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MEDITERRANEAN ACTION PLAN

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ASSESSMENT OF THE STATE OF POLLUTION OF THE MEDITERRANEAN SEA BY PERSISTENT SYNTHETIC MATERIALS WHICH MAY FLOAT, SINK OR REMAIN IN SUSPENSION

IOC FAO

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1. BACKGROUND

According to the Protocol for the Protection of the Mediterranean Sea against Pollution from Land-based Sources (LBS Protocol) the Contracting Parties shall take all appropriate measures to prevent, abate, combat and control pollution of the Mediterranean Sea Area caused by discharges from rivers, coastal establishments or outfalls, or emanating from any other land-based sources within their territories.

Article 5 of this Protocol stipulates that:

- The Parties undertake to eliminate pollution of the Protocol Area from land-based sources by substances listed in Annex I to this Protocol;
- To this end they shall elaborate and implement, jointly or individually, as appropriate, the necessary programmes and measures;
- These programmes and measures shall include, in particular, common emission standards and standards for use.

The Meeting of Experts for the Technical Implementation of the LBS protocol (December, 1985) proposed that the measures to be recommended to the Contracting Parties for each group of substances should be based on an "assessment document" which should be prepared by the Secretariat. According to this proposal, which was adopted by the Fifth Ordinary Meeting of the Contracting Parties to the Barcelona Convention (September, 1987), such assessments should include *inter alia* chapters on:

- sources, point of entries and amounts of pollution for industrial, municipal and other discharges to the Mediterranean Sea;
- levels of pollution;
- effects of pollution;
- present legal, administrative and technical measures at national and international level.

Persistent synthetic materials which may float, sink or remain in suspension and which may interfere with any legitimate use of the sea are included in Annex I to this Protocol. One of the first MED POL activities on the subject was the organization of an IOC/FAO/UNEP *ad hoc* meeting (Athens, 14-16 October 1987) to discuss the extent of the problem in the Mediterranean region and recommend further activities. Recognizing the fact that only very limited information was available, the meeting recommended the initiation of a pilot monitoring study in selected areas to asses the quantity of litter present in the marine environment and to determine its origin and any seasonal changes in its composition and quantity.During the same meeting, methodological instructions were drawn up as well as an annotated outline for the assessment document.

In the meantime, the Sixth Session of the IOC Committee for the Global Investigation of Pollution in the Marine Environment (GIPME) (Paris, 25 September - 1 October 1986) recommended to the GIPME Groups of Experts to develop methodologies and facilitate efforts to monitor, inter alia, the amounts and types of persistent plastic debris in the ocean.

As requested by the Sixteenth Session of the FAO Committee on Fisheries (Rome, 22 - 26 April 1985) a document (COFI/87/8) on the Protection of living resources from entanglement in fisshing nets and debris was prepared and submitted to its Seventeenth Session (Rome, 18 - 22 May 1987) for discussion.

The results of the pilot survey which lasted for 12 months (May 1988 - May 1989) were reviewed at a meeting of the principal investigators (Haifa, Israel, 12 -14 June 1989) and constitute the main basis for the present assessment document.

The IOC/UNEP Group of Experts on Methods, Standards and Intercalibration (GEMSI) during its joint meeting with the IOC/UNEP/IMO Group of Experts on Effects of Pollutants (GEEP) (Moscow, 15-19 October 1990) examined the report of the Haifa meeting (IOC/FAO/UNEP, 1989) and considered that the document is a useful basis for a manual which could be applied to all regions. The importance of such a manual was stressed and it was felt by the Experts Group that it could provide the means for a valid assesssment of the impact of beach litter worldwide, also taking into account other guidelines prepared for beach debris surveys, particularly in the USA.

The Seventh Session of the GIPME Committee (Paris, 21-25 January 1991) recommended that monitoring of persistent synthetic materials on beaches should be included in the monitoring parameters in the future development of the Marine Pollution Monitoring System (MARPOLMON). It was further recommended that pilot beach litter surveys, similar to that carried out in the Mediterranean, should be conducted on a widespread basis as a simple, low cost and effective technique for assessing the nature and sources of marine contamination by litter.

The present document was prepared by the Secretariat with the help of a consultant and in close cooperation with IOC and FAO. It is based on an extensive bibliographic search while it makes full use of the results of the MED POL pilot survey. The document does not restrain itself to land-based sources but addresses litter contamination in general.

2. INTRODUCTION

During the last 2-3 decades, there has been growing concern in the world due to an increase in the quantity of litter in the marine environment. This increase is a result of the fast development of plastic materials, which were invented in the middle of this century. The resistance of plastics to natural degradation made them very useful in the service of mankind, but this persistence turned into a menace when these materials completed their useful life and became

garbage. The common practice to dispose of trash at sea was until recently, and to a certain extent still is, by throwing it into the sea. The continuous discard of plastics into the marine environment on the one hand, and their slow degradation on the other, led to the observed increase of this contaminant in the sea.

However, plastics are not the only persistent material which is discarded into the sea. Persistent litter in the marine environment consists of a large variety of other materials: metal, lumber, glass, rubber, styrofoam, cloth, foam rubber and others. Most of the marine and coastal litter consists of containers and packaging material which were discarded after use, but fishing gear, debris of building material, tires, medical waste and personal items such as pieces of clothing, combs, toys, etc., are also found. Although non-persistent litter such as food debris, paper cartons, etc. are also found in the marine environment, this document deals only with persistent material, and the terms litter, garbage, trash, rubbish, debris and refuse are related here to these materials only.

The growing quantity of litter in the sea affects the marine environment in many ways. It is harmful to the marine fauna either through the entanglement or ingestion of litter by marine animals. It damages free navigation by entanglement in ships propellers or by clogging cooling intake pipes, and it causes aesthetic damage to the coastal zone and thereby to coastal oriented tourism. The harmful effect of litter to the marine environment is widely recognized, and dumping or discarding of persistent synthetic material into the Mediterranean Sea is prohibited according to the Protocol for Prevention of Pollution of the Mediterranean Sea by Dumping from Ships and Aircraft. In addition, the Mediterranean sea has been designated as a "special area" for the purposes of Annex V to MARPOL 73/78.

The first to raise concern about the presence of human refuse in the marine environment was probably Heyerdahl (1971), who reported that during his "RA" expedition he observed significant quantities of tar and solid litter floating in the ocean. Since then, reports on the presence of litter in the marine environment have come from all over the world. Some reports (e.g. Carpenter et al., 1972; Gregory, 1977, 1983; Shiber, 1979, 1987) provided qualitative and quantitative information on the garbage, others described the deleterious effect of the rubbish on marine fauna (e.g. Merrell, 1980; Schrey and Vauk, 1987), and others investigated the sources and fate of the litter (Dixon and Cooke, 1977; Merrell, 1980; Dixon and Dixon, 1981; Vauk and Schrey, 1987a). The problem was also addressed by UNEP (1989) and GESAMP (1990).

The First Workshop on the Fate and Impact of Marine Debris which took place in Honolulu, Hawaii in 1984 (Shomura and Yoshida, 1985), as well as the 6th International Ocean Disposal Symposium which was carried out in Pacific Grove, California in 1986 (Wolfe, 1987), focused the attention of many scientists on the marine garbage problem, resulting in an increasing number of studies and scientific papers on this subject. Indeed, the Second International Conference on Marine Debris which was conducted in Honolulu, Hawaii in April 1989 (Shomura, ed., in preparation), included close to 100 papers which deal with

various aspects of the marine litter problem including its origin, distribution, quantity, biological and economical impact, treatment, and legal and educational implications. The Co-ordinating Unit for the Mediterranean Action Plan has compiled a bibliography on marine litter (consisting of about 400 references) which will be published in the MAP Technical Reports Series.

Awareness of the coastal litter problem has grown beyond scientific and administrative circles. In Britain, the "Keep Britain Tidy Group" program involves the public, on a voluntary basis, in conducting beach surveys and reporting quantities, types and distribution of garbage on the beaches (Dixon and Dixon, 1981). In the U.S., groups of volunteers even conduct beach clean-ups (O'Hara, 1989). Recent discoveries of disposable syringes, blood vials as well as other medical-related wastes on the beaches of New York, coupled with the fear of the AIDS disease, caused wide public concern and the closure of public beaches in New Jersey and New York (New York State DEC Report, 1988).

The coastal region of the Mediterranean Sea is presently undergoing intensive development which is due partly to the migration of people to the coastal zone (a worldwide phenomenon) and partly to the increase of coastal tourism in the Mediterranean. Pollution of the Mediterranean coastline by litter is therefore becoming an important issue in this part of the world. It is disappointing, therefore, to find out that the only studies carried out on litter in the Mediterranean Sea and its coasts are short reconnaissance surveys (Shiber, 1979, 1982, 1987; Morris, 1980; Saydam et al., 1985; Gramentz, 1988; McCoy, 1988). The only systematic effort to study litter contamination in the Mediterranean Sea was initiated by IOC, FAO and UNEP in 1988 in the framework of the MED POL activities.

3. SOURCES AND INPUTS

3.1 Sources

In general terms, litter reaches the marine environment either as discard from ships, or as runoff from land or as leftover by people who come to the beach for recreation. Determination of litter sources is very important for designing a strategy to handle litter pollution. However, even determination of litter sources in terms of land- or marine-based is a rather difficult problem due to the lack of criteria needed to define the source of the litter. Several studies have addressed this problem. Merrell (1980) carried out a litter survey on 10 beach sections on Amchitka Island, Alaska, in 1972, 1973 and 1974. He found that most of the litter consisted of debris related to the fishing industry: nets, trawl floats, ropes, gill net floats, etc. Other litter components such as beverage bottles and cans, bleach bottles, plastic fragments and others, were rather rare, constituting less than a percent each. From the nature of the debris and inscriptions on it, Merrell concluded that its sources were mostly from fishing activities carried out in the North Pacific Ocean by Japanese and Russian fishing fleets.

In 1982, Merrell (1984) repeated his litter survey on the beaches of Amchitka Islands and found that there was a 26% reduction in the litter quantity on the beach. Merrell attributes this reduction to the decrease in the fishing effort off Alaska which resulted from the extension of the U.S. fishery jurisdiction from 19 km to 322 km off shore in 1976. This caused a decline of 66% in the number of foreign trawlers off Alaska. It is obvious that in the case of Amchitka Island, where local production of litter is negligible, the coastal litter is almost entirely marine-based litter, in this case, debris of the fishing industry.

Vauk and Schrey (1987a) monitored litter which accumulated on a beach section in Helgoland Island in the German Bight. In 106 litter collections which were conducted in 1983-1984, 8539 litter pieces with a total weight of 1360 kg were collected. More than 95% of these were identified as ship waste. The heavy traffic in the German Bight is reflected in the origin of the litter which was determined from inscriptions and imprints on the plastic, metal, glass and paper components of the litter. 39.5% of the debris were from Germany, 17.8% from Great Britain, 16.5% from the Netherlands and 9.6% from Denmark. The rest was practically from all over the world. The authors relate their findings to the wind direction and show that the litter must have been carried by wind from the main shipping lanes in the German Bight to the island.

Coastal litter on the shores of western Europe was investigated in a series of studies which were carried out in the framework of the "Keep Britain Tidy" Group. This was done by Dixon and Cooke (1977) on a Kent beach in UK, by Dixon and Dixon (1980) on the shores of Cherbourg Peninsula, France, and west Jutland, Denmark, and by Dixon and Dixon (1983) in Portugal and the Western Isles of Scotland. The imprints on the container fraction of the litter show that in all the study areas, most of the containers originated from foreign countries. It was also found that the most abundant fraction of the litter population was plastic containers which were used for cleansers and household detergents. In addition, most of the metal containers were used for marine engine oil or grease and most of the carton containers for long-life milk. As these could not have reached the shores from the municipal garbage dumps, these findings led the authors to conclude that the origin of most of the containers (and hence most of the other fractions of the litter as well) was from ships which discarded them at sea.

In contrast to the ubiquity of debris of fishing equipment found on Amchitka Island and of containers of household detergents and cleansers on the shores of western Europe, Golik and Gertner (1989, 1991) were impressed by the abundance of containers of beverages, food and cosmetics, plastic handbags, debris of cloth, toys, combs and rubber foam mattresses which were found on the Israeli beaches. They argued that this type of litter is generated by people who come to the beach for bathing and recreation and therefore this litter should be considered as land-based in its origin. The impression that land-based litter on Mediterranean shores is more abundant than marine-based litter is shared by other investigators in the Mediterranean (IOC/UNEP/FAO, 1989). It is further supported by the rarity of debris

of fishing gear on the Mediterranean beaches. From the studies made so far in the Mediterranean region, the largest concentration of fishing gear in the coastal litter (2.8%) was found in Turkey (IOC/UNEP/FAO, 1989).

The difference between coastal litter in the Mediterranean and that of the east Atlantic is not surprising. Bathing and recreation on the sea shore are more popular in the Mediterranean, and the bathing season is longer there than on the east Atlantic coast. In addition, ship traffic in the east Atlantic, and in particular in the English Channel, is heavier in comparison to that off the Mediterranean coastline. These activities should increase the proportion of the land-based fraction in the Mediterranean litter and the marine-based fraction in that of the east Atlantic.

Another aspect related to the sources of litter in the Mediterranean, which has not been investigated at all, is related to the population distribution around the Mediterranean Sea. Eighteen countries border the Mediterranean Sea. Table I provides statistics on the population size of each of the Mediterranean countries. Fig. 1 shows the degree of urbanization of the Mediterranean coastline as demonstrated by density and size of the coastal cities. It can be seen that the northwestern Mediterranean is both heavily populated and the most urbanized part of the Mediterranean, whereas the eastern part of the southern coastline is lighter in population density and is not urbanized at all. This must have a bearing on the litter distribution in the Mediterranean because litter quantity and composition are a function of population size and degree of urbanization.

3.2 Inputs

Although there is no quantitative information on the input of litter into the Mediterranean Sea through any of the above-mentioned sources, several attempts were made in the past to speculate on the contribution of litter which is discarded from ships. Matthews (1975) gathered quantitative information on the magnitude of various marine activities, such as traffic of passenger liners and merchant ships, military activity, recreational boating, fishing industry and offshore oil production and drilling. This information was manipulated into terms of person-day per year, number of vessels per year, crew unit per year, etc. For each of these categories, a factor of trash generation was estimated, e.g. the trash production for a passenger ship is 1.6 kg/person/day, whereas for crew members on merchant ships it is only 0.8 kg/person/day. Table II is a summary of the values proposed by Matthews as the input of litter into the Mediterranean Sea. In that table the largest contributor of litter is cargo-associated trash discarded from merchant ships. This trash generation rate is estimated at 285 tons/ship/year. Matthews does not provide information on the number of merchant ships in the Mediterranean and gives only a global figure, 5.6 million tons/year of garbage input from this source. In order to estimate this value for the Mediterranean, the relative proportion of the number of ships sighted per day in the Mediterranean (Matthews, 1975) was used. The total value obtained is 663,000 tons per year discarded from various marine activities into the Mediterranean

Table I

Population in the Mediterranean countries and their Mediterranean regions, 1985 (in thousands) (Source: Blue Plan, 1987).

Country	Total	Mediterranean region	Share of Mediterranean region (%)
Albania	3,050	3,050	100.0
Algeria	21,718	11,902	54.8
Cyprus	669	669	100.0
Egypt	46,909	15,957	34.0
France	54,621	5,496	10.1
Greece	9,878	9,117	92.3
Israel	4,252	2,886	67.9
Italy	57,300	42,069	73.4
Lebanon	2,668	2,668	100.0
Libya	3,605	2,284	63.4
Malta	383	383	100.0
Monaco	27	27	100.0
Morocco	21,941	3,384	15.4
Spain	38,542	14,410	37.4
Syria	10,505	1,140	10.9
Tunisia	7,081	4,998	70.6
Turkey	49,289	9,992	20.3
Yugoslavia	23,153	2,492	10.8

Sea, and is about 10% of the global discard. This is probably an underestimate since it is based on old data (early 1970's), did not include data on recreational boating and the data on fishing activity came only from Greece and Italy.

Horsman (1982) carried out detailed counts of items which were disposed of at sea from two merchant ships. He did it by using the ship's store list at various dates, computing in this way the quantity of commodities used between dates. Under the assumption that all the waste, which was generated from the used goods, was dumped into the sea, his figures show that each man afloat dumps daily between 3.2 and 6.2 trash objects made of metal, 0.2-0.3 pieces of glass and 0.3 plastic containers. Using data provided by Matthews (1975), the number

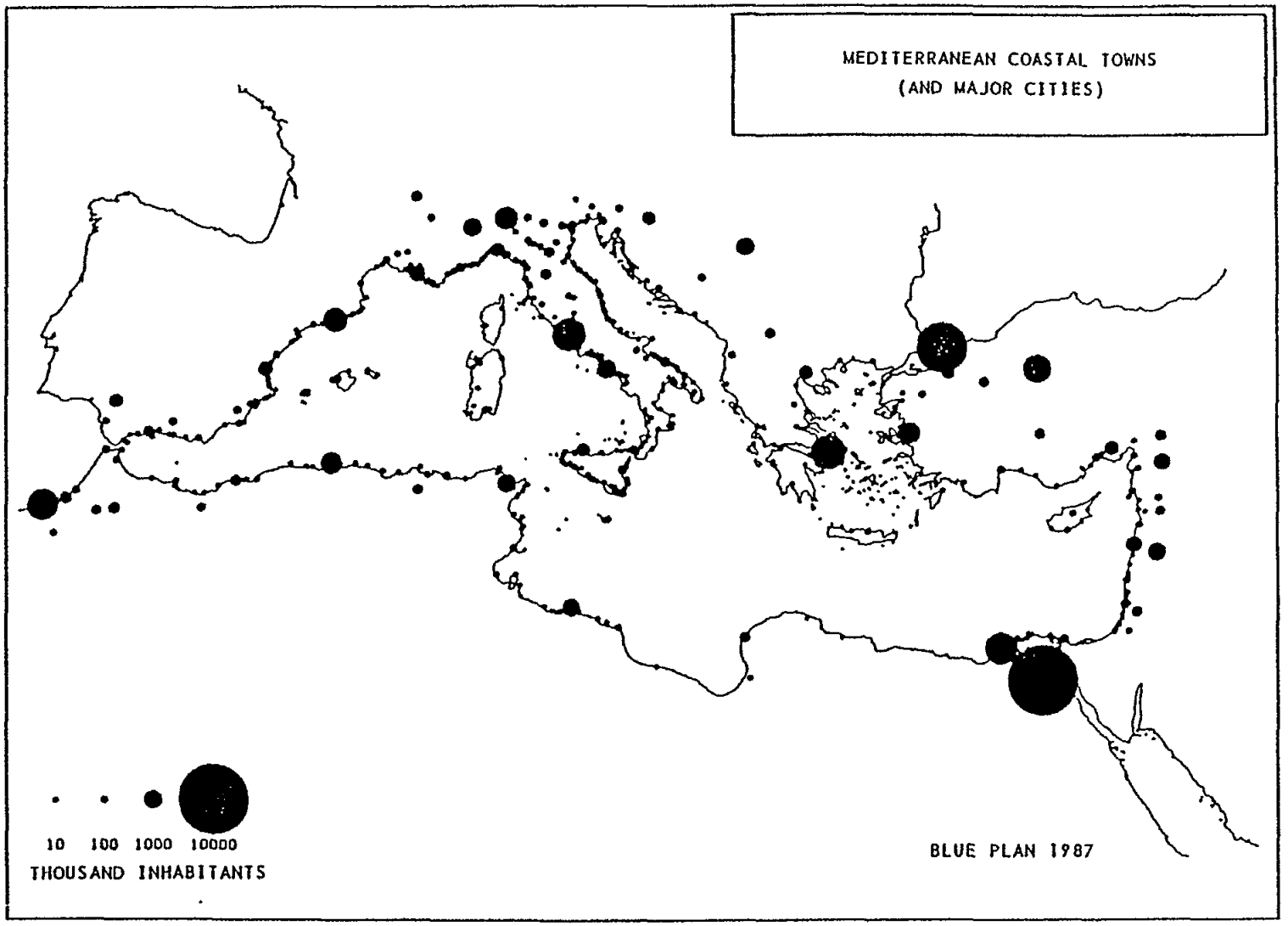

Fig. 1 Mediterranean coastal towns (from Blue Plan, 1987)

Table II

Estimate of trash discarded from ships into the Mediterranean Sea (From Matthews, 1975).

Source	Trash discarded (10^6 kg/y)
Passenger liners	2.4
Merchant ships[1]	12.1
Merchant ships[2]	632.8
Fishing boats[3]	5.0
Military activity	10.0
Offshore oil production	0.3
Total	662.6

1. Trash produced by crews.
2. Cargo waste (pellets, wires, plastic covers, dunnage, etc.)
3. Based on data from Italy and Greece only.

of merchant ships' personnel in the Mediterranean every day is 41,400, and accordingly the quantity of litter which enters the Mediterranean daily from this source only is 1.3-2.5 x 10^5 metal pieces, 10,350 glass items and 12,420 plastic containers.

Bingel (1989) made an attempt to estimate the quantity of litter contributed to the Mediterranean Sea as a result of loss of fishing gear. He used statistics on loss of fishing gear in Turkey, in terms of weight of lost gear per vessel, per unit of coastal length or per unit of continental shelf area. He then applied these statistics to the Mediterranean as a whole and obtained the following estimates:

Loss of Fishing Gear (tons/year)

According to number of vessels	3342
According to length of coastline	2803
According to shelf area	2637

The review of the various attempts to estimate the rate of input of litter into the Mediterranean only demonstrates how far we are from obtaining this information. There is no information at all on land-based litter, and the information on marine-based litter is fragmentary, based on old data and on many assumptions and extrapolations.

4. FACTORS INFLUENCING LITTER DISTRIBUTION AND FATE

It has been shown (e.g. Dixon and Dixon, 1981; Vauk and Schrey, 1987a) that litter pieces travel large distances at sea and, in fact, may reach any point in the ocean. Two groups of factors control the distribution of the litter: one is the source of the litter and the other is driving forces such as currents, winds, waves and tide which disperse it from its source.

4.1 Effect of sources on litter distribution

Monitoring litter on the coasts of Sicily and Israel (IOC/FAO/UNEP, 1989) was carried out on more than one beach in each country, thus permitting the investigation of factors which control the distribution of litter in space. In Sicily, 3 beaches were sampled between October 1988 and May 1989. It was found that the beach of Ficarazzi, near Palermo (see Fig. 2), is more than 4 times as polluted by litter as the beach of Balestrate which is 3 km from an inhabited center, and 25 times as polluted as the beach of Eraclea Minoa, which is far from a population center and has low accessibility. These results demonstrate the effect of proximity of a beach to the source of the litter. Undoubtedly, Palermo, which is the main city in Sicily, is also a major contributor of litter to the beach. In Israel, 6 beaches were sampled between May 1988 and May 1989. Table III provides a comparison between litter levels on these beaches (see Fig. 3) as well as the results of grouping them, according to their litter level. Although the differences in mean litter concentration between the beaches in Israel are not very large, some of these differences were found to be statistically significant (see Table III). Carmel Beach and Haifa Bay beach, which are near a major city in Israel, Haifa (Fig. 3), are significantly more polluted by litter than the beach of Neveh Yam, where access to the beach is difficult. The beach of Akhziv, Israel, is the most polluted one in that country, eventhough it is rather distant from a population centre. However, this beach is located near the border with Lebanon, and according to Golik and Gertner (1989), it is possible that most of the litter originates from coastal garbage dumps in Lebanon which is swept by the northerly winds to Akhziv Beach. The results of the litter studies in Sicily and Israel suggest, therefore, that beaches close to major population centres are susceptible to litter pollution.

There are only two studies on floating litter in the Mediterranean which, perhaps, may demonstrate the effect of sources on litter distribution. On the basis of counting floating debris from a ship and then manipulating the results to concentration of litter, Morris (1980) reported that he observed approximately 2000 pieces of litter per km^2 some 40 miles SW of Malta. On the other hand, McCoy (1988), who used the same method from a stationary ship in the Ionian Sea, found on the average only one floating object per day, observing an area of 8.3 km^2, or 0.12 pieces per km^2. McCoy attributed the low value to the fact that his ship was located away from the common ship traffic lanes. Thus, traffic lanes may also be considered "sources" and, like the observations on land, affect the level of pollution at sea.

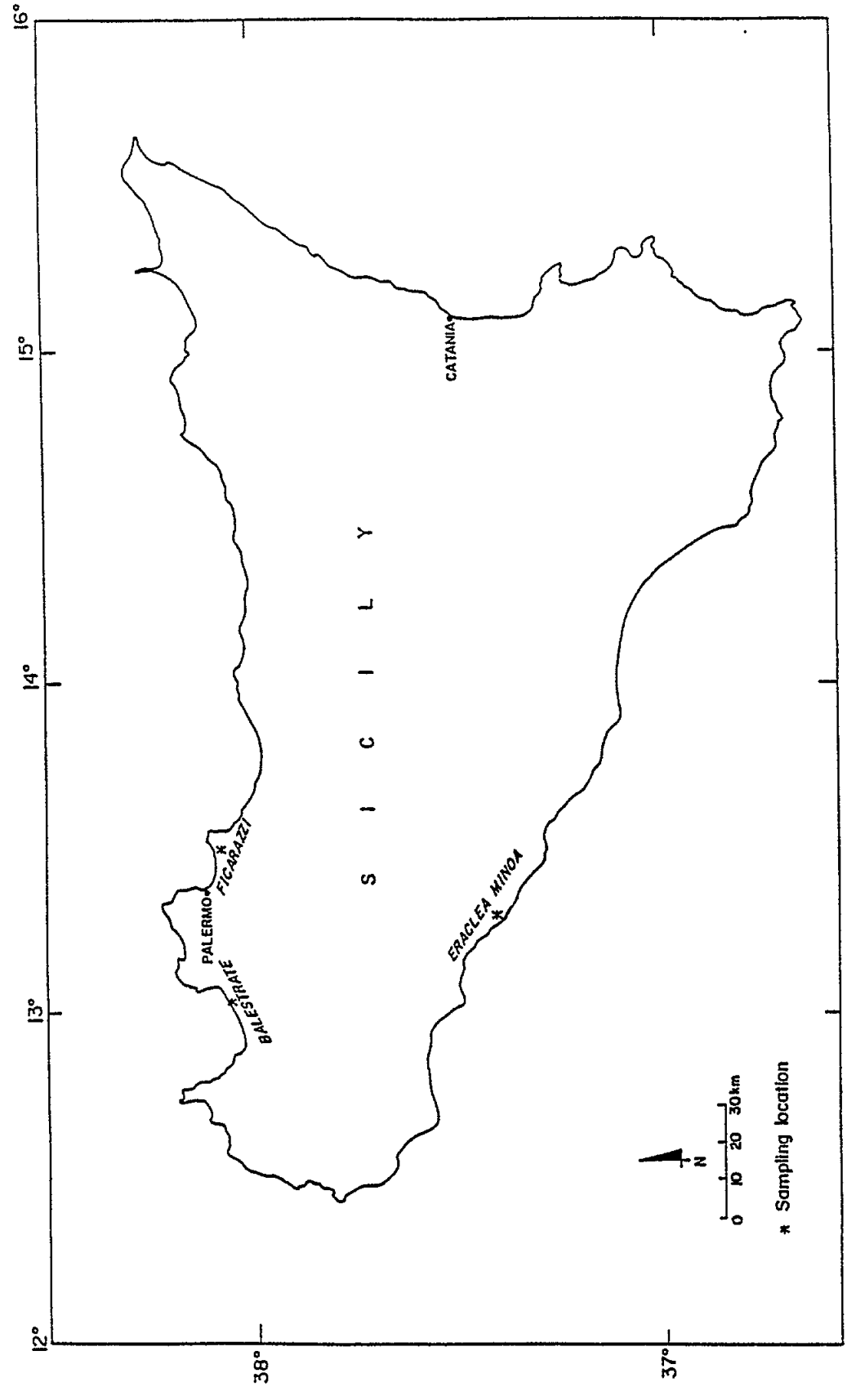

Fig. 2 Location of sampling stations used for litter monitoring in Sicily (from IOC/FAO/UNEP, 1989)

Table III

Comparison of litter level between beaches in Israel using the Duncan test (Source: IOC/FAO/UNEP, 1989).

Beach	No. of samples	Mean litter counts	Duncan grouping*
Akhziv	96	45.88	A
Carmel Beach	84	41.00	A
Haifa Bay	72	37.26	A B
Dor	64	33.11	B C
Beit Yanay	78	31.15	B C
Neveh Yam	78	29.17	C

* Beaches with the same letter are not significantly different to each other

4.2 Effect of winds, waves and currents on litter distribution

The findings of a coastal litter survey which was conducted in Cyprus (IOC/FAO/UNEP, 1989) did not concur with the hypothesis that large concentrations of litter are related to a nearby population center. There, the litter level in Lara Beach was about twice as high as that on Makronissos Beach (see Fig. 4). Yet, Lara Beach is remote from a population center whereas Makronissos Beach is close to one. Loizides (1989) attributes the high level of litter on Lara Beach to the effect of the wind. Lara is located on the western side of Cyprus and is exposed to winds which most of the time blow from the west, driving the floating litter to the beach in Lara.

Seasonal fluctuations in the level of coastal litter were noticed in Cyprus and Israel. Loizides (1989) proposed that the increase in litter quantity on Lara Beach during the months of October-December is related to the westerly winds which blow landward during these months, causing accumulation of litter on the beach. During the months of January-April, the predominant winds are from northeast and north and therefore do not affect Lara Beach. Fig. 5 shows the seasonal distribution of coastal litter in Israel. Two minima are observed: one in July and one in December-February. Both were found to be statistically significant. Golik and Gertner (1989) relate the July minimum to the beach clean-up which is conducted along most of the Israeli coastline every summer, and the other one to winter storms, when high waves wash the litter to the back of the beach and even beyond it landward, leaving the beach clean from litter.

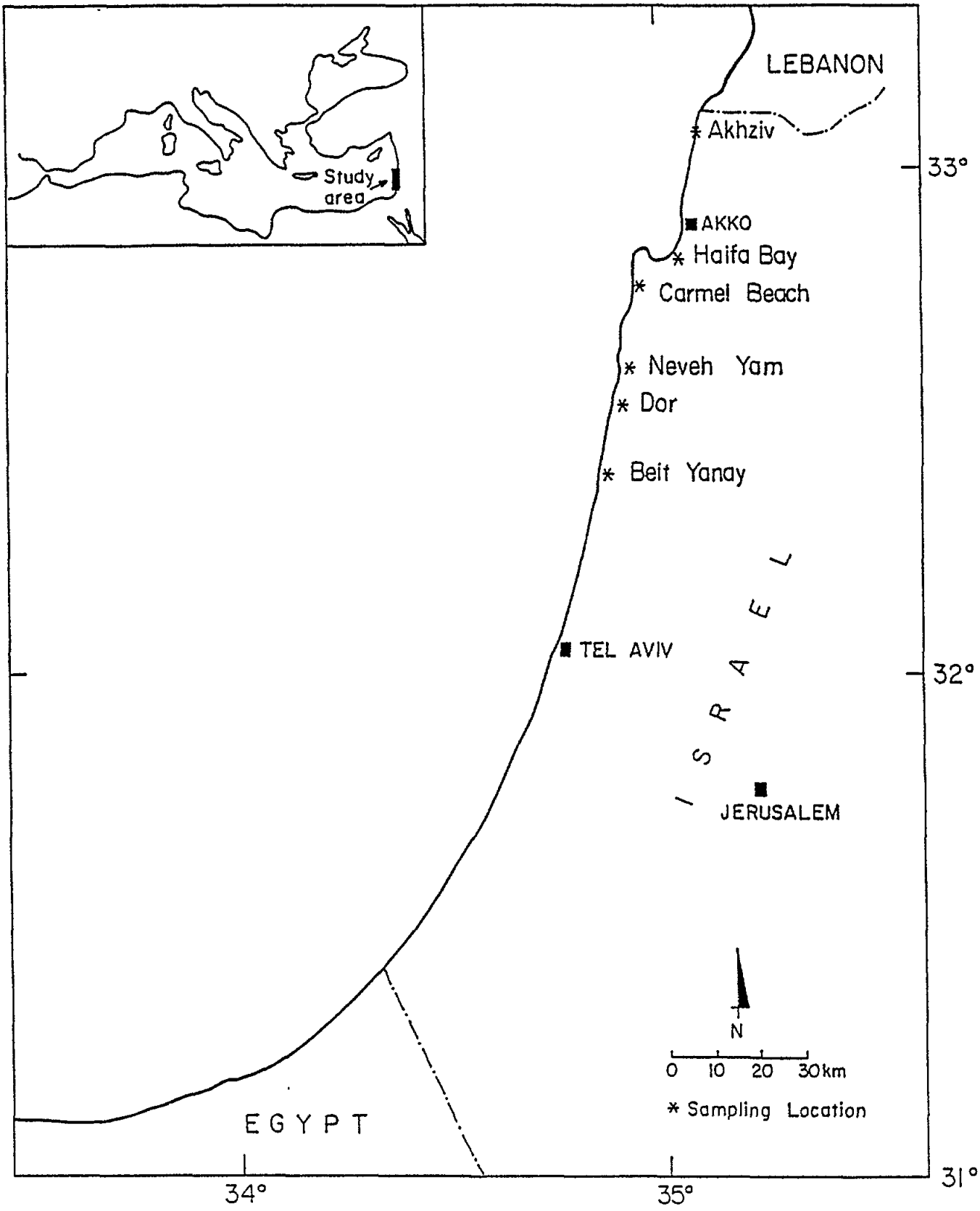

Fig. 3 Location of sampling stations used for litter monitoring in Israel (From IOC/FAO/UNEP, 1989)

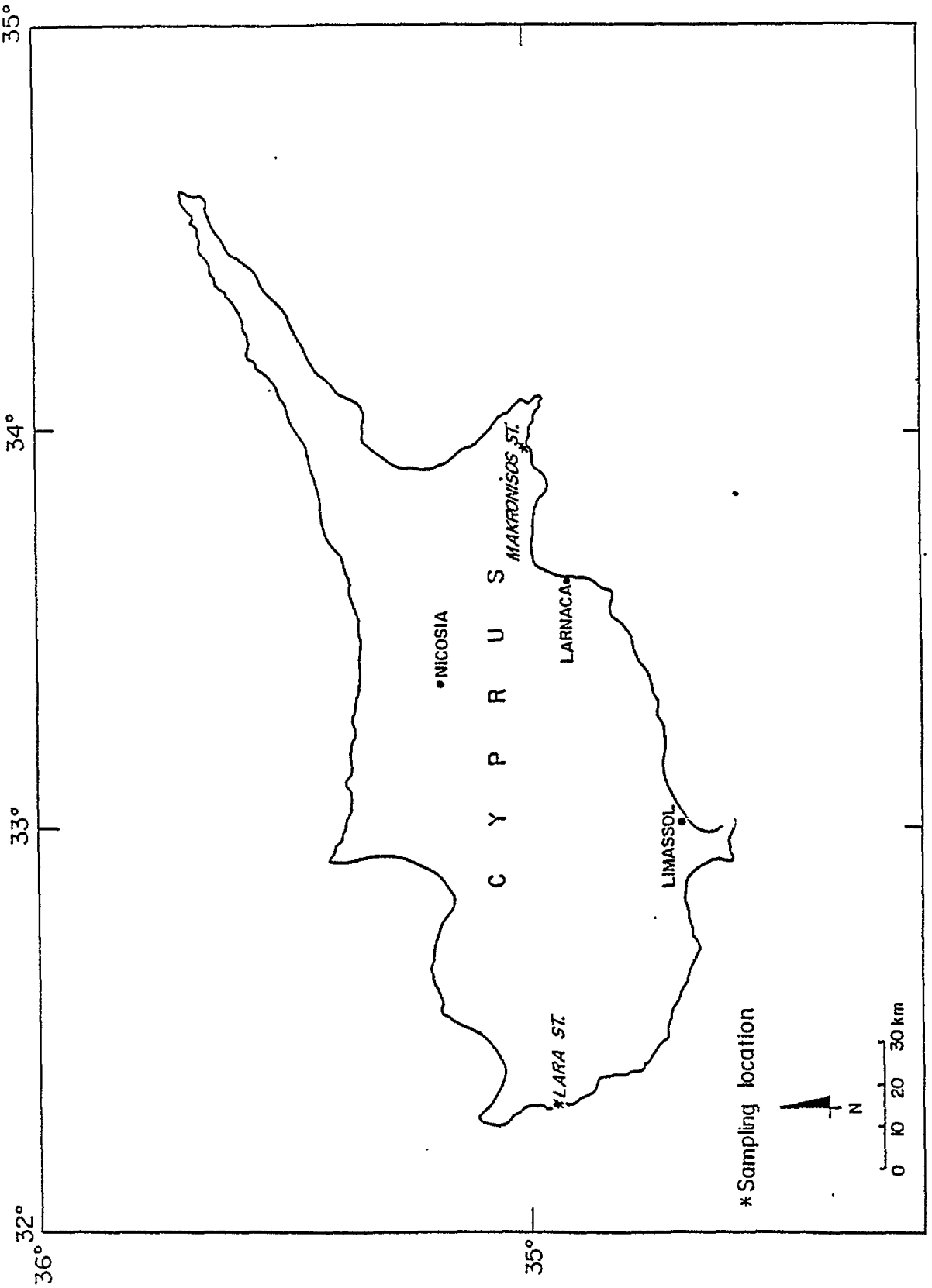

Fig. 4 Location of sampling stations used for litter monitoring in Cyprus (From IOC/FAO/UNEP, 1989)

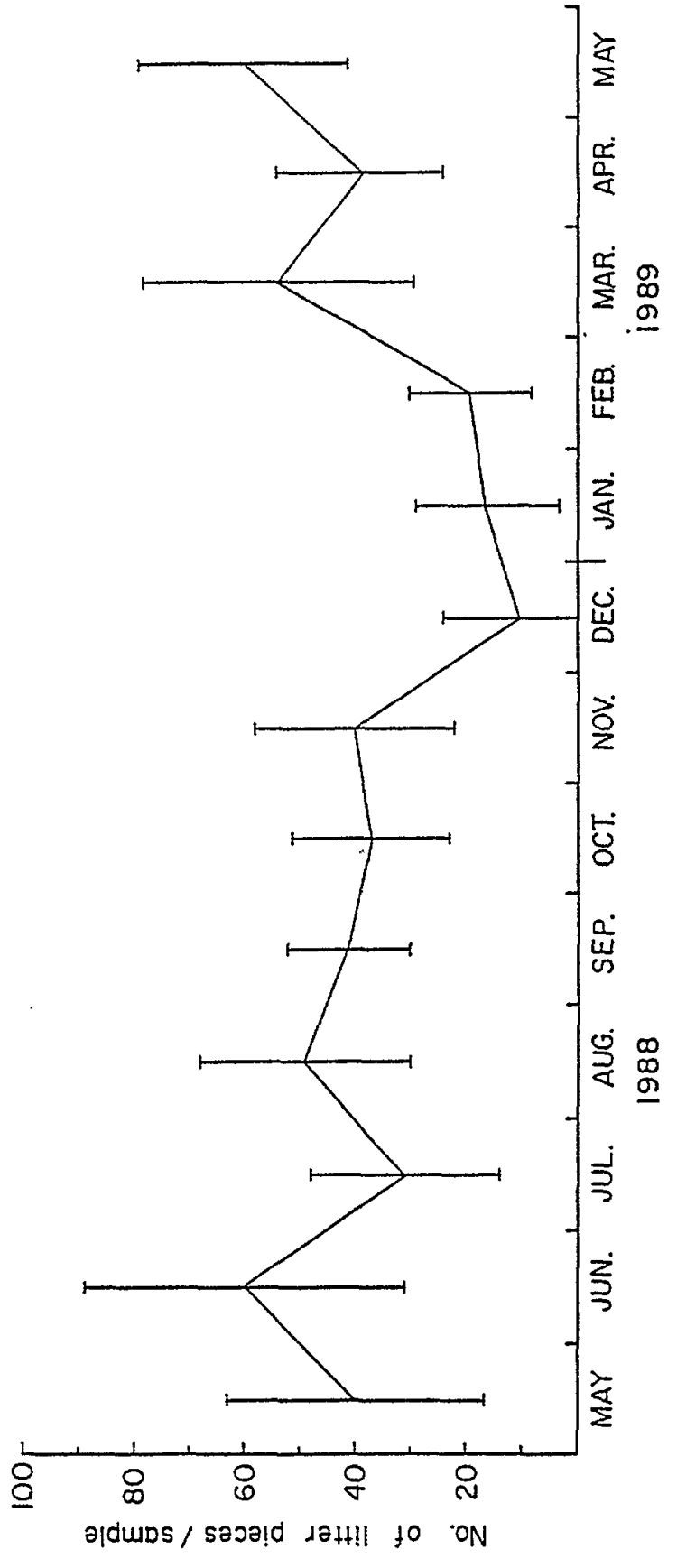

Fig. 5 Variations of monthly means and standard deviations of litter quantity (counts/sample) on all the Israeli beach stations (From Golik and Gertner, 1989)

Another example of the wind effect on litter distribution is brought by Marino et al. (1989) from a survey of floating litter off the northeastern coast of Spain (Fig. 6). The mean concentrations of floating plastics, Styrofoam and wood during an expedition which was conducted on July 1988 were 2086 pieces, 1061 pieces and 48.7 kg per km^2 respectively. However, during another expedition, in March 1989 the values for the same components were 380 pieces, 307.6 pieces and 13.1 kg per km^2 respectively. Marino et al. (1989) attribute the difference in the floating litter quantity between the two sampling periods to the fact that prior to the March 1989 sampling, a strong westerly wind blew over the sampling area, driving all the floating litter to the beach and leaving the sea relatively clean.

Recently, several eddies were discovered in the eastern Mediterranean (Saydam et al., 1985; Brenner, 1989; Ozsoy et al., 1989). Some of them show geographical stability for a long period of time. It is quite possible that similar eddies exist in many other locations in the Mediterranean. Although their role in influencing distribution of flotsam in the sea is not yet known, it has been suggested that they may cause concentration of floating tar and litter (Saydam et al., 1985).

4.3 Fate of the litter

Very little work was done on the fate of the litter. Dixon and Cooke (1977) approached this problem by investigating the container fraction of the litter on a beach in Kent, U.K. Shore retention rates of the containers were estimated by marking the plastic and glass items and counting the remaining marked items after 7, 14, 21, 28 and 56 days. This showed an exponential disappearance with only 20-30% of the debris remaining after 7 days. Glass retention on a sandy beach was twice as high as on a shingle beach. Persistence of litter in adjacent waters was determined by age estimation of some of the debris. Age was determined either by the date inscribed on the item or by knowing the age of various series (according to shape or color) of container products. It was found that 83% of the containers were less than 2 years old. Allowing 6 to 18 months for production to disposal period, this finding indicates a very short retention time of litter in the coastal waters. In contrast to this, preliminary results of a study which is presently underway in Israel show that although there is a transport of litter in the longshore as well as the on- offshore directions, this transport, at least during the summer months, was limited, and painted pieces of litter were found on the same beach even after several months (N. Samsonov, personal communication). It should be borne in mind that the beach in Kent, U.K. is affected by a large tidal range (mean spring tide range is 5.9 m) and strong (0.3-1.6 m/sec) tidal currents, whereas the tidal range in Israel is only 0.5 m.

A similar experiment was carried out by Merrell (1980), who spray-painted gill net floats on two beaches (1000 m long each) on both sides of Amchitka Island, Alaska. He found that after one year, 70% of the floats disappeared from one of the beaches and 25% from the other (41% combined). These floats were not found on other beaches, and Merrell suggests that they were buried by storm surf in the beach sand or blown by the wind to the back shore and into the island.

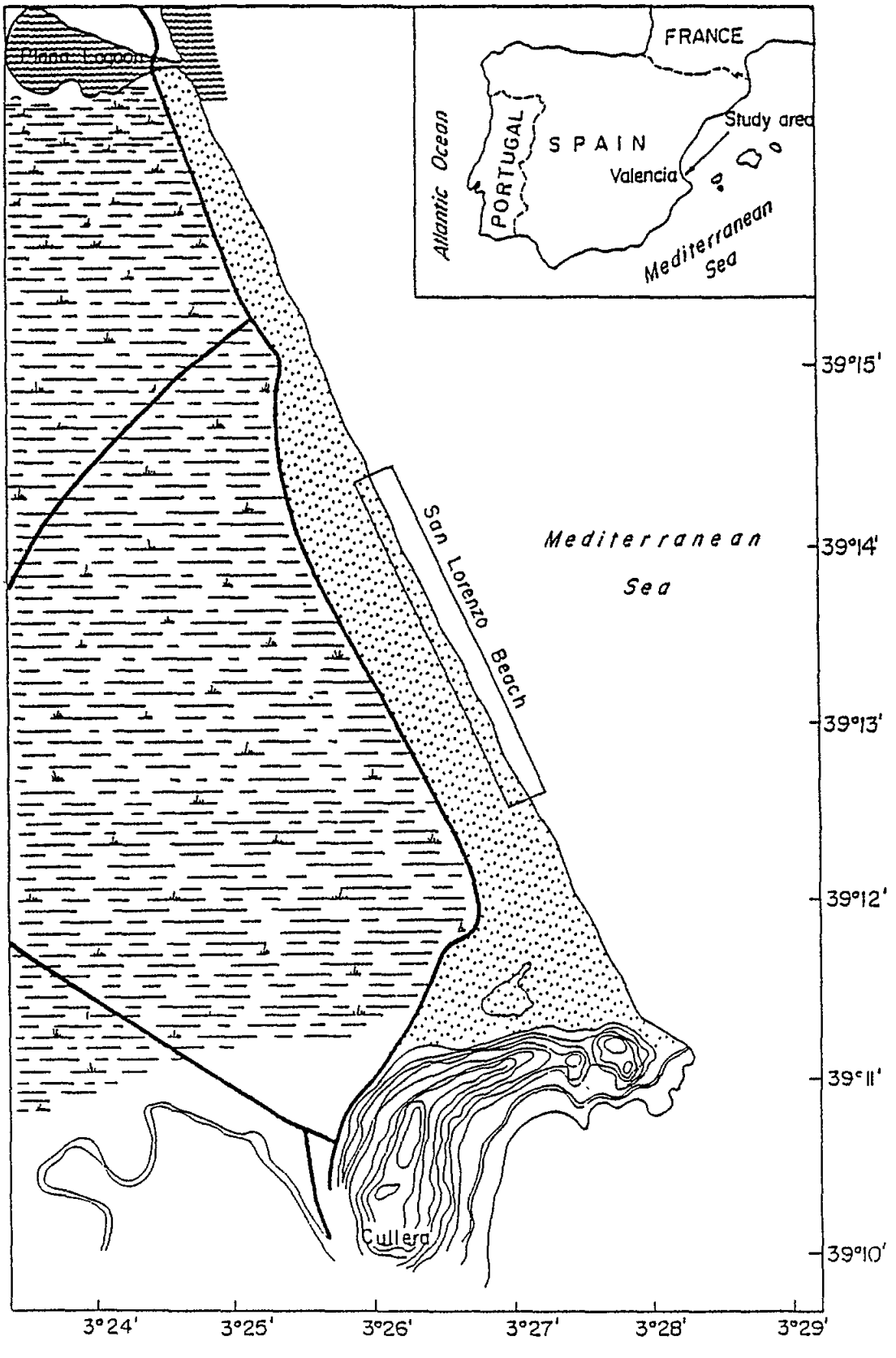

Fig. 6 Sampling area in Spain

5. LEVEL OF PERSISTENT LITTER IN THE MEDITERRANEAN SEA

5.1 Methodology

Monitoring marine litter is relatively young, and no widely accepted methods for sampling of litter at sea and on the beach have yet been developed. Several considerations must be taken into account in designing a monitoring programme of marine litter. First, the term "monitoring" implies comparison between at least two series of observations in either space or time or both, thus requiring analysis of data using statistical procedures. This implies that some randomness should be introduced in the process of selection of sampling stations. Secondly, results of various studies show that the litter population is highly variable and does not follow any known distribution pattern. Therefore, a large number of samples and the use of non- parametric statistical procedures are required to reach valid conclusions. Another issue involved in litter monitoring is the question of what exactly to measure and, accordingly, in what units to express the results. Litter may be measured in terms of number of litter pieces, of litter weight or of area occupied by the litter. Each of these introduces some distortion to the results but this is inevitable in view of the great variety of materials of which the litter population is composed.

Coastal litter sampling is commonly done from a unit of beach area or length. In most of the cases, the beach unit is a transect which is oriented normal to the coastline from the water line to the back of the beach, which is defined either by the foot of the coastal cliff or dune, or by the beginning of the vegetated area. The width of the transect (which is the beach length) may vary, and there are reports based on transect widths which range from 1 meter to 1 mile. The ideal transect width is in the order of 3-5 m. It is small enough for an individual to count or collect litter items, and large enough to be representative of the litter population.

Very few reports exist on studies of floating litter. Most of them are based on eye sighting of litter from a vessel. In some cases, attempts were made to provide quantitative data based on counting pieces of litter in the water and estimating the area covered by the observer (McCoy, 1988). Another method is to employ a neuston net for sampling. This method is more accurate but it is applicable only to small (a few cm) pieces of litter.

Quantitative information on litter from the sea bed may be obtained by trawling on the sea bottom. In this case it is important to know the horizontal opening of the trawling net as well as the distance covered by the ship in order to obtain the concentration of debris per unit area of sea bed.

Another consideration is what to sample. The litter consists of items ranging in size from a few millimeters (plastic granules) to a few meters (construction debris, car racks, etc.), a large variety of materials and a wide spectrum of functions which were fulfilled by these items during their "life". There is no common consensus on which fraction of the litter to sample and which to ignore. However, the most

informative fraction of the litter is discarded containers. In many cases these bear inscriptions and imprints which provide information on their place of origin, age, and function, therefore providing information on the sources, path of transport and fate of the litter population. They also provide information on their role before turning into litter, thus providing additional insight into the origin of the litter.

5.2 Litter level in the Mediterranean sea

5.2.1 Coastal litter

Tables IV-IX provide quantitative information on the litter found on several Mediterranean beaches in Spain, Sicily, Cyprus and Israel (IOC/FAO/UNEP, 1989). Examination of the data shows a wide range of litter concentration, from a mean of 0.53 to 1105 pieces/frontal meter of beach in counts, or from 4.2 to 6,628 g/m in weight. The high variability in the litter quantity is reflected in the high standard deviation which in many cases is close to the mean value.

Table X provides a comparison of the mean litter quantities on the coastlines of Spain, Sicily Cyprus and Israel (IOC/FAO/UNEP, 1989). The findings were normalized to quantity of litter per 1 m of frontal beach to allow comparison. This comparison must, however, be made with caution because of the large difference in the number of samples collected in each of the countries. The high values of litter which were obtained in Sicily are certainly biased because of the findings on the beach of Ficarazzi which is near Palermo (Fig. 2), and which probably serves as a dumping ground for construction refuse of that city. Although it is impossible to test statistically whether the differences observed in litter level between the coastlines of these countries are significant, due to the large differences in sample numbers, Table X provides, for the first time, an order of magnitude of the coastal litter quantity in the Mediterranean. Further sampling is required in order to determine whether the trends observed in Table X are valid. In addition, sampling on more Mediterranean coastlines is required in order to get a better estimate on the coastal litter level.

5.2.2 Floating litter

Collection and measurement of floating litter was conducted by Marino et al. (1989) in two expeditions off the northern Spanish Coast in the Mediterranean, in July 1988 and March 1989. The results are given in Table XI and they show that the mean concentration of plastic was 867 pieces per km^2, Styrofoam 522 pcs/km^2 and wood 23.3 kg/km^2. Saydam et al. (1985) measured pelagic litter in the northeastern Mediterranean using neuston net. Many of their neuston tows did not contain any litter and the largest value they report is 7.2 mg/m^2 (= 7.2 kg/km^2).

Table IV

Statistics on beach litter in Spain (Source: IOC/FAO/UNEP, 1989).

		May 1988	Jun 1988	Jul 1988	Aug 1988	Sep 1988	Oct 1988	Nov 1988	Dec 1988	Jan 1989	Feb 1989	Total
Counts (pcs/m)	n	1	1	2	2	2	2	2	2	2	2	18
	Σ	41	38	65	77	57	46	51	52	60	112	599
	x	41	38	32.5	38.5	28.5	23.0	25.5	26.0	30.0	56	33.2
Weights (g/m)	n	1	1	2	2	2	2	2	2	2	2	18
	Σ	517.5	366.2	185.5	159.5	136.1	589.4	492	91.2	99.2	230.8	2867.4
	x	517.5	366.2	92.8	79.8	68.1	294.7	246	45.6	49.6	115.4	159.3
Surface area (cm^2/m)	n	1	1	2	2	2	2	2	2	2	2	18
	Σ	2939	2039	2792	1854	1898	1556	1510	858	882	1824	18152
	x	2939	2039	1396	927	949	778	755	429	441	912	1008

n = number of samples
Σ = total
x = mean

Table V

Statistics on beach litter (number of pieces) in Sicily
(Source: IOC/FAO/UNEP, 1989).

Beach		Oct 1988	Nov 1988	Dec 1988	Jan 1989	Feb 1989	Mar 1989	Apr 1989	May 1989	Total
Ficarazzi	n	2	2	2	2	2	2	2	2	16
	Σ	3839	2154	1854	762	705	530	663	592	11099
	x	1919	1077.0	927.0	381.0	352.5	265.0	3315	296.0	693.7
	σ	1252.3	73.5	69.3	24.0	62.9	80.6	30.4	49.5	651.9
Balestrate	n	2	2	2	2	2	2	2	2	16
	Σ	477	268	202	217	264	240	549	390	2607
	x	238.5	134.0	101.0	108.5	132.0	120.0	274.5	195.0	162.9
	σ	6.4	12.7	70.7	7.8	5.7	12.7	7.8	58.0	67.4
Eraclea Minoa	n		2	2	2	2	2	2	2	14
	Σ		47	54	38	49	66	54	63	371
	x		23.5	27.0	19.0	24.5	33.0	27.0	31.5	26.5
	σ		3.5	8.5	5.7	2.1	11.3	2.8	5.0	6.5
Total	n	4	6	6	6	6	6	6	6	46
	Σ	4316	2469	2110	1017	1018	836	1266	1045	14077
	x	1079.0	411.5	351.7	169.5	169.7	139.3	211.0	174.2	306.0
	σ	1210.2	518.9	449.1	169.0	152.2	111.1	145.5	124.2	477.7

n = number of samples
Σ = total (pcs/3m)
x = mean (pcs/3m)
σ = standard deviation

Table VI

Statistics on beach litter (weights) in Sicily
(Source: IOC/FAO/UNEP, 1989).

Beach		Oct 1988	Nov 1988	Dec 1988	Jan 1989	Feb 1989	Mar 1989	Apr 1989	May 1989	Total
Ficarazzi	n	2	2	2	2	2	2	2	2	16
	Σ	39770	33558	21500	24368	4695	10780	6320	9582	15057.3
	x	19885.0	16777.0	10750.0	12184.0	2347.5	5390.0	3160.0	4791.0	9410.8
	σ	6625.6	1603.7	4381.2	8507.9	1347.0	4659.8	1060.7	2360.3	7156.3
Balestrate	n	2	2	2	2	2	2	2	2	16
	Σ	9517	4366	18191	3473	4379	6493	8070	6466	60955
	x	4758.2	2183.0	9095.5	1736.5	2189.5	3246.5	4035.0	3233.0	3809.7
	σ	108.2	913.0	9429.3	487.2	202.9	262.3	42.4	626.5	3353.8
Eraclea Minoa	n		2	2	2	2	2	2	2	14
	Σ		1092	1929	957	756	882	1751	1231	8598
	x		546.0	964.5	478.5	378.0	441.0	875.5	615.5	614.1
	σ		405.9	321.7	130.8	384.7	7.1	21.9	402.3	303.2
Total	n	4	6	6	6	6	6	6	6	46
	Σ	49287	39016	41620	28798	9830	18155	16141	17279	220126
	x	12321.8	6502.7	6936.7	4799.7	1638.3	3025.9	2690.2	2879.8	4785.4
	σ	9534.5	8038.2	6602.2	6896.5	1165.7	3047.0	1534.4	2187.9	5848.5

n = number of samples
Σ = total weight (g/3m)
x = mean weight (g/3m)
σ = standard deviation

Table VII

Statistics on beach litter (number of pieces) in Cyprus
(Source: IOC/FAO/UNEP, 1989).

Beach		Oct 1988	Nov 1988	Dec 1988	Jan 1989	Feb 1989	Mar 1989	Apr 1989	May 1989	Total
Makronissos	n	5	5	5	5	5		5	5	35
	Σ	21	40	52	33	16		48	21	231
	x	4.2	8	10.4	6.6	32.		9.6	4.2	6.6
Lara	n	11	11	11	11	11	11	11	11	88
	Σ	178	202	306	108	62	44	58	86	1044
	x	16.2	18.3	27.8	9.8	5.6	4.0	5.2	7.8	11.8
Total	n	16	16	16	16	16	11	16	16	123
	Σ	199	242	358	141	78	44	106	107	1275
	x	10.2	13.1	19.1	8.2	4.4	4.0	7.4	6.0	10.36

n = number of samples
Σ = total (pcs/m)
x = mean (pcs/m)

Table VIII

Statistics on beach litter (weights) in Cyprus
(Source: IOC/FAO/UNEP, 1989).

Beach		Oct 1988	Nov 1988	Dec 1988	Jan 1989	Feb 1989	Mar 1989	Apr 1989	May 1989	Total
Makronissos	n	5	5	5	5	5		5	5	35
	Σ	77	531	205	32	21		592	323	1781
	x	15.4	106.2	41.0	6.4	4.2		118.4	64.6	50.8
Lara	n	11	11	11	11	11	11	11	11	88
	Σ	1233	1536	1451	1091	904	827	807	1082	8931
	x	112.0	139.6	131.9	99.2	82.1	75.1	73.3	98.3	101.4
Total	n	16	16	16	16	16	11	16	16	123
	Σ	1310	2067	1656	1123	925	827	1399	1405	10712
	x	63.7	122.9	86.4	52.8	43.1	15.1	95.8	81.4	87.08

n = number of samples
Σ = total (g/m)
x = mean (g/m)

Table IX

Statistics on beach litter in Israel (Source: IOC/FAO/UNEP, 1989).

Beach		May 1988	June 1988	Jul 1988	Aug 1988	Sep 1988	Oct 1988	Nov 1988	Dec 1988	Jan 1989	Feb 1989	Mar 1989	Apr 1989	May 1989	Total
Akhziv	n	8	8	8		8	8	8	8	8	8	8	8	8	96
	Σ	420	683	349		292	349	370	132	179	143	542	424	521	4404
	x	52.50	85.38	43.63		36.50	43.63	46.25	16.50	22.37	17.87	67.75	53.00	65.13	45.88
	σ	31.27	36.21	22.17		9.87	13.55	16.09	24.44	17.59	6.90	34.46	15.55	27.56	29.67
Haifa Bay	n	6	6	6		6	6	6	6	6	6	6	6	6	72
	Σ	120	290	139		271	219	373	89	119	115	258	274	416	2683
	x	20.00	48.33	23.17		45.17	36.50	62.17	14.83	19.83	19.17	43.00	45.67	69.33	37.26
	σ	8.67	29.43	7.31		11.32	16.75	19.82	11.34	10.15	8.75	5.93	6.31	7.97	21.44
Carmel Beach	n	6	6	6	6	6	6	6	6	12	6	6	6	6	84
	Σ	270	425	284	234	288	297	245	55	240	137	362	236	371	3444
	x	45.00	70.83	47.33	39.00	48.00	49.50	40.83	9.17	20.00	22.83	60.33	39.33	61.83	41.00
	σ	12.54	12.86	14.42	17.88	13.27	11.27	6.18	13.06	12.75	12.32	24.02	15.38	17.97	21.87
Neveh Yam	n	6	6	18		6	6	6	6	6	6	6	6		78
	Σ	271	265	483		207	196	225	10	60	83	272	197		2275
	x	45.17	44.17	26.83		34.50	32.67	37.50	2.67	10	13.83	45.33	32.83		29.17
	σ	26.06	15.68	15.42		13.46	5.99	3.89	2.07	2.1	1.17	14.07	7.63		17.76
Dor	n	5	5	11		3	5	5	5	5	5	5	5	5	64
	Σ	232	327	258		133	153	154	41	69	133	229	143	247	2119
	x	46.40	65.40	23.45		44.33	30.60	30.80	8.20	13.80	26.60	45.80	28.60	49.40	33.11
	σ	20.74	20.63	14.07		4.73	15.84	17.30	8.32	13.14	20.68	34.26	16.21	12.97	22.44
Beit Yanay	n	6	6	6	6	6	6	6	6	6	6	6	6	6	78
	Σ	178	214	193	359	238	165	128	28	41	77	350	158	301	2430
	x	29.67	35.67	32.17	59.83	39.67	27.50	21.33	4.67	6.83	12.83	58.33	26.33	50.17	31.14
	σ	12.29	13.88	11.55	13.85	5.09	5.96	12.64	5.50	3.87	8.80	15.28	6.80	15.08	19.83
Total	n	37	37	55	12	35	37	37	37	43	37	37	37	31	472
	Σ	1491	2204	1706	593	1429	1379	1495	361	708	688	2013	1432	1856	17355
	x	40.30	59.57	31.02	49.42	40.83	37.27	40.41	9.76	16.47	18.59	54.41	38.70	59.87	36.77
	σ	22.78	28.91	17.01	18.73	11.03	13.78	18.14	14.06	12.53	10.99	24.49	15.10	19.11	23.48

n = number of samples; Σ = total (pcs/5m); x= mean (pcs/5m); σ = standard deviation

Table X

Comparison of litter level between various Mediterranean coastlines (Source: IOC/FAO/UNEP, 1989).

Study area	Spain	Sicily	Cyprus	Israel
No. of samples	17	46	123	472
Mean counts (pcs/m)	33.2	102	10.36	7.35
Mean weight (g/m)	159.3	1595	87.08	

The other studies on floating litter in the Mediterranean were only semi quantitative, based on counting floating debris from a ship and then manipulating the results to concentration of litter. Morris (1980) reports that he observed in this way approximately 2000 pieces of litter per km^2 some 40 miles SW of Malta. On the other hand, McCoy (1988), who used the same method from a stationary ship in the Ionian Sea, found on the average only one floating object per day, or, according to his computations, 0.12 pieces per km^2. Again, the values brought above are based on a small number of measurements or observations as to allow definite conclusions on the level of litter floating in the Mediterranean. At best, they provide an order of magnitude.

5.2.3 Sea bed litter

There are many reports on the presence of litter on the Mediterranean sea bed. Most of them are of anecdotal nature. During a dive with the submersible "Cyana" in the submarine canyon off Toulon, France, in 1989, large quantities of litter, consisting of plastic bags, bottles and crates were observed on the sea bottom (Y. Mart, personal communication). In recent sediment sampling by dredging the sea bottom at depths ranging from 200 to 1400 m off Israel, all the samples which were collected contained litter consisting mostly of shredded plastic sheets, but plastic bottles and plates were also present (B. Galil, personal communication). However, the only systematic measurement of litter on the sea bed in the Mediterranean Sea was carried out by Bingel et al. (1987) and Bingel (1989) on the Turkish continental shelf of the Mediterranean and their results are given in Tables XII and XIII. It can be seen that there is a general trend of increase in litter density with depth. The data, however, are still too sparse to determine whether this trend is real, and if yes, what are the reasons for it.

Bingel (1989) made an attempt to assess the quantity of litter on the Mediterranean sea bed on the basis of the mean concentration of litter found by him off Turkey, which is 28.63 kg/km^2. Applying this value to the whole continental shelf of the Mediterranean, Bingel obtained 16,000 tons.

Table XI

Litter concentration off the Mediterranean Spanish Coast (From Marino et al., 1989).

Station	Transect	Date	Plastic		Wood kg/km^2	Styrofoam $pieces/km^2$
			$pieces/km^2$	kg/km^2		
Barceloneta	2c	26 Jul 88	3510	94.2	45.6	1011
Mataro	3c	26 Jul 88	1375	43.2	40.8	485
Areyns de Mar	4c	25 Jul 88	2720	92.2	67.9	606
Tordera	5c	25 Jul 88	741	17.6	41.2	2143
Castel-defelch	1a	4 Mar 89	108	3.4	0.0	0
Barceloneta	2a	4 Mar 89	105	2.4	17.6	0
Mataro	3a	4 Mar 89	0	0.0	0.0	0
Areyns de Mar	4a	5 Mar 89	908	39.7	18.8	869
Tordera	5a	5 Mar 89	72	1.5	18.4	567
Castel-defelch	1b	7 Mar 89	71	2.1	0.0	0
Barceloneta	2b	7 Mar 89	843	16.0	1.0	0
Mataro	3b	7 Mar 89	36	2.8	0.0	397
Areyns de Mar	4b	6 Mar 89	1486	35.7	71.9	418
Tordera	5b	6 Mar 89	169	7.0	3.3	825

It is quite obvious from the data and estimates of litter quantities which were presented here that it is impossible to present a coherent picture of the pollution level by litter of the Mediterranean Sea. The reasons for this are many: the litter consists of many components which differ in their input rate, behavior and fate; most of the available information is derived from extrapolation based on estimates and therefore suffers badly from errors; measurement of litter is very difficult, certainly on the surface water and the seabed and the available quantitative data are extremely rare for the size of the Mediterranean Sea. These difficulties will not disappear soon. It may therefore prove more profitable to invest future efforts in investigating processes which control the distribution, behavior and fate of litter as well as intensive monitoring projects, each on a small geographical area, with the aim of detecting temporal changes in the litter quantity and nature.

Table XII

Amount of plastics and nylon materials and other litter in Mersin and Iskenderun Bays (wet weights) (From Bingel, 1989).

Region	Depth range (m)	Amount plastics (tons)	Amount litter (tons)	Amount litter (kg/kg^2)
Iskenderun Bay	0-50 50-100	31.8 24.0	33.3 24.0	36 23
Total		55.8	57.3	29
Mean catch (g)	0-50 50-100	473.6 g 305.0 g	496.4 g 305.0 g	
Coeff. of var.	0-50 50-100	52.4% 70.6%	53.3% 70.6%	
Mersin bay	0-50 50-100	17.8 21.5	23.7 103.6	19 78
Total		39.3	127.3	49
Mean catch (g)	0-50 50-100	198.7 g 213.1 g	263.5 g 1027.3 g	
Coeff. of var.	0-50 50-100	54.5% 54.0%	53.6% 148.5%	

Table XIII

Amount of plastic matter in Mersin and Iskenderun Bays in different years and seasons (From Bingel, 1989).

Year & season	Depth range (m)	Iskenderun Bay		Mersin Bay	
		kg/km^2	tons	kg/km^2	tons
1983 autumn	0-50 50-100	23.8 24.0	22 25	10.5 33.8	13 45
1984 spring	0-50 50-100	54.1 93.2	50 97	12.1 33.8	15 45
1984 autumn	0-50 50-100	24.9 46.1	23 48	8.1 4.5	10 6
1989 spring	0-50 50-100	34.6 23.1	32 24	14.5 16.5	18 22
Mean	0-50 50-100	34.4 46.6	32 49	11.3 22.2	14 30

6. COMPOSITION

6.1 Coastal litter

Fig. 7 presents the relative abundance of the various coastal litter components in several Mediterranean countries. It shows that in all of the study areas, plastic debris are the most abundant component in the litter, ranging between 34 and 75%. The only exception is Sicily, where, due to large concentration of construction debris on one beach, the relative abundance of plastic is lower. Considering that unspecified garbage pieces (termed as "various" or "others") were between 10 to 20%, the relative abundance of other components, such as glass or metal, was only a few percent each.

The plastic fraction consists, in decreasing order of abundance, of plastic fragments, plastic bags and sheets, and containers of soft drinks, food, cosmetics, engine oil, etc. Most of the metal components are tins used for beverages; the rest are either food cans or aerosols. In a similar way the glass fraction contains mostly soft drink bottles and, in small numbers, other glass items such as light bulbs. Wood includes driftwood as well as crate fragments. In addition to these, cartons, Styrofoam, garments and foam rubber are found in smaller numbers.

Table XIV presents the relative abundance of litter components from various beaches in the world which were reported in the literature. Comparison of these findings with the composition of coastal litter in the Mediterranean shows slight differences. Relative abundance of plastics debris is higher in the Mediterranean whereas the metal and glass components are less. Also, remnants of fishing gear are rather rare in the Mediterranean - 2.8% was the highest abundance recorded.

6.2 Floating litter

The composition of the floating litter which was found off the Spanish coast in the Barcelona area (Marino et al., 1989) consisted of (in number of pieces) 74.5% plastics, 15.2% styrofoam and 3.05% wood. In terms of weight, the percentages are 55.5%, 1.1% and 36.2, respectively. Similar composition of floating litter was reported by Morris (1980), who observed near Malta that 60-70% of the litter consisted of plastic material including bags, cups, plastic sheets, packing material, bottles and fragment. The rest of the litter observed by Morris (1980) included timber, rubber, nylon ropes, glass bottles and paper. McCoy (1988), who made similar observations of floating litter in the Ionian Sea, does not provide quantitative information on the composition of the litter but he too reports on plastic (mostly containers) and wood as the most abundant materials.

6.3 Sea bed litter

The only quantitative information on the composition of the sea bed litter in the Mediterranean Sea is provided by Loizides (in Bingel, 1989) from Cyprus and by Bingel (1989) from the northeastern coast of Turkey. The findings off Cyprus, which are based on a relatively small number of samples and therefore may be misleading, are that metal

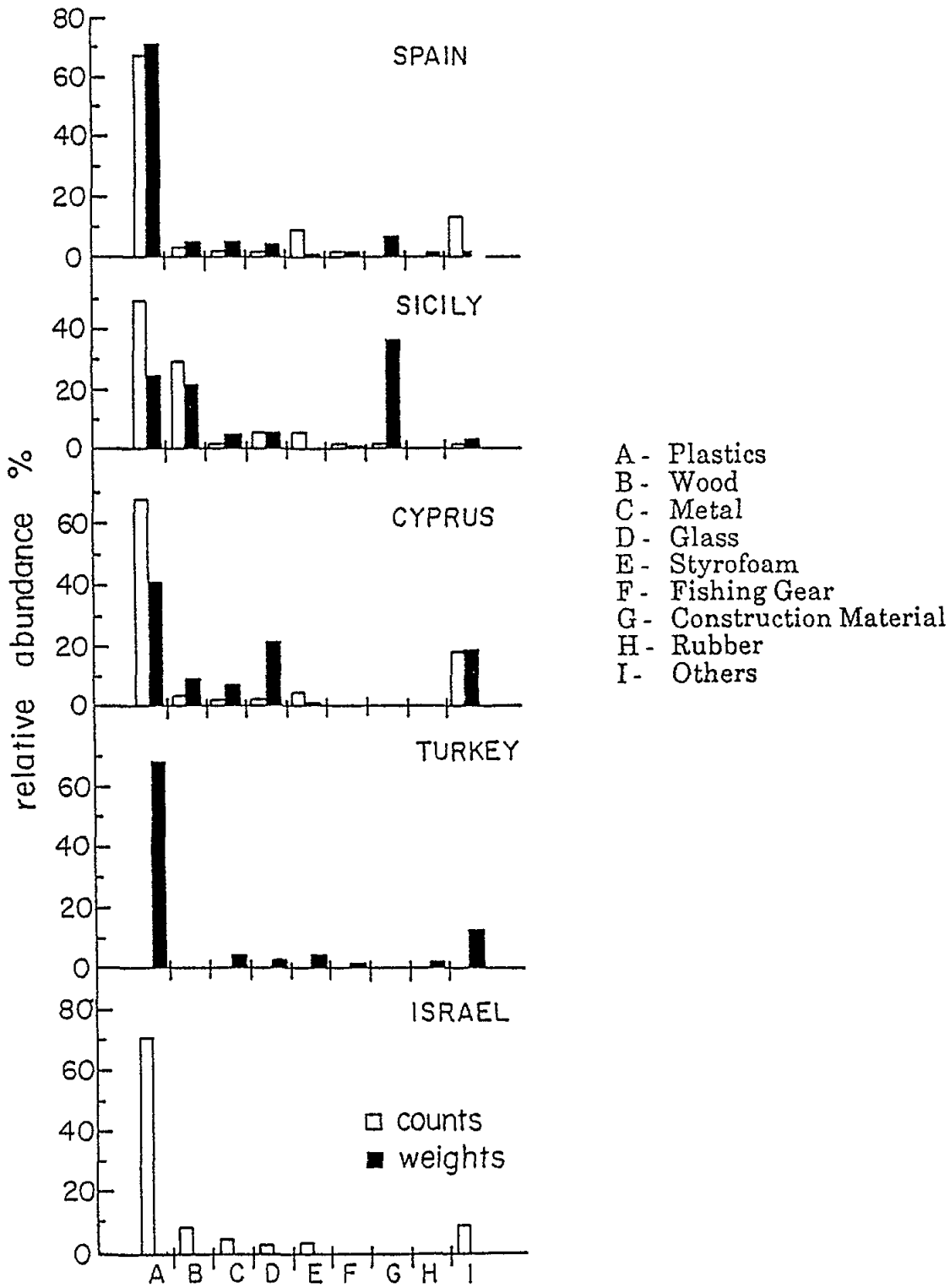

Fig. 7 Relative abundance of various litter components on the beaches of five Mediterranean countries (From Gabrielides et al., 1991)

Table XIV

Percentage of various litter components found on various beaches (based on counting of pieces of litter).

Author	Location	Plastic	Styro-foam	Wood	Metal	Glass	Paper	Fishing	Other
Vauk & Schrey 1987a	German Bight	74.9		11.5	4.4	2.7	3.7	0.7	
Dixon & Cooke 1977	Kent Beach, England*	37.9		0.6	27.7	32.1	3.9		0.7
Dixon & Dixon 1980	Cherburg & Channel Isl.*	56.0		2.6	16.9	20.5	3.9		
"	West Jutland*	44.2		6.7	17.0	25.6	6.4		
Dixon & Dixon 1983	Portugal*	63.2		1.7	19.4	13.8	1.5		2.1
"	Western Isles, Scotland*	56.0		2.4	14.4	20.7	5.8		0.6
Centaur Assoc. 1986	Maine, USA	27.6	27.4		6.6	12.9		11.4	14.1
"	Massachusetts, USA	71.3	5.7		3.9			15.9	3.4
"	New Jersey, USA	59.9			24.4	15.1			0.6
"	Texas, USA	55.5	17.2		11.3	16.0			

* Containers only

objects are more than 80% of the litter if measured by weight, but only 23% if counted as pieces. On the other hand, plastics constitute only 1.4% of the litter by weight but more than 45% by number of pieces. Off the southern coast of Turkey the most abundant material by weight was wood - 43%, whereas plastics constituted 32%.

Table XV provides information on floating and sea bottom litter from various parts in the world as reported in the literature. It is difficult to determine the relative abundance of each of the litter components on the basis of this information, because of the different interests and various methods employed by the various authors. The floating litter, as determined by observation from a boat or by neuston net sampling, consists almost entirely of plastics and fishing gear (which is also mostly plastics). On the sea bed, however, wood dominates over plastics, metal and glass, which are of more or less the same relative abundance.

7. EFFECTS

Marine litter has a deleterious effect on the biota in the sea, on free navigation and on the aesthetics of the beach and coastal waters. Most of the studies on the damage caused by litter to organisms are related to litter floating on the sea surface or in the water column. Organisms suffer from litter in two ways: entanglement and ingestion. Lost or discarded gill nets, trawl nets and strapping bands pose the greatest entanglement threat to marine mammals, fish, sea turtles and sea birds. Ingestion of debris is reported in mammals, sea birds and sea turtles. Most of the ingested debris found in the guts of organisms are plastic beads, but plastic sheets are also found, mostly in turtles. The list of papers and reports on the effect of pelagic litter on organisms is a very long one, and Table XVI provides a summary of some of them. Stranded litter on the beach is apparently less harmful to organisms than pelagic litter. Six-pack yokes, which are rather abundant on the beach, are the most dangerous to birds which get entangled in them by inserting a leg through one hole of the six pack and the beak through another (Evans, 1971).

There is only one report from the Mediterranean on the harmful effect of litter on the biota. Gramentz (1988) examined loggerhead turtles which were fished off Malta and found that 20% of them were affected by oil, plastic and metal. He noticed that although plastic sheets are found in the water in a large number of colors, those found in the intestines of the turtles were only transparent or milky in color. He therefore suggests that the turtles mistakenly take plastics for jellyfish and try to feed on them.

The ill effect of floating litter to navigation is mentioned in many reports but no specific study devoted to this problem was found. Debris, mostly fishing nets and plastic sheets, affect vessel operation by entanglement in the propellers and by clogging the intake pipes for cooling waters. No estimate on the magnitude of this problem, in or outside of the Mediterranean Sea, is available.

Table XV

Floating and sea bottom litter in various parts of the world.

Region	Observation methods	Composition of debris	Estimated and/or obs. abundance	Reference
Subtropical North Pacific	Visual observ. and strip transecting. Ring net.	Large plastic Small plastic	1.8 obj/km^2 1.2 mg/m^2	Day & Shaw, 1987
Subarctic North Pacific		Large plastic Small plastic	0.9 obj/km^2 0.05 mg/m^2	
Bering Sea		Large plastic Small plastic	0.2 obj/km^2 80 obj/km^2	
Worldwide	Commercial fishing	Plastic packing material	>23000 t/y	Horsman, 1985
Worldwide	Commercial fishing	Lost & dischar. fishing gear	135000 t/y	Merrell, 1980
Central North Pacific. Out of major shipping	Visual observ.	Plastics	2.2 obj/km^2	Venrick et al., 1973
South Pacific New Zealand	Neuston net	Chunks of degraded polystyrene foam, most common plastic	Minor amounts of all types 18 pellets/km^2	Gregory et al., 1984
Sargasso Sea & edge of Gulf Stream	Neuston net	Plastic partic. mostly pellets (2.5-5mm)	3500 pellets/km^2	Carpenter & Smith, 1972
North Sea-Helgoland	Trawling surveys	Plastic, artif. sponge, styrofoam Paper, cardboard Metal Glass, china Fishing gear Cloth Food stuff Wood	25.4 kg/km^2 3.1 kg/km^2 15.6 kg/km^2 8.6 kg/km^2 13.8 kg/km^2 1.1 kg/km^2 1.3 kg/km^2 138.6 kg/km^2	Vauk & Schrey, 1987b

Table XV (continued)

Region	Observation methods	Composition of debris	Estimated and/or obs. abundance	Reference
North Sea-Schahorn	Trawling surveys	Plastic, artif. sponge, styrofoam	20.1 kg/km2	Vauk & Schrey, 1987b
		Paper, cardboard	4.0 kg/km2	
		Metal	4.8 kg/km2	
		Glass, china	20.1 kg/km2	
		Fishing gear	11.1 kg/km2	
		Cloth	1.3 kg/km2	
		Food stuff	2.3 kg/km2	
		Wood	102.7 kg/km2	
North Sea-Norderoogsand	Trawling surveys	Plastic, artif. sponge, styrofoam	13.2 kg/km2	Vauk & Schrey, 1987b
		Paper, cardboard	0.02 kg/km2	
		Metal	17.8 kg/km2	
		Glass, china	4.7 kg/km2	
North Sea-Hauke-Halen-Koog	Trawling surveys	Plastic, artif. sponge, styrofoam	3.3 kg/km2	Vauk & Schrey, 1987b
		Paper, cardboard	0.4 kg/km2	
		Metal	3.6 kg/km2	
		Glass, china	0.7 kg/km2	
		Fishing gear	1.7 kg/km2	
		Cloth	0.2 kg/km2	
		Food stuff	0.1 kg/km2	
		Wood	12.9 kg/km2	
North Sea-Juist	Trawling surveys	Plastic, artif. sponge, styrofoam	44.5 kg/km2	Vauk & Schrey, 1987b
		Paper, cardboard	8.3 kg/km2	
		Metal	5.7 kg/km2	
		Glass, china	27.4 kg/km2	
		Fishing gear	12.5 kg/km2	
		Cloth	7.7 kg/km2	
		Food stuff	1.0 kg/km2	
		Wood	211.5 kg/km2	

In a similar way, no evaluation of the harmful effect of litter to the aesthetics of the beach and the coastal water was found, but there is no question that this effect exists though it is difficult to quantify it. In the case of the Mediterranean this issue is of great economic importance in view of the flux of tourists who come to the Mediterranean beaches for recreational purposes. Table XVII provides statistics on the growth of tourism in the Mediterranean countries between 1970 and 1987. The increase is in all countries and it ranges from 50% to more than 600%. It is estimated that at least half of the "tourists nights" are spent in the coastal area. To cater for these tourists, hotels, restaurants, marinas, bathing beaches and other recreational facilities are constructed along all of the Mediterranean coastline. Yet, filthy beaches are a major deterrent to tourists who go there for recreational purposes, and hence the gravity of coastal pollution problem.

Table XVI

Tabulated summary of the effects of persistent plastic on marine life.

	Causes & Effect	References
Entanglement	Physical entanglement Abrasion or cutting action of debris	
	- Infection	Day et al., 1985
	- Lacerations & infections on the neck	Scordino & Fisher, 1983
	- Lost and discharged gill nets, trawl nets and strapping and other bands	Kozloff, 1985
	- - Steller sea lions	Loughlin et al., 1986
	- - California sea lions	Stewart & Yochem, 1987
	- - Hawaiian monk seals	Cawthorn, 1985
	- - South African fur seals	Shaughnessy, 1980
	- - Arctic fur seals	Bonner & McCann, 1982
	- - Humpback fin & white whales	Kraus, 1985
	Attraction of entangled individuals as prey for other organisms	
	- Increased danger of entanglement	Day et al., 1985
	- - Marine birds (diverse species)	Piatt & Nettleship, 1987
	- - Sula bassana	Schrey & Vauk, 1987
	- - Sea turtles	Carr, 1986
	Monofilament line, rope, netting, cloth debris, tar	Balazs, 1985
Behavioral	Objects to play especially for young animals-mammals	
	- Increased danger of entanglement	
	- - Marine mammals	Day et al., 1985
	- - Newly weaned monk seal pups	Henderson, 1984, 1985
	- Migration	Fowler, 1987
	- Swimming towards plastic packing bands and nets and insertion of heads	Yoshida et al., 1985

Table XVI (continued)

	Causes & Effect	References
Ingestion	Selective or accidental ingestion of small fragments	
	- Blocking of digestive tract - Lessening the feeding drive - Ulceration and injury - Source of toxic chemicals	Day et al., 1985
	- - Laysan albatrosses:	
	Plastic fragments, toys, bottled caps or cigarette filters in the upper GI tract	
	- Impacted preventriculi, starvation - Preventricular ulceration - Chronic inflammatory lesions in the muscularis and mucosal lamina probia - Partial obstruction of gut	Fry et al., 1987
	Paint chips and other foreign objects	
	- Wing-droop syndrome-lead poisoning	Fry et al., 1987
	- - Sea turtles:	
	Synthetic scrap, fishing nets and lines plastic bags, beads, bottles, vinyl films and tar balls	Balazs, 1985
Regurgitation	Adult birds feeding chicks	Kenyon & Kridler, 1969
	- Retain indigestible items for long period, eventually for more than 40 days	Petitt et al., 1981
	- - Wedge-tailed shearwaters:	
	Plastic pellets and fragments	
	- Necrosis	Fry et al., 1987
Predation	Mechanically or through other ways or means disadvantaged (less conditioned) individuals will get easier predated)	Day et al., 1985
Spawning	Weakened individuals might be less fit to breed or rear their young	Day et al., 1985
Populations	Decline of population levels	
	- - Northern fur seal	DC (Dept. of Commerce), 1985; NPFSC (North Pacific Fur Seal Commission), 1985
	- - Fur seals - Pribilof Islands	Fowler, 1985; 1987
	- - Sea turtles	Carr, 1986

Table XVII

Increase in number of international tourist arrivals to Mediterranean countries, 1970-1987 (thousands).

Country	Arrivals in 1970	Arrivals in 1987	% increase
Albania	-	-	-
Algeria	236	849*	259
Cyprus	127	949	647
Egypt	348	1,795	415
France	18,130	36,818	103
Greece	1,407	8,004	468
Israel	419	1,101*	162
Italy	14,188	21,323	50
Lebanon	900	118**	-87
Libya	77	120*	55
Malta	171	746	336
Monaco	-	-	-
Morocco	747	2,128	184
Spain	15,320	30,545	99
Syria	409	1,160*	183
Tunisia	411	1,875	356
Turkey	446	2,856	540
Yugoslavia	4,749	8,907	87

* 1986, no data for 1987
** 1980, no data since then
Source: Statistical Yearbooks and the Blue Plan "Tourism Group".

8. ACTION TAKEN AT THE NATIONAL AND INTERNATIONAL LEVEL

Marine littering is a cultural problem and has to be treated as such, namely by education, legislation and law enforcement. In addition, innovative technologies for treating garbage may prove useful in controlling this problem. These avenues of treating the litter pollution should be adopted by local authorities, national governments and international organizations. Certainly, law enforcement, and to a certain extent even legislation, can best be carried out by the local authorities of the city or province of a particular coastline. This

level of government will be most effective in dealing with litter which is produced by beach goers, or at times by building contractors who use the beach as a dump site for building debris. Education, legislation and research should be the responsibility of the national government. In terms of litter sources, it is the land-based litter which should be treated by this level. The actions which should be taken by the international level should be directed to the marine-based litter, and to problems rising from lateral drift of litter between neighbouring countries. Education, international treaties and research should be the tools at the international level to combat the litter problem in the Mediterranean Sea. Initial steps in all these directions of activity, and in all levels of government, have already been taken all over the world as well as in the Mediterranean region.

8.1 Education

Increase in awareness of marine and coastal littering may be achieved by involving the public in voluntary beach clean-ups. This approach is especially effective if youngsters are involved, because it directly contributes to their education and personal behaviour when they reach adulthood. In recent years, voluntary beach clean-ups have been carried out all over the world and lately in some Mediterranean countries as well. In Greece, the Hellenic Marine Environment Protection Association (HELMEPA), an organization of ship owners and seamen devoted to protecting the marine environment, has already conducted massive beach clean-ups with the participation of more than a thousand young volunteers. The gains made by these operations are not only clean beaches and additional statistical information on coastal litter, but also, and most important, increasing awareness of young people to environmental problems. HELMEPA has also organised in Athens (29-30 June 1989) a Workshop on the elimination of garbage from the Mediterranean and its adoption as an effective special area to Annex V of MARPOL 73/78 (HELMEPA, 1989).

Similar developments are now taking place in Turkey, where a national plan has recently been designed for the education of youngsters to keep the coastline clean. In Israel, sporadic beach clean-up campaigns by volunteers have been carried out in recent years. Also, the Israeli Government financially supports local councils in cleaning their beaches, provided that the local councils bear half of the financial burden. This, again, is an educational step designed to motivate local authorities to bear responsibility for the cleanliness of the beaches which fall under their jurisdiction. It seems that the educational approach is effective. Golik and Gertner (1989, 1991) report that in many cases they found on the beach plastic bags which were filled by bathers with their trash (meal remnants, bottles, cans, etc.). Apparently these visitors to the beach were sensitive to the cleanliness of the beach and did not wish to leave their debris dispersed on the beach. However, due to lack of reception facilities such as trash bins, they left the debris-full plastic bags on the beach.

8.2 Legislation and law enforcement

Two of the protocols to the Barcelona Convention make special reference to persistent synthetic litter. According to article 4 and Annex I of the Protocol for the Prevention of Pollution of the

Mediteranean Sea by Dumping from Ships and Aircraft, it is prohibited to dump into the Mediterranean sea area plastic and other persistent synthetic materials which may materially interfere with fishing or navigation, reduce amenities, or interfere with other legitimate uses of the sea. The Protocol for the Protection of the Mediterranean sea against pollution from Land-based sources stipulates that Contracting Parties undertake to eliminate pollution from land-based sources by persistent synthetic materials which may float, sink or remain in suspension and which may interfere with any legitimate use of the sea.

Other important international agreements related to the prevention of marine pollution by persistent synthetic materials are the London Dumping Convention (LDC) which was agreed upon in 1972, and Annex V 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 LDC prohibits disposal at sea of waste and garbage loaded onto a ship from a land-based source. In the list of wastes and other materials prohibited from dumping are persistent plastics and other persistent synthetic material. This convention does not include, however, garbage generated in the course of normal operation of the ship.

On 31 December 1988, Annex V to MARPOL 73/78, came into effect. This is certainly the most important legislative step in protecting the marine environment from ship-generated garbage pollution. The Mediterranean sea has already been designated a "special area" and according to regulation 5 of Annex V no garbage may be discarded from ships into this area. The only exception is ground wastes ("capable of passing through a screen with openings no greater than 25 mm") which may be dumped into the sea but not within 12 miles from land.

It must be pointed out, however, that these special provisions have not yet come into force since paragraph 4(b) of regulation 5 stipulates that the clauses referring to pollution produced by ships travelling across the "special area" can only be applied 12 months after a sufficient number of Contracting Parties notify IMO that they have adequate garbage reception facilities in their ports to satisfy the requirements of the ships calling at these ports without causing undue delays. There are still 8 Mediterranean countries which have not yet ratified Annex V. During the 30th session of the Marine Environment Protection Committee of IMO a relevant resolution was proposed by the Italian delegation and was approved by the Committee as it appears in the Annex to this document.

On the national level, in many countries various legislations exist which prohibit littering the "public domain". Since in most countries the beach, and certainly the sea, are considered "public domain", these laws will also apply there. The responsibility for enforcing such regulations usually lies with local authorities. An extensive review of the national laws is not considered necessary here while it is considered doubtful that any specific legislation exists aiming at the prevention of land-based litter from reaching the beach and the sea. The indication that land-based garbage constitutes a significant portion of the Mediterranean litter raises the need for such legislation.

8.3 Beach cleaning

Another approach to control coastal litter is beach cleaning. This is done on many coasts of the Mediterranean which are visited by a large number of bathers. These public beaches are cleaned daily, or close to daily, by the local authorities and the cost of the cleaning operation is carried, directly or indirectly, by the beach users. However, cleaning of coastlines which are not frequented by large masses of people is a heavy financial burden and therefore is rather rare. In Greece, where massive clean-up of beaches was carried out by volunteers (see above), the collection of 1,389 m^3 of garbage cost $4,000 (D. Mitsatsos, personal communication) and this does not include the cost of labor. In Israel, the Ministry for Environmental Quality, together with the local councils, carry out a clean-up of almost the entire coastline of Israel once or twice a year. The cost of this cleaning is about $200 per km of coastline (E. Adler, personal communication). Golik and Gertner (submitted for publication) monitored several beaches in Israel after such a clean-up to determine its effectiveness. From Fig. 8, which presents the results of this monitoring, it is obvious that the effect of clean-up is rather short in time, less than a month. It is therefore obvious that massive clean-ups of beaches may have an educational value but are certainly not a practical solution.

9. SUMMARY

a) Attention has focused recently on the increasing amounts of man made debris littering the world oceans and coastlines and the Mediterranean is no exception. However, the studies made on this problem are very limited and the available information does not allow us to provide a quantitative assessment of litter input, level and decay in the Mediterranean Sea and its coasts. The quantities of litter which are based on measurements in the field cover only a small part of the Mediterranean Sea and its coasts and are not enough to provide a quantitative assessment of the litter problem. However, the MED POL survey provided for the first time some indication of the quantities of litter found on various beaches in some Mediterranean countries(see Table X).

b) There are 3 sources of litter input: i) litter which reaches the beach and the sea as drainage from land; ii) litter which is left on the beach by beach goers who come to the beach for recreation and by construction contractors who at times dump building debris there; iii) litter which is discarded from ships directly into the sea.

c) Factors which control the distribution of litter are: proximity to the litter source which may be shipping lanes at sea or population concentration on land, winds and currents which disperse the litter from its source, and waves which drive the litter from the front of the beach to its back and in case of storms even beyond it, landward.

d) Close to 3/4 of the coastal litter is composed of plastic materials. The remaining are litter pieces which are made of metal, glass, lumber and wood, Styrofoam and others. Floating

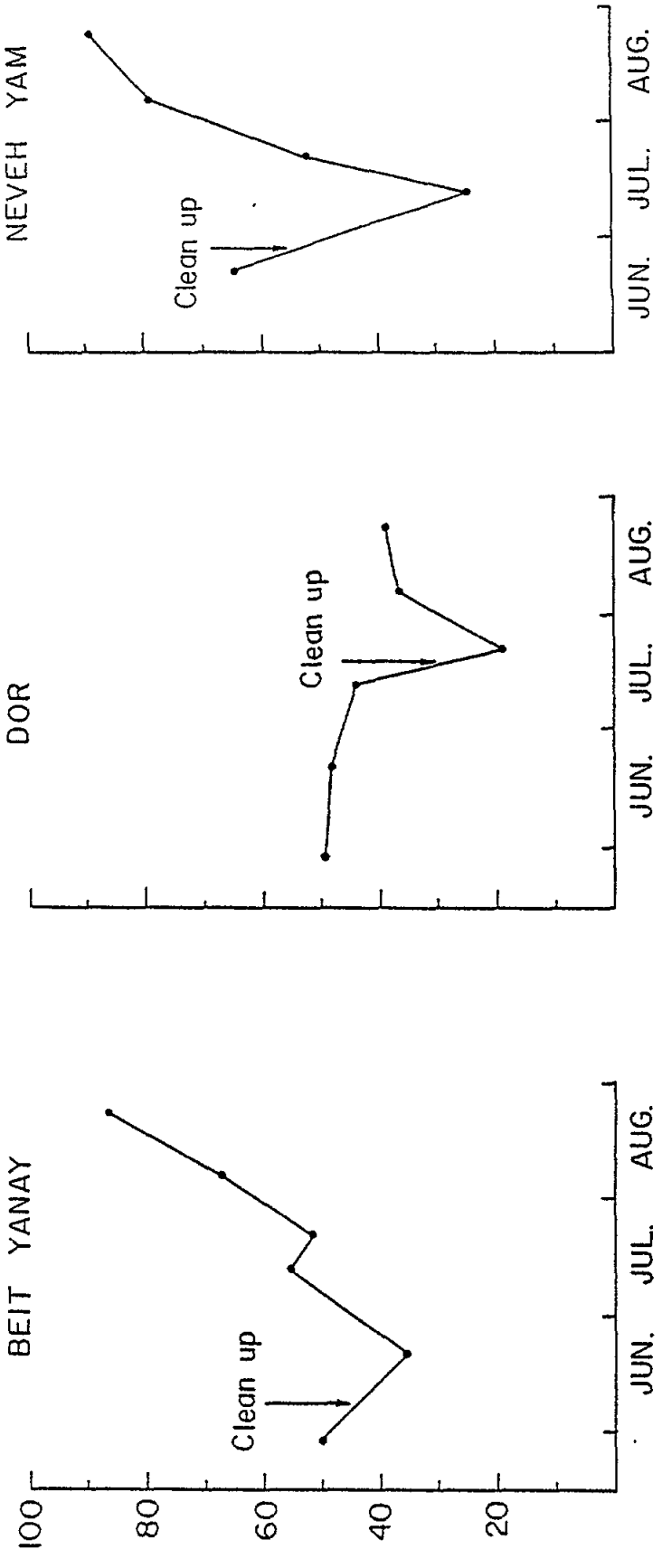

Fig. 8 Monitoring the effect of clean-up on three Israeli beaches (From Golik and Gertner, submitted for publication)

litter consists almost entirely of plastics, Styrofoam and wood, whereas seabed litter consists mostly of wood and then plastics, metal and glass in the same abundance.

e) Field observations yield the impression that the container fraction of the coastal litter in the Mediterranean consists mostly of those used for beverages, food and cosmetics. This is in contrast to containers of household detergents and cleansers which are the most abundant on the European coastline of the Atlantic. It has been proposed that most of the Mediterranean coastal litter is left by beach goers and therefore should be considered as land-based litter whereas that of the Atlantic beaches of Europe is mostly discarded from ships and therefore marine-based.

f) Eventhough the studies on the damage caused by marine litter in the Mediterranean are limited, it is to be expected that the same ill effects that marine litter has in other parts of the world would also exist in the Mediterranean. These are damage to fish, marine mammals and birds through entanglement and ingestion; damage to free navigation through entanglement in ship propellers and clogging intakes of cooling water systems, and damage to beaches by deterioration of their aesthetics. In the case of the Mediterranean the last one may be the most serious one, economically, in view of the heavy investments which are made to attract tourists to the Mediterranean coastline.

10. REFERENCES

Balazs, G.H. (1985), Impact of ocean debris on marine turtles: Entanglement and ingestion. In Proc. Workshop on the fate and impact of marine debris, 27-29 Nov. 1984, Honolulu, Hawaii, edited by R.S. Shomura and H.O. Yoshida, U.S. Dept. Commerce, NOAA Tech. Memo. NMFS. NOAA-TM-NMFS-SWFC-54. pp.336-343.

Bingel, F. (1989), Plastic in the Mediterranean Sea. Report prepared for IOC/UNESCO: pp.1-65.

Bingel, F., D. Avsar and M. Unsal (1987), A note on plastic materials in trawl catches in the north-eastern Mediterranean. Meeresforchung, 31:227-233.

Blue Plan (1987), Mediterranean basin environmental data (natural environment and resources). Mediterranean Blue Plan Regional Activity Center. Sophia Antipolis 06560 Valbonne, France: 283 p.

Bonner, W.N. and T.S. McCann (1982), Neck collars on fur seals, Arctocephalus gazella at south Georgia. Br.Antarct.Surv.Bull., 57:73-77.

Brenner, S. (1989), Structure and evolution of warm core eddies in the Eastern Mediterranean Levantine Basin. J.Geophys.Res., 94, no. C9:12593-12602.

Carpenter, E.J. and K.L. Jr. Smith (1972), Plastics on the Sargasso Sea surface. Science, 175:1240-1241.

Carpenter, E.J., S.J. Anderson, G.R. Harvey, H.P. Miklas and B.B. Peck (1972), Polystyrene spherules in coastal waters. Science, 178:749-750.

Carr, A. (1986), Rips, FADS and little loggerheads. BioScience, 36:92-110.

Cawthorn, M.W. (1985), Entanglement in, and ingestion of, plastic litter by marine mammals, sharks, and turtles in New Zealand waters. In Proc. Workshop on the fate and impact of marine debris, 27-29 Nov. 1984, Honolulu, Hawaii, edited by R.S. Shomura and H.O. Yoshida, U.S. Dept. Commerce, NOAA Tech. Memo. NMFS. NOAA-TM-NMFS-SWFC-54. pp.336-343.

Centaur Associates, Inc. (1986), Issue report and work plan for the development of a marine debris education program for the northwestern Atlantic and Gulf of Mexico. Report prepared for the National Marine Fisheries Service, 61 p.

Day, R.H. and D.G. Shaw (1987), Pattern in the abundance of pelagic plastic and tar in the North Pacific Ocean, 1976-85. Mar.Pollut.Bull., 18:311-315.

Day, R.H., D.H.S. Wehle and F.C. Coleman (1985), Ingestion of plastic pollutants by marine birds. In Proc. Workshop on the fate and impact of marine debris, 27-29 Nov. 1984, Honolulu, Hawaii, edited by R.S. Shomura and H.O. Yoshida, U.S. Dept. Commerce, NOAA Tech. Memo. NMFS. NOAA-TM-NMFS-SWFC-54. pp.344-386.

DC (U.S. Dept. of Commerce) (1985), Environmental impact statement on the Interim Convention on Conservation of North Pacific Fur Seals. NMFS, NOAA, Washington DC.

Dixon, T.R. and A.J. Cooke (1977), Discarded containers on a Kent beach. Mar.Pollut.Bull., 8:105-109.

Dixon, T.R. and A.J. Dixon (1980), Marine litter research program stage 2. Marine Litter Surveillance at two sites on the Western Cherbourg Peninsula and West Jutland shores of the English Channel and southern North Sea. Keep Britain Tidy Group, Bostel House, 37 West Street, Brighton. 44 p.

Dixon, T.R. and T.J. Dixon (1981), Marine litter surveillance. Mar.Pollut.Bull., 12:289-295.

Dixon, T.R. and T.J. Dixon (1983), Marine litter research program stage 5. Marine Litter Surveillance on the North Atlantic Ocean shores of Portugal and the Western Isles of Scotland. Keep Britain Tidy Group, Buckinghamshire College of Higher Education. 73 p.

Evans, W.E. (1971), Potential hazards of non-degradable materials as an environmental pollutant. In Naval underwater center symposium on environmental preservation, 20-21 May 1970.

Fowler, C.W. (1985), An evaluation of the role of entanglement in the population dynamics of northern fur seals on the Pribilof Islands. In Proc. Workshop on the fate and impact of marine debris, 27-29 Nov. 1984, Honolulu, Hawaii, edited by R.S. Shomura and H.O. Yoshida, U.S. Dept. Commerce, NOAA Tech. Memo. NMFS. NOAA-TM-NMFS-SWFC-54. pp.291-307.

Fowler, C.W. (1987), Marine debris and northern fur seals: a case study. Mar.Pollut.Bull., 18(6B):326-335.

Fry, D.M., S. Fefer and L. Sileo (1987), Ingestion of plastic debris by Laysan albatrosses and wedge tailed shearwaters in the Hawaiian islands. Mar.Pollut.Bull., 18(6B):339-343.

Gabrielides, G.P., A. Golik, L. Loizides, M.G. Marino, F. Bingel and M.V. Torregrossa (1991), Man-made garbage pollution on the Mediterranean coastline. Mar.Pollut.Bull., (in press).

GESAMP (1990), The state of the marine environment. UNEP Regional Seas Reports and Studies no. 115. UNEP, Nairobi, 111 p.

Golik, A. and Y. Gertner (1989), Litter on the Israeli coastline. Israel Oceanographic and Limnological Research, Report no. H12/89:1-14.

Golik, A. and Y. Gertner (1991), Solid waste on the Israeli coast - composition, source and management. Proc. 2nd Inter. Conf. on Marine Debris, Honolulu, Hawaii (in press).

Gramentz, D. (1988), Involvement of loggerhead turtle with the plastic, metal, and hydrocarbon pollution in the central Mediterranean. Mar.Pollut.Bull., 19:11-13.

Gregory, M.R. (1977), Plastic pellets on New Zealand beaches. Mar.Pollut.Bull., 8:82-84.

Gregory, M.R. (1983), Virgin plastic granules on some beaches on eastern Canada and Bermuda. Mar.Environ.Res., 10:73-83.

Gregory, M.R., R.M. Kirk and M.C.G. Mabin (1984), Pelagic tar, oil, plastics and other litter in surface waters of the New Zealand sector of the southern ocean, and on Ross Dependency shores. New Zealand Antarctic Record 6:12-26.

HELMEPA (1989), Proceedings of a workshop on the elimination of garbage from the Mediterranean and its adoption as an effective special area to Annex V of MARPOL 73/78 (Athens, 29-30 June 1989), 235 p.

Henderson, J.R. (1984), Encounters of Hawaiian monk seals with fishing gear at Lisianski Island, 1982. Mar.Fish.Rev., 46:59-61.

Henderson, J.R. (1985), A review of Hawaiian monk seal entanglement in marine debris. In Proc. Workshop on the fate and ipact of marine debris, 27-29 Nov. 1984, Honolulu, Hawaii, edited by R.S. Shomura and H.O. Yoshida, U.S. Dept. Commerce, NOAA Tech. Memo. NMFS. NOAA-TM-NMFS-SWFC-54. pp.325-335.

Heyerdahl, H. (1971), Atlantic Ocean pollution and biota observed by the Ra expeditions. Biol.Conserv., 3:164-167.

Horsman, P.V. (1982), The amount of garbage pollution from merchant ships. Mar.Pollut.Bull., 13:167-169.

Horsman, P.V. (1985), Garbage kills. BBC Wildlife, August, pp.391-393.

IOC/FAO/UNEP (1989), Report of the IOC/FAO/UNEP review meeting on the persistent synthetic materials pilot survey. Haifa, Israel, 12-14 June 1989, 46 p.

Kenyon, K.W. and E. Kridler (1969), Laysan albatross swallow indigestible matter. Auk. 86:339-343.

Kozloff, P. (1985), Fur seal investigations, 1982. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS, NOAA-TM-NMFS-F/NWC-71.

Kraus, S.D. (1985), A review of the status of right whales (Eubalaena glacialis) in the western north Atlantic with a summary of research and management needs. Final Report to the Marine Mammal Commission. NTIS, PB86- 154143. Springfield, VA.

Loizides, L. (1989), Study on the type and quantity of litter on Cyprus beaches. Dept. of Fisheries, Ministry of Agriculture and Natural Resources. 6 p.

Loughlin, T.R., P.J. Gearin, R.L. DeLong and R.L. Merrick (1986), Assessment of net entanglement on northern sea lions in the Aleutian Islands, 25 June - 15 July 1985. U.S. Dept. of Commerce, NWAFC Processed Report 86-02. Northwest and Alaska Fisheries Center, NMFS, Seattle, WA.

Marino, M.G., P. Aranzadi and J. Sobrino (1989), Litter on the beaches and littoral waters of the Spanish Mediterranean coast. Progress Report: 1-8.

Matthews, W. (1975), Marine litter. In Assessing potential ocean pollutants: 405-438, a report of the study panel on assessing potential ocean pollutants to the Ocean Affairs Board, Commission on Natural Resources, National Research Council, Washington D.C., National Academy of Sciences.

McCoy, F.W. (1988), Floating megalitter in the Eastern Mediterranean. Mar.Pollut.Bull., 19:25-28.

Merrell, T.R. Jr. (1980), Accumulation of plastic litter on beaches of Amchitka Island, Alaska. Mar.Environ.Res., 3:171-184.

Merrell, T.R. Jr. (1984), A decade of change in nets and plastic litter from fisheries off Alaska. Mar.Pollut.Bull. 15:378-384.

Morris, R.J. (1980), Floating plastic debris in the Mediterranean. Mar.Pollut.Bull., 11:125.

New York State DEC Report (1988), Investigation: sources of beach washups in 1988. New York State Department of Environmental Conservation. 1-75.

O'Hara, K.J. (1991), National marine debris data base. in Shomura, ed. 2nd Intern. Conf. on Marine Debris, Honolulu, Hawaii 2-7 April, 1991. Abstracts.

Ozsoy, E., A. Hecht and U. Unluata (1989), Circulation and hydrography of the Levantine Basin. Results of POEM coordinated experiments 1985-1986. Proc.Oceanogr., 22:125-170.

Petitt, T.N., G.S. Grant and G.C. Whittow (1981), Ingestion of plastics by Laysan albatross. Auk., 98:839-841.

Piatt, J.F. and D.N. Nettleship (1987), Incidental catch of marine birds and mammals in fishing nets off Newfoundland, Canada. Mar.Pollut.Bull., 18(6B):344-349.

Saydam, C., I. Salihoglu, M. Sakarya and A. Yilmaz (1985), Dissolved/ dispersed petroleum hydrocarbon, suspended sediment, plastic, pelagic tar and other litter in the northeastern Mediterranean. Journ.Etud.Pollut.CIESM, 7(1984):509-518.

Schrey, E. and G.J.M. Vauk (1987), Records of entangled gannets (Sula bassana) at Helgoland, German Bight. Mar.Pollut.Bull., 18:350-352.

Scordino, J. and R. Fisher (1983), Investigations on fur seal entanglement in net fragments, plastic bands and other debris in 1981 and 1982, St. Paul Island, Alaska. Background paper submitted to the 26th Ann. Mtg. Standing Scientific Committee of the North Pacific Fur Seal Commission, 28 March - 8 April 1983, Washington DC.

Scott, G. (1989), The philosophy and practice of degradable plastics. Second International Conference on Marine Debris. Honolulu, Hawaii, edited by R.S. Shomura.

Shaughnessy, P.D. (1980), Entanglement of cape fur seals with man-made objects. Mar.Pollut.Bull., 11:332-336.

Shiber, J.G. (1979), Plastic pellets on the coast of Lebanon. Mar.Pollut.Bull., 10:28-30.

Shiber, J.G. (1982), Plastic pellets on Spain's Costa del Sol beaches. Mar.Pollut.Bull., 13:409-412.

Shiber, J.G. (1987), Plastic pellets and tar on Spain's Mediterranean Sea. Mar.Pollut.Bull., 18:84-86.

Shomura, R.S and H.O. Yoshida eds. (1985), Proceedings of the workshop on the fate and impact of marine debris. 27-29 Nov. 1984, Honolulu, Hawaii. NOAA Tech. Memo:580 NMFS. 530 p. NOAA - TM - NMFS - SWFC - 54. U.S. Dept. Commerce.

Stewart, B.S. and P.K. Yochem (1987), Entanglement of Pinnipeds in synthetic debris and fishing net and line fragments at San Nicholas and San Miguel Islands, California, 1978-1986. Mar.Pollut.Bull., 18(6B):336-339.

UNEP (1989), The state of the Mediterranean marine environment. MAP Technical Reports Series no. 28. UNEP, Athens, 221 p.

Vauk, G.J.M. and E. Schrey (1987a), Litter pollution from ships in the German Bight. Mar.Pollut.Bull., 18:316-319.

Vauk, G.J.M. and E. Schrey (1987b), Vermullung der Nordsee. Umweltvorsorge Nordser, Belastungen Gutesituation Masnahmen. Niedersachsische Umwelt-minister, 67-73 p.

Venrick, E.L., T.W. Backman, W.C. Bartram, C.J. Platt, M.S. Thornhill and R.E. Yates (1973), Man made objects on the surface of the central north Pacific Ocean. Nature, 241:271.

Wolfe, D.A. ed. (1987), Plastics in the sea. Mar.Pollut.Bull., 18:303-365.

Yoshida, K., N. Baba, M. Nakajima, Y. Fujimaki, A. Furuta, S. Nomura and K. Takahashi (1985), Fur Seal Entanglement Survey Report Test Study at a Breeding Facility, 1983. Document submitted to the 28th Meeting of the Standing Scientific Committee on the North Pacific Fur Seal Commission. Tokyo, April 4-12, 1985.

ANNEX

RESOLUTION MEPC.43(30) ADOPTED BY THE 30TH SESSION OF THE IMO MARINE ENVIRONMENT PROTECTION COMMITTEE
(London, 15 November 1990)

PREVENTION OF POLLUTION BY GARBAGE IN THE MEDITERRANEAN

THE MARINE ENVIRONMENT PROTECTION COMMITTEE,

NOTING regulation 5 of Annex V of the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78), which designates the Mediterranean Sea as a special area,

BEING CONSCIOUS of the need to protect the Mediterranean Sea to the fullest possible extent that MARPOL 73/78 will allow,

URGES the coastal States of the Mediterranean Sea not Party to Annex V or to MARPOL 73/78 to accede to the Annex or to MARPOL 73/78 including Annex V.

INVITES the government of each State with a coastline bordering the Mediterranean Sea, whether or not Party to Annex V, to ensure that facilities are provided at all its ports for the reception of garbage from ships as soon as possible but not later than 1 January 1992,

RECOMMENDS the Governments of Mediterranean States to notify the Organization when such facilities have been provided so that the special area requirements can be implemented as soon as possible,

RECOMMENDS ALSO that the Governments urge ships flying their flag to apply as far as practicable the provisions of regulation 5 of Annex V of MARPOL 73/78 concerning the discharge of garbage within a special area when operating in the Mediterranean Sea.