over geological times, particularly in the northeastern parts. However, the oil pollution of anthropogenic origin is substantial and considerable amounts are frequently observed, mainly as lumps of tar on beaches or off-shore often together with surface film contamination. In fact, the Mediterranean is considered to be relatively more polluted by oil than any other sea from which data are available (NAS, 1975, UNEP, 1980).

The Mediterranean has so far been spared from major oil spills. However, a large number of minor accidental or deliberated spills occur each year in connection with oil transport activities within the region. Pollution is observed along the tanker routes particularly in the eastern parts of the sea (IOC, 1981). In addition, considerable quantities of oil are also released from coastal urban and industrial areas (UNEP, 1977).

A number of monitoring activities to assess the oil pollution in the region have been carried out from Mediterranean research centers. These studies have mostly been part of the Mediterranean Action Plan. Although there is still a lack of knowledge in a number of fields, parts of the problem have been studied during the last decade, for example the quantitative and qualitative assessment of dissolved/dispersed hydrocarbons in water and of tar on beaches and in surface waters. More recently, interest for other components, especially benthic and marine atmospheric environments and marine biota has been developed, giving rise to the first rough estimates of fluxes and mass balance of petroleum hydrocarbons in the Mediterranean.

1. SOURCES AND INPUT OF PETROLEUM HYDROCARBON POLLUTION IN THE MEDITERRANEAN

1.1 Input of petroleum hydrocarbons into the marine environment ranges from diffuse chronic inputs (terrestrial run-off and natural seeps) to large point source releases (e.g. tanker spills). Deliberate release of oil into the world's oceans from marine operations or land-based activities are relatively more important pollution sources than accidents involving single massive inputs of oil (table 1). Although there is very little data for the relative importance of the different sources in the Mediterranean, the deliberate chronic oil pollution is cosidered far more important compared to accidental pollution (Jeffery, 1974, Le Lourd, 1977).

1.2 In 1979, Le Lourd estimated that the amount of oil released into the Mediterranean was between 0.5 and 1 million tonnes per year, with half discharges from the coast and half in the open sea. These represent about a fifth of the total marine oil inputs (around 4 million tonnes), which are released in a region representing no more than 1% of the total world oceans surface. Other authors (Longé, 1980) evaluated this quantity in 1.7 million tonnes, which is probably overestimated.

1.3 Le Lourd's estimate was based on local tanker practices and remains a reasonable figure. The amount of oil transported over the world's oceans has considerably increased (table 2) but despite this there has been a significant reduction of the quantity of oil discharged into the sea during transportation, due to the entering into force of the MARPOL Convention. Based on these estimates and on the 350 million tonnes of oil crossing the Mediterranean each year (Smith, 1975) it can be assumed that oil entering the Mediterranean by these practices is around 330 x 10^3 tonnes. Even a figure of 500 x 10^3 tonnes has not been considered unreasonable by IMO (UNEP, 1985). It must be considered that in late 1978, 10 loading terminals out of the 19 existing in the Mediterranean did not possess any deballasting installations, although they handled over 190 million tonnes of oil traffic. On basis of published data it does not appear reasonable to give a quantitative estimate of the input caused by lack of reception facilities for ballast water from tankers or for sludge and bilge water from all ships, although it is expected that resulting inputs may be considerable.

1.4 The estimates of inputs from other sources can be defined by inclusion of land-based industrial discharges summarized by Helmer (1977). There are more than 60 oil refineries located along the coasts of the Mediterranean. The input of petroleum hydrocarbons from these sources into the Mediterranean has been conservatively estimated at 20,000 tonnes per year (Rout, 1975). The main part of this oil comes from the old refineries, which were not designated with water treatment as a priority. Their water consumption is high and effluent streams are often not segregated. Often the waste water is only subjected to primary treatment. These refineries have a higher waste water flow and much higher pollutant load per tonne of crude processed, compared to the modern refineries. The modern refineries apply either air or recirculating water for cooling purposes which generate minimal quantities of waste water.

1.5 No figures or estimates are available regarding the amounts of petroleum hydrocarbons carried directly through land run-off into the Mediterranean or indirectly via rivers. As the pollution load and pollution pattern vary widely in rivers it seems impossible to transfer the results of detailed analysis from rivers outside the region without substantial amendments. However, as several of the countries surrounding the Mediterranean are among the most industrialized in the world, it seems very likely that considerable amounts of oil are entering the sea through run-offs from land. An overall input of 110,000 tonnes of oil from different industrial sources is estimated.

1.6 Urban inputs can be computed by using the estimates of Eganhouse and Kaplan (1981) of 1,014 g/year per person for urban populations and 398 g/year per person from rural areas. Taking into account the Mediterranean population distribution given by Henry (1977) results a total input of 160,000 tonnes of oil per year.

1.7 Finally, only very few studies are available on quantities of the amount of hydrocarbons entering the Mediterranean through atmospheric fall-out. However, it can be expected that considerable quantities arrive via the atmosphere as many of the Mediterranean countries are heavily industrialized and consequently burn large amounts of oil.

1.8 Combustion products are estimated from atmospheric fluxes given by Ho et al. (1983) at 35,000 tonnes per year, including dry and wet deposition. Although these fluxes were derived from two shipboard transects in the western basin, which probably is the more affected area by this type of pollution, the estimate represents a contribution only about 10% of the total worlwide input (Table 1).

1.9 The resulting value of 0,6 million tonnes (Table 6) fall within the Le Lourd's estimates.

Table 1. Inputs of petroleum hydrocarbons in the marine environment
(million metric tonnes per annum)
(from IMCO, 1981; and Baker, 1983; US/NAS, 1985)

	Best estimate	Probable range	US.Nat.Acad. of Sci.1985
Transportation	1.49	1.00-2.60	1.47
Tanker operation	0.71	0.44-1.45	0.7
Drydocking	0.03	0.02-0.05	0.03
Marine terminals	0.02	0.01-0.03	0.02
Bilge and fuel oil	0.32	0.16-0.60	0.3
Tanker accidents	0.39	0.35-0.43	0.4
Non-tanker accidents	0.02	0.02-0.04	0.02
Production platforms	0.05	0.04-0.07	0.05
Atmospheric	0.30	0.05-0.50	0.3
Municipal, industrial wastes, run-off	1.40	0.70-2.80	1.18
Natural seeps/erosion	0.03	0.03-2.60	0.25
Total	3.27	1.82-8.57	3.25

Table 2. Quantities of oil movement at sea and the size of the world's merchant and tanker fleets in 1970 and 1980
(from IMCO, 1981)

	1970	1980	Ratio 1980/70
Oil movement at sea (million tonnes)			
Crude oil	1,100	1,319.3	1.20
Product oil	255	268.9	1.05
Total	1,355	1,588.2	1.17
World's merchant fleet			
No. of ships	55,041	73,832	1.34
Tons gross tonnage	247,202,634	419,910,651	1.70
World's tanker fleet			
No. of ships	6,292	7,112	1.13
Total deadweight tonnes	169,354,743	339,801,719	2.0
Average deadweight tonnes	36,900	47,800	1.78

Table 3.- Loading terminals in the Mediterranean. (Longé, 1980)

Port	Max. ship tonnage	Facilities	Oil shipment (in million tonnes)	
TURKEY				37,5
Dortyol	35.000	YES	2,5	
Botas	150.000	YES	35,0	
SYRIA				38,0
Banias	120.000	NO	34,0	
Tartous	100.000	NO	4,0	
LEBANON				41,0
Tripoli	140.000	NO	23,0	
Sidon	150.000	NO	18,0	
ISRAEL				15,0
Ashkelon	150.000	YES	15,0	
EGYPT				41,5
Sidi Kreir	250.000	YES	40,0	
Marsa Al Hamra	100.000	YES	1,5	
LYBIA				108,5
Marsa Al Hariga	120.000	YES	17,5	
Zueitina	250.000	NO	31,5	
Marsa El-Brega	300.000	NO	12,5	
Ras Lanuf	265.000	NO	12,5	
Es-Sider	250.000	NO	34,5	
TUNISIA				16,0
La Sknirra	120.000	YES	14,0	
Ashtart	100.000	NO	2,0	
ALGERIA				36,0
Skikda	50.000	YES	7,5	
Bejaia	100.000	YES	13,0	
Arzew	100.000	NO	15,5	
			TOTAL	333,5

Table 4. Weighed average volume of liquid effluent discharged (m^3) per tonne of crude oil processed for European refineries (CONCAWE, 1977)

	Refineries constructed before 1960	1960-1969	since 1969
1969 performance	10.45	2.17	
1974 performance	6.37	0.92	0.38

Table 5. Weighed average oil content of European refinery effluents expressed as kg oil in effluent per 1000 tonnes or crude oil processed (CONCAWE 1977)

Refinery location	before 1960	1960-1969	since 1969
Coastal	80	10.6	1.82
Inland	56	4.1	0.92

Table 6. Inputs of petroleum hydrocarbons in the Mediterranean (10^3 tonnes per year)

Source	Estimate
- Spilled oil from tankers, ballasting and loading operations, bilge and tank washings.	330
- Land-based discharges, run-off	
Municipal	160
Industrial	110
- Atmospheric deposition	35
Total	635

2. PROCESSES AFFECTING THE BEHAVIOUR OF PETROLEUM HYDROCARBONS

2.1 Any anthropogenic input of hydrocarbons into the marine environment, once introduced to the recipient water body is subject to a subsequent series of physical, chemical and biological processes which define the biogeochemical cycle of oil at the sea. The understanding of the transport and fate of these inputs is of major importance for interpreting their environmental consequences and particularly for evaluating the capacity of the receiving waters to accept wastes without detrimental effects.

2.2 Physical factors and processes have the most significant initial effect upon oil discharged into the marine environment. Factors like spreading, dispersion, evaporation, dissolution and aerosol formation, emulsification, sorption onto particulate matter and settling of the oil alter the potential impact on the living marine resources. Meanwhile dynamical processes such as current, wave and tidal movements have also a pronounced effect on the marine oil pollution as they, together with the wind, control the advective and dispersive behaviour of oil in the sea. Talbot (1972) and Weidemann and Sendner (1972), among several others investigated the effect of these factors and processes in greater detail. However, some attention is given here to the transport processes of oil pollutants in the Mediterranean, as far as they affect the distribution and fate of oil pollutants in the Mediterranean, as far as they affect the distribution and fate of oil in the marine environment, i.e. factors mainly due to winds and surface currents are the main advective agents affecting these pollutants.

2.3 In general, circulation of the Mediterranean is influenced by several factors : the internal density distribution, the surface wind speed, the Coriolis force and the topographic features of the sea bottom. The tidal current has a negligible role in the general circulation of the Mediterranean. Except in certain limited areas such as the Gibraltar region, the Strait of Messina, the Gulf of Gabes, the North Adriatic and at Bosphorus and Dardanelles, the tidal amplitudes are small by world ocean standards. This, together with the existence of narrow continental shelves, results in very little tidal amplification along the Mediterranean coasts. Thus, as far as the net circulation is concerned, the tidal movements themselves generate very little net motion and are not considered as contributing to the net circulation. Particularly poorly flushed regions include the N. Adriatic and the Saronikos Gulf.

2.4 The Mediterranean circulation pattern has some stationary general features, but with noticeable seasonal variabilities. The winter pattern of the circulation has been obtained using geostrophic calculations by Ovchinnikov (1966) and a numerical model by Gerges (1976, 1977). The principal features of the winter circulation as obtained by both authors, as well as by previous investigators based on the distribution of hydrographic properties of the different water masses (e.g. Nielsen, 1912; Lacombe and Tchernia, 1960 and 1972; Wüst, 1961, etc.), indicate the tendency for general eastward flow along the north African coast and following the shore of Asia Minor into the Aegean and back to the Western Mediterranean as a general westward flow. The summer pattern is shown in Figure II According to Gerges (1977), the velocities of the surface drift currents are ranging from 15 to 30 cm/sec, having a general cyclonic direction. Due to the narrowness of the Gibraltar Strait, the velocities of the drift currents in this region are weaker (5-10 cm/sec). Greater velocities are noticed in the Ionian Sea, where values exceeding 35 cm/sec are indicated.

2.5 In addition the existence of some interbasin scale features has also been confirmed, e.g. the cyclonic features between Cyprus and Crete and between Crete and Cyrenaica. Another cyclonic feature exists in the northern Ionian, while in the south, in the Gulf of Sirte, an inticyclonic feature is indicated which is dynamically reminiscent of the Alboran anticyclone (Hopkins, 1983a). These features of gyratory motions are of particular importance, since in some other ocean areas, such as in the Sargasso Sea, gyres of the surface circulation tend to accumulate floating tar (IOC, 1981). Thus, one might expect that higher concentrations of oil be observed in the areas where gyres are usually dominating features.

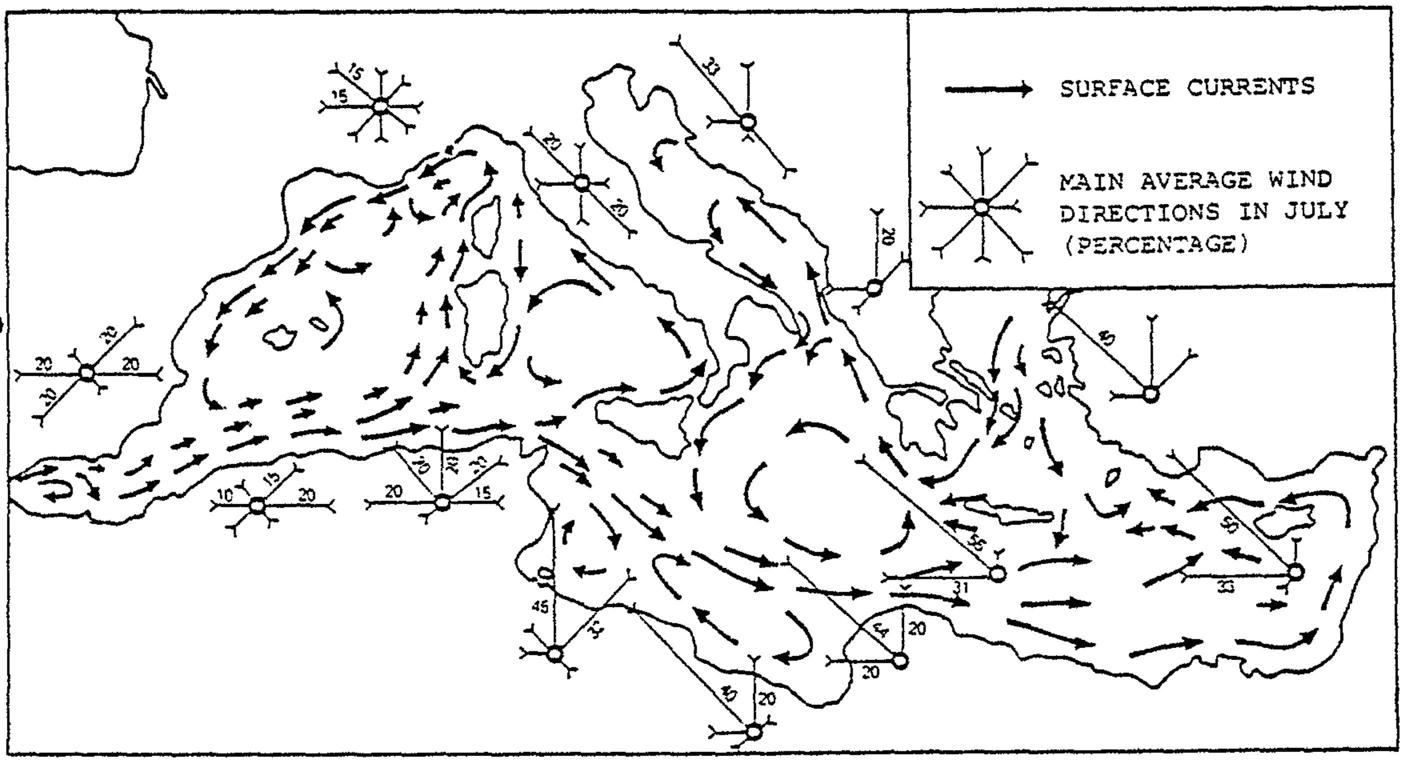

Fig. II. Surface currents and main winds in the Mediterranean in summer
From Lacombe and Tchernia (1972)

2.6 This general surface circulation of the Mediterranean has, in fact, much greater detail, particularly in the coastal areas. Moreover, it is also well known that the summer surface flow is more complex owing to more diverse and smaller-scale wind regimes. The increased complexity in summer is often manifested in smaller gyre-like flow cells; for example, the Tyrrhenian may have several cyclonic surface features in contrast to one basin-wide winter cyclone (Hopkins, 1983b). However, the principal features of the Mediterranean surface circulation as described by Ovchinnikov (1966) and Gerges (1976, 1977) are generally persistant.

2.7 Dispersal systems such as those discussed do not remove the pollutants from the environment but only redistribute them into the various reservoirs or compartments. An important point to be stressed here is that during transport, petroleum can be chemically fractionated by partitioning into the atmosphere, surface microlayer, water column (dissolved and particulate phases), sediment and biota, depending on the volatility, solubility and adsorptive properties of the components.

2.8 Selective chemical compositional changes of oil can also occur during weathering, both as a result of microbiological degradation and processes such as atmospheric oxidation. In the late sixties it was believed that degradation processes were the main answer to the question of the ultimate fate of oil spilled at sea. However, it was demonstrated later that they usually proceed slower than the disappearance of the oil from the sea surface, although both mechanisms are interrelated.

2.9 Although it is difficult to assess the relative importance of the above processes in the ultimate fate of petroleum hydrocarbons in the Mediterranean some estimates are given in Table 7.

2.10 Evaporation removes the most volatile fractions of the spilled oils, which contain a large portion of the acutely toxic volatile aromatic hydrocarbons. These fractions compose 20 to 50% of most crude oils and 10% or less of residual fuel-oils. Several mathematical models have been developed to give a quantitative description of this process (Butler, 1975). An average loss to the atmosphere of 30% of spilled oil inputs and 10% of land-based residues can be estimated, taking into account the particular hydrogeographical conditions of the Mediterranean. Recent studies have shown the air/sea exchange route to be the only route of importance for volatile hydrocarbons in seawater, compared to other possible sinks such as particle adsorption and sedimentation (Gschwend et al., 1982).

2.11 Tar formation from oil residues followed by stranding on shores has been estimated to occur for approximately 30% of spilled oil in the Mediterranean (NAS, 1975). This is higher than expected in the open ocean because of the increased probability of suspended tar contacting shores in an enclosed sea.

Table 7. Outputs of hydrocarbons in the Mediterranean (10^3 tonnes per yer)

Process	Estimate
Evaporation	125
Tar formation and stranding	100
Sedimentation	230
Biodegradation and biological uptake	180
TOTAL	635

2.12 Nevertheless, although petroleum tars are currently found on beaches, long-term buildup concentrations have not been reported, thus indicating that degradation of stranded tar occurs and that coastal stranding is not the only removal mechanism of the pelagic residues. Blumer et al., (1973) found that in temperate climates, the oil remaining on a beach retained, after one year, practically all of the original hydrocarbons above $n\text{-}C_{22}$ (b.p.> 320°C). Whether the ultimate fate of petroleum residues is due to biodegradation (in water and sediment) or sedimentation (burial) remains to be determined.

2.13 Sedimentation rates have been estimated from a long-term sediment trap experiment conducted off Monaco in the Western basin (Burns and Villeneuve, 1983). The rate reflects the situation of coastal waters but probably is an underestimate for estuaries where sedimentation is enhanced and substantial accumulation of petroleum in sediments has been noted (Albaiges et al., 1985). The processes occurring during sedimentation and particularly the mediation of biological feces have also been investigated but will be discussed in another section.

2.14 Based on the lack of positive evidence of large scale accumulation of petroleum in the Mediterranean, except in areas where petroleum inputs are large, biodegradation should account for the disappearance of the remaining residues. As estimated in table 7, this is one of the major output pathways.

2.15 The Mediterranean is a warm sea with bottom water temperatures above 10°C even in winter (Lacombe and Tchernia, 1972). Given favorable conditions, micro-organisms will degrade 50% or more of crude oil (Bayona et al., 1986). Microbial degradation greatly depends on the degree of dispersion of oil in water, hence, biodegradation becomes the preferential process by which dissolved hydrocarbons are removed from the sea (Button, 1976).

2.16 Outputs to adjacent bodies of water are considered to be insignificant to the flux calculations as the levels of petroleum residues are expected to be low in subsurface waters (Ho et al., 1982), which are generally exchanged into adjacent water masses.

3. CONCENTRATIONS OF PETROLEUM HYDORCARBONS IN THE MEDITERRANEAN

3.1 The number of reported data on hydrocarbon concentrations in water and on beaches has been steadily increasing during the last 10 years, mainly as a result of the activities generated by the projects MED POL I (Baseline studies and monitoring of oil and petroleum hydrocarbons in marine waters, UNEP) and MAP MOPP (IOC/WMO IGOSS Marine Pollution Monitoring Pilot Project). In this respect, the availability of reference methods (UNESCO, 1983) and the training facilities provided to the participating laboratories was of much importance. MED POL - PHASE II is yielding data obtained from laboratories which have participated in intercalibration exercises and which are using reference methods for sampling and analysis.

3.2 Comparatively little is known about the occurrence of hydrocarbons in benthic sediments, probably because of the later issue of a reference method (UNESCO, 1983) and the greater complexity involved in the determination. The information is even lower with respect to levels in marine biological samples, where a reference method has not yet been adopted.

3.3 The first large surveys were devoted to the evaluation of pelagic tars and dissolved/dispersed hydrocarbons in open waters. After the cruise by the R/V Atlantis II in 1969 (Horn et al., 1970), the region was surveyed in 1975 by R/V Westward (Morris et al., 1975; Zsolnay, 1979), in 1975 and 1977 by R/V Cornide de Saavedra (Faraco and Ros, 1979; Ros and Faraco, 1979) and in 1978 by R/V Meteor (Ehrhardt, unpublished data). Unfortunately, the large survey undertaken by the R/V Calypso in 1977-1978 (Cousteau, 1979) was only focussed on metals and organochlorinated compounds).

3.4 Since then, monitoring programmes in several mainly coastal areas are underway, involving dissolved/dispersed hydrocarbons, surveys of tar on beaches and petroleum hydrocarbons in sediments and marine biota. The Western Mediterranean basin has been more extensively studied than the Eastern.

The coasts of the Western Mediterranean are the most potentially affected by pollution due to the major concentration at its boundaries of urban population, industrial activities and river discharges (Helmer, 1977).

3.5 The available data are presented in tables 8 to 12.

Analytical techniques and quality assurance studies

3.6 The large number of analytical measurements performed in a regional monitoring programme and the participation of several laboratories necessitates the existence of a common basis for comparing data, enabling their integration in a coherent data set. At present, there are several difficulties, some arising from the analytical methodologies themselves and others derived from the little knowledge on the comparability of hydrocarbon data among laboratories of the area.

3.7 From the methodological point of view it should be considered that petroleum hydrocarbon contains a large suite of molecular types of hydrocarbons (namely saturated and unsaturated aliphatic, aromatic and heteroaromatic) which require elaborated protocols for their isolation and analysis. Hydrocarbons are also supplied by other sources, such as coal-tars and combustion products, each one contributing with characteristic compounds or mixtures of compounds. Finally, the marine environment contains also a variety of biogenic hydrocarbons related to the primary productivity, which are particularly abundant in the surface waters of the coastal zones. Therefore, it is practically impossible to select any particular technique suitable for the analysis of all hydrocarbon types in all matrices. Excellent reviews have been published, enabling laboratories to select the most appropriate methods (Farrington et al, 1980; Clark and Brown, 1977). In this respect there is some controversy about which methodology to apply for assessing petroleum contamination. Some claim, simple, rapid and less discriminatory analytical methods for survey type monitoring (e.g. UV-fluorescence), while others advocate sophisticated and more specific methods for measuring a suite of indicator compounds (e.g. COM-GC-MS), although usually economic considerations and the availability of trained personnel are the major constraints in such studies.

3.8 Another difficulty arises from the variety in quantification methods. Although a description of recommended techniques for measuring oil in water and beaches is given (UNESCO, 1983) results of beach tar, for example, are expressed sometimes in units of weight/area and sometimes in weight/meter of beach line. Concentrations of petroleum hydrocarbons measured by UV-fluorescence are often reported in terms of chrysene equivalents or in crude oil units. Sediment and biological tissues can be analysed fresh or dried and consequently the results can be reported on a wet or dry weight basis. When GC analysis is carried out, there is a large suite of parameters to report petroleum pollution (n-alkanes, pristane, phytane, UCM, PAHs, etc...).

3.9 On the other hand the frequency distribution of any data set for a given area is very variable. It should be considered not to publish the data until a sufficiently large number of samples allow an adequate statistical analysis, for the assessment of spatial and temporal variations.

3.10 The problem of data quality control must be seriously considered. One method to increase quality control is through the participation of laboratories in intercomparison exercises. Ideally, an intercomparison exercise would be conducted with a specified method applied to a reference material that has been certified to contain a known amount of constituents of concern. These materials are not available for petroleum hydrocarbons, because of the complexity in defining and quantifying the analyte.

3.11 Alternatively, interlaboratory comparison exercises may be performed using field samples (sediment or tissue homogenates) that have been collected in sufficient quantity to permit wide distribution and that have been homogenised as well as possible. In addition, the gathering of analysts in a common exercise who compare their individual methods and discuss analytical differences in order to investigate their sources, will guarantee the validation of data on a regional basis. This is absolutely necessary when the component to be analysed is sea water, because of the difficulties in distributing samples.

3.12 Very recently, several laboratories of the region had the opportunity to participate in different exercises concerning hydrocarbons in water (DDPH), sediment and biota.

3.13 In November 1984 an intercalibration exercise for oil and petroleum hydrocarbons was held in Barcelona (IOC/CSIC/UNEP/MED CAL I) following a recommendation of the Working Group for Scientific and Technical Co-operation for MED POL (Athens, 21-25 November 1983). The participants in the exercise were from 9 countries.

3.14 Each laboratory group made an analysis for DDPH in water samples collected in a fairly polluted area, following the procedure given in M/G No. 13 (UNESCO, 1983). Measurements gave a concentration of 1.65 µg/l of chrysene equivalents (excluding two outliers) with a 33% relative standard deviation (RSD), which was considered as satisfactory for this level of concentrations. In a similar exercise held in Bermuda (December, 1984) a 60% RSD was obtained for measurements at much lower levels (0.057 µg/l). The method is indeed very sensitive, so that the problem of blanks must always be carefully checked. In 1986 a similar intercalibration exercise was repeated in Barcelona with 11 participants, also with a satisfactory result.

3.15 Although there is a question about the meaning of the measurements in the open ocean samples as the fluorescence is not only related to the occurence of petroleum hydrocarbons but also to other biogenic compounds, the method is adequate for "hot spot" determinations. In addition, the scanning of the whole spectra in the normal or synchronous modes provide useful information about the hydrocarbon sources (Solonas et al, 1982).

3.16 During the IOC-CSIC-UNEP exercise a freeze-dried and sieved (< 250 μm) sediment sample was also analysed following the procedure given in M/G No. 11 (UNESCO, 1983). Total n-alkanes and the unresolved complex mixture (UCM) were calculated by GC, and aromatic hydrocarbons by UV-fluorescence. The precision of the results improved from total n-alkanes (RSD = 70%) to UCM (RSD = 45%) and to total aromatics (RSD = 26%), which is consistent with the degree of difficulty in sample handling and analysis. Obviously, GC analysis, especially with capillary columns, permits individual known compounds to be quantified, thus eliminating many of the ambiguities arising from the UV-fluorescence, although at the expense of precision. Notice, however, that even though the method involves a chromatographic separation, the precision of the results obtained for aromatic hydrocarbons using UV-fluorescence is of the same order of magnitude as that of hydrocarbons in water.

3.17 Finally, twelve laboratories (6 from France, 3 from Spain, Monaco, Malta and Cyprus) participated in 1984 in the ICES/IOC Intercomparison Exercise for hydrocarbons in biological tissue, performed on a freeze-dried mussel homogenate sent to each laboratory by the Bermuda Biological Station.

3.18 The number of laboratories was rather low taking into account that 129 having any ability to carry out analytical chemistry were contacted. It is interesting to note that none of the laboratories utilized GC-MS. Although in this case no particular method was suggested the results reported had a confidence limit of about 80%, which was not very much different from that reported by other participating regional groups.

3.19 However, these coefficients of variation should serve as a warning against overinterpretation of measurements, when designing and interpreting results of any future pollution monitoring programmes.

3.20 The lack of uniformity in reported data, the differences in sampling frequencies in different areas and the quality control of data generated by the different monitoring programmes are some of the questions that require further attention. Finally, a major training effort will be required in the Mediterranean region to ensure a widespread participation of laboratories in a petroleum monitoring programme.

Dissolved/dispersed petroleum hydrocarbons (DDPH)

Results of MAPMOPP in the Mediterranean Sea

3.21 The results of MAPMOPP have been reported in the IOC Report "Global Oil Pollution" (IOC, 1981). The data base consisted of 465 values, mainly concentrated in the eastern and central basins. Concentrations were generally between 0 and 5 µg/l, although a small number of values exceeded 10 µg/l. The overall arithmetic mean was 2.0 µg/l, however, this is not an appropriate indicator of central tendency when populations are highly skewed, as in this case. The frequency distribution after a logtransformation of the data suggested the presence of two different groups, one comprising samples with concentrations less than 0.4 µg/l and a second with higher concentrations. Geometric means of 0.04 and 2.0 µg/l provided acceptable estimates of central tendency for these populations (Table 8).

3.22 A possible interpretation is that the lower values represent the background level of DDPH in the region whereas the higher group indicates recent inputs of petroleum which had not yet become diffused. Another possibility is that of an artifact arising from the procedures used to obtain the data. However, the geographical situation of the samples more heavily polluted was in the eastern region, along the tanker routes (Table 8). Contamination levels in the western Mediterranean were lower, although there were insufficient samples for a meaningful statistical analysis. Despite the uneven sampling coverage of the whole area it is apparent that the levels found in the Mediterranean were significantly higher than those reported for other oceanic regions (Table 8). With the entering into force of the International Convention for the Prevention of Pollution from Ships (1973) as modified by the Protocol of 1978 (MARPOL 1973/78) this picture is likely to gradually improve.

3.23 In the following section an extended list of DDPH data is shown, particularly for areas that were not well covered by MAPMOPP. However, a preliminary assessment can be made of the concentrations reported so far.

Taking into account the following assumptions for the Mediterranean :

(i) a surface of 2.96 x 10^6 square kilometres,
(ii) a yearly input of 0.6 million tonnes of petroleum hydrocarbons (Table 6),
(iii) that most of the input occurs in the nearshore areas (Table 6),
(iv) the mean residence time in the top 100 metres is one year (Burns et al, 1985).

This results in an estimate to the order of 0.2 µg/l of total petroleum compounds to be expected in the top 100 metres of the open Mediterranean.

3.24 Errors in these assumptions so as to change the estimate by order of magnitude are highly unlikely, so that values exceeding this level in offshore areas should be considered cautiously and most likely represent either contamination in sample handling or a contribution by fluorescing biogenic compounds.

Western Mediterranean

3.25 The concentrations of dissolved/dispersed petroleum hydrocarbons in this part of the Mediterranean have been obtained from a number of cruises. Samples collected nearshore frequently show concentrations above 10 µg/l, particularly if they were taken close to industrialized areas or river mouths (Table 9).

Table 8.- Concentrations of dissolved/dispersed petroleum residues in the Mediterranean (n = number of values; c = arithmetic mean; s = standard deviation; G.M. = geometric mean). All values in µg/l (IOC,1981).

Region	Normal statistics			Logtransformed data	
	n	c	s	n	G.M.
Mediterranean	466	2.0	5.0	462	0.33
< 0.4 µg/l	219	0.07	0.08	215	0.04
> 0.4 µg/l	247	3.7	6.4	247	2.0
Aegean Sea	134	1.3	0.79	134	1.1
Eastern Region	133	5.5	8.3	131	1.5
< 0.4 µg/l	29	0.04	0.06	27	0.03
> 0.4 µg/l	104	7.0	8.8	104	4.0
Central Region	176	0.17	0.42	175	0.06
< 0.4 µg/l	156	0.07	0.07	155	0.05
> 0.4 µg/l	20	1.0	0.86	20	0.77
Western Region	22	0.02	0.01	22	0.02
Baffin Bay	104	0.11	0.12	93	0.09
Indian Ocean	45	60.1	92.7	36	8.9
Japan	1666	0.31	1.21	1640	0.13
North Am. East Coast	80	0.11	0.10	71	0.09
North Sea	90	0.02	0.12	9	0.15
South China Sea	272	0.20	0.28	256	0.10
Strait of Malacca	14	0.11	0.12	10	0.13

3.26 From the Spanish coast between Castellon and Cartagena results have been reported from sampling along nine transects (de Leon, 1984). This study showed concentrations between 0.06 and 8.26 ppb as mean values at each station. In Mar Piccolo, Taranto, Italy, concentrations ranging from 0.1-36 µg/l have been reported (Strusi, 1984). Mean values are 3.26, 7.42 and 7.98 µg/l from three sampling occasions. More precise determinations (GC) were carried out during the PHYCEMED cruises (Ho et al, 1982, Sicre et al, 1984). Concentrations of petrogenic hydrocarbons ranged between 1.1 - 4.5 µl/l for the aliphatic fraction and 0.1 - 0.8 µg/l for the aromatic one. During these cruises, relevant information was obtained on the accumulation of hydrocarbons in the air-seawater interface. Enrichment factors up to 50 were observed in the surface microlayer (Sicre et al, 1984), although the effect was more evident for the biogenic hydrocarbons. Table 10 summarizes the information obtained in this study which can be compared with that reported in Table 9 for the same area. Few or no values are available from countries along the North African coast.

Adriatic

3.27 Results of analyses of water samples are reported in Table 9. Most of these studies have dealt with the Rijeka Bay area, although recently data from Sibenik and Split have been obtained. Concentrations from these areas range from 0.1 µg/l and below in unpolluted zones, to 50 µg/l in polluted parts.

Central Mediterranean

3.28 The only concentrations reported from sampling offshore are those from Monaghan et al (1974). From nearshore areas (Libyan coast) Gerges and Durgham (1982) report concentrations between 0.6 and 28 µg/l. The highest values (10 - 28 µg/l) are reported from areas far from major industrial activities. Similar concentrations ranging from 0 (unpolluted) to 27.6 µg/l (polluted) were reported in a study by Marine Fisheries Research Center, Tripoli (MFRC, 1981). From coastal waters around Malta, concentrations between 0.02 and 0.29 µg/l have been reported (UNEP, 1980).

Table 9. Dissolved/dispersed petroleum hydrocarbons

Area	Year	Concentrations ug/l	Technique	Reference
Western Mediterranean (offshore)				
Northern part	1973	10-2200 (surface) (av. 448)	Fluorescence	Monaghan *et al.*, 1974
		3-37 (10 m) (av. 15)	"	"
	1975-77	2-6 (surface) (av. 3.3)	"	Faraco and Ros, 1978
	1981	1.5-21.1 (surface)	GC-n-alkanes	Ho *et al.* 1982
		3.5-4.6 (surface)	-UCM	"
		0.5-0.8 (chr. eq.)	Fluorescence	"
	1983	1.9 (surface)	GC-n-alkanes	Sicre *et al.* 1984
		1.3 (surface)	-UCM	"
Central part	1981	0.33 (chr. eq.)	Fluorescence	Ho *et al.*, 1982
	1983	0.68 (surface)	GC-n-alkanes	Sicre *et al.*, 1984
		1.37 (surface)	- UCM	"

Table 9. 'Dissolved/dispersed petroleum hydrocarbons (continued)'

Area	Year	Concentrations µg/l	Technique	Reference
Western Mediterranean (offshore)				
Southern part	1973	2-17 (surface) (av. 8.5) 2.7 (10 m)	Fluorescence	Monaghan *et al.*, 1974
	1974-75	av. 6.9 (surface)	"	Zsolnay, 1979
	1975-77	1-123.5 (surface) (av. 17.5)	"	Faraco and Ros, 1978
	1981	0.23 (surface) 0.81 (surface) 0.07-0.2 (chr. eq.)	GC-n-alkanes - UCM Fluorescence	Ho *et al.*, 1982 " "
	1983	0.31 (surface) 1.15 (surface)	GC-n-alkanes - UCM	Sicre *et al.*, 1984 "
Alboran Sea	1975-77	4.3-14.6 (surface) (av. 7.9)	Fluorescence	Faraco and Ros, 1978
	1981	0.2 (chr. eq.)	"	Ho *et al.*, 1982
Tyrrhenian Sea	1973	8-614 (surface) (av. 180) 3-19 (10 m) (av. 7)	"	Monaghan *et al.*, 1974
	1974-75	av. 4.8 (surface)	"	Zsolnay, 1979
	1975-77	1.9-20.5 (av. 7.4)	"	Faraco and Ros, 1978

Table 9. Continued

Area	Year	Concentrations ug/l	Technique	Reference
Western Mediterranean (nearshore)				
French coast, Banyuls-sur-Mer	1975-78	50-5000 (av. 580)	IR	UNEP, 1980
Var Estuary	1981	0.4-1.0	GC-UCM	Burns and Villeneuve 1982
Golfe de Fos	1983-84	290-30		MEDPOL phase II
Golfe dAjaccio	1983-84	100-0		MEDPOL phase II
Spanish coast				
Castellon	1983	1.36-2.40		de Leon, 1984
Sagunto	"	0.06-3.40		"
Valencia	"	0.63-4.35		"
Spanish coast				
Cullera	1983	0.06-3.10		de Leon, pers. comm.
Benidorm	"	0.60-1.80		"
Alicante	"	0.95-8.26		"
Guardamar	"	1.15-3.15		"
Portman	"	0.26-6.50		"
Cartagena	"	0.26-3.22		"
Italian coast				
Taranto, Mar Piccolo	"	0.2-11.6 (av. 3.26)	GC	Strusi, pers. comm.
"	"	0.5-23.0 (av. 7.42)	"	"
"	"	0.1-36.0 (av. 7.98)	"	"

Table 9. Continued

Area	Year	Concentrations µg/l	Technique	Reference
Central Mediterranean				
South Ionian Sea	1973	3-423 (surface) (av. 58)	Fluorescence	Monaghan *et al.*, 1974
		2-120 (10m) (av. 16)	"	"
	1974-75	av. 14.9 (surface)	"	Zsolnay, 1979
Malta, coastal waters	1977-78	0.02-0.29	"	UNEP, 1980
	1984	0.03-1.70 (av. 0.51)	"	" , 1985 (MED POL - PHASE II)
Libyan coast	1974-75	av. 24.9 (surface)	"	Zsolnay, 1979
W Sedra, Tripoli harbour Zawia	1980	20-28	"	Gerges & Durgham, 1982
Janzur, W&E Brega, Zawia W Khoms	"	12.5-19	"	"
Zlitan, Zwetina, Benghazi, E Sirte, Tajura		4.6-5.3	"	"
Sabratha, Derna, Sidi Blal		0.6-2.9	"	"
Libyan coast 171 samples from coastal areas	"	0.0-27.6 (av. 3.6 ppb)	"	MFRC, Tripoli 1981
Adriatic				
Yugoslavia, Rijeka Bay	1976-77	1-50	"	UNEP, 1980
		100-1100	IR	
" "		below 0.1	GC	Ahel & Picer, 1978
" "	1976-78	1-7 ("polluted") 0.2-0.5 ("unpolluted")	Fluorescence	Ahel, 1984
" , Sibernik area	1984	<0.2-16.4 (av. 1.4)	"	UNEP, 1985 (MED POL - PHASE II)
" , Split	"	av. 24.9 (surface)	"	" "

Table 9. Continued

Area	Year	Concentrations µg/l	Technique	Reference
Eastern Mediterranean				
Aegean Sea	1974-75	av. 20.5	Fluorescence	Zsolnay, 1979
Greece				
Coastal waters		below 3	"	Mimicos, 1980
Saronikos Gulf	1980-81	1.6-5.6	"	Gabrielides *et al.*, 1984
Aegean Sea	"	2.9-13.7	"	"
Thessaloniki harbour	1976-79	1500	IR	UNEP, 1980
Cavala harbour	"	2600	"	"
Strymonikos Bay	"	1100	"	"
Patraikos Gulf	1977-83	0.12-28.2	Fluorescence	Mimicos *et al.*, 1984
Ackeloos River estuary	"	1.3-4.5	"	"
Turkey				
Mersin-Akkuyu	1977-78	8.2-39.4	"	UNEP, 1980
Southern coast	1980-82	0.5-3.5 (av. 1.5)	"	Sunay *et al.*, 1982
Offshore between Turkey and Cyprus	"	2.0-6.0	"	"
Iskenderun Bay	"	0.7-7.0	"	"
Sea of Marmara	1983	0.88 (max.8.07)	"	Sakarya *et al.*, 1984
Izmit Bay	"	0.75-5.0	"	"
Aegean Sea	"	0.14-1.39	"	"
Mediterranean coastal waters	"	0.02-1.1	"	"
Iskenderun Bay	"	0.11-1.0	"	"
Candarli Bay	1983-84	1.20-80.0	"	Topcu & Muezzinoglu, 1984
Aliaga	"	0.53-7.30	"	"
Saros Bay	1983	0.77	"	"
Izmir Bay	"	9.40	"	"
Southern Aegean Coast	"	0.86	"	"

Table 9. Continued

Area	Year	Concentrations ug/l	Technique	Reference
Eastern Mediterranean				
Offshore South of Cyprus, Southeast of Crete	1975-76	10-40	Fluorescence	UNEP, 1980
Israel				
Ashkelon	"	9.4-19.4	"	"
Haifa Bay	"	15.0-15.6	"	"
Plamachin	"	10.7-12.5	"	"
Bardawil Lagoon	"	20.6	"	"
Tel Shikmona	"	1.1-45.3	"	"
Egypt				
Alexandria	1978-79	0.7-35.2 (av. 3.7)	"	Aboul-Dahab & Halim, 1980b
Alexandria	1979-80	6.6-41.4 (nearshore)	"	Wahby & El Deeb, 1980
		0.7-3.9 (offshore)	"	"
Mouth of Suez Canal	1980-81	0.5-14	"	Samra *et al.*, 1982
Cyprus, Limassol Bay	1983	2.6-8.1	"	MED POL - PHASE II
	1984	1.15-1.40	"	"
Larnaca Bay	1983	4.2-13.6	"	"
	1984	1.74-2.53	"	"

Table 10.- Hydrocarbons in the surface microlayer

Area	Year	Concentrations (in µg/l)	Technique	Reference
off-Monaco	1981	6.0 - 11.4 (n-alk) 23 - 61 (UCM)* 4.3 - 4.9 (arom.)	GC GC GC	Burns and Villeneuve, 1983
North Western basin	1981	1.0 - 13.48 (n-alk) 8.11- 22.1 (UCM)* 0.26- 0.35 (arom.)	GC GC UV-fl	Ho et al. 1982
	1983	0.55 (n-alk)	GC	Sicre et al. 1984
Central Western basin	1981	0.69 (n-alk) 6.8 (UCM) * 0.70 (arom.)	GC GC UV-fl	Ho et al. 1982
	1983	0.96 (n-alk)	GC	Sicre et al. 1984
South Western basin	1981	0.57 (n-alk) 0.25- 5.15 (arom.)	GC UV-fl	Ho et al. 1982
	1983	1.67- 1.86 (n-alk)	GC	Sicre et al. 1984
Alboran Sea	1983	1.4 (n-alk)	GC	Sicre et al. 1984.

* UCM : unresolved complex mixture

Eastern Mediterranean

3.29 Values ranging from 0.1 - 2.6 µg/l are reported for Greek coastal waters (Table 9), while concentrations in the range 1 - 2.6 mg/l were reported from harbour areas and were measured by infrared spectroscopy. However, some studies in areas quite far from major land-based industrial activities such as off-shore in the Aegean Sea, show concentrations over 10 µg/l. Sakarya et al, 1984, reported values between 0.14 - 1.39 µg/l from the Aegean Sea.

3.30 From Turkish waters, data ranging from 0.02 - 40 µg/l are reported (Sunay et al, 1982 ; Sakarya et al, 1984). Concentrations of around 1.5 µg/l are reported from coastal waters southwest of Mersin (Sunay et al, 1982). However, the same authors report concentrations of 2.0 - 6.0 µg/l from off-shore areas between Turkey and Cyprus. Concentrations up to 7.0 µg/l were reported from the industrialized Iskenderun Bay (Sunay et al, 1982). Sakarya et al, 1984, reported concentrations ranging between 0.11 - 1.0 µg/l from the northeastern Mediterranean coast off Turkey.

3.31 Concentrations between 10 and 20 µg/l have been reported from areas close to harbours, oil refineries, river mouths, etc, in Israel. High concentrations of dissolved hydrocarbons were found south of Cyprus (25 - 40 µg/l) and southeast of Crete (10 to above 40 µg/l), although more recently concentrations ranging between 2.6 and 8.1 µg/l are reported from Limassol Bay, Cyprus, and levels from 4.2 and 13.6 µg/l from Larnaca Bay, Cyprus, (unpublished report to IOC, 1984). This is another situation where an offshore contamination by ship traffic may have occurred.

3.32 Several reports are available on the oil contamination of coastal waters off Egypt (Aboul-Dahab and Halim, 1980; Wahby and El Deeb, 1980; Samra et al, 1982). Concentrations up to 30-40 µg/l have been reported in areas influenced by various industrial activities (Aboul-Dahab & Halim, 1980; Wahby and El Deeb, 1980). The same authors report concentrations below 10 µg/l and usually below 5 µg/l in offshore waters. One study of the petroleum hydrocarbon content of the waters reaching the Mediterranean from the Suez Canal has been reported by Samra et al 1982. This study showed that the water contained 0.5 - 14 µg/l.

3.33 However, some observations can be made which are worthy of note. Zsolnay et al (1978) report that the concentrations of "aromatic hydrocarbons" in Baltic Sea water are almost twice as high as those in the Mediterranean and almost 10 higher than in the northwest Atlantic, including the Sargasso Sea.

By contrast, the Mediterranean is reported to be more heavily polluted with surface-floating tar balls than the Baltic and the northwest Atlantic (see also para. 3.35). It would seem that there is little or no correlation between the quantity of tar derived from oil spills (and, by reference, the quantity of oil spilled) and the degree of contamination by DDPH. Indeed Zsolnay et al (1978) and Faraco and Ros (1978) found no such correlation in a group of samples taken throughout the Mediterranean. This can be explained on the assumption that dissolved hydrocarbons are derived from coastal industrial and municipal waste discharges, whereas pelagic tars are derived from tanker ballasts. However, another possibility is that dissolved hydrocarbons are leached out during initial deposition of tarry materials in the marine environment and their subsequent accumulation and transport then depends on different factors ,which include currents and concentration of other substances with which the materials interact . Currents partly driven by winds are the main transport actions for the surface layer materials.

Oil slicks, floating tar and tar on beaches

3.34 As a part of the MAPMOPP (IOC/WMO Marine Pollution Monitoring Pilot Project) visual observations of oil slicks were carried out from ships (IOC, 1981). Position, date, time and slick size were noted for observed slicks. Since it is as important to know which areas are not polluted as it is to know which ones are, a report was made during each 24 hour period, even if no pollution was observed. In the Mediterranean, surface slicks were present in more than 10% of the observations almost throughout the Region. These data compared with MAPMOPP results from other regions, provide evidence of a relatively extensive surface pollution in the Mediterranean.

3.35 Available data on pelagic tar from the Mediterranean (Table 11) show that between 1969 and 1983 mean concentrations in the Mediterranean ranged from 0.5 to 130 mg/m^2 and that the Ionian Sea was the most tar polluted area in the Mediterranean Sea. The data also suggest that normal values for offshore areas are up to 5 mg/m^2, while in nearshore waters, concentrations can be much higher -10 -100 mg/m^2.

3.36 The data also suggest that the eastern basin was the relatively most heavily contaminated by this pollutant source, although some indication of an improving situation was observed during the last ten years. Confirmatory evidence of the nature and sources of these floating tars (tanker deballasting waters) has been obtained (Albaiges, 1978).

3.37 The data on tar on Mediterranean beaches show considerable variation and mean quantities were found to range between 0.2 and 4388 g/m (Grolik 1986).

3.38 On the basis of geographical considerations, it seems that the areas in the Mediterranean where deballasting of oily waters and release of oily compounds into the sea were permitted until 1978 were areas for tar contamination. However, measurements of pelagic tar conducted after 1980 indicate that there may have occured a reduction in tar quantity especially in the Eastern Mediterranean during the last years.

3.39 Measurements on tar on beaches in Cyprus and in Israel conducted during a 10 years period (Golik, 1985. Demetropoulos, 1985), suggest a similar reduction of the quantities of tar in the Eastern Mediterranean. These findings show a drastic decrease in the amount of tar on beaches.

Table 11 : Pelagic tar in the Mediterranean Sea (mg/m²) (Golik, 1986)

Area	Period	Range	Arith-metic mean	Geometric mean	Reference
Alboran Sea					
	1969		6.5		Horn et al., 1970*
	1974-75	0.35-45.11	11.0	4.4	Morris et al., 1975
	1976	0.04-6.6	0.6	0.22	Ros & Faraco, 1979
	1981-82	0.01-25.6	0.8	0.17	De Armas, in press
Balearic Sea					
	1969		2.4	2.2	Horn et al., 1970*
	1972-73		3.1	2.5	Polikarpov and Benzhitsky, 1974*
	1974-75	0.1-27.9	0.5	0.4	Morris et al., 1975
north	1975-77	0-77.7	5.4	1.06	Ros & Faraco, 1979
south	1975-77	0.05-26.8	3.9	1.18	Ros & Faraco, 1979
	1981-82		3.6	0.63	De Armas, in press
Tyrrhenian Sea					
	1969		1.5		Horn et al., 1970*
	1972-73		4.7		Polikarpov and Benzhitsky, 1974*
	1974-75	0.2-14.7	3.2	1.4	Morris et al., 1975
	1975-77	0-10	0.9	0.3	Ros & Faraco, 1979
Ionian Sea					
	1969		130.0	60.0	Horn et al., 1970*
	1974-75	0.9-109.9	16.0	5.0	Morris et al., 1975
East Mediterranean					
	1970-71	0-58.3	5		El Hehyawi, 1979
	1977-79	0.2-1.33**			Wahby & El Deeb, 1981
	1978-79	0-8.91	2.82		Aboul-Dahab & Halim, 1981a
NE Medit.	1983-84	0-33.4			Saydam et al., in press

* Values are those quoted in Morris et al., 1975

** mg/m^3

Petroleum hydrocarbons in sediments

3.40 The application of the concept that sediments represent a sink for some pollutants, and hydrocarbons among them, has only recently been attempted in the Mediterranean. Studies have been conducted primarily in the Western basin, involving the French (Mille et al, 1982 and 1984) (Table 12).

3.41 Along the French coast between Fos-sur-Mer and Monaco, Mille et al, (1982) reported concentrations of aliphatic and aromatic hydrocarbons ranging between 20 and 950 µg/g. The highest concentrations were found outside a refinery.

3.42 Comparable results have been reported by Albaiges et al (1982) in sediments collected along the Spanish coast outside harbours, oil terminals and river mouths (1 - 62 µg/g of aliphatics and 2 - 66 µg/g of aromatics). In order to get some insight into the sources of these hydrocarbons, the extracts were analyzed for individual components by GC-MS. Levels of pyrolytic-like PAHs ranges from 0.3 to 2.3 µg/g dry weight. These concentrations are also similar to those reported by Mille et al (1982) and Burns and Villeneuve (1983) (0.6 - 0.7 µg/g) for the French coast. Two samples collected in the central part of the Western basis provided information about the background levels of petrogenic hydrocarbons for the area (1.2 µg/g of aliphatics, and 0.6 µg/g of aromatics).

3.43 In Mar Piccolo, Taranto, Italy, average concentrations of 14.7 µg/g aliphatic and aromatic hydrocarbons were found at 8 stations at depths from 1 to 10 metres (Strusi, 1984). Similar results have recently been reported for the Yugoslavian coast.

3.44 From the eastern Mediterranean, results are available from Cyprus and Turkey. From Cyprus concentrations of 0.114 to 1.35 µg/g are reported in sediment samples collected at 90m depth. From Iskenderun Bay, Turkey, average sediment concentrations of 0.24 µg/g were reported by Sunay et al (1982). The samples were collected at 10 to 90 metres depth and the range of concentrations were 0.04 - 0.68 µg/g. Recent measurements in Turkish waters have shown very low levels of petroleum hydrocarbons (Table 12).

3.45 In general, the hydrocarbon concentrations encountered in the area indicated a moderate contamination compared with other sites for which petroleum contamination has been assessed (2 - 1200 µg/g for the New York Bight and 45 - 730 µg/g for the California Bight). Nevertheless, the use of sediments for monitoring programmes of coastal zones looks promising for the recognition of land-based pollutant sources and, particularly, of "hot spots".

Petroleum hydrocarbons in organisms

3.46 Few studies have been carried out on the uptake of petroleum hydrocarbons in organisms from the Mediterranean. From the Spanish coast analysis of samples of fish and molluscs collected from the mouth of the river Ter and south to the Ebro delta, have been reported by Albaiges et al (1982); Balleter et al, (1982); Albaiges et al (1984; and Risebrough et al, (1983).

3.47 Risebrough et al (1983) used the technique employed in the Mussel Watch project in a study of petroleum hydrocarbons in molluscs from the Ebro delta. Mussels (Mytilus galloprovincialis), oysters (Ostrea edulis), and clams (Venus gallinae) were selected as the indicator organisms. Petroleum hydrocarbons were measured on the basis of the unresolved complex mixture (UCM) in the chromatograms of the saturated and aromatic fractions. The levels found were generally in the order of 100 - 300 mg/g. These concentrations were equivalent to those in mussels in the most polluted harbours and bays in California.

3.48 In another study by Albaiges et al, (1982), relatively high concentrations of petroleum hydrocarbons were found in bivalves from the same area (190 - 215 µg/g (dw)) (Table 13). Pelagic fish showed lower concentrations in tissue samples (less than 10 µg/g). A study by Ballester et al, (1982), of mussels from a drilling platform in the Ebro river delta, showed concentrations of up to 20-30 µg/g of n-alkans.

Table 12 Petroleum hydrocarbons in benthic sediments

Area	Concentrations (in µg/g)	Reference
French coast (Fos sur Mer to Monaco) (1979) Côte Bleue Les Embiez Monaco	 13-952 aliphatics + aromatics 69-93 " " 51-77 " "	 Mille, et al., 1982
Spanish coast (1980-1982) off Valencia 3-10m (0-5cm) off Alicante off Delta del Ebro off other Catalan rivers - river mouths and cities	0.6-2.3 (D/W) C_{14}-C_{20} (GC) 0.1-5.8 (D/W) C_{14}-C_{24} (GC) 0.3-1.1 (D/W) C_{15}-C_{24} (GC) 0.07-0.56 (D/W) "	J.A. García-Regueiro, et al., 1983 Sanchez-Pardo and Rovira, 1985
Ter river mouth (10-60m) (3 samples)	0.5 - 1.9 (D/W) n-alkanes (GC) 1.8 - 9.8 UCM 5.1 - 10.1 aromatics	Albaiges et al., 1982 and 1984
off Barcelona (10-80 m) (9 samples)	1.3 - 17.0 24.5 - 52 8 " " 3.1 - 66.8	"
off Tarragona (17-95 m) (6 samples)	0.9 - 5.[illegible] 4.8 - 77.1 " " 7.8 - 21.2	"
Ebro Delta (10-100 m) (5 samples)	0.4 - 3.2 1.3 - 12.9 " " 0.6 - 15.2	"
off Valencia (10-100 m) (5 samples)	0.8 - 1.0 3.8 - 12.3 " " 4.8 - 26.0	"
off Benidorm (10-100 m) (2 samples)	0.8 - 0.9 1.9 - 4.0 " " 2.8 - 5.5	"
Western Mediterranean (1000 m)	1.2- - 1.6 UCM " 0.6 - 2.3 . aromatics	"

Table 12 Petroleum hydrocarbons in benthic sediments (cont'd)

Area	Concentrations		Reference
Italy, Taranto, Mar Piccolo, 1983 8 stations (1-10m depth)	1.3-45 (av. 14.73) (L/W)		(Strusi, pers. communication)
Yugoslavia, Split, 1984	1.0-18.9 (D/W)	Fluorescence	UNEP report, 1985 (MED POL - PHASE II)
Cyprus,			
Larnaca Bay, 1983	0.114-0.135 (4 samples)	"	"
(90 m) 1984	0.442-1.301 (4 samples)	"	"
Limassol Bay 1984 (18-90 m)	0.308-0.417 (2 samples)	"	"
Turkey, Iskenderun Bay 1980-82, 10-90m depth	0.04-0.68 (av. 0,24 ug/g	PAHs (GC)	Sunay et al., 1982
Turkey			
Candarli Bay, 1983-84	0.0043-0.375 (fw)	Fluorescence	Topcu & Muezzinoglu, 1984
Aliaga, 1983-84	0.0175-0,025 (fw)	"	"
Saros Bay, 1983	1,0 (fw)	"	"
Izmir Bay, 1983	0.047 (fw)	"	"
Southern Aegean Coast, 1983	0.1575 (fw)	"	"

3.49 Petroleum concentrations of tissues of three species of fish (Mullus barbatus, Merluccius merluccius, Trachurus trachurus) have been reported by Albaiges et al (1984). This study showed that baseline levels in muscle tissues for the area between Barcelona and the French border were 1.5 - 12 µg/g and 1.7 to 8.4 µg/g (dw) of saturated and aromatic hydrocarbons respectively. Higher concentrations were found in fish off Barcelona and the Ebro river. The results are summarized in Table 13.In this study, it was also dhown that hydrocarbons are largely accumulated in liver and in adult species.

3.50 From data available it cannot be concluded that the higher concentration of petroleum hydrocarbons existing in the Mediterranean with respect to other oceanic areas have biological effects on pelagic fishes. However monitoring of selected species is desirable.

3.51 Few studies of the petroleum hydrocarbon contamination of marine organisms from other parts of the Mediterranean are available. From the coast of Turkey, notably from Iskenderun Bay, a study of the concentration of PAHs in fish has been carried out (Sunay et al, 1982). The average concentrations in muscles and livers were 0.13 and 0.79 µg/g, respectively.

3.52 From Mar Piccolo, Taranto, Italy, a study has been reported on the levels of hydrocarbons in mussels (Strusi, 1984). The results, which are given as wet weight concentrations, range from 0.5 - 10.1 ug/g with an average of 2.7 ug/g. If these concentrations were to be transformed into dry weight figures, they would become roughly ten times higher.

Table 13 - Hydrocarbons in biota samples from the Spanish Mediterranean Coast. (in µg/g dry wt) (Albaiges et al, 1982 and 1984)

Species	Area(year)	Saturate fraction (UCM)	Aromatic fraction (crude oil eq)
Mytilus (10 samples)	Palamós	106-190	-
	Barcelona	500-3200	-
	Ebro Delta	8-216	-
Mullus sp. (muscle) (14 samples)	Palamós	12.6	4.4
	Barcelona	22.2	9.3
	Ebro Delta	5.8	11.1
Merluccius sp. (muscle) (14 samples)	Palamós	1.5	1.7
	Barcelona	0.2	3.9
	Ebro Delta	0.2	2.4
Trachurus sp. (muscle) (14 samples)	Palamós	11.2	4.2
	Barcelona	1.4	10.9
	Ebro Delta	5.4	3.7
Engraulis sp. (muscle) (19 samples)	Barcelona	7.7	7.8

4. DISTRIBUTION OF PETROLEUM HYDROCARBONS IN MEDITERRANEAN ECOSYSTEM COMPARTMENTS AND TENTATIVE MASS BALANCE ASSESSMENT

4.1 A considerable amount of data is available on the distribution of petroleum hydrocarbons in some environmental components of the Mediterranean. A critical point in any long-term monitoring programme is the management and interpretation of the data generated. Monitoring is not simply an exercise in data accumulation (Albaiges and Frei, 1982), but should be designed to answer specific questions and, more important, it should be coupled to concurrent research and be adjusted as new information becomes available.

4.2 An assessment of the information available requires an adequate knwoledge of the biogeochemical processes controlling the transport andfate of petroleum residues introduced into the sea. This is why, more recently, attention has been focussed on the investigation of these processes. Thus, in 1981 and 1983, the PHYCEMED cruises were concerned with the evaluation of the atmospheric budget of hydrocarbons in the Western Mediterranean and with the investigation of mechanisms of exchange of these materials across the air/sea water interface (Hô et al., 1982 and 1982; Sicre et al, 1984).

4.3 The relative importance of these exchanges, as far as the atmospheric deposition is concerned, is assessed in Table 14. The atmospheric compartment, however, has been recognised not only as a source of hydrocarbons, mainly derived from combustion, but also as a sink for those which are volatized from the petroleum discharged to the sea. This two-way flux across the air-sea boundary is difficult to measure but requires further investigation.

4.4 In addition, semi-permanent traps have been set up by the Laboratory of Marine Radioactivity in Monaco (at 100 m depth in a 250 m water column approximately 2 km off the Monaco coast) to obtain information on the downward flux of anthropogenic substances in theLigurian Sea and particularly on the dominant processes controlling the transport to and retention of hydrocarbons in the sediment reservoir. These include biological uptake and concomitant faeces production, biological/chemical degradation and physical/chemical partitioning between marine compartments (Burns et al, 1983 and 1985).

Table 14 .- Estimated annual input of atmospheric hydrocarbons into the Western Mediterranean (Ho et al., 1982).

Transect (Fig. VI)	HCs	Deposition ($mg/m^2 yr$).	
		wet	dry
a-b	aromatic	0.04 - 0.44	0.025 - 0.25
	total	1.67 - 16.70	0.94 - 9.4
b-c	aromatic	0.05 - 0.5	0.03 - 0.3
	total	0.84 - 8.4	0.47 - 4.7

Table 15 .- Hydrocarbon fluxes at Monaco trap station (Burns et al., 1983 and 1985).

Fluxes	Hydrocarbons ($\mu g/cm^2 yr$).	
	Petroleum	Unresolved mixture
On zooplankton feces	8.2-9.0	—
At 100 m (a)	0.8-1.0	0.6-0.9
At sediments (b)	0.9	0.8

a) estimated from sediment trap material.

b) estimated from sedimentation rate and average sediment concentrations.

4.5 The quantitative importance of zooplankton feces in transporting organic contaminants and particularly petroleum hydrocarbons into sediments was estimated by Burns et al, (1985), by computing pollutant flux based on analyses of residues in feces and on estimates of fecal pellet production rates and average zooplancton biomass off Monaco. Average fluxes of the site (Table 15) were higher by a factor of six than those estimated for the Sargasso Sea (Sleeter and Butler, 1982).

4.6 On the other hand, Table 14 shows that although petroleum is relatively non-soluble and rapidly transported to depth on feces at the site, only about 10% of that falling through the water column survives long enough to be incorporated into the sediments. This discrepancy implies rapid biodegradation of the majority of petroleum hydrocarbons delivered to these sediments. In this way, sediments incorporate the most refractory components which can be used as tracers for flux and mass balance assessment.

4.7 The chemical characterization of the different marine compartments (dissolved, particulate and sedimentary), through the application of the molecular marker concept, has been carried out to gain some insight into the input sources and their fate in the sea (Albaiges et., 1984; Grimalt et al, 1984). Hydrocarbon inputs from domestic wastes, used oils, coal tars and fossil combustion were identifyed, providing evidence of urban run-off as the most important hydrocarbon input to coastal areas. PAHs are particularly abundant in sediments, thus being useful markers for establishing couplings between surface inputs, particle transport and sediment incorporation.

4.8 Residence times of hydrocarbons in surface waters were computed (by Burns et al, 1985), according to recent partitioning models and compared with those calculated from fluxes of settling particles and from sediment data (Table 16). The agreement in flux rates calculated from feces and sediment trap material suggests that the residence time of about 1 year is a reasonable estimate. The discrepancy with the calculation based on sediment concentrations again demonstrates the rapid rate of biological degradation at the sediment interface.

Table 16 - Estimated residence times of hydrocarbon residues in the top 100 m. of the Mediterranean water column (Burns et al., 1985).

Data base	Petroleum (years)
Surface particles and seawater conc.	0.6
Sediment trap material	1.0
Seawater and sediment conc.	10.5

Table 17 Distribution of hydrocarbons in the ecosystem compartments. (in 10^3 tonnes/year).

Beach tar	100
Surface microlayer	0.018
Floating tar	8.8
Surface water (0-5 m)	30
Subsurface water	72
Sediment flocculent layer	230
Sediments	120
Biomass	0.220
Atmosphere	155
Total	716

4.9 These calculations imply that significant changes in the input of organic contaminants to the Mediterranean should be detectable as changes in surface water concentrations within one year period.

Tentative Mass Balance Assessment

4.10 From these investigations on fluxes by Burns et. al. (1985), as well as from the data derived from monitoring activities (Tables 8 to 13) a crude estimate can be made of the amount of petroleum hydrocarbons associated to the different ecosystem compartments and the fluxes involved.

4.11 Using the above estimates and following the rationale established by the GIPME Programme (IOC.1984) for mass balance calculations by which inventories equal inputs on an annual basis and thus assuming that inputs are continuously replacing residues in each compartment as they are lost by the output processes, we obtain the results computed in Table 17. These estimates represent an updated calculation of that made previously by GEMSI ad hoc Working Group to identify existing gaps in mass balance/flux type information for contaminants in the oceans (GEMSI, Paris, 1983). The estimates were made taking a Mediterranean surface of 2.96×10^{12} m^2 and a volume of 3.7×10^{15} m^3. It is understood, that the mass balance is very crude.

4.12 Beach tar can be estimated as 30% of the spilled oil input as discussed under outputs. The estimate could be verified if large scale monitoring data were published for comparison.

4.13 Surface microlayer concentrations have been listed in Table 10. Values corrected for the thickness of microlayer sampled by each technique (0.44 mm for Ho et al and Sicre et al, and 0.11 mm for Burns and Villeneuve) gave an average of 6 $\mu g/m^2$ of petrogenic hydrocarbons in the microlayer. Pelagic tar can be estimated by averaging measurements reported in Table 11 to yield an average of 3.0 mg/m^2.

4.14 Many authors have reported values of petroleum hydrocarbons in surface seawater (Table 8) and levels range between 0.05 and 423 µg/l with averages in the range of 1 to 20 µg/l. The tabulated estimate is based on an average concentration of 2 µg/l down to a depth of 5 m as found in MAPMOPP (Table 9). Much uncertainty, however, exists for measurements of levels of petroleum in seawater and the estimate can only be regarded as giving the order of magnitude. Even more uncertainty exists for concentrations in subsurface waters. The few values reported indicate levels at least an order of magnitude lower than surface waters. The estimate for this compartment has been made assuming an average concentration of 0.02 µg/l.

4.15 The amounts within sediment flocculent layer cannot be estimated on the basis of data. However if it is assumed that the amount sedimented through the water column measured in the Monaco trap experiment (8 ug/cm^2) gives an order of magnitude value and for the Mediterranean an extrapolated crude estimate is obtained (Table 15). Coastal sediment content can be estimated from the calculated flux at the sediments underneath the sediment traps at 0.9 µg/cm^2 yr. Integrating this down to 2 cm depth and over 20% of the total area yields the value given in Table 17. The open sea sediment load can be computed by assuming open sea sediments receive deposits at the rate of 10% of the coastal flux per year. The few reports of sediment concentrations generally support this order of magnitude difference between concentrations in coastal and off-shore sediments (Albaiges et. al. 1982).

4.16 Biomass load in the western basin can be computed by assuming an average hydrocarbon concentration of 225 µg/g dry weight and a standing stock of zooplankton biomass of 1 g/m^2 when integrated over the top 100 m of the water column (Burns et al, 1985).

As it has already been mentioned, the atmosphere could be assumed to be a sink for volatile hydrocarbons discharged to the sea surface but also a source of combustion products. The atmosphere petroleum hydrocarbon budget has been computed from Tables 6 and 7.

4.17 The mass balance approach permits an assessment of the rates of dissipation of pollutant inputs and of the ecosystem components more affected. Ambient levels of petroleum in surface waters are causing relatively high levels of hydrocarbons in organisms and their feces. Values exceeding 6,000 µg/g dry weight have been measured in freshly defecated feces from surface zooplankton (Burns et Villeneuve, 1983). This and other indirect evidence suggests high levels of petroleum hydrocarbons are contained at the sea-sediment interface even in areas where levels in underlying sediments may be misleadingly low. There is urgent need to examine the deep sea sediments and their associated flocculent layers. Other critical reservoirs are the sea surface microlayer and the near surface seawater, as these determine the pollution load in the biota.

4.18 The uncertainty in measurements of trace levels of petroleum in seawater limits the usefulness of such data for determining long term trends in major ecosystem compartments.

4.19 The major weak parts in the mass balance for the Mediterranean are the estimates for the amounts in the deep sediments, the magnitude of atmospheric fluxes and the levels in oceanic particles and biota. More attention should be given to the determination of these parts in the mass balance. An assessment of the inherent uncertainties in the chemical measurements and identification of critical ecosystem compartments, will help devise more effective monitoring strategies.

5. EFFECTS OF PETROLEUM HYDROCARBONS

5.1 Oil tainting of seafood products has been reported sporadically from various areas in the Mediterranean Sea. Thus, some reports of oil taste in fish and mussels has been reported from Spain, France, Italy and Yugoslavia (Le Lourd, 1977). Environmental deterioration owing to oil pollution has also been reported in the Marmara Sea and Bay of Izmir in Turkey, as well as the Gulf of Naples and Cagliari, the lagoons of Venice and the Bay of Muggia in Italy (Le Lourd, 1977). In all these cases the reproduction of fishes and molluscs has been affected and fisheries have suffered. Apart from this, no studies of the effects of oil pollution on the Mediterranean ecosystems are available.

5.2 In other regions some investigations have been carried out which show the full spectrum of effects of oil-spills on the various parts of the ecosystems. Such studies are the ones following the accidental discharge from the "Torrey Canyon", Cornwall, England, 1967 (Southward and Southward, 1978); "Florida", west Falmouth, Massachusetts, USA, 1969 (Sanders, 1978); the "Amoco Cadiz", Brittany, France, 1978 (Laubier, 1980); the "Argo Merchant", Georges Bank, NW Atlantic Ocean 1976 (Univ. Rhode Island, 1978); and the "Tsesis", Baltic Sea, 1977 (Linden et al, 1979). All these spills have occurred in temperate climatic zones. The higher temperature of the Mediterranean environment may produce a slightly different impact. Thus, the acute effect might be somewhat more pronounced, while in the long-term, a recovery may occur more rapidly. However, it appears very likely that the general conclusions that can be drawn from these studies can be applicable also for spills occuring in the Mediterranean. Therefore, a brief summary of the general conclusions from the above mentioned spills will be given below.

5.3 The recovery of ecosystems affected by oil pollution varies considerably. In some cases, large spills have caused minor impact, while in other cases only very small quantities have causes severe and indeed long-term effects on large parts of the marine ecosystem. Both abiotic and biotic factors govern the extent of the biological consequences of each oil spill and it is the interaction and relative contribution of each of these factors that are important.

5.4 An abiotic parameter of importance for the extent of biological damage and the time required for complete recovery is the capacity for the polluted area of water to be diluted to concentrations too low tocause any lethal or important sublethal effects. It is clear that the quantity of oil and the morphology and hydrography of the affected area are important here. Therefore it seems quite obvious that single oil spills in off-shore areas with considerable water depth cause less biological damage than oil spilled close to the coast or in shallow and confined water bodies. The impact on sea bird populations may, however, be serious in any of these cases. The impact of the "Argo Merchant" accident seems to be an example of a spill which caused comparatively little damage to the ecosystems in the area while the "Florida" spill in West Falmouth, Massachusetts, is an example of a spill close to the shore where the oil concentrations in the confined water body rapidly reached toxic concentrations. However, the type of oil involved is also important in these two cases (see below).

5.5 In addition, the spills close to open coasts (i.e. no tidal flats or marshes) in areas with large tidal water amplitudes and good water exchange appear to cause considerably less damage than spills in atidal bays and archipelagos where winds and currents cannot dilute the oil. Although locally extensive, the damage caused by the large quantities of oil from the "Torrey Canyon" did not seem to cause very long-term damage. This however, does not apply to the areas where dispersants were used extensively in the clean-up of the oil. Considering the large amount of spilled oil, the limited results obtained so far from the "Amoco Cadiz" may also indicate a fairly rapid recovery, at least in exposed locations. The "Tsesis" oil spill on the contrary, although only involving a very small quantity of oil, caused comparatively long-lasting damage in the enclosed low-turbulent archipelago.

5.6 Most of the spill studies that have shown particularly long-term damage to the marine communities have been spills in which the oil is accumulated in fine-particle sediments in the inter-tidal or sub-tidal region, where the degradation and evaporation of the oil is slow or almost non-existent.

The long-term action of the higher molecular weight aromatic hydrocarbons on living organisms will become important under such circumstances. Examples of spills where the oil has been accumulated in sediments, thus prolonging the impact, are the "Florida" (West Falmouth), the "Arrow" and the "Tsesis" oil spills.

5.7 Another abiotic factor of high significance for the extent of the damage is the composition of the spilled oil. The light refined products such as No. 2 fuel oil or similar oils containing high proportions of light, readily soluble, aromatic hydrocarbons are considerably more toxic than normal crude oils or heavy refined oils. Furthermore, the light refined oils are usually more easily emulsified into the water body by wave action. The "Florida" (West Falmouth) oil spill involved such a light diesel oil with considerable long-term effects on the near-shore communities. The "Tsesis" oil spill, also occurring close to the coast and involving approximately the same quantity of heavy distillate (No. 5 fuel oil) causes less impact on the coastal ecosystem.

The Extent of Damage in Different Communities

5.8 Few studies exist on the effects of single oil spills on planktonic communities. Some effects were observed on phytoplankton following the "Torrey Canyon", Santa Barbara (Straughan, 1971) and "Tsesis" oil spills. These effects were, however, minor. Some impact on zooplankton was observed after the "Torrey Canyon" spill, although the effect was probably related to the toxicity of dispersants rather than oil. The "Amoco Cadiz" oil spill apparently resulted in effects on zooplankton up to a few months after the spill in off-shore areas. Following the "Argo Merchant" spill some effects were observed on zooplankton in the oil contaminated area. These effects did not, however, appear to be very drastic. After the "Tsesis" oil spill zooplankton were severely affected only immediately after the spill and in the close vicinity of the wreck.

5.9 Based on these observations it would appear that the impact of the oil spills on the planktonic community is not of a long-term nature. The water exchange and turbulence in off-shore areas rapidly dilute the oil and replace the affected communities. It seems likely that the period necessary for recovery of the plankton community from single spills, is usually a question of weeks rather than months.

5.10 Studies in the littoral zone are more frequent. Extensive and lasting damage was caused to the littoral communities after the "Tampico Maru", "Florida", "Arrow" and "Tsesis" oil spills. These accidents occurred in bays and estuaries where the spilled oil was not diluted sufficiently. In several cases the oil was also accumulated and retained in sediments. The spills from "Tampico Maru" and "Florida" also involved highly toxic products. The spill from "Amoco Cadiz" caused severe acute effects along the coast of Brittany. Except in the estuaries, however, the spill does not appear to have caused very long-term impact in the littoral zone. It appears from these studies that the impact on littoral communities may be drastic and lasting depending on a number of factors. The recovery of affected littoral communities is usually a question of several years. In the worst cases, the time necessary for a complete recovery of the ecosystem may take one or more decades.

5.11 Only a few studies are available on the impact of acute oil spills in benthic sub-tidal and sub-littoral communities. The studies following the "Florida" and "Tsesis" oil spills indicate, however, that the impact in this zone may be severe, and may perhaps last longer than in any other part of the ecosystem. The "Tsesis" oil spill caused effects in soft bottom sub-littoral communities that lasted longer than those in the littoral zone. The oil was incorporated into sediments and organisms and as the water exchange was limited and the temperature and oxygen content were low, the oil was preserved for a longer period than in the littoral zone.

5.12 The immediate effects of catastrophic oil-spills may be obvious, although their long-term consequences are often difficult to quantify, since the abundance of plants and animals in any locality fluctuates naturally from year to year and catches vary with fishing effort and so forth.

5.13 Assessing the impact of chronic pollution, which is the most common in the Mediterranean, is even harder, as it may not cause an appreciable increase in mortality, and other forms of pollution are usually also present. With these limitations in mind, however, one can make some generalisations about the biological effects of long-term, low level pollution of marine habitats by oil.

5.14 Among individuals, young stages are more sensitive than adults, while some species are more sensitive than others at any stage, as it has been described in comprehensive reviews (Nelson-Smith, 1975, IMCO et al., 1977). Some illustrative examples are given below.

5.15 It is well documented that even 1 mg/l of oil dispersed in seawater or 1 µg/l of water-soluble oil components can harm sensitive organisms. For example, it has been recognized that they may impede that the larvae hatching from fish eggs are healthy. Also, trace amounts of oil components in sea-water interfere with sex behaviour of marine animals, and they may have an effect on chemical orientation of marine organisms. Salmon fry, for example, avoid oil concentrations as low as 1.6 mg/l, which must frequently occur around a river mouth and which therefore disrupt their migration patterns. Exposure to low-boiling hydrocarbons at 12 mg/l halves the rate at which mussels can assimilate food, the effect is enhanced by low salinities and high temperatures to the extent that bivalves inhabiting estuaries or bays, where these conditions often occur, may not be able to breed in spring. Synergistic effects particularly between aromatic hydrocarbons and trace metals may also occur in natural environments.

5.16 Some organisms are, of course, more tolerant than others to chronic pollution. Sublethal effects will soon exclude particular groups and those surviving may be able to take advantage of the extra space or food which becomes available, so that there may not be a drop in the overall abundance of biomass, but in the species diversity. If the organisms which are excluded occupy a key ecological role, a major change may occur in the nature of the community. This has been demonstrated in shores crossed by refinery effluents (Crapp, 1971).

5.17 These ecosystem disturbances may have unforeseen effects for fishes and birds, simply because of the limitations of food.

5.18 Bearing in mind the importance of chronic inputs in certain Mediterranean coastal areas, where many effluents are incorporated into the sea without any treatment or regulatory constraint, it is expected that chronic effects occur, although at present, there is little or practically no information in this respect.

6. EVALUATION OF AVAILABLE DATA BASE AND STATE OF KNOWLEDGE

6.1 The review of the available data base on hydrocarbon levels in the Mediterranean Sea shows that most of the data are from coastal and nearshore areas with a lack of data from the open sea. Most of the data are not comparable in the sense that they have not been obtained by intercalibrated methods. Very little information is available on biological effects of petroleum hydrocarbon pollution from the Mediterranean Sea. A reliable scientific evaluation of the state of pollution and associated possible biological effects cannot be made on basis of existing data with reasonable confidence.

6.2 In order to improve the pollution assessment there is a need for data covering various parts of the Mediterranean Sea which have been obtained through agreed Reference Methods which have been intercalibrated. This could be achieved through one or more baseline studies so as to cover as large a part of the Mediterranean Sea as possible.

6.3 There is also need for investigations of coastal ecosystems and wildlife on oil-sensitive shorelines to determine where relative vulnerability to spilled oil, information which may provide a basis for oil-spilled response priorities, and aid in the selection of protection and clean-up methods for oil-sensitive areas.

6.4 There is a need for investigations of possible biological effects of chronic petroleum hydrocarbons pollution.

6.5 There is finally need for further studies of the fate of petroleum hydrocarbons in the marine environment in the Mediterranean Sea.

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PART B

LEGAL, ADMINISTRATIVE AND TECHNICAL ARRANGEMENTS FOR THE PROTECTION OF THE MEDITERRANEAN SEA FROM PETROLEUM HYDROCARBON POLLUTION

INTRODUCTION

The report which follows has been compiled at the request of the Co-ordinating Unit for the Mediterranean Action Plan as part of a series of documents being prepared for the purpose of assessing pollution of the Mediterranean by major pollutants monitored as part of the MED POL - PHASE II Programme. It reviews the current situation with regard to the assessment and control of pollution by petroleum hydrocarbons and highlights pollution from shipboard operations and the disposition of material therefrom. It also assesses the work of the Regional Oil Combating Centre in Malta and makes some recommendations which it is hoped will assist in promoting a pollution-free Mediterranean Sea.

Pollution of the sea by petroleum hydrocarbons does not entirely come from marine operations, in fact only slightly more than one-third of petroleum hydrocarbons which reach the sea emanate from maritime operations.

Table 1 in part A, page 8, shows the estimated quantities of petroleum hydrocarbons entering the oceans. The report of the National Academy of Sciences entitled "Petroleum in the Marine Environment" 1975, gave an estimate of 6.1 million tonnes per annum total input. The total of oil entering the oceans is thus estimated to have fallen by 45% over the decade 1975-1985 and the oil originating from transporation was reduced by 33%.

These figures were arrived at prior to the entry into force of the International Convention for the Prevention of Pollution from Ships, 1973 as modified by the Protocol of 1978 relating thereto (MARPOL 73/78), the implementation of which will result in a steady diminution in the amount of oil entering the sea as a result of tanker operations. It is probable that by the end of 1983 the global figure for oil entering the oceans as a result of maritime transportation had already fallen below the one million tonne level.

It is estimated that some 35% of ships engaged in the transportation of petroleum, loads, discharges or passes through the Mediterranean Sea. On this basis and taking the revised National Academy of Sciences figure of 1.44 millions tonnes (shown in table 1 part A, page 8) as the global figure for oil entering the oceans from ships, a figure of half a million tonnes of oil entering the Mediterranean Sea from that source would not appear unreasonable. However, with the advent of MARPOL 73/78 backed by suitable reception facilities, this figure should be dramatically reduced.

Note: This part was prepared in 1983-1984 by an IMO Consultant and as such does not necessarily reflect the views of the secretariat. It has since been only partly updated.

Other controllable sources of pollution of the sea are from land-based sources, from offshore oil production and from ocean dumping. Dealing specifically with the Mediterranean Sea, the Convention for the Protection of the Mediterranean Sea against Pollution (1976) covers abatement of pollution from ships in conformity with internationally accepted standards, and two of its related Protocols cover ocean dumping from ships and aircraft and pollution from land-based sources.

Certain of the Mediterranean coastal States are also Members of the European Economic Community or are Parties to such international treaties as the Paris Convention. Anti-pollution regulations and standards arising from such commitments are referred to in the following section.

1. LEGAL STATUS OF THE MEDITERRANEAN SEA AREA

International Conventions in Force in Mediterranean Sea Area

1.1 Table 1 sets out the position of Mediterranean States (with the exception of Albania which is not a signatory to the Barcelona Convention) with regard to International Conventions relevant to pollution of the sea by petroleum hydrocarbons.

1.2 The table shows that for all the 17 Contracting Parties to the Convention for the Protection of the Mediterranean Sea against Pollution ("The Barcelona Convention"), the Convention has entered into force. By article 6 thereof they are obligated to:

> "... take all measures in conformity with international law to prevent, abate and combat pollution of the Mediterranean Sea Area caused by discharges from ships and to ensure the effective implementation in that Area of the rules which are generally recognized at the International level relating to the control of this type of pollution".

1954 OILPOL with 1969 Amendments

1.3 All States for whom the Barcelona Convention has entered into force, with the exception of Turkey, are parties to the International Convention for Prevention of Pollution of the Sea by Oil 1954 (OILPOL), as amended in 1962 and 1969.

1.4 The relevant part of these latter amendments prohibits discharge from oil tankers into the sea of oil or oily mixtures within 50 miles of the nearest land. Beyond the 50 mile limit such discharge is restricted to an instantaneous rate of discharge of 60 litres per mile of oily residue whilst underway and limits the overall overboard discharge to one fifteen thousandth part of the cargo of which the residue formed a part.

1.5 Because of the geographical configuration of the Mediterranean Sea Area the 1969 amendments effectively prohibited the discharge of oil or oily mixtures in the Mediterranean Sea Area except for two small areas (one to the East and one to the West of Malta) where discharges at 60 litres per mile are permissible.

Table 1. Date of entry into force of conventions relevant to pollution of the sea

	Barcelona Convention 1976	MARPOL 73/78	OILPOL 54/69*	London Dumping Convention 1972	Civil Liability Convention 1969	Fund Convention 1971	Intervention Convention 1971	Intervention Protocol 1973
DATE OF ENTRY INTO FORCE	12 Feb.1978	2 Oct.1983	20 Jan.1978*	30 Aug.1975	19 June 1975	16 Oct.1978	6 May 1975	30 March 1983
COUNTRY								
Algeria	17 Mar.1981		20 Apr.1964		19 June 1975	16 Oct.1978		
Cyprus	19 Dec.1979		10 Sep.1980					
Egypt	23 Sep.1978	7 Nov. 1986	22 July 1963					31 March 1986
France	10 Apr.1978	2 Oct.1983	26 July 1958	5 Mar.1977	19 June 1975	16 Oct.1978	6 May 1975	
Greece	2 Feb.1979	2 Oct.1983	28 June 1967	9 Sep.1981	27 Sep. 1976	16 Mar.1987		
Israel	2 Apr.1978	2 Oct.1983	11 Feb.1966					
Italy	5 Mar.1979	2 Oct.1983	25 Aug.1964	30 May 1984	28 May 1979	28 May 1979	28 May 1979	30 March 1983
Lebanon	12 Feb.1978	2 Oct.1983	31 Aug.1967		19 June 1975		3 Sep.1975	
Libya	3 Mar.1979		18 May 1972	22 Dec.1976				
Malta	12 Feb.1978		10 Apr.1975					
Monaco	12 Feb.1978		25 June 1970	15 June 1977	19 Nov. 1975	21 Nov.1979	6 May 1975	
Morocco	14 Feb.1980		29 May 1978	20 Mar.1977	19 June 1975		6 May 1975	
Spain	12 Feb. 1978	6 Oct.1984	22 Apr.1964	30 Aug.1975	7 Mar. 1976	6 Jan.1982	6 May 1975	
Syria	25 Jan.1979		24 Mar.1969		19 June 1975	16 Oct.1978	6 May 1975	
Tunisia	12 Feb.1978	2 Oct.1983	11 Sep.1973	13 May 1976	2 Aug.1976	16 Oct.1978	2 Aug.1976	30 March 1983
Turkey	6 May 1981							
Yugoslavia	12 Feb.1978	2 Oct.1983	11 June 1974	25 July 1976	16 Sep.1976	16 Oct.1978	3 May 1976	30 March 1983

* Date of entry into force of 1969 Amendments.

1.6 Compliance with this Convention is extremely difficult to monitor and relies, in the main, on good operating practices by the vessel and on inspection of the tanker's Oil Record Book by Maritime Authorities since obtaining a representative sample of the vessel's overboard discharge is virtually impossible.

1.7 With much of the oil produced in the Mediterranean Sea Area being discharged at ports within the area it is difficult, within the time available on the ballast voyage, to carry out the "Load-on-Top" procedure devised by industry which is necessary to comply with the 60 litres per mile and one fifteen thousandth criteria. The cost of delaying the vessel in order to carry out this process would result in a prohibitive increase in the freight charged. In the absence of shore reception facilities residues are, in some cases, discharged into the sea despite the OILPOL Convention being in force for the coastal States.

1.8 Nevertheless, it should be noted that this is the only international convention on prevention of oil pollution to which virtually all Mediterranean States subscribe.

MARPOL 73/78

1.9 The International Convention for the Prevention of Pollution from Ships, 1972, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78) entered into force on 2 October 1983 and at that time seven Mediterranean States were parties thereto - one State, however (France) had made the following important declaration with regard to the provisions relating to the Mediterranean Special Area:

> "As far as the Mediterranean Sea area only is concerned, the provisions of Regulation 10 (paragraph 2) of Annex I of the Convention can be applied to tankers engaged in voyages within the Mediterranean only if such tankers are proceeding to a port equipped with the reception facilities required by Regulation 12 of the Convention".

For an eighth State (Spain), the MARPOL 73/78 Convention entered into force on 6 October 1984.

1.10 It should be noted that the definition of oil or oily mixtures was extended by MARPOL 73/78 to include all hydrocarbon oils (both "black" and "white" oils) whereas OILPOL 54 with its amendments dealt only with "black" oils. "White" oils, being refined products of crude oil, are generally more volatile and therefore less persistent in the marine environment. However, since the aromatic content is higher their initial impact upon the environment may be greater.

1.11 MARPOL 73/78 lays down discharge criteria for all oil tankers of 150 gross tons and above. However, tables 2, 3 and 6 in this report, which have been prepared from industry data, cover only ships of 10,000 dwt (approx. 6,000 grt) and above. They are therefore not entirely complete but the inclusion of vessels between 150 grt and 10,000 dwt in the figures would not make any significant difference to the overall picture they present.

1.12 Table 2 shows that the eight Mediterranean States which are Contracting Parties to MARPOL 73/78 and to the Barcelona Convention between them have 449 tankers under their flags which represent 15.77% of the carrying capacity of the world fleet.

Table 2. States for which MARPOL 73/78 has entered into force with number of tankers above 10,000 dwt and percentage of world fleet by carrying capacity at 31.12.83

State	No. of tankers over 10,000 dwt	Percentage of world fleet at 31.12.83
BARCELONA CONVENTION STATES		
Egypt	5	0.05
France	58	3.67
Greece	254	7.46
Israel	-	-
Italy	76	2.18
Lebanon	1	-
Spain*	55	2.34
Tunisia	-	-
Yugoslavia	5	0.12
Sub-total Barcelona States	454	15.82
OTHER STATES		
Bahamas	21	1.24
Belgium	9	0.18
China	50	0.55
Colombia	1	0.01
Czechoslovakia*	-	-
Denmark	48	1.60
Finland	31	0.78
Gabon	1	0.05
German Democratic Republic	2	0.03
Federal Republic of Germany	26	1.24
Japan	193	9.30
Liberia	598	26.98
Netherlands and Neth. Antilles	33	1.00
Norway	147	6.67
Oman	-	-
Peru	7	0.09
Republic of Korea*	15	0.56
St. Vincent and Grenadines	-	-
Sweden	24	0.94
USSR	199	2.21
U.K.	175	5.39
Uruguay	2	0.06
U.S.A.	289	5.82
Sub-total other States	1,871	64.70
TOTAL	2,325	80.52
No. of tankers above 10,000 dwt	3,160	
% by vessels of MARPOL States	82.84	

* Entry into force October 1984

1.13 The nine other States which are Contracting Parties to the Barcelona Convention, but not to MARPOL 73/78, have 99 tankers under their flags representing 2.86% of the world fleet (table 3).

Table 3. Barcelona Convention States which have not ratified MARPOL 73/78 with number of tankers above 10,000 dwt and percentage of world fleet by carrying capacity at 31.12.83

State	No. of tankers over 10,000 dwt	Percentage of World Fleet at 31.12.83
Algeria	11	0.38
Cyprus	44	1.28
Libya	13	0.52
Malta	-	-
Monaco	-	-
Morocco	7	0.08
Syria	-	-
Turkey	19	0.55
TOTAL	94	2.81

Definition of "Special Area"

1.14 By Regulation 10 of annex I of MARPOL 73/78 (which regulates pollution by oil and oily wastes) the Mediterranean Sea is declared a special area for the purpose of that annex. A special area is defined by Regulation 1(10) of that annex as:

> "... a sea area where for recognized technical reasons in relation to its oceanographical and ecological condition and to the particular character of its traffic the adoption of special mandatory methods for the prevention of sea pollution by oil is required. Special areas shall include those listed in Regulation 10 of this annex".

1.15 The Mediterranean Sea is defined in Regulation 10 as bounded in the West by the Straits of Gibraltar at the Meridian of 5°36'W and the boundary between the Mediterranean and the Black Sea is defined as the 41°N parallel. Regulation 10(2)(a) of the annex prohibits any discharge into the sea of oil or oily mixtures from any oil tanker or any ship of 400 grt and above whilst in a special area.

1.16 Regulation 10(3), however, permits the discharge of clean or segregated ballast. The definition of clean ballast is that it shall be from a tank which has been cleaned so that effluent discharged therefrom leaves no visible trace of oil on the water. Proof that the clean ballast contained less than 15 ppm of oil is a valid defence if visible traces of oil are seen. Herebelow is presented Regulation 10(3):

(a) The provisions of paragraph (2) of this Regulation shall not apply to the discharge of clean or segregated ballast.

(b) The provisions of sub-paragraph (2)(a) of this Regulation shall not apply to the discharge of processed bilge water from machinery spaces, provided that all of the following conditions are satisfied:

(i) the bilge water does not originate from cargo pump room bilges;

(ii) the bilge water is not mixed with oil cargo residues;

(iii) the ship is proceeding en route;

(iv) the oil content of the effluent without dilution does not exceed 15 parts per million;

(v) the ship has in operation oil filtering equipment complying with Regulation 16(7) of this Annex; and

(vi) the filtering system is equipped with a stopping device which will ensure that the discharge is automatically stopped when the oil content of the effluent exceeds 15 parts per million.

Obligations of Mediterranean Coastal States Parties to MARPOL 73/78

1.17 By Regulation 10(7) of annex 1 each Contracting State to MARPOL 73/78 which borders on a special area undertakes to ensure that all oil loading terminals and repair ports under its jurisdiction are provided with facilities adequate for the reception and treatment of all the dirty ballast and tank washing waters from oil tankers. In addition, facilities for receiving other residues and oily mixtures from all ships must be provided. Contracting States to MARPOL 73/78 are required under Regulation 10(7)(iv) to advise IMO, for transmission to other Parties, of all cases where the required facilities are inadequate.

Obligations of Mediterranean Coastal States which are also members of the European Economic Community

1.18 Three States (France, Italy and Greece) which are Parties to the Barcelona Convention, 1976 are also Member States of the European Economic Community (EEC). The EEC is a Contracting Party to the Barcelona Convention by an instrument of Approval dated March 1978.

1.19 There are certain Directives of the Commission of the European Communities which cover pollution of the sea by oil, with which Member States must comply. Thus, for the three States which are Parties to both instruments, there are additional responsibilities over and above those for Barcelona Convention States.

1.20 Three of the Directives are relevant to pollution of the Mediterranean Sea area, two of which relate to transportation of oil by sea, whilst the third deals with the disposal of waste oils (particularly used lubricating oil) - Directive 75/439.

Those which refer to pollution from ships are:

1. "Decision of 3 December 1981 establishing a Community information system for the control and reduction of pollution caused by hydrocarbons discharged at sea", and

2. "Decision of 27 September 1983 on drawing up of contingency plans to combat accidental oil spills at sea".

Present position and future action

1.21 Since there are eight Barcelona Convention States which are not Contracting Parties to MARPOL 73/78 and there have been reports of inadequate facilities in the ports of some of the Contracting States, it must be assumed that not all the Mediterranean ports meet the reception facility requirements prescribed for special areas by MARPOL 73/78.

1.22 However, reference to the second section of table 2 shows that Nations responsible for over 80% of the carrying capacity of the world tanker fleet and 75% by number of tankers are Parties to MARPOL 73/78 which means that all those States accept that the Mediterranean Sea is a special area and that it is an offence under their national law for ships of their flag to fail to comply with the requirements of the Convention insofar as this is possible.

1.23 It could, therefore, be argued that acceptance of the provisions of MARPOL 73/78 by States which control so large a proportion of the world tanker fleet, makes the Regulations in Annex I "... the rules which are generally recognized at the International level relating to control of this type of pollution" referred to in Article 6 of the Barcelona Convention.

1.24 Thus, nine out of seventeen States which are Contracting Parties to both the Barcelona Convention 1976 and MARPOL 73/78 have a legal obligation under these two instruments to ensure effective implementation of the provisions of Annex I of MARPOL 73/78 in respect of the Mediterranean area which is recognized, for the purposes of this Annex, as a "special area". It could certainly be most beneficial for the region if the eight remaining States would also ratify MARPOL 73/78 although it seems clear that even without doing so those States are implicitly obliged (as well as the Contracting Parties to MARPOL 73/78) to implement Annex I by virtue of Article 6 of the Barcelona Convention which reads:

> "The Contracting Parties shall take all the measures in conformity with international law to prevent, abate and combat pollution of the Mediterranean Sea area caused by discharges from ships and to ensure the effective implementation in that area of the rules which are generally recognized at the International level relating to the control of this type of pollution".

1.25 For those States which are not party to the three other Conventions governing pollution by oil shown in table 1, participation in these Conventions could only be of benefit. The International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties, 1969 (Intervention 1969) provides the basis for a State threatenend by oil pollution from a ship to take any necessary action outside its territorial waters in order to protect its coasts and the International Convention on Civil Liability for oil Pollution Damage 1969, (CLC 1969) with the international Convention on the Establishment of an International Compensation Fund for Oil Pollution Damage, 1971 (IOPC FUND 1971) provide compensation for damage sustained by oil pollution from ships and for the costs of clean-up.

2. RECEPTION FACILITIES

Requirements of MARPOL 73/78

2.1 Reference has been made in the previous section to the obligation placed upon Contracting States to MARPOL 73/78 to provide reception facilities. Regulation 10(7) of Annex I deals with such facilities in special areas and the relevant section covering the Mediterranean Sea area States:

> "The Government of each Party to the Convention, the coastlines of which borders on any given special area undertakes to ensure that not later than 1 January 1977 all oil loading terminals and repair ports within the special area are provided with facilities adequate for the reception and treatment of all the dirty ballast and tank washing water from oil tankers. In addition all ports within the special area shall be provided with adequate reception facilities for other residues and oily mixtures from all ships. Such facilities shall have adequate capacity to meet the needs of the ships using them without causing undue delay".

2.2. Regulation 12 of the same annex defines in more detail the type of facilities required:

Regulation 12

Reception Facilities

(1) Subject to the provisions of Regulation 10 of this Annex, the Governement of each Party undertakes to ensure the provision at oil loading terminals, repair ports, and in other ports in which ships have oily residues to discharge, of facilities for the reception of such residues and oily mixtures as remain from oil tankers and other ships adequate to meet the needs of the ships using them without causing undue delay to ships.

(2) Reception facilities in accordance with paragraph (1) of this Regulation shall be provided in:

(a) all ports and terminals in which crude oil is loaded into oil tankers where such tankers have immediately prior to arrival completed a ballast voyage of not more than 72 hours or not more than 1,200 nautical miles;

(b) all ports and terminals in which oil other than crude oil in bulk is loaded at an average quantity of more than 1,000 metric tons per day;

(c) all ports having ship repair yards or tank cleaning facilities;

(d) all ports and terminals which handle ships provided with the sludge tank(s) required by Regulation 17 of this Annex;

(e) all ports in respect of oily bilge waters and other residues, which cannot be discharged in accordance with Regulation 9 of this Annex; and,

(f) all loading ports for bulk cargoes in respect of oil residues from combination carriers which cannot be discharged in accordance with Regulation 9 of this Annex.

(3) The capacity for the reception facilities shall be as follows:

(a) Crude oil loading terminals shall have sufficient reception facilities to receive oil and oily mixtures which cannot be discharged in accordance with the provisions of Regulation 9(1)(a) of this Annex from all oil tankers on voyages as described in paragraph (2)(a) of this Regulation.

(b) Loading ports and terminals referred to in paragraph (2)(b) of this Regulation shall have sufficient reception facilities to receive oil and oily mixtures which cannot be discharged in accordance with the provisions of Regulation 9(1)(a) of this Annex from oil tankers which load oil other than crude oil in bulk.

(c) All ports having ship repair yards or tank cleaning facilities shall have sufficient reception faciliites to receive all residues and oily mixtures which remain on board for disposal from ships prior to entering such yards or facilities.

(d) All facilities provided in ports and terminals under paragraph (2)(d) of this Regulation shall be sufficient to receive all residues retained according to Regulation 17 of this Annex from all ships that may reasonably be expected to call at such ports and terminals.

(e) All facilities provided in ports and terminals under this Regulation shall be sufficient to receive oily bilge waters and other residues which cannot be discharged in accordance with Regulation 9 of this Annex.

(f) The facilities provided in loading ports for bulk cargoes shall take into account the special problems of combination carriers as appropriate.

(4) The reception facilities prescribed in paragraphs (2) and (3) of this Regulation shall be made available no later than one year from the date of entry into force of the present Convention or by 1 January 1977, whichever occurs later.

(5) Each Party shall notify the Organization for transmission to the Parties concerned of all cases where the facilities provided under this Regulation are alleged to be inadequate.

2.3 The cost of providing appropriate reception and treatment facilities as required by MARPOL 73/78 has been cited as one of the major reasons for the failure of a number of States to become Parties to the Convention.

2.4 States which are Parties to MARPOL 73/78 however, frequently draw attention to the impossible situation in which vessels of their flag are placed when they are ordered to proceed to a loading port (often at very short notice) in a State which is not Party to MARPOL 73/78 or does not have facilities are required by that Convention.

2.5 In such circumstances, if the loading port in question is in a Special Area they may find it extremely difficult to comply with the provisions of Regulation 10(2)(b) which prohibits discharge to the sea of oily mixtures and requires all oil drainage and sludge, dirty ballast and tank washing waters to be discharged only to reception facilities. Faced with such a situation the Master, owner and/or charterer of the vessel will be faced with a dilemma as to how to meet the Convention requirements and may well be tempted to discharge any dirty ballast or residue to the sea.

Deficiencies in Reception and Treatment Facilities in Mediterraenan Sea area

2.6 Since MARPOL 73/78 was adopted there have been two major studies undertaken to review the situation regarding reception facilities in the Mediterranean Sea area. The first of these was carried out by a team of experts in response to a recommendation of IMO's Marine Environment Protection Committee and with financial support provided by UNEP (IMCO/UNEP Project FP/0503-78-01(1372)).

2.7 The team of experts were:

Capt. G. Steinman, USCG (Retired)

M. G.P. Guerin - Port Autonome de Marseille

M. J.P. Longe - " " " "

M. C.L. Montfort - " " " "

which produced the "Report on a Feasibility Study on Reception Facilities for Selected Ports in a Special Area - Mediterranean" - September 1979. The second study was carried out by the SNAM PROGETTI Organization of Italy under a joint Italy/European Economic Community project entitled "Feasibility Study on Deballasting Facilities in the Mediterranean Sea" - February 1983.

2.8 Table 4 gives a summary of the cost of implementing the recommendations of the two studies both of which were based upon treating facilities which would be capable of producing an effluent containing no more than 10 ppm oil.

2.9 The major cost differences in the two reports for the States of Italy and Syria result from the inclusion in the figures of provision for "grass roots" facilities in the Italy/EEC report rather than additions to existing facilities at nearby locations in the IMO/UNEP Study.

2.10 Amounts of the magnitude shown in table 4 are likely to be a deterrent to the full implementation of MARPOL 73/78 by States faced with major expenditure on such facilities.

Table 4. Estimated cost for oil reception and treating facilities

Country	Steinman Report - Sept. 79	SNAM Progetti Feb. 83
	US $	US $
Algeria	8,100,000	Not reported
Cyprus	450,000	880,000
Egypt	840,000	2,740,000
France	2,650,000	1,550,000
Greece	2,150,000	6,150,000
Israel	1,100,000	550,000
Italy	4,500,000	47,400,000
Lebanon	Not reported	35,530,000
Libya	102,150,000	Not reported
Malta	3,700,000	Not reported
Monaco	Not reported	Not reported
Morocco	300,000	1,220,000
Spain	2,000,000	1,350,000
Syria	13,950,000	33,950,000
Tunisia	1,400,000	Not reported
Turkey	1,680,000	1,300,000
Yugoslavia	5,650,000	Not reported
TOTAL	150,620,000	132,620,000
No. of Countries	(15)	(11)
Design Effluent Standard	10 ppm	10 ppm

2.11 These figures, however, represent the cost of installation of reception facilities as perceived at the time the reports were prepared and therefore represent the maximum requirement since they take no account of the developments which have subsequently occurred and which are outlined in the following paragraphs. Further, visits by IMO experts to certain of the States on missions of a more general nature, and under the IMO/UNDP Project RAB/79/015 - "Advisory Services with regard to port reception facilities in the Mediterranean Sea area", have led to suggestions which could provide workable reception facilities at costs somewhat less than those shown in the table. This would indicate that the cost of providing appropriate reception and treatment facilities to meet present conditions need not be a major obstacle to bringing into force the requirements of MARPOL 73/78.

Development which may affect the volume of reception facilities required to meet present and future requirements

Segregated Ballast Tankers

2.12 Although MARPOL 73/78 did not enter into force until October 1983 virtually all new tankers 70,000 dwt and above ordered between 1975 and 1979 have been constructed with segregated ballast capacity in accordance with Regulation 13 of Annex I to MARPOL 73. Tankers ordered since June 1979, if they are crude oil carriers in excess of 20,000 dwt or product carriers in excess of 30,000 dwt, must be built with segregated ballast which must also be protectively located.

2.13 Thus, increasingly, the world tanker fleet will be equipped to carry ballast water which will not require shore facilities for its disposal. However, such ships may occasionally need to carry extra ballast in their cargo tanks during stormy weather conditions and in special areas such ballast would require to be discharged to reception facilities.

Clean Ballast Tankers

2.14 Until October 1985, existing crude oil tankers of 70,000 dwt and above may use a clean ballast system whereby certain tanks are used solely for ballast but this will be discharged through the vessel's cargo system. Until October 1987, existing crude oil tankers between 40,000 and 70,000 dwt may also use this system. After these dates the vessels must either fit a full segregated ballast system or install a crude oil washing system.

2.15 Tankers operating in the clean ballast mode in accordance with laid down procedures should not need to use shore reception facilities unless, due to bad weather, they have carried extra ballast in their cargo section.

Crude Oil Washing

2.16 From the entry into force of MARPOL 73/78 all existing crude oil carriers of 30,000 dwt and above which are not segregated or clean ballast ships,must be capable of carrying out crude oil washing during discharge of cargo in accordance with the regulations covering this operation. However, effluent from crude oil washed tanks which are ballasted prior to departure from the oil discharge port ("departure ballast") is not clean ballast and must be subject to load-on-top decanting procedure before discharging in accordance with Regulation 9 of MARPOL 73/78, Annex I. COW tankers operating entirely within a special area would be required to discharge departure ballast to reception facilities.

Tankers for which reception facilities will be required

2.17 Existing tankers below 40,000 dwt and new tankers below 20,000 dwt are not required to operate with any of the above mentioned systems but will still need to operate the retention on board system previously referred to as "Load-on-Top". Vessels which carry fuel oil cargoes are unable to crude oil wash and on the ballast voyage following discharge may need to discharge the tank washing slops to shore facilities prior to loading the next cargo. Combination carriers switching trades to dry bulk may also need to discharge the oil slops from their previous cargo to reception facilities. Ships operating in short haul trades (less than 72 hours) which are unable to practice "Load-on-Top" efficiently will, if below the minimum tonnages referred to above, need to discharge their dirty ballast ashore.

2.18 To cater for these vessels it is imperative that loading ports provide reception and treatment facilities sufficient to meet the needs of the number of vessels likely to require this service without causing undue delays.

Size of Tankers and Volume of Oil Movements

2.19 In assessing the volume of reception facility tankage likely to be required, it is essential to conduct a detailed study of current and future trade using the port. Volumes of oil to be exported, the size and frequency of loading, the amount of short-haul movements which may require special facilities need to be considered and attention also needs to be directed to general trends in global oil movements. Table 5 shows that world oil demand peaked in 1979, since then it has fallen by more than ten per cent. Of more immediate relevance is the reduction in the import of oil by sea which shows that from their 1979 peak, total oil imports have declined by over 30% and movements of crude oil alone were down by 37.5% between 1979 and 1983.

2.20 Another relevant factor is the average size of tankers comprising the world fleet and the average size of new buildings. Since 1979, when the average tanker was almost 100,000 tons dwt, this had dropped to 91,000 dwt by the end of 1983. The reduction in average size is more significant when referring to the note on table 6 which shows that the average size of operating tankers (i.e. excluding lay-up) has dropped to 81,000 dwt - a reduction of almost 20% in five years.

2.21 A review of the new buildings on order shows that since the end of 1977 the average size of new buildings has gone down by no less than 50%.

Environmental and Economic Factors

2.22 Since MARPOL 73/78 was adopted there has been an ever-increasing global awareness of environmental matters and of the need to bring the expectations of those who developed its provisions to fruition by enforcing its more stringent standards. This increasing awareness of environmental needs was demonstrated by the adoption of the 178 Protocol which was added before the 1973 Convention had entered into force and which strengthened still further the standards required.

Table 5

WORLD OIL CONSUMPTION	
Year	Million Tonnes
1977	2972.4
1978	3075.9
1979	3119.6
1980	3001.4
1981	2901.7
1982	2824.9
1983	2801.4
1984	2844.5

IMPORTS AND EXPORTS OF CRUDE OIL AND PRODUCTS			
Year	Crude Oil	Products	Total (Million Tonnes)
1977	1458.6	265.4	1724.0
1978	1429.8	251.3	1681.1
1979	1494.7	256.9	1751.6
1980	1317.5	270.7	1588.2
1981	1164.4	258.7	1423.1
1982	998.4	271.4	1269.8
1983	935.9	270.2	1206.1
1984	933.8	296.1	1229.9

Source: BP Statistical review of world energy. June 1985

Table 6. World tanker fleet over 10,000 dwt

Year	Average size of existing tankers at 31 December	Average size on order at 31 December
1977	94,984	104,278
1978	98,384	96,315
1979	99,876	60,990
1980	97,350	51,700
1981	95,051	45,256
1982	93,049	47,055
1983	91,006 (a)	50,463

(a) At 31 December 1983 the breakdown between operating and laid-up tankers was:

	No. of Vessels	Average dwt
Operating tankers	2,693	80,950
Laid-up tankers	296	182,770
TOTAL	2,989	91,006

2.23 Coincident with this movement was the rapid increase in oil prices which provided a major incentive to oil cargo owners to reduce, as far as practicable, losses in the transportation of oil. Thus, it became economic to install crude oil washing and inert gas systems which dramatically reduced losses in transit and which also benefited the environment. This has meant that oil and oily mixtures which were once discharged to the sea or to reception facilities are now discharged as cargo. This trend will receive further impetus as the new segregated ballast ships enter the fleet since their advent will increase freight costs and therefore the landed value of oil.

2.24 As each year passes the economics of building new reception and treatment facilities for tanker ballast water become more uncertain due to many of the preceding factors. In a world where there is competition for available resources it is not surprising that some nations are reluctant to commit their limited resources to such projects. Nevetheless, it is of vital importance to the marine environment in general, and to special areas in particular, that sufficient facilities are provided to meet the continuing needs of a limited number of vessels. The urgency of providing such facilities cannot be overstressed.

Sludge and Bilge Collection Facilities

2.25 By far the most important aspect of the provision of reception and treating facilities to prevent oil or oily mixtures being dumped at sea, is the problem of the collection of sludge and bilge residues from all vessels both tanker and dry cargo. Reference to table 1 indicates that this is currently the second largest source of oil entering the sea from ships, and may well become the most significant as the requirements of MARPOL 73/78 are implemented by tankers.

2.26 The advent of higher bunker prices has caused a major change in the propulsion systems of the world merchant fleet. There has been a rapid increase in the use of diesel engines and most now burn heavy fuel oil. To enable the engines to operate efficiently it is necessary to centrifuge the oil in an oil purifier before combustion. This process produces sludges which cannot easily be burned and is therefore kept in a sludge tank on board the ship until it can be pumped to a reception facility either afloat or ashore. Since such facilities are often not available it is not unknown for this material to be discharged overboard when the holding tank is full. The volume of material for which a ship needs a receiving vehicle at any one time, is not very large and one logical method of disposing of it is to a small craft which can come alongside and collect the material whilst other operations are taking place. The receiving small ship or barge can then make collections from other ships before discharging its load to a treatment facility.

3. DISPOSAL PROBLEMS WITH MATERIAL RECEIVED

3.1 Disposal of material received and treated by shore reception facilities can be a simple and economic proposition or a major technical problem according to the properties of the material received.

3.2 Mixtures of water and light crudes typical of much of Middle East production (API 36° and above) will separate quite easily by gravity, permitting much of the water to be pumped out with negligible oil content. The recovered oil can be burned as a fuel or may be mixed with fresh crude oil which is being loaded. There may, however, remain a quantity of oil/water emulsion which requires further treatment with emulsion breakers and filtration through secondary or even tertiary treatment facilities before the separated water can be discharged to the sea and the recovered oil utilised commercially.

3.3 Mixtures of water and heavier crude oils or those with a high wax content have a greater tendency to form emulsions and will normally require secondary and sometimes tertiary treatment before the water can be discharged.

3.4 The whole question of water discharge from reception facilities on shore requires careful consideration. Not only are part per million of the effluent extremely important but the total amount of oil being discharged over a given period should also be calculated and its potential to cause damage assessed. Chronic pollution, even though at a low level, can be more damaging to the immediate environment than an accidental spill. The environment will usually recover quite quickly from an accidental spill but may well be extremely slow to recover from ecological damage caused by continuous low-level discharges.

3.5 The problems of disposal of sludges from diesel vessel centrifuges and residues from bilges and from cleaning bunker tanks are much greater than those of the disposal of washings from oil tanker cargo tanks. Much of this material is not easily combustible - and if burning is possible it may create air pollution unless carried out in special equipment under carefully controlled conditions. Some of the methods for disposal of this sludge which have been adopted are by use as land fill and as a binder for dirt roads in remote locations.

3.6 Disposal of oily materials containing weathered oil and debris also pose major problems for States. In addition to oil which is recoverable following treatment, emulsions known as "chocolate mousse" are formed and much of the oily mixture will be contaminated with debris and flotsam. "Chocolate mousse" will not burn and is best used as land fill where it will ultimately degrade. Under some circumstances contaminated oil and debris may be disposed of by burning under controlled conditions. In this regard attention is drawn to two reports by CONCAWE on "Sludge Farming: a technique for the disposal of oily wastes" and "Disposal techniques for spilt oil" (see annex I, items 28 and 29).

4. ALERTS AND ACCIDENTS

Oil Spills in the Mediterranean Sea Area

4.1 Soon after its establishment, in August 1977, the Regional Oil Combating Centre for the Mediterranean (ROCC) started to keep careful records of alerts and spills which were reported to it. The information provided from the coastal States proved to be incomplete and consequently contacts were established with all other possible sources of information and in particular with insurance companies. By 31 December 1985, 120 significative spills had been reported to ROCC, the cause of 35 amongst them still remains unidentified. A summary of these is given in table 7.

Role of the Regional Oil Combating Centre (ROCC) in Emergencies

4.2 ROCC has monitored all the major maritime accidents which have occurred in the area since it was established at the end of 1976 and has acted as a communication centre as requested. On five occasions ROCC was asked to provide expert help to States in the area faced with an emergency and on each occasion it was able to respond positively by finding the appropriate expert (through IMO) or by the attendance of ROCC personnel.

4.3 It is of interest that the technical expertise accummulated by ROCC in responding to spillages has resulted in requests for assistance from outside the Mediterranean region.

4.4 In 1983 the Centre was asked for technical assistance through UNEP by the Marine Emergency Mutual Aid Centre (MEMAC) in Bahrain (Note - MEMAC was largely modelled on ROCC) which is a component Organization of the Kuwait Action Plan. This request for assistance, complied with by the Centre's Technical Consultant, was able to assist MEMAC at the time of the initial problems experienced in that area following the damage to oil wells in the NAWRUZ oil field.

Table 7. Spills reported to Regional Oil Combating Centre, Malta

Year	Total spills reported	Cause of identified spills				Un-identified spills	Size of Spill				Dispersants used	Remarks
		Collision	Wreck or grouding	Fire and/or Explosion	Other		Under 1,000 Tonnes	1,000 to 5,000 Tonnes	5,000 to 10,000 Tonnes	Over 10,000		
1977 (July/Dec)	6	1	–	–	3(a)	2	1	1	1	–	4	(a) Two accident discharges during pumping one tank overflow
1978	11	1	5	1	1(b)	3	1	–	–	–	2	(b) Wrong manoeuvres in terminal
1979	10	5	2	–	–	3	3	1	2	1	5	
1980	12	3	2	2	1	4	5	–	–	2	4	
1981	23	2	3	5	6(c)	7	5	–	–	1	7	(c) Two pipeline rupture; two leakages while discharging
1982	12	–	4	4	–	4	1	–	–	–	3	
1983	20	1	3	3	7(d)	6	3	–	–	–	2	(d) Two pipeline rupture; two technical failure
1984	10	–	2	2	4(e)	2	2	–	–	–	3	(e) Three leakages while unloading
1985	16	1	4	4	2(f)	5	2	1	–	–	3	(f) One leakage while unloading
TOTAL	120	14	25	21	25	35	23	3	3	4	33	

4.5 In July 1985 ROCC disseminated the first draft of an antipollution manual which together with the National Contingency Plan is aimed to make up the set of documents to be used as a tool by decision-makers in the conduct of combating operations.

5. ROLE OF ROCC IN REGIONAL CO-OPERATION

Establishment of ROCC

5.1 The Regional Oil Combating Centre on Manoel Island, Malta was established by Resolution 7 of the Conference of Plenipotentiaries of the Coastal States of the Mediterranean Region on the Protection of the Mediterranean Sea (Barcelona, 1976) and was inaugurated in December of that year.

5.2 The basic objective of the Centre is to facilitate co-operation among Mediterranean coastal States in case of massive oil pollution and to assist them in developing their own anti-pollution capability. The centre has no operational role in combating oil pollution nor does it have any anti-pollution equipment.

5.3 Its role is currently limited to the combating of oil pollution and it has therefore had to concentrate its efforts on facilitating information exchange, encouraging and providing training, assisting States with their contingency planning when so requested and providing help and co-ordination in times of emergency (to which reference is made in Section 4).

Relationship with UNEP and IMO

5.4 Resolution 7 referred to above requested the Executive Director of UNEP, after consultation with the Government of Malta and the Secretary-General of IMO, to assist in the establishment of the Centre. The Governing Council of UNEP was also requested to defray the expenses of establishing the Centre and its initial operating expenses under the assumption that the operating expenses would subsequently be funded by contracting States to the Convention. UNEP was requested to provide secretariat services to the Barcelona Convention and to act as overall co-ordinator for the Mediterranean Action Plan as part of its Regional Seas Programme.

5.5 As was envisaged by Resolution 7, UNEP initially provided funds to establish and operate the Centre but funding has now been assumed by the Contracting States with the secretariat functions and co-ordination of the Action Plan being undertaken by the Co-ordinating Unit for the Mediterranean Action Plan based in Athens.

5.6 IMO is entrusted with responsibility for the establishment and operation of the Centre. It provides administrative and technical support and ensures the technical competence of the staff as well as providing back-up by experts for the implementation of its work programmes.

5.7 The budget for the Centre and decisions as to programme content are decided at periodic meetings of the Contracting Parties which review the overall operation of the Mediterranean Action Plan. Thus the Centre finds itself in competition for funds to implement programmes it believes to be important, with other elements of the Action Plan

Limitations on the role of ROCC

5.8 As stated earlier, the role of ROCC is presently restricted to combating massive pollution by oil, especially in cases of emergency. Contracting Parties to the Barcelona Convention may extend the scope of ROCC to other fields including for example to deal with spillages of hazardous substances other than oil.

5.9 ROCC could make an increasingly significant contribution to the control of pollution in the Mediterranean region if greater demands were made upon it by the Coastal States, for example in the development of national, bilateral and multilateral contingency plans.

Enhancement of the role of ROCC

5.10 Areas within its existing mandate in which the Centre could benefit participating States are:

(a) Review of major incidents

Much can be gained by States with little or no experience of major pollution incidents by learning from the experience of those who have had to deal with such an emergency. Any effective national contingency plan should require a review of each occasion when the plan has been implemented in order to see what improvements can be incorporated. ROCC should be invited to convene periodic meetings at which such reviews, if made available to it, could be studied and discussed by representatives from all States in the area whenever incidents produce circumstances which will add to the general body of knowledge on pollution response.

(b) Census of training needs and trained personnel

In order that ROCC may be able to carry out its training responsibilities efficiently, it needs to undertake a study, in collaboration with the focal point in each State, to establish:

- The number of people required to handle the emergency envisaged by the national Contingency Plan;

- The degree of special knowledge required by each group of people in the plan;

- The number of people in each group who have the required knowledge and experience;

- The number of people requiring to be trained with the type of knowledge each group requires.

5.11 With such information and the co-operation of the States, ROCC should be able to co-ordinate a long-term training programme at appropriate levels (and in suitable languages) to produce the necessary trained personnel to man the national contingency plans at minimum cost. It is recognized that there would also have to be a long-term financial commitment on the part of coastal States.

5.12 The terms of reference given by the Governments to ROCC do not include "Prevention" and "Co-ordination of Compliance with MARPOL 73/78". There would, however, appear to be some potential for ROCC to become involved in some training requirements associated with MARPOL 73/78 if Mediterranean Governments so agree.

6. CONTINGENCY PLANNING IN THE MEDITERRANEAN SEA AREA

The need for National Contingency Plans and mutual assistance arrangements

6.1 Whilst it is to be hoped that wider implementation of international agreements on safety and anti-pollution standards will result in a reduction in incidents which cause oil pollution, it is certain that there will continue to be some maritime accidents involving oil tankers and offshore platforms which could result in the large scale release of oil. Such accidents, even though comparatively rare, do not respect national frontiers; therefore it is also desirable for neighbouring States to enter into bilateral or multilateral agreements covering the basis of organization to be adopted in the event that more than one State is involved. States should also enter into mutual assistance arrangements on a regional basis to facilitate the loan of personnel and equipment in incidents which escalate to a point which is beyond the capability of a single State.

6.2 The need for this latter type of arrangement was recognized by the Barcelona Convention which added a Protocol Concerning Co-operation in Combating Pollution of the Mediterranean Sea by Oil and Other Harmful Substances in Cases of Emergency to which all 17 Barcelona Convention States are Party.

6.3 Bilateral, multilateral and regional arrangements are an essential part of the successful response to a major pollution incident. They are, however, only a back-up to the national contingency plan which is imperative for each State to maintain in an up-to-date operational condition by regular exercises and call-out checks.

Mediterranean States with operational and tested plans

6.4 Mediterranean States known to have operational national plans are:

France
Greece
Israel
Italy
Monaco
Spain
Turkey

An analysis of the plans of each country is to be found in the country by country review which follows later in this section.

Mediterranean States in process of developing national contingency plans

6.5 At the present time eight States are reported to be in process of preparing and implementating national contingency plans. The present state of each plan is set down in the country by country review which follows. The eight States are:

Algeria
Cyprus
Egypt
Malta
Morocco
Syria
Tunisia
Yugoslavia

States which have not reported preparation of national contingency plans

6.6 Two States have, so far, not reported preparation of a national plan. They are:

Lebanon
Libya

Review of each State's state of readiness to respond to major pollution incident

6.7 *Table 8 summarizes the state of readiness of the Mediterranean Sea area.* A more detailed review of each State which is based on information provided to ROCC by its national focal points is as follows:

(a) Algeria

At present Algeria has no national plan or organization to respond to a national emergency. Since 1977 there have been four pollution alerts reported, only one of which resulted in a major incident. This occurred in 1980 when the JUAN A LAVALLEJA was seriously damaged in a freak storm after breaking out of its moorings. Algeria called on ROCC for assistance in handling this incident and subsequently IMO's Inter-Regional Consultant on Marine Pollution, Cdr. T.M. Hayes, was despatched to the scene where he rendered first-hand advice on means to deal with the resultant pollution.

Whilst oil interests have limited facilities for handling small local spills at oil loading ports, much remains to be done in the planning sphere, in the development of trained teams to handle a national emergency and in making the detailed arrangements to procure the essential basic equipment required to meet the initial response to an emergency. Discussions should also be instituted with neighbouring States on mutual assistance arrangements, risk assessment and scope of sub-regional or bilateral response capability.

ROCC has sponsored eleven candidates to participate in overseas international or regional courses.

Table 8. Status of contingency plans in the Mediterranean Sea area as advised to ROCC, Malta on the 31st December 1985

COUNTRY	OPERATIONAL CONTINGENCY PLAN			OIL SPILLS		TRAINED PERSONNEL		REMARKS
	Yes	No	In Process	No spill or up to 5000 T	Over 5000 Tonnes	From National Training	From ROCC Courses Fellowships	
Algeria			X	1	1	-	11	
Cyprus			X	7	-	44(a)	7	(a) IMO/ROCC 1983 National Seminar
Egypt			X	2	-	67(b)	11	(b) IMO/ROCC Seminars in 84 and 85
France	X			2	-	Yes	1	
Greece	X			6	1	Yes	7	
Israel	X			2	-	Yes	9	
Italy	X			12	3	Yes	6	
Lebanon		X		1	-	-	2	
Libya		X		1	-	-	7	
Malta			X	9	-	-	7	
Monaco	X			-	-	-	4	
Morocco			X	-	-	-	10	
Spain	X			2	1	-	1	
Syria			X	1	-	-	5	
Tunisia			X	2	-	-	8	
Turkey	X(d)			2	1	-	10	
Yugoslavia				2	-	-	12	

(b) Cyprus

Although it is not yet finalized, the national plan has been prepared in draft, following assistance from ROCC who provided an expert to undertake the necessary draft.

A start has been made on training the necessary personnel to operate the plan by the holding of a national basic training seminar for 44 people which was mounted by IMO/ROCC. In addition, seven other people have received training at overseas courses as a result of fellowhips made available by ROCC.

Limited equipment is available for dealing with an incident. This comprises a small length of boom, some skimmers and dispersant spraying units. There have been eight pollution alerts since 1977. On none of these occasions was there significant pollution which would have called for the implementation of a national plan, although the ZENOBIA incident in 1980 was potentially a major pollution casualty. A request for assistance in this case was received by ROCC which responded by sending one of its technical staff to advise on action to be taken.

(c) Egypt

At the moment Egypt is in the process of adopting National Contingency Plan, although equipment for combating oil spillages arising during tanker loading operations is held by the operators of the SUMED Pipeline Terminal at Sidi Kerir and oil spill combating equipment is maintained by the Suez Canal Authority in the event of a spill occurring within the Canal limits. However, following the 1983 MEDAS Workshop on Mediterranean Assistance organized by ROCC, it has been indicated that ROCC will be requested to assist in the preparation of a national plan.

Action is being taken to train the necessary personnel to implement the plan. To date 11 people have been sent to overseas training courses through ROCC and two ROCC national seminar on basic training have been organized jointly with AMTA in 1984 and 1985.

Whilst there is limited equipment to handle in-port spills on the Mediterranean seaboard, considerably more equipment is needed to permit an effective rapid response to a major incident.

Since 1977 there have been only three pollution alerts reported on the Mediterranean coast, neither of which has resulted in serious pollution.

(d) France

There is a well tried and tested national plan which is regularly exercised, in force for the Mediterranean coasts as part of the overall French national contingency plan.

There are two fully trained permanent teams to deal with pollution emergencies based in Toulon and Marseille and these have available a full range of vessels and aircraft capable of dealing with spills at sea and a variety of land-based equipment to deal with shore clean-up. This equipment is mainly concentrated at Toulon and Marseille but some equipment (booms and dispersant spraying units) are located in Corsica. In addition, the oil industry also has personnel and equipment available at its ports and installations.

Whilst France is Party to multilateral arrangements for mutual assistance on its northern coasts, it does not have similar arrangements with its Mediterranean neighbours. There is a trilateral agreement with Italy and Monaco concerning the protection of Mediterranean waters (which was signed in Monaco on 10 March 1976) but this does not cover mutual assistance in case of marine emergencies.

There have been three pollution alerts reported since 1977, neither of which has resulted in serious pollution.

(e) <u>Greece</u>

Greece has a well tried and tested national contingency plan in operation, together with equipment and personnel to handle an emergency.

There has been one incident in which it has requested outside assistance through ROCC. This was in February 1980 when the IRENES SERENADE caught fire in the harbour of Pylos. ROCC was able to send one of its technical staff and the insurers called in the expert advice of the International Tanker Owners Pollution Federation Ltd. (ITOPF). ROCC has also sponsored seven people to participate in overseas courses.

Since 1977 there have been 16 pollution alerts reported. Of these only two have resulted in pollution in excess of 5,000 tonnes, one of which was the IRENES SERENADE.

(f) <u>Italy</u>

There is a long-standing contingency plan in effect in Italy with a well trained group of personnel to operate it. Training programmes have been organised at Urbino to which other States were invited to send trainees and ROCC has arranged fellowships for personnel from other States to attend.

A full range of equipment is available for responding to emergencies both from national and commercial sources.

Since 1977 there have been 24 pollution alerts reported but fortunately none has resulted in a major emergency except for the collision in 1985 between MT PATMOS and MT CASTILLO DE MONTE ARAGON involving around 1000 tonnes of crude oil.

Italy has a bilateral agreement with Yugoslavia for co-operation on protecting the Adriatic Sea and its shores from pollution (signed in Grada on 14 February 1974) and one with Greece for the protection of the Ionian Sea and its coasts (signed in Rome on 6 March 1979). It is also Party to the trilateral agreement with France and Monaco concerning protection of Mediterranean waters (signed in Monaco on 10 March 1976). None of these agreements, however, cover anti-pollution response arrangements or mutual aid in times of emergency.

(g) <u>Israel</u>

Israel has a national plan and trained personnel to staff it. It has equipment available to make an initial response to an emergency. Since 1977 there has been two reported pollution alert but this did not result in serious pollution. ROCC has sponsored the participation of nine persons to overseas training courses.

(h) Libya

Libya has no national contingency plan and has not reported plans to prepare one. It has sent seven persons to overseas training courses through the co-operation of ROCC and there are a number of experienced staff in the oil exporting companies who can deal with limited pollution incidents at loading ports.

These companies also have a range of anti-pollution equiment comprising booms, skimmers, spraying vessels, dispersants, sorbents and flexible tanks.

Since 1977 only two pollution alerts have been reported which did not result in serious pollution

(i) Lebanon

There is no national contingency plan in operation. However, during the 1983 ROCC MEDAS Workshop the Lebanese representative expressed his Government's intention to request the assistance of ROCC in the preparation of a national plan.

Only two persons have been trained at overseas locations under the auspices of ROCC and there are no reports of whether anti-pollution equipment is available.

Since 1977 only three oil spill alerts have been reported which did not result in serious pollution.

(j) Malta

A draft national contingency plan is awaiting adoption.

Seven Maltese have received training at overseas courses with assistance provided by ROCC.

There is very little equipment to respond to a major pollution incident, there being only a small amount of boom and some spraying equipment available.

There have been eleven pollution alerts reported since 1977 all of which were of a minor nature.

(k) Monaco

Monaco's contingency plan has been in existence for many years and it has adequate personnel and equipment to make an immediate response to a pollution incident.

Since 1977, however, there have been no pollution alerts involving the Principality. Monaco is Party to the trilateral agreement with France and Italy concerning protection of Mediterranean waters but this does not cover mutual assistance in the event of a major pollution incident involving the shore of more than one of the three States.

Four candidates have been either fully or partly sponsored by ROCC to attend training courses.

(l) Morocco

There is no national plan in operation. Assistance was provided by ROCC in 1981 and further assistance in drafting the plan has been offered.

Eleven persons have attended overseas training courses through arrangements with ROCC but as far as is known there is no anti-pollution equipment available.

There has been one pollution alert reported since 1977. This occurred in 1982 on Morocco's Atlantic Coast but a request for expert assistance was immediately responded to by ROCC with the full support of IMO. A ROCC technical expert was despatched to the scene to assist in the co-ordination of response and as the result of action taken, the threat of pollution was averted.

(m) Spain

The Spanish national contingency plan is now in operation but has, so far, not been called upon to deal with any emergency.

One person has been sent to overseas training courses through the aegis of ROCC.

Oil companies have personnel and equipment at refineries and discharge terminals capable of dealing with in-port spills but there are no reports of other equipment being available.

There have been four pollution alerts reported since 1977, one of which resulted in the spillage of 18,000 tonnes of naphta in open seas towards Corsica.

(n) Syria

Although there is no national plan in operation, ROCC has been requested to provide assistance in its preparation which is planned for the near future. Five persons have received overseas training as a result of ROCC assistance.

Anti-pollution equipment available is extremely limited, comprising a small length of booms and some spraying equipment.

There have been two pollution alerts reported since 1977, one of them being the cause of minor pollution.

(o) Tunisia

A draft national contingency plan was prepared by ROCC experts in 1978. During the 1983 ROCC MEDAS Workshop the Tunisian representative requested further ROCC assistance in completing the plan and in bringing it into operation.

Eight persons have received overseas training as a result of ROCC efforts.

There are no reports of whether there is any anti-pollution equipment available in the event of a major emergency.

There have been five pollution alerts reported since 1977. One was the PARNASSOS in 1978 when ROCC was asked to assist. ROCC in turn requested IMO to provide help and they were able to arrange for two experts to deal with lightening and salvage of the vessel as a result of which pollution was avoided. The other four alerts did not result in any pollution.

(p) Turkey

Turkey has a contingency plan in operation which it envisages reviewing and updating in the immediate future.

Ten persons have received training overseas as a result of ROCC assistance.

There are no reports of the type and amount of anti-pollution equipment available.

There have been five pollution alerts reported since 1977. Of these, four resulted in no significant pollution. However, in 1979 the INDEPENDENTA incident in the Bosphorus was a major pollution and fire hazard. ROCC was requested to assist and sent its technical expert to the scene. The vessel's insurers called in the team from ITOPF.

(q) Yugoslavia

The national contingency plan is currently under preparation. In addition to personnel trained locally, 12 have attended overseas courses under the auspices of ROCC.

A full range of anti-pollution equipment is available from local companies and port authorities. Arrangements for its co-ordinated deployment in time of emergency will need to be dealt with in the national contingency plan.

There have been two pollution alerts reported since 1977, one of which resulted in minor pollution.

7. TRAINING

Training needs

7.1 For a Mediterranean State to be able to carry out its obligations under the Barcelona Convention and other international Conventions which deal with pollution of the sea (such as MARPOL 73/78), it requires an adequate number of skilled and trained personnel who will be capable of ensuring that Convention standards are complied with.

7.2 The training required to enable a State to be satisfied that it is meeting its treaty obligations, needs to be adequate to produce and maintain the following:

(a) an inspectorate which can carry out the survey and certification of vessels of the flag of the State required in order that the International Oil Pollution Prevention (IOPP) Certificate can be issued to such vessels and revalidated as required;

(b) an enforcement inspectorate which can visit vessels entering the ports of the State to ensure that the vessels comply with the requirements of the appropriate conventions and that they carry valid certificates to show that this is the case;

(c) a team of experts who are capable of implementing the national contingency plan in the event of a maritime emergency. This calls for a variety of skills and such people need to be trained down to the smallest detail of administration of the plan. There have been many examples where the efforts of a well-trained team have been frustrated because someone down the line had not been instructed in his duties in sufficient detail;

(d) where States have issued or intend to issue licenses for offshore prospecting for oil or for its production from successful wells, it is essential to have available trained experts who can lay down the standards for safety and environmental protection and ensure that these are enforced.

Provision of Training

7.3 For those States which do not have an adequately staffed and trained maritime inspectorate to certify their own flag vessels or which can inspect visiting ships to ensure their compliance with international pollution prevention standards, provision of effective training is difficult. The proven method of producing the necessary skills is by properly supervised on-the-job training by working alongside an experienced inspector in a State which has had an inspectorate for many years. A number of nations have provided this type of experience training which has been arranged through IMO and in some cases with financial assistance from the United Nations Development Programme (UNDP) sources or fund from the Swedish International Development Authority (SIDA). Depending on the background of the trainee, such experience training may take from three to six months.

7.4 Training for contingency planning, however, is a more complex and ongoing activity. Basic training is best carried out in national seminars such as those which have been mounted in a number of States by IMO, and by ROCC and IMO jointly in Cyprus. Certain States, notably France and Italy, have invited participation by representatives from Mediterranean States in their regular programmes of national training seminars and ROCC has facilitated the attendance of representatives from a number of Mediterranean States by granting fellowships within the constraints of its budget.

7.5 More advanced training is better organized on a regional basis since it has been found more meaningful and more economic to provide a course for a wider based and more experienced group. To run such courses nationally is often difficult since it is not always possible to release a sufficient number of people of the requisite calibre simultaneously.

7.6 The number of people requiring varying degrees of contingency planning training in a State needs to be carefully calculated and a trained manpower requirement and inventory should be an integral part of every national contingency plan.

7.7 Training in new techniques, paper exercises, call-outs on a national and regional basis also need to be built into an ongoing retraining programme. Emergencies may not happen for long periods but when they do it is essential for the national contingency plan to swing smoothly into action with a full team trained to handle any foreseeable situation.

The Role of ROCC in Training

7.8 As mentioned earlier, ROCC has endeavoured to facilitate training in combating oil pollution by granting fellowships to enable students to attend courses run by established organisations. Up to the end of 1985, 136 such fellowships have been taken up.

7.9 The main effort of ROCC in the training field has been to mount its MEDIPOL basic training course, beginning in 1978, and continuing annually thereafter.

7.10 In 1983 a pilot national seminar was mounted in Cyprus which was most successful and further national seminars are being organized.

7.11 At present, ROCC is organizing on an annual basis, at its own premises, a general training course - MEDIPOL - aimed at new comers in the field of oil pollution combating. A specialized practical training course - MEDEXPOL - is also being organized each year; this course is aimed at people already in the field needing specialized training. The programme of each of these courses is drawn up according to the requirements expressed by the Focal Points. ROCC is also organizing, on request, national training courses aimed at reaching a larger number of personnel who are actually involved in pollution combating operations. These courses are organized in co-operation with the national authorities.

Future training areas to which ROCC could contribute

7.12 In February 1987, the Contracting Parties to the Barcelona Convention will be meeting in Malta to review the activities of the Centre. ROCC's terms of reference may, on this occasion, possibly be expanded to cover new objectives and consequently the training of personnel will then be reviewed accordingly.

8. INFORMATION EXCHANGE AND COMMUNICATIONS

8.1 In this extremely valuable, but often neglected, area of containing and reducing pollution of the sea by oil, ROCC Malta has played a highly effective role.

8.2 Within the constraints of its budget it has:

(a) Established a Focal Point within each State party to the Barcelona Convention and has maintained close liaison with them. A list of Focal Points has been produced and circulated to each Contracting State and this is updated on a regular basis.

(b) Published the ROCC bulletin (ROCC-INFO) twice yearly in both the English and French languages. This provides regular information on experience of oil pollution in the area; reports and publications relevant to the various aspects of oil pollution; training courses available world-wide; new equipment and products; meetings of related bodies and information on ROCC activities. It also includes contributions from the coastal States on subjects of general interest to all States.

(c) Produced an inventory of oil-combating equipment and anti-pollution materials available in each coastal State. An updated computerized version will be disseminated in the near future.

(d) Similarly, a listing of all experts in the region who are available in times of emergency, is maintained and circulated to all member States. The number of experts available is in excess of one hundred.

(e) Provided member States with an updated listing of anti-pollution equipment and material available of which it has knowledge, together with the names and addresses of the manufacturers.

(f) Circulated to all Contracting States details of existing organizations both inside and outside the Mediterranean area who can offer specialist services in time of emergency. This inventory includes, inter alia:

Surveillance services
Salvage
Transfer of cargo
Impact assessment
Clean-up operations afloat and ashore
Disposal of recovered oil and debris

(g) Maintained and circulated a regularly updated inventory of national contingency plans and bilateral and multilateral agreements. This not only covers existing fully operational plans, but also those in process of completion.

(h) Carried out regular alert and communications exercises with national focal points to test the state of readiness of contingency organizations in the States.

(i) Provided information, on request from States, covering all aspects of anti-pollution combating measures. To this end, it maintains close contacts on a regular basis with IMO and with UNEP.

(j) Convened a workshop in September 1978 in Malta at which 14 coastal States participated. The importance of national contingency planning was established, as a result of which several States have requested assistance in formulating their national contingency plans.

(k) Convened a workshop of focal points in June 1983 to discuss ways to improve and strengthen the assistance available to countries in the region. On the basis of this meeting, a work programme for 1984-1985 and 1986 has been prepared.

(l) Convened a workshop of operational Focal Points in November 1985 in Malta to discuss the Guide for Oil Pollution Combating in the Mediterranean disseminated as a draft earlier in the year.

8.3 ROCC Malta is in a unique position to act as a disseminator of information to coastal States of all matters relating to the prevention of oil pollution of the Mediterranean Sea. Its role in this important aspect of the overall fight against pollution would be enhanced if the scope of the Centre is broadened as suggested in Section 5 and Recommendations.

RECOMMENDATIONS

1. The Contracting Parties to the Barcelona Convention not Contracting Parties to MARPOL 73/78 should continue to be encouraged and where appropriate assisted to become Parties thereto inter alia as a means of discharging their responsibilities under Article 6 of the Barcelona Convention whereby such Parties undertake to take all measures in conformity with international law to prevent, abate and combat pollution of the Mediterranean Sea area caused by discharges from ships and to ensure the effective implementation in that area of the rules which are generally recognized at the international level relating to the control of this type of pollution.

2. Pursuant to the recommendations adopted by the Fourth Ordinary Meeting of the Contracting Parties to the Barcelona Convention, Mediterranean coastal States should provide adequate port reception facilities as required by the MARPOL 73/78 Convention and participate actively in the implementation of one or several floating reception facilities in the vicinity of ports or sheltered areas in which important maritime traffic of tankers may need such facilities in order to comply with the "Special Area" requirements of MARPOL 73/78.

3. Mediterranean States should be encouraged to ratify and implement existing international conventions relating to the safety of navigation and comply with guidelines and rules relating to traffic separation schemes, traffic services and ships' reporting systems promulgated by IMO. States should also actively participate in the Action Cost 301 project in order to ensure that all the Mediterranean Sea area can be adequately covered by an effective regional network of vessel traffic services centres.

4. All Mediterranean coastal States should develop and improve national contingency plans which are an essential prerequisite to the implementation of the Protocol Concerning Co-operation in Combating Pollution of the Mediterranean by Oil and Other Harmful Substances in Cases of Emergency and operationally-oriented sub-regional and bilateral arrangements for mutual assistance in cases of emergency. The Regional Oil Combating Centre (Malta) should develop specific proposals for sub-regional and bilateral arrangements for co-operation in cases of marine emergencies involving oil pollution.

5. Within the context of a review of the structure and functions of the ROCC, consideration should be given to what extent the ROCC's terms of reference could be expanded to include providing advice, assistance and training with respect to spills of hazardous substances other than oil.

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