MEDITERRANEAN ACTION PLAN
MED POL

UNITED NATIONS ENVIRONMENT PROGRAMME

CO-ORDINATED MEDITERRANEAN POLLUTION MONITORING AND RESEARCH PROGRAMME (MED POL - PHASE I)

FINAL REPORT 1975 - 1980

PROGRAMME COORDONNE DE SURVEILLANCE CONTINUE ET DE RECHERCHE EN MATIERE DE POLLUTION DANS LA MEDITERRANEE (MED POL - PHASE I)

RAPPORT FINAL 1975 - 1980

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This volume is the ninth issue of the Mediterranean Action Plan Technical Reports Series.

This Series will collect and disseminate selected scientific reports obtained through the implementation of the various MAP components: Pollution Monitoring and Research Programme (MED POL), Blue Plan, Priority Actions Programme, Specially Protected Areas and Regional Oil Combating Centre.

Ce volume constitue le neuvième numéro de la série des Rapports techniques du Plan d'action pour la Méditerranée.

Cette série permettra de rassembler et de diffuser certains des rapports scientifiques établis dans le cadre de la mise en oeuvre des diverses composantes du PAM: Programme de surveillance continue et de recherche en matière de pollution (MED POL), Plan Bleu, Programme d'actions prioritaires, Aires spécialement protégées et Centre régional de lutte contre la pollution par les hydrocarbures.

INTRODUCTION

The United Nations Environment Programme (UNEP) convened an Intergovernmental Meeting on the Protection of the Mediterranean (Barcelona, 28 January - 4 February 1975), which was attended by representatives of 16 States bordering on the Mediterranean Sea. The meeting discussed the various measures necessary for the prevention and control of pollution of the Mediterranean Sea, and concluded by adopting an Action Plan consisting of three substantive components:

- legal (framework convention and related protocols);
- scientific (research and monitoring);
- integrated planning.

All components of the Action Plan were interdependent and provided a framework for comprehensive action to promote both the protection and the continued development of the Mediterranean ecoregion. No component was an end in itself. The Action Plan was intended to assist the Mediterranean Governments in formulating their national policies related to the continuous development and protection of the Mediterranean area and to improve their ability to identify various options for alternative patterns of development and to make choices and appropriate allocations of resources.

The environmental assessment (scientific) component of the Mediterranean Action Plan had the following overall objectives:

- to formulate and carry out a co-ordinated pollution monitoring and research programme taking into account the goals of the Mediterranean Action Plan and the capabilities of the Mediterranean research centres to participate in it;
- to assist national research centres in developing their capabilities to participate in the programme;
- to analyse the sources, amounts, levels, pathways, trends and effects of pollutants relevant to the Mediterranean Sea;
- to provide the scientific/technical information needed by the Governments of the Mediterranean States and the EEC for the negotiation and implementation of the Convention for the Protection of the Mediterranean Sea against Pollution and its related protocols.

UNEP, in co-operation with the relevant specialized United Nations Agencies (FAO, WHO, WMO, IOC), presented to the Intergovernmental Meeting of Mediterranean countries (Barcelona, 1975) a proposal for a Co-ordinated Mediterranean Pollution Monitoring and Research Programme (MED POL).

MED POL was approved and UNEP was requested to implement the Programme, consisting of seven pilot projects, in close collaboration with the relevant specialized United Nations Agencies.

Its pilot phase (MED POL - Phase I) was designed to prepare a long-term programme for pollution monitoring and research in the Mediterranean (MED POL - Phase II) to be carried out according to the provisions of the legal component of the Mediterranean Action Plan.

The pilot projects approved at the 1975 Barcelona Meeting as parts of MED POL - Phase I were:

MED POL I: Baseline Studies and Monitoring of Oil and Petroleum Hydrocarbons in Marine Waters

MED POL II: Baseline Studies and Monitoring of Metals, particularly Mercury and Cadmium, in Marine Organisms

MED POL III: Baseline Studies and Monitoring of DDT, PCBs and Other Chlorinated Hydrocarbons in Marine Organisms

MED POL IV: Research on the Effects of Pollutants on Marine Organisms and their Populations

MED POL V: Research on the Effects of Pollutants on Marine Communities and Ecosystems

MED POL VI: Problems of Coastal Transport of Pollutants

MED POL VII: Coastal Water Quality Control

Subsequent to the 1975 Barcelona Meeting, several other projects were added or considered as collaterals to MED POL to broaden the scope of the programme and to provide the necessary support to it. They were:

MED POL VIII: Biogeochemical Studies of Selected Pollutants in the Open Waters of the Mediterranean

MED POL IX: Role of Sedimentation in the Pollution of the Mediterranean Sea

MED POL X: Pollutants from Land-Based Sources in the Mediterranean

MED POL XI: Intercalibration of Analytical Techniques and Common Maintenance Services

MED POL XII: Input of Pollutants into the Mediterranean Sea through the Atmosphere

MED POL XIII: Modelling of Marine Systems

The co-ordination of the MED POL - Phase I (1975-1981) was carried out by UNEP as a part of the Mediterranean Action Plan (MAP).

Participants in the pilot projects were national research centres designated by the States participating in the Mediterranean Action Plan.

Each of the pilot projects was based on an "operational document" formulated at meetings of experts from Mediterranean research centres identified by their Governments as participants in the pilot project. These documents specified all the substantive and methodological details needed for carrying out the pilot projects.

For the day-to-day co-ordination of the work of national research centres participating in the pilot projects, a specialized body of the United Nations system was selected. In certain pilot projects this co-ordination was carried out in co-operation with additional United Nations bodies and with the assistance of national institutions designated, in consultation with the States participating in the Mediterranean Action Plan, as Regional Activity Centres (RAC) for that pilot project.

The following United Nations Co-operating Agencies were responsible for the technical implementation of various pilot projects :

- The Food and Agriculture Organization of the United Nations (FAO) through the General Fisheries Council for the Mediterranean (GFCM) (MED POL II, III, IV and V),

- The United Nations Educational, Scientific and Cultural Organization (UNESCO) (MED POL IX and XIII),

- The World Health Organization (WHO) (MED POL VII and X),

- The World Meteorological Organization (WMO) (MED POL XII),

- The International Atomic Energy Agency (IAEA) (MED POL VIII and XI) and

- The Intergovernmental Oceanographic Commission (IOC) of UNESCO (MED POL I and VI)

The participation of the national research centres in the pilot projects was formalized through "research agreements" signed between the centres and the relevant specialized United Nations bodies responsible for the day-to-day co-ordination of the work.

Financial support to individual pilot projects was provided through "project documents" signed between UNEP and the United Nations bodies responsible for the day-to-day co-ordination of the work on individual pilot projects. In order to cover the costs of the overall co-ordination of MED POL and some of the common costs relevant to all pilot projects, an "internal project" was established and administered directly by UNEP. Funds used to support MED POL were those from UNEP's regular budget and from the Mediterranean Trust Fund.

The funds provided through the project documents were used to support the research centres participating in the pilot projects:

- directly (fellowships for training; provision of equipment, spare parts and expendable materials; consultants and maintenance engineers visiting research centres at their request; financing of national experts' attendance at meetings; etc.);

- indirectly (organization of meetings; preparation of manuals, guidelines and reports; consultants employed to analyse the results of the project and to co-ordinate its execution; etc.).

Assistance in kind was provided to participants in the pilot projects by the specialized United Nations bodies participating in MED POL through their staff time, expertise and services.

The national contributions to MED POL, provided through the professionals and supporting staff of the research centres participating in the pilot projects, through the operating cost of their equipment and the cost of expendable material used in the work, constituted a considerable part of the overall expenditures of MED POL.

The first eight volumes of the MAP Technical Reports Series present the collection of final reports of the Principal investigators who participated in the relevant pilot projects (MED POL I - MED POL VIII).

This ninth volume of the MAP Technical Reports Series is the final report on the implementation of MED POL - Phase I in the period from 1975 to 1980. It was prepared, primarily, on the basis of individual final reports of the principal investigators with the co-operation of the General Fisheries Council for the Mediterranean (GFCM) of the Food and Agriculture Organization of the United Nations (FAO) (sections on MED POL II, III, IV and V), the World Health Organization (WHO) (section on MED POL VII), the International Atomic Energy Agency (IAEA) (sections on MED POL VIII and XI) and the Intergovern- mental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization (UNESCO) (sections on MED POL I and VI). A detailed description of the MED POL - Phase I programme is contained in document UNEP Regional Seas Reports and Studies No. 23, UNEP, 1983.

INTRODUCTION

Le Programme des Nations Unies pour l'environnement (PNUE) a convoqué une réunion internationale sur la protection de la Méditerranée (Barcelone, 28 janvier - 4 février 1975) à laquelle participaient les représentants de 16 Etats riverains de la mer Méditerranée. Cette réunion a examiné les diverses mesures nécessaires pour prévenir et combattre la pollution en mer Méditerranée, et elle s'est achevée sur l'adoption d'un Plan d'action comportant trois éléments fondamentaux:

- juridique (convention-cadre et protocoles y relatifs);
- scientifique (recherche et surveillance continue);
- planification intégrée.

Tous les éléments du Plan d'action étaient interdépendants et fournissaient le cadre d'une action d'ensemble visant à promouvoir tant la prévention que le développement soutenu de l'écorégion méditerranéenne. Aucun élément ne constituait une fin en soi. Le Plan d'action était destiné à aider les gouvernements méditerranéens à formuler leurs politiques nationales concernant le développement continu et la protection de la zone méditerranéenne, à améliorer leur faculté de définir les diverses options s'offrant quant aux schémas de développement, d'opérer des choix et d'y affecter les ressources appropriées.

L'évaluation du milieu, à savoir l'élément scientifique du Plan d'action, visait les objectifs globaux suivants:

- formuler et mettre en oeuvre un programme coordonné de recherche et de surveillance continue en matière de pollution en tenant compte des buts du Plan d'action et des aptitudes des centres de recherche méditerranéens à y participer;
- aider les centres de recherche à développer leurs aptitudes à participer au programme;
- analyser les sources d'émission, les quantités, les niveaux, les voies de cheminement, les tendances et les effets des polluants concernés en mer Méditerranée;
- fournir les renseignements scientifiques/techniques indispensables aux gouvernements des Etats méditerranéens pour négocier et appliquer la Convention pour la protection de la mer Méditerranée contre la pollution et les Protocoles y relatifs.

Le PNUE, en coopération avec les organismes spécialisés compétents des Nations Unies (FAO, OMS, OMM, COI), a présenté à la Réunion intergouvernementale des pays méditerranéens (Barcelone, 1975), une proposition de Programme coordonné de surveillance continue et de recherche en matière de pollution dans la Méditerranée (MED POL).

Le MED POL a été approuvé, et il a été demandé au PNUE de mettre en oeuvre le programme qui se compose de sept projets pilotes, en étroite collaboration avec les organismes spécialisés compétents des Nations Unies.

Sa phase pilote (MED POL - Phase I) a été conçue comme le prélude d'un programme à long terme de surveillance continue et de recherche en matière de pollution dans la Méditerranée (MED POL - Phase II) à mettre en oeuvre conformément aux dispositions de l'élément juridique du Plan d'action pour la Méditerranée.

Les projets pilotes approuvés à la Réunion de Barcelone, en 1975, dans le cadre de la Phase I du MED POL, comprenaient:

MED POL I: Etudes de base et surveillance continue du pétrole et des hydrocarbures contenus dans les eaux de la mer

MED POL II: Etudes de base et surveillance continue des métaux, notamment du mercure et du cadmium, dans les organismes marins

MED POL III: Etudes de base et surveillance continue du DDT, des PCB et des autres hydrocarbures chlorés contenus dans les organismes marins

MED POL IV: Recherche sur les effets des polluants sur les organismes marins et leurs peuplements

MED POL V: Recherche sur les effets des polluants sur les communautés et écosystèmes marins

MED POL VI: Problèmes du transfert des polluants le long des côtes

MED POL VII: Contrôle de la qualité des eaux côtières

A la suite de la Réunion de Barcelone de 1975, plusieurs autres projets ont été adjoints ou considérés comme subsidiaires au MED POL en vue d'étendre la portée du programme et de lui assurer l'appui indispensable. Ce sont:

MED POL VIII: Etudes biogéochimiques de certains polluants au large de la Méditerranée

MED POL IX: Rôle de la sédimentation dans la pollution de la mer Méditerranée

MED POL X: Polluants d'origine tellurique dans la Méditerranée

MED POL XI: Inter-étalonnage des techniques d'analyse et services communs d'entretien

MED POL XII: Apports de polluants par voie atmosphérique dans la Méditerranée

MED POL XIII: Modélisation des systèmes marins

La coordination de MED POL - Phase I (1975-1981) a été assumée par le PNUE dans le cadre du Plan d'action pour la Méditerranée (PAM).

Les participants aux projets pilotes étaient des centres nationaux de recherche désignés par les Etats prenant part au Plan d'action pour la Méditerranée.

Chacun des projets pilotes se fondait sur un "document opérationnel" formulé lors des réunions d'experts des centres de recherche méditerranéens désignés par leur gouvernement respectif pour participer au projet pilote concerné. Ces documents spécifiaient tous les détails d'ordre organique et méthodologique nécessaires à l'exécution des projets pilotes.

Pour la coordination courante des travaux des centres nationaux de recherche participant aux projets pilotes, un organe spécialisé du système des Nations Unies a été retenu. Pour certains projets pilotes, cette coordination a été assumée en coopération avec d'autres organismes des Nations Unies et avec le concours d'institutions nationales désignées, en consultation avec les Etats participant au Plan d'action pour la Méditerranée, comme Centres d'activités régionales (CAR) pour chaque projet concerné.

Les organismes coopérants des Nations Unies qui étaient chargés de l'exécution technique des divers projets pilotes sont les suivants:

- Organisation des Nations Unies pour l'alimentation et l'agriculture (FAO) par l'entremise du Conseil général des pêches pour la Méditerranée (CGPM) (MED POL II, III, IV et V).

- Organisation des Nations Unies pour l'éducation, la science et la culture (UNESCO) (MED POL IX et XIII).

- Organisation mondiale de la santé (OMS) (MED POL VII et X).

- Organisation météorologique mondiale (OMM) (MED POL XII).

- Agence internationale de l'énergie atomique (AIEA) (MED POL VIII et XI), et

- Commission océanographique intergouvernementale (COI) de l'UNESCO (MED POL I et VI).

La participation des centres de recherche nationaux aux projets pilotes a été officialisée dans le cadre d'"accords de recherche" signés entre ces centres et les organismes spécialisés compétents des Nations Unies en vue de la coordination régulière des travaux portant sur chacun des projets pilotes.

Pour couvrir le coût de la coordination globale du MED POL et certains des frais afférents à tous les projets pilotes, un "projet interne" a été soumis et directement géré par le PNUE. Les fonds utilisés pour financer le MED POL provenaient du budget ordinaire du PNUE et du Fonds d'affection spéciale pour la Méditerranée.

Les fonds fournis au titre des documents de projet ont été utilisés pour appuyer les centres de recherche participant aux projets pilotes

- soit directement (bourses de formation; octroi d'équipements, de pièces de rechange et de matériel consomptible; visites de consultants et de techniciens d'entretien aux centres de recherche sur requête de ces derniers; financement de la participation d'experts nationaux aux réunions; etc.);

- soit indirectement (organisation de réunions, préparation de manuels, directives et rapports; consultants chargés d'analyser les résultats du projet et de coordonner son exécution; etc.).

Les organismes spécialisés des Nations Unies coopérant au MED POL ont délivré aux participants aux projets pilotes une aide en nature sous forme de temps de travail du personnel, de compétence technique et de services.

Les contributions nationales au MED POL correspondant aux emplois d'administrateurs et de personnel d'appui des centres de recherche participant aux projets pilotes ainsi qu'aux charges d'exploitation de leurs équipements et aux dépenses en matériel consomptible utilisé aux cours des travaux ont représenté une part considérable des dépenses globales du MED POL.

Les huit premiers volumes de la série des Rapports techniques du PAM rassemblent les rapports finaux des chercheurs responsables ayant participé aux projets pilotes correspondants (MED POL I - MED POL VIII).

Le présent volume, le neuvième de la série des Rapports techniques du PAM, se compose du rapport final sur la mise en oeuvre de la phase I du MED POL au cours de la période 1975 - 1980. Il a, pour l'essentiel, été établi sur la base des rapports finaux individuels des chercheurs responsables, avec la coopération du Conseil général des pêches pour la Méditerranée (CGPM) de l'Organisation des Nations Unies pour l'alimentation et l'agriculture (sections consacrées à MED POL II, III, IV et V), de l'Organisation mondiale de la santé (OMS) (section consacrée à MED POL VII), de l'Agence internationale de l'énergie atomique (AIEA) (sections consacrées à MED POL VIII et XI) et de la Commission océanographique intergouvernementale (COI) de l'Organisation des Nations Unies pour l'éducation, la science et la culture (UNESCO) (sections consacrées à MED POL I et VI). Une description détaillée du programme MED POL - Phase I figure dans le document PNUE No. 23 des Rapports et études des mers régionales (PNUE, 1983).

Contents

MED POL I : BASELINE STUDIES AND MONITORING OF OIL AND PETROLEUM HYDROCARBONS IN MARINE WATERS (IOC/WMO/UNEP)

1. INTRODUCTION

The pollution of the Mediterranean by oil or petroleum hydrocarbons is a serious problem on beaches and other coastal recreational areas. As yet too little is known about the present levels of hydrocarbon pollution and about its effects on the Mediterranean ecosystem. The measurement of the present level of petroleum in all its manifestations in the Mediterranean assumed greater importance because of the increase of oil tanker traffic resulting from the reopening of the Suez Canal. The aim of the Pilot Project was to develop a capability to assess the present levels and the short and long-term trends of pollution of the Mediterranean by petroleum hydrocarbons. This assessment could be achieved by using accessible, agreed techniques, verified by a carefully co-ordinated intercalibration exercise. The results should contribute substantially to the formulation of contingency plans for dealing with important oil spills and with effects of localized operational spills. These contingency plans were to be developed by the Regional Oil Combating Centre in Malta. The pilot project included the visual observation of oil slicks and other floating pollutants, tar balls sampling, surveys for tar on beaches and the determination of dissolved and dispersed hydrocarbons in sea-water.

The pilot project was considered to be a contribution to the Integrated Global Ocean Station System (IGOSS) organized by the Intergovernmental Oceanographic Commission (IOC) of UNESCO in co-operation with the World Meteorological Organization (WMO).

The rationale for initiating a pilot project based on IGOSS methodology in the Mediterranean region rested mainly on three factors:

- the IGOSS observational methodology was available at the initiation of MED POL I and could be easily adapted to suit the purposes of the pilot project, thereby avoiding the necessity of taking time to establish new methods. In addition, the methodology could be further developed during the first phase of the project bearing in mind the desirability of providing data that would be fully comparable to those produced by the IGOSS pilot project;

- by using common methods and strategy throughout the Mediterranean, the comparison of the effects of accidental and operational discharge from tankers and shore facilities in the various parts of the Mediterranean Sea would be possible;

- by adopting a methodology already in use in other regions of the world, the Mediterranean could be truly compared with other areas having quite different oceanographic regimes, e.g. the North Atlantic, in which the possibilities for dispersion and dilution are greater and evaporation lower.

The actual work of the national research centres on the pilot project started in November 1975.

This report is based on the following material:

a) A compilation of the individual reports of the Principal Investigators of MED POL I (UNEP/IG.18/INF.3) presented to the UNEP Intergovernmental Review Meeting of Mediterranean Coastal States on the Mediterranean Action Plan (Barcelona, 11-13 February 1980).

b) An ad hoc IOC document entitled "Summary report on the scientific data of the Pilot Project Baseline Studies and Monitoring of Oil and Petroleum Hydrocarbons in Marine Waters - MED POL I."

c) The final reports from the Principal Investigators in the following countries: Cyprus, Egypt, France, Greece, Malta, Spain, Turkey and Yugoslavia, covering the period up to March 1980.

d) The papers presented at the ICSEM/UNEP Workshops held at Antalya in 1978 and at Cagliari in 1980.

2. PARTICIPANTS

Twenty-eight research centres from fourteen Mediterranean States were designated to participate in the pilot project. By the end of December 1980, 16 research agreements had been signed.

3. CO-ORDINATING ARRANGEMENTS

IOC, in co-operation with WMO, maintained the operational contacts with research centres participating in the pilot project.

The Department of Chemistry, University of Malta, Msida, Malta, was selected in August 1976 to assist IOC as the Regional Activity Centre for this pilot project.

Specific meetings held in connection with this pilot project included:

- IOC/WMO/UNEP Mid-term Review Meeting (Barcelona, 23 - 27 May 1977) which also covered MED POL VI, and was attended by 15 participants from 15 research centres in 12 States.

4. FINANCIAL ARRANGEMENTS

Specific financial support to the pilot project was provided through projects FP/0503-75-06 and FP/0503-76-03. Costs (in US dollars) were shared between the three co-sponsors of these projects as follows:

	1975	1976	1977	1978	1979	1980	Total	Percentage
IOC	6,400	22,300	16,450	22,750	17,000	7,100	92,000	27.4
WMO	4,000	3,500	3,600	2,800	4,200	1,500	19,600	5.9
UNEP	8,808	14,036	91,487	34,403	73,728	1,400	223,862	66.7
TOTAL	19,208	39,836	111,537	59,953	94,928	10,000	335,462	100.0

5. OPERATIONAL DOCUMENT

The operational document of the pilot project was formulated at the IOC/WMO/UNEP Expert Consultation on the joint Coordinated Projects in the Mediterranean (Msida, 8 - 13 September 1975) attended by 36 participants from 12 Mediterranean States. Certain provisions of the operational documents were modified at the IOC/WMO/UNEP Mid-term Review Meeting for MED POL I and MED POL VI (Barcelona, 23 - 27 May 1977). The operational document is contained in UNEP Regional Seas Reports and Studies No. 23, UNEP, 1983.

6. AREAS STUDIED

Most of the areas covered by the participating Research Centres were rather limited; indeed, some of them were very local (Figure 1). The reasons for this were mainly logistical, e.g. availability of suitable ships and adequate manpower to carry out the MED POL projects. Nevertheless, the Israel Oceanographic and Limnological Research Co. Ltd., in Haifa, conducted several cruises covering most of the Levantine Basin, and the Demokritos Nuclear Research Institute in Athens was able to sample regularly various sites in the Aegean Sea and, at a later stage, a part of the Ionian Sea as well.

7. MATERIAL AND METHODS

Oil slicks: The procedure recommended in the IOC document Manuals and Guides No.7, UNESCO 1977, was generally followed by participants in MED POL I.

Floating tar balls: The Manual leaves considerable freedom to the participating institutes as far as choice of equipment and frequency of observations are concerned.

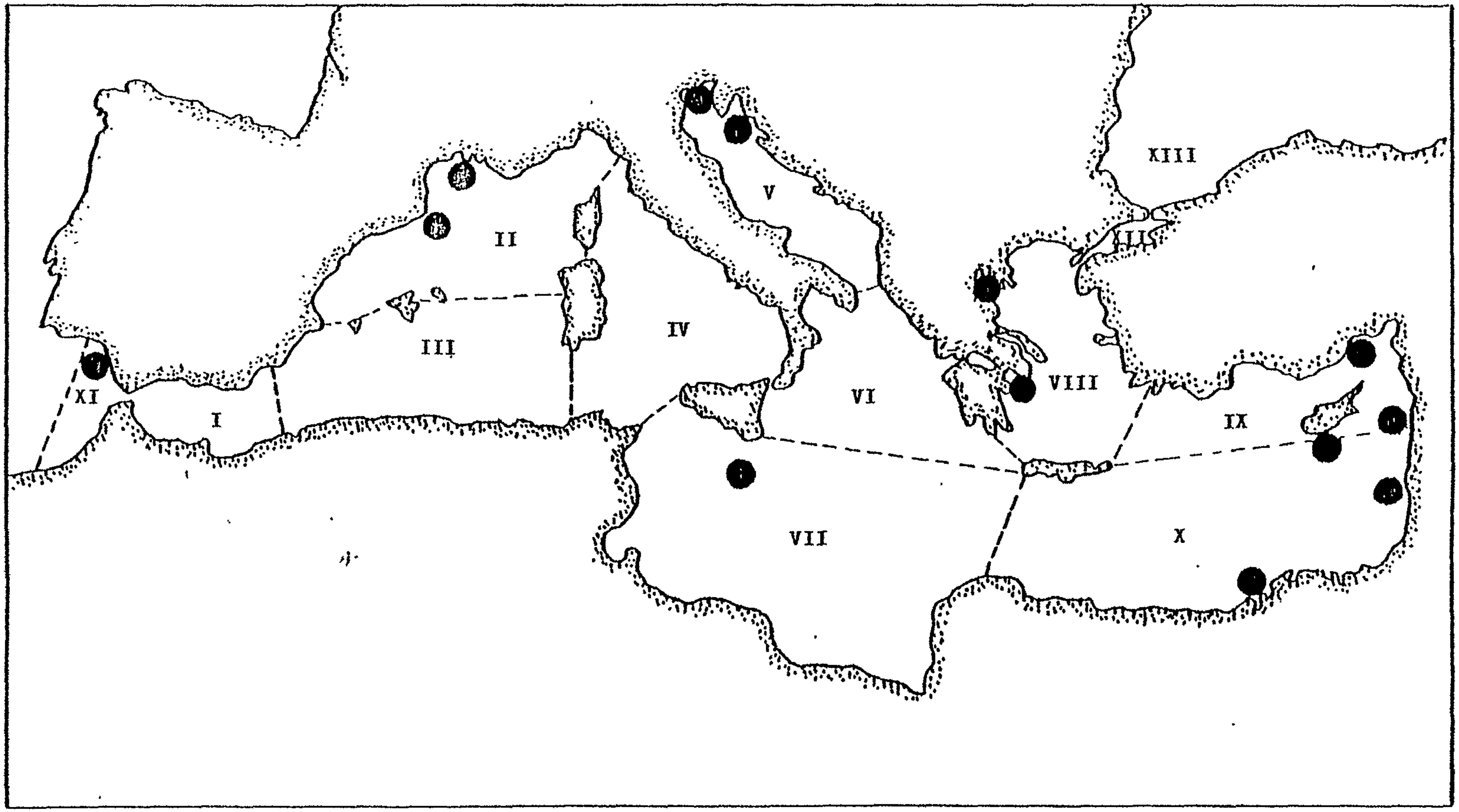

Figure 1. Sampling areas for MED I

Tar on the beaches: Various techniques had been favoured by the Principal Investigators, although the Manual calls for sampling of a few 1m-wide strips on each beach and with a frequency of at least every two weeks. All Principal Investigators used strip sampling in one way or the other. One of them also used sampling of 1-m^2 quadrats for complementary information (with an accompanying uncertainty in the reporting as to which data came from the use of which method). Some of the reports reflected sampling every 15 days, and some others, sampling apparently every 9th and 10th day. One institute reported a variant of this with sampling every 9th and 10th day in each month.

Dissolved/dispersed hydrocarbons: Most of the Principal Investigators' reports indicated that they had adhered to the Manual. Most reports contained data for the 1m depth and the sampling seems to have been carried out according to the Manual in most cases. However, most investigators took only one sample on each occasion and only few practised multiple sampling or reported data from multiple samples.

Two different analytical techniques were employed: infra-red spectrophotometry and ultraviolet fluorescence spectrophotometry. Most of the Principal Investigators followed the procedure in the Manual or at least something rather similar.

One of the Principal Investigators reported data from sediment analysis.

8. SCIENTIFIC RESULTS AND DISCUSSION

8.1 Visual observation of oil slicks

The reported data were very sparse with information received from only five of the participating research centres. Only one centre (Cyprus) established a regular observation programme in conjunction with coastal and port authorities for reporting sightings and extent of oil slicks. A total of 57 sightings of oil slicks was reported by the Cyprus laboratory during 1976-1979 period. Of these reports 42 per cent, 32 per cent and 26 per cent corresponded to small, medium and large oil medium and large oil slicks, respectively.

The old University of Malta with the co-operation of the Maritime Division of the Malta Armed Forces, the Civil Aviation Authorities and the Regional Oil Combating Centre for the Mediterranean, reported few oil slicks from 1976 to 1979.

During that period only five oil slicks were detected (three tracked by aircraft and two by ships).

The reports of oil slicks for Rijeka Bay, Yugoslavia, depended on spontaneous reporting by local port authorities. No major oil slicks were detected during the period of observation, though minor oil slicks were observed. No data are available on the extent of the latter. The reports provided by the centres of Lebanon and Spain were negative in the main.

Complementary information on visual observation of oil slicks in the Mediterranean is available through the IGOSS Pilot Project on Marine Pollution (Petroleum) Monitoring (MAPMOPP). This information is presented in the document IOC-WMO/MAPMOPP-II/3, UNESCO, 1978.

8.2 Particulate petroleum residues ("tar balls")

This component of MED POL I provided a simple quantitative method of monitoring one of the products of petroleum pollution:

- the quantity of weathered oil in the form of tar balls. Since tar balls originate from tanker operations, oil spills and other shipping, monitoring of tar all concentration in the sea, over a reasonable time period, should provide information on the effectiveness of the measures that have been introduced to reduce oil pollution.

Before 1975 very little information on tar ball concentration in waters of the Mediterranean was available. In 1975, and after the approval of the Mediterranean Action Plan, the Instituto Espanol de Oceanografia conducted three cruises to determine the concentration of tar balls in the surface waters of the Western Mediterranean. A total of 143 samples were collected from MED POL areas I, II, III and IV (Figure 1) during 1975, 1976 and 1977. The concentration of tar balls in the areas referred to ranged from 0.04 mg/m^2 to 77.7 mg/m^2, the average concentrations in areas I, II, III and IV were 0.6 mg/m^2, 5.4 mg/m^2, 3.9 mg/m^2 and 0.9 mg/m^2, respectively.

According to the classification of Wong et al. (1976) the concentration of tar balls recorded in areas II and III must be considered as an index of considerable oil pollution, while tar ball concentrations determined in areas I and IV are the result of average oil pollution.

Albaiges et al. (1978) reported on the chemical characterization of 42 pelagic tar ball samples collected in the Western Mediterranean. These authors indicated that the majority of the tars found in the area originated from Middle Eastern crude oils. Recently Balkas et al. (1981) reported on chemical analysis of tar balls collected from the coasts of Turkey, Cyprus and Malta.

In Table I are shown values for tar ball concentrations reported by three of the research centres. The data presented are so few as to make an evaluation of the results premature.

8.3 Tar on beaches

Data on the concentration of tar on beaches were submitted by eight of the participating research centres. In some cases, the observations covered more than a year's work and thus allowed some general conclusions to be drawn. This information is presented in Table II.

Variations in the values obtained at different beaches proved that some of them are strongly susceptible to contamination by tar, whereas others less susceptible are relatively free of tar. This varying concentration of tar appears to depend upon exposure of the beach to prevailing onshore winds (and sometime currents) with a fairly long fetch of open water.

Table I - Summary of available data on floating "tar balls"

RESEARCH CENTRES	SAMPLED AREAS	DATE	N	CONCENTRATION (mg/m^2) Range	Mean	REMARKS
F.D.M.A.N.R. Nicosia, Cyprus	Limassol Bay to Paphos	5-1978	9	$<$0.1 - 5.6	0.7	
	Akrotiri Bay	6-1978 3-1979	16	$<$0.1 - 1.2	0.3	
I.O.F. Alexandria, Egypt	Mex - Maamoura coastal area	5-1977 4-1979	-	$<$0.1 - 1.3	0.5	
I.I.P. Cadiz, Spain	Cadiz Harbour Cadiz Bay	1-1979 3-1980	-	-	-	Floating tar balls not detected during the sampling period
I.O.C. San Pedro del Pinatar Spain	W. Mediterranean					
	Zone I	1975-1977	23	$<$0.1 - 6.6	0.6	Ros and Faraco,1979
	Zone II		42	$<$0.1 -77.7	5.4	
	Zone III		34	$<$0.1 -26.8	3.9	
	Zone IV		44	$<$0.1 -10.0	0.9	

Table II - Summary of available data on tar concentration on beaches

RESEARCH CENTRES	SAMPLED AREAS	DATE	N	CONCENTRATION (mg/m^2) Range	Mean	REMARKS
F.D.M.A.N.R. Nicosia, Cyprus	Lara Beach	10-76 12-79	39	0.1 - 2,494	368	Tar concentration from one to nine days was also determined on monthly basis during 1979
	Ladies Mile	10-76 8-79	35	1.1 - 102	19.8	
I.O.F. Alexandria, Egypt	Alexandria coastal area	4-77 10-79	52	21 - 347	134	
N.C.R. (Demokritos) Athens, Greece	Lesbos Island	1-79 11-79	4	2 - 31	16	
	Patraikos Gulf	1-79 6-80	36	< 0.1 - 382	65	
	Messiniakos Gul	9-79 6-80	25	< 0.1 - 250	39	
	Rhodes Island	10-77 6-80	23	< 0.1 - 337	55	
	Crete Island	3-78 3-80	6	< 0.1 - 136	41	
	Cephalonia Island	8-79	2	17 - 21	19	
	Katakolon	9-79 6-80	32	< 0.1 - 98	28	
I.O.R.L. Haifa, Israel	Rosh Hanikka	1975 - 1976	-		3,902	Mean values reported in grams of tar per metre on beach
	Atlish				4,388	
	B. Yanai				4,114	
	Galash				4,186	
	Askalon				3,014	
	El Arish				884	

Table II (Continued) - Summary of available data on tar concentration on beach

RESEARCH CENTRES	SAMPLED AREAS	DATE	N	CONCENTRATION (mg/m^2) Range	Mean	REMARKS
C.R.M. (C.N.R.S.)	Ramlet		11	0.1 - 14.8	4	
Beirout, Lebanon	Sidar	4-1977 8-1978	12	0.1 - 33.6	3.5	
	Tripoli		3	0.1 - 0.4	2.3	
T.O.U.	Anchor Bay	4-1977 9-1979	25	0.1 - 1,260	161	
Msida, Malta	Marsaxlokk Bay	4-1977 1-1980	30	0.1 - 83	8.8	
	Qawra	4-1977 1-1980	30	0.1 - 68	5.8	
M.E.T.U.	Erdemli coast	6-1977 6-1979	8	4.1 - 52.8	29.8	
Erdelmi-Icel	Akkuyu	7-1978	2	2.5 - 24.4	12.4	
Turkey						
R.B.I	Jelenscica beach	12-1977 4-1978	10	0.5 - 8.6	1.2	
Zagreb, Yugoslavia						

The results submitted by the Cyprus and Malta research centres are cases in point. For example on the south-western coast of Cyprus, Lara Beach, which is exposed to onshore winds, showed a far higher concentration of tar than Ladies Mile Beach, situated on the southern coast of Cyprus and sheltered from the prevailing winds by a headland. The mean concentration of tar in these two beaches were 368 g/m^2 and 19.8 g/m^2, respectively. Similarly a beach at Anchor Bay, Malta, showed a high accumulation of tar with a mean value of 161 g/m^2; this beach is exposed to the prevailing westerly winds. On the other hand, beaches located on the eastern coast of Malta exhibited lower tar concentrations.

Information from Greece also showed that beaches exposed to westerly winds, such as the beach at Patraikos Gulf, contained more tar than the monitored beaches from Lesbos and Chephalonia islands that open to the south.

Seasonal variations in the tar present on the beaches studied also seemed to be dependant on the strength and direction of the prevailing winds. Along the coast of Cyprus, tar concentration on beaches is higher in winter than in summer, correlating well with the wind strength and direction. The same correlation was also observed for data gathered from Malta and Egypt.

With regard to the report from Israel, the large quantity of tar reported on beaches was attributed to the following factors: the transport of oil in the general area, the existence of oil terminals, and the area 150 to 200 km offshore where tanker discharges are believed to occur. Other reasons for the high concentration of tar on the beaches were the local meteorological conditions and the ocean current regime. As in other areas, seasonal variations from the spring of 1974 to the winter of 1976 were also observed.

Where values have been determined for a nine day period, the concentration of tar after the first day is usually far higher than the value recorded after 9 days divided by 9, but not equal to the value after 9 days. In other words the beach sorts itself fairly quickly but needs more than one day to reach equilibrium. Thus the concentration of tar should not be considered as an accumulation but should be regarded as an instantaneous value of the mean tar concentration on the beach.

It is necessary to consider that the concentration of tar recorded in any beach will also depend on the character of the beach, including its slope and tidal range; consequently, any regional assessment is extremely difficult. The property that should be studied is the long-term variation of the concentration, eliminating, if possible, the seasonal variation. Only this long-term variation may be compared from area to area to produce a regional assessment.

8.4 Dissolved/dispersed petroleum hydrocarbons in surface waters

This parameter is the one for which most data were reported. It may also be regarded as the most significant of the parameters when evaluating the effectiveness of measures taken to reduce oil pollution, since it is the only one to indicate pollution by aromatic hydrocarbons.

The data reported for dissolved/dispersed petroleum hydrocarbons may be divided into two groups depending on the analytical technique used.

The technique adopted for MED POL I, UVF spectrophotometry, was used by most of the participating laboratories. However, some institutes where UVF spectrophotometers were not available submitted data obtained by infra-red spectrophotometry.

The standard material chosen for MED POL I was Chrysene but, unfortunately, not all the results were reported in concentrations that referred to Chrysene.

The gravimetric concentrations of the pollutant oil may be from 2 to 20 times the values in Chrysene units, depending on the type of oil and the proportion of aromatic hydrocarbons it contains. Moreover, the oil is often not strictly dissolved in the sea-water, some hydrocarbons being associated with particulate matter; hence, the sea-water cannot be considered homogeneous. Because of these problems a careful evaluation of the data is required to produce a reliable regional assessment. These data are summarized in Table III.

Data obtained by UVF spectrophotometry using Chrysene as reference material were submitted by eight of the thirteen participating research centres. The interpretation and comparison of the reported results is rather difficult at this point considering the limited number of areas surveyed during the implementation of MED POL I.

For localized coastal zones a total of 790 samples were collected and analysed. The results expressed in Chrysene units ranged from <0.1 µg/l for samples from the coastal area around Malta to 9.1 µg/l for samples off the Alexandria coast, Egypt.

With regard to data gathered by infra-red spectrophotometry a total of 320 samples were collected and analysed by three of the participating laboratories, using crude oil as reference material. One of the laboratories submitted data on dissolved/dispersed petroleum hydrocarbon in surface waters obtained by both UVF and IR spectrophotometry using Chrysene as standard.

Some of the laboratories that used UVF spectrophotometry and crude oil or diesel oil as reference materials reported comparison ratios to Chrysene units ranging from 4.1 to 6.2.

The occasional high dissolved/dispersed petroleum hydrocarbon levels recorded in some areas are probably due to sampling after recent localized discharges of bilge water from ships or tankers. In contrast, consistently low levels of petroleum hydrocarbons were determined at coastal stations around Malta, as compared to levels detected in other coastal areas of the Mediterranean that were surveyed.

One of the laboratories, the Israel Oceanographic & Limnological Research Ltd., conducted four cruises to gather information on the dissolved/dispersed petroleum hydrocarbon levels in surface waters from the Eastern Mediterranean, Levantine Basin, reporting mean values ranging from 5.3 µg/l to 8.6 µg/l. These values are relatively higher than those reported by Faraco and Ros (1979) for the Western Mediterranean. These authors reported dissolved/dispersed petroleum hydrocarbon levels ranging from 0.2 µg/l to 30 µg/l with a mean value of 1.5 µg/l. These values expressed in Chrysene units were converted from values determined using Kuwait oil as standard. Therefore, there is some uncertainty in comparing the petroleum hydrocarbon levels in the waters from the Eastern and Western basins of the Mediterranean, owing to the different standards used and the accuracy of the comparison ratio to Chrysene.

Table III - Summary of data on dissolved/dispersed petroleum hydrocarbons

RESEARCH CENTRE	SAMPLED AREA	N	CONCENTRATION (µg/l) Range	Mean	REFERENCE MATERIAL	COMPARISON RATIO TO CHRYSENE	REMARKS
F.D.M.A.N.R. Nicosia, Cyprus	Limassol Bay	8	0.1 - 6.9	3.0	Chrysene	-	UVF
I.O.F. Alexandria, Egypt	Alexandria coast	14	0.7 - 41.6	9.1	Chrysene	-	UVF
L.C.A.E. Montpellier France	Banyuls-sur-mer	127	50 - 5000	400	API Crude Oil	-	IR
N.R.C. (Demokritos) Athens, Greece	Lesbos Island	66	0.5 - 11.5	2.9			
	Crete Island	77	0.4 - 11.2	2.9			
	Rhodes Island	81	0.2 - 12.1	2.9			
	Messiniakos Gulf	83	0.3 - 16.7	4.1			
	Patraikos	59	0.8 - 28.2	5.9	Chrysene	5.35	UVF
	Cephalonia I.	7	2.4 - 6.7	4.4			Data reported
	Corfu Island	17	0.4 - 4.8	2.4			µg/kg
	Arcadia Bay	21	0.4 - 7.3	2.5			

Table III (Continued) - Summary data on dissolved/dispersed petroleum hydrocarbons

RESEARCH CENTRE	SAMPLED AREA	N	CONCENTRATION (µg/l) Range	Mean	REFERENCE MATERIAL	COMPARISON RATIO TO CHRYSENE	REMARKS
A.U.T.	Thessaloniki Bay	19	100 - 400	220	Diesel oil	-	I.R.
Thessaloniki	Kavala Bay	18	100 - 400	240			
Greece	Thermaikos Bay	17	100 - 200	140			
	Strymonikos Bay	15	100 - 400	220			
I.O.R.L.	Haifa Coast	19	0.9 - >45	3	Chrysene	-	UVF
Haifa, Israel	Levant Basin						
	Cruise I	7	4.5 - 15	8.6			
	Cruise II	11	1.6 - 23.1	7.3			
	Cruise III	21	0.3 - >40	8.0	Chrysene	-	UVF
	Cruise IV	16	0.4 - >25	5.3			
U.D.S.D.V.	Off Venezia Lido	8	0.2 - 1.1	0.7	Chrysene	-	UVF
Venezia, Italy							
T.O.U.	Off Grand Harbour	15	<0.1 - 0.2	<0.1			
Msida, Malta	Off Marsaxlokk	12	<0.1 - 0.3	<0.1			
	Off Ghar Lapsi	9	<0.1 - 0.3	<0.1	Chrysene	-	UVF
	Malta Channel	11	<0.1 - 0.2	<0.1			
	Off Qawra	9	<0.1 - 0.2	<0.1			
I.I.P.	Cadiz Harbour	184	3.9 - 147.4	28.2	Gas oil	5.52	UVF
Cadiz, Spain	Cadiz Bay	184	2.6 - 20.9	8.6			

Table III (Continued) - Summary data on dissolved/dispersed petroleum hydrocarbons

RESEARCH CENTRE	SAMPLED AREA	N	CONCENTRATION (µg/l) Range	Mean	REFERENCE MATERIAL	COMPARISON RATIO TO CHRYSENE	REMARKS
I.B.C. Barcelona Spain	Barcelona - Tortosa coastal area	52	<25 - 4,580	425	Iso-Octane 37.5%	-	
					Hexadecane 37.5%	-	IR
					Benzene 25.0%		
I.E.O. San Pedro del Pinatar, Spain	Western Mediterranean	121	1 - 125	9.9	Kuwait Crude Oil	4.1	UVF Faraco & Ros (1979)
		62	5 - 199	80.5	"		
M.E.T.U. Erdemli-Içel Turkey	Mersin - Tasucu	-	8.2 - 39.4	17.0	Crude Oil	4.1	
	Mersin - Tasucu	24	0.5 - 7.9	4.1	Chrysene		
	Mersin - Goksu	19	0.1 - 3.4	0.9	"		
	Tasucu - Goksu	25	0.1 - 3.2	1.2	"		UVF
	Mersin - Magosa (Cyprus)	79	0.1 - 14.4	2.0	"		
R.B.I. Zagreb Yugoslavia	Rijeka Bay	72	0.1 - 1.2	0.9	"		UVF
		72	<100 - 500	395	"		IR

Other similar data are available for open-water stations in the Mediterranean in reports from the Exxon Company by Monaghen et al. (1975) and Brown et al. (1978). The results gathered in the Exxon studies are not comparable with those obtained during MED POL I because of the different analytical techniques employed. Consequently, the Exxon data is probably an order of magnitude greater than those reported in MED POL I.

The network of research centres capable of monitoring dissolved/dispersed petroleum hydrocarbons in Mediterranean waters has been strengthened during the implementation of the MED POL I pilot project; thus, UVF spectrophotometric data should be routinely available during the long-term programme contemplated for PHASE II.

8.5 Extractable organics from surface sea-water

Most of the available information on extractable organic matter in the waters of the Mediterranean Sea are found in the Exxon Co. reports of 1974 and 1978, as well as the reports of the Réseau National d'Observation de la Qualité du Milieu Marin of 1976 and 1978.

In the survey conducted by the Exxon Co. (Brown et al. 1978), data on extractable organic matter from Mediterranean surface water from Gibraltar to Alexandria ranged from 3 µg/l to 1,097 µg/l with a mean value of 80 µg/l. The highest values were determined near coastal areas.

During the implementation of the MED POL I project, five of the participating laboratories reported on extractable organic matter in waters from coastal, as well as bays and harbour areas; these data are presented in Table IV. These laboratories used infra-red spectrophotometric techniques that, although not identical, are similar enough for a comparison to be made. The infra-red method is sensitive to the organic compounds dissolved in sea-water that are extracted by the solvent used (normally CCl_4) and so the values presented may be regarded as the concentration of extractable organics, which, in turn, is far below the total concentration of organic material in the water. The values obtained are useful in as much as the petroleum hydrocarbons present in the water do not exceed the extractable organics.

The observations made in the pilot project regarding the concentration of organic matter extractable from surface waters yielded, for coastal areas, similar values to those presented in the Exxon Co. Report.

8.6 Intercalibration

An intercalibration exercise was conducted during MED POL I project for dissolved/dispersed petroleum hydrocarbons. This exercise was part of the IGOSS Pilot Project on Marine Pollution (Petroleum) Monitoring Intercomparison Exercise (MAPMOPP).

After the selection of a suitable standard reference material, Chrysene, two sets of intercomparison material labelled Chrsene I and Chrisene II were sent, with attached instructions, to the participating research centres.

The Chrysene I samples were intended to determine whether the participants had functioning fluorimeters, which were being used properly, whereas, the intent of Chrysene II samples was to determine the precision and accuracy of the work-up procedure used by the laboratories.

Table IV - Summary of data on extractable organic compounds

RESEARCH CENTRE	SAMPLED AREA	CONCENTRATION (mg/l)		REMARKS
		Range	Mean	
A.U.T. Thessaloniki Greece	Thessaloniki Bay	< 0.1 - 3.8	0.8	-
	Kavala Bay	0.5 - 3.2	1.8	-
	Strymonikos Bay	0.2 - 3.7	1.4	-
L.C.A.E. Montpellier France	Banyuls-sur-Mer coastal area	0.1 - 4.0	0.1	-
I.B.C. Barcelona Spain	Harbour	1.4 - 4.6	2.7	-
	coastal area	< 0.1 - 0.5	0.1	-
R.B.I. Zagreb Yugoslavia	Rijeka Bay	< 0.1 - 1.1	0.2	-

Regrettably, only a limited number of research centres were able to take part in the intercalibration exercise. A serious difficulty was the distribution of the reference material, since some of the standards never arrived at their destination or arrived in a condition that indicated they had been opened in transit. Presumably this is an inherent difficulty in an exercise of international scope. Moreover, in a few cases there was leakage from the vials containing the standards.

Some of the laboratories questioned the use of Chrysene as standard reference material considering that both the excitation and fluorescence spectra from the samples collected in various regions showed different wave lengths of maximum response as compared to those of Chrysene. The fact that they were different suggests that the intercalibration exercise did not show true comparability between the participating research centres.

9. GENERAL CONCLUSIONS

The pilot phase of the MED POL I project should be regarded as a baseline study. Its continuation as part of the long-term programme, however, would be of greater importance provided that the areas studied were extended to include other coastal zones in the southern part of the Mediterranean as well as offshore regions.

Most of the areas covered in the pilot project by the different research centres were rather limited; indeed, some of them were extremely localized. However, it must be recognised that several important coastal regions with fisheries, tourism and industrial facilities were surveyed during the implementation of MED POL I.

The four main operational aspects of the pilot project were conducted with varying degrees of success. For example, very limited information on oil slicks and floating tar balls was provided by the participating laboratories. This sparse information is attributed to logistical problems, e.g. availability of suitable ships and access of manpower to carry out this part of the project. On the other hand, all the participating laboratories provided data on dissolved/dispersed hydrocarbons on surface waters. However, in reporting this parameter, some research centres used Chrysene equivalent units, while others used equivalents of crude oils. For reporting purposes, it would be desirable to adopt only one standard, though this could prove difficult since scientists have divergent views on this subject. Consequently, parallel units will have to be accepted at the present time.

As already pointed out in this report, the intercalibration exercise was only partially successful. However, towards the end of the project information on intercalibration matters was exchanged between the designated Regional Activity Centre and several participating laboratories.

The measurement of tar on beaches was also one of the operational aspects reported by the majority of the research centres. In spite of certain discrepancies in the sampling techniques and the irregular frequency of sampling practiced by some of the laboratories, the reported results may be considered valid. It was clearly established that the accumulation of tar on beaches was dependant on factors such as the strength and direction of prevailing winds as well as coastal currents. It is hoped, therefore, that when more information has been obtained from MED POL VI, especially with regard to coastal currents, that this additional input will also prove to be valid in forecasting the accumulation of oil in coastal areas. Thus, to achieve this aim it would be advisable to include in the long-term programme the monitoring of beaches which are clear of tar at the present time to determine future patterns of oil pollution along the coastal areas of the Mediterranean.

It may be concluded that further work is required to extend the network of stations and the period of observation to be able to gather more information to assess the impact of oil pollution on coastal and offshore areas of the Mediterranean. It should be pointed out, however, that due to the MED POL I pilot project many regional laboratories have been able to establish analytical capabilities, to study oil pollution previously non-existent in certain areas.

10. OTHER ACHIEVEMENTS

The formalization of the research agreements between IOC and the research centres was too slow, which hampered the early start of the work by all centres designated as participants in the pilot project.

The periodic reporting to IOC by the research centres was not satisfactory; less than 50 per cent of the centres respected the deadlines and even those who submitted their reports did not always follow the reporting format agreed upon.

Only three out of eight trainees submitted reports on the results of their training, which did not allow for a thorough evaluation of either the effectiveness of the training or the adequacy of administrative arrangements related to it.

No evaluation of the assistance provided by the Regional Activity Centre was made available by IOC.

Documents specifically developed for this pilot project include:

- Guidelines for the Implementation of Pilot Projects MED I and MED VI. Supplements 1 and 3 to IOC-WMO-UNEP/MED-MRM/3. UNESCO 1977;
- Manual for Monitoring Oil and Petroleum Hydrocarbons in Marine Waters and on Beaches. Supplement to manuals and guides No. 7. UNESCO 1977.

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MED POL II : BASELINE STUDIES AND MONITORING OF METALS, PARTICULARLY MERCURY AND CADMIUM, IN MARINE ORGANISMS (FAO(GFCM)/UNEP)

1. INTRODUCTION

Metals, particularly heavy metals like mercury, are toxic to man and to most marine organisms. They can reach man through food-chains and thus one of the sources of greatest concern is seafood. It is, therefore, most important to determine the concentration of such metals in fish, shellfish and other edible marine organisms.

It is recognized that the Mediterranean is, tectonically speaking, an active region and that, as a result, some metals may have high natural levels and great regional variations in their concentration in sea-water and in sediments. The bluefin tuna, as well as other tuna, is known to accumulate mercury, and Mediterranean tuna apparently have much higher levels than those from the Atlantic Ocean.

The pilot project dealt primarily with the concentration of selected metals, particularly mercury and cadmium, in marine organisms. In addition to these elements, the measurement of the levels of copper, lead, manganese, selenium and zinc was recommended, particularly when detection methods providing for multi-elemental analysis were available. The striped mullet, the Mediterranean mussel and the bluefin tuna represent three different ecotypes that were selected as indicator species for the monitoring programme. The sampling frequency was seasonal.

Although the information on levels of selected metals in representative marine organisms was being collected primarily to assess the health risks stemming from consumption of seafood, data collected through the project might help to clarify whether the relatively high concentrations of some metals observed in Mediterranean organisms were due to natural phenomena or anthropogenic inputs.

The actual work of the national research centres on the pilot project started in late autumn of 1975.

The evaluation contained in this document is based on the final reports submitted by the participating research centres, as well as on data provided on LOG FORMS for computer treatment.

During the first half of the pilot phase the number of analyses reported was rather limited; this made possible the evaluation of results from all participants without the use of computer facilities. A preliminary evaluation on a Mediterranean basis was also presented and discussed at the FAO(GFCM)/ UNEP Mid-term Expert Consultation on the Joint Coordinated Project on Pollution in the Mediterranean (MED POL II, III, IV and V) (Dubrovnik, 2 - 13 May 1977). As the participating centres improved their analytical capabilities during the second half of the pilot phase, the number of analyses performed increased considerably. It was, therefore, apparent that, for the preparation of the final report, the use of computer facilities for data treatment would be necessary.

The LOG FORMS, developed to serve as the basis for entering the data into a computer system, were completed by 29 centres. A total of more than 13,000 data lines, each giving one analytical value, as well as information on location and biological parameters, was reported.

FAO made use of an existing computer system designed essentially for the Fisheries Commodities Data Base, with supplementary print programmes to generate tables in order to meet the requirements of the pilot project.

The results presented in this report are mainly based on tables giving concentrations by species and elements for different sampling stations and MED POL areas, which were produced by the FAO Fisheries Information Data and Statistics Service.

2. PARTICIPANTS

Thirty-six research centres from fifteen Mediterranean States were designated to participate in the pilot project.

By the end of December 1980, 32 research agreements were signed and one was cleared and ready for signature.

3. CO-ORDINATING ARRANGEMENTS

FAO(GFCM) maintained the operational contacts with the national research centres designated to participate in the pilot project.

The Centre for Marine Research, "Rudjer Boskovic" Institute, Zagreb, Yugoslavia, was nominated in August 1976 to assist FAO(GFCM) as the Regional Activity Centre for this pilot project.

The following meeting was held in specific connection with the project:

- FAO(GFCM)/UNEP Mid-term Expert Consultation (Dubrovnik, 2 - 6 May 1977), which also covered MED POL III, and was attended by 44 participants from 32 research centres in 14 Mediterranean States.

4. FINANCIAL ARRANGEMENTS

Specific financial support to the pilot project was provided through projects FP/0502-75-01 and FP/0503-75-07 (both projects covering activities relevant to MED POL II, III, IV and V). Costs relevant to MED POL II (in US dollars) were shared between the two co-sponsors of these projects as follows:

	1975	1976	1977	1978	1979	1980	Total	Percentage
FAO(GFCM)	6,000	16,200	17,300	17,800	16,700	12,345	86,345	10.9
UNEP	8,422	131,640	175,050	130,450	146,720	110,803	703,085	89.1
TOTAL	14,422	147,840	192,350	148,250	163,420	123,148	789,430	100.0

Direct support to participants in MED POL II up to 31 December 1980 amounted to US $ 508,805 including:

- US $ 333,332 for equipment, including 13 atomic absorption spectrophotometers;
- US $ 97,633 for expendable materials;
- US $ 34,922 for training of twenty trainees (total of 21 man/months) from twelve research centres in eight host institutions;
- US $ 13,747 for attendance at meetings;
- US $ 19,171 for consultants to participating research centres;
- US $ 10,000 as assistance to the Regional Activity Centre.

Indirect support to participants in MED POL II up to 31 December 1980 amounted to US $ 194,280. This sum included:

- US $ 106,384 for the services of consultants to assist FAO(GFCM) in the organization and execution of the pilot project, and in the evaluation of its results;
- US $ 15,395 for the organization of meetings;
- US $ 70,401 for the preparation of manuals, guidelines and reports;
- US $ 2,100 for miscellaneous expenses.

The national contributions to the pilot project, estimated on the basis of incomplete information supplied by 25 participating research centres as equivalent to US $ 1,100,400, included:

- 790 man/months of professional and supporting staff (US $ 474,000 estimated at US $ 600 per man/month);
- US $ 277,850 as expendable materials;
- US $ 348,550 as operating costs of equipment.

5. OPERATIONAL DOCUMENT

The operational document of the pilot project was formulated at the FAO(GFCM)/UNEP Expert Consultation on the Joint Coordinated Project on Pollution in the Mediterranean (Baseline studies and monitoring of some metals and chlorinated hydrocarbons in marine organisms) (Rome, 23 - 27 June 1975) attended by 35 participants from 13 Mediterranean States. Certain modifications of the operational document were agreed upon at the FAO(GFCM)/UNEP Mid-term Expert Consultation for MED POL II and MED POL III (Dubrovnik, 2 - 6 May 1977) attended by 32 experts from 28 research centres participating in MED POL II.

6. AREAS STUDIES

The baseline studies and monitoring were to be carried out primarily in coastal waters. Furthermore, the sampling stations were to be selected by the participating research centres so that the results obtained could be used to characterize the level of pollutants in certain areas. The sampling frequency was to be seasonal (March, June, September and December).

The number of sampling stations selected by the different centres varied considerably, from two stations to over 30. In the latter case, the samples were, however, collected only occasionally, which makes statistical treatment of the data from one particular station impossible. In fact very few centres strictly followed the agreed sampling frequency with regard to seasonal sampling. Figure 1 shows the different areas that have been monitored or where monitoring was planned but data have not been reported. The whole Mediterranean is quite well covered by sampling areas and in all 12 sub-regional MED POL areas there is at least one centre that has reported results. The number of sampling stations is more than 300, but, as previously mentioned, many of them have only been sampled once or twice for perhaps one species during the duration of the whole project. This makes the number of stations for which time-trends could possibly be calculated about 100. Table I shows for each MED POL sub-regional area the number of research centres that have reported results.

Table I - Number of research centres by MED POL areas

MED POL AREA	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Research centres	1	9	1	4	4	1	1	7	2	3	1	1

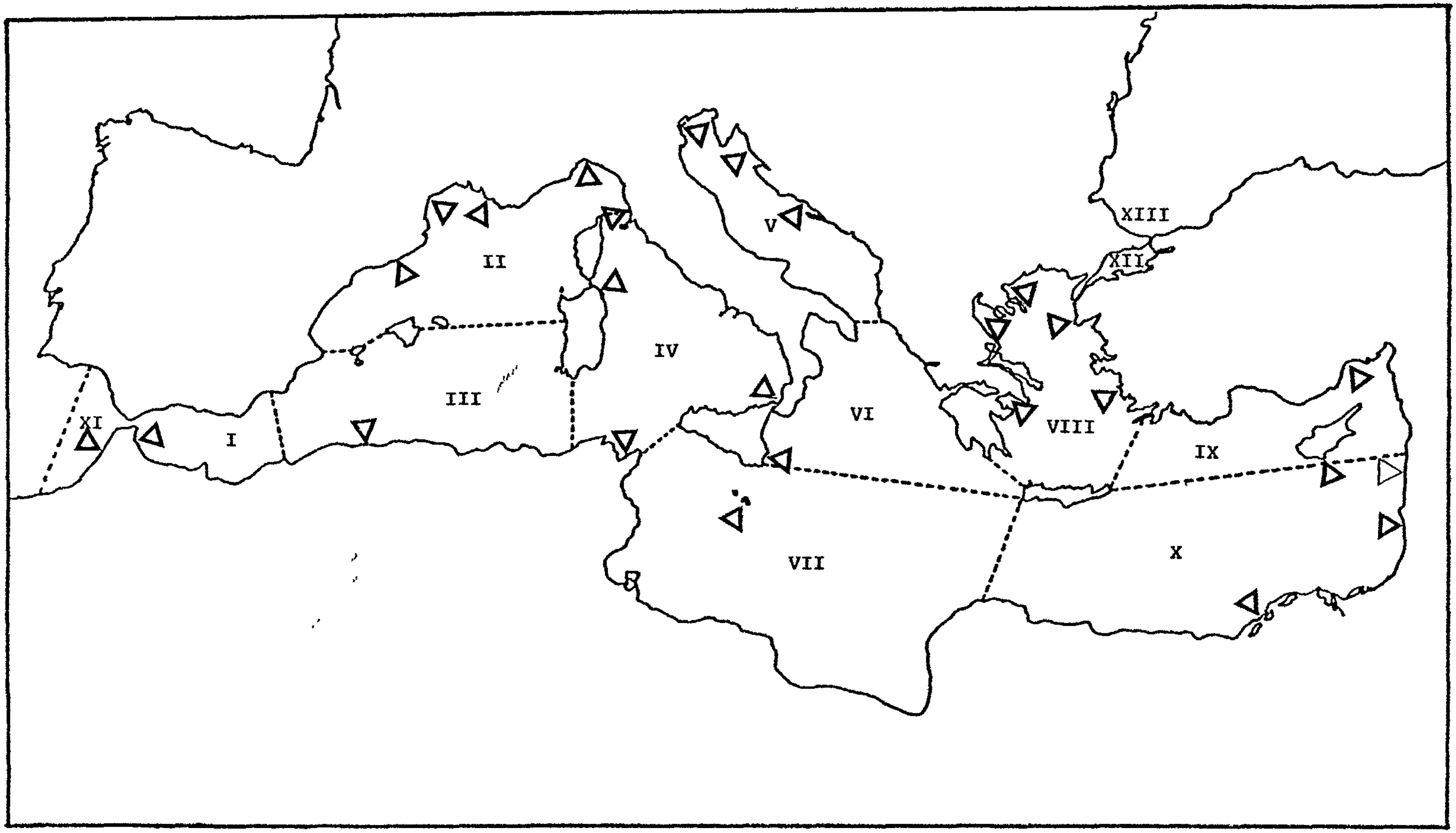

Figure 1. Sampling areas for MED II

I.	Alboran	IV.	Tyrrhenian	VII.	Central	X.	S. Levantin
II.	North-Western	V.	Adriatic	VIII.	Aegean	XI.	Atlantic
III.	South-Western	VI.	Ionian	IX.	N. Levantin	XII.	Sea of Marmara
						XIII.	Black Sea

▷ Data reported　　▷ No data reported

7. MATERIAL AND METHODS

7.1 Selection of the species

The marine organisms selected in the operational document as mandatory species were Mytilus galloprovincialis (Mediterranean mussel) and/or M. edulis, Mullus barbatus (striped mullet), Thunnus thynnus thynnus (bluefin tuna) and/or Xiphias gladius (broadbill swordfish). These species were selected as being representatives of different ecotypes. They are also of considerable economic importance and are common almost everywhere in the Mediterranean.

Results on Mytilus galloprovincialis and Mullus barbatus were reported respectively by 22 and 27 centres participating in the pilot project.

Mullus barbatus was sampled by all institutes with the exception of the centres operating in the Western Mediterranean. These two centres had selected another member of the Mullidae family, Mullus surmuletus (red mullet), as an alternative species. It can therefore be concluded that Mullus barbatus, as far as availability was concerned, is a very useful organism for monitoring purposes.

Mytilus galloprovincialis has been reported as being unavailable in some areas of the Central and Eastern Mediterranean. No information regarding its availability was received from the other centres that did not sample Mytilus. It can nevertheless be concluded that Mytilus galloprovincialis is sufficiently common in the Mediterranean coastal areas to make it, from this point of view, a suitable organism for a monitoring exercise.

Thunnus thynnus thynnus was sampled only by 11 centres. As Thunnus migrates over great distances it is not so much the number of sampling areas as the number of samples that is determinant for the evaluation of results. The same also applies to Xiphias gladius which, being the alternative to Thunnus, was sampled by six centres.

The total number of additional species that were sampled is close to 70, but the number of samples and the frequency of sampling, though variable, are generally low. Table II lists the research centres that have sampled the obligatory species and analysed the heavy metals, while Table III lists the additional species sampled by a limited number of research centres. Only species for which the full scientific names were given have been included in the list. Most of the species have only been sampled by one centre. Some, however, have been used more frequently and the following species have been sampled by three or more centres: Engraulis encrasicolus, Mullus surmuletus, Trachurus mediterraneus, Merluccius merluccius, Boops boops, Pagellus acarne, Pagellus erythrinus, Carcinus mediterraneus and Penaeus kerathurus.

Some of the additional species are also sampled for analysis of chlorinated hydrocarbons (MED POL III) but not necessarily by the same research centre. An evaluation, on a Mediterranean basis, of the levels of contamination in all the additional species is impossible because of the limited number of samples. The results can, however, be useful for the assessment of local pollution and to provide baseline information. Furthermore, many of the species sampled are of local commercial importance. For some migratory species the data may also give an indication of body burdens in the Mediterranean.

In a few cases, results of analyses of zooplankton, sediments and water have also been reported.

Table II - Species sampled and metals analysed

Research Centre	Final report	Species					Metals							
		Mytilus galloprovincialis	*Mullus barbatus*	*Thunnus thynnus thynnus*	*Xiphias gladius*	Other	Hg	Cd	Cu	Pb	Mn	Se	Zn	Other
Centre de Recherches océanographique et des pêches, Alger	X					X	X	X					X	
Fisheries Department, Nicosia	X		X		X	X			X				X	
Institute of Oceanography and Fisheries, Alexandria	X		X				X							
Centre for Post-graduate Studies and Research, Alexandria	X		X			X	X							
Laboratoire Central d'Hygiène alimentaire, Paris	X		X	X			X	X	X	X			X	
Laboratoire de Chimie analytique et Toxicologie, Montpellier	X	X	X			X	X	X			X			
Institut scientifique et technique des pêches maritimes, Sète	X	X	X	X		X	X	X		X				
Institute of Oceanographic and Fisheries Research, Athens	X	X	X			X		X	X	X	X		X	X
Nuclear Research Centre "Demokritos", Athens	X	X	X			X			X			X	X	X
General Chemical State Laboratory, Athens	X	X	X		X	X	X							
Department of Food Hygiene, University of Thessaloniki	X	X	X	X	X	X	X							

continued

Table II - Species sampled and metals analysed (continued-2)

Research Centre	Final report	Species					Metals							
		Mytilus galloprovincialis	*Mullus barbatus*	*Thunnus thynnus thynnus*	*Xiphias gladius*	Other	Hg	Cd	Cu	Pb	Mn	Se	Zn	Other
Laboratory of Analytical Chemistry, University of Thessaloniki	X	X	X	X	X		X	X		X				
Israel Oceanographic and Limnological Research Ltd., Haifa	X		X			X	X	X	X	X			X	X
Laboratory of Hydrobiology and Fish Culture, Siena	X	X	X	X	X	X	X	X	X	X	X	X	X	
Marine Contamination Laboratory - CNEN, Fiascherino	X	X	X	X	X	X	X	X						
Centre for Radiochemistry and Activation Analyses - CNR, Pavia														
Group for Oceanographic Research, University of Genova	X	X	X			X	X	X	X	X	X		X	X
Station for Marine Biology, University of Messina	X	X	X	X		X	X	X		X				
Centre de Recherche marine, Beyrouth														
The University of Malta, Msida	X		X			X	X	X	X	X	X		X	
Institut scientifique des Pêches maritimes, Casablanca	X	X		X		X	X	X	X					
Instituto de Investigaciones Pesqueras, Barcelona		X	X	X		X	X	X	X				X	

continued

Table II - Species sampled and metals analysed (continued-3)

Research Centre	Final report	Species					Metals							
		Mytilus galloprovincialis	*Mullus barbatus*	*Thunnus thynnus thynnus*	*Xiphias gladius*	Other	Hg	Cd	Cu	Pb	Mn	Se	Zn	Other
Laboratorio Oceanográfico del Mar Menor, San Pedro del Pinatar		X	X			X		X		X				
Instituto Químico de Sarria, Barcelona	X	X	X			X	X	X	X	X	X		X	X
Institut national scientifique et technique d'océanographie et de Pêche, Salammbô	X	X	X				X							
Hydrobiological Research Institute, Istanbul		X	X			X	X							
Marine Science Department (METU), Erdemli-Içel	X	X	X			X	X	X	X	X	X		X	X
Institute of Hydrobiology, Ege University, Izmir		X	X	X		X	X	X	X	X	X		X	X
Laboratory for Trace Element Analyses, Rijeka														
Institute for Oceanography and Fisheries, Split	X	X	X				X	X						
"Rudjer Bošković" Institute, Zagreb	X	X	X			X	X	X	X	X		X	X	X
Marine Biological Station, Portorož	X	X	X			X	X	X	X	X	X	X	X	X

Table III - Additional species sampled

Species sampled	Number of centres	Sampled also in MED III
Arca noae	1	X
Aristeus antennatus	1	
Belone belone	1	X
Boops boops	4	X
Carcinus mediterraneus	3	X
Clupea pilchardus	1	
Crenilabrus tinca	1	
Conger conger	2	X
Dentex filosus	1	
Dentex macrophtalmus	1	X
Diplodus annularis	2	
Engraulis encrasicolus	3	X
Ephinephelus guaza	1	
Lithophaga lithophaga	2	X
Loligo vulgaris	1	X
Maena maena	1	X
Maena smaris	1	
Merlangius merlangus	2	X
Merluccius merluccius	4	X
Microcosmus sulcatus	1	
Mugil auratus	1	X
Mugil capito	1	X
Mugil cephalus	1	
Mugil chelo	1	
Mugil saliens	1	X
Mullus surmuletus	8	X
Nephrops norvegicus	4	X
Oblata melanura	1	X
Octopus vulgaris	2	
Ophiotrix fragilis	1	
Ostrea edulis	1	X
Pagellus acarne	5	X
Pagellus erythrinus	4	X

continued

Table III - Additional species sampled (continued)

Species sampled	Number of centres	Sampled also in MED III
Pagrus ehrenbergii	1	
Parapenaeus longirostris	4	X
Patella coerulea	2	X
Pegusa lascaris	1	
Penaeus kerathurus	5	X
Perna perna	1	
Phycis blennoides	1	
Pomatomus saltator	2	
Portunus depurator	1	
Raja asterias	1	
Raja alaueta	1	
Sarda sarda	1	
Sardina pilchardus	1	X
Sardina vulgaris	1	
Sardinella maderensis	1	
Saurida undosquamis	1	X
Scomber japonicus	1	
Scomber scombrus	1	X
Scorpaena porcus	1	
Scorpaena scrofa	2	
Sepia officinalis	2	
Serranus cabrilla	1	
Serranus scriba	1	
Solea vulgaris	1	
Squilla mantis	1	
Synodus saurus	1	
Torpedo marmorata	1	
Trachinus draco	1	
Trachurus mediterraneus	4	X
Trachurus trachurus	1	X
Upeneus molluccensis	2	X
Upogebia littoralis	1	X
Uranoscopus scaber	1	

7.2 Pollutants analysed

Results on mercury were reported by 25 centres and on cadmium by 21 centres. Analysis of cadmium was apparently rather difficult, requiring the use of graphite furnace techniques together with the atomic absorption spectrophotometer. It was clear, therefore, that several of the centres that did not report results on cadmium had only recently begun analysis of heavy metals, and it may be assumed that, when their analytical capability is further improved, cadmium will be one of the elements to be analysed.

Among the additional elements in the operational document, copper and zinc received most attention, both being reported on by 15 centres.

An appreciable number of results were also received for lead and manganese, while selenium was only reported on by four centres.

The interrelation between mercury and selenium concentrations in organisms makes this latter element especially interesting. Methyl-mercury, the most common organic form of mercury in organisms, was, unfortunately, only reported on by one centre.

Besides these mandatory and additional elements, many others were also monitored but only by a limited number of centres. Among them special mention should be made of arsenic, antimony, cobalt, chromium, iron, nickel and silver.

7.3 Sampling and analytical techniques

Sampling and sample preparation were generally carried out in accordance with the recommendations given in the Manual of Methods in Aquatic Environment Research, Part 3 (Bernhard, 1976). In some cases, however, the samples were obtained from the market. But as this was generally done only for tuna or swordfish an appropriate subsampling should prevent the risks of contamination.

For destruction of the organic material, wet combustion was generally used. The pressure decomposition vessels, which many centres were provided with through the project, constituted the equipment most commonly used. In some cases low temperature ashing was utilized.

For the analysis, atomic absorption spectrophotometers (AAS) were employed. The determination of mercury was carried out by the cold vapour technique, while the other metals were generally determined by air-acetylene flame at higher concentrations, or graphite furnace at lower concentrations. With the comparatively low concentrations of cadmium, in particular, graphite furnace techniques had to be used. This technique apparently caused initial difficulties for those centres that were just embarking on metal analysis with AAS.

Other methods that were used were: neutron activation analysis (NAA), electroanalytical techniques (polarographic and voltametric) and X-ray fluorescence.

7.4 Intercalibration

The participating centres were provided with three or four different intercalibration samples depending on the stage of the pilot project at which they commenced the analyses. Results for three or four samples were reported by 26 centres, while two centres analysed only one sample. The remaining centres did not participate in the intercalibration, although two of them reported monitoring results (Table IV). However, as these two centres were just recently in a position to perform the analysis, it can be expected that they will carry out the intercalibration, this being an obligatory part of the pilot project.

The intercalibration exercise was a world-wide one with not only Mediterranean research centres reporting results. For each sample and compound, the arithmetic mean and standard deviation (SD) of the results reported by the participating centres have been calculated.

In order to exclude "outliers", Dixon's test was used. As a basis for estimating the reliability of the data and their fitness for inclusion in the evaluation of the monitoring exercise, the following criteria were used:

(i) results within one standard deviation from the mean (after Dixon's test) to be considered as "good";

(ii) results within two standard deviations to be considered as "acceptable";

(iii) results deviating more than two standard deviations from the mean to be considered as "not acceptable".

For the overall evaluation of three intercalibration samples, the average of two "good" or "acceptable" results and one "not acceptable" was considered as acceptable. With two "not acceptable" and one "good" or "acceptable" the average was considered as "not acceptable". In the cases where four samples were reported on and two results were "not acceptable", the judgement was based on how much the values deviated from the mean.

When considering these principles for accepting the data for evaluation of the monitoring results it was revealed that, in general, only data from a limited number of centres would have to be deleted. One centre for mercury, and two for cadmium would have to be eliminated. In the case of copper, one, and, for zinc, two centres did not have acceptable intercalibration results. For lead the situation was somewhat different as five of the 14 centres that reported results for this metal would have to be excluded.

It can, hence, be concluded that, with the exception of lead, an evaluation of the baseline studies and monitoring without rejecting data could be made without introducing unacceptable errors. However, consideration has, in this case, to be given to the variation related to the analytical performance. Nevertheless, for the evaluation, data from those centres with "not acceptable" values or with no intercalibration performed, have been deleted in order to improve the comparability of the results.

For the other metals analysed, an evaluation of the performance of the individual laboratories was not possible due to the limited number of results reported.

Table IV - Participation in intercalibration of samples MA-M-1 (oyster), SP-M-1 (sea plant), MA-A-1 (copepod) and MA-A-2 (fish)

Research Centre	Data reported	MA-M-1	SP-M-1	MA-A-1	MA-A-2
Centre de Recherches océanographiques et des pêches, Alger	X	X	X	X	X
Fisheries Department, Nicosia	X	*	X	X	X
Institute of Oceanography and Fisheries, Alexandria	X				
Centre for Post-graduate Studies and Research, Alexandria	X	*	*	X	X
Laboratoire Central d'Hygiène alimentaire, Paris	X	*	X	X	X
Laboratoire de Chimie analytique et Toxicologie, Montpellier	X				
Institut scientifique et technique des pêches maritimes, Sète	X	X	X	X	X
Institute of Océanographic and Fisheries Research, Athens	X	X	X	X	X
Nuclear Research Centre "Demokritos", Athens	X	X	X	X	X
General Chemical State Laboratory, Athens	X	X	X	X	X
Department of Food Hygiene, University of Thessaloniki	X	X	X	X	X
Laboratory of Analytical Chemistry, University of Thessaloniki	X	X	X	X	X
Israel Oceanographic and Limnological Research Ltd., Haifa	X	X	X	X	X
Laboratory of Hydrobiology and Fish Culture, Siena	X	X	X	X	X
Marine Contamination Laboratory - CNEN, Fiascherino	X	X	X	X	X
Centre for Radiochemistry and Activation Analyses - CNR, Pavia		X	X	X	
Group for Oceanographic Research, University of Genova	X	X	X	X	X
Station for Marine Biology, University of Messina	X	X	X	X	X
Centre de Recherche marine, Beyrouth					
The University of Malta, Msida	X	*	X	X	X
Institut scientifique des Pêches maritimes, Casablanca	X	*		X	
Instituto de Investigaciones Pesqueras, Barcelona	X	X	X	X	X
Laboratorio Oceanográfico del Mar Menor, San Pedro del Pinatar	X	X	X	X	
Instituto Químico de Sarria, Barcelona	X	*	X	X	X
Institut national scientifique et technique d'océanographie et de Pêche, Salammbô	X	*	X	X	X
Hydrobiological Research Institute, Istanbul	X	*	X	X	X
Marine Science Department (METU), Erdemli-Içel	X	X	X	X	
Institute of Hydrobiology, Ege University, Izmir	X	*	X	X	X
Laboratory for Trace Element Analyses, Rijeka		X	X	X	X
Institute for Oceanography and Fisheries, Split	X	X	X	X	X
"Rudjer Bošković" Institute, Zagreb	X	X	X	X	X
Marine Biological Station, Portorož	X	X	X	X	X

* Sample not sent.

A comparison of the results in this intercalibration exercise with those that have been reported in the International Council for the Exploration of the Sea (ICES), North Sea and North Atlantic baseline studies, shows that the coefficient of variation between the laboratories is larger in the Mediterranean than in the ICES area, (ICES, 1978). This is, however, to be expected as all laboratories in the ICES study are well established, while many centres in the Mediterranean have only recently begun analysis of heavy metals. As was pointed out for the ICES studies, a regular repetition of the exercise will certainly further improve the quality of the data.

8. SCIENTIFIC RESULTS AND DISCUSSION

8.1 Introduction

The levels of contamination presented in this section are based only on data reported on LOG FORMS received before 15 June 1980. Data from the very first phase of the pilot project, before the LOG FORMS were introduced, have not been key-entered unless these data have been transferred to LOG FORMS by the reporting research centre.

Data presented for the different pollutants and organisms are mean arithmetic values of all results reported for the various stations in the relevant MED POL area, with due consideration given to the intercalibration results. They do not take into account the differences between the conditions prevailing at the individual sampling stations, i.e. levels of pollution. Bearing in mind the wide extent of heterogeneous conditions within each MED POL area, it is obvious that the overall averages of the levels reported should not be interpreted as mean values for an area. References (author, final report) appearing in the text here below relate to the individual summary reports prepared by the principal investigators.

8.2 Mercury

Levels of total mercury in the obligatory species, by area, are reported in Figure 2.

8.2.1 *Mytilus galloprovincialis*

The highest levels are reported in samples from area V (Adriatic), collected in rather polluted sites (Gomiscek and Stegnar, final report) (Table V). Also values from area IV (Tyrrhenian) are rather high with an average concentration of 524 µg/kg.

All other results are below 200 µg/kg FW. The variation between the individual samples are considerable as can be seen from the standard deviation (SD) which in many cases is more than 100 per cent of the mean.

The highest values reported were in several cases in areas IV and V above 1000 µg/kg. A statistical comparison (t-test) of the average concentrations in areas II, IV and VIII, which are based on a sufficient number of samples, shows significantly higher concentrations in area IV.

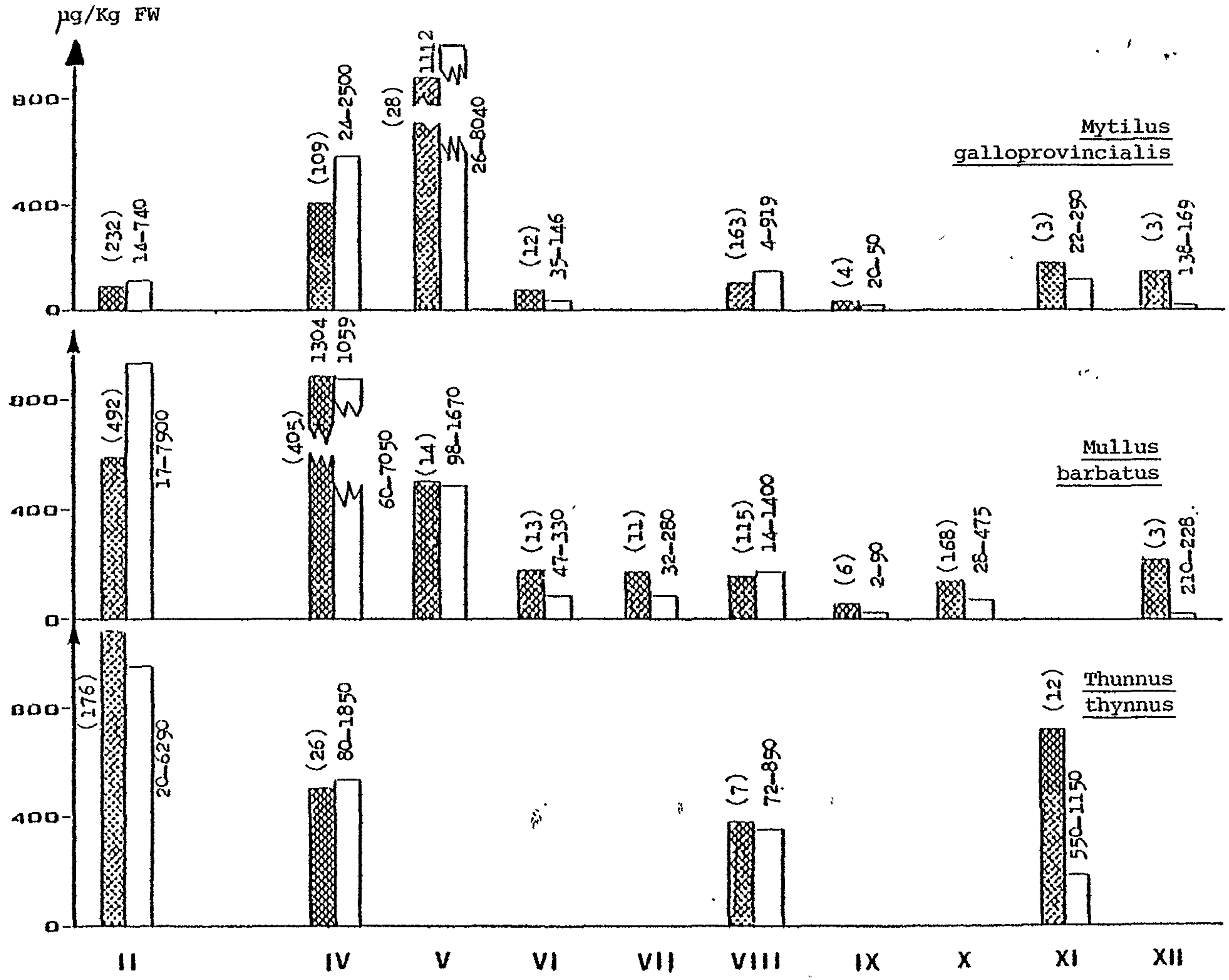

Figure 2. Average levels of mercury in different species by MED POL areas

( ) n
arithmetical mean
range
standard deviation

The lower averages are similar to the levels reported for Mytilus edulis in the North Sea by ICES as part of the baseline survey of 1972 (ICES, 1974). Levels reported from the Canadian coast in the ICES North Atlantic baseline study are, however, lower with concentrations between 10 and 100 µg/kg with an overall average of 50 µg/kg, (ICES, 1980).

Table V - Average levels of mercury in Mytilus galloprovincialis

sampling area	no. of centres sampling	no. of samples (n)	mean conc. µg/kg FW	standard deviation	range	average* length (mm)
II	4	232	94	108	9 - 740	47 (226)
IV	2	109	524	602	24 - 2500	38 (106)
V	2	28	1112	2329	26 - 8040	51 (28)
VI	1	12	77	37	35 - 146	49 (12)
VIII	5	163	102	158	4 - 919	35 (98)
IX	1	4	37	13	20 - 50	63 (4)
XI	1	3	191	120	22 - 290	-
XII	1	3	158	14	138 - 169	72 (3)

*Number of specimens in brackets

8.2.2 Mullus barbatus

The concentrations of mercury in Mullus barbatus are generally around 200 µg/kg or less. In areas II, IV, V and VIII however, and, in particular, samples from the Tyrrhenian Sea have elevated averages (Table VI).

Along the Italian coast in area IV is the Mount Amiata region with cinnabar-rich bedrock and mercury-extracting industries. Bacci et al. (1980) have reported an increase in levels of mercury in Mullus barbatus from this region with increasing depth and distance from the coast. The average of data reported from sampling stations in area IV were 1,304 µg/kg with a range of 60-7,050 µg/kg. The average concentration in this area is significantly higher than in areas II, V and VIII.

8.2.3 Thunnus thynnus thynnus

The levels of mercury in Thunnus thynnus thynnus are generally high, especially in specimens of large size. The average concentration in 176 specimens caught in area II was 1,096 µg/kg with a range of 20-6, 290 (Table VII).

Table VI - Average levels of mercury in Mullus barbatus

sampling area	no. of centres sampling	no. of samples (n)	mean conc. µg/kg FW	standard deviation	range	average* length (mm)	average* weight (g)
II	4	492	595	944	17 - 7900	133 (478)	45 (487)
IV	3	405	1304	1059	60 - 7050	140 (405)	46 (405)
V	2	14	513	486	98 - 1670	154 (14)	38 (14)
VI	1	13	188	82	47 - 330	129 (13)	23 (13)
VII	1	11	166	86	32 - 280	135 (11)	39 (11)
VIII	5	115	155	169	14 - 1400	134 (99)	-
IX	1	6	55	28	2 - 90	163 (6)	64 (6)
X	2	168	141	73	28 - 475	148 (168)	34 (168)
XII	1	3	217	8	210 - 228	148 (3)	41 (3)

Table VII - Average levels of mercury in Thunnus thynnus thynnus

sampling area	no. of centres sampling	no. of samples (n)	mean conc. µg/kg FW	standard deviation	range	average* length (mm)
II	1	176	1096	937	20 - 6290	1219 (89)
IV	1	26	497	545	80 - 1850	-
V	1	2	1485	625	860 - 2110	650 (2)
VIII	2	6	300	331	50 - 890	634 (6)
XI	2	12	715	181	550 - 1150	-

* Number of specimens in brackets

Cumont et al. (1972, 1975) and Renzoni et al. (1979) have shown that levels of mercury in tuna from the Mediterranean are higher than levels in tuna from the Atlantic. As tuna migrates over great distances the values reported are not only valid for one area but can be considered as Mediterranean levels.

8.2.4 Other species

Several additional species have also been analysed for mercury, although most of them only in one or two areas. The average concentrations based on three or more samples for each species are shown in Table VIII. *Nephrops norvegicus* have higher values in areas II and IV with average concentrations of 967 and 961 µg/kg respectively.

The correlation between mercury concentration, body weight and sex has been discussed in the final report (Renzoni, area IV). The levels in *Sarda sarda* are also somewhat higher in area II with an average concentration of 1,002 µg/kg. For *Merluccius merluccius* the levels are higher in samples from area XII (Sea of Marmara) but the small number of samples makes the results quite uncertain.

In the ICES baseline study in the North Atlantic, the mean concentrations in samples of *Merluccius* were between 30 and 130 µg/kg (ICES, 1977b).

Results from the Egyptian coast, which were received after the processing of the data, indicate high values in *Mullus surmuletus* at one sampling station with the maximum of 2,200 µg/kg. Average levels in *Trachurus mediterraneus*, which are between 93 and 345 µg/kg, are similar to the mean values between 170 and 330 µg/kg reported for *Trachurus trachurus* in the North Sea (ICES, 1977b). The anchovy *Engraulis encrasicolus*, a plankton feeder, generally shows levels below or near 150 µg/kg.

Concentrations of methyl-mercury are only reported for a small number of samples of *Sarda sarda* and *Nephrops norvegicus* (Capelli, final report).

8.3 Cadmium

Concentrations of cadmium in the obligatory species, by area, are reported in Figure 3.

8.3.1 *Mytilus galloprovincialis*

Average levels in *Mytilus galloprovincialis* are approximately 100 to 250 µg/kg in all areas, except area VI (Ionian Sea) where the mean of the samples is below 50 µg/kg (Table IX).

The highest maximum values which were around 1000 µg/kg were reported from areas II and IV. In 1972, the North Sea Baseline Study mean values reported for *Mytilus edulis* ranged from 100 to 500 µg/kg (ICES, 1974). In the subsequent monitoring exercises of 1974 and 1975, mean values were between 30 and 390 µg/kg (ICES, 1977a; 1977c). Values from the Canadian coast in the ICES North Atlantic baseline study were between 90 and 330 µg/kg (ICES, 1980).

8.3.2 *Mullus barbatus*

The levels of cadmium in *Mullus barbatus* are lower than in *Mytilus*, with averages in samples from the different areas of between 17 and 69 µg/kg (Table X).

Table VIII - Overall averages of levels of mercury in samples of non-obligatory species

sampling areas	species	No. of samples (n)	mean conc. µg/kg F.W.	standard deviation	range
II	Boops boops	8	127	70	23- 250
	Engraulis encrasicolus	114	179	107	21- 425
	Maena smaris	5	188	55	150- 280
	Mullus surmuletus	9	211	148	60- 510
	Nephrops norvegicus	345	967	850	350-3000
	Sarda sarda	14	1002	641	290-2300
	Sardina pilchardus	46	247	70	150- 390
	Scomber scombrus	16	335	121	125- 510
	Scorpaena scrofa	5	90	42	40- 160
	Solea vulgaris	11	65	64	20- 220
	Squilla mantis	20	151	86	65- 455
	Trachurus trachurus	3	705	397	330-1255
	Trisopterus minutus capelanus	5	308	304	60- 840
III	Mullus surmuletus	210	90	43	30- 380
	Perna perna	192	76	50	20- 370
IV	Engraulis encrasicolus	98	162	64	64- 380
	Nephrops norvegicus	189	961	507	59-2900
	Thunnus alalunga	8	215	85	90- 336
VI	Engraulis encrasicolus	11	144	74	53- 270
	Nephrops norvegicus	7	291	52	190- 360
	Thunnus alalunga	8	276	124	60- 399
VII	Lithophaga lithophaga	5	163	76	79- 290
	Trachurus mediterraneus	5	345	317	80- 955

continued

Table VIII - Overall averages of levels of mercury in samples of non-obligatory species (continued-2)

sampling areas	species	No. of samples (n)	mean conc. µg/kg F.W.	standard deviation	range
VIII	Merluccius merluccius	10	317	337	62- 838
	Pagellus erythrinus	3	219	6	213- 228
	Parapenaeus longirostris	42	339	225	110-1195
	Trachurus mediterraneus	3	338	19	320- 365
	Xiphias gladius	8	279	281	84- 755
IX	Boops salpa	3	8	7	3- 17
	Mugil auratus	39	170	881	1-5600
	Mullus surmuletus	13	35	23	1- 78
	Penaeus kerathurus	7	20	12	8- 48
	Upeneus molluccensis	7	199	118	110- 430
X	Boops boops	5	134	149	40- 432
	Dentex dentex	6	385	92	220- 480
	Dentex gibbosus	12	139	19	99- 178
	Donax trunculatus	42	209	220	35- 909
	Epinephelus aeneus	4	252	120	99- 397
	Merluccius merluccius	6	152	102	31- 258
	Pagellus acarne	7	190	80	71- 337
	Pagellus erythrinus	112	204	115	53- 805
	Saurida undosquamis	143	137	93	42- 649
	Sphyraena sphyraena	7	164	45	81- 246
	Trachurus mediterraneus	48	93	107	8- 417
	Upeneus molluccensis	120	439	292	38-1122
XI	Mullus surmeletus	5	147	129	15- 380
XII	Merluccius merluccius	3	817	30	778- 850
	Pagellus erythrinus	3	219	6	210- 225
	Parapenaeus longirostris	3	299	38	269- 352
	Trachurus mediterraneus	3	346	5	340- 352

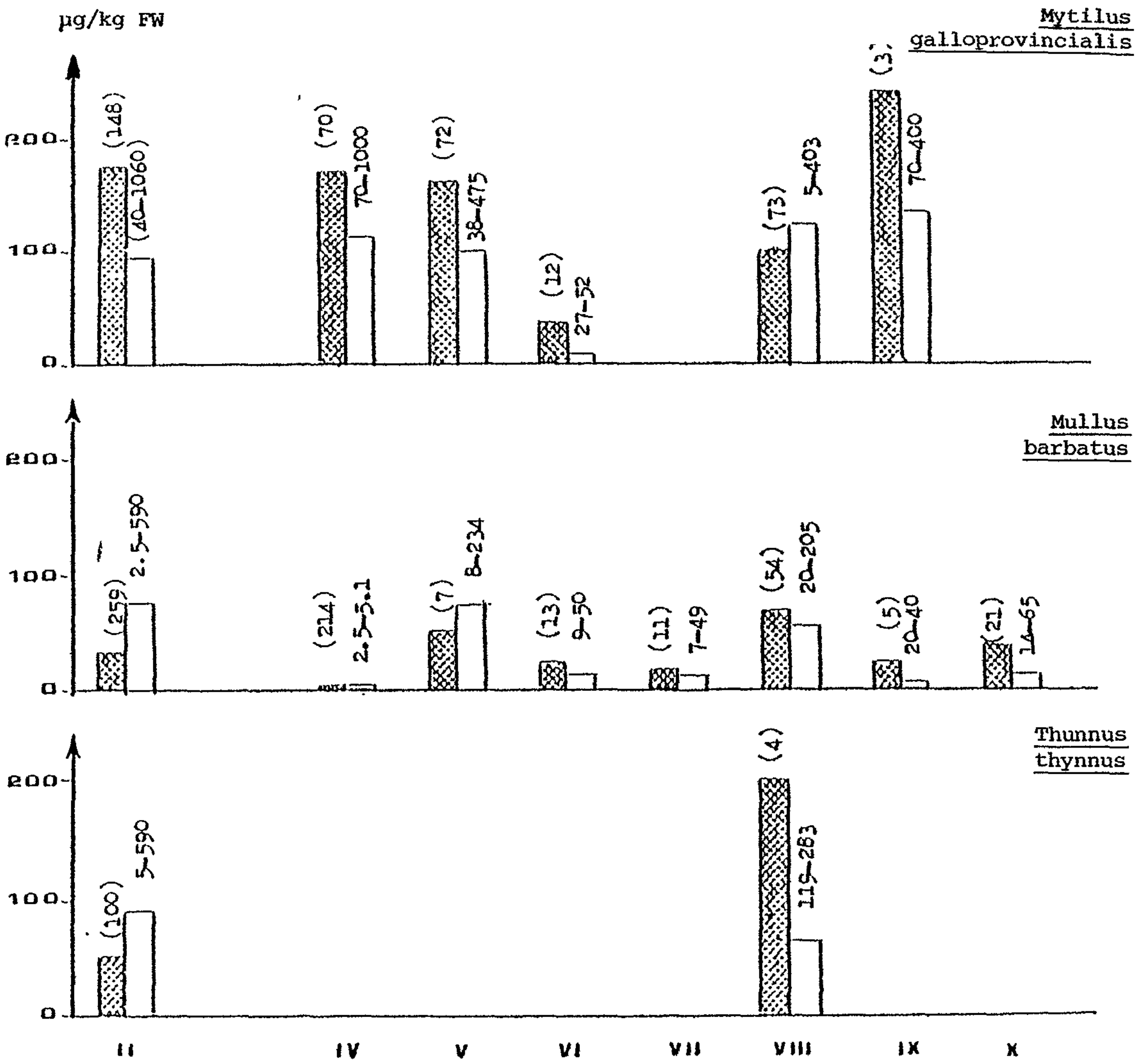

Figure 3. Average levels of cadmium in different species by MED POL areas

( ) n — range

arithmetical mean — standard deviation

Table IX - Average levels of cadmium in *Mytilus galloprovincialis*

sampling area	no. of centres sampling	no. of samples (n)	mean conc. µg/kg FW	standard deviation	range	average* length (mm)
II	4	148	169	111	40-1060	46(147)
IV	1	70	169	118	70-1000	33(67)
V	2	72	157	100	38- 475	50(14)
VI	1	12	36	8	27- 52	49(12)
VIII	2	73	97	122	5- 403	33(71)
IX	1	3	237	135	70- 400	72(3)

Table X - Average levels of cadmium in *Mullus barbatus*

sampling area	no. of centres sampling	no. of samples (n)	mean conc. µg/kg FW	standard deviation	range	average* length (mm)	average* weight (g)
II	5	259	31	71	2.5-590	140 (247)	57 (254)
IV	2	214	4	5	2.5- 51	141 (214)	48 (214)
V	2	7	49	75	8-234	155 (7)	41 (7)
VI	1	13	25	14	9- 50	129 (13)	23 (13)
VII	1	11	17	15	7- 49	135 (11)	39 (11)
VIII	2	54	69	55	20-205	122 (54)	41 (41)
IX	1	5	26	8	20- 40	164 (4)	73 (4)
X	1	21	39	14	14- 65	140 (21)	33 (21)

* Number of specimens in brackets

From an analytical point of view, determinations at such low levels are very difficult, which may render the results somewhat uncertain. It is therefore advisable that the intercalibration exercises in the future should include samples with cadmium levels below 100 µg/kg. The analytical techniques may also have to be improved in order to enhance the reliability of the data. Nevertheless it can be concluded that the concentrations of cadmium in *Mullus barbatus* are generally low, with only a few high values reported in the range of about 200 to 500 µg/kg (areas II, V and VIII).

8.3.3 Thunnus thynnus thynnus

Data on cadmium in Thunnus are only available from three centres sampling in areas II, V and VIII (Aegean Sea). The levels are rather low as for Mullus barbatus (Table XI).

The mean concentration of 100 samples in area II was 53 µg/kg with a range of 5-590 µg/kg.

Table XI - Average levels of cadmium in Thunnus thynnus thynnus

sampling area	no. of centres sampling	no. of samples (n)	mean conc. µg/kg FW	standard deviation	range	average* length (mm)
II	1	100	53	88	5 - 590	1,225 (88)
VIII	1	4	196	61	119 - 283	772 (4)

* Number of specimens in brackets

8.3.4 Other species

The overall averages of levels of cadmium based on three or more samples of non-obligatory species are shown in Table XII. Contrary to the results for mercury, the levels of cadmium in Nephrops norvegicus are very low with mean values of between 5 and 26 µg/kg. The molluscs Mytilus edulis and Perna (Mytilus) perna show about the same or slightly lower averages than Mytilus galloprovincialis. The mean concentration in another mollusc Lithophaga lithophaga sampled in area VII is over 600 µg/kg. This value is however based on only five samples. Average values of samples of fish are generally low (less than 50 µg/kg).

8.4 Copper and zinc

Levels of copper and zinc in Mytilus galloprovincialis, Mullus barbatus and Mullus surmuletus are reported in Figures 4 and 5 respectively.

Table XII - Overall averages of levels of cadmium in samples of non-obligatory species

sampling areas	species	No. of samples (n)	mean conc. µg/kg F.W.	standard deviation	range
II	Boops boops	7	11	3	10 - 20
	Engraulis encrasicolus	83	18	31	2.5- 160
	Maena smaris	5	12	4	10 - 20
	Mullus surmuletus	5	40	-	-
	Mytilus edulis	10	85	36	40 - 140
	Nephrops norvegicus	249	11	27	2.5- 200
	Sarda sarda	14	40	-	-
	Scorpaena scrofa	5	220	40	200 - 300
	Solea vulgaris	11	10	-	-
	Trisopterus minutus capelanus	4	12	4	10 - 20
III	Mullus surmuletus	203	151	79	30 - 310
	Perna perna	192	126	67	30 - 361
IV	Engraulis encrasicolus	91	5	7	2.5- 40
	Nephrops norvegicus	117	5	12	2.5- 111
	Thunnus alalunga	8	18	3	14 - 22
VI	Engraulis encrasicolus	11	20	7	13 - 39
	Nephrops norvegicus	7	26	14	13 - 48
	Thunnus alalunga	8	16	5	9 - 26
VII	Lithophaga lithophaga	5	666	481	311 -1590
	Trachurus mediterraneus	5	46	57	7 - 160
VIII	Parapenaeus longirostris	14	26	12	20 - 50
	Xiphias gladius	2	112	-	76 - 148

8.4.1 Mytilus galloprovincialis

Average values for copper in Mytilus galloprovincialis (see Table XIII) vary between 1,002 to 1,730 µg/kg with the highest concentrations in areas II, IV and VIII.

Table XIII - Average levels of copper in Mytilus galloprovincialis

sampling area	no. of centres sampling	no. of samples (n)	mean conc. µg/kg FW	standard deviation	range	average* length (mm)
II	3	71	1730	1224	504-6000	42 (71)
IV	1	71	1659	773	650-4300	34 (68)
V	2	63	1002	855	190-4400	53 (5)
VIII	1	5	1686	596	1080-2800	49 (3)
IX	1	7	1466	600	750-2650	64 (7)
XI	1	3	1300	356	1000-1800	-

* Number of specimens in brackets

Taking into consideration the limited number of samples from each area and the relatively high standard deviations, it can nevertheless be concluded that these differences are not significant.

A "typical" concentration of copper in Mytilus galloprovincialis in the Mediterranean seems from these data to be about 1,200 to 1,400 µg/kg. The variations between the samples from the ICES North Sea and North Atlantic studies of Mytilus edulis are slightly higher. The concentrations seem also in many cases to be somewhat higher.

In the 1972 baseline study in the North Sea, the sample means reported varied between 1,600 and 13,000 µg/kg (ICES, 1974). In the subsequent monitoring exercises of 1974, 1975 and 1976 the values varied between 600 and 9,400 µg/kg, (ICES, 1977a; 1977c).

Also for zinc, the number of samples of Mytilus galloprovincialis is too limited to allow any conclusion about differences between areas (Table XIV).

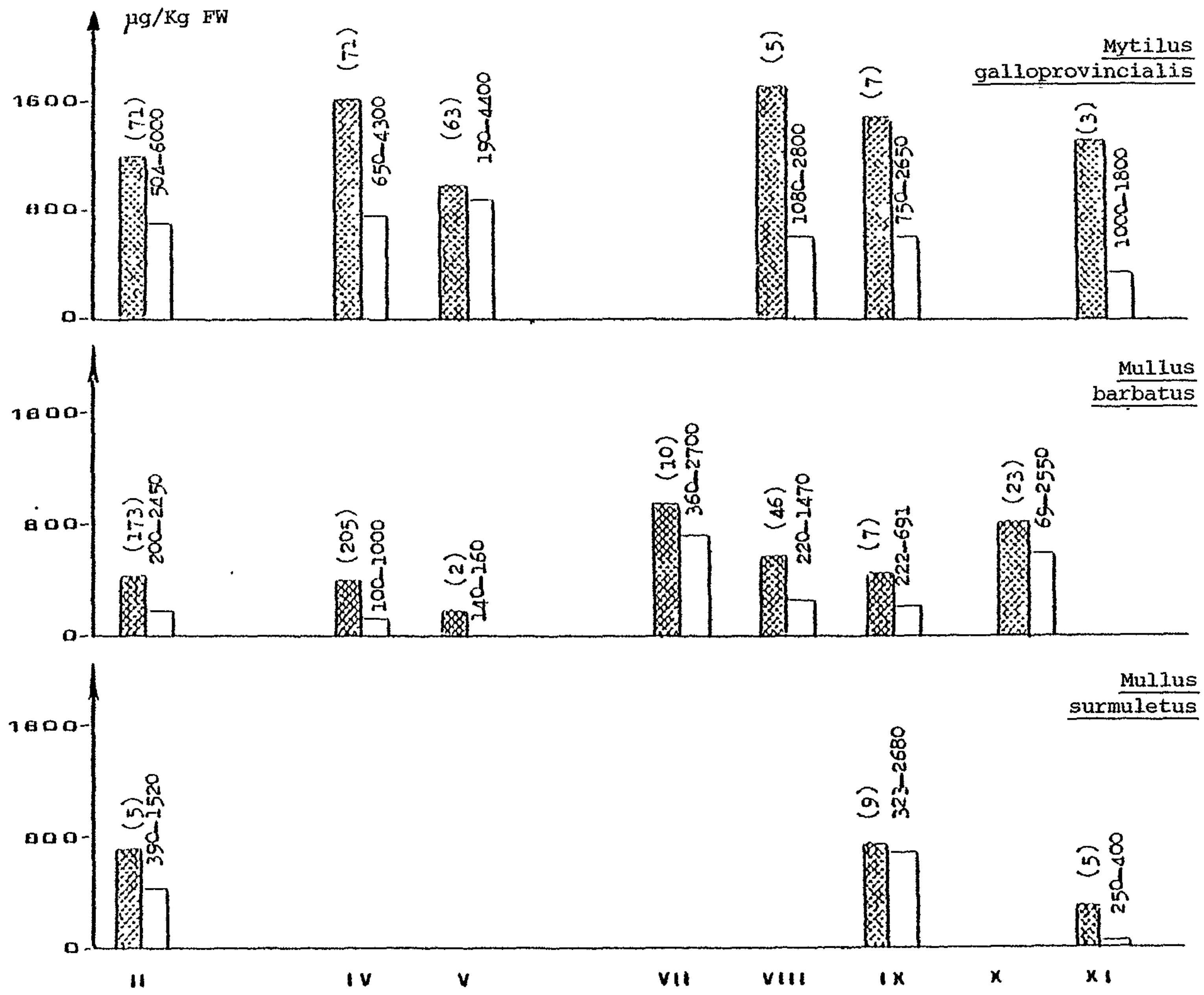

Figure 4. Average levels of copper in different species by MED POL areas

( ) n — range

arithmetical mean — standard deviation

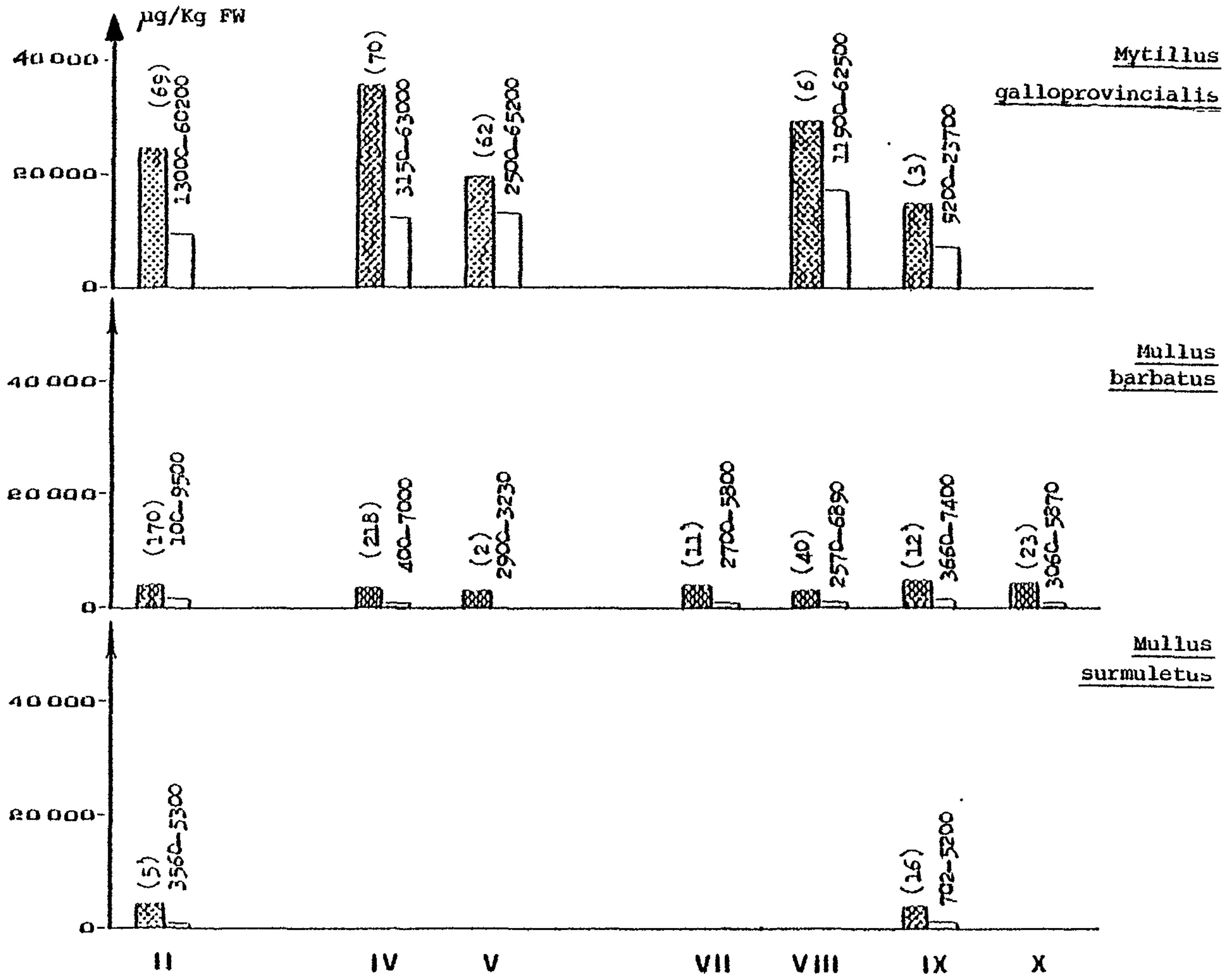

Figure 5. Average levels of zinc in different species by MED POL areas

( ) n

arithmetical mean

range

standard deviation

Table XIV - Average levels of zinc in *Mytilus galloprovincialis*

sampling area	no. of centres sampling	no. of samples (n)	mean conc. µg/kg FW	standard deviation	range	average* length (mm)
II	2	69	27768	9528	13000-60200	41 (69)
IV	1	70	34032	11133	3150-63000	34 (67)
V	2	62	17752	13195	2500-65200	53 (5)
VIII	1	6	29300	16183	11900-62500	51 (5)
IX	1	3	14567	6491	9200-23700	62 (3)

* Number of specimens in brackets

The averages of samples from the different areas are between 14,567 (area IX, North Levantine) and 34,032 (area IV). A "typical" value for the Mediterranean based on these samples seems to be around 20,000 to 30,000 µg/kg. The variation between individual samples is, however, considerable with a lowest concentration of 2,500 µg/kg and the highest 63,000 µg/kg. Zinc values from the North Sea baseline studies and monitoring show an equal scatter of data with concentrations of the same levels as in the Mediterranean (ICES 1974, 1977a, 1977b, 1977c).

8.4.2 *Mullus barbatus* and *Mullus surmuletus*

The average concentration of copper in *Mullus barbatus* and *Mullus surmuletus* are all below 1,000 µg/kg varying between 150 and 926 µg/kg (Table XV).

A "typical" concentration of copper in these species is about 500 µg/kg. The variation is, however, quite high, which may not only reflect variations between specimens but also variations due to the analytical procedure.

The average levels of zinc in *Mullus barbatus* and *Mullus surmuletus* vary between 3,065 and 5,067 µg/kg (Table XVI).

The averages from the different areas are very similar and the standard deviations are comparatively small. This indicates a rather uniform body burden which, however, may not reflect the actual environmental concentrations.

Table XV - Average levels of copper in Mullus barbatus and Mullus surmuletus

sampling area	no. of centres sampling	no. of samples (n)	mean conc. µg/kg FW	standard deviation	range	average* length (mm)	average* weight (g)
			Mullus barbatus				
II	3	173	436	259	200-2450	137 (173)	46 (173)
IV	1	205	384	126	100-1000	146 (205)	52 (205)
V	1	2	150	-	140- 160	148 (2)	45 (2)
VII	1	10	926	684	360-2700	134 (10)	38 (10)
VIII	2	46	548	250	220-1470	140 (45)	49 (33)
IX	1	7	453	198	222- 691	171 (5)	80 (5)
X	1	23	797	563	69-2550	141 (23)	33 (23)
			Mullus surmuletus				
II	1	5	705	412	390-1520	164 (5)	67 (5)
IX	1	9	731	698	323-2680	139 (9)	55 (9)
XI	1	5	318	50	250- 400	216 (5)	240 (5)

* Number of specimens in brackets

8.4.3 Other species

Overall averages of levels of copper in non-obligatory species are shown in Table XVII and for zinc in non-obligatory species in Table XVIII. Only averages based on three or more samples are presented. It may be noted that the levels of copper in crustaceans seem to be almost an order of magnitude higher than in teleosts.

8.5 Other elements

As was discussed in section 7.4 (Intercalibration exercise), the results for lead highlighted the difficulties with the analyses of this metal in biological material. In fact, results from five of the 14 research centres had to be deleted on the basis of the intercalibration exercise.

The remaining results should also be considered with caution when interpreting the levels of lead. Overall averages for all species, where there are more than three samples collected in each area, are shown in Table XIX. The average levels in Mytilus galloprovincialis in areas II, IV, V and VIII are between 901 and 1,634 µg/kg with a considerable variation between individual samples. Values from the Canadian coast in the ICES North Atlantic baseline study show a similar variation with an overall average of 330 µg/kg (ICES, 1980).

Table XVI - Average levels of zinc in _Mullus barbatus_ and _Mullus surmuletus_

sampling area	no. of centres sampling	no. of samples (n)	mean conc. µg/kg FW	standard deviation	range	average* length (mm)	average* weight (g)
			Mullus barbatus				
II	3	170	4248	1264	100-9500	137 (170)	46 (170)
IV	1	218	3869	988	400-7000	146 (218)	51 (218)
V	1	2	3065	-	2900-3230	148 (2)	45 (2)
VII	1	11	4332	864	2700-5800	135 (11)	39 (11)
VIII	1	40	3499	804	2570-6890	145 (39)	-
IX	1	12	5067	1042	3660-7400	167 (10)	74 (10)
X	1	23	4370	651	3060-5870	141 (23)	33 (23)
			Mullus surmuletus				
II	1	5	4222	580	3560-5300	164 (5)	67 (5)
IX	1	16	3897	1101	702-5200	158 (16)	78 (16)

* Number of specimens in brackets.

Another additional element that was recommended in the operational document was selenium. The limited number of centres reporting and of samples analysed does not permit any evaluation of levels on a Mediterranean basis. The results, which should be considered only as indicative until more data are available, are presented in Table XX.

Among other elements that have been analysed are chromium, nickel, iron and manganese but the scarcity of data does not permit an evaluation even on an area basis. Results for chromium and nickel are however presented in Table XXI. Reference is also made to the final reports by the participating research centres presented.

8.6 Discussion

The results presented in this evaluation and in the final reports of the research centres should be considered primarily as baseline information on the levels of heavy metals in marine organisms in the Mediterranean. These results may be used to evaluate health hazards from the consumption of seafood and possible adverse effects on the marine ecosystem. It is, for example, clear that some migratory species such as _Thunnus thynnus thynnus_ have high body burdens of mercury which often exceed the national standards. _Mytilus galloprovincialis_ and _Mullus barbatus_ show high average concentrations in samples from the Tyrrhenian Sea, the North-West Mediterranean and the Adriatic. Although the high levels of mercury in tuna were expected it is perhaps more surprising that the crustacean Nephrops norvegicus sampled in the Tyrrhenian Sea and the North-West Mediterranean has the same average concentration (about 1000 µg/kg). For the other areas and species the average concentrations are generally lower and of the same order as those found in the ICES North Sea studies. The range and the standard deviation indicate however that organisms in certain areas may also have high body burdens.

Table XVII - Overall averages of levels of copper in samples of non-obligatory species

sampling areas	species	No. of samples (n)	mean conc. µg/kg F.W.	standard deviation	range
II	Engraulis encrasicolus	65	884	495	150- 1800
	Nephrops norvegicus	209	6283	2816	1250-24400
	Sarda sarda	12	1347	877	370- 3900
IV	Engraulis encrasicolus	32	1223	613	400- 2200
	Nephrops norvegicus	110	5867	1999	2150-11350
VII	Lithophaga lithophaga	5	3892	754	3140- 5140
VIII	Parapenaeus longirostris	9	12508	10826	4570-35400
IX	Mugil auratus	31	697	964	200- 5700
	Mugil saliens	3	483	245	150- 730
	Pagellus acarne	3	450	42	390- 480
	Penaeus kerathurus	12	5253	2727	1770-11400
	Pomatomus saltator	3	760	178	510- 910
	Sardinella maderensis	4	728	557	350- 1690
	Upeneus molluccensis	4	466	149	366- 723
X	Donax trunculatus	19	3478	1810	1454- 7742
	Pagellus erythrinus	4	835	179	570- 1040
	Saurida undosquamis	6	452	136	310- 670
	Trachurus mediterraneus	3	713	232	530- 1040

Table XVIII - Overall averages of levels of zinc in samples of non-obligatory species

sampling areas	species	No. of samples (n)	mean conc. µg/kg F.W.	standard deviation	range
II	Engraulis encrasicolus	63	17122	6213	6500-41650
	Nephrops norvegicus	217	15676	4460	6500-35600
	Sarda sarda	14	4793	1312	2600- 7500
IV	Engraulis encrasicolus	36	20393	5580	9600-29400
	Nephrops norvegicus	110	14662	2057	10700-20700
VIII	Merluccius merluccius	4	2615	1001	1000- 3740
	Parapenaeus longirostris	19	10834	3419	3810-16700
IX	Boops salpa	9	6559	1157	4620- 8220
	Mugil auratus	50	4780	1474	2700- 9680
	Mugil saliens	3	2833	249	2500- 3100
	Pagellus acarne	3	4770	905	4100- 6050
	Penaeus kerathurus	12	13546	2653	9250-18800
	Pomatomus saltator	3	10400	6438	5600-19500
	Sardinella maderensis	5	9338	4241	4420-14440
	Upeneus molluccensis	12	2553	195	2200- 2950
X	Donax trunculatus	17	21420	16697	9172-82144
	Pagellus erythrinus	4	5820	1324	3760- 7300
	Saurida undosquamis	6	3910	700	2610- 4900
	Trachurus mediterraneus	3	6027	682	5140- 6800

Table XIX - Overall averages of levels of lead in samples of obligatory and non-obligatory species

sampling areas	species	No. of samples (n)	mean conc. µg/kg F.W.	standard deviation	range
II	Boops boops	7	314	485	100- 1500
	Engraulis encrasicolus	59	50	-	-
	Maena smaris	5	360	355	100- 1000
	Mullus barbatus	163	55	17	33- 169
	Mytilus galloprovincialis	110	901	1050	50- 6800
	Nephrops norvegicus	214	50	-	-
IV	Engraulis encrasicolus	91	74	66	50- 391
	Mullus barbatus	214	56	26	50- 200
	Mytilus galloprovincialis	71	1634	2606	50-16100
	Nephrops norvegicus	117	68	104	50- 865
	Thunnus alalunga	8	195	79	45- 256
V	Mytilus galloprovincialis	77	960	1340	50- 7825
VI	Engraulis encrasicolus	11	149	75	43- 236
	Mullus barbatus	13	135	67	30- 233
	Mytilus galloprovincialis	12	503	237	165- 960
	Nephrops norvegicus	7	604	253	186- 900
	Thunnus alalunga	8	202	91	40- 290
VIII	Mullus barbatus	29	286	189	41- 861
	Mytilus galloprovincialis	83	1070	1492	55- 8260
	Parapenaeus longirostris	3	300	-	-
	Thunnus thynnus thynnus	6	377	156	159- 560
	Xiphias gladius	2	242	-	126- 358
IX	Mugil auratus	7	243	278	50- 790
	Mugil saliens	3	210	226	50- 530
	Mullus barbatus	5	64	28	50- 120
	Mytilus galloprovincialis	4	550	47	480- 610
	Upeneus molluccensis	3	50	-	-

continued

Table XIX - Overall averages of levels of lead in samples of non-obligatory species (continued-2)

sampling areas	species	No. of samples (n)	mean conc. µg/kg F.W.	standard deviation	range
X	Donax trunculatus	19	1200	647	357- 2957
	Mullus barbatus	22	371	121	144- 610
	Pagellus erythrinus	4	393	158	166- 590
	Saurida undosquamis	6	510	144	292- 735
	Trachurus mediterraneus	3	401	113	290- 556

Table XX - Overall average of levels of selenium in samples of obligatory and non-obligatory species

sampling areas	species	No. of samples (n)	mean conc. µg/kg F.W.	standard deviation	range
II	Mullus barbatus	14	575	130	350- 850
	Nephrops norvegicus	16	634	254	310-1250
IV	Mullus barbatus	65	686	281	150-1500
	Nephrops norvegicus	16	1007	586	490-3050
V	Mytilus galloprovincialis	9	845	464	123-1750
VIII	Merluccius merluccius	4	261	94	171- 416
	Mullus barbatus	38	468	111	290- 723
	Mytilus galloprovincialis	6	331	137	101- 550
	Parapenaeus longirostris	19	1247	556	525-2500

Table XXI - Overall averages of levels of chromium and nickel in samples of obligatory and non-obligatory species

sampling areas	species	No. of samples (n)	mean conc. µg/kg F.W.	standard deviation	range
chromium					
V	Mytilus galloprovincialis	19	260	140	89- 558
VIII	Merluccius merluccius	4	91	66	21- 156
	Mullus barbatus	38	88	151	24- 981
	Mytilus galloprovincialis	5	287	194	113- 530
	Parapenaeus longirostris	18	111	64	64- 300
IX	Mugil auratus	15	115	206	12- 850
	Mugil saliens	3	346	77	250- 440
	Mullus surmuletus	5	74	49	40- 170
	Penaeus kerathurus	4	140	110	70- 330
nickel					
V	Mytilus galloprovincialis	18	409	300	125-1216
IX	Mugil auratus	7	240	153	30- 540
	Mugil saliens	3	263	57	190- 330
	Mullus surmuletus	4	1147	474	690-1800
	Penaeus kerathurus	3	1610	927	910-2920
X	Donax trunculatus	4	641	80	560- 766
	Mullus barbatus	17	246	76	122- 455
	Pagellus erythrinus	4	209	22	177- 231
	Saurida undosquamis	6	276	70	209- 423

For cadmium and the other heavy metals studied the situation is somewhat different as there is no pronounced difference between the areas. Mytilus galloprovincialis and other molluscs seem to have higher average concentrations than teleosts.

The information made available through the project is also an important basis for the planning of future long-term monitoring activities using marine organisms. It is certainly neither feasible nor desirable to include such a variety of organisms and pollutants, as has been studied in this pilot phase, in any long-term monitoring exercise. The following brief discussion of the combinations of species and pollutants used may therefore be useful for future activities.

8.6.1 Mercury

Mytilus galloprovincialis and/or M. edulis and Perna (Mytilus) perna have a wide distribution in the Mediterranean, being unavailable only in a few regions. They are able to accumulate and release mercury in proportion to the environmental levels. As they are sessile organisms feeding on plankton and particulate matter, the concentrations of pollutants should be considered primarily as indications of levels in relatively small areas (i.e. harbours or river mouths).

From the final reports by the principal investigators it seems that factors like sex, body size, temperature, salinity and depth (i.e. taken in the intertidal zone or not) are more important than the sampling season.

Mullus barbatus and/or Mullus surmuletus are available all over the Mediterranean and are suitable indicators of environmental levels of mercury, as mercury is not regulated in the axial muscle of finfish. These species can be very useful for monitoring of continental shelves. Thunnus thynnus thynnus, as a migratory predator at the top of the food-chain, seems to be suitable for the monitoring of the levels of mercury on a Mediterranean basis and for the assessment of the eventual risks to human health from mercury. For Mullus, sex and particularly age and size are the principal factors affecting mercury levels at the same environmental concentrations. Attention should be paid to the possibility of variation of the bioavailability of mercury due to the sampling depth. Also, for Thunnus, the size or age appears to be an important parameter affecting the mercury levels. The possibilities of different body burdens of tuna of Atlantic and Mediterranean origin would, however, have to be taken into account.

8.6.2 Other metals

The soft parts of mulluscs, especially Mytilus, are recognized as good indicators of environmental levels of cadmium, zinc, lead and probably copper. For teleosts and probably crustaceans the situation is somewhat different, as these organisms seem to regulate metabolically the concentration of certain metals irrespective of the degree of ambient contamination. Phillips (1977) in a review of the use of biological indicators to monitor trace metal pollution, concluded that several elements are strictly regulated in the muscle of finfish and that, as a result, the values reported may not reflect the environmental levels. The results obtained during the pilot phase are, however, most useful as baseline data for the assessment of the human intake of trace metals through seafood. Other organs like the kidney or liver in the teleosts may be more suitable for monitoring the environmental levels of trace metals which are regulated in the muscle.

9. CONCLUSIONS

The purpose of this pilot project was to provide baseline data and to initiate monitoring of contaminants in marine organisms in the Mediterranean. Through the project it was expected to achieve a better co-ordination of ongoing and new studies, to improve comparability of the results and to obtain an overall picture of levels of contaminants considered to be important.

A common system of sampling, sample preparation, analysis and reporting was introduced during this pilot phase. This system, together with other experiences gained, could also serve as the basis for future monitoring activities.

For the first time, consolidated baseline data on levels of heavy metals in marine organisms in the Mediterranean are at our disposal, some of them from areas where data were previously not available.

Some migratory species such as tuna (*Thunnus thynnus thynnus*) have high body burdens of mercury which often exceed the national standards. The mussel (*Mytilus galloprovincialis*) and striped mullet (*Mullus barbatus*) show high average concentrations in samples from three areas. Although high levels of mercury were expected in tuna, it is surprising that the Norway lobster (*Nephrops norvegicus*), sampled in two areas, has the same average concentration as tuna.

The levels of this pollutant are influenced more by sex, body size, temperature, salinity and depth than by sampling season.

For cadmium and the other heavy metals studied, the situation is somewhat different as there is no pronounced difference between the areas. The mussel and other molluscs seem to have higher average concentrations than teleosts.

The results obtained through this pilot project can be used to evaluate possible adverse effects on the marine environment and for the assessment of the eventual risks to the consumer of seafood.

10. OTHER ACHIEVEMENTS

Research agreements were successfully negotiated with most of the research centres, and signed by 89 per cent of those designated as participants in the pilot project.

Unfortunately, the periodic reporting to FAO by the research centres was generally inadequate in that most of the centres did not respect the deadlines and those who submitted their reports frequently did not follow the format agreed upon.

10.1 Technical assistance

Information relevant to the effectiveness of the administrative and financial arrangements made by FAO in connection with the pilot project was received from 25 research centres (78 per cent of those with signed research agreements) and therefore only a partial evaluation of these arrangements is possible. According to the replies received, the pilot project was of great value to research centres in that it:

- increased the contacts between scientists working on similar problems and thus contributed to an exchange of results and a better understanding between scientists of the region;
- initiated or strengthened seasonal monitoring of heavy metals during a longer span of time and provided the opportunity for the comparison of pollution levels between the different regions;
- stimulated research, particularly in younger scientists who gained confidence and accuracy in techniques of heavy metals analysis;
- introduced new analytical methods and improved the research and monitoring capability of the centres;
- stimulated the establishment of concrete national and/or institutional research and monitoring programmes and incorporated the existing ones in a regional network;
- provided the essential equipment and material needed for the work;
- trained national experts in analytical techniques enabling them to analyse heavy metals for the first time.

Practically all research centres indicated their continued interest in participating in follow-up activities. In several cases the continued participation of the research centres was conditional, and in most cases conditional on additional financial support from national and international sources.

10.2 Training

Out of twenty trainees, only two failed to submit technical reports, and fifteen of them submitted evaluation reports on the results of their training. Given hereunder is the analysis of their reports.

In most cases the training followed the programme agreed upon in advance. In some cases, however, the training programme had to be modified on arrival of the trainee at the host institution either because the period during which training to be given did not coincide with the work programme of the host institution, or because the specific requirements of the trainee had not been realized clearly enough beforehand.

The training was particularly successful for scientists and technicians familiar with the basics of atomic absorption spectrophotometry prior to training. Their training lasted for short periods (two weeks on an average) with the aim of improving their practice and/or experience from the analytical viewpoint. In the case of scientists trained for longer periods to learn new techniques, the outcome of the training, although generally successful, could have been better had the established training programme been adhered to more closely and had the training period been longer.

Trainees, in general, expressed their satisfaction with the arrangements made by FAO(GFCM) and with the programme followed by them in the host institution. Some trainees expressed the view that, prior to the training, closer contacts should have been established between the trainees and their supervisors.

There is no doubt that the training undertaken in the framework of MED POL II has considerably improved the capability of research centres to analyse heavy metals. The difficulties experienced in organizing the training were mostly due to the time constraint under which it had to be organized and, in many cases, to the fact that the prospective trainees did not (or could not) provide FAO(GFCM) and the host institution with sufficient previous information about the kind of training they wanted to have.

10.3 Regional Activity Centre

The assistance provided by the Regional Activity Centre to the operation of the pilot project consisted of:

- hosting the FAO(GFCM)/UNEP Mid-term Expert Consultation on the Joint Coordinated Project on Pollution in the Mediterranean (MED POL II, III, IV and V) (Dubrovnik, 2-13 May 1977);

- collaboration with FAO(GFCM) in the analysis and evaluation of the interim and final reports of the MED POL II principal investigators;

- newsletter (three issues) giving news relevant to MED POL II.

10.4 Documentation

Documents specifically developed for this pilot project include:

- Manual of Methods in Aquatic Environment Research. Part 2: Guidelines for the Use of Biological Accumulators in Marine Pollution Monitoring. FAO, Fisheries Technical Paper No. 150. (Portmann, 1976);

- Manual of Methods in Aquatic Environment Research. Part 3: Sampling and Analysis of Biological Material. FAO Fisheries Technical Paper No. 158. (Bernhard, 1976);

- Manual of Methods in Aquatic Environment Research. Part 5: Statistical Tests. FAO, Fisheries Technical Paper No. 182. (Möller, 1979).

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MED POL III : BASELINE STUDIES AND MONITORING OF DDT, PCBs and OTHER CHLORINATED HYDROCARBONS IN MARINE ORGANISMS (FAO(GFCM)/UNEP)

1. INTRODUCTION

Similar arguments to those advanced for the monitoring of metals (MED POL II) apply to chlorinated hydrocarbons. They are usually accumulated by marine organisms, they are potentially harmful to man either directly or indirectly through the marine organisms he consumes. In addition, many chlorinated hydrocarbons are very persistent so, as a result, tend to accumulate with time. Furthermore, even less is known about the present concentration of these chemicals in the Mediterranean than about the concentrations of metals. Since most chlorinated hydrocarbons are produced by man, natural background levels of these substances do not present such a great problem in baseline studies as metals.

The pilot project was concerned with determining the levels of organochlorine compounds which were considered to be especially harmful, either directly or indirectly, to representative components of the Mediterranean ecosystem. DDT and its metabolites, PCBs and dieldrin were singled out as falling into this category. Whenever possible, other persistent organic compounds were identified and quantified in samples. As with metals, the organisms selected for monitoring were striped mullet, Mediterranean mussel and pink shrimp. These oganisms are not only important economically but are almost ubiquitous throughout the Mediterranean. The sampling frequency was seasonal.

Although there is no present evidence of harm to man caused by the current levels of chlorinated hydrocarbons in marine organisms from the Mediterranean, it is reasonable to expect, owing to the nature of these substances, that their build-up may lead to damage of certain components of the marine ecosystem and consequently to consumers.

The results of the project should greatly contribute to the assessment of the present distribution of chlorinated hydrocarbons in the Mediterranean Sea and thus to a better understanding of the eventual risk to which the marine ecosystems may be exposed.

The actual work of the national research centres on the pilot project started in late autumn of 1975.

The evaluation contained in this document is based on the final reports submitted by the participating research centres, as well as on data provided on LOG FORMS for computer treatment.

For the final report the principal investigators were requested to make a scientific evaluation of the results obtained during the pilot phase, giving comments and eventually drawing comparisons with other Mediterranean and non-Mediterranean results.

During the first half of the pilot phase the number of analyses carried out was rather limited; this made possible the evaluation of results from all participants without the use of computer facilities.

A preliminary evaluation on a Mediterranean basis was also presented and discussed at the Mid-term Expert Consultation on the Joint Coordinated Project on Pollution in the Mediterranean (MED POL II, III, IV, and V) (Dubrovnik, 2-13 May 1977). As the participating centres improved their analytical capabilities during the second half of the pilot phase, the number of analyses performed increased considerably. It was, therefore, apparent that, for the preparation of the final report, the use of computer facilities for data treatment would be necessary.

The LOG FORMS, which served as the basis for entering the data into a computer system, were completed by 16 centres. A total of about 7,000 data lines, each giving one analytical value as well as information on location and biological parameters, was reported.

FAO made use of an existing computer system designed essentially for the Fisheries Commodities Data base, with supplementary print programmes to generate tables in order to meet the requirements of the pilot project.

The results presented in this report are mainly based on tables giving concentrations by species and elements for different sampling stations and MED POL areas which were produced by the FAO Fisheries Information Data and Statistics Service.

2. PARTICIPANTS

Thirty-one research centres from fifteen Mediterranean States were designated to participate in the pilot project.

By the end of December 1980, 25 research agreements had been signed and one was cleared and ready for signature.

3. CO-ORDINATING ARRANGEMENTS

FAO(GFCM) maintained the operational contacts with the national research centres designated to participate in the pilot project.

The Marine Science Department of the Middle East Technical Univesity, Erdemli-Icel, Turkey, was nominated in August 1976 to assist FAO(GFCM) as the Regional Activity Centre for this pilot project.

Specific meetings held in connection with the pilot project include:

- FAO(GFCM)/UNEP Mid-term Expert Consultation on the Joint Coordinated Project on Pollution in the Mediterranean (MED POL II,III,IV and V) (Dubrovnik, 2-6 May 1977), which also covered MED POL II, was attended by 44 participants from 32 research centres in 14 Mediterranean States.

4. FINANCIAL ARRANGEMENTS

Specific financial support to the pilot project was provided through projects FP/00502-75-01 and FP/0503-75-07 (both projects covering activities relevant to MED POL II, III, IV and V). Costs relevant to MED POL III (expressed in US dollars) were shared between the two co-sponsors of these projects as follows:

	1975	1976	1977	1978	1979	1980	Total	Percentage
FAO(GFCM)	6,000	12,310	12,694	12,900	12,600	9,645	66,149	13.6
UNEP	8,422	57,870	106,200	68,850	86,192	94,317	421,851	86.4
TOTAL	14,422	70,180	118,894	81,750	98,792	103,962	488,000	100.00

Direct support to participants in MED POL III up to 31 December 1980 amounted to US $ 273,840 comprising:

- US $ 172,907 for equipment, including 11 gas chromatographs;
- US $ 37,701 for expendable materials;
- US $ 32,218 for training of 19 trainees (total of 15 man/months) from fourteen research centres in nine host institutions;
- US $ 7,031 for attendance at meetings;
- US $ 13,983 for consultants to participating research centres;
- US $ 10,000 as assistance to the Regional Activity Centre.

Indirect support to participants in MED POL III up to 31 December 1980 amounted to US $ 148,011. This sum included:

- US $ 83,288 for the services of consultants to assist FAO(GFCM) in the organization and execution of the pilot projet, and in the evaluation of its results;
- US $ 11,546 for organization of meetings;
- US $ 53,167 for the preparation of manuals, guidelines and reports.

The national contributions to the pilot project, estimated on the basis of information supplied by 17 participating research centres as equivalent to US $ 542,600, included:

- 370 man/months of professional and supporting staff (US $ 222,000 estimated at US $ 600 per man/month);
- US $ 201,050 as expendable materials;
- US $ 119,550 as operating costs of equipment.

5. OPERATIONAL DOCUMENT

The operational document of the pilot project was formulated at a joint FAO(GFCM)/UNEP Expert Consultation on the Joint Coordinated Project on Pollution in the Mediterranean (Rome, 23-27 June 1975) attended by 35 participants from 13 Mediterranean States. Certain modifications of the operational document were agreed upon at the Mid-term Expert Consultation for MED POL II and MED POL III (Dubrovnik, 2-6 May 1977) which was attended by 20 experts from 16 research centres participating in MED POL III.

6. AREAS STUDIED

According to the operational document the baseline studies and monitoring were to be carried out primarily in the coastal waters. Furthermore the sampling stations were to be selected by the participating research centres so that the results obtained could be used to characterize the level of pollutants in certain areas. The sampling frequency was to be seasonal (March, June, September and December).

The number of sampling stations selected by the different centres varied considerably, from two stations to over 20. In the latter case the samples were however collected only occasionally. In fact very few centres strictly followed the agreed sampling frequency with regard to seasonal sampling. Figure 1 shows the different areas that were monitored or where monitoring was planned but data were not reported.

The northern Mediterranean coast was relatively well covered by a number of research centres but those from the southern Mediterranean cover only a small part of the coast and some of them were unable to produce any data. Table I shows the number of research centres and sampling stations for the different MED POL areas.

No data were reported for areas III (South-Western), VI (Ionian) and VII (Central) while three or more centres reported results from areas II (North-Western), V (Adriatic) and VIII (Aegean). For the remaining areas results were reported by one centre in each area.

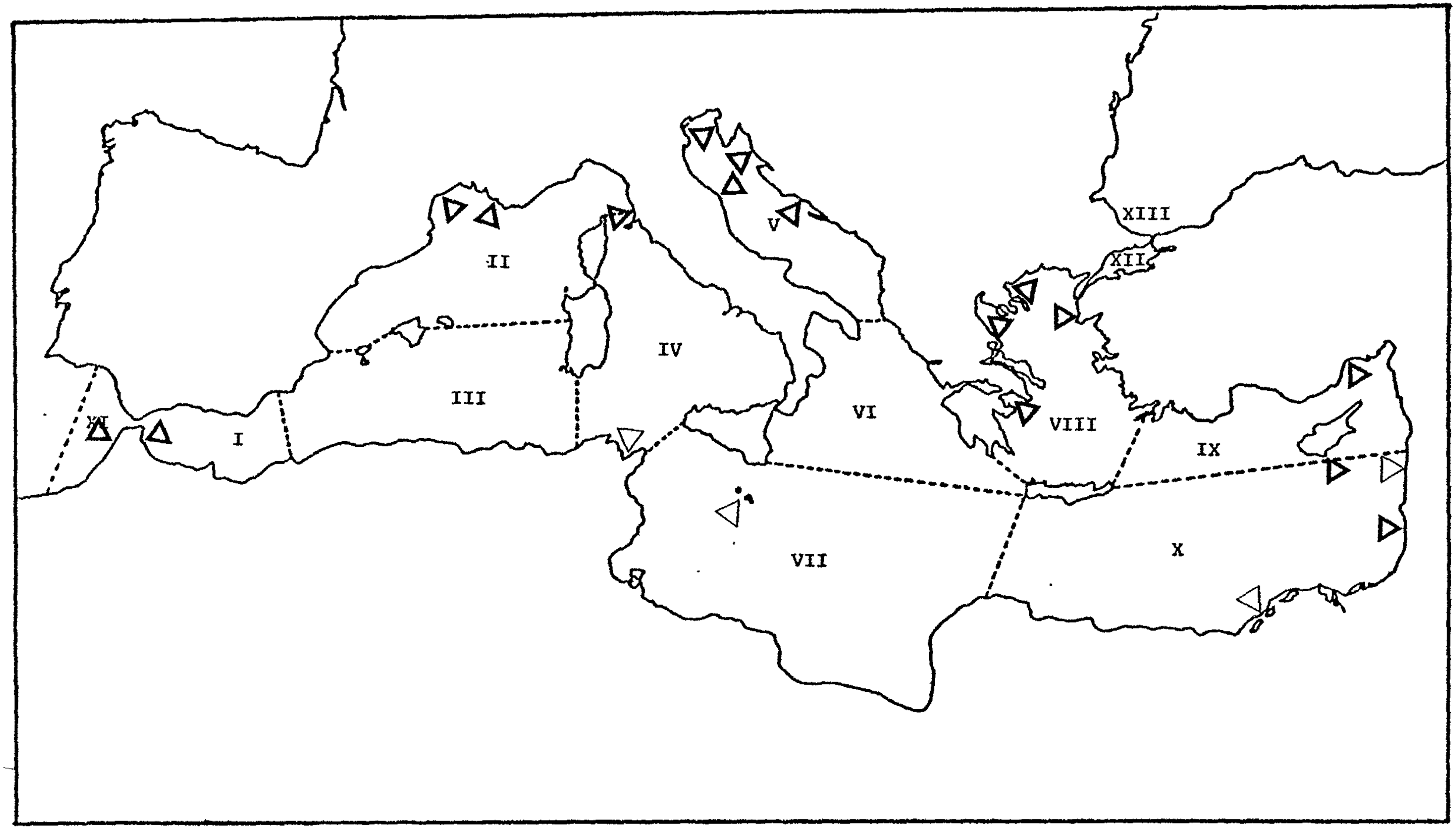

Figure 1. Sampling areas for MED III

I. Alboran	IV. Tyrrhenian	VII. Central	X. S. Levantin
II. North-Western	V. Adriatic	VIII. Aegean	XI. Atlantic
III. South-Western	VI. Ionian	IX. N. Levantin	XII. Sea of Marmara
			XIII. Black Sea

▷ Data reported ▷ No data reported

Table I - Number of research centres and sampling stations

MED POL area	Research centre	Sampling stations
I	1	8
II	3	16
III	-	-
IV	1	8
V	5	31*
VI	-	-
VII	-	-
VIII	4	28
IX	1	8
X	1	18
XI	1	3
XII	1	2
Total	18	122

** One centre did not report the co-ordinates for the sampling stations*

7. MATERIALS AND METHODS

7.1 Selection of the species

The marine organisms selected in the operational document as mandatory species were Mytilus galloprovincialis (Mediterranean mussel) and/or M. edulis, Mullus barbatus (Striped mullet), Parapenaeus longirostris (deep-water pink shrimp) and/or Carcinus mediterraneus (Mediterranean shore crab). The basis for this selection was that these organisms are representatives of different ecotypes, they are of considerable economic importance and they are common in almost the whole Mediterranean.

As can be seen from Table II, Mytilus galloprovincialis and Mullus barbatus were sampled by a majority of the participating centres. In fact 15 and 16 centres respectively reported results for these species. However, in some areas in the Central and Eastern Mediterranean, Mytilus was reported as not being available. On the whole, however, this species proved to be a useful organism for monitoring purposes, as far as availability was concerned.

Mullus barbatus was sampled by all centres with the exception of one research centre operating in the Adriatic which had selected another member of the Mullidae family, Mullus surmuletus (red mullet), as an alternative species. The conclusion on the usefulness of Mytilus for monitoring is therefore undoubtedly valid also for Mullus barbatus.

Table II - Species sampled and compounds analysed

Research Centre	Final report	Species: *Mytilus galloprovincialis*	*Mullus barbatus*	*Parapenaeus longirostris*	*Carcinus mediterraneus*	Other	Elements: PCB	DDT	DDD	DDE	Dieldrin	Other
Fisheries Department, Nicosia	X		X				X	X	X	X	X	X
Institute of Oceanography and Fisheries, Alexandria												
Centre for Post-graduate Studies and Research, Alexandria												
Laboratoire de chimie appliquée à l'expertise, Montpellier	X	X	X		X	X	X	X	X	X	X	X
Institut scientifique et technique des pêches maritimes, Sète	X	X	X		X	X	X	X	X	X		
Institute of Oceanographic and Fisheries Research, Athens	X	X	X	X			X	X	X	X	X	X
Department of Food Hygiene, University of Thessaloniki	X	X	X			X	X	X	X	X	X	X
Laboratory of Analytical Chemistry, University of Thessaloniki												
Benaki Institute of Phytopathology, Athens	X	X	X	X			X	X	X	X		
Israel Oceanographic and Limnological Research Ltd., Haifa	X		X	X		X	X	X	X	X		X
Laboratory of Hydrobiology and Fish Culture, Siena	X	X	X			X	X	X	X	X	X	X
Institute of Marine Biology - CNR, Venice	X	X	X		X	X	X	X	X	X	X	X

continued

Table II - Species sampled and compounds analysed (continued)

Research Centre	Final report	Species: *Mytilus galloprovincialis*	*Mullus barbatus*	*Parapeneus longirostris*	*Carcinus mediterraneus*	Other	Elements: PCB	DDT	DDD	DDE	Dieldrin	Other
Centre de Recherche marine, Beyrouth												
The University of Malta, Msida												
Institut scientifique des Pêches maritimes, Casablanca	X	X	X			X	X	X	X	X		
Instituto de Investigaciones Pesqueras, Barcelona		X	X		X	X	X	X	X	X		
Instituto Químico de Sarria, Barcelona	X	X	X				X	X	X	X		
Institut national scientifique et technique d'océanographie et de Pêche, Salammbô												
Hydrobiological Research Institute, Istanbul		X	X	X	X	X		X	X	X	X	X
Marine Science Department (METU), Erdemli-Içel	X		X	X	X	X	X	X	X	X		
Institute for Oceanography and Fisheries, Split	X	X	X		X	X	X	X	X	X	X	
The Biological Institute, Dubrovnik	X	X				X	X	X	X	X	X	
"Rudjer Bošković" Institute, Zagreb	X	X	X			X	X	X	X	X	X	
Marine Biological Station, Portorož	X	X	X		X	X	X	X	X	X	X	X

As regards Parapenaaeus longirostris this species was sampled by only four centres thus rendering the results less useful for evaluation of levels of contamination on a Mediterranean basis.

The reason for this limited sampling could be that Parapenaeus requires more sophisticatead fishing techniques than the previously mentioned species. This was possibly also the reason why the alternative species Carcinus mediterraneus was sampled by more centres (8) than Parapenaeus. The total number of additional species sampled is close to 40, but the number of samples and the frequency of sampling are, although varying, generally low. Table III shows all the additional species and the number of centres that collected samples. Only species where full scientific names were given are included. Most of the species were sampled by only one centre. Some, however, were utilized more and Engraulis encrasicolus, Sardina pilchardus, Merluccius merluccius, Mullus surmuletus Mugil auratus, Patella coerula and Pagellus erythrinus were sampled by three or more centres. In fact, Sardina, Merluccius, Mugil and Patella were recommended as additional or alternative species in the operational documeant and at the Mid-term Expert Consultation on the Joint Coordinated Project on Pollution in the Mediterranean (MED POL II and III) (Dubrovnik, 2-6 May 1977) . Most of the additional species (about 40) were also sampled for analysis of heavy metals (MED POL II) but not necessarily by the same research centre.

Table III - Additional species sampled

Species sampled	Number of centres	Sampled also in MED II
Arca noae	1	X
Belone belone	1	X
Boops boops	2	X
Boops salpa	2	-
Callinectes sapidus	1	-
Carcinus maenas	1	-
Conger conger	1	X
Dentex macrophtalmus	1	X
Engraulis encrasicolus	3	X
Lithophaga lithophaga	1	X
Loligo vulgaris	1	X
Maena maena	1	X
Merlangius merlangus	1	X
Merluccius merluccius	5	X
Monodonta turbinata	1	-

continued

Table III - Additional species sampled (continued-2)

Species sampled	Number of centres	Sampled also in MED II
<u>Mugil auratus</u>	3	X
<u>Mugil capito</u>	1	X
<u>Mugil saliens</u>	1	X
<u>Mullus surmuletus</u>	5	X
<u>Nephrops norvegicus</u>	1	X
<u>Oblata melanura</u>	1	X
<u>Ostrea edulis</u>	2	X
<u>Pagellus acarne</u>	1	X
<u>Pagellus erythrinus</u>	3	X
<u>Patella coerulea</u>	3	X
<u>Penaeus kerathurus</u>	1	X
<u>Sardina pilchardus</u>	3	X
<u>Sardinella aurita</u>	1	-
<u>Saurida undosquamis</u>	1	X
<u>Scomber scombrus</u>	1	X
<u>Solea vulgaris</u>	1	-
<u>Thunnus thynnus thynnus</u>	2	X
<u>Trachurus mediterraneus</u>	1	X
<u>Trachurus trachurus</u>	2	X
<u>Trisopterus minutus capelanus</u>	1	-
<u>Upeneus molluccensis</u>	2	X
<u>Upogebia littoralis</u>	1	X
<u>Venerupis aureus</u>	1	-
<u>Xantho hydrophilus</u>	1	-
<u>Xiphias gladius</u>	1	X

An evaluation on a Mediterranean basis of the levels of pollution in all the additional species was impossible because of the limited number of samples. The results could, however, be useful for the assessment of local pollution and provide baseline information. For some migratory species the data might also give an indication of the body burdens in the Mediterranean.

In a few cases results of analysis of zooplankton, sediments and water were also reported.

7.2 Pollutants analysed

With one exception, all research centres that reported data, analysed PCB.

For DDT, DDE and DDD results were received from all reporting centres (Table I). As regards dieldrin, this pollutant was analysed only by 11 centres, which may be due to the fact that the analytical procedure for dieldrin is somewhat different from that for PCB and DDT. As dieldrin is related to aldrin, being its epoxide, some centres analysed both compounds, or aldrin as an alternative to dieldrin. Endrin, which is also derived from aldrin, was analysed by two centres. Lindane, the γ-isomer of hexachlorocyclohexane (BHC or HCH) was analysed by five centres, some of them also analysing the α-, β-, and δ-isomers of BHC.

While only one centre analysed the pesticide heptachlor, five centres made analyses of its conversion product heptachlorepoxide.

7.3 Sampling and analytical techniques

Sampling and sample preparation were generally carried out in accordance with the recommendations given in the Manual of Methods in Aquatic Environment Research, Part 3 - Sampling and Analysis of Biological Material; FAO Fisheries Technical Paper No. 158 (Bernhard, 1976). In a few cases, however, some samples were obtained from the market. These samples, since they were not handled with special care, might have been contaminated on arrival at the laboratory.

The samples were either homogenized with anhydrous sodium sulphate or, as in most cases, lyophilized before extraction. Extraction of the samples was done with either a blender or a Soxhlet apparatus. The Solvents used were also different, i.e. n-hexane or petroleum ether, but in most cases Soxhlet extraction with n-hexane was used. Since the extractable organic matter (EOM) is a solvent-dependent, the different solvents used might have affected the results, at least for some organochlorine residues.

Several different clean-up procedures were used of which the most common were:

i) partitioning with either hexane-acetonitrile or petroleum ether;

ii) clean-up with sulphuric acid which, however, destroys dieldrin as this pesticide is not acid stable;

iii) elution on fluorisil or alumina.

Although all these methods are generally accepted as clean-up procedures they may not necessarily give the same results for all chlorinated hydrocarbons. Therefore the participating research centres made evaluations of loss of the chlorinated hydrocarbons due to the pretreatment.

For the separation of some chlorinated insecticides from PCBs, many research centres used silica-gel chromatography with different eluants. In the subsequent gas chromatographic analyses with electron capture detectors, columns containing various types of supports and stationary phases were used.

Sometimes the samples were analysed on two types of columns for control of the identification.

For confirmation many centres used alcoholic saponification with KOH, while the perchlorination of PCBs to decachlorobiphenyl (DCB) was not reported by any centre.

The quantification of the PCBs was generally carried out by matching the chromatograms of the samples with those of known quantities of Aroclor 1254 or 1260. Sometimes other commercially available PCBs like DP5 and DP6 were used.

7.4 Intercalibration

The International Laboratory for Marine Radioactivity in Monaco was responsible for the intercalibration exercise as part of pilot project MED POL XI.

The participating centres were provided with three different intercalibration samples as well as standards for the most common organochlorine residues. Analyses of all three samples were reported by ten of the eighteen centres that reported data. Of the remaining eight centres, six reported results for one or two samples while the remaining two did not perform any intercalibration analyses (Table IV). To allow for a sufficiently reliable evaluation of the results from the individual centres, preferably two or three intercalibration samples had to be reported.

For each sample and compound the mean and standard deviation (S.D.) of the results reported by the participating centres were calculated.

In order to exclude "outliners", Dixon's test was used. As a basis for estimating the reliability of the data and its fitness for inclusion in the evaluation of the monitoring exercise the following criteria were used:

i) results within one standard deviation from the mean (after Dixon's test) to be considered as "good";

ii) results within two standard deviations to be considered as "acceptable";

iii) results deviating more than two standard deviations from the mean to be considered as "not acceptable".

For the overall evaluation of the three intercalibration samples the average of two "good" or "acceptable" results and one "not acceptable" was considered as acceptable. With two "not acceptable" and one "good" or "acceptable" the average was considered as "not acceptable". In the cases where only two samples were reported and one result was "not acceptable" the judgement was based on how much the values deviated from the mean.

Table IV - Participation in intercalibration of samples MA-M-1 (oyster), MA-A-1 (copepod) and MA-A-2 (fish)

Research Centre	Data reported	MA-M-1	MA-A-1	MA-A-2
Fisheries Department, Nicosia	X			
Institute of Oceanography and Fisheries, Alexandria				
Centre for Post-graduate Studies and Research, Alexandria				
Laboratoire de chimie appliquée à l'expertise, Montpellier	X	X	X	X
Institut scientifique et technique des pêches maritimes, Sète	X	X	X	X
Institute of Oceanographic and Fisheries Research, Athens	X	X	X	X
Department of Food Hygiene, University of Thessaloniki	X	X	X	
Laboratory of Analytical Chemistry, University of Thessaloniki				
Benaki Institute of Phytopathology, Athens	X	X	X	
Israel Oceanographic and Limnological Research Ltd., Haifa	X	X	X	X
Laboratory of Hydrobiology and Fish Culture, Siena	X	X		
Institute of Marine Biology - CNR, Venice	X	X	X	X
Centre de Recherche marine, Beyrouth				
The University of Malta, Msida				
Institut scientifique des Pêches maritimes, Casablanca	X			
Instituto de Investigaciones Pesqueras, Barcelona	X	X	X	
Instituto Químico de Sarria, Barcelona	X	X	X	X
Institut national scientifique et technique d'océanographie et de Pêche, Salambô				
Hydrobiological Research Institute, Istanbul	X	X		
Marine Science Department (METU), Erdemli-Icel	X	X	X	X
Institute for Oceanography and Fisheries, Split	X	X	X	X
The Biological Institute, Dubrovnik	X	X	X	X
"Rudjer Bošković" Institute, Zagreb	X	X	X	X
Marine Biological Station, Portorož	X	X	X	X

When considering these principles for accepting the data for evaluation it was revealed that the quantity of data would be noticeably reduced. For an evaluation of the levels of contamination on a Mediterranean basis it is however preferable to have a smaller number of data which are reasonably comparable. From a total of 17 research centres the results of 5 were deleted due to unacceptable values or lack of intercalibration results. As a consequence, only results from areas II, IV, V, IX and X could be used (Table I). For DDT and its derivatives data from these areas and area VIII were acceptable. Due to the limited number of reports, results for dieldrin and aldrin could be used only from areas II, IV, V, X and II, IV, IX, X respectively. For the other pollutants an evaluation of the intercalibration results was not possible.

A comparison of the results in this intercalibration exercise with those that have been reported in the ICES North Sea baseline studies shows that the coefficient of variation between the laboratories is larger in the Mediterranean than in the ICES area (ICES, 1978). This is, however, to be expected as all laboratories in the ICES study are well established, while many centres in the Mediterranean have only recently begun gas chromatographic analysis of chlorinated hydrocarbons. As was pointed out for the ICES studies, a regular repetition of the exercises will certainly further improve the quality of the data.

8. SCIENTIFIC RESULTS AND DISCUSSION

The data presented for the different pollutants and organisms are mean values of all results reported for the various stations in the relevant MED POL area, with due consideration given to the intercalibration results. They do not take into account the differences between the prevailing conditions at the individual sampling stations (e.g. level of pollution).

Bearing in mind the wide extent of heterogeneous conditions within each MED POL area, it is apparent that the overall averages of the levels reported should not be interpreted as mean values for one particular area.

References (author, final report) relate to the individual summary reports prepared by the principal investigators, and presented in a separate document.

The reporting centres used different detection limits depending on the conditions under which the analyses were carried out. For the purpose of reporting in this document, intermediate detection limits were selected arbitrarily and may not be the same as those reported by the individual centres. However, the limits were high enough to make the evaluation of the data reliable.

8.1 PCBs

Levels of PCBs in the mandatory species, by area, are reported in Figure 2. The highest average values for *Mytilus galloprovincialis* were reported in samples from stations in area II (North-Western) (Table V).

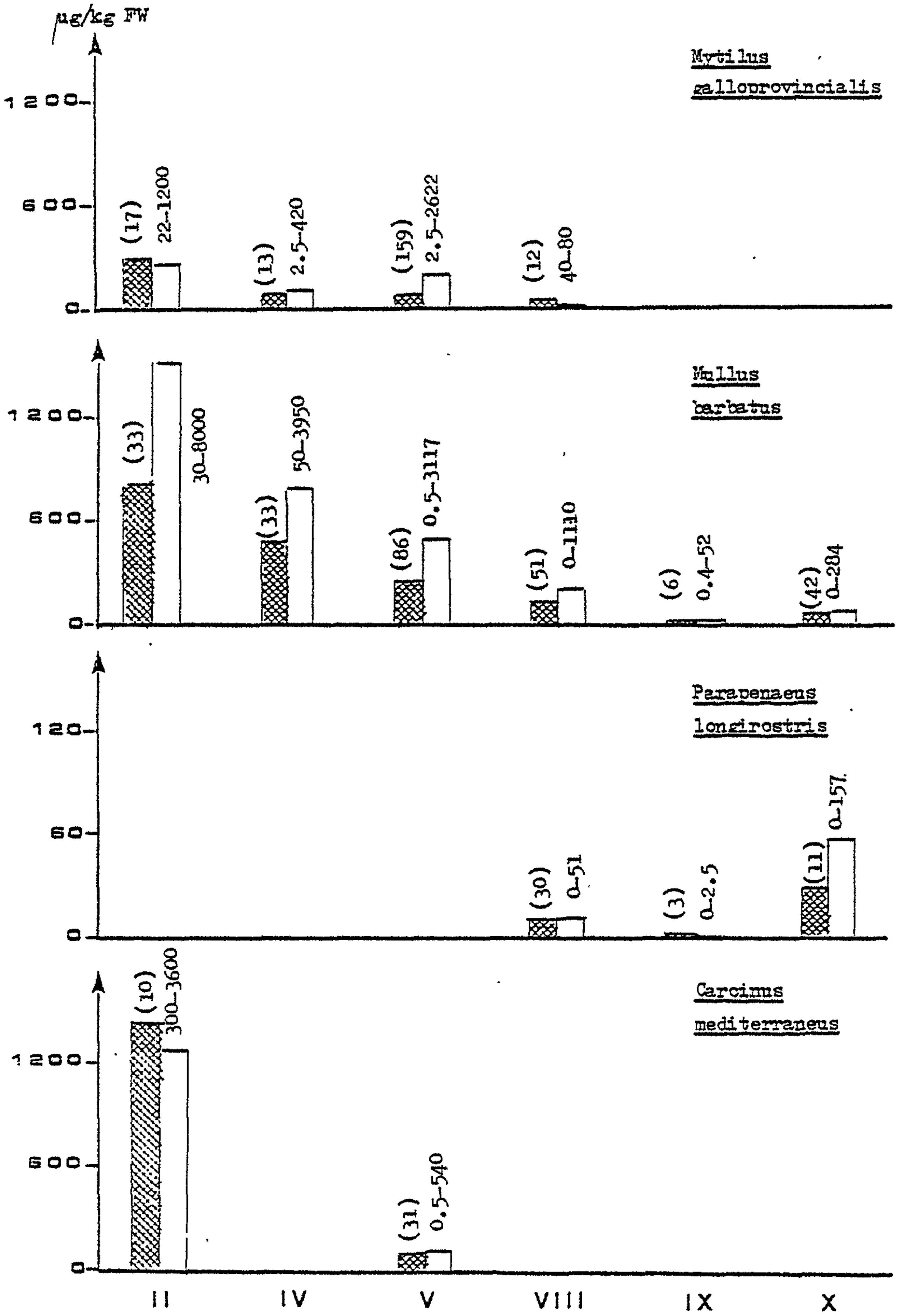

Figure 2. Average levels of PCB in different species by MED POL areas

( ) n — range

arithmetical mean — standard deviation

Table V - Average levels of PCBs in Mytilus galloprovincialis

area	No. of centres	No. of samples (n)	mean conc. µg/kg FW	standard deviation	range	average* length (mm)
II	2	17	307	266	22-1200	53(17)
IV	1	13	95	114	>5- 420	32(13)
V	4	159	84	221	>5-2622	48(159)
VIII	2	12	62	12	40- 80	48(11)

* Number of specimens in brackets.

As the number of samples is quite small and the data are scattered, a comparison between the different areas is not possible.

The levels are similar to those reported for Mytilus edulis in the North Sea by ICES as part of the baseline survey 1972 (ICES, 1974). The highest mean value reported in this study was 390 µg/kg in samples collected off the coast of the Netherlands. Similar values were also reported in the monitoring exercises during 1974, 1975 and 1976, with the highest mean values around 300 µg/kg, which is of the same order as the value for area II in the Mediterranean (ICES, 1977a; 1977c).

The highest average values in Mullus barbatus were reported in samples from stations in areas II and IV (Tyrrhenian Sea) (Table VI).

Table VI - Average levels of PCBs in Mullus barbatus.

area	No. of centres	No. of samples (n)	mean conc. µg/kg F.W.	standard deviation	range	average* length (mm)	average* weight (g)
II	2	33	813	1496	30 -8000	144 (33)	56 (33)
IV	1	33	477	770	50 -3950	142 (33)	62 (33)
V	4	86	234	473	<1 -3117	134 (84)	33 (84)
VIII	2	51	113	204	0 -1110	138 (51)	42 (43)
IX	1	6	9.3	19	0.4- 52	187 (6)	-
X	1	42	69	75	0 - 284	143 (42)	31 (42)

* Number of specimens in brackets.

There is a considerable variation between the values with an overall range from 0-8,000 µg/kg, the latter value being reported from area II. The difference between the averages is also quite pronounced, with the mean value in area II being almost two orders of magnitude higher than in area IX (North Levantine).

A statistical evaluation (t-tests) shows that the average level in area II is significantly higher than the averages in all other areas except area IV. Area IV shows a significantly higher average than areas V, VIII, IX and X.

The concentrations in Parapenaeaus longirostris in all three areas studied are very low, while samples of Carcinus mediterraneus collected in area II have a mean concentration as high as 1,448 µg/kg, (Table VII).

Table VII - Average levels of PCBs in *Parapenaeus longirostris* and *Carcinus mediterraneus*

area	No. of centres	No. of samples (n)	mean conc. µg/kg F.W.	standard deviation	range	average* length (mm)	average* weight (g)
			Parapenaeus longirostris				
VIII	2	30	12.3	12.2	0- 51	133 (27)	13 (27)
IX	1	3	1.5	-	0- 2.5	177 (3)	26 (3)
X	1	11	31	57	0- 157	102 (11)	4 (11)
			Carcinus mediterraneus				
II	1	10	1448	1295	300-3600	41 (10)	-
V	2	31	87.5	93.5	<1- 540	45 (31)	-
X	1	4	0	0	-	24 (4)	-

* Number of specimens in brackets.

Owing to the low concentrations in *Parapenaeus*, the scale in Figure 2 is an order of magnitude lower than for the other species. As the chlorinated hydrocarbons, essentially non-polar, have a high affinity to lipids, organisms with higher fat content like *Mullus barbatus* normally show a higher concentration than, for example, *Mytilus galloprovincialis* and *Parapenaeus longirostris*. *Parapenaeus*, in particular, has a very low fat content in the abdomen which has been used for the analysis.

Although not all areas have been covered and the number of samples is quite small, the results from the mandatory species give an indication that the concentration of PCBs is higher in area II than in the eastern Mediterranean.

Several additional species have also been analysed for PCBs, most of them, however, in only one or two areas. The average concentration based on three or more samples for each species are shown in Table VIII.

The highest values were reported for Engraulis encrasicolus in area II with a mean concentration of 385 µg/kg. The concentrations in Merluccius merluccius sampled in area V (Adriatic) and X (South Levantine) are similar to, or lower than, those from the ICES North Atlantic baseline study 1975 (mean concentrations from 20-390 µg/kg) (ICES, 1977b).

As regards the form of PCBs present in the organisms, it appears from the final reports of the principal investigators, as well as from the LOG FORMS, that PCBs are usually present as mixtures of highly chlorinated compounds. Most results were reported as Aroclor 1254 or Aroclor 1260 or a mixture of the two. This can, however, be expected as the PCBs with lower chlorine content are more easily eliminated from the organism (WHO, 1976).

8.2 DDT and its derivates

Overall averages of levels of p,p'-DDT, DDE and p,p'-DDD based on three or more samples of mandatory and non-mandatory species are shown in Tables IX, X and XI. The values are considerably less scattered than for PCB. In Mytilus galloprovincialis the mean values of p,p'-DDT in samples from the different areas vary between 2.3 and 28.5 µg/kg. The concentrations of p,p'-DDD and DDE are of the same level, varying between 6.0 to 48.5 and 6.1 to 17.8 µg/kg respectively. Concentrations of the same size or slightly lower were reported for Mytilus edulis from the ICES North Sea baseline study 1972 (ICES, 1974). In the following monitoring exercises of 1974, 1975 and 1976 the concentrations of both p,p'-DDT and DDE were generally lower than 10 µg/kg (ICES, 1977a; 1977b; 1977c).

For Mullus barbatus it can be seen from Figure 3 that almost all the mean concentrations of p,p'-DDT, DDE and p,p'-DDT are of the same level. Especially the contamination of p,p'-DDT and DDE are very similar.

The variation between the individual samples is, however, considerable as can be seen from the standard deviation which is usually of the same order as or higher than the mean. No difference between the areas can be distinguished on the basis of these results.

For the other species the major concentrations are generally less than 30 µg/kg. One exception is, however, Thunnus thynnus thynnus which shows average concentrations for p,p'-DDT and DDE of 343 and 352 ug/kg respectively. The concentration of p,p'-DDD is somewhat lower (107 µg/kg) but still one order of magnitude higher than for the other species. This can be expected, however, considering the role of tuna as predator, its long life and its relatively high fat content in the muscle.

Table VIII - Overall averages of levels of PCB in non-obligatory species

sampling areas	species	No. of samples (n)	mean conc. µg/kg F.W.	standard deviation	range
II	Engraulis encrasicolus	6	385	151	140 - 160
IV	Engraulis encrasicolus	10	153	63	40 - 260
	Mullus surmuletus	6	87	17	60 - 110
	Nephrops norvegicus	28	25	17	8 - 90
V	Engraulis encrasicolus	8	106	98	21 - 325
	Loligo vulgaris	4	128	77	30 - 235
	Merluccius merluccius	6	26	20	5 - 52
	Mugil auratus	4	330	422	64 -1060
	Mullus surmuletus	9	101	130	5 - 441
	Ostrea edulis	8	13	8	5 - 30
	Pagellus erythrinus	4	44	35	2.5- 96
	Patella coerula	4	10	4	2.5- 14
	Penaeus kerathurus	7	45	31	20 - 118
	Sardina pilchardus	8	303	153	129 - 602
	Trachurus trachurus	4	151	92	34 - 287
	Venerupis aureus	15	7	8	0.5- 30
	Xantho hydrophilus	10	93	71	7 - 242
IX	Mugil saliens	5	18	29	0.5- 77
X	Boops boops	4	44	22	19 - 55
	Maena maena	5	77	91	7 - 254
	Merluccius merluccius	5	29	23	0 - 70
	Pagellus erythrinus	12	231	287	36 - 994
	Saurida undosquamis	15	190	297	11 -1190
	Sphyraena sphyraena	3	275	167	80 - 487
	Trachurus mediterraneus	3	72	33	27 - 100
	Upeneus mollucensis	16	145	187	3 - 800

Table IX - Overall averages of levels of p,p' DDT in obligatory and non-obligatory species

sampling areas	species	No. of samples (n)	mean conc. µg/kg F.W.	standard deviation	range
II	*Boops boops*	7	21	20	5 - 69
	Engraulis encrasicolus	6	45	22	13 - 72
	Maena smaris	5	33	13	13 - 49
	Mullus barbatus	27	28	35	8 - 170
	Mytilus galloprovincialis	113	22	23	3 - 150
	Solea vulgaris	10	10	7	1 - 18
	Thunnus thynnus thynnus	21	343	362	25 -1401
	Trisopterus minutus capelanus	4	5	2	2.5- 7
IV	*Engraulis encrasicolus*	10	22	12	2.5- 40
	Mullus barbatus	33	23	17	6 - 89
	Mullus surmuletus	6	6	3	4 - 13
	Mytilus galloprovincialis	12	7	5	1.2- 17
	Nephrops norvegicus	28	1.8	1.6	0.5- 5
V	*Boops boops*	3	8	7	1 - 17
	Carcinus mediterraneus	31	1.7	1.4	0.2- 5
	Engraulis encrasicolus	8	14	6	3.7- 2.4
	Loligo vulgaris	4	12	7	7 - 24
	Merluccius merluccius	8	5	4	0.6- 12
	Mugil auratus	4	39	20	23 - 73
	Mullus barbatus	102	17	26	0.2- 205
	Mullus surmuletus	11	9	11	0.5- 40
	Mytilus galloprovincialis	180	15	77	0 -1014
	Ostrea edulis	10	2	2	0.3- 6
	Pagellus erythrinus	4	8	6	2 - 18
	Patella coerula	4	0.5	0.4	0.3- 1.3
	Penaeus kerathurus	7	1.5	0.8	0.3- 2.8
	Sardina pilchardus	8	36	18	7 - 67
	Trachurus trachurus	4	25	23	1 - 56
	Venerupis aureus	15	0.5	0.8	0.2- 3.6
	Xantho hydrophilus	10	1.7	1.4	0.5- 5

continued

Table IX - Overall averages of levels of p,p' DDT in obligatory and non-obligatory species (continued-2)

sampling areas	species	No. of samples (n)	mean conc. µg/kg F.W.	standard deviation	range
VIII	Mullus barbatus	51	23	25	4 -110
	Mytilus galloprovincialis	12	2.3	1.7	0 - 5
	Parapenaeus longirostris	29	0.9	1.4	0 - 6
IX	Carcinus mediterraneus	6	1.6	0.7	0.4- 2.6
	Mugil auratus	15	10	8	0.8- 2.7
	Mugil saliens	11	34	20	5.5- 6.8
	Mullus barbatus	17	38	29	0.5- 92
	Parapenaeus longirostris	4	4.2	3.5	0.3- 9
	Penaeus kerathurus	10	4.8	0.9	3.5- 6
X	Boops boops	4	0.9	1.3	0.4- 3.1
	Maena maena	5	7	4.4	0 - 13
	Merluccius merluccius	5	6	5	0 - 14
	Mullus barbatus	44	8	9	0 - 37
	Pagellus erythrinus	12	6	6	0 - 15
	Parapenaeus longirostris	10	0.1	0.2	0 - 0.8
	Saurida undosquamis	15	4.2	4.9	0 - 16
	Sphyraena sphyraena	3	37	38	0 - 89
	Trachurus mediterraneus	4	4.7	1	3 - 6
	Upeneus molluccensis	16	7	9	0 - 32

Table X - Overall averages of levels of p,p' DDD in obligatory and non-obligatory species

sampling areas	species	No. of samples (n)	mean conc. µg/kg F.W.	standard deviation	range
II	Boops boops	7	9	8	6 - 26
	Carcinus mediterraneus	10	10	9	1.2- 26
	Maena smaris	5	19	14	7 - 44
	Mullus barbatus	12	38	52	0 - 180
	Mytilus galloprovincialis	108	15	13	5 - 125
	Solea vulgaris	10	12	10	1 - 24
	Thunnus thynnus thynnus	21	107	98	5 - 117
	Trisopterus minutus capelanus	4	5	4	2 - 10
V	Engraulis encrasicolus	3	10	5	5 - 117
	Loligo vulgaris	4	11	11	3 - 29
	Mullus barbatus	5	28	40	2.2- 107
	Mullus surmuletus	3	7	6	2 - 15
	Mytilus galloprovincialis	11	49	124	0 - 440
	Pagellus erythrinus	3	1.1	0.5	0.4- 1.5
	Sardina pilchardus	4	21	16	4 - 46
	Trachurus trachurus	4	11	11	0 - 30
VIII	Merluccius merluccius	6	10	3.5	3.6- 15
	Mullus barbatus	78	14	25	0 - 140
	Mytilus galloprovincialis	90	7	7	0 - 45
	Parapenaeus longirostris	29	0.8	1.4	0 - 7
	Thunnus thynnus thynnus	4	323	422	26 -1052
IX	Carcinus mediterraneus	6	4.2	3.7	0 - 10
	Mugil auratus	7	8	7	1.5- 22
	Mugil saliens	11	24	12	7 - 47
	Mullus barbatus	17	18	14	0 - 44
	Parapenaeus longirostris	4	2.2	1.3	0.5- 4.2
	Penaeus kerathurus	3	2.2	1.0	1.0- 3.4

continued

Table X - Overall averages of levels of p,p' DDD in obligatory and non-obligatory species (continued-2)

sampling areas	species	No. of samples (n)	mean conc. µg/kg F.W.	standard deviation	range
X	Maena maena	5	7	6	0 - 17
	Merluccius merluccius	5	1.4	2.1	0 - 5
	Mullus barbatus	44	1.6	3.8	0 - 21
	Pagellus erythrinus	12	2.2	3.4	0 - 11
	Parapenaeus longirostris	11	0.4	0.8	0 - 2.7
	Saurida undosquamis	15	3.5	6	0 - 24
	Sphyraena sphyraena	3	17	19	0 - 44
	Trachurus mediterraneus	4	2	2	0 - 4.3
	Upeneus molluccensis	16	1.7	2.3	0 - 7

8.3 Other chlorinated hydrocarbons

As was mentioned in section 7.2, many centres did not report data on dieldrin. The results reported show that the concentration of dieldrin is generally low in all organisms analysed, with the highest mean values around 6 µg/kg (Table XII). The average levels were however generally below 1 µg/kg.

Aldrin has only been analysed in samples from four areas but the results available indicate that the concentrations in marine organisms in the Mediterranean are generally low (Table XIII).

For the other compounds analysed it was possible to take into account the intercalibration exercise when evaluating the data. The concentrations were however generally low. For heptachlor and heptachlorepoxide almost all values were lower than 1 µg/kg. For hexachlorcyclohexane and its isomer (lindane), some results are presented in Tables XIV and XV. Considering the analytical difficulties when analysing at these low levels, these data should only be regarded as an indication of orders of magnitude.

Table XI - Overall averages of levels of p,p' DDE in obligatory and non-obligatory species

sampling areas	species	No. of samples (n)	mean conc. µg/kg F.W.	standard deviation	range
II	Boops boops	7	6.7	2	3 - 10
	Carcinus mediterraneus	10	36	24	14 - 72
	Engraulis encrasicolus	6	47	19	16 - 66
	Maena smaris	5	28	8	14 - 40
	Mullus barbatus	34	29	14	11 - 70
	Mytilus galloprovincialis	114	13	9	2.2- 42
	Solea vulgaris	10	7	4	1.2- 12
	Thunnus thynnus thynnus	21	352	415	23 -1582
	Trisopterus minutus capelanus	4	3.7	0.7	3 - 4.6
IV	Engraulis encrasicolus	10	24	13	5 - 50
	Mullus barbatus	33	33	18	7 - 93
	Mullus surmuletus	6	11	3	6 - 15
	Mytilus galloprovincialis	13	6	4	2 - 17
	Nephrops norvegicus	28	3.8	1.8	1.1- 8
V	Carcinus mediterraneus	4	2.5	3.0	0.1- 6.2
	Engraulis encrasicolus	4	22	12	6 - 40
	Loligo vulgaris	4	33	25	6 - 61
	Merluccius merluccius	8	5.4	5.4	0.3- 20
	Mugil auratus	4	17	8	5 - 25
	Mullus barbatus	43	8	12	0.1- 75
	Mullus surmuletus	10	12	12	0.1- 33
	Mytilus galloprovincialis	145	5	13	0.1- 118
	Ostrea edulis	10	1.2	0.8	0.1- 2.8
	Pagellus erythrinus	4	7.2	4.3	0.6- 13
	Patella coerula	4	10	5	2.3- 17
	Sardina pilchardus	4	133	49	80 - 211
	Trachurus trachurus	4	35	23	15 - 70
	Venerupis aureus	15	0.2	0.2	0.1- 0.8
	Xantho hydrophilus	10	7	8	3.3- 24

continued

Table XI - Overall averages of levels of p,p' DDE in obligatory and non-obligatory species (continued-2)

sampling areas	species	No. of samples (n)	mean conc. µg/kg F.W.	standard deviation	range
VIII	Carcinus mediterraneus	3	23	3	20 - 26
	Merluccius merluccius	4	18	4.5	12 - 26
	Mullus barbatus	88	33	39	1 - 255
	Mytilus galloprovincialis	99	10	12	1 - 75
	Pagellus erythrinus	3	46	25	28 - 82
	Parapenaeus longirostris	31	1.6	5	0 - 25
	Thunnus thynnus thynnus	4	601	659	161 -1737
IX	Carcinus mediterraneus	7	22	15	0.3- 4.5
	Mugil auratus	17	16	11	1.4- 45
	Mugil saliens	11	70	30	33 - 115
	Mullus barbatus	16	53	42	0.9- 117
	Parapenaeus longirostris	4	3.1	1.6	1.0- 5.4
	Penaeus kerathurus	10	36	11	28 - 52
X	Boops boops	4	0.9	0.8	0 - 2.0
	Carcinus mediterraneus	4	3.1	3.5	0.7- 8
	Maena maena	5	6	3	2.3- 10
	Merluccius merluccius	5	15	9	7 - 32
	Mullus barbatus	44	15	12	2 - 67
	Pagellus erythrinus	11	14	10	4.9- 39
	Parapenaeus longirostris	11	1.5	2.6	0 - 9
	Saurida undosquamis	15	13	8	4.6- 30
	Sphyraena sphyraena	3	21	5	16 - 28
	Trachurus mediterraneus	4	10	4.4	3.2- 15
	Upeneus molluccensis	16	40	35	5 - 106

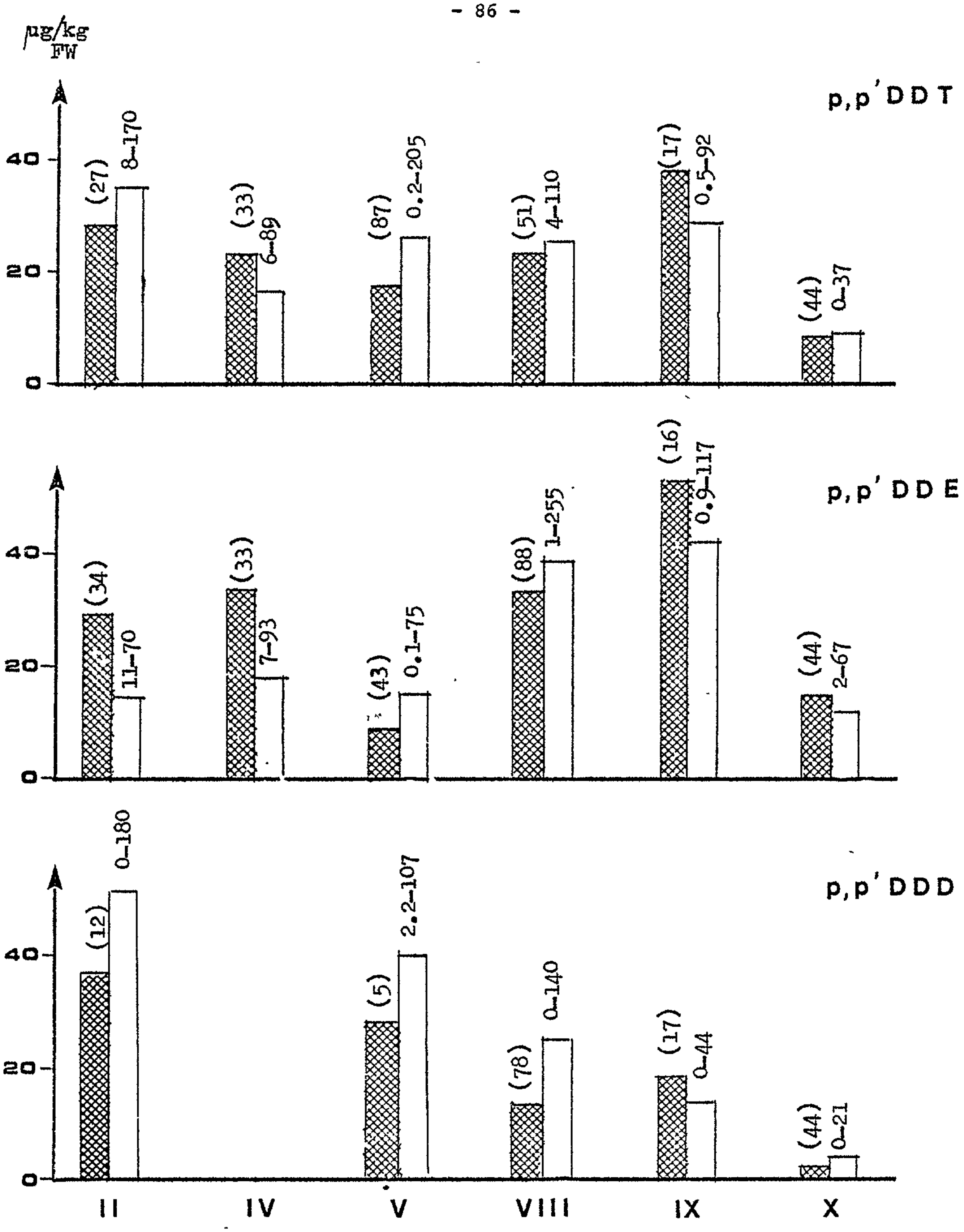

Figure 3. Average levels of DDT, DDE and DDD in Mullus barbatus by MED POL areas

( ) n — arithmetical mean (cross-hatched bar)

range — standard deviation (open bar)

Table XII - Overall averages of levels of dieldrin in obligatory and non-obligatory species

sampling areas	species	No. of samples (n)	mean conc. µg/kg F.W.	standard deviation	range
II	Mullus barbatus	11	6.2	5.3	0.5-19
	Mytilus galloprovincialis	2	3.5	-	1 - 6
IV	Engraulis encrasicolus	4	5	2.6	1.2- 7
	Mullus barbatus	9	6	3.6	0.5-12
	Mytilus galloprovincialis	6	2.8	2.6	0.5- 6
	Nephrops norvegicus	7	0.9	0.5	0.5- 1.8
V	Carcinus mediterraneus	31	0.5	0.6	0 - 2.4
	Engraulis encrasicolus	4	1.1	0.6	0.5- 1.9
	Merluccius merluccius	8	0.3	0.2	0 - 0.7
	Mullus barbatus	67	1.7	4.1	0.1-17
	Mullus surmuletus	8	0.4	0.2	0 - 0.7
	Mytilus galloprovincialis	145	0.8	4.4	0.1- 56
	Ostrea edulis	8	0.4	0.5	0.1- 2.0
	Patella coerula	5	1.1	1.0	0.1- 2.4
	Penaeus kerathurus	7	0.3	0.1	0.2- 0.5
	Sardina pilchardus	4	0.8	0.5	0 - 1.4
X	Carcinus mediterraneus	4	3.1	4.5	0.4-10
	Mullus barbatus	35	0.4	1.1	0 - 5.5

Table XIII - Overall averages of levels of Aldrin in samples of obligatory and non-obligatory species

sampling areas	species	No. of samples (n)	mean conc. µg/kg F.W.	standard deviation	range
II	Mullus barbatus	9	0.5	-	0.5- 0.5
IV	Engraulis encrasicolus	4	0.6	0.2	0.5- 1.0
	Mullus barbatus	9	1.5	1.9	0.5- 5.0
	Mytilus galloprovincialis	6	2.0	2.1	0.5- 5.0
	Nephrops norvegicus	7	0.6	0.2	0.5- 1.0
IX	Mugil auratus	14	1.2	0.6	0.2- 2.3
	Mugil saliens	6	1.8	0.7	0.9- 2.7
	Mullus barbatus	5	0.5	0.4	0.0- 1.0
	Parapenaeus longirostris	4	1.4	1.0	0.0- 2.8
X	Carcinus mediterraneus	5	1.6	2.8	0.0- 6.5
	Maena maena	5	4.2	3.9	0.0-10
	Merluccius merluccius	5	0.1	0.2	0.0- 0.4
	Mullus barbatus	44	1.5	4.7	0.0-28
	Pagellus erythrinus	12	2.9	6.4	0.0-22
	Parapenaeus longirostris	11	0.2	0.6	0.0- 2.2
	Saurida undosquamis	15	1.6	4.7	0.0-19
	Trachurus mediterraneus	4	0.1	0.1	0.0- 0.3
	Upeneus molluccensis	16	0.1	0.4	0.0- 1.9

Table XIV - Overall averages of levels of hexachlor cychlohexane in obligatory and non-obligatory species

sampling areas	species	No. of samples (n)	mean conc. µg/kg F.W.	standard deviation	range
V	Carcinus mediterraneus	27	0.9	-	0 - 8
	Engraulis encrasicolus	7	0.4	0.4	0 -10
	Loligo vulgaris	3	0.6	0.5	0 - 1.3
	Mullus barbatus	63	2.6	2.8	0.2-12
	Mullus surmuletus	4	1.2	1.7	0 - 4.0
	Mytilus galloprovincialis	43	1.1	1.0	0 - 5.0
	Penaeus kerathurus	7	0.2	-	0 - 0.4
	Sardina pilchardus	7	2.5	2.1	0.2- 6.0
VIII	Merluccius merluccius	6	1.5	0.6	0.8- 2.5
	Mullus barbatus	4	5	8	0.8-50
	Mytilus galloprovincialis	55	1.9	1.5	0.4- 5
	Parapenaeus longirostris	7	0.7	0.3	0.2- 1.1
IX	Carcinus mediterraneus	6	20	-	12 -34
	Mugil saliens	7	13	6	5 -22
	Mullus barbatus	5	3.9	3.9	1.0-11

Table XV - Overall averages of levels of lindane in obligatory and non-obligatory species

sampling areas	species	No. of samples (n)	mean conc. µg/kg F.W.	standard deviation	range
II	*Carcinus mediterraneus*	4	19	14	2 -36
	Mullus barbatus	17	3.0	4.4	0.5-20
	Mytilus galloprovincialis	7	4.8	6	0.5-20
IV	*Engraulis encrasicolus*	4	6.7	3.4	4.2-12
	Mullus barbatus	9	1.5	1.4	0.5- 5
	Mytilus galloprovincialis	6	1.7	0.9	0.5- 3
	Nephrops norvegicus	7	0.5	-	-
V	*Carcinus mediterraneus*	27	0.2	-	-
	Engraulis encrasicolus	4	0.1	-	-
	Mullus barbatus	62	0.7	0.9	0 - 3.8
	Mytilus galloprovincialis	36	0.4	0.4	0 - 2.0
	Sardina pilchardus	4	0.7	0.9	0.2- 2.3

9. CONCLUSIONS

The purpose of this pilot project was to provide baseline data and to initiate monitoring of selected contaminants in selected marine organisms in the Mediterranean. Through the project it was expected to achieve a better co-ordination of ongoing and new studies, to improve comparability of results and to obtain an overall picture of levels of contaminants considered to be important.

A common system of sampling, sample preparation, analysis and reporting was introduced during this pilot phase. This system, together with other experience gained, could also serve as the basis for future monitoring activities.

For the first time, consolidated baseline data on levels of chlorinated hydrocarbons in marine organisms in the Mediterranean are at our disposal, some of them from areas where data were not previously available.

From the data presented it can be concluded that a distinction can be drawn between chlorinated insecticides on the one hand and PCBs on the other. For most of the chlorinated insecticides the concentrations are quite low and close to, or below, detection limits. DDT and its derivatives show an even distribution in the obligatory organisms over the whole Mediterranean. For PCBs there is a considerable scatter of the data with ranges of several orders of magnitude.

A possible explanation for this difference between the compounds may be that chlorinated insecticides enter the sea through run-off or atmospheric fall-out while PCBs, being of industrial origin, enter the Mediterranean to a large extent through point sources. The utilization of DDT in particular is prohibited or restricted in many countries around the Mediterranean while PCBs have only been used in considerable quantities for the last 20 years or less and are still in use. DDT and other chlorinated insecticides therefore have a tendency towards a more uniform distribution in the Mediterranean compared to PCBs, for which the results indicate very high levels in some industrialized areas.

The results obtained through this pilot project can be used to evaluate possible adverse effects on the marine environment and for the assessment of the eventual risks to consumers of seafood.

10. OTHER RESULTS

Research agreemeants were successfully negotiated with most of the research centres, and signed by 77 per cent of those designated as participants in the pilot project.

Information on the effectiveness of the administrative and financial arrangements made by FAO in connection with the pilot project was received from 17 research centres (71 per cent of those with signed research agreements).

10.1 Training

Out of 18 trainees, only two failed to submit technical reports and 12 of them submitted evaluation reports on the results of their training.

The evaluation of the benefits the participants gained from training, is similar to that described under MED POL II.

10.2 Regional Activity Centre

The assistance provided by the Regional Activity Centre to the efficient operation of the pilot project consisted of collaboration with FAO(GFCM) in the analysis and evaluation of the interim and final reports of the MED POL III principal investigators.

10.3 Documentation

Documents specifically developed for this pilot project include:

- Manual of Methods in Aquatic Environment Research. Part 2: Guidelines for the Use of Biological Accumulators in Marine Pollution Monitoring. FAO, Fisheries Technical Paper No. 150. (Portmann, 1976).
- Manual of Methods in Aquatic Environment REsearch. Part 3: Sampling and Analysis of Biological Material. FAO Fisheries Technical Paper No. 158. (Bernhard, 1976).
- Manual of Methods in Aquatic Environment Research. Part 5: Statistical Tests. FAO, Fisheries Technical Paper No. 182. (Möller, 1979).

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MED POL IV : RESEARCH ON THE EFFECTS OF POLLUTANTS ON MARINE ORGANISMS AND THEIR POPULATIONS (FAO(GFCM)/UNEP)

1. INTRODUCTION

The marine environment is characterized by relatively constant physical and chemical conditions. As a result, marine organisms are not adapted to sudden changes in their environmental conditions, to certain substances not normally present in sea-water, or to unusually high concentrations of substances which are ordinarily present as microconstituents.

The project dealt mainly with long-term experiments that aimed to investigate the sub-lethal effects of potential pollutants, including functional as well as morphological changes. When organisms could not be kept long enough under culture conditions to allow long-term toxicity tests, acute toxicity experiments were carried out.

The experiments were not limited to individual organisms but also covered populations where subtle changes in the behavioural pattern could serve as early warning signs and lead to the possibility of predicting the moment at which the organisms would be harmed at the population level. Influences transmitted through the trophic levels, particularly in experiments on populations, were also studied.

Work was carried out to establish the most sensitive stages in the life-cycle of the organisms tested. Physiological and biochemical studies were conducted in order to provide information on the mechanisms involved in the effects and transport of pollutants. The functional and structural damage to the genetic material of individuals and their populations was also studied.

The objective of the project was to provide the biological background for monitoring and to generate the data required as the scientific basis for the development of water quality criteria in general. Naturally, these criteria cannot be based solely on biological tests, but the results should provide the basis for understanding potential hazards to the ecosystems, including man, caused by increased levels of pollutants in the marine environment.

The actual work of the national research centres on the pilot project started in January 1976.

The purpose of pilot project MED POL IV was to study the effects of pollutants on marine organisms and their populations, giving priority to determining toxicity levels by "bioassay" methods. The project also provided data on the dynamics of pollutants and their synergistic and antagonistic effects. In addition, research was done on morphological and anatomical changes and changes in reproduction and behaviour. Physiological studies were carried out to elucidate the functional response of organisms to pollutants, and analyses were made to show possible genetic changes in stressed populations.

The results described in this report on MED POL IV are based on the eleven final reports submitted by participants in the project.

2. PARTICIPANTS

Twenty-seven research centres from thirteen Mediterranean States were designated to participate in the pilot project.

By the end of December 1980, 19 research agreements had been signed and one cleared and ready for signature.

3. CO-ORDINATING ARRANGEMENTS

FAO(GFCM) maintained the operational contacts with the national research centres designated to participate in the pilot project.

The Station Marine d'Endoume et Centre d'Océanographie, Marseille, France, was nominated in August 1976 to assist FAO(GFCM) as the Regional Activity Centre for this pilot project. The following meeting was held in specific connection with this pilot project:

- FAO(GFCM)/UNEP Mid-term Expert Consultation on the Joint Coorinated Project on Pollution in the Mediterranean (MED POL IV and V) (Dubrovnik, 9 - 13 May 1977), which also covered MED POL V and was attended by 25 participants from 17 research centres in 10 Mediterranean States.

4. FINANCIAL ARRANGEMENTS

Specific financial support to the pilot project was provided through projects FP/0502-75-01 and FP/0503-75-07 (both projects covering activities relevant to MED POL II, III, IV and V). Costs relevant to MED POL IV (expressed in US dollars) were shared between the two co-sponsors of these projects as follows:

	1975	1976	1977	1978	1979	1980	Total	Percentage
FAO(GFCM)	6,000	9,700	9,922	9,890	9,400	7,325	52,237	18.6
UNEP	8,421	44,696	52,628	48,300	47,813	26,894	228,752	81.4
TOTAL	14,421	54,396	62,550	58,190	57,213	34,219	280,989	100.0

Direct support to participants in MED POL IV up to 31 December 1980 amounted to US $ 108,846 including:

- US $ 11,546 for equipment;
- US $ 54,214 for expendable materials;
- US $ 23,916 for training of 14 trainees (total of 23 man/months) for eight research centres in eight host institutions;
- US $ 4,265 for attendance at meetings;
- US $ 4,905 for consultants to participating research centres;
- US $ 10,000 as assistance to the Regional Activity Centre.

Indirect support to participants in MED POL IV up to 31 December 1980 amounted to US $ 119,906. This sum included:

- US $ 68,353 for the services of consultants to assist FAO(GFCM) in the organization and execution of the pilot project, and in the evaluation of its results;
- US $ 9,142 for the organization of meetings;
- US $ 42,411 for the preparation of manuals, guidelines and reports.

The national contributions to the pilot project, estimated on the basis of incomplete information supplied by 10 participating research centres as equivalent to US $ 1,044,150, included:

- 1,004 man/months of professional and supporting staff (US $ 602,400 estimated at US $ 600 per man/month);
- US $ 320,000 as expendable materials;
- US $ 121,750 as operating costs of equipment.

5. OPERATIONAL DOCUMENT

The operational document of the pilot project was formulated at a joint FAO(GFCM)/UNEP Expert Consultation on the Joint Coordinated Project on Pollution in the Mediterranean, (Rome, 30 June - 4 July 1975) attended by 25 participants from 13 Mediterranean States. Certain modifications of the operational document were agreed upon at the Mid-term Expert Consultation for MED POL IV and MED POL V (Dubrovnik, 9 - 13 May 1977) which was attended by 16 experts from 12 research centres participating in MED POL IV.

6. AREAS STUDIES

In general, the organisms and populations investigated belonged to the areas near the research centres carrying out the studies.

7. MATERIAL AND METHODS

7.1 Selection of species

It was agreed that the experiments should be made on a small number of species previously recommended for use in pilot projects MED POL II and MED POL III. These species, which might be described as "mandatory", were the following: Mullus barbatus, Mytilus galloprovincialis and/or M. edulis, Parapenaeus longirostris and Carcinus mediterraneus. In the end, only Mytilus galloprovincialis was used by three laboratories.

It had also been recommended that a number of other organisms should be studied, and 18 of them had been designated. Of these "alternative" species, the following 13 were chosen: Phaeodactylum tricornutum, the sponge Geodia cydonium; the polychaetes Capitella capitata, Scolelepis fuliginosa; the echinoderms Paracentrotus lividus, Arbacia lixula; the arthropods Acartia clausi, Idotea balthica basteri, Penaeus kerathurus; and the fishes Mugil cephalus, Sparus auratus, Dicentrarchus labrax, Scyliorhinus canicula.

In fact, the laboratories chose a much larger number of species, which had not been contemplated. It may even be said that some of these "additional" species were chosen by a larger number of laboratories than the preceding ones. In all, the following 42 additional species were selected: Nereis caudata, Nereis succinea, Nereis diversicolor, Cardium glaucum, Venerupis aureus, Abra ovata, Patella lusitanica, Murex trunculus, Murex brandaris, Monodonta turbinata, Monodonta articulata, Cerithium scabridum, Sepia officinalis, Artemia salina, Acartia tomisi, Tisbe holothuriae, Tisbe bulbisetosa, Sphaeroma serratum, Jassa falcata, Hyale spp., Orchestia mediterranea, Echinogammarus stocki, Leptomysis mediterraneus, Pagurus sp., Palaemon spp. Palaemon elegans, Palaemon serratus, Palaemonetes varians, Xantho hydrophilus, Microcosmus sulcatus, Mugil auratus, Mugil capito, Mugil (Lyza) saliens, Maena maena, Maena smaris, Boops boops, Boops salpa, Halobatrachus didactylus, Coryphaena hippuris, Sardina pilchardus, Blennius pavo and Trachurus trachurus. Thus, in all, 56 species were selected.

7.2 Pollutants analysed

Generally speaking, the substances recommended for study were used. Some laboratories specialized in the study of heavy metals and others in the study of chlorinated hydrocarbons and organophosphorous compounds. The following pollutants were selected; - Heavy metals: mercury (sulphate, chloride, acetate, methyl); copper (sulphate, chloride, acetate, nitrate);cadmium (chloride, sulphate, acetate, nitrate); chromium (hexavalent and trivalent); zinc; aluminum; selenium; thallium; Polychlorinated biphenyls (including Aroclor 1254), organophosphates and carbamates, aldrin, dieldrin, permethrin, DDT, various herbicides and insecticides. Petroleum from various sources, anionic, non-ionic and cationic detergents. Miscellaneous substances; 3,4-benzopyrene, 20-methylcholanthrene, 9,10-dimethyl-1,2-benzanthracene, 6-phenolbarbital, cyanides and, in a few cases, sea-water polluted by various sources.

7.3 Techniques followed

The research methods used were very varied. They may ba said to range, in increasing order of technicality, from research on short-term lethality in a static environment to sophisticated biochemical studies. This classification is no criterion for either the quality or the value of the research carried out.

Among the methods most commonly used were: Short term static tests and, less frequently, tests with various "continuous flow" systems for the measurement of lethal concentrations or minimum lethal times (50 per cent, 10 per cent); Long-term static or "continuous flow" tests for the observation or quantitative assessment of longevity, mating egg production, larval development, duration of larva stages, instar periods and more physiological phenomena such as respiration and food assimilation.

Behaviour was taken into account and sometimes recorded by kymography. Histological and cytological methods were used to study external and internal malformations and organ deterioration. The absorption of pollutants by various organs was shown by atomic absorption spectrophotometry or, after the marking of the pollutants, by autoradiography and liquid scintillation spectrometry.

Biochemical techniques, sometimes the most effective, were applied. Use was made of electrophoresis (particularly in genetics) and various methods of measuring cholinesterase inhibition, protein synthesis, ATP and numerous enzyme activities, such as pyruvate kinase, malate dehydrogenase, benzo (a)pyrene dehydrogenase (BPMO), 5-aminolevulinic acid dehydrogenase (ALA-D), lactic dehydrogenase (LDH), alkaline acid phosphatase (AP and AC), glutamate oxalate transaminase (GOT) and glutamate pyruvate transaminase (GPT). Liver esterases were studied by electrophoretic and histochemical methods. The usual haematological characteristics were studied and measured, particularly in fishes. The methods used appear to be conventional.

7.4 Intercalibration

There was no intercalibration as such. Moreover, none was planned. Two laboratories did, however, have analyses of pollutants in organs made by laboratories which were taking part in projects MED POL II and III and in the intercalibration exercise.

8. SCIENTIFIC RESULTS AND DISCUSSION

8.1 Mandatory species: Mytilus galloprovincialis

Heavy metals: it was shown that the combined effects of mercury chloride and temperature, caused an increase in the toxicity of mercury when the temperature rose (synergism), while tests on the combined effects of mercury chloride and salinity levels showed that decreases in salinity (up to 25 per cent) caused a reduction of mercury toxicity (antagonism).

Studies on copper salts showed a rapid accumulation of copper in tissues (up to 40 µg/g in the gills in 7 days), a reduced rate of protein synthesis (from 5 per cent to 70 per cent in 7 days), a fall in ATP and a considerable concentration of proteins of molecular weight 11,000-12,000 (similar to thioneins and chelatins) in the gills.

Effects of Exposure to Cu^{2+} (0.008 ppm)			
Tissues	Original Concentration	After 3 days	After 7 days
Gills	0.89	0.81 (-9 per cent)	0.64 (-28 per cent)
Digestive gland	1.41	1.23 (-13 per cent)	0.99 (-30 per cent)
Mantle	2.60	2.10 (-20 per cent)	1.77 (-32 per cent)

The ATP content of the tissues examined is expressed in µ moles ATP/g of wet weight. The values obtained are the mean of at least four results.

One pesticide (Slimicide C30), at a concentration of 0.02 mg/l, had harmful effects on the development of the eggs of *M. galloprovincialis*; in 96 hours, the 30 per cent effective concentration (EC 50) is 0.07 mg/l.

8.2 Alternative species

Phaeodactylum tricornutum

Heavy metals: Mercury caused a substantial decrease in chlorophyl production at concentrations as low as 0.01 ppm after 24 hours.

Cadmium in concentrations of between 5 and 75 ppm impedes growth and cell multiplication. This is clearly apparent after 48 hours when, at more than 25 ppm, the number of cells decreases. It does not seem to make much difference which salts of these metals are used (chloride, acetate, sulphate, nitrate).

Capitella capitata

Detergents: Research carried out before MED POL IV showed that exposure of *C. capitata* larvae to detergents caused deaths at concentrations as low as 0.01 mg/l. Teratological phenomena were also observed. Since then, it has been found that the toxicity of detergents is definitely increased (synergism) when salinity levels are much lower (18 to 22 $^{o}/oo$) or higher (44 to 50$^{o}/oo$) than normal (37 to 38$^{o}/oo$) Conversely, toxicity is reduced (antagonism) when salinity levels are nearer to normal; this was more apparent in the case of detergents of medium toxicity.

Scolelepis fuliginosa

Detergents: Data entirely similar to those on the preceding species were found in the case of S. fuliginosa though no malformed larvae were observed.

Paracentrotus lividus

Heavy metals: Mercury salts were found to be acutely toxic. The 24h LC 50 was between 0.5 and 1.5 ppm and the 48h LC 50 between 0.4 and 0.8 ppm. Mercury chloride was the most toxic; it had particularly toxic effects on different larval stages of P. lividus. For example, a 0.10 mg/l concentration of $HgCl_2$ prevents formation of the fertilization membrane in 2 per cent of the cases, and the first division in 9 per cent of the cases, but stops gastrulation in 70 per cent and metamorphosis to the pluteus stage in 100 per cent of cases. Cadmium is markedly less toxic than mercury (48h LC 50 is between 2.2 and 3.5 ppm).

Arbacia lixula

Heavy metals: The 50 per cent lethal concentration of mercury sulphate is 1.5 ppm in 24 hours, 0.5 ppm in 48 hours and 0.35 in 78 hours. At concentrations of between 0.1 and 0.5 ppm of Hg, pigments are discharged into the environment.

Acartia clausi

Heavy metals: Copper, cadmium and chromium are highly toxic, in descending order, for A. clausi. Very low concentrations of metals (fractions of mg/l) affect its physiological processes. A. clausi populations from polluted areas are distinctly less affected than those from areas with clean (or little polluted) water. For example, the cell ingestion rate in 24 hours for clean-water populations is 25,550 for the control and 3,065 for population in water with 0.005 mg/l of copper, whereas for polluted-water populations it is 25,600 and 122,290 respectively.

Idotea balthica basteri

Detergents: Detergents systematically disturb all phases of the growth and life cycles of this species (number of eggs and young animals, length of the instar period, longevity, feeding, etc). These disturbances do not always take the form of reduced spawning periods, for example, or longer instar pariods; but there may be a speeding up. Serious histological and cytological changes in various internal organs are also observed, including stoppage of the prophase and the maturation of germinal cells in males, and abnormalities in external organs (gills, antennae, etc.)

Penaeus kerathurus

Heavy metals: The study of the effects of heavy metals on the various larval stages of P. kerathurus showed that, generally, the most sensitive stages were those closest to the nauplius; the protozoea stages were particularly sensitive. Thus, the 24h LC 50 for the nauplius, protozoea II and P_4 and P_6 post-larval stages were 0.0054 mg/l, 0.0095 mg/l and 0.0469 mg/l, respectively, with methyl-mercury; 0.937 mg/l, 1.270 mg/l and 4.890 mg/l with cadmium chloride; and 0.103 mg/l, 0.107 mg/l and 1.470 mg/l with copper sulphate. The accumulation of cadmium in the hepatopancreas was 319.64 mg/kg, and 15 times less in the muscles. The tissues of the hepatopancreas showed deterioration.

Mugil cephalus

Chlorinated hydrocarbons and organophosphorus compounds: in concentrations of less than 1 ppm, the toxicity of Paraquat is not particularly acute. But although the LT 50 at 1 ppm is 16 days, at 10ppm it is only 1 hour. At a concentration in the environment of 1 ppm, over a period of 15 days Paraquat accumulates mainly in the skin (4 µg/g) and the digestive tract (6.083 µg/g).

It was demonstrated that, in vitro, DDT stimulated liver lactate dehydrogenase and fumarase and inhibited liver β-hydroxybutyrate dehydrogenase. The results obtained in vivo were slightly different. DDT generally slows down the working of the citric acid cycle and the respiratory chain, and the catabolism of fatty acids and glycolysis in the liver, whereas it intensifies lactate dehydrogenase activity. Permethrin increases pyruvate kinase and malate dehydrogenase activity in the muscle. On the other hand, a change was noted as regards lactate dehydrogenase or acetylcholinesterase. Organophosphorous compounds inhibit brain cholinesterase in M. cephalus.

Sparus auratus

Heavy metals: After 41 days at a concentration of 0.1 ppm of mercury chloride, the accumulation of mercury in the liver was 323.6 mg/kg (wet weight); after 80 days at 0.008 ppm, the accumulation of mercury methylate was 21.33 mg/kg. Signs of substantial histological and haematopoietic deterioration of various internal organs were observed in each case.

In the case of cadmium, after 96 hours at 23 ppm, an accumulation of 74.76 mg/kg (wet weight) was found in the liver; after 60 days at 3.0 ppm, 140.07 mg/kg had accumulated. Substantial histopathological deterioration occurred in the gills, liver, pancreas, intestine and kidneys.

At a concentration of 0.20 mg/l of Cu, after 77 days 20 mg/kg (wet weight) of copper had accumulated in the liver. Deterioration of the epithelium of the intestine was considerable.

Dicentrarchus labrax

Heavy metals: Up to 329.25 mg/kg (wet weight) of mercury accumulate in the liver after 62 days at 0.01 mg/l; about half as much accumulates in the kidney and spleen. Serious cytoheamatological and histopathological deterioration follows. The same occurs with cadmium, which may accumulate in various organs, especially the kidney (12.79 mg/kg after 96h at 50 mg/l).

Scyliorhinus canicula

Heavy metals: The action of lead on 5-aminolevulinic acid dehydrogenase activity in erythrocytes was measured. In vitro this activity decreased steadily to 64 per cent of normal at a concentration of 0.1350 mg of lead per ml of blood. In vivo, it decreased to 61.8 per cent of normal at a dose of 43 mg/kg of lead. At a concentration of 0.25 mg/l of lead, the activity was reduced to 40-44 per cent of normal and, at a concentration of 1 mg/l, 10-25 per cent or normal.

8.3 Additional species

Venerupis aureus (*Tapes aureus*)

Heavy metals: With mercury chloride, an increase in temperature produces synergistic phenomena, while a decrease in salinity (from 37 to 25°/oo) has an antagonistic effect, mercury being less toxic if the salinity of the environment is lower.

Detergents: It was found that without the addition of detergents there was no mortality if salinity was lowered to 25°/oo, lethal salinity being 20°/oo. If detergents are added, their toxicity is reduced when salinity is lowered, but shortly before the lethal salinity level is reached, the toxicity of the detergent produces synergistic phenomena and mortality is greatly increased.

Patella lusitanica

Heavy metals: In terms of acute toxicity, mercury is slightly more toxic than cadmium.

	Hg	Cd
LC 50 24 h	38 - 48 ppm	39 - 60 ppm
LC 50 48 h	20 - 28.5 ppm	21.5 - 29 ppm

Mercury acetate is the most toxic of the mercury salts, while cadmium acetate is less toxic than cadmium sulphate.

Murex trunculus

Pesticides: With Paraquat, mortality occurs only at conentrations of more than 0.1 ppm. At 1 ppm, the LT 50 is 18 days, but at 10 ppm, it is only 10 hours. Up to 5 ppm, aldrin and dieldrin have no apparent effect on the various properties of haemocyanin.

Murex brandaris

Pesticides: The acute toxicity of Paraquat is the same as for the preceding species. Its accumulation in *M. brandaris* is proportional to the concentration of Paraquat in the test environment.

Monodonta turbinata

Crude oil: At a concentration of 20,000 ppm, the LT 50 of surface and mixed oil is 68 hours, whereas for floating oil at the same concentration, it is 120 hours. Sublethal effects include: loss of gregarious instinct, increase (tenfold) in the time spent at the water-air interface and a considerable reduction in emersion time. The "interface period" seems to depend on the population of fractions with a high boiling point (experiments conducted with crude oil distillates).

Monodonta articulate

Heavy metals: The 24h LC 50s of mercury sulphate, chloride and acetate are 8 ppm; the 48h LC 30 of mercury sulphate is 6 ppm. With regard to behaviour, it was found that emersion time increased after 24 hours and that the period of activity at the interface decreased when the mercury concentration reached 0.003 ppm. Oxygen consumption decreases at a concentration of 0.01 ppm of mercury. The acute toxicity of cadmium is less than that of mercury. At concentrations between 0.01 and 1.0 ppm, there is an increase in emersion time and the period of activity at the interface; oxygen consumption does not seem to be affected.

Sepia officinalis

Heavy metals: The 24h LC 50s are: $HgCl_2$, 23.7-28 µg/l; CH_3HgCl, 17-19 µg/l; $CdCl_2H_2O$, 6-8 mg/l; and $CuSO_4.5H_2O$, 0.17 mg/l.

Artemia salina

Heavy metals: Starting at 0.1 pmm, mercury salts reduce egg fertilization. The reduction reaches 50 to 95 per cent at 1 ppm. While there is no mortality of adults up to 0.7 ppm, the same is not true of larvae. With cadmium, fertilization is reduced by 20 to 60 per cent at 1.0 ppm. The growth of larvae is slowed down and their mortality rate is high. The LT 50s vary between 50 and 120 hours for cadmium concentrations between 1.0 and 0.025 ppm. A copper concentration of 5 ppm reduces fertilization by 85 per cent. It was also found that the growth rate of larvae is restricted by a copper concentration of 0.025 ppm; the LT 50s range from 10 to 35 hours at concentrations of 10 to 1 ppm. Acclimatization of larvae increases their tolerance.

Anti-petroleum products: For 13 of these products, the 24h LC 50s are between 1 and 500 ppm, and the 48h LC 50s, between 0.5 and 230 ppm.

Petroleum: The toxic water-soluble fractions cause 20 to 40 per cent mortality.

Tisbe bulbisetosa

Polychlorinated biphenyl (Aroclor 1254): Aroclor is toxic only in concentrations of more than 10 µg/l; at 500 µg/l, males are more sensitive to it than females. No particular phenomena related to acclimatization were observed. At 10 µg/l, fertility and the formation of nauplii do not seem to be affected, but the duration of the biological cycle is extended. The survival period of nauplii is definitely affected. The number of nauplii is ultimately reduced.

Concentration of Aroclor 1254	Control	1.6 µg/l	16 µg/l	80 µg/l
Survivors (per cent)	63.33	38.33	19.58	11.67
Sex ratio	1.05	1.14	1.47	1.33

Subsequent mating and offspring do not seem to be affected. There may be some prior selection of breeders which have become resistant to PCBs.

Orchestia mediterranea

Dispersants: The 24h LC 50s are between 25 and 7,200 ppm and the 48h LC 50s, between 15 and 200 ppm.

Echinogammarus stocki

Heavy metals: The influence of tank-storage time appears to be considerable.

Detergents: The test temperature modifies the toxicity of the detergent appreciably.

Leptomysis mediterraneus

Pesticides: The 96h LC 50 of Slimicide C30 is 0.11 mg/l.

Cyanides: The 96h LC 50 is very low: 45 µg CN/$^{-}$l.

Palaemon sp.

Pesticides: The LT 50 of Paraquat is 10 days at 1 ppm and 36 hours at 10 ppm. Of three herbicides, Propanyl is the most toxic and Mecoprop the least: at 8 ppm, Propanyl kills 78.8 per cent of specimens in 96 hours; at 10 ppm, Molinate kills 72 per cent of specimens in 96 hours; a concentration of 100 ppm of Mecoprop is needed to kill 88.5 per cent of specimens in the same time.

Palaemon serratus

Heavy metals: The interaction between mercury and selenium showed some notable effects. When P. serratus, exposed to a concentration of 4 mg/l of mercury, was treated with selenium for four days, the LT 50 increased considerably. In addition, the loss of Se and Hg by the Palaemon is less when they are subjected to the simultaneous action of the two metals.

Petroleum: The alkaline and acid phosphatase activity (AP and AC) of the hepatopancreas if affected by the water-soluble fractions.

Palaemon elegans

Heavy metals: For young P. elegans larvae, the 24h LC 50 of mercury salts is between 0.6 and 1.5 ppm and the 48h LC 50 between 0.3 and 0.5 ppm; mercury acetate is the most toxic. There is a close correlation between the mortality rate and the concentration of mercury chloride. Homozygotes are more resistant than heterozygotes to low (0.02-0.08 ppm) and high (0.26-0.40 ppm) concentrations.

For P. elegans larvae, the 24h LC 50 of copper citrate decreases as temperature rises (86 ppm at 20°C and 46 ppm at 23°C); but the same is not true for the 48h LC 50, which is 25ppm at 20° and at 23°C.

Pagurus sp.

Pesticides: At 1 ppm, the LT 50 for Paraquat is three days and, at 10 pp, 36 hours. Heavy accumulations of Paraquat were found after three days of exposure to various concentrations:

Concentration of Paraquat in water (ppm)	Amount of Paraquat in body (µg/g)
5.0	17.63
2.5	9.21
1.0	3.16

Xantho hydrophilus

Petroleum: The soluble fractions affect AP and AC activity in the blood plasma.

Mugil auratus

Heavy metals: Cadmium is toxic for the young of M. auratus; in 96 hours, the mortality rate is 33.3 per cent at 18 mg/l and 40 per cent at 32 mg/l; the mortality rate is 100 per cent after only 24 hours at a concentration of 56 mg/l. The inhibition of ALA-D activity is proportional to the concentration of lead. It was found that zinc had a strong restorative effect on ALA-D activity affected by other metals (mercury, copper, cadmium, zinc and aluminum).

Phenol: High concentrations of phenol cause neurotoxic symptoms, haemorrhaging, tissue oedema and various forms of liver deterioration, which are confirmed by increased LDH, GOT and GPT activity in the blood, in which proteins are also affected.

Mugil capito

Heavy metals: Thalium does not affect the metabolism of K^+, but causes a significant increase in Na^+ and Cl^- exchange through the gills.

Lyza saliens (Mugil saliens)

Anti-petroleum products: Juvenile L. saliens die in 48 hours at a concentration of about 1,000 ppm. For three out of four products, the LT 50 is between 5.5 and 7.2 hours at 5,000 ppm, and for the fourth, 13 hours.

Maena maena

Pesticides: for this species, Slimicide C30 has a 96h LC 50 of 0.34 mg/l.

Maena smaris

Pesticides: Organophosphorous compounds caused cholinesterase activity of 2,500 in the brain of M. smaris after only 2 hours' exposure.

Boops boops

Pesticide: Permethrin increases the maximum rate of pyruvate kinase, malate dehydrogenase, succinate dehydrogenase and cytochrome oxidase; it does not affect lactate dehydrogenase in the muscles of this fish.

Halobatrachus didactylus

Heavy metals: There is a substantial accumulation of the salts of various metals.

Accumulation rate (mg/kg of wet weight):

Organs	Mercury (0.1 mg/l for 35 days)	Cadmium (50 mg/l for 96 hours)
Liver	70.86	5.21
Kidney	39.84	12.79
Spleen	37.50	-
Blood	3.60	1.20
Intestine		39.0
Muscle		0.15

Substantial cytohaematological and histological deterioration occurs, particularly of the blood, liver and kidney.

Coryphaena hippuris

Pesticides: Permethrin has the same effects on C. hippuris as on B. boops.

Sardina pilchardus

Pesticides (organophosphates and carbamates) have various inhibiting effects. All liver esterases are completely inhibited by Para-oxon, but not by Phosalone.

Blennius pavo

Petroleum: As a result of an oil spill, the BPMO levels of B. pavo populations increased eight times. This was confirmed by an experimental test with No. 2 diesel oil at a concentration of 170 ppm.

8.4 Discussion

It is first of all interesting to summarize the various approaches adopted and the biological phenomena considered by the different laboratories. A certain selection must, of course, be made. It cannot and will not be determined by the extent or evidence of the results obtained by the laboratories; special account will, of course, be taken of the studies which, by the species and pollutants selected and the bioassays carried out, come closest to the most clearly defined objectives of pilot project MED POL IV (Table I).

8.4.1 Toxicity tests

The tests used may be divided into short-term and long-term tests, but most of the laboratories carried out research on short-term toxicity. It appears that in most cases the object of this research was to determine the limits of the toxicity of pollutants used for other studies on organisms which were available to the laboratories, or which they wished to use as test organisms in other studies. Consequently, the experiments varied very widely.

For instance, a great deal of attention was given to the effects of detergents produced by the petrochemical industry on various marine invertebrates, polychaetes and molluscs (Mytilus and Tapes) with sudden or gradual changes in salinity. These studies dealt with synergistic and antagonistic action.

Studies of the toxic effects of heavy metals on populations of the copepod Acartia clausi revealed differences in their resistance to pollutants. Some of these populations were from a very polluted area, while others were from an area which might be described as "clean". The differences were certainly connected with genetic data.

One laboratory found very significant differences in the short-term resistance of Murex, Pagurus and Mugil to the herbicide Paraquat.

Another laboratory made a long study of the short-term toxic effects of heavy metals on various invertebrates (gastropods, sea-urchins and shrimps), making a special effort to determine the toxicity of the various salts of these metals.

Table I - Effects of pollutants on various species under different experimental conditions

Pollutants	Species	Life stage	Effective concentrations	Exposure time	Effects
Hg	*Mytilus galloprovincialis*	adults	0.08 ppm	7 days	Lowering of ATP content 28% (gills) 30% (digestive glands) 32% (mantle)
Hg	*Phaeodactylum tricornutatum*	n.i.	0.01 - 3 ppm	24 h.	Decrease of chlorophyll-a production
Hg	*Arbacia lixula*	n.i.	1.5 ppm	24 h.	LC - 50
Hg	*Arbacia lixula*	n.i.	0.5 ppm	48 h.	LC - 50
Hg	*Paracentrotus lividus*	n.i.	0.4-0.8 mg/l	48 h.	LC - 50
		larval stages			
Hg(Methyl-Hg)	*Penaeus kerathurus*	Nauplius to Mysis III	3.5-9.8 µg/l	24 h.	LC - 50
Hg	*Penaeus kerathurus*	" "	4.7-9.8 µg/l	24 h.	LC - 50
Hg	*Sparus auratus*	larval stages	0.35 mg/l	24 h.	LC - 50
Hg(Hg Cl_2)	*Sparus auratus*	larval stages	0.1 ppm	20-54 days	Accumulation in liver: 323.6 mg/kg WW
Hg(Methyl-Hg)	*Sparus auratus*	larval stages	0.008 ppm	80 days	" " " 21.35 mg/kg WW
Hg	*Dicentrachus labrax*	n.i.	0.8 mg/l	62 days	Accumulation in liver: 329.25 mg/kg WW " " kidney: 176.50 mg/kg WW
Hg (4 salts)	*Patella lusitanica*	adults	38-48 ppm	24 h.	LC - 50
		adults	20-28.5 ppm	48 h.	LC - 50
Hg	*Monodonta articulata*	n.i.	8 ppm	24 h.	LC - 50
		n.i.	0.03 - 1.0 ppm	24 h.	Trouble in emersion/immersion period
		n.i.	1 mg/l	24 h.	Retraction into shell
Hg(Methyl-mercury)	*Sepia officinalis*	larval stages	17.0 -19.0 µg/l	24 h.	LC - 50
Hg(Chlorite)	*Sepia officinalis*	larval stages	23.7-28.0 µg/l	24h.	LC - 50

continued

Table I - Effects of pollutants on various species under different experimental conditions (continued-2)

Pollutants	Species	Life stage	Effective concentrations	Exposure time	Effects
Hg	*Artemia salina*	hatched eggs	1.0 ppm	n.i.	Reduction of hatched eggs (50-95%)
Hg	*Palaemon elegans*	larval stages	0.3-0.5 ppm	48 h.	LC - 50
Hg (Methyl-Hg)	*Palaemon elegans*	n.i.	36 µg/l	96 h.	LC - 50
Hg(Methyl-Hg)	*Mugil auratus*	n.i.	0.008 mg/l	45 days	Accumulation in kidney: 16.72 mg/kg WW
Hg	*Mugil auratus*	n.i.	0.10 mg/l	56 days	" in liver : 101.23 mg/kg WW
Hg	*Halobatrachus didactylus*	n.i.	0.1 mg/l	35 days	" in liver : 70.06 mg/kg WW kidney : 39.04 " " blood : 3.68
Cd(4 salts)	*Phaeodactylum tricornutum*	n.i.	5 ppm	48 h.	Partial inhibition of multiplication of cells
Cd	*Paracentrotus lividus*	n.i.	2.2-3.5 ppm	48 h.	LC - 50
Cd	*Acartia clausi*	adults	clean area: 1.20 mg/l polluted area: 1.50 mg/l	48 h.	LC - 50 (14°C)
			clean area: 0.60 mg/l polluted area: 0.74 mg/l	48 h.	LC - 50 (22°C)
					Oxygen consumption µl O_2 clean area / polluted area
			clean area: 0.2 mg/l	24 h.	0.025 / 0.037
			" " : 0.6 mg/l	24 h.	0.025 / 0.038
			" " : 0.8 mg/l	24 h.	0.044 / 0.043
Cd	*Penaeus kerathurus*	larval stages Nauplius to Mysis III	0.94-1.3 mg/l	24 h.	LC - 50
		adults	0.8 mg/l	n.i.	Accumulation of Cd/mg/kg WW Hepatopancreas : 319.64 Muscle : 7.92

continued

Table I - Effects of pollutants on various species under different experimental conditions (continued-3)

Pollutants	Species	Life stage	Effective concentrations	Exposure time	Effects
Cd	Sparus auratus	larval stages	2.80 mg/l	24 h.	LC - 50
		n.i.	25 ppm	96 h.	Accumulation in liver: 74.76 mg/kg
Cd	Patella lusitanica	adult	39-60 ppm	24 h.	LC - 50
		adult	21.5-29 ppm	48 h.	" "
Cd(sulphate)	Monodonta articulata	n.i.	710 ppm	24 h.	LC - 50
		n.i.	8 ppm	48 h.	" "
Cd	Artemia salina	hatched eggs	1 ppm	n.i.	Reduction of hatched eggs: 20-60%
Cd	Palaemon elegans	larvae	3-10 ppm	48 h.	LC - 50
Cd	Mugil auratus	juveniles	18 mg/l	33 h.	% of dead : 11.1
			18 mg/l	96 h.	: 33.3
			32 mg/l	24 h.	: 10
			"	48 h.	: 20
			"	72 h.	: 30
			"	96 h.	: 40
			56 mg/l	8 h.	: 0
			"	24 h.	: 100
			100 mg/l	6 h.	: 1
			"	24 h.	: 100
Cd	Halobatrachus didactylus	adults	50 mg/l	96 h.	Accumulation in liver: 5.21 mg/kg WW in kidney: 12.79 mg/kg WW in blood: 1.20 mg/kg WW
Cu	Acartia clausi	adults	clean area: 0.034 mg/l polluted area: 0.002 mg/l	48 h.	LC - 50(18°C)

continued

Table I - Effects of pollutants on various species under different experimental conditions (continued-4)

Pollutants	Species	Life stage	Effective concentrations	Exposure time	Effects	
Cu	*Acartia clausi*	adults			Ingestion rate (cells 24 h^{-1})	
					clean area	polluted area
			0.001 mg/l	48 h	1440	25550
			0.005 mg/l	48 h	3065	22290
					Egg production	
					clean area	polluted area
			0.001 mg/l	3 days	1.0	6.0
			0.005 mg/l	"	-	7.06
			0.01, mg/l	"	0	5.69
					Oxygen consumption µl O_2	
					clean area	polluted area
			0.001 mg/l	20 h.	0.009	0.018
			0.002 mg/l	"	0.019	0.022
			0.01 mg/l	"	0.024	0.030
Cu	*Penaeus kerathurus*	larval stages Nauplius to Mysis III	0.077-0.107 mg/l	24 h.	LC - 50	
Cu	*Sparus auratus*	"	0.27 mg/l	24 h.	LC - 50	
Cu	*Sepia officinalis*	larval stages	0.17 mg/l	24 h.	LC - 50	
Cu	*Artemia salina*	old larvae	5 ppm	n.i.	Reduction of hatched eggs: 85%	
Cu	*Palaemon elegans*	larvae	25 ppm	48 h.	LC - 50	
Cr (Na_2CrO_4)	*Acartia clausi*	n.i.	16.99 mg/l	48 h.	LC - 50 (14°C)	
"	" "	"	11.47 mg/l	48 h.	LC - 50 (18°C)	
"	" "	"	8.83 mg/l	48 h.	LC - 50 (22°C)	
Cr (CrO_3)	*Acartia clausi*	adults	19.27 mg/l	48 h.	LC - 50 (14°C)	

continued

Table I - Effects of pollutants on various species under different experimental conditions (continued-5)

Pollutants	Species	Life stage	Effective concentrations	Exposure time	Effects
					ALA - D activity
Pb	*Scyliorhinus canicula*	n.i.	0.002-0.1350 mg/ml (blood)	30 mn.	*in vitro* : 117.0 - 64.0%
"	" "	"	1-43.0 mg/kg	48 h.	*in vivo* : 111.0 - 61.8%
"	" "	"	0.25-1.00 mg/l (in sea water)	48 h.	40.8 - 25.3%
Pb(Pb(NO_3)2)	*Mugil auratus*	n.i.	500 μg/l	n.i.	Enzymatic effects ALA-D
Zn	*Mugil auratus*	n.i.	500 μg/l	n.i.	Restoring effect of the lead loaded(ALA-D)
Pesticides (DDT)	*Mugil cephalus*	juvenile	0.5 - 1.0 μg/l	n.i.	Enzymatic effects (inhibitory)
Pesticides (Paraquat)	*Mugil cephalus*	n.i.	1 mg/l	16 days	LC - 50
"	*Murex brandaris*	i.	"	10 days	LC - 50
"	*Pagurus sp.*	n.i.	"	8 days	LC - 50
					Inhibition of cholinesterase activity in the brain(subsisting activity):
Pesticides (Dimethoate)	*Mugil cephalus*	n.i.	1 ppm.	2 h	92.4 %
			"	4 h	79.6 %
			"	24 h	29.9 %
			5 ppm	2 h	94.6 %
			"	4 h	72.9 %
			"	24 h	19.1 %
			10 ppm	2 h	85.9 %
			"	4 h	55.1 %
			"	24 h	11.8 %

continued

Table I - Effects of pollutants on various species under different experimental conditions (continued-6)

Pollutants	Species	Life stage	Effective concentrations	Exposure time	Effects
Pesticides (Chlorpyriphos)	*Mugil cephalus*	n.i.			Inhibition of cholinesterase activity of the brain(subsisting activity):
			30 ppm.	2 h.	86.0 %
			"	24 h.	2.6 %
			"	35 h.	dead
			100 ppm	2 h.	60.6 %
			"	24 h.	dead
			200 ppm	2 h.	7.9 %
			"	24 h.	dead
					% of dead animals :
Pesticides (Molinate)	*Palaemon sp.*	adults	5 ppm	48 h.	3.4
			"	96 h.	10.3
			"	240 h.	69.0
			10 ppm	48 h.	12.3
			"	96 h.	72.0
			"	168 h.	100.0
			20 ppm	24 h.	18.0
			"	48 h.	58.0
			"	72 h.	100.0
Pesticides (Propanyl)	*Palaemon sp.*		1 ppm	168 h.	19.0
			"	216 h.	28.6
			"	254 h.	38.1
			4 ppm	96 h.	50.8
			"	120 h.	72.8
			"	168 h.	100.0
			8 ppm	96 h.	78.8
			"	120 h.	86.5
			"	[illegible] h.	100.0

continued

Table I - Effects of pollutants on various species under different experimental conditions (continued-7)

Pollutants	Species	Life stage	Effective concentrations	Exposure time	Effects
Pesticides (Mecoprop)	Palaemon sp	adults			% of dead individuals:
			20 ppm	24 h.	0
			"	48 h.	2.4
			50 ppm	96 h.	11.4
			"	216 h.	59.1
			"	264 h.	65.9
			100 ppm	48 h.	32.7
			"	96 h.	88.5
			"	120 h.	100.0
Pesticides (Slimicide C-30)	Mytilus galloprovincialis	eggs	0.07 mg/l	96 h.	LC - 50
"	Leptomysis mediterranea	n.i.	0.11 mg/l	"	"
"	Maena maena	adult	0.34 mg/l	"	"
Pesticides (Paraoxon)	Sardina pilchardus	n.i.	$10^{-3} - 10^{-6}$ m	n.i.	Total inhibition of liver esterase
Pesticides (Phosolone)	" "	"	"	"	No inhibition of liver esterase
PCB (Aroclor)	Tisbe bulbisetosa		10 µg/l Aroclor (+0.2 ml/l Corexit)	24.67 days	Minimum generation interval
			control	22.10 days	" " "
Crude oil	Monodonta turbinata	n.i.	20.000 ppm	68 h.	LT - 50

continued

Table I - Effects of pollutants on various species under different experimental conditions (continued-8)

Pollutants	Species	Life stage	Effective concentrations	Exposure time	Effects	Research centre code
Diesel oil (+PCB and Aroclor)	Eurydice truncata	adults	1 ppm(diesel)	24 h.	Synergistic effect diesel+PCB+temperature (as % of mortality) 16°C : 0	9503
			"	96 h.	16°C : 60	
			10 ppm(diesel)	24 h.	16°C : 70	
			"	96 h.	16°C : 100	
			10 ppm(diesel + 0.2ppb PCB)	96 h.	14°C : 60	
			"	96 h.	16°C : 60	
Crude oil	Blennius pavo	adults	170 ppb	n.i.	IPN 0 level x 8	9504
Detergent n°1	Mytilus galloprovincialis	adults	5.70 mg/1	96 h.	12.5°C LC - 50	3510
			4.75 "	96 h.	17°C "	
			2.50 "	96 h.	23°C "	
Detergent n°1	Venerupis aureus	adults	5.41 mg/1	96 h.	12.5°C LC - 50	
			3.39 "	96 h.	17°C "	
			2.50 "	96 h.	23°C "	
Detergent n°2	Venerupis aureus	adults	1.30 mg/1	96 h.	12.5°C LC - 50	
			1.00 "	96 h.	17°C "	
			0.35 "	96 h.	23°C "	
Oil dispersants(n°13)	Artemia salina	n.i.	1 - 500 ppm	24 h.	LC - 50	HA 01
"	" "	n.i.	0.5 -250 ppm	48 h.	LC - 50	
"	Orchestia mediterranea	adults	25 - 7200 ppm	24 h.	LC - 50	
"	" "	adults	15 - 200 ppm	48 h.	LC - 50	

continued

Table I - Effects of pollutants on various species under different experimental conditions (continued-9)

Pollutants	Species	Life stage	Effective concentrations	Exposure time	Effects
Oil dispersants (various)	<u>Mugil saliens</u>	young	100 ppm	48 h.	0 - 70 % of dead
			1000 ppm	48 h.	0 - 100 % " "
			5000 ppm	48 h.	100 %
			100 ppm	17 h.	LT 50
			1000 ppm	5.5-7.2 h.	"
			5000 ppm	2.1-13 h.	"
			10.000 ppm	1.8-7 h.	"

Attention was also given to the synergistic effects of an oil (diesel No. 20) and a polychlorinated biphenyl on the benthic isopod Eurydice truncata, whose nychthemeral activity is particularly well known.

While much research was carried out on adult specimens, some was also done on juveniles. For example, the effect of cadmium chloride on young Mugil auratus and the short-term action of anti-petroleum products on Mugil saliens were determined.

This brings us to the research on larval stages. The effect of detergents and heavy metals on the growth cycle of the sea-urchin Paracentrotus lividus were studied. The mortality at different stages was noted, together with the normal duration of the different phases of the growth cycle.

One laboratory studied the effects of various salts of heavy metals on nine larval stages of the shrimp Penaeus kerathurus. It supplemented its research by using, for the same purpose and with the same pollutants, larval stages of the cephalopod Sepia officinalis and the fish Sparus auratus.

Studies were made of the survival of Tisbe bulbisetosa nauplii in an environment polluted by Aroclor (PCB) and of the effects of metals on the fertilization of Artemia salina eggs.

It seems permissible to believe that, biologically speaking, these "short term" experiments on larval stages are really "long-term", because of the rapid succession of the various stages observed. In any event, such data must also be taken into account in the studies on development.

The idea of "short-term" and "long-term" experiments was thus found to be rather ambiguous. It will also be noted that rather little research was done to determine the long-term toxic effects of pollutants on organisms.

Generally speaking, research on long-term toxicity served rather as support for other studies -physiological, behavioural, histopathological, genetic studies, etc.- which will be considered later.

8.4.2 Pollutant dynamics

Some attention was devoted to accumulation phenomena, but generally speaking, their study does not seem to have generated much enthusiasm. The studies were carried out by a small number of laboratories and covered heavy metals and pesticides.

Studies by two laboratories showed that organochlorinated compounds are extremely unstable in the experimental environment and are able to attach themselves to all substrates available. One laboratory expressed concern about the accumulation of heavy metals, which is greater in specimens living in polluted environments. Attention was also given to the accumulation of salts of mercury and cadmium in various organs (muscle, blood, intestine, liver, spleen, kidney) of three species of fish and one cephalopod.

The accumulation of detergents marked with tritium was clearly shown in most of the internal organs of the isopod Idotea balthica. There is clear evidence that these accumulations which are sometimes substantial, cause damage to the organs in which they are present, as will be seen below. It would be interesting, but certainly hazardous and difficult, to try to establish an objective correlation between the levels of pollutant accumulations and the extent of organ deterioration.

8.4.3 Physiological and behavioural effects

Particular attention was devoted to these effects and to enzymatic problems and most of the laboratories made a significant contribution to their study.

General physiology

One laboratory studied the growth and chlorophyll production of the alga Phaeodactylum tricornutum in the presence of heavy metal salts, and the consumption of oxygen by gastropods.

The number of erythrocytes, the quantities of haemoglobin and the haematocrit value in Halobatrachus didactylum subjected to the effects of mercury were also measured.

It is assumed that oil droplets blocking the anterior part of the digestive tract of Eurydice truncata affect the digestion process.

Behaviour

One laboratory studied the nutritional activity of copepods, while much of the work of another was devoted to the study of the reaction of Monodonta gastropods to mercury and cadmium salts, and to crude oil. The studies dealt more specifically with the phenomena of retraction of the animal into its shell and gregarious behaviour, and the limits of impairment of such behaviour were determined. Reduction of mobility of the sea-urchin Strongylocentrotus lividus when treated with crude oil was also studied.

8.4.4 Changes in enzyme activity

Enzyme

Much research on enzymes was carried out, and most of the laboratories devoted at least a small proportion of their work to it. The approach differed very widely, not only as to the species, which comprised both invertebrates and fishes, and the pollutants, which were mostly heavy metals or organochlorinated compounds, but also to the enzymes since changes in the activity of several dozen enzymes were studied in both respiratory and digestive organs.

Particular attention was given to the action of organochlorinated compounds. Thus, results were obtained on the anti-cholinesterase activity of phosphorated esters in the brain and blood of Mugil cephalus. One laboratory studied the action of Permethrin on various enzymes (pyruvate kinase, malate dehydrogenase, succinate dehydrogenase and cytochrome oxidase) of three species of fishes, Boops, Coryphaena and Mugil, while another studied the action of DDT and aldrin on six enzymes in Mugil cephalus (particularly in the liver).

The action of lead on δ-aminolevulinic acid dehydrogenase in the blood of Scyliorhinus was also studied.

Enzyme studies also served as a basis for some genetic research.

8.4.5 Morphology and histology

One laboratory had previously studied the teratological effects of detergents on the morphology of larvae of the polychaete Capitella capitata and the isopod Idotea balthica. It found histological deterioration in various internal organs of Idotea, particularly the gonads, and demonstrated the lethal teratological effects of detergents and heavy metals on Paracentrotus lividus larvae.

Many signs of cytoheamatological and histological deterioration were found in the digestive and excretory organs of fish subjected to the action of heavy metals.

8.4.6 Development: reproduction and population genetics

Under this heading may be considered the studies of the larval stages of Paracentrotus lividus, which showed an increase in the duration of the development stages. Studies of Idotea balthica basteri showed similar phenomena, with either lengthening or shortening of the instar period, which was always different from that of the control specimens.

Other studies showed that the reproductive potential of species of crustaceans was severely affected (by hypermortality of the larvae).

One laboratory which carried out genetic research considered that the differences observed in the effects of pollutants on two populations of the copepod Tisbe acartia, one living in a polluted environment and the other in a non-polluted environment, might be of generic (phenotypic) origin. The study of 20 loci of Palaemon elegans showed that phosphate glucomatase was highly polymorphic, whereas in three others it was slightly so.

8.5 Conclusions

In general, it may be noted that, within each research centre and at the overall level, some selection was made with regard to pollutants, organisms and the studies themselves.

Pollutants

It may be noted that most of the centres used heavy metals and/or pesticides (or herbicides), i.e. the pollutants studied more specifically as part of MED POL II and MED POL III; this is quite normal, since many of the MED POL IV centres were also taking part in MED POL II and MED POL III. Some laboratories used hydrocarbons, but it was entirely exceptional for a laboratory to chose petrochemical detergents.

An effort was made by some laboratories to use the different physical and chemical forms, in which pollutants might be present (particularly in the case of heavy metals). Such research and observation of absorption (primarily of chlorinated hydrocarbons) should be encouraged, with a view to evaluating the effective concentrations and toxicity of the pollutants to which animals are exposed.

Organisms

The species selected were very rarely those which had been designated as mandatory. It may even be considered that the alternative species did not receive the attention that might have been expected, since five of them were not used at all. On the other hand, 41 of the "additional" species were chosen.

It seems necessary to try to understand why the laboratories proceeded in this way.

The explanation is not difficult as regards the mandatory species which, it must be emphasized, were not well chosen for this pilot project. That point had, moreover, already been stressed by the participants at the meeting of principal investigators (Dubrovnik, May 1977). Parapenaeus longirostris is a fairly deep water species. Its laboratory acclimatization and, a fortiori, its use as a test species raises difficulties which have not been overcome and may not be in the near future. Moreover, although it is a species that is said to be present all over the Mediterranean, its real distribution is localized, and its geographical and seasonal abundance varies widely. The requirements for catching it are not easy to meet. Similar, though less complex, problems arise with regard to Mullus barbatus. Carcinus mediterraneus seems to be abundant. It is easy to gather, provided laboratories are situated near lagoons or estuaries, where it usually lives. But it is precisely this preferred biotope which raises problems; in the Mediterranean, C. mediterraneus is not normally a true marine species. None of these three species was used.

The fourth species (omitting at the outset Mytilus edulis, about which the least than can be said is that it is rare in the Mediterranean) is Mytilus galloprovincialis. This species is fairly abundant (especially in polluted waters) in the northern part of the Mediterranean, but rare along the African coast, where Perna perna (sometimes included in the genus Mytilus) is found in some places. M. galloprovincialis seems to be totally absent from the south-eastern part of the Mediterranean, approximately south of a line from Izmir to Tunisia. Moreover, it raises many problems for those using it for experimental purposes. Three laboratories used it but not very intensively.

Of the 18 "alternative" species, 13 were used. Since these species were originally proposed by those who had already worked on them or planned to do so, it is not surprising that a fair proportion of the species finally chosen were in this caterogy.

The additional species were varied, but were in fact often closely related to if not of the same genus as the alternative species. In this connection, it is perhaps to be regretted that the laboratories did not make more systematic efforts to show "resemblances" and/or "differences" in the results obtained with those zoologically allied species.

Effects studied

Acute toxicity was studied extensively, both in adults and in larvae. A broad range of continuing bioassays was developed for the study of sublethal effects. Most of this research was based on the study of enzyme activity. Many laboratories seem to have been keenly interested in enzymology, and some of their research goes well beyond the framework of project MED IV.

From a brief survey of what has been done, it may, of course, be concluded that the results are perhaps not what was requested in the report of the FAO (GFCM)/UNEP Expert Consultation on the Joint Coordinated Project on Pollution in the Mediterranean, held in Rome from 23 June to 4 July 1975.

The species recommended first were hardly used at all. It may well be that they were difficult to use and inappropriate (even if the centres were able to obtain them and keep them alive in the laboratory). The list of additional species, which was rather long, was used extensively and ultimately considerably lengthened. It would be useful to review the tests, so that species might be better selected in the light of the experience gained.

Too little research was done on heterotrophic micro-organisms and phytoplankton. Similarly, little use was made of zooplankton (real), whereas zoobenthos and nekton (especially fish) were widely used.

With regard to the effects studied, interest was shown in direct toxicity and enzymology. Research on the physiology of nutrition and respiration generated little interest (except in so far as it related to enzymology).

As the programme expanded, it became clear that more attention was being devoted to the frequently lethal effects of pollutants on the morphology of larvae and adults, since reproductive phenomena (changes in the development cycle, reductions in the number of larvae, abortions, etc.) directly affect populations, either by enabling them to increase or by gradually reducing them, which in time will affect ecosystems.

Very few laboratories studied the problem in terms of populations. They experimented with populations of the same species, but of different origins, (for example, populations taken from clean water and populations taken from polluted water) or with similar species living in different environments.

Thus it may fairly be said that few centres stressed the value of their research for the marine environment. Most of the research did not take special account of the marine environment, as has already been clearly shown. Not only were organisms studied more than their populations, but little seems to have been done to investigate species which are representative of particular aspects of the polluted or unpolluted natural environment. The same seems to apply to pollutants, whose presence or abundance in, and potential danger to the environment, do not seem to have been considered as criteria for selection.

An effort should therefore be made to establish a more rational and effective correlation between laboratory results and observations - experimental, if possible - which can be made in the natural environment.

It is obvious that, in the natural environment, pollutants are not only generally numerous in their joint action on populations, but do not act independently of one another. It is therefore regrettable that so few studies were carried out on interactions (synergism and/or antagonism), however difficult and perhaps somewhat "unrealistic" such studies may be; though their lack of realism is, after all, not necessarily any greater than than of other in vitro research.

It is also regretted that so few studies were carried out on problems of accumulation, particularly through food-chains. Due allowance must, however, be made for the difficulty of developing such chains with some semblance of realism and for the delicate problems involved in measuring accumulations at the different levels of the chain. This might, perhaps, be made easier by the use of tracers.

In conclusion, it may be said that, although the laboratories used classical methodological principles and, on the whole, took the usual experimental precautions, there was, nevertheless, a regrettably wide variety not only in the choice of species and pollutants but also in the choice of methods, so that it is rather difficult to attempt any rigorous and detailed comparison of the results obtained.

9. SUMMARY

The purpose of this pilot project was to study the effects of pollutants on marine organisms and their populations. The project outline suggested the study of a limited number of species and pollutants, mainly those recommended also for the monitoring projects MED POL II and MED POL III.

However, the participating laboratories used as many as 56 species in laboratory experiments. Only one mandatory and 13 alternative species were used since with all others, the scientists had difficulties keeping them (in the laboratory) as test animals. Little research was done on heterotrophic micro-organisms and on phytoplankton as well as on zooplankton. Too few laboratories studied the problem in terms of populations.

Concerning the pollutants, generally speaking, the substances recommended were used and efforts were made to use also different physical and chemical compounds in which these pollutants might be present.

Among the most common studies were: short-term tests and, less frequently, tests with various "continuous flow" systems for the measurement of lethal concentrations or minimum lethal times, and long-term static or "continuous" flow tests for the observation of quantititive assessment of longevity, mating, egg production, larval development, duration of larval stages and some physiological phenomena such as respiration and food assimilation. Behaviour was taken into account and sometimes recorded by kymography. Histological and cytological methods were used to study external and internal malformations and organ deterioration. Biochemical techniques, sometimes the most effective, were also applied. The usual haematological characteristics were studied and measured, particularly in fishes. Use was made of various methods for measuring protein synthesis, ATP and numerous enzyme activities. Only few studies were carried out on interactions (synergism and/or antagonism) of pollutants and on problems of their accumulation, particularly through food-chains.

However, it may be said that although the laboratories used classical methodological principles, they made too wide a choice of species and pollutants. In this way, it was rather difficult to attempt any rigorous and detailed comparison of the results obtained.

Valuable information on the effects of pollutants has certainly become available through the above studies and some research centres with no previous experience in this field have been able to start important experiments.

10. OTHER RESULTS

Research agreements were successfully negotiated with most of the research centres, and signed by 70 per cent of those designated as participants in the pilot project.

Information relevant to the effectiveness of the administrative and financial arrangements made by FAO in connection with the pilot project was received from only 10 research centres (53 per cent of those with signed research agreements) and therefore only a partial evaluation of these arrangements is possible.

10.1 Training

Out of 14 trainees, two failed to submit technical reports and only five of them have submitted evaluation reports on their training.

The evaluation of the benefits gained by the participants from training, is similar to that described under MED POL II and MED POL III.

10.2 Regional Activity Centre

The assistance provided by the Regional Activity Centre to the efficient operation of the pilot project consisted of:

- collaboration with FAO(GFCM) in the analysis and evaluation of the interim and final reports of the MED POL IV principal investigators;

- preparation of a draft manual on selected bioassay techniques.

The importance of the assistance received from the research centre selected as the RAC for this pilot project was marginal to the pilot project.

10.3 Documentation

Documents specifically developed for this pilot project include:

- Manual of Methods in Aquatic Environment Research. Part 2: Guidelines for the Use of Biological Accumulators in Marine Pollution Monitoring. FAO, Fisheries Technical Paper No. 150. FAO, 1976; 76 p.

- Manual of Methods in Aquatic Environment Research, Part 3: Sampling and Analysis of Biological Material. FAO Fisheries Technical Paper No. 158. FAO, 1976; 124 p.

- Manual of Methods in Aquatic Environment Research, Part 4: Bases for Selecting Biological Tests to Evaluate Marine Pollution, FAO, Fisheries Technical Paper No. 164. FAO, 1977; 31 p.

- Manual of Methods in Aquatic Environment Research. Part 5: Statistical Tests. FAO Fisheries Technical Paper No. 182. FAO, 1979; 131 p.

- Manual of Methods in Aquatic Environment Research. Part 7: Selected Bioassays for the Mediterranean. FAO Fisheries Technical Paper No. 208. FAO, 1981; 31 p.

MED POL V : RESEARCH ON THE EFFECTS OF POLLUTANTS ON MARINE COMMUNITIES AND ECOSYSTEMS (FAO(GFCM)/UNEP)

1. INTRODUCTION

Theoretically, several types of marine communities and ecosystems could have been studied in the framework of this pilot project. For practical purposes, the project focused on natural communities and ecosystems in coastal waters, lagoons and brackish coastal lakes, where changes might be anticipated as a consequence of man's activities. In addition, ecosystems in relatively unpolluted areas such as marine parks were studied for reference.

In order to detect long-term changes, particular emphasis was given to studying ecosystems in areas that had been studied previously.

To the largest possible extent the ecosystems were studied as integral units, taking into account the dynamic interactions among their various components. Special attention was given to the transport of pollutants between trophic levels by those organisms which were used in the monitoring pilot projects, MED POL II and MED POL III.

The parameters and effects under study varied, depending on the community and ecosystems. The most common ones were community structure, functional indices and body burden of pollutants.

The overall objective of the project was to provide information about the structural and functional state of Mediterranean marine communities and ecosystems which could then be used as the basis for analysing trends in their changes.

Furthermore, this project had the task of developing and testing methods which could be used for observing community and ecosystem modifications and in determining the waste-receiving capacity of various parts of the Mediterranean, as well as perhaps, the Mediterranean Sea as a whole. In connexion with these objectives, the project was expected to contribute directly to the development of principles and guidelines for the selection and management of specially protected marine areas.

The actual work of the national research centres on the pilot project started in March 1976.

This pilot project focused its research programmes on pollution-induced modifications of marine communities, usually in comparison with biocoenotic conditions in similar but non-polluted habitats. Whenever possible and practical, the studies of communities were accompanied by simultaneous measurements of basic physico-chemical environmental conditions and detections of the presence of pollutants, both in sea-water and on the sea bed.

The account of the results obtained through the pilot project is based on the results reported from the fourteen participants in the project.

2. PARTICIPANTS

Twenty research centres from eleven Mediterranean States were designated to participate in the pilot project.

By the end of December 1980, fifteen research agreements had been signed and one was cleared and ready for signature.

3. CO-ORDINATING ARRANGEMENTS

FAO(GFCM) maintained the operational contacts with the national research centres designated to participate in the pilot project.

The Centre de Recherche Océanographique et des Pêches, Alger, Algérie, was nominated in August 1976 to assist FAO(GFCM) as the Regional Activity Center for this pilot project.

Specific meetings held in connection with the pilot project included:

- FAO(GFCM)/UNEP Mid-term Expert Consultation on the Joint Coordinated Project on Pollution in the Mediterranean, (Dubrovnik, 9 - 13 May 1977), which also covered MED POL IV, and was attended by 25 participants from 17 research centres in 10 Mediterranean States.

4. FINANCIAL ARRANGEMENTS

Specific financial support to the pilot project was provided through projects FP/0502-75-01 and FP/0503-75-07 (both projects covering activities relevant to MED POL II, III, IV and V). Costs relevant to MED POL V (expressed in US dollars) were shared between the two co-sponsors of these projects as follows;

	1975	1976	1977	1978	1979	1980	Total	Percentage
FAO(GFCM)	6,000	6,900	8,168	7,800	6,700	5,785	41,353	15.2
UNEP	8,421	42,373	56,254	49,450	44,344	29,434	230,278	84.8
TOTAL	14,421	49,275	64,422	57,250	51,044	35,219	271,631	100.0

Direct support to participants in MED POL V up to 31 December 1980 amounted to US $ 132,939 and included the following:

- US $ 20,477 for equipment;
- US $ 46,318 for expendable materials;
- US $ 6,147 for training of five trainees (total of 4.5 man/months) from four research centres in two host institutions;
- US $ 5,912 for attendance at meetings;
- US $ 4,085 for consultants to participating research centres;
- US $ 50,000 as assistance to the Regional Activity Centre.

Indirect support to participants in MED POL V up to 31 December 1980 amounted to US $ 97,339. This sum included:

- US $ 56,325 for the service of consultants to assist FAO(GFCM) in the organization and execution of the pilot project, and in the evaluation of its results;
- US $ 7,217 for the organization of meetings;
- US $ 33,797 for the preparation of manuals, guidelines and reports.

The national contributions to the pilot project, estimated on the basis of incomplete information supplied by 11 participating research centres as equivalent to US $ 1,020,450, included:

- 1,083 man/months of professional and supporting staff (US $ 649,800 estimated at US $ 600 per man/month);
- US $ 150,550 as expendable materials;
- US $ 220,100 as operating costs of equipment.

5. OPERATIONAL DOCUMENT

The operational document of the pilot project was formulated at a joint FAO(GFCM)/UNEP Expert Consultation on the Joint Coordinated Project on Pollution in the Mediterranean, (Rome, 30 June - 4 July 1975) attended by 25 participants from 13 Mediterranean States. Certain modifications of the operational document were agreed upon at the Mid-term Expert Consultation for MED POL IV and MED POL V (Dubrovnik, 9 - 13 May 1977) which was attended by 16 experts from 13 research centres participating in MED POL V.

6. AREAS STUDIED

Since pollution mostly affects marine ecosystems in neritic zones, and also for practical reasons, the investigations were limited, with few exceptions, to coastal marine environments. Many polluted areas of the Mediterranean influenced by big rivers (Nile, Po and Rhône), large cities (Alexandria, Algiers, Athens, Izmir, Marseilles) and adjacent industrial agglomerations were investigated, as well as reference "clean" and insignificantly polluted areas for useful comparisons.

7. MATERIAL AND METHODS

7.1 Communities studied

Practically all the investigations whithin this project were carried out in neritic zones of the Mediterranean Sea, and by far the greater part of the research, with few exceptions (Gulf of Marseilles, Adriatic), was concentrated on inshore waters. About half the national programmes focused their research on pelagic communities and half on benthic. The above-mentioned exceptional programmes organized their investigations as a complex ecosystem approach which included both pelagic and benthic communities. The same approach was also used for studies of the effects of artificial pollution on an experimental lagoonary ecosystem (Strunjan, Adriatic).

Among benthic communities the greatest attention was paid to soft bottom communities of the infralittoral and circalittoral zones. Only three national programmes included investigations into hard-bottom communties, these usually being made in transects from intertidal to circalittoral zones.

In addition, some rather elementary research was done on lagoonary ecosystems. One programme was devoted entirely to studies of "fouling communities" on experimentally exposed substrata (Gulf of Athens).

Investigations into pelagic communities were focused mainly on phytoplankton, its structure, standing crops and productivity, while some programmes included zooplanktological research as well, and only one programme was entirely involved in zooplanktonic communities.

As previously mentioned, most of the community studies were accompanied by more or less systematic measurements of environmental conditions in the areas investigated.

7.2 Methods

7.2.1 Environmental measurements and analysis

The majority of the collaborating research centres used standard oceanographic procedures and more or less systematic year-round frequency of observations for the following parameters:

- temperature
- salinity
- turbidity (Secchi disc)
- pH
- dissolved oxygen
- BOD
- nutrients (N,P)
- total seston

Some centres applied in situ measurements of temperature, turbidity, salinity and dissolved oxygen.

Sediments were analysed by a number of research centres for granulometric composition and some geochemical determinations such as carbon content etc., by appropriate standard methods, but usually the sampling of sediments was performed by gear designed for benthos, which is not quite adequate for that purpose.

Some research centres made efforts to monitor specific pollutants such as faecal coliforms (bacteriological tests as recommended by MED POL VII), trace elements (polarographic and AAS determinations), anionic detergents (colorimetrically), organic carbon (IR analyses) and phenols (colorimetrically).

7.2.2 Pelagic investigations

In general, all research centres used methods that were at least comparable, usually the same as those recommended by UNESCO-IBP for both phytoplankton and zooplankton sampling, as well as for the determinations of standing crops and biomass.

Phytoplankton was collected by large inert plastic samplers, biomass as chlorophylls determined fluorometrically or by trichromatic spectrophotometry, and density and community structures were studied by the Uttermohl technique or by regular microscopy of concentrates made by membrane filtration. The functional primary productivity was measured according to ^{14}C assimilation or by diurnal oxygen dynamics.

Zooplankton was sampled by IBP- recommended nets, usually as vertical hauls. Biomass was determined gravimetrically as total dry weight and/or its organic fraction after ashing. Abundance and faunistic structure of the zooplankton was studied by well-known procedures of sorting, identification and counting zooplankton samples, usually at species level.

One research centre also measured total pelagic biopotential as adenilphosphates (ATP, ADP, AMP) by the Holm-Hansen bioluminescence method.

7.2.3 Benthic investigations

Due to important differences between the benthic habitats investigated, and also taking into account the unequal technical means and facilities at the disposal of the collaborating research centres, the methods used for investigating the benthos, and in particular the sampling, were not as comparable as for the pelagic studies.

However, at least the sampling of soft bottom communities was performed by a fairly similar technique, i.e. with two types of grab samplers: Van Veen and "Orange-peel", delivering 5-40 l of sediment. In addition, a newly developed quantitative benthos-nektoncorer for the sampling of shallow lagoonary communities and a number of dredges such as Charcot-Picard and Spatangue were used.

Hard bottom communities were sampled only orientatively by rock-dredges, while quantitative sampling was performed as a rule by divers. Samples were usually collected from 400 cm^2 of substrate surface.

Samples were always sieved through 0.5-2.0 mm mesh, preserved in formalin or ethanol and processed later on in a laboratory by well-known procedures of sorting, identification and quantitative analyses of taxonomic structures of communities. Biomass was determined quite variably: as wet weight, total dry weight or ash-free dry weight.

Based upon data on the quantitative taxonomic structure of communities, the results were evaluated according to dominance, affinity and diversity indices, using a number of different mathematical expressions such as those of Sorensen, Margalef and Shannon-Weaver.

7.2.4 Experimental research

Two participating research centres devoted their programmes entirely to experimental investigations, one on the modifications of the whole lagoonary ecosystem caused by artificial discharges of sewage, the other on successions of fouling communties on artificial substrata exposed to variably polluted environments. The methodological details on the performance of experiments are described in the relevant reports, but most of the methods applied for experimental measurement and sampling of communities were about the same as those described above.

8. SCIENTIFIC RESULTS AND DISCUSSION

A summary of the types of pollution in the areas studied is given in Table I. As a rule, almost all the areas investigated represent coastal marine environments under the influcence of large inputs of pollutants, the origins of which are fairly big cities (Alexandria, Algiers, Athens, Izmir, Marseilles, Rijeka, Split and Thessaloniki), their harbours, maritime traffic and important industrial activities. Although biodegradable municipal sewage usually makes up the main constituent of effluents, these discharges also contain a large variety of industrial pollutants. The identification of the types and composition of pollutants responsible for observed ecosystem modifications, in the sense of their physico-chemical and toxicological properties, was therefore not possible. The nature of the pollutants was even more difficult to identify in cases where, in addition to the above-mentioned sources, the areas investigated also receive discharges of big and heavily polluted rivers such as the Rhône and the Po. The only areas found to be polluted by effluents that could be identified were the coastal waters of Cyprus (discharges from the beverages industry) and experimental lagoons in Strunjan, Adriatic (domestic sewage of known rate and composition).

A summarized inventory of subjects investigated is given in Table I. The majority of the results obtained can be considered within the following four typical approaches.

Table I - Basic information on activities carried out by research centres participating in MED POL V

AREAS INVESTIGATED	POLLUTION SOURCES	POLLUTION TYPES	SUBJECT OF INVESTIGATIONS
Bay of Algiers	Algiers (2 million)	Domestic sewage Port - industry	Some environmental measurements
Bay of Bou Ismail	None	-	Sedimentological analyses
Lake of Mellah	None	-	Soft bottom communities
Limassol Bay	Limassol (65,000)	Domestic sewage Biodegradable industrial effluents	Soft bottom communities Demersal fish populations Systematic environment survey
Episkopi Bay	None	-	Sedimentological analyses
Coastal waters of Alexandria	Alexandria (2 million)	Domestic sewage Industry - rivers	Zooplankton-hyponeuston Fish-landing facilities Environmental survey
Harbour of Alexandria	Alexandria (2 million)	Domestic sewage Port - industry	Pelagic communities Some environmental measurements
Lake Menzalah		River discharges	
Gulf of Marseilles (Cortiou)	Marseilles (1 million)	Domestic sewage Port - industry	Pelagic communities Systematic environmental survey Analyses of pollutants Complex ecosystem approach

continued

Table I - Basic information on activities carried out by research centres participating in MED POL V (continued-2)

AREAS INVESTIGATED	POLLUTION SOURCES	TYPES	SUBJECT OF INVESTIGATIONS
Gulf of Marseilles (Cortiou)	Marseilles (1 million)	Domestic sewage Port - industry	Soft and hard bottom communities Environmental measurements
Gulf of Fos	River Rhône	Industry-polluted river	Sedimentological analyses Complex ecosystem approach
Saronikos Bay	Athens (1 million)	Domestic sewage Port - industry	Soft bottom communities Some environmental measurements Sedimentological analyses
Harbour of Piraeus	Piraeus (190,000)	Domestic sewage	Development and successions of fouling communities on experimentally exposed substrata
Harbour of Lavrion	Industry	Industrial effluents	
Bay of Thermaikos	Thessaloniki (350,000)	Domestic sewage Industrial effluents	Soft bottom communities
Kavala	Industry	-	Systematic environmental survey
Strymonikos	None	-	Sedimentological analyses
Gulf of Izmir	Izmir (650,000)	Domestic sewage Port - industry	Soft bottom communities Environmental survey
Bay of Kastela Sibenik Channel	Split (200,000) Sibenik (100,000)	Domestic sewage Ports	Pelagic communities Systematic environmental survey

continued

Table I - Basic information on activities carried out by research centres participating in MED POL V (continued-3)

AREAS INVESTIGATED	POLLUTION SOURCES	POLLUTION TYPES	SUBJECT OF INVESTIGATIONS
Bay of Rijeka	Rijeka (300,000)	Industry	Soft and hard bottom benthic communities
Mid-Adriatic (Reference Area)	None	-	
Coastal waters of Dubrovnik Bay of Gruz	Dubrovnik Gruz (100,000)	Domestic sewage Port	Pelagic communities Environmental measurements
North Adriatic Open waters Bay of Rijeka Istria coastal waters	River Po etc. Rijeka (300,000) Small local pollution	Complex pollution Domestic sewage Port - industry -	Pelagic and benthic communities of soft and hard bottoms Systematic environmental survey Complex ecosystem approach
Lagoon of Strunjan Gulf of Trieste	Experimental discharge 300 litres/day	Purely domestic sewage	Pelagic and benthic communities Pollutants analyses Systematic environmental survey Complex ecosystem approach

8.1 Complex ecosystems investigations

Polluted ecosystems were studied simultaneously from the aspects of physico-chemical environmental conditions and pelagic as well as benthic communities. Heavily polluted areas of the whole North Adriatic and of the Gulf of Marseilles were studied in this way. Results are comparable mutually as well as with other approaches and particularly with the results of artificially polluted experimental lagoons, and are reported below as conclusions.

8.2 Investigations into pelagic communities

Results obtained by pelagic investigations made in coastal waters of, e.g. the Middle and South Adriatic, are fully comparable with those of the above ecosystem approach and lead to mutual conclusions as reported below. Due to specific environmental and biogeographic conditions, results obtained in the coastal waters of Alexandria cannot be correlated as above. The modified dynamics of phytoplankton blooms, the frequency of which is increasing, are reported and explained by the changed hydrology of the Nile as well as by increasing pollution.

8.3 Investigations into soft bottom benthic communities

Since practically all the national programmes that focused their work on benthic communities used about the same sampling technique, their results are comparable mutually as well as with the results of complex ecosystem investigations as outlined above. There are, of course, quite important differences between observed communities due to the variety of habitats and biogeographic zones, yet a number of trends and phenomena in common were observed, as reported in the conclusions.

8.4 Experimental research

There is no methodological connection between the following two experimental programmes executed by this project:

- studies of recruitment and successions of fouling communities on experimentally exposed artificial substrata in the Harbour of Piraeus (polluted by domestic sewage) and in the Harbour of Lavrion (industrially polluted by elemental phosphorus, etc) demonstrated strong inhibitions in the latter environment, since developed communities were significantly less diverse than in the first case, although here too the environment was heavily polluted, by sewage in this instance. These specific observations are, of course, not comparable with other programmes of this pilot project;

- experiments of long-term artificial discharges of domestic sewage (300 l/day) into the lagoonary ecosystem of Strunjan gave results on pollution-induced environmental, pelagic and benthic modifications, which are fully comparable with those obtained by the particular complex ecosystem approaches of this project reported above.

8.5 Major issues of investigation

Environment

Investigated marine environments receiving significant inputs of pollutants in the form of a mixture of domestic sewage, urban run-off and some industrial effluents show some obvious deviations from natural conditions in the form of fluctuating and decreasing salinity, increasing turbidity, higher concentrations of organic matter and nutrients, particularly nitrogen and silicium compounds, silting of bottom substrata, etc. All the modifications mentioned can be considered more or less as the primary effects of the input of pollutants.

However, more important environmental stresses appear as the secondary consequences of modified trophic conditions which can, in most cases, be considered arbitrarily as eutrophication. As a rule, an increase in amounts of dead organic matter mainly deposited on the sea bed was observed, the decomposition of which leads to decreased oxygenation or even to anoxic conditions, with an obvious formation of H_2S in the bottom layers of the sea-water and a remarkably increased content of black sulphides even on the surface of sediments.

Anoxic conditions appear in very shallow inner parts of bays or in lagoons which are heavily polluted. They are usually periodic phenomena.

In eutrophicated environments, during the periods of active primary productivity, there were extremely sharp diurnal oscillations of the oxygen, CO_2 and pH values observed, e.g. up to 10 ml/l O_2 at noon and less than 2 ml/l during the night, while pH flactuated from 8.0 to 8.7 and total CO_2 from 1.5 to 2.6 mmol/l. The remarkable consequence of an extraordinary bloom in North Adriatic phytoplankton were observed in early summer 1977, with decreased oxygenation in the bottom layers (only 13 per cent saturation) and pH 7.8, while in surface layers it reached the expremely high value of 8.8.

Although there are obvious modifications in the concentrations and dynamics of nutrients, they are clearly recognizable only in rather localized sites of pollution sources, while for larger areas significant differences were not proved. As was shown, e.g. by pollution experiments in the lagoons of Strunjan, pollution-born nutrients are rapidly taken up by plant consumers, absorbed by sediments and dispersed. Therefore, data on concentrations and distribution of nutrients cannot be considered as a measure of eutrophicated conditions, unless they are accompanied by information on populations of primary producers, etc.

Pelagic communities

Considering eutrophication processes as observed in the areas investigated, it is evident that, in large areas such as the North Adriatic and the Gulf of Marseilles, combined pollution and riverborne enrichment increase overall primary productivity as expressed in terms of biomass (chlorophylls), density of phytoplankton populations and functional assimilation rates (^{14}C). Trends indicate a fairly steady increase in productivity. There also seems to be an increase in the intensity and frequency of bloom outbreaks which are not longer in line with the previous spring and autumn maxima and also appear during the summer period. The most typical examples of such phenomena was recorded in the North Adriatic; e.g. during 1977 the whole water-mass was "blooming" due to extremely dense phytoplankton populations (2.20 X 10^6 cells/l, chlorophyll a 10 µg/l) composed mainly of non-identified chrysoflagellate species, a few species of dinnoflagellates and remarkable red-tides of Noctiluca miliaris. Similar shifts of previously normal bimodal (spring-autumn) maxima to successive blooming pulses at 2-3 month intervals (including early and late summer peaks) are reported by one national programme for coastal formations of the Alexandria region as well as by other national programmes for Saronikos Bay (Aegean Sea) and the Bay of Kastela (mid-Adriatic).

Quite different seems to be an immediate influence of pollutants on phytoplanktonic communities as observed in discharge areas of municipal effluents of Marseilles (Cortiou) and as found also by pollution experiments in lagoons. Although pelagic biomass, in terms of chlorophylls, was quite high, this was not the case with phytoplankton densities, which were even lower than those found in comparable, natural or slightly polluted, environments. The high biomass might be due to allochtonous pigments (debris of terrestrial vegetation in effluents) or to specifically increased populations of microflagellates which escape routine phytoplankton counts. There is, however, little doubt about the fact that mixed municipal effluents in the "immediate contact zones" inhibit conventional phytoplankton communities. In such environments both density and diversity of species are very low and, apart from microflagellates, there are very few highly resistant species that can survive. These are the euglenoid Eutreptia spp., dinoflagellates Prorocentrum sp., Gymnodinium spp., diatoms Nitzschia spp., and tychopelagic naviculoids, etc.

Typical "bloom species" which have been reported as the major causes of the eutrophication phenomena in pollution-enriched areas are actually quite common neritic species of the diatoms Skeletonema costatum, Leptocylindrus danicus, Nitzschia seriata and Chaetoceros. Blooms (red tides) are caused, however, by a number of dinoflagellate species, a still unidentified chrysophyte species and heterotrophic Noctiluca.

Zooplankton communities seem to be less affected than phytoplankton communities except under an immediate pollution stress which drastically reduces species diversity as well as abundancy and standing crops. Larger enriched areas also show relatively decreased diversity, although standing crops and abundance of some tolerant neritic species may significantly increase. Such arbitrarily "indicative species" as the copepods Acartia clausi, Oithona nana, Euterpina acutifrons and the cladoceran Penilia avirostris were found in almost all investigated areas.

Benthic communities

(a) Hard-bottom communties were investigated only in the Adriatic and in the Gulf of Marseilles. Although it is quite difficult to compare situations found in these biogeographically different zones some phenomena are common to both:

- Habitats within the immediate influence of effluent discharges are practically free of any macrobenthic fauna except some barnacles, Balanus spp.

- Moderately polluted habitats are characterizied by rich nitrophilic vegetation composed usually of the green algae Enteromorpha spp. and Ulva rigida. As a rule such substrata are also covered by deposits of organic detritus and mineral particles inhabited by a number of highly resistant species of polychaetes, e.g. Platynereis dumerili and amphipods; in one case also dense populations of the ophiuroid Ophiocomina nigra was reported. Mediolittoral and upper infralittoral zones are often densely covered by a number of euryvalent filtrator organisms such as the mussel Mytilus galloprovincialis, the ascidian Pyura spp. and the recently introduced exotic oyster Crassostrea gigas (North Adriatic).

- Slightly polluted habitats may show higher values of standing crops and overall productivity combined with decreased diversity and a general simplification of communities. However, significant scientific evidence is rarely obtained.

(b) Soft bottom communities were at the centre of investigations, and from quite comparable results some general conclusions can be drawn.

Regarding inshore benthic communities of sedimentary bottoms affected by important amounts of mixed domestic-industrial pollutants, the following three levels of biocoenotic degradation were found in common:

- azoic zone where no living benthic organisms are found. Such zones were observed in the immediate vicinity of sewage outlets and in the most polluted harbours. Azoic refers to the absence of macrofauna although such areas might be inhabited by highly resistant species of meiofaunal nematods, harpacticoids and oligochaetes;

- heavily polluted zones are characterized by communities composed of highly resistant organisms which can survive in an environment where practically all environmental factors sharply oscillate, waters are turbid, sedimentation rates and silting are very intense, oxygenation is low and bottom layers are often anoxic. The main components are those species of polychaetes which can be considered to some degree as "pollution indicators", such as Capitella capitata and Scololepis fuliginosa in all observed areas, and Notomastus latericeus in Aegean areas; in the North-Western area Dorvillea rudolphi and Nereis caudata were found as well;

- moderately or slightly polluted zones can be considered as subnormal and usually eutrophicated environments, inhabited by communities composed of a great number of species known to be ecologically quite resistant. Due to the high trophic potential of such environments, standing crops are abundant and the productivity of benthic communities is high, mainly on the part of molluscs, polychaetes, echinoderms and crustaceans. For these reasons, and since those sensitive species, which would in natural conditions form part of those communities, have disappeared, the diversity of such communities is rather low, as was proved by the results of this pilot project. The taxonomical structures of such communities were found, however, to be very different from site to site - for obvious reasons of different habitats and biogeographical situations.

With regard to sea-grass communities, mainly the dominant vegetations of *Posidonia oceanica* or *Cymodocea nodosa*, the reports made clear that in many localities of the Mediterranean these communities are degraded or are totally disappearing in areas of important urbanistic and industrial development. Not only pollution effects, but also man-made modifications of hydrologic and sedimentation conditions are blamed for this phenomenon, and the overall ecological consequences might be responsible for one of the most negative impacts on coastal and lagoonary environments of the Mediterranean. Artificial discharges of purely domestic sewage (300 l/day) into the experimental lagoons of Strunjan, dominated by the vegetation of *Cymodocea nodosa*, demonstrated how easily and quickly this community could be totally destroyed: within one year all sea-grass was replaced by nitrophilic green algae, and two years after the experiment was discontinued none of the sea-grass vegetation had reappeared.

8.6 Conclusions

The research carried out under the pilot project has certainly contributed towards a better understanding of the impact of pollution on Mediterranean marine ecosystems. The results pointed out a number of extremely degraded pollutants where communities of macro-organisms are almost totally exterminated, and regressively modified in large sub-areas where pollution effects are traceable. Examples of such local ecological disasters are found in the inshore waters of Alexandria, Athens, Izmir, Marseilles and Thessaloniki. Results also indicate that massive combined loads of coastal and river-borne pollution are causing considerable modifications of whole ecosystems in the North Adriatic and possibly in the golfe du Lion, showing clear trends towards a general eutrophication and consequent ecological disequilibria. Man-made modifications of sea-grass communities were pointed out as being an expanding phenomenon of general importance.

These conclusions, of course, cannot be generalized for obvious reasons, and particularly because the investigations of this pilot project did not cover as many Mediterranean areas as would have been desirable.

9. OTHER RESULTS

Research agreements were succesfully negotiated with most of the research centres, and signed by 75 per cent of those designated as participants in the pilot project.

Information relevant to the effectiveness of the administrative and financial arrangements made by FAO in connection with the pilot project was received from 11 research centres (75 per cent of those with signed research agreements).

9.1 Training

All five trainees submitted their technical reports but only three of them submitted reports evaluating their training.

The problems encountered in reporting to FAO, the participants' evaluation of the benefits they had gained from participation in MED POL V and the evaluation of the benefits from training, are similar to those described under MED POL II, III and IV.

9.2 Regional Activity Centre

The assistance provided by the Regional Activity Centre to the efficient operation of the pilot project consisted of:

- collaboration with FAO(GFCM) in analysis and evaluation of the interim and final reports of the MED POL V investigators;
- preparation of a manual on ecological assessment of pollution effects;
- collaboration in the preparation of the MED POL V Data Inventory Form;
- contribution of 293 references to the Mediterranean pollution bibliography.

In view of the initially insufficient expertise available at the research centre selected as the RAC for this pilot project, its performance is evaluated as good and of importance to the pilot project.

9.3 Documentation

Documents specifically developed for this pilot project include:

- Manual of Methods in Aquatic Environment Research. Part 2: Guidelines for the Use of Biological Accumulators in Marine Pollution Monitoring. FAO, Fisheries Technical Paper No. 150. FAO, 1976, 76 p.
- Manual of Methods in Aquatic Environment Research. Part 3. Sampling and Analysis of Biological Material. FAO, Fisheries Technical Paper No. 158. FAO, 1976, 124 p.
- Manual of Methods in Aquatic Environment Research. Part 5: Statistical Tests. FAO Fisheries Technical Paper No. 182. FAO, 1979, 131 p.
- Manual of Methods in Aquatic Environment Research, Part 8; Ecological Assessment of Pollution Effects. FAO Fisheries Technical Paper No. 209. FAO, 1981, 70 p.

10. SUMMARY

This pilot project focused its research on pollution-induced modifications of marine communities in comparison with biocoenotic conditions in similar but not polluted habitats. The project was unable to cover all areas of the Mediterranean; however, many polluted areas influenced by big rivers, large cities and adjacent industrial conglomerations were quite well investigated.

The majority of the collaborating research centres used standard oceanographic procedures for environmental measurements, granulometric procedures for the study of sediments, IBP- recommended methods for phyto-and zooplantkton studies, different but comparable techniques for soft-bottom communities and for hard-bottom communities which were studied only for orientative purposes. The samples were processed according to commonly accepted procedures and biomass determination was made by various methods.

The results reported refer to the environmental stresses and effects on phyto-and zooplankton communities as well as on soft- and hard-bottom communities of selected marine areas. They pointed out a number of extremely degraded coastal environments in immediate contact with pollutants, where some communities are almost totally exterminated and regressively modified. Results also indicated that massive and combined loads of river-borne and coastal pollution in certain areas caused considerable modifications of the whole ecosystem with trends towards general eutrophication and consequently to ecological disequilibria. Modifications of sea-grass communities should be considered as an expanding phenomenon of general importance.

The research carried out under this pilot project has certainly contributed towards a better understanding of the impact of pollution on Mediterranean marine ecosystems, but it is obvious that these results cannot be generalized for the whole Mediterranean.

MED POL VI: PROBLEMS OF COASTAL TRANSPORT OF POLLUTANTS (IOC/UNEP)

1. INTRODUCTION

The investigation of surface circulation in the Mediterranean is obviously necessary to understand the problems of coastal transport of pollutants. Most pollutants either float on the sea surface or exist in a mixed state within the upper surface layer. The transport of such pollutants is, therefore, affected by surface circulation. Hence, for the Mediterranean coast in general, where different sources of pollution exist, knowledge of coastal currents, and a better understanding of their seasonal variability in relation to wind action and offshore exchange is essential.

The main aim of the MED POL VI Pilot Project was the investigation of water circulation and stratification in coastal areas, and the exchange of water between the coastal and offshore regions, so as to provide the necessary information on one of the main physical processes contributing to the coastal transport of pollutants in the Mediterranean Sea. Special attention was paid to the movement of the surface layer since this contributes to the rapid spread of certain pollutants (e.g. floating oil and litter).

The account of the data obtained through the MED POL VI project is based on the information provided by seventeen participating laboratories representing eleven Mediterranean countries. No attempt has been made to include the very large amount of previous and present research information relevant to the problem of coastal transport of pollutants in the Mediterranean conducted by research centres not participating in the MED POL VI project.

The information provided by this project is useful in the assessment of all the aspects of marine pollution covered by the other pilot projects. This information is also necessary for the formulation and testing of predictive models of the biogeocycles of pollutants in the Mediterranean Sea.

2. PARTICIPANTS

Twenty-three research centres from thirteen Mediterranean States were designated to participate in the pilot project.

By the end of December 1980, 13 research agreements had been signed and three were cleared and ready for signature.

3. CO-ORDINATING ARRANGEMENTS

IOC maintained the operational contacts with the national research centres designated to participate in the pilot project.

The Institute of Oceanography and Fisheries, Mediterranean Branch, Alexandria, Egypt, was nominated in August 1976 to assist IOC as the Regional Activity Centre for this pilot project.

Specific meetings held in connection with this pilot project included:

- IOC/WMO/UNEP Mid-term Review Meeting (Barcelona, 23-27 May 1977) which covered MED POL VI as well as MED POL I, was attended by 32 participants from 24 research centres in 12 states.

4. FINANCIAL ARRANGEMENTS

Specific financial support to the pilot project was provided through projects FP/0503-75-06 (provided also support to MED POL I) and FP/0503-76-04. Costs (in US dollars) were between the three co-sponsors of the project as follows:

	1975	1976	1977	1978	1979	1980	Total	Percentage
IOC	3,500	8,600	12,300	16,100	10,000	4,000	54,500	20.2
UNEP	8,808	10,134	97,866	18,227	79,323	1,000	215,358	79.8
TOTAL	12,308	18,734	110,166	34,327	89,323	5,000	269,858	100.0

5. OPERATIONAL DOCUMENT

The operational document of the pilot project was formulated at a joint IOC/WMO/UNEP Expert Consultation on the joint Coordinated Projects on Pollution of the Mediterranean (Msida, 8-13 September 1975) attended by 36 participants from 12 Mediterranean States. Certain modifications of the operational documents were agreed upon at the Mid-term Review Meeting for MED POL I and MED POL VI (Barcelona, 23-27 May 1977) which was attended by 17 experts from 17 research centres participating in MED POL VI.

6. STUDIED AREAS

The areas included in the MED POL VI pilot project were usually those in the vicinity of the participating research centres where present or future pollutant discharges might cause problems, such as river estuaries or coastal areas affected by industrial development. To understand the water exchange between coastal and offshore regions, some of the laboratories also conducted studies in offshore as well as coastal areas. The zones covered by these investigations are shown in Figure 1.

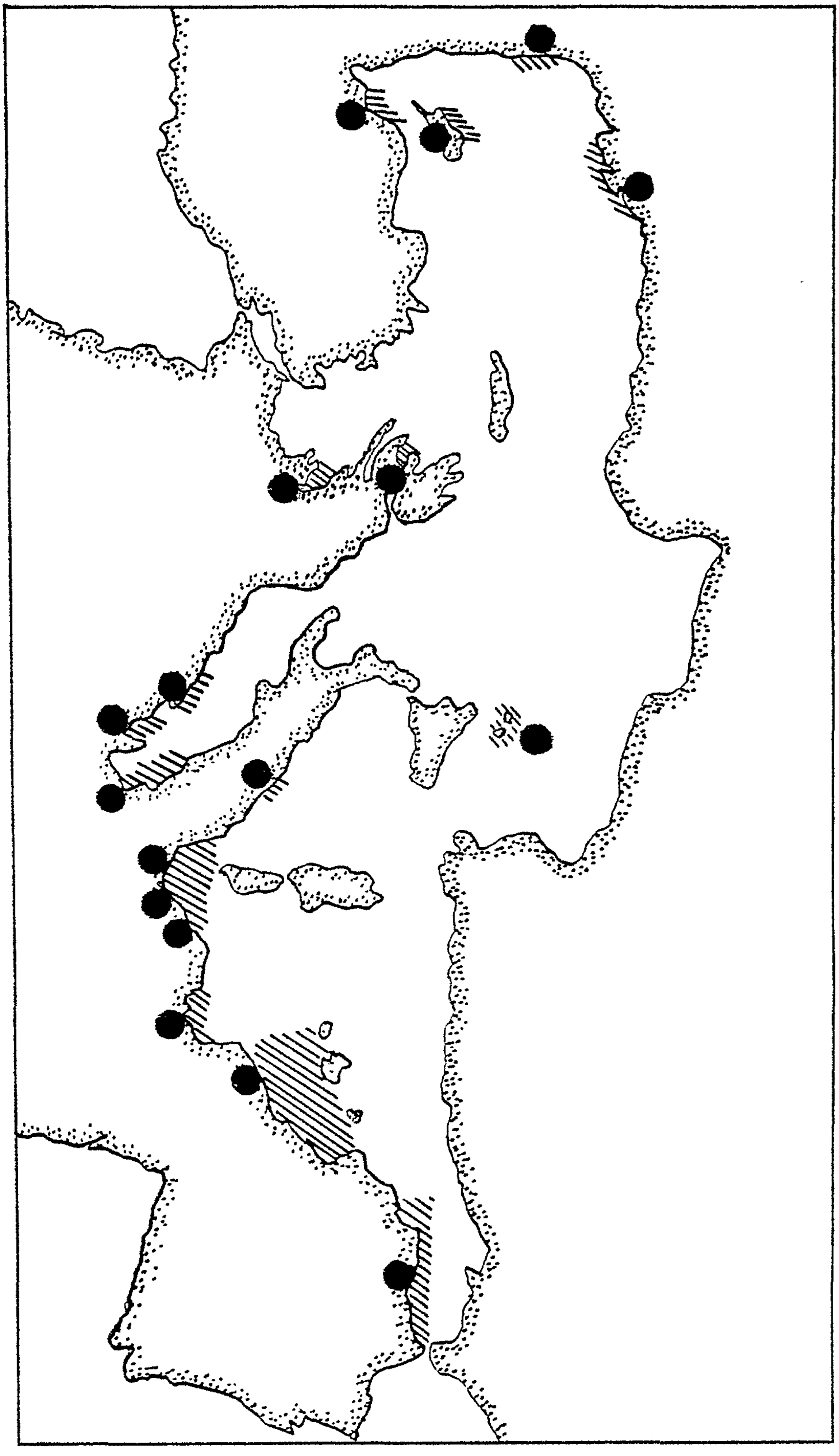

Figure 1. Areas covered by the research centres MED POL VI

Basic parameters and techniques

The basic parameters monitored were:

- currents both above and below the thermocline (if this existed);
- salinity and temperature, to provide data on the water stratification, which is normally very important in pollutant transport since pollutants are often discharged in a body of relatively low-density water (e.g. effluent outfalls - river water outflow):
- surface wind, which is a major driving factor in many coastal circulation systems;
- bathymetry, since it has a major influence on coastal circulation.
- river discharge, where applicable.

The techniques used for current measurements included:

- drift-cards or drifters;
- drogues;
- traces and dyes;
- current meters.

In addition, several research centres provided further complementary information such as hydrochemical parameters (e.g. dissolved oxygen and nutrient substances). Data were also available to some extent on suspended solids, transparency of the water, organic matter in sediments, etc.

7. RESULTS

Most of the data included in this report have been presented by the participating laboratories at the ICSEM/UNEP workshop in Antalya, Turkey in 1978 and Cagliari, Italy in 1980.

Table I shows the basic parameters monitored by each of the participating research centres.

The DRIFTEX experiment

At the IOC expert consultation held at Msida, Malta, in 1975, a recommendation was put forward on the use of the drift-cards and drifters as means of studying the general surface circulation of the Mediterranean Sea within the framework of MED POL. This recommendation was later implemented at the meeting that took place at Split, Yugoslavia in 1976 where it was agreed to start the DRIFTEX experiment as a subregional activity with the main thrust in the Ligurian Sea and parallel experiments in the Eastern Levantine Sea (Egyptian cost) and the Adriatic Sea (Rijeka Bay).

Table I - Basic parameters monitored by the participating laboratories

INSTITUTE	DRIFTEX EXP.	METERS	DROGUES	CURRENTS DRIFTCARDS	DYES	GEOSTROPHIC CALCULATION	5°/oo	T°C	WINDS	REMARKS
F.D.M.A.N.R. Nicosia, Cyprus	-	x	x	-	-	-	x	x	x	
I.O.F. (a) Alexandria, Egypt	x	x	-	x	-	-	x	x	x	
I.O.F.R. Athens, Greece	-	x	-	-	-	-	-	-	x	
U.T.L.H. Thessaloniki, Greece	-	x	x	-	-	-	x	x	x	
S.Z. Villefranche-sur-Mer, France	x	-	-	-	-	-	-	-	-	
L.O.P. Paris, France	-	-	-	-	-	-	-	-	-	Satellite infra-red photographs
O.L.R.L. Haifa, Israel	-	x	-	-	-	-	-	-	-	
G.R.O.G. Genova, Italy	x	-	-	x	-	x	x	x	x	

(a) MED POL VI Regional Centre

Continued

Table I - Basic parameters monitored by the participating laboratories (continued-2)

INSTITUTE	DRIFTEX EXP.	METERS	DROGUES	CURRENTS DRIFTCARDS	DYES	GEOSTROPHIC CALCULATION	S^{o}/oo	T°C	WINDS	REMARKS
I.R.S.A. Rome, Italy	–	x	x	–	–	–	x	x	x	River discharge Remote sensing by satellite and aircraft
T.O.U. Msida, Malta	–	x	x	x	–	–	–	–	x	
C.S.M. (b) Monaco, Monaco	x	–	–	x	–	–	–	–	–	
I.I.P. (c) Barcelona, Spain	x	–	–	–	–	x	x	x	–	
I.E.O. Málaga, Spain	–	–	–	–	–	x	x	x	–	
M.E.T.U. Erdemli-Içel, Turkey	–	x	–	–	–	–	–	–	x	
R.B.I. Zagreb, Yugoslavia	x	x	–	x	–	x	x	x	x	
I.O.F. Split, Yugoslavia	–	x	–	–	x	–	x	x	x	

(b) Mailing Centre for DRIFTEX experiment in the Ligurian Sea

(c) Developed computer method for processing drift-card data and analysis of DRIFTEX results

The first experiment was considered a trial for further experiments and involved three research groups: the Gruppo di Ricerca Oceanologica di Genova, the Centre Scientifique de Monaco and the Station Zoologique de Villefranche-sur-Mer. The Centre Scientifique de Monaco, in addition to participating in the launching of drift-cards, was to act as the mailing centre for the experiment. The other two DRIFTEX experiments were carried out at the national level by the Institute of Oceanography and Fisheries of Alexandria, Egypt and by the Centre for Marine Research of the "Rudjer Boskovic" Institute of Zagreb, Yugoslavia.

The DRIFTEX experiment was initiated in April 1977, for the Ligurian Sea, while the other two experiments were already operating on a routine basis. Three vessels were involved in the Ligurian Sea experiment: Petrarca, Ramage and Korotneff. Five thousand drift-cards were released at 38 different locations in groups of 100 and 200 cards. The recovered cards were mailed to the Centre Scientifique de Monaco where the information from the recovering sites was classified and translated into geographic co-ordinates. A little more than a year after the beginning of the experiment, slightly more than 500 cards were recovered throughout the western basin of the Mediterranean Sea.

As a result, it was clear to all participants in the experiment that a comprehensive computer programme was necessary for processing the data. With financial support from IOC, the Instituto Investigaciones Pesqueras de Barcelona, Spain, developed a computer programme for processing the drift-card data (Cruzado, 1978; Salat y Cruzado, 1981). The system was planned to estimate the surface velocity field, using the information obtained through the drift-card experiments.

This system carried out:

- computation from release and recovery data, of simple parameters (distance, linear velocity) and overall statistics (dispersion, frequency of arrival);

- selection based on these parameters and statistics, of a set of drifters to be further processed;

- simulation of individual trajectories by means of numerical model;

- computation of a surface velocity field, over the region covered by the experiment, on the basis of the simulated trajectories.

The computer model considers that all cards in a set, advance simultaneously stepwise forming a pencil of trajectories. When certain criteria hold, the initial pencil trajectory subdivides until the cards are dispersed and allowed to proceed to their respective arrival points. The coastline, as a boundary, is included in the model.

The surface drift computed from the drift-cards trajectories in the Ligurian Sea was coherent and consistent with previous oceanographic knowledge. The general NE to SE currents along the French and Spanish coasts and the cyclonic gyre in the Ligurian Sea were features clearly identified by the experiment. The effect of the meteorological conditions on the trajectories of the drift-cards was also evidenced. Unfortunately, since this information was not available, the effect of the wind was not included in the model. A final report on the DRIFTEX experiment was published as document UNEP/WG.118/Inf.6.

The results of the DRIFTEX experiment in the Adriatic Sea (Rijeka Bay) were reported by Ilic et al., (1979). A total of 4,200 drifters were released in the bay between 1976 and 1977 with an avarage recovery of 21 per cent. The results of the experiments indicated that in winter there is a cyclonic flow of currents prevailed, particularly in the N and NW areas of the bay.

The experiments carried out in the Levantine Sea (Egyptian coast) were reported by Gerges (1979). A total of 2,664 drifters were released along the Egyptian coast with an average return of about 20 per cent. The results of the experiment pointed out the influence of the main eastward flow, circulation in the eastern Mediterranean, on the surface water movement at the offshore stations. Meanwhile, a tendency for strong onshore components of surface drift was revealed at the nearshore stations, with great variabilities of speed and direction, depending upon the prevailing winds.

Reports from the studied areas

Since the MED POL VI data are specific to each area studied, a brief compilation of the results is presented in this section, starting from the Straits of Gibraltar and proceeding clockwise around the Mediterranean.

Spain

Instituto Espanol de Oceanografia, Laboratorio Oceanografico de Malaga

This laboratory conducted hydrographic studies during November 1978 in the Alboran Sea from the Straits of Gibraltar to the meridian that passes through Oran and Cabo de Palos.

The results of geostrophic current calculations indicated that the Atlantic current gives rise to two large gyres in the Alboran Sea, the first, in the western part, being anti-cyclonic and the second, in the eastern sector, being cyclonic. The latter was larger and more intense than previously observed.

It was also found that the 36.7 $^{o}/oo$ isohaline, at the time of the year, divides the Alboran Sea into two zones to the east and west of the imaginary line joining Alboran Island and Almeria.

Water surface temperatures were quite uniform in the Alboran Sea and the thickness of the mixed layer varied from 20 to 70 meters in depth.

Instituto de Investigaciones Pesqueras de Barcelona

This research centre made estimations of the general circulation in the Catalonian Sea based on geostrophic computations.

The Catalonian Sea is under the influence of a cyclonic gyre between the mainland and the Balearic Islands maintained by the density gradient established in the centre of the Sea. This gradient is due to the fresh water from the River Rhône along the north-west coast, and to the Atlantic current passing through the channels between the islands (Font, 1979).

Geostrophic current calculations confirm the generally cyclonic circulation characteristic of the western basin of the Mediterranean in the summer with a well-defined north-east-south-west current along the Catalonian Coast being strongest to the east of Cape Creus. This current weakens considerably in winter.

In the vicinity of the Balearic Islands, on the other hand, a south-west-north-west current, which is relatively strong (40 cm/s) strengthens in winter (50 cm/s). In the channels between the islands, the Atlantic water is displaced at the surface towards the west, with a counter-current at depth. In the channel between Ibiza and Cape Nao there is a displacement of water southwards at the surface and subsurface.

Off the coast of Barcelona, the water tends to flow south-westwards throughout the year at the outer edge of the continental shelf at speeds between 20 and 40 cm/s, with short-lived reversals in summer (August-September) and winter (February-March). Over the continental shelf the current direction is north-westward but weaker, again with short-lived reversals during the same periods.

It is necessary to point out, however, that geostrophic current calculations must be used cautiously in a nearly closed sea like the Mediterranean with complex bottom topography. The need for direct measurements is seen to be important to the verification of these calculated geostrophic currents.

The calculated trajectories of the drift-cards released in the Ligurian Sea during the implementation of the DRIFTEX experiment, also confirm the cyclonic gyre of the western basin of the Mediterranean. Cards that entered the Catalonian Sea tended to continue, parallel to the coast, to the south-west, whereas those passing to the east of the Balearic Islands followed elliptical trajectories returning towards Corsica, Sardinia and the Italian mainland.

A computer programme for analysing drif-card data was developed by the Insitute and applied to the DRIFTEX data gathered in the Ligurian Sea and the Levantine Sea.

France

Laboratorie Arago, Banyuls-sur-Mer

This research centre made a series of measurements over a network of coastal stations, but no results were submitted.

Laboratoire d'Oceanographie Physique du Muséum, Paris

The scientific studies carried out by this research centre in the Mediterranean Sea included:

- air-sea interaction: turbulent exchanges of energy have been studied in relation to waves and currents formation:
- marine climatology: preparation of an atlas of characteristics (temperature, salinity, etc) for Mediterranean surface and deep waters (Saint-Guilly, 1979);
- deep water formation and vertical motions: analysis of the results are being completed;
- currents and upwelling in the Golfe du Lion and in the Ligurian Sea have been investigated with sea-moorings, remote sensing techniques and numerical models.

Station Zoologique, Villefranche-sur-Mer

Active participation in MED POL VI by this institution was limited to the DRIFTEX experiment in the Ligurian Sea.

Centre Scientifique du Monaco, Monaco

This research centre participated in the DRIFTEX experiment in the Ligurian Sea.

Italy

Gruppo di Ricerca Oceanologica, Università di Genova, Genova

This research centre participated in the DRIFTEX experiment in which a total of 64,000 cards were released at stations up to 12 miles from the coast. Initial results of the data confirmed the cyclonic pattern of the littoral current. It is also interesting to note that the released cards were scattered unevenly over long stretches (110-130 miles) of the coastline west of their release point.

Recent data on current measurements as well as hydrological determinations gathered in the coastal region, indicate that the general circulation is a longshore flow of surface water from east to west.

Istituto di Ricerca sulle Acque, Consiglio Nazionale della Ricerca, Roma

A study of the River Tiber to ascertain the fate of river-borne pollutants in the estuary and adjacent coastal area, was the research, relevant to MED POL VI, conducted by this research centre.

Both the results of water sample analysis and the measurement of currents have made it possible to draw isopleths of the concentration of various substances, showing their distribution on the coastal area.

Remotely sensed data have also been used to provide synoptic images of the affected area.

Osservatorio Geofisico Sperimentale, Trieste

An extensive study of the northern Adriatic, from Trieste to Ancona, has been conducted by this research centre. The whole of the area is shalllow, descending gradually from about 20 m in the Gulf of Trieste to 80 m in the central part of the section Ancona-Zadar. Many important rivers, including the Po, flow into this shallow area.

The general circulation pattern in this area is cyclonic with tidal and wind-driven currents superimposed. Both moored recording current-meters and GEK methods have been used for current measurements.

Yugoslavia

Centre for Marine Research, "Rudger Boskovic" Institute, Zagreb

This research centre proposed Rijeka Bay as the area for the studies related to MED POL VI. The main reasons for the choice were:

- ongoing complex ecological studies;
- well-defined physical bounderies;
- interest in the transport of pollutants within the Bay.

The results of the drif-card experiment indicated that in the winter period (December-February) there was a cyclonic flow of currents in the surface water of Rijeka Bay, while in the summer period (August) a rotatory flow of current prevailed, especially in the N and NW sections of the Bay.

The measurements at Rijeka Bay have been expanded to include data gathered with recording current-meters at eleven stations five times a year during periods of 24 and 72 hours. The surface water circulation was found to be anti-cyclonic during the summer months (May-August) with an exchange rate of about 0.07 km^3/h. During the rest of the year the circulation was cyclonic leading to exchange rates of about 0.2 km^3/h (Jeftic et al., 1981).

Study of the kinematics and dynamics of Rijeka Bay surface currents shows that mechanical factors can be, at least partly, responsible for the anticlockwise circulation in winter while non-mechanical factors contributed to both the clockwise circulation in summer and anticlockwise circulation in winter. This analysis represents a basis for the application of numerical models, which should help shed light on the quantitative relationship between the above mentioned factors and those that act outside the Bay.

Regarding the modelling of thermal plumes, seven models were compared in items of their structural, predictive and implementational characteristics. On the basis of this comparison, the Shirazi-Davis model was selected for application to the Urinj and Sepen sites, where cooling waters from a power and petrol-chemical plant, will be discharged. The model was successfully applied at both locations to obtain spatial behaviour of the steady-state temperature field.

Institute for Oceanography and Fisheries, Split

The Dalmatian coast from Zadar to Dubrovnik has been studied by this research centre. Currents were measured by direct-reading and recording current-meters, and the results of the study carried out in the area described indicated their current speeds were rather low from 5 to 15 cm/s on the average. Tides were not important in the water transport (average amplitudes between 11 and 14 cm).

Dispersion of current directions is large, the prevalence of the north-westerly direction being statistically evident, especialy during the winter season. The westerly direction is also frequent in the surface layer and is assumed to be offshore current due to the "Bora" (cold north-easterly wind), associated with coastal upwelling.

The current system is strongly influenced by atmospheric forcing (Gacic, 1981). During summer the response is predominantly baroclinic, the upwelling and coastal jet being caused by the offshore wind. Summer upwelling was apparent in the temperature data. In winter the barotrophic motions are more important. Shore-ward sea-water transport is the consequence of the south-easterly winds over the whole Adriatic Sea. Oscillations in the current field over a period of about ten days are present, and can be expected in terms of internal Kelvin waves originating in the Mediterranean. Inertial oscillations are found to occur very rarely and their energy is on average, smaller than the energy of tidal oscillations.

Diffusion experiments were carried out at three sites, Zadar, Split and Dubrovnik, using Rhodamine B as an instantaneous spot source. The relation between currents and diffusion coefficients showed that pollutants are transported faster in the Split area than in the other two sites.

Greece

Institute of Oceanography and Fishing Research, Athens

The Saronikos Gulf was selected by this research centre to conduct oceanographic studies, within the framework of MED POL VI, as part of a major environmental pollution control project. This region is of primary interest considering that:

- it is a pathway from Pireus Harbour which contributes to the pollutant load of the Gulf;

- it is the area where the main sewage outfall of metropolitan Athens is located;

- it is a densely populated area, and the eastern coast is used for recreational purposes.

Current measurements were carried out using recording current-meters moored at a network of stations in the Saronikos Gulf, both in the upper water layer and near the bottom.

The most frequently recorded current velocities were within the range of 3 to 7 cm/s, although the maximum observed velocity was 27 cm/s. All measurements showed a high predominance of two modal directions, though very often they differed by 180°, which is evidence of the presence of tidal periodicities.

The inner Saronikos Gulf is characterized by a weak field of velocities. There are no significant tidal forces and the evaluation of tidal components becomes rather difficult and of minor importance. Baroclinic conditions are developed only in the summer (April-October).

The evidence of clockwise and counter-clockwise circulation, as well as the fact that the predominant winds are northerly and southerly, gave some indication of wind-driven circulation in the Gulf. Additional computations are being made with wind records to determine whether southern winds develop an anti-cyclonic circulation and northern winds, a cyclonic one.

Laboratory of Hydraulics, Aristotle University of Thessaloniki, Thessaloniki

This research centre has conducted current measurements using recording current-meters in Thessaloniki Bay. The Bay is a semi-enclosed basin presenting an opening shoutwards to the Aegean Sea. It is naturally divided into three sections, the inner part and central by having a mean depth of about 20 meters, and the outer bay (Thermaikos Bay) into which two major rivers flow.

A numerical simulation of the hydrodynamics of Thessaloniki Bay was prepared, based on the completed studies, and computations on the water circulation for various boundary conditions (wind, tide, river discharge, etc) is available on the UNIVAC 1106 computer of the University. Calibration of the mathematical model to find the eddy viscosity distribution, thus giving more satisfactory results for the surface elevation and the water currents, has neared completion (Ganoulis and Koutitas, 1981).

Turkey

Marine Science Department, Middle East Technical University, Erdemli-Icel

Very little is known about the dynamics of the deep and shallow waters along the southern coast of Turkey. This is especially unfortunate because the region extending from the Bay of Iskenderun in the east to Anamur in the west is rapidly being industrialized. This meagre knowledge of the aforementioned waters is particularly evident regarding the characteristics of currents, including both spatial and temporal variabilities.

As a first step, a measurement programme involving a sequence of observations was carried out to investigate the characteristics of currents in coastal waters 40 kilometers west of Mersin where the Marine Science Department of METU is located. The results of these preliminary experiments, using recording current-meters moored at 5 and 10 meters depths, indicated that the longshore currents were stronger than those in the onshore-offshore directions. They showed significant oscillations with periods greater than two days, which correlated with wind stress as well as diurnal and semidiurnal components (Unluata et al., 1979).

Further studies conducted on the Turkish continental shelf adjoining the Cilician Basin from August 1978, through January 1979, indicated low frequency currents with periods of up to 16 days or more due to topographic Rossby waves in the canal-like Cilician Basin region. Motions with periods up to 10 days were attributed to internal Kelvin waves. Superimposed on these low frequency motions, a net current flows in a westernly direction. In the high frequency range, surface currents are generated by the highly energetic sea-breeze system during the summer months. Inertial motions are detected during winter when cyclonic disturbance are increased.

The results of additional research carried out from June to August 1 1980, were in harmony with earlier studies and clearly demonstrated the variability of the currents over the shelf. The detailed spectral examination of the currents and their correlation with the local winds has been under study. A north-westerly flow parallel to the coast was present in the measurements, implying a net westerly transport of materials introduced locally. The fluctuations in the onshore-offshore currents pointed to the possibility of coastal trapping of pollutants (Unluata, et al., 1981).

Analytical models were being developed to study the diurnal and inertial oscillations from current-meter data, using wind-stress as input, and also to understand mean circulation in variable currents.

Cyprus

Fisheries Department, Ministry of Agriculture and Natural Resources, Nicosia

The study of coastal currents by the use of sea-bed drifters and drogues was carried out by this research centre. Two series of experiments were conducted: the first in November 1977 and the second in January 1979. The releases of the drifters were made at 5, 10, 15, 25 and 50 fathoms depth at Amathus Bay and Akrotiri Bay. Owing to the short distance travelled by the drifters, and the fact that the recovery areas were not always properly described, no firm conclusions were drawn from these experiments.

Recording current-meters have been deployed in the area under study (Akrotiri Bay), but no information has yet been made available regarding these current determinations.

Israel

Oceanographic and Limnological Research Ltd., Haifa

Continuous current measurements have been recorded at two coastal stations. The analyses of the data have yet to be presented.

Egypt

Institute of Oceanography and Fisheries, Alexandria

The area studied by this research centre is off the coast of Alexandria extending from El-Max to Rosetta. This area, which covers 80 km of the Egyptian Mediterranean coast, receives almost all the main pollutants generated in the Egyptian mainland.

To study coastal water transport in the area mentioned, monthly release of plastic Woodhead surface drifters were carried out at various stations along the coast, for a period of two years (Gerges, 1979).

The results of current measurements revealed great monthly variability in both speed and direction caused by the prevailing meteorological conditions. They also indicated the influence of the main longshore eastward flow at offshore stations. The drifter movements gave a rather good estimate of the velocity of the upper surface layer of water, about 3.6 per cent of the speed of the wind blowing over the area.

Preliminary analysis of current measurements in the Port Said area, using recording current-meters, indicated that mean currents near the surface showed speeds fluctuating between 2 and 17 cm/s, with varying directions from north-east to south-east. On the other hand, near bottom currents were generally weaker, fluctuating between 2 and 12 cm/s. Since the velocity and direction of the near-surface and near-bottom currents showed covariation only during certain periods, the effects of water stratification on the currents were being studied.

It has been concluded that for investigating the transport of pollutants, direct measurements by moored current-meters can provide the best data in terms of understanding of the driving forces, scale of motions and variability. However, Lagrangian techniques, tracing current following drifters, offer the benefits of easy visualization of the flow and, in theory, represent the actual motion of a parcel of water, and presumably the actual motion of contaminants associated with that parcel (Gerges, 1981).

Malta

Department of Physics, the Old University, Msida

Measurements of surface and subsurface currents were carried out off the east coast of Malta by this research centre.

Previous current data for the area around Malta were available from ships draft measurements. These data were not considered very accurate but they did show the high degree of variability in the estimated currents, particularly during the winter months. The mean of a large number of reading over several years gave a value for the currents in the range of 10 to 20 cm/s, setting to the south-east.

The drift-card experiments showed diurnal variation of the currents. During periods of light surface winds, the current sets along the coast to the south-east for the greater part of the day (about 16 hrs) with velocities in the range of 10 to 30 cm/s, and reverses for the rest of the day with weak currents rarely exceeding 10 cm/s. During a period of stronger north-westerly winds the current always set to the south-east with a maximum velocity of 50 cm/s, the diurnal variation showing as a change in current speed.

The changes in coastal currents off the east coast of Malta have also been estimated by an indirect method. The end potentials of obsolete, broken, submarine telegraph cables have been time-sampled and potentially recorded. During a period of persistent north-westerly gales, coastal water transport in excess of 300 cm/s, setting to the south-east, were indicated by this method. The method also showed evidence that the current system often exhibits only small variations over periods of several days; while on other occasions, particulary in winter, changes of the order of $\pm$ 50 cm/s in the N-S component of the current east of Malta often occur. It is sometime, but not always, possible to associate these changes with strong winds (Havard, 1979).

The subsurface currents were measured using recording current-meters moored at the location of a submarine outfall (35°54.0'N, 14°32.7'E) 800 metres long. The recorded tapes were translated into printout and graphic display by Aanderaa instruments. Three tapes were sent to the Instituto de Investigaciones Pesqueras de Barcelona where the progressive vector diagrams and component plot were prepared.

The progressive vector diagrams for the data recorded between April and September 1978, showed that the mean transport of water, at 25 meters depth, is to the east-south-east with a velocity of the order of 7 cm/s. The variations in the current are more easily seen on the component plots. The component plots clearly showed diurnal variations in the current with higher frequency components superimposed. The maximum current recorded during the observation period was 45 cm/s to the east-south-east (Havard, 1981).

As was expected from the bathymetry, the coastal currents measured have strong longshore components, with a mean water transport to the south-east. The relatively strong diurnal variation in the subsurface current was not expected as there is no significant vertical tide in Malta. It is not certain that the diurnal and higher frequency variations are tidal in origin but the long period over which they have been observed seems to indicate tidal origin. Unfortunately, no tide gauge exists at Malta so no correlation with vertical tides has yet been possible.

8. GENERAL CONCLUSIONS

Only a small amount of the research conducted in the Mediterranean on coastal currents and exchange between coastal and offshore regions has been reported through the MED POL VI pilot project.

The bulk of the ovservations was made using recording current-meters near the surface or at moderate depths, sometimes near the bottom. Many research centres encountered difficulties in mooring the current-meters, particularly for extending period, so that there were some occasional losses; and there were logistical problems in meter maintenance. Likewise, several countries had difficulties in reducing the data stored on the recording tapes of the meters.

The use of floating drift-cards and drifters was a particularly useful method of observing sea-surface currents, with a low cost/benefit ratio. The DRIFTEX experiment was carried out, in general terms, as planned. A thorough computer programme to analyse the DRIFTEX data was developed by the Instituto de Investigaciones Pesqueras de Barcelona, Spain, under contract to the IOC, and applied to the data gathered in the Ligurian Sea and the Levantine Sea (Egyptian coast).

Geostrophic current calculations based on temperature-salintiy distribution were presented by some of the participating research centres. However, it seems very doubtful that calculated (geostrophic) currents are reliable in the Mediterranean where the boundary conditions (coast line and bottom) and vigorous vertical mixing in certain seasons and areas compromise such calculations.

During the implementation of the pilot project little work was reported by the research centres on the more complex problem of dispersion and diffusion of pollutions in coastal areas. Coastal transport is only one stage in the cycle from pollutant source to sink. Within the long-term programme phase consideration should be given to other stages, including possible pollutant transfer between the various basins within the Mediterranean, and between the Mediterranean Sea and the Atlantic Ocean.

9. OTHER ACHIEVEMENTS

Documents specifically developed for this pilot project include:

- Guidelines for the Implementation of Pilot Projects MED I and MED VI. Supplements 1 and 3 to IOC-WMO-UNEP/MED-MRM/3, UNESCO, 1977;
- Provisional Bibliography related to hydrography and Circulation in the Mediterranean Sea. IOC-WMO-UNEP/MED-MRM 24, UNESCO, 1977.

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MED POL VII : COASTAL WATER QUALITY CONTROL (WHO/UNEP)

1. INTRODUCTION

The serious and rapidly growing pollution of the coastal waters of the Mediterranean is having an increasing impact on the social and economic well-being of the countries bordering it. In addition to the millions of inhabitants living along the coastline of the Mediterranean, millions of tourists spend their holidays on the shores of this sea, and there is a considerable potential for spreading of disease-causing micro-organisms.

The present situation constitutes a significant health hazard in many places. Salmonellosis, dyssentery, viral hepatitis and poliomyelitis have all been endemic in the Mediterranean area, and during recent years there have been a number of cholera outbreaks. There is ample evidence that contaminated shellfish are an important concern to public health. There is however a distinct need for better epidemiological data concerning correlation between diseases and coastal water pollution. The risk of infection from swiming and other recreational activities in coastal waters is increased in certain areas by the absence or inadequacy of beach sanitary facilities. Thus, actual and potential health effects are of prime importance.

The overall objective of the project was to produce statistically significant data, scientific information and technical principles which are required for the assessment of the present levels of coastal pollution as it concerns human health. This was considered to be indispensable for the rational design and efficient implementation of national programmes to control coastal pollution from land-based sources in the Mediterranean area.

The pilot project was not a "one-shot" exercise intended to provide rigid rules and procedures for the establishment and management of a monitoring network, or required as an assessment of pollution and for providing information and data necessary for its apraisal and control. On the contrary, it was intended to develop a dynamic and at the same time, elastic approach that would permit improved efficiency and quality, and expansion of the work carried out.

Using commonly agreed methods, the project initiated a sanitary and health surveillance of coastal recreational waters and of shellfish-growing waters in selected areas. Microbiological indicators were used as the most significant criteria of the sanitary quality of coastal waters and organisms living in them, particularly those molluscs most commonly eaten.

Scientfic studies were prepared of the epidemiological evidence of effects on health caused by inadequate sanitary conditions in coastal areas.

The pilot project was initiated in July 1976 and actual work by national research centres started in late autumn 1976.

The elements of the programme of work were as follows:

a. the monitoring of selected coastal areas;

b. the initiation and promotion of scientific studies on the epidemiological evidence of health effects caused by pollution in coastal areas;

c. the development of principles and guidelines for coastal water pollution management;

d. the development and dissemination of relevant technical documentation;

e. training and technical assistance.

The present report is intended to analyse, evaluate and discuss the practical and theoretical scientific results of the work carried out and implemented since the actual initiation of the pilot project in July 1976. Special attention was given to the monitoring programme which constituted the larger and main scientific activity of the pilot project.

2. PARTICIPATION

Thirty-one research centres from fourteen Mediterranean States were designated by their national authorities to participate in the pilot project. One of them was officially withdrawn.

By the end of December 1980, 30 research agreements had been signed.

3. CO-ORDINATING ARRANGEMENTS

WHO maintained the operational contacts with the national research centres designated to participate in this pilot project.

The Istituto Superiore di Sanità, Rome, Italy, was nominated in August 1976 to assist WHO as the Regional Activity Centre for this pilot project.

Scientific meetings held in connection with this pilot project are mentioned in section 5, below, which describes the development of the operational document for MED POL VII.

4. FINANCIAL ARRANGEMENTS

Specific support to the pilot project was provided through projects FP/0501-74-08, FP/0503-75-08 and FP/0503-76-05. Costs (in US dollars) were shared between the two co-sponsors of the project as follows:

	1974	1975	1976	1977	1978	1979	1980	Total	Percentage
WHO	5,000	18,000	20,000	90,000	47,000	21,000	12,000	213,000	28.3
UNEP	11,284	20,866	24,525	86,540	170,001	100,415	125,079	538,710	71.7
TOTAL	16,284	38,866	44,525	176,540	217,001	121,415	137,079	751,710	100.0

Direct support to participants in MED POL VII up to 31 December 1980 amounted to US $ 215,423 and included the following:

- US $ 84,050 for equipment
- US $ 34,040 for expendable materials;
- US $ 31,241 for training of 15 trainees (total of 14 man/months) from 10 research centres in 17 host institutions;
- US $ 53,592 for attendance at meetings;
- US $ 12,500 as assistance to the Regional Activity Centre.

Indirect support to participants in MED POL VII up to 31 December 1980 amounted to US $ 536,287. This sum included:

- US $ 195,559 for the services of consultants to assist WHO in the organization and execution of the pilot project and in the evaluation of its results;
- US $ 117,838 for the organization of meetings;
- US $ 184,490 for the preparation of manuals, quidelines and reports;
- US $ 38,400 for miscellaneous expenses.

The national contribution to the pilot project, estimated on the basis of incomplete information supplied by 27 out of 30 participating research centres as equivalent to US $ 1,753,956, included:

- 1954 man/months of professional and supporting staff (US $ 1,172,400 estimated at US $ 600 per man/month):

  US $ 260,689 as expendable materials;
- US $ 320,867 as operating costs of equipment.

5. OPERATIONAL DOCUMENT

The operational document of the pilot project was formulated at the WHO/UNEP Expert Consultation (Geneva, 15 - 19 December 1975) attended by 27 participants from 16 Mediterranean States. Certain modifications to the operationsl document were proposed and agreed upon at a meeting of the Group of Experts on Health Related Monitoring and Coastal Water Quality (Rovinj, 23 - 25 February 1977) attended by ten experts from nine research centres, at a meeting of the Group of Experts on Health Criteria and Epidemiological Studies Related to Coastal Water Pollution (Athens, 1 - 4 March 1977) attended by eight experts from eight research centres, at the Mid-term Review Meeting of Principal Investigators of Collaborating Laboratories (Rome, 30 May - 1 June 1977) attended by 24 experts from 22 research centers, at the workshop on Coastal Water Pollution Control (Athens, 27 June - 1 July 1977) attended by 31 experts from 26 research centers, at the Seminar on Monitoring of Recreational Coastal Water Quality and Shellfish Culture Areas (Rome, 4 - 7 April 1978) attended by 25 experts from 25 research centres, at the Workshop on Coastal Quality Monitoring of Recreational and Shellfish Areas (Rome, 17 - 19 January 1979) attended by 31 experts from 27 research centres and at the Workshop on Coastal Quality Monitoring of Recreational and Shellfish Areas (Rome, 20 - 23 November 1979) attended by 28 experts from 26 research centres.

6. AREAS STUDIED

The monitoring included two aspects: (a) the surveillance of beaches and bathing-waters; and (b) the surveillance of shellfish culture waters and shellfish flesh.

The collaborating laboratories represented 14 Mediteranean countries out of a total of 18. However, the distribution of the collaborating institutions and of the areas selected for monitoring (Figure 1) did not constitute a well-balanced representation of all the coastal areas.

7. MATERIAL AND METHODS

For the monitoring of the selected coastal areas standard methods agreed by the principal investigators were used. These covered the compulsory minimum programme which included indicators of physical, chemical, biological and microbiological nature. They were formulated and further elaborated at the meetings listed in section 5 ("Operational document") above.

The selected parameters were divided into compulsory and voluntary ones.

For monitoring of recreational waters, in realization of the importance of developing and applying similar methods and materials for the analysis of the various parameters, the Pilot Project included in its first activities the preparation and distribution of a document entitled "Guidelines for Health Related Monitoring of Coastal Water Quality". In addition to these "Guidelines", the collaborating laboratories agreed to apply a more specific method for each of the compulsory microbiological parameters for monitoring of shellfish areas, in order to strengthen harmonization and comparability of results, it was agreed by the collaborating laboratories to utilize the same methods and the same media, particularly for the analysis of the compulsory parameters.

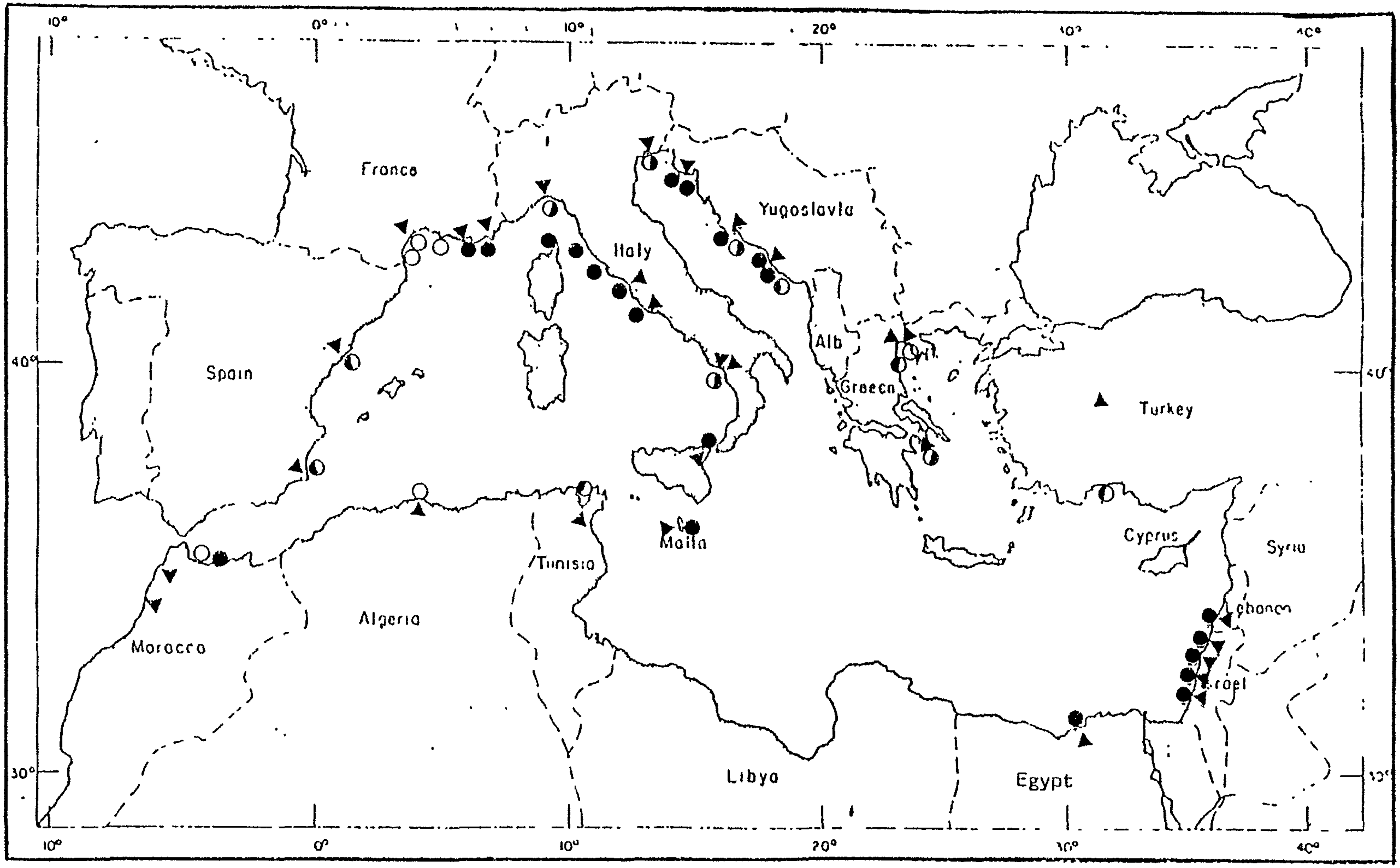

Figure 1. Collaborating laboratories and monitored areas

Collaborating Laboratories ▲

Areas monitored for:

Shellfish ○
Recreational waters ●
Shellfish and recreational waters ◐

Appropriate standard forms, tables and graphs were developed for assisting in recording the collected data and in handling them in an orderly fashion.

In addition to classifying the primary data according to seasonal variations, currents or other factors, some collaborating institutes used statistical methods in order to assist in the summarizing process, in sorting out facts and in assigning significant probabilities. Such methods included the frequency distribution, the calculation of the average and empirical variance, the "t" test procedure, etc.

8. SCIENTIFIC RESULTS AND DISCUSSION

8.1 Recreational waters

Most of the collaborating laboratories monitored only the microbiological compulsory parameters, i.e. total coliforms, faecal coliforms and faecal streptococci. To a lesser degree, they included additional microbiological, as well as physical and chemical parameters such as temperatures, dissolved oxygen and meteorological factors, in their monitoring programmes (Table I). This was mainly due to the absence of the necessary facilities, equipment and personnel.

Table I. Optional parameters, carried out by some of the institutes collaborating in MED POL VII

Microbiological	Chemical	Biological
V. parahaemolyticus	Nutrients (occasionally)	phytoplankton
Salmonella	CO	chlorophyll
Shigella	pH	
Fungi	COD	
Sulphite reducer	NH_4	
Clostridia	NO_2	
Coagulase-positive staphylococci	NO_3	
	P	
Total and faecal coliforms		
Faecal streptococci in the sediments		
Vibrio cholerae		
Enterovirus		
Bacterial count		
Pseudomonas		
Aeromonas		

However, the following parameters: temperature of the sea-water, salinity, rainfall, with reference to date of sampling were considered to be the most important accompanying parameters and were recommended to be included in the compulsory parameters.

While BOD_5, settleable solids (SS) and the volume of the discharge were included in the compulsory parameters for the identification of effluents or outfalls, these were not widely applied owing to the fact that in many of the monitored areas there were no distinct effluents or outfalls. However, some of the collaborating laboratories considered that the above parameters were insufficient for the assessment of the pollution in rivers and outfalls. They proposed the inclusion of pH, COD and TSS (total suspended solids).

The adoption of the membrane filtration method for the analysis of the microbiological parameters in sea-water brought some difficulties to the laboratories who were routinely using the MPN method. However, some of these decided to run the two methods in parallel, thus giving the possibility of comparing them.

Some contradictory results from the above exercise emerged. In one study it appeared that the MPN and MF methods did not differ significantly. However, in ohter studies, the MPN results gave higher counts. In yet another study, the comparison of the MPN with the MF method showed a fairly good correlation ($r=0.8$).

The suitability of proposed nutrients for the microbiological parameters was studied. From the experience gathered during the project it appeared that the adopted m-FC medium incubated at 32°C for the determination of total coliforms did not give satisfactory results. In this connection it was suggested that the M-endo broth might be used. Further invesigation into this matter would be required.

In the operational document it was specified that the samples should be taken at a distance of 10m from the low tide mark. However, this presented some difficulties, especially to those laboratories usually concerned only with microbiological parameters and which did not have an appropriate boat for sampling. Various solutions were applied and some laboratories sampled at the knee or the chest level. However, it was recognized that such sampling was exposed to a number of interferences affecting the quality of the coastal water tested. Comparative studies were encouraged with the aim of reaching a better sampling procedure.

From the results obtained it appeared that higher counts were experienced for total coliforms than for faecal coliforms and faecal enterococci. These last were also reported, in a number of results, to invariably give the lowest count values with respect to the other two compulsory parameters.

Although the concentration of total coliforms might not be the best indicator of contamination of sea-water with faecal material, some results obtained showed a close correlation with the location of outfalls which discharge faecal material into the sea, or material which seems to enhance the survival and reproduction of micro-organisms in the sea.

Studies carried out by one collaborating institute showed that viruses were detected in all coastal water samples exceeding 920 E. coli per 100 ml. A significant correlation was also found between the numbers of E. coli and those of enteroviruses.

However, studies conducted by a few other collaborating institutes showed that faecal streptococci have a survival and frequency similar to those of enteroviruses (Figures 2 to 4). Furthermore a comparative study on the inactivation rates of faecal coliforms and faecal streptococci showed a higher persistence of faecal streptococci after discharge into the sea. It was also noted that when warm, industrial, alkaline wastes are present, large numbers of enterococci may be isolated while coliforms may be absent. The results from these studies point out the influence of the trajectory of a water-mass on its microbiological quality, and particularly the potential of faecal streptococci as an additional quality indicator for recreational waters.

In some studies, the microbial concentration level in the sea was recorded as low in summer as compared to other seasons. This was ascribed to the effects of increased daylight and solar radiation. However, in other studies, higher mean values were noted during the summer season. This was attributed to the increase in coastal pollution due to the number of summer tourists accommodated along the coast. In the former studies, the microbial concentration in sediments was recorded as higher in summer, the discrepancy between this and the concentration in sea-water being attributed to the relative protection of the sedimentary layer from solar radiation.

A detailed analysis of the microbiological data collected at 250 sampling stations by nine collaborating institutes showed that a log normal probability distribution provides an adequate interpretation of the experimental results. Moreover, a 10-fold ratio between the concentration not to be exceeded in 50 per cent of the samples, approximates quite well to the naturally observed variation of the microbiological quality of Mediterranean coastal waters, as regards the three microbiological indicators selected.

One of the collaborating institutes carried out a study on the statistical variation of microbiological quality of coastal waters. From this study it appears that:

- The microbiological quality of coastal waters can be adequately interpreted by a log normal probability distribution model;

- Correct compliance with any statistically expressed water quality standard requires comparison of two probability distributions and not only two pairs of frequencies;

- The standard deviation of concentration of the three indicators approximates quite closely to that implied by the proposed interim coastal water quality criteria;

- The standard deviation of a microbiological indicator concentration at a sampling station is a useful and sensitive parameter for detecting discontinuous sources of pollution;

- A standard deviation estimate, derived from sets of 12 to 14 values, which lies outside the 1 to 3 interval is likely to be associated with a single water sampling station.

The results of the monitoring have indicated that for routine monitoring the total number of coliforms could be discontinued, though these might be used as an indicator for cleaner waters. Thus, basically, faecal coliforms and faecal streptococci would be retained as compulsory bacteriological parameters.

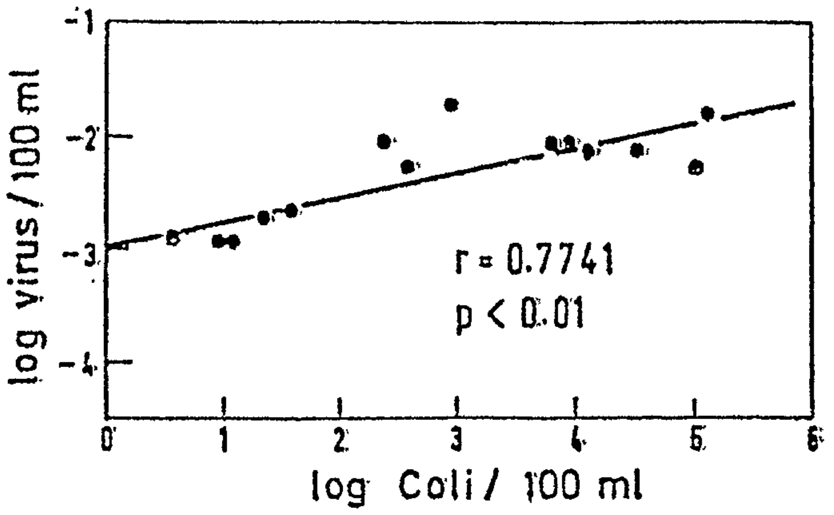

Figure 2. Correlation between coliforms and viruses found at beaches

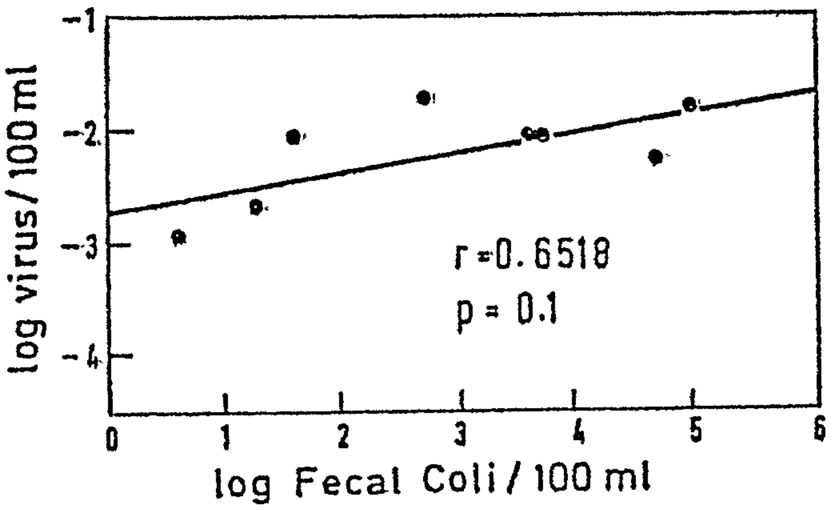

Figure 3. Correlation between faecal coli and viruses found at beaches

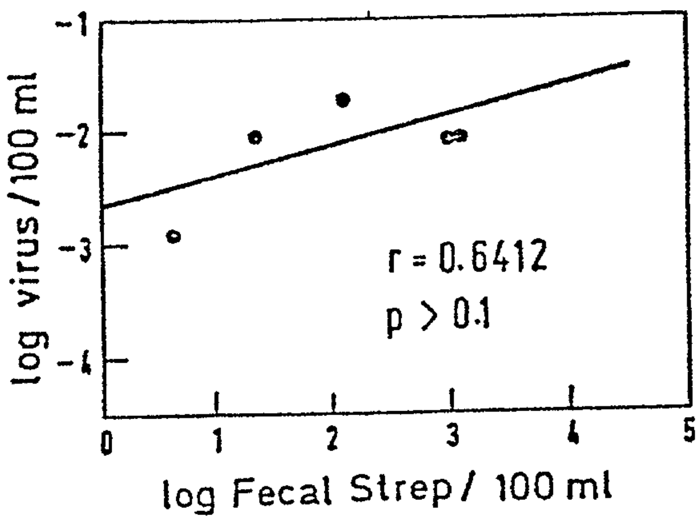

Figure 4. Correlation between faecal streptococci and viruses found at beaches

Considering that the selected indicators of pollution are relatively sensitive to certain conditions in the marine environment, it appeared advisable to investigate, develop and eventually to use a more suitable organism. To this end, studies were carried out on Salmonella, E. coli, bacteriophages and enteric viruses. Salmonella was occasionally isolated from fairly clean beaches with no sewage outfall in the vicinity. Their source was attributed to birds or other animals. However, no definite results were available by the end of this first phase of the project.

8.2 Shellfish areas

The great majority of collaborating laboratories used the four bacteriological indicators, i.e. total coliform, E. coli, Streptococcus faecalis and total heterotrophic bacteria included in the minimum compulsory programme.

Adherence to the prescribed standarization of methods and media was unfortunately not applied by the majority of the collaborating Institutes and comparison of the results obtained was weakened by this deficiency. More experience and results would be required in order to further assess the relevant value of the proposed nutrients and consider the need to change them or not.

The sampling networks lacked uniformity. Density, direction, and number of sampling points did not follow some of the current general guidelines. Additional work and studies would be required in order to assess and further develop these guidelines.

In the results of one of the collaborating laboratories it was found that the positivity of V. parahaemoliticus in shellfish increased during the warmer months and decreased markedly during the cold ones. V. parahaemoliticus was present in 30 to 60 per cent of the samples. Although there is a well-established view that V. parahaemoliticus is a natural inhabitant of sea-water and does not correlate with pollution, in the absence of additional data, these results cannot be interpreted as confirming this view.

From the experience gained during the pilot project, it appears that the most important parameters in shellfish monitoring are faecal coliforms and faecal streptococci. Their importance is related to the hygienic and sanitary aspects of the control of shellfish. However, it has been found that although faecal streptococci and faecal coliforms are both indicators of faecal pollution, the value of their analysis cannot always be correlated. Thus, high values of anterococci were found in shellfish with only a few E. coli per gram of flesh.

The results of one collaborating institute that total heterotrophic bacteria concentration in shellfish seem to be practically constant and independent of the concentrations of total coliforms and faecal coliforms. The concentration of total heterotrophic bacteria found in shellfish growing in unpolluted waters were always below 10,000 per gram.

The concentration of faecal indicators in shellfish collected at a sampling station seems to follow a log normal probability distribution with considerably lower fluctuations than that of the surrounding waters. The experimental data available indicate that an approximate 5-fold ratio exists between the faecal indicator concentration not exceeded in 90 per cent of the samples and that not exceeded in 50 per cent of the samples.

A comparative analysis of faecal coliforms and faecal streptococci concentrations from 25 sampling stations surveyed by collaborating institutes shows that faecal streptococci seem to be more persistent than faecal coliforms both in shellfish-growing waters and in shellfish flesh.

Experimental data from 32 sampling stations surveyed by five collaborating institutes indicate that the majority of the stations satisfy the proposed interim criteria for shellfish-growing waters and that compliance with the limitation that requires 80 per cent of the water samples not to exceed 10 faecal coliforms per 100 ml, results in the systematic compliance with the additional limitation that requires 20 per cent of the samples not to exceed 100 faecal coliforms per 100 ml.

Collaborating institutes agreed that the microbiological parameters to be used for shellfish monitoring should be limited to faecal coliforms and faecal streptococci. On the other hand, they were of the opinion that other potential indicators such as salmonella and enteric viruses should be further investigated.

8.3 Fish

Although not specifically referred to in the operational document some investigations were carried out on fish. In polluted waters, fish might concentrate bacteria and viruses from the water in their organs and muscles and become a public health hazard. The result of a preliminary study conducted by one of the collaborating laboratories indicated that when the concentration of coliforms in the water was 10^2/100 ml and the total bacteria count was $1.x10^3$/ml, coliforms bacteria were recovered from all the organs of fish as well as the muscles. The bacterial concentration in the organs was higher than in the water in which the fish lived. In view of the correlation between the concentration of bacteria in water and the recovery of bacteria from fish organs, the question arose as to whether consumption of fish grown in waters in which the concentrations of faecal coliforms were considered safe by normal recreational standards might actually constitute a public health hazard.

8.4 Evaluation of results

The collaborating institutes nominated by the Mediterranean States and the subsequent selection of coastal areas to be monitored, did not provide a balanced representation of either the Mediterranean countries or their surrounding coastal areas.

Any proposed monitoring of quality of coastal areas should not be limited to bacteriological quality, as in the case of MED POL VII, but should cover all relevant and necessary physical, chemical, bacteriological and other parameters of quality.

In proposing a future monitoring programme of quality of coastal areas, due attention should be given to including monitoring of rivers, outfalls from major municipal sewage discharges, outfalls from industrial units and any others which might have a substantial effect on the selected monitoring area.

While it was agreed by the Principal Investigators that the compulsory parameters utilized for recreational coastal waters should be maintained, they suggested that the total number of coliforms should be discontinued in the future for routine monitoring. Notwithstanding, total coliforms might be used as an indicator for cleaner waters. Thus, basically, faecal coliforms and faecal streptococci should be retained as compulsory bacteriological parameters.

As far as shellfish monitoring was concerned, it was considered that the four compulsory bacteriological parameters, namely total coliforms, faecal coliforms, faecal streptococci and heterotrophic bacteria, could be reduced to two: faecal coliforms and faecal streptococci.

As far as shellfish culture areas was concerned, physical and chemical parameters might not be of great importance for routine monitoring. However, this view requires additonal investigation as it was not shared by all the collaborating institutes. The importance of testing salmonella in shellfish and its inclusion in the minimum programme was being considered. However, further study would still be needed before recommending it for inclusion in the minimum compulsory programme.

The results of the comparison of the compulsory membrane filtration method with MPN (most probable number), undertaken by a number of laboratories, would clarify this issue. From the preliminary readings,results appear to be comparable.

As far as media was concerned, there was some evidence that the m-FC broth for the detection of total coliforms in sea-water presented some difficulties in interpreting the results. A comparative study using m-endo broth or agar was under way in order to resolve this controversy.

8.5 Quality Control Pilot Programme

The execution of the Pilot Project progressively increased the need to develop a Quality Control Programme with the aim of identifying a variety of laboratory variables and specifying essential quality control practices to assure the present and continued productions of reliable data.

8.6 Quality criteria

As part of the project, the first draft Mediterranean environmental quality criteria (UNEP/WG.62/6), were formulated for:

a. recreational waters, and,

b. shellfish growing waters.

8.7 Initiation and promotion of epidemiological studies

The hazards to human health from bathing-waters arise primarily from the swallowing of polluted waters and from direct contact with the skin. There is circumstantial evidence of association between disease and bathing in polluted water. However, additional epidemiological studies are required in order to better ascertain and establish the relationship of cause and effect. These studies should aim at providing the necessary data base for evaluating health effects and developing water quality criteria for the recreational use of coastal waters in the Mediterranean.

The pilot project did not go further than to establish two interim criteria, one for recreational water and the other for shellfish (culture areas and shellfish flesh). However, an epidemiological study carried out by two collaborating institutes indicated that skin, ear and eye ailments are the commonest suffered by recreationists in the coastal areas surveyed. The habit of immersing the head in the water while swimming follows a statistically significant association with the occurence of ear and eye ailments.

8.8 Principles and guidelines for coastal water pollution control

The operational document of the MED POL VII Pilot Project recognized the importance, complexity and need of coastal water pollution control. Effective marine pollution control will ultimately depend on modification, reduction and dispersion of wastes discharged and dumped into the sea. It will be necessary to institute and execute a series of local and regional pollution abatement programmes covering the major population and industrial centres around the Mediterranean. Such programmes should aim at the development of long-range plans covering large geographical areas.

In response to the priority needs of the Mediterranean countries, the development of principles and guidelines for coastal water quality managemement was included in this Pilot Project as one of its main objectives.

A workshop was convened by WHO/UNEP on Coastal Water Pollution Control, Athens, 27 June to 1 July 1977, in order to examine the methodology for marine pollution control planning and to outline a plan of action leading to the development of a model Code of Practice for the disposal of liquid wastes into the Mediterranean.

The workshop, among other proposal, suggested an "Outline of Contents of a Code of Practice for Coastal Pollution Control in the Mediterranean", intended as a guide to the preparation of the different sections of the Code.

Considering the priority importance of pollution from land-based sources, UNEP, in collaboration with the World Health Organization and with the assistance of national Mediterranean experts, developed a Protocol for the Protection of the Mediterranean Sea Against Pollution from Land-Based Sources, which was agreed and signed at the meeting of Plenipotentiary Ministers of the Mediterranean States in Athens, 12-17 May 1980.

To assist responsible national authorities in the negotiation and eventual implementation of this protocol, a publication on "Principles and Guidelines for the Discharge of Waters into the Marine Environment" was prepared and published under the joint sponsorship of UNEP and WHO.

Following the progress made in the monitoring and assessment of pollution the time has come to proceed from monitoring to pollution control. The Protocol for the Protection of the Mediterranean Sea Against Pollution from Land-Based Sources, as already mentioned, provides the legal basis for the development and implementation of a pollution control programme.

9. OTHER ACHIEVEMENTS

9.1 *General value of the pilot project*

The periodic reporting to WHO by the research centres was weak until 1978 (only 62 per cent of the centres respected the deadlines and half of the submitted data was not in the agreed format), but afterwards the situation imporoved considerably (79 per cent of the centres submitted adequate reports in time).

Information relevant to the effectiveness of the administrative arrangements by WHO in connection with the pilot project was received from 27 research centres (90 per cent of those that signed research agreements). According to the replies received, the pilot project:

- greatly increased the ability of the research centres to control, on a routine basis, the quality of the national recreational and shellfish-growing waters;

- improved the research and monitoring methods used in research centres and harmonized the approach to the evaluation of the environmental quality of coastal waters;

- assisted in development of national programmes to control the quality of coastal waters;

- contributed, through personal contacts, to the exchange of views between experts and to the development of interim environmental quality criteria for recreational and shellfish-growing waters.

Most of the research centres expressed their appreciation for the assistance received through the project, although some indicated that it did not meet all their requirements. The administrative support was generally described as excellent, but a few centres suggested that there should be a simpler procedure for the transfer of funds, equipment and material.

9.2 Training

Only four (out of 10) trainees submitted reports on the effectiveness of their training. They commented very favourably on the benefits derived from training and expressed satisfaction with the arrangements made by WHO and host institution, as well as with the training programme.

In addition to individual on-the-job training, training was also provided through specific meetings and seminars, see section 5 ("Operational document") above.

Without any doubt, the training accomplished through the project greatly enhanced the quality of the work performed in the national research centres participating, although it was limited by shortage of funds.

9.3 Regional Activity Centre

The assistance provided by the Regional Activity Centre to the efficient operation of the pilot project consisted of:

- hosting and co-organizing four meetings;
- issuing a newsletter (five issues);
- visits of experts from RAC to seven research centres participating in the pilot project in order to help them to play a full part in the MED POL VII project;
- assistance in the development of data-recording forms;
- development of a quality scheme for microbiological examination of sea-water;
- collation, analysis and evaluation of data submitted to WHO by research centres participating in the project.

The contribution of the Regional Activity Centre to the successful day-to-day operation of the pilot project and to its overall success was essential.

9.4 Documentation

Documentation specifically developed for this pilot project is contained in the reports of the various meetings mentioned in section 5 ("Operational Document") above.

10. NOTES AND REFERENCES

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Health criteria and epidemiological studies related to coastal water pollution. Report of a meeting of WHO/UNEP joint group of experts (Athens, 1 - 4 March, 1977). WHO, 1977.

Guidelines for health related monitoring of coastal water quality. Report of a meeting of WHO/UNEP joint group of experts (Rovinj, Yugoslavia, 23 - 25 February, 1977). WHO, 1977.

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Report of the WHO/UNEP Expert consultation on coastal water quality control programme in the Mediterranean (Geneva, 15 - 19 December, 1975). EHE/76.1. WHO, 1976.

Waste discharge into the marine environment. Principles and guidelines for the Mediterranean Action Plan. WHO/UNEP. Pergamon Press 1982.

MED POL VIII : BIOGEOCHEMICAL STUDIES OF SELECTED POLLUTANTS IN THE OPEN WATERS OF THE MEDITERRANEAN (IAEA/IOC/UNEP)

1. INTRODUCTION

The project formally started in October 1976 as a specific extension of earlier work carried out by the IAEA International Laboratory of Marine Radioactivity in Monaco since 1974.

Heavy metals and chlorinated hydrocarbons are two types of pollutants identified in most oceanic areas. Although the coastal zones of the oceans are generally the most polluted, being the areas most affected by man's activities, the levels in the open Mediterranean are probably more important because the open waters comprise a larger volume of water than the coastal zones and therefore probably contain the bulk of the total pollutant load. Furthermore, knowing offshore concentrations of pollutants in the Mediterranean is important for comparison with other seas and oceans and with the levels found in coastal waters to ascertain the degree of degradation of the Mediterranean as a whole.

In addition to pollution load assessment, by measuring the amounts of heavy metals and chlorinated hydrocarbons in water, sediments, biota and, in some cases, the air, one can define transport pathways and reservoirs in the open Mediterranean. This provides the unifying concept that will help understand the results obtained through MED POL II and MED POL III in the coastal area as well as complement information obtained in MED POL IV and MED POL V.

Data obtained through the project, combined with those which will be collected through the other Mediterranean projects, will provde a sound basis for a model on the biogeochemical cycle of pollutants in the Mediterranean (MED POL XIII).

The immediate goal of the project was to obtain data on levels of metals and chlorinated hydrocarbons in open waters of the Mediterranean in order to assess the total present load of these pollutants and to understand their dynamics (entry, transport, transformation and decay) thus complementing the coastal monitoring undertaken by the original seven MED POL pilot projects.

Long-term goals were to provide the data needed for development of models of the biogeocycling of pollutants in the Mediterranean.

During the course of the project two proposals, "Mussel Watch Experiment in the Mediterranean" and "Proposal for a Joint Mediterranean Cruise (MED CRUISE)", were generated for the development of more information on temporal changes in pollution of coastal waters and on the quality of data regarding pollution of the open Mediterranean. The MED CRUISE proposal, in particular, was the product of the considerable effort of a joint interagency committee chaired by IAEA and including representatives from UNEP, FAO, IOC, WMO and IAEA. Due to the lack of funds and difficulties in securing suitable research vessels the ideas were not pursued to completion.

The International Laboratory of Marine Radioactivity of IAEA was charged with co-ordinating the MED POL VIII pilot project in the overall framework of the UNEP-launched Mediterranean Action Plan. The principal purpose of MED POL VIII was to obtain baseline data on levels of pollutants in sea-water, organisms, particulate matter and sediments from the open Mediterranean Sea.

The overall philosophy of MED POL VIII was twofold. First, to gather as much information as possible on inputs, levels and fluxes of pollutants in all major components of the Mediterranean in order that a general model of the bio-geochemical cycles of these substances could be elaborated. These steps are considered to be essential in any attempt to assess pollutant mass balance in oceanic systems. Second, these data were intended to supplement and enhance those gathered on levels in selected marine species in the coastal areas. Pollutants in water and sediment were not measured in the four MED POL monitoring pilot projects and, without such information, any future attempt to calculate mass balances for pollutant inputs to the Mediterranean, or to explain abnormally high concentrations of these substances in the marine organisms being monitored, would be impossible.

The marine biogeochemical cycle of a given pollutant can be conceptualized as outlined diagramatically in Figure 1. Briefly, contaminants entering the marine environment either from natural or anthropogenic sources may remain in the aqueous phase, become involved in biological cycles or precipitate out by biological and physico-chemical processes. Most of the pollutants which become associated with biotic or abiotic particles sink under the influence of gravity and eventually reach the sediments. Once incorporated in sediments, these substances may be released back to the water column by both biotic and abiotic processes. Some pollutants such as metals and certain organic compounds may be released back into the atmosphere as volatile sea salts.

The approach used in the MED POL VIII pilot project was to measure a suite of heavy metals and organochlorine compounds in the prime components shown in Figure 1. To complete the picture, flux measurements of pollutants in certain matrices were also taken. This involved studying biokinetic behaviour of certain pollutants in important marine species and assessing the vertical transport of biogenic detritus by collecting sinking particulates in sediment traps moored at different depths.

In order to effect the baseline measurement programme the IAEA International Laboraty undertook the following oceanographic cruises during the period 1975-79:

R/V Chain	3-19 May 1975 (Istanbul-Cadiz)
USNS Kane	10-14 April 1975 (Piraeus-Monaco)
Atlantis II	14-23 April 1977 (Suez-Malta)
USNS Hayes	13-23 June (Piraeus-Corsica)
Shikmona	5-12 July 1977 (Haifa-Crete) (under subcontract with the Israel Oceanographic and Limnological Research, Ltd.)
Cornide de Saavedra	15-26 July 1977 (Civitavecchia-Barcelona)
Calypso	10-20 November 1977 (Piraeus-Sicily)
Researcher	18-22 June 1979 (Port Said-Piraeus)

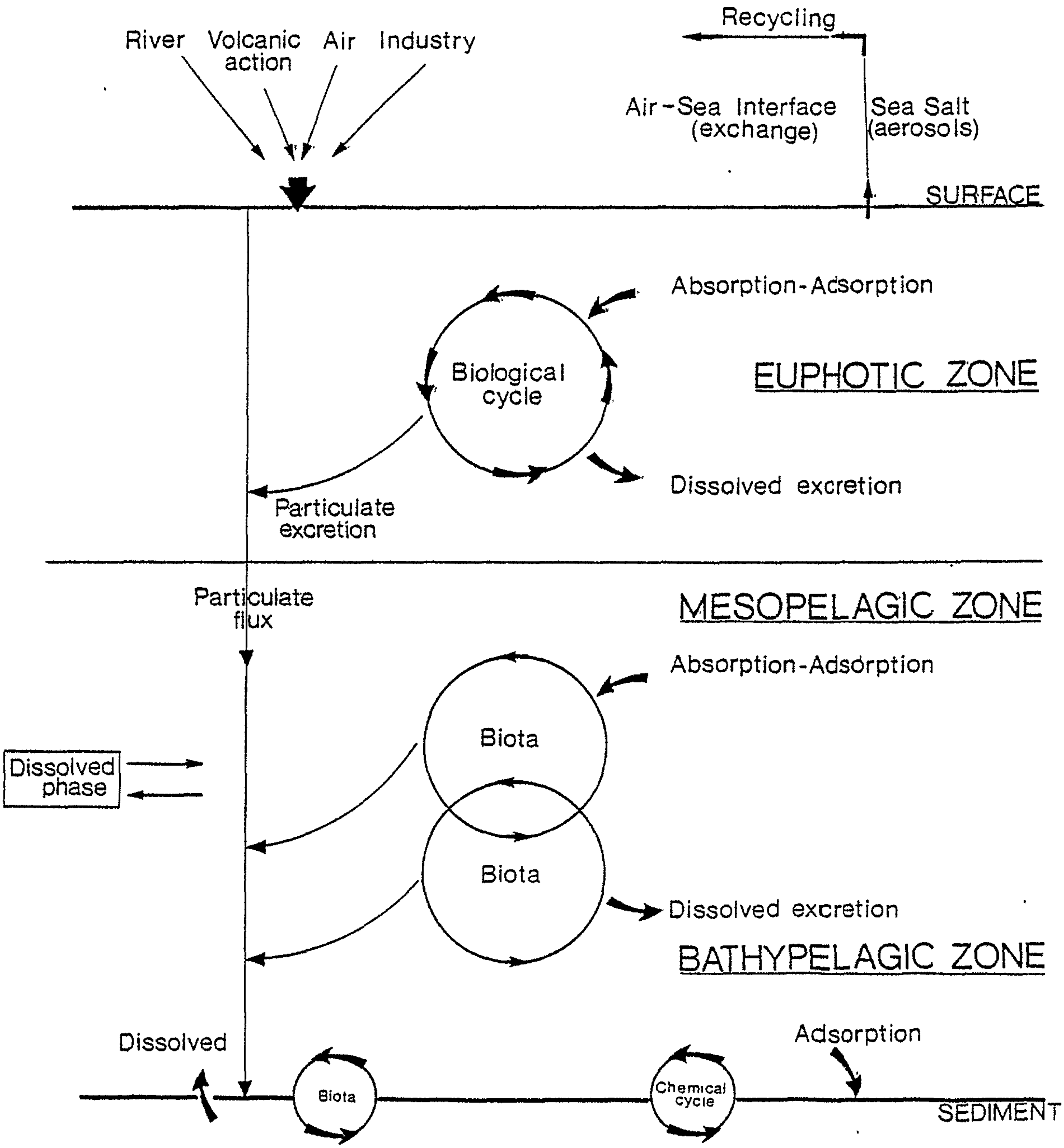

Figure 1. Schematic Diagram of Oceanic Biochemical Cycle

Sea-water, sediments and pelagic biota were sampled during these series of cruises which covered almost all the principal geographical regions of the Mediterranean Sea (Figure 2). Samples were analysed for selected trace elements and chlorinated hydrocarbon compounds either at the ILMR or by the "Demokritos" Nuclear Research Centre in Greece under subcontract to the MED POL VIII project. In addition to these baseline measurements, determination of trace elements in marine aerosols and particulate matter in sea-water was carried out by the Centre des Faibles Radioactivités, CNRS, France, in order to study the flux of pollutants through the air-sea interface of the Mediterranean.

The biokinetic behaviour of arsenic, vanadium, nickel and PCBs in various marine organisms was examined to gain information on the fluxes of these substances once they enter biological cycles. These contaminants were chosen for study on the basis of both their recognized potential as marine pollutants and the fact that little is known about their transfer rates through the biosphere. This information is instrumental in establishing flux rates for materials in the biotic component of the biogeochemical cycle and in supplying fundamental data for future studies on the effects of these pollutants on aquatic species. The laboratory studies in biokinetics were conducted at the Monaco Laboratory and also under subcontract at the University of Malta and the Instituto de Investigaciones Pesqueras, Barcelona, Spain.

Vertical flux studies of pollutants were undertaken by utilizing both in situ measurements and analyses of freshly produced biogenic particulates which account for a large fraction of the particulates trapped at depth. Sediment traps were deployed for periods of up to two weeks at various depths off Monaco. The material was quantified for mass flux calculations and analysed for several heavy metals and organochlorine compounds. At the same time shipboard collections of freshly produced biogenic particulates were made, using pelagic organisms which were residing in the water column directly over the traps. Pollutant concentrations in this "source" material were compared with those in material trapped at depth in order to estimate the rate at which certain pollutants are remineralized from biogenic particles as they sink.

All the above data are used as input parameters for models which are intended to delineate the biogeochemical flux of pollutants through the open Mediterranean Sea. In addition, the information on pollutant concentrations in the various components of the Mediterranean will serve as a valuable baseline for judging possible changes in these levels in future years.

2. PARTICIPANTS

In addition to the IAEA Monaco Laboratory, five research centres from five Mediterranean States were selected as participants in the project.

By the end of June 1980, research agreements had been signed with all five research centres.

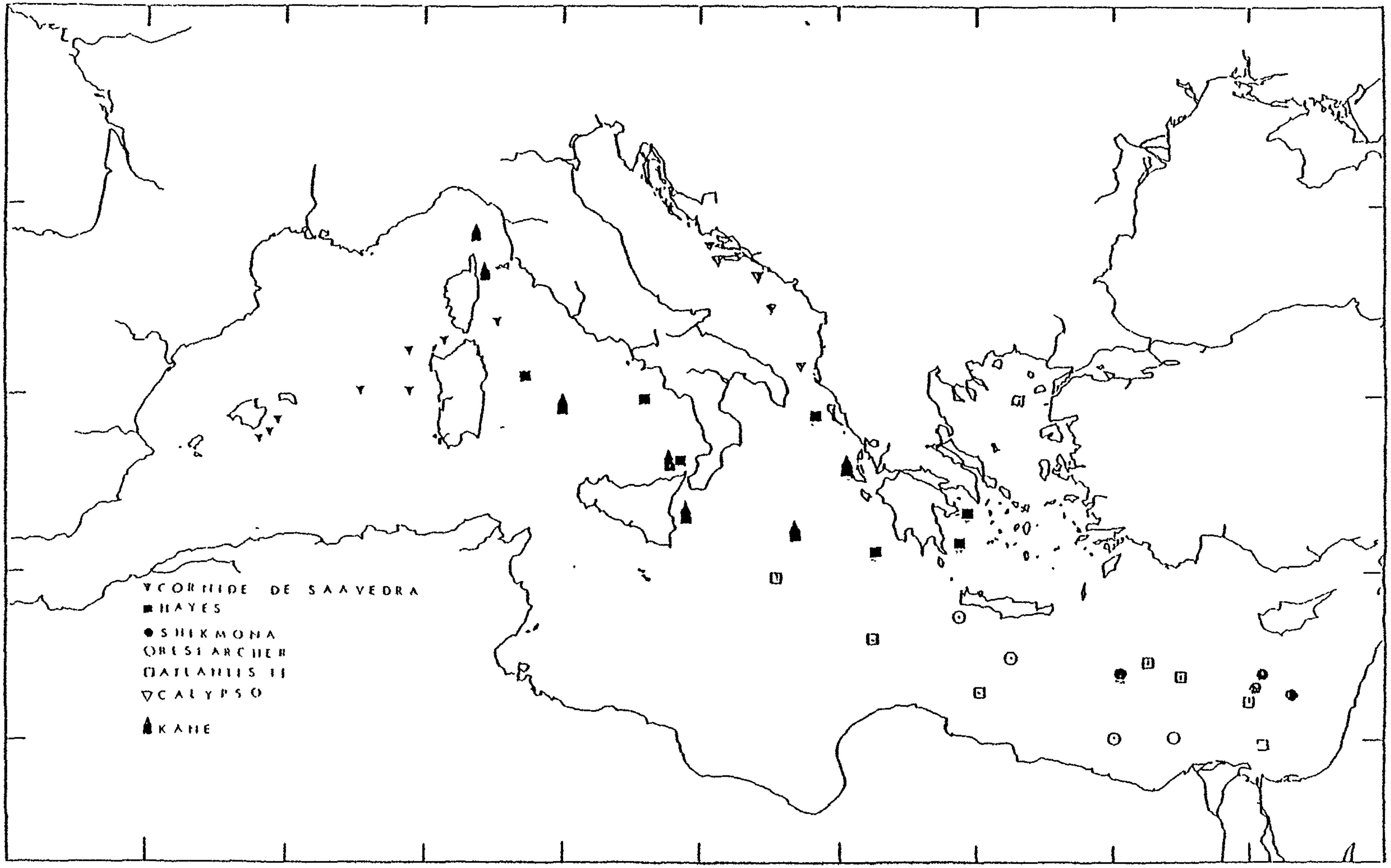

Figure 2. Sampling stations chosen for the open Mediterranean cruises

3. CO-ORDINATING ARRANGEMENTS

The IAEA Monaco Laboratory maintained the operational contacts with the research centres participating in the project. IOC was associated, through the IAEA Monaco Laboratory, with the execution of the project.

In view of the small number of research centres participating in the project and the highly specific and different contribution of each centre, no meetings were held in connection with the project.

Instead of meetings, personal contacts between IAEA Monaco Laboratory and the participating research centres were used to review the work.

4. FINANCIAL ARRANGEMENTS

Specific financial support to the project was provided through project FP/0503-76-09. Costs (in US dollars) were shared between the three co-sponsors of the project as follows:

	1976	1977	1978	1979	Total	Percentage
IAEA	2,000	150,000	95,000	95,000	342,000	58.7
IOC	-	5,000	7,500	7,500	20,000	3.4
UNEP	325	126,211	56,195	37,805	220,536	37.9
TOTAL	2,325	281,211	158,695	140,305	582,536	100.0

These costs included:

- US $ 56,200 as direct assistance to the five national research centres;
- US $ 51,000 for the operation of research vessels;

The contributions in kind and services from the national research centres participating in the project were estimated at US $ 52,600 and included:

- 12 man/months of professional and supporting staff estimated as equivalent to US $ 33,600 (estimated at US $ 2,800 per month);
- US $ 8,500 as expendable materials;
- US $ 10,500 as operating cost of equipment.

5. OPERATIONAL DOCUMENT

The technical details of the project were formalized in the description contained in the project document signed between IAEA and UNEP (FP/0503-76-09).

6. SCIENTIFIC RESULTS AND DISCUSSION

6.1 Open Mediterranean baseline measurements

6.1.1 Heavy metals in sea-water and sediments

During the period 1975-1979, a number of sea-water samples were collected throughout various zones of the Mediterranean and analysed for selected heavy metals such as Cu, Zn, Cd and Hg (Huynh-Ngoc and Fukai, 1979). In order to understand the atmospheric transport of trace elements from land to the Mediterranean, particulate Al, Fe, Cu, Zn, Pb, Cd and As were determined in marine aerosols collected at 3 m over the sea surface, and in suspended matter collected at various depths in the region between the south coast of France and Corsica. These studies on marine aerosols and suspended matter were carried out by the Centre des Faibles Radioactivités at Gif-Sur-Yvette, France (Chesselet *et al.*, 1979). In addition to these measurements a few deep sediments and a number of coastal sediments were collected and analysed for selected heavy metals.

The results of the measurements of heavy metals on open Mediterranean surface waters were grouped according to the different zones of the Mediterranean, which were defined for establishing the inputs of pollutant into various parts of the Mediterranean Sea (UNEP, 1977). The average surface concentrations for Cu, Zn, Cd and Hg were computed on the basis of the grouped results for each of these zones and are given in Table I. To compute average concentrations, the sample collection date was disregarded as it appeared that spatial differences were more significant that those of time. Since the representativeness of average concentrations presented in Table I depends on the amount of data available, the significance of average values is different from one value to another. Despite the limited representativeness of these average values presented, as well as inevitable risks of sample contamination for low-level heavy metal measurements, the table gives some idea of the overall distribution of trace metals in the Mediterranean Sea.

Since far more than half the samples were below the detection limit for Cu measurements and approximately half of those were below the detection limit for Cd measurements, the average values for these metals represent only the upper limits of the average concentrations. In these cases comparisons between different zones in the Mediterranean are less meaningful. However, the grand averages for the Mediterranean of these metals, <0.33 µg/l for Cu and <0.13 µg/l for Cd, appear to be similar to those values given for oceanic waters by Goldberg *et al.* (1971), Brewer (1975) and Robertson and Carpenter (1976). There was no correlation between the appearance of high Cu values and high Cd values.

The average concentrations of Zn tend to differ from one zone to another; values are higher in the north-western Mediterranean and Aegean basins and lower in the Tyrrhenian and south Levantine basins, despite the large associated uncertainties. The grand average for the Mediterranean of Zn tends to be lower than the values given in the references cited above.

Table I - Average concentrations of copper, zinc, cadmium and mercury in various zones of the Mediterranean sea

	Zone	Cu		Zn		Cd		Hg	
		n*	μg/l**	n*	μg/l**	n*	μg/l**	n*	ng/l**
II	N.W. Med.	34	< 0.4 ±0.2 (< 0.04–5.8)	34	2.7 ±0.4 (0.02–10)	33	< 0.15±0.03 (< 0.02–0.70)	7	20±3 (8–32)
III	S.W. Med.	13	< 0.10±0.04 (< 0.04–0.60)	13	1.2 ±0.5 (0.02–6.0)	13	< 0.11±0.04 (< 0.02–0.51)	14	14±2 (5–30)
IV	Tyrrhenian	9	< 0.18±0.08 (< 0.04–0.62)	9	0.9 ±0.3 (0.02–2.3)	9	< 0.11±0.04 (< 0.02–0.33)	10	26±4 (10–40)
VI-VII	Ionian-Central	6	< 0.7 ±0.4 (< 0.04–2.5)	6	1.8 ±0.9 (0.02–5.7)	6	< 0.15±0.09 (< 0.02–0.57)	6	30±10 (5–80)
VIII	Aegean	4	< 0.3 ±0.1 (< 0.04–0.64)	4	3 ±1 (0.9 –5.8)	4	< 0.07±0.02 (< 0.02–0.12)	3	40±20 (15–80)
X	S. Levantin	4	< 0.04±0.01 (< 0.04)	4	0.9 ±0.2 (0.3 –1.3)	4	< 0.04±0.03 (< 0.02–0.11)	4	16+2 (12–20)
	Grand average	70	< 0.33±0.09 (< 0.04–5.8)	70	2.0 ±0.2 (0.02–10)	69	< 0.13±0.02 (< 0.02–0.70)	44	22±3 (5–80)

*n = No. of samples measures.
** = Uncertainties are expressed in terms of standard errors. Ranges are given in brackets.

The zonal differences in the distribution of Hg are not clear from the average concentrations presented in Table I due to large associated uncertainties. It appears, however, that average concentrations are lower in the southern Mediterranean, for example in the south-western and south Levantine basins. The grand average of Hg is lower than the values given in the references cited above, as well as in other values obtained for the Atlantic and Pacific by various investigators, but similar to or slightly higher than those given by Gardener (1975) for various parts of oceans and definitely higher than those obtained by Matsunaga et al. (1975) for the western Pacific.

The results of the trace element measurements on marine aerosols collected in June 1978 from the coastal zone of the north-western Mediterranean show that concentrations of Al and Fe, which are closely associated with alumino-silicate brought from land, are found to be relatively low compared with those observed over oceanic regions. Considering that collections were made 3 m from the water surface, these relatively low Al and Fe concentrations suggest that an effective cleaning process of aeorosols is taking place in the marine atmosphere at a very low altitude. While Co concentrations in Mediterranean aerosols are 10 times higher than the general average for the oceanic aerosols, the concentrations of Zn are 5 to 10 times lower than the minimum value observed in the region of Fos-Etang de Berre by Viala et al. (1978). The average concentration of Pb in the Mediterranean appears to be close to the values observed over various regions in the North Atlantic.

The average concentrations of trace elements such as Al, Fe, Cu, Zn, Pb, Cd and As in suspended matter collected between the south coast of France and Corsica are, in general, similar to those measured in the Atlantic, except for Cu. No increase or decrease in these concentrations was observed with increasing depth.

Taking Al as a reference element, the enrichment of trace elements in marine suspended matter relative to terrestrial crustal matter has been studied. It was found that enrichment factors for Cu, Cd and Pb are slightly higher than those observed in the Atlantic. It seems that among the trace elements in marine aerosol and in suspended particulate matter collected in the Mediterranean region, Pb is the only element the origin of which can be exclusively attributed to the influence of industrial pollution. While the concentrations of Cu in particulate matter are definitely higher in the Mediterranean than those observed in the Atlantic, it is not certain that the atmospheric transport flux of volcanic origin such as that coming from Etna for heavy metals like Cu is comparable with the flux from industrial activities in Mediterranean countries.

The results of trace metal measurements on suspended particulate matter in Mediterranean sea-water demonstrate that enrichment anomalies exist for Cu, Pb, Cd, Zn and possibly for Fe in this region. Nevertheless, the concentrations and degree of enrichment are of the same order of magnitude as those found in the Atlantic and Pacific oceans. This indicates that the chemical behaviour of trace metals in the Mediterranean is governed by laws similar to those controlling the distribution of these elements in the world oceans.

The vertical distribution of selected trace metals in offshore Mediterranean bottom sediments has been studied on two core samples taken from 500 m and 1,000 m depth in an area located off Villefranche in 1978. The cores of approximately 30 cm were divided into several vertical sections and selected trace metals such as Mn, Cu, Zn, Pb, etc. were measured on each section. For the Pb measurements, various procedures of sediment pretreatment were applied to differentiate between the different chemical forms of Pb associated with sediment particles. Depending on the treatment applied, acid-extractable Pb, EDTA-exchangeable Pb, total organic Pb, alkyl Pb, etc. were distinguished. The vertical distribution of these different chemical forms of Pb within the sediments demonstrates that some fractions of Pb in the upper parts of the sediment cores are introduced anthropologically; the Pb concentration decreases from the surface of the sediments to 6-8 cm in depths for both sediment cores and the concentration of Pb at the surface in the shallower core (500 m) is always higher than that in the deeper core (1,000 m). Considering the expected sedimentation rate in the area under study, the vertical distribution of Pb within the sediments suggests the downward migration of certain forms of Pb in the sediments.

6.1.2 Trace elements in biota

During the period 1975-1977, pelagic organisms ranging in size from plankton to tuna were sampled throughout the Mediterranean and analysed for selected heavy metals (Fowler et al. 1979a). Large zooplankton and small nekton from both western and eastern basins were sorted according to individual species, thus allowing realistic comparisons to be made between the levels in similar species inhabiting different areas. In some cases, organisms were dissected to examine inter-tissue distribution of certain pollutants. In general, although occasional high concentrations were noted, the levels encountered in the majority of the organisms were not too unlike those reported for pelagic species from other oceanic regions.

To date, mixed plankton sampled in 1977 have been analysed only for Hg and V (Table II). Mercury levels were generally low, averaging approximately 46 ppb dry (range 15-116 ppb) for the entire Mediterranean. There was a slight tendency towards lower values ($\bar{X}$ = 28 ppb) in the Levantine basin, although the differences between areas were not statistically significant ($P < 0.05$). In general, overall Hg levels in mixed plankton were in the same range as those measured in similar samples collected throughout the open Mediterranean on the Chain cruise in 1975 (Fowler et al. 1976). Vanadium concentrations in plankton were considerably higher than mercury, with levels averaging about 0.9 ppm dry (range 0.2 to 1.7 ppm).

Euphausiids were usually the most prevalent group found at each station. Results of the heavy metal analyses of these pelagic crustaceans are given in Table III. Mercury levels averaged 138 ppb dry and were notably higher than the concentrations in the mixed plankton upon which euphausiids feed. Interstation variation in the concentration of most elements in euphausiids was less than one order of magnitude except in the case of Se and Ag.

Table II - Total mercury and vanadium in mixed plankton from the Mediterranean Sea. Samples were collected during May - August, 1977

Region	Station	Net mesh size (μm)	Hg/g dry Hg	V
Eastern	A-1	60	0.036	0.37
	A-3a	280	-	1.45
	S-1	280	0.020	-
	S-2	280	0.031	-
	S-3	280	0.034	-
	S-4	280	0.018	-
Ionian	H-4	60	0.063	1.52
	H-4	280	0.039	1.04
	H-14	60	0.116	0.86
	H-14	280	0.048	0.91
Tyrrhenian	H-23	60	0.066	6.32
	H-23	280	0.036	6.29
	H-37	60	0.050	1.54
	H-37	280	0.041	1.67
North-Western	CS-39	500	0.024	-
	CS-42	500	0.015	0.22
	CS-44	500	0.021	-
	CS-49	500	0.026	-
	CS-51	500	0.078	-
	CS-51	333	0.116	-

Several other individual zooplankton and micronekton species were analysed for selected trace elements and, in general, for any one species no striking differences or similarities in element concentration were observed (Tables IV - VII). In the case of Hg, for which we have the most comprehensive data, it appears that, along with mixed plankton, the smaller forms with high water content (e.g. _Pyrosoma atlanticum_, _Abylopsis tetragona_ and leptocephali of eels) displayed the lowest levels. Although there were some exceptions, a trend towards higher concentrations (0.1 to 0.2 ppm Hg dry) was noted in pelagic crustaceans and molluscs, with the highest levels generally found in pelagic fish. As was the case with euphausiids, in general, relatively little variation in element concentration was noted among individual species from different stations. One notable exception was cobalt, which was consistently higher in the mesopelagic fish _Myctophum glaciale_, from the eastern basin compared to the other regions (Table V).

Table III - Trace metals in euphasiids (Euphausia sp.) from the open Mediterranean Sea. Values in parentheses represent samples of Meganyctiphanes norvegica

Region	Station	Range of size (cm)	As	V	Zn	Co	Cd	Ag	Se	Sb	Rb	Sc	Fe	Hg*
			μg/g dry											
Eastern	A-3a		49.9	<0.06	58	0.29	0.18	2.7	7.2	0.050	0.11	0.005	150	
	A-6a		33.8	0.24	107	0.24	0.21		4.6		0.31			
	S-2		18.7		100	0.15	0.60		4.0		0.25			
	S-3		18.4		123	0.15	0.43		4.2		0.65			
	S-4		47.2	0.84	140	0.26	0.16	0.92	2.1	0.046	0.08	0.040	40	0.028
Ionian Sea	H-4 (≤1)			0.37										
	H-4(1.5-2)													0.148
	H-14(≈1)		56.9		84	0.15	0.12		3.6		0.32			0.130
	H-14(1.5-2)													0.192
	H-14			(<0.07)	(39)	(0.06)	(0.06)	(0.16)	(2.9)		(0.27)			(0.097)
Tyrrhenian Sea	H-23(≤1)		20.0	0.48	120	0.23	0.29	2.3	2.9	0.031	0.17	0.038	191	0.076
	H-23(1.5-2)													0.176
	H-37(>2)		34.9	1.24	57	0.19	0.26	1.7	3.5	0.040	0.11	0.013		0.239
	H-37			(1.10)	(144)	(0.25)	(0.08)		(3.3)	"	(0.38)			
North-western	CS 46		29.6	0.23	39	0.23	0.33	1.2	1.4	0.050	0.11	0.070		0.109

* Analysed by AAS.

Table IV - Trace metals in pelagic eel leptocephali (*Anguilla* sp.) from the eastern basin of the Mediterranean Sea

Station	As	V	Zn	Co	Cs	Ag	Se	So	Rb	Hg*
	µg/g dry									
A-3a	32.1	0.36	71	0.22	0.21	1.6	4.1	0.033	0.054	-
A-6a	37.3	-	25	0.067	0.03	-	2.9	-	0.22	0.064
S-1	17.1	-	25	0.073	0.70	-	4.5	-	0.17	0.059
S-2	26.9	0.15	26	0.086	0.09	-	4.2	-	0.18	0.048
S-4	22.0	2.3	20	0.47	0.35	0.86	3.6	0.050	0.14	-

* Analysed by AAS.

Table V - Trace metals in myctophid fish, *Myctophum glaciale*, from different regions of the Mediterranean Sea

Region	Station	size cm	As	V	Zn	Co	Cs	Se	Rb	Hg*
			µg/g dry							
Eastern	A-6a	-	44.8	<0.06	69	0.21	0.090	6.1	0.31	-
	S-1	-	-	0.66	51	0.24	0.080	3.5	0.22	-
	S-2	-	-	1.12	80	0.22	0.080	3.1	0.31	-
	S-3	(1 -3.5)	-	-	-	-	-	-	-	0.097
	S-4	-	-	0.30	93	0.12	0.070	3.0	0.25	0.116
Ionian Sea	H-4	(2 -3.5)	-	-	85	0.10	0.060	5.8	0.26	0.175
	H-4	(6.5-7.5)	-	0.35	90	0.067	0.054	5.9	0.24	0.168
	H-14	(2.5)	-	<0.08	73	0.067	0.056	5.4	0.21	0.190
	H-14	(4 -5)	-	-	43	0.06	0.070	5.2	0.32	0.172
Tyrrhe-nian Sea	H-23	(1 -3.5)	-	-	64	0.044	0.054	5.0	0.24	0.120
	H-23	(5.9-7.5)	-	<0.05	76	0.054	0.033	4.1	0.25	0.279
	H-33	(1 -3)	-	0.98	-	-	-	-	-	-
	H-37	(3 -4)	-	0.74	66	0.035	0.069	4.4	0.19	-
	H-37	(6 -7)	-	0.60	78	0.11	0.038	5.2	0.20	0.160
North-western	CS-46	-	-	-	-	-	-	-	-	0.142

* Analysed by AAS.

Table VI - Trace metals in the pelagic tunicate, Pyrosoma atlanticum, from the central and eastern regions of the Mediterranean Sea

Region	Station	size	As	V	Zn	Co	Cs	Ag	Se	Rb	Hg
						µg/g dry					
Eastern	A-3a	-	-	-	131	0.24	0.04	0.37	4.6	0.32	-
	A-6a	-	26.8	0.32	98	0.17	0.04	0.56	6.2	0.38	-
Ionian Sea	H-4	6 cm	35.6	0.39	64	0.10	0.03	0.05	3.3	0.18	0.047
	H-4	8 cm	-	-	-	-	-	-	-	-	0.042
	H-4	10 cm	-	0.52	180	0.20	0.91	0.08	4.1	0.38	0.037
	H-4	12 cm	-	0.43	-	-	-	-	-	-	-
	H-14	6-10 cm	34.2	0.30	173	0.16	0.03	0.09	4.3	0.29	0.041
Tyrrhe-nian Sea	H-37	-	-	-	136	0.13	0.03	-	4.4	0.40	0.075

Size may also be a factor to consider concerning the concentration of certain trace elements in pelagic organisms. For example, vanadium concentration in Myctophum glaciale collected at a single station was inversely related to size (Table V). However, the same trend was not evident with all the elements examined, and analyses of more individuals representing a wider range in weight would be necessary in order to evaluate which element shows variation in concentration with size.

An analysis of food-chain relationships of elemental concentrations was often hampered by lack of samples of complete food-chains at a given station. For this reason, several species comprising a complete, multiple food-chain were sampled from a single net haul and analysed for As and V. The data in Table VIII show that in passing along the food-chain from microplankton to euphausiids to carnivorous decapods and fish, concentrations of As displayed no noticeable trend, whereas V levels clearly decreased.

Food-chains consisting of microplankton, macroplankton and pelagic fish were also sampled in the Aegean Sea (Papadopoulou, 1979). No trend of "food-chain magnification" was noted: As, Zn, Cs and V concentrations decreased at high trophic levels, whereas Se levels remained fairly constant (Table IX). Dissection of fish tissues showed that As, Zn, Co and Se accumulate preferentially in the liver, whereas Cs and Rb concentrations are roughtly the same in muscle and liver (Papadopoulou, 1979). Similarly, V concentrations have been found to be five times higher in pelagic shrimp hepatopancreas than in muscle.

Table VII - Total mercury (µg/g dry) in various Mediterranean pelagic organisms sampled during a series of cruises in 1977

Region	Station	COELENTERATA		TUNICATA	MOLLUSCA				CRUSTACEA				PISCES			
		Abylopsis tetragona	Medusa	*Salpa maxima*	*Sepiola rondeleti*	*Loligo vulgaris*			*Sergestes arcticus*	*Sergestes corniculum*			*Vinciguerria* sp.	*Chauliodus* sp.	*Lampanyctus* sp.	[illegible]
						muscle	hepatopancreas	remainder		whole	muscle	exoskeleton				
[illegible]	A-4	0.022														
	A-15	0.015											0.225	0.112		[illegible]
	A-6a														[illegible]	
	[illegible]													0.172		
[illegible]	B-1					0.168	0.106	0.153								
[illegible]	B-6		0.044		0.126				0.152	0.175	0.198	0.131				
[illegible]	B-14	0.021							0.155	0.194						
	B-25	0.012		0.013												
	B-17	0.020							0.115							
[illegible]	CS-62			0.014												
	CS-66			0.028						0.292						

Table VIII - Arsenic and vanadium in pelagic organisms from the north-western Mediterranean. Samples were collected during March 1977 off Villefranche-sur-Mer, France

Organism	weight ratio dry/wet	µg/g dry	
		As	V
Microplankton	.11	12.2	1.45
Meganyctiphanes norvegica	.21	55.8	0.23
moults	.22	2.4	10.3
faecal pellets	.14	35.9	N.A.
Phronima sedentaria	.10	27.2	0.45
Pasiphaea sivado	.24	114	0.07
Myctophym glaciale	.28	12.7	< 0.08

* = Principally copepods, unidientified small crustaceans, chaetognaths, phytoplankton and derritus.
N.A. = Not analysed.

Table IX - Trace element concentrations in plankton and Trachurus mediterraneus (µg/g, dry ± standard deviation)

SAMPLE	As (2)	Zn	Co	Se	Cs	Rb	V (3)
60 µ net sample	18	-	-	-	-	-	-
250 µ net sample	18	162±5	0.060±0.002	2.0±0.3	0.99 ±0.035	0.32±0.08	11.1 ±0.4
500 µ net sample	7.7	119±4	0.36 ±0.014	2.2±0.3	0.37 ±0.013	-	4.6 ±0.2
Euphausia Kronnii	5.4	77±3	0.17 ±0.07	1.8±0.3	0.55 ±0.020	0.17±0.05	1.62 ±0.03
Trachurus m. (1) (flesh)	7±2	19±9	0.030±0.014	2.9±0.7	0.067±0.012	0.32±0.05	0.095±0.02

(1) For Zn, Co, Se, Cs and Rb mean of 14 specimens analysed, for As and V mean of 9 specimens.
(2) Analytical standard deviations for As are up to 10%.
(3) Overall standard error of the counting technique.

Tissues of bluefin tuna (Thunnus thynnus thynnus) have also been analysed for heavy metals to gain insight into the intricate food-chain relationships involved in the transfer of pollutants to top-level pelagic predators. Levels of vanadium in tuna are given in Table X. Gut contents are normally higher that either liver or muscle indicating that vanadium does not show a biomagnification effect in passing from prey to predator. Mercury has also been analysed in muscle, and values ranging between 0.6 and 1.2 ppm wet appear similar to those which have been previously reported for Mediterranean tuna (Renzoni *et al.* 1979).

Table X - Vanadium concentration (ppb) in tissues and stomach contents of the Mediterranean bluefin tuna (*Thunnus thynnus thynnus*) caught off the Côte d'Azur

Fish No	Port of landing	Date	Length (cm)	Weight (kg)	ng V/g dry ± 1σ		
					Muscle	Liver	* stomach contents
1	Nice	21/7/77	82	10.2	18.7±1.9	158±18	469±64
2	Menton	7/8/77	84	11.0	39.2±5.0	139±18	397±34
3	Cannes	13/8/77	88	11.0	14.9±1.4	73± 9	130±14
4	Antibes	21/8/77	83	12.8	9.3±0.7	26± 2.4	136±12
5	Monaco	4/9/77	116	27.8	26.6±4.0	66± 8	31± 2

* = Composed principally of euphausiids.

6.1.3 Vertical transport flux of trace elements

Heavy metals were also analysed in sinking particulates, which were collected in sediment traps moored at 100 m depth several kilometres off the coast of Monaco. Preliminary results for selected trace elements in particulates sampled during the summer-autumn period 1978 are given in Table XI. it is immediately evident that trace metal concentrations in this material are relatively high. Much of the material trapped at 100 m was in the form of zooplankton faecal pellets. Metal levels in pure copepod faecal pellets collected near the traps are also high and are similar to concentrations found in the trapped particulates. In general, metal levels in these particulates are much higher than those in the organisms producing them (Table XI). The data clearly illustrate the variation in trace element vertical flux that occurs seasonally.

Table XI - Trace elements in biogenic particulates from the Ligurian Sea

Sample	Date	Mass flux $g\ m^{-2}\ d^{-1}$	Cd	Cu	Fe ($\mu g\ g^{-1}$ dry)	Mn	Zn
Sediment trap particulates	6/78	0.77	1.3	62	27000	812	402
	7/78	0.64	N.D.	21	24100	247	125
	10/78	0.77	N.D.	23	28700	583	99
Copepod faecal pellets			N.D.	950	15400	277	915
Copepods	-	-	0.9	10.1	129	5.5	71

6.1.4 Chlorinated hydrocarbons in sea-water, air and sediments

To establish the baseline levels of organo-chlorine compounds in the open Mediterranean Sea, as well as to understand major geochemical processes involved in distributing these compounds in the open Mediterranean environment, the measurements of PCBs have been carried out in sea-water, air and sediments collected during several cruises conducted in 1977-79. The collections of these samples were made on board Atlantis II, Hayes, Cornide de Saavedra, Shikmona, Calypso and Researcher (Figure 2).

During these cruises, 76 surface and subsurface sea-water samples were collected, and various organic constitutents were preconcentrated on X-AD-2 resin on board. The resin columns were brought back to the laboratory at Monaco and chlorinated hydrocarbons were analysed by gas chromatography after the separation and cleaning procedures. Due to low levels of concentrations of organo-chloride compounds, it was only possible to determine the PCBs. A summary of the results obtained on the PCB concentrations in Mediterranean sea-water is given in Table XII. The results show that, although higher concentrations of PCBs at the surface were observed at some stations, no systematic vertical variation is generally observed. The levels of PCBs in near-surface layers are not very much different from those in deep layers beyond 2,000 m. PCB concentrations measured on these sea-water samples range from 0.1 to 2.5 ng/l with an average of 0.7 ng/l. This average value is found to be significantly different statistically from the average PCB concentration 2.0 µg/l obtained for sea-water samples collected in the same regions during 1975 (Elder and Villeneuve, 1977). This indicates that the concentration of PCBs in open Mediterranean waters decreased slightly from 1975 to 1977-79.

Since 1975 the ILMR has also undertaken the measurements of PCBs in air samples collected during the cruises as well as in those collected from a fixed station in Monaco.

Table XII - Concentrations of PCBs in Mediterranean sea-water (in ng/l as DP5)
- a summary table -

Cruise	Atlantis II	Hayes	Cornide de Saavedra	Shikmona	Calypso	Researcher
Date	April 1977	June 1977	July 1977	July 1977	Nov. 1977	June 1979
Area	Eastern Med.	Ionian-Tyrrhenian	Western Med.	Eastern Med.	Adriatic	Eastern Med.
0 - 100 m	0.3 - 1.4	0.2 - 2.5	0.2 - 0.6	$<$0.1 - 0.1	0.2 - 1.8	0.2 - 0.5
500 m	0.7 - 1.9	$<$0.1 - 1.0	-	0.2 - 0.3	-	0.2 - 0.3
1000 - 1500 m	0.4 - 1.5	0.7 - 1.1	-	-	-	0.1 - 0.2
2000 - 2500 m	0.5 - 0.7	1.5	-	-	-	-
3000 - 4500 m	1.3	0.9	-	-	-	-

The concentration of PCBs measured in six open Mediterranean air samples collected from the western Mediterranean during September 1975 ranged from 0.1 to 0.3 ng/m^3. While two samples collected from a similar region in July 1977 show a range of 0.05 - 0.08 ng/m^3, the data obtained for the Adriatic sea during November 1977 range from 0.04 to 0.1 ng/m^3. It appears that the concentration of PCBs in the air masses lying above the Mediterranean decreased slightly from 1975 to 1977, as has been indicated for the sea-water concentration. It has been observed, however, that the effects of climatic conditions upon the PCB concentration in air are substantial. Thirty-six measurements of air samples collected from a fixed station at Monaco show that the PCB concentration in air varies within a wide range of 0.03 - 1.0 ng/m^3, tending to decrease from summer to winter by a factor of 10.

The results of the PCB measurements carried out on sediment core samples collected during several cruises in the Mediterranean are summarized in Table XIII. PCBs were observed in all samples analysed, with quite high concentrations in the top centimetre of some core samples. In most core samples, it is generally noted that a substantial decrease in PCB concentration occurs from the first to the second centimetre below the sediment surface, and also that a subsurface maximum of PCB concentration appears about 3 cm from the sediment surface. Although mechanisms for the appearance of these subsurface maxima in marine sediment cores have not yet been understood, their frequent occurrence only in offshore cores indicates that they are not likely to be artefacts related to the sampling procedure. It is considered that they are related to the behaviour of PCBs in sediment layers.

Table XIII - Concentrations of PCBs in Mediterranean sediments (in ng/g dry sediment as DP6) - a summary table -

Cruise	Atlantis II	Hayes	Shikmona	Meteor
Date	April 1977	June 1977	July 1977	August 1979
Area	Eastern Med.	Tyrrhenian	Eastern Med.	Ionian
Station Depths	2650 - 3840 m	1000 - 2300 m	-	-
Depth in sediment				
Top - 1 cm	5.1 - 8.9	0.8 - 1.3	0.6	1.2 - 1.6
1 - 2 cm	1.6 - 2.3	0.3 - 0.8	0.3	0.3 - 0.9
2 - 3 cm	2.3 - 3.1	0.6 - 1.2	0.6	0.8 - 1.0
3 - 4 cm	2.3	0.3 - 0.7	-	0.9 - 1.2
4 - 5 cm	0.9	0.3	-	0.2 - 0.3
5 cm	-	0.3	-	0.8 - 0.9

6.1.5 Chlorinated hydrocarbons in biota

Pelagic species from the central and eastern basins of the Mediterranean Sea were surveyed for PCBs and DDT. Residues levels in mixed microplankton from two cruises *Atlantis II* and *Shikmona*, (Figure 2), show some clear differences. PCBs were significantly higher in samples from station 3a and 6a taken aboard the Atlantis II (Table XIV). A careful examination of possible sources of contamination suggested that the observed differences might be real, although PCB concentrations in water from these two stations were not significantly higher than at other stations. The high DDT/PCB ratio found in plankton from station 2 sampled by the Shikmona may also reflect a relatively recent input of DDT to this region.

Table XIV - Chlorinated hydrocarbon residues in microplankton collected in the eastern Mediterranean during two cruises in 1977

Cruise	Station	PCB (DP-5)	µg/kg dry*			ΣDDT / PCB
			pp'DDT	pp'DDD	pp'DDE	
Atlantis II	1	30	7.1	2.4	2.7	0.40
(4/77)	3a	100	8.7	1.1	3.6	0.13
	6a	230	20	3.1	8.9	0.14
Shikmona	1	35	6.9	12	13.6	0.92
(7/77)	2	19	17	58	9.9	4.57
	3	22	9.4	2.7	2.5	0.66
	4	15	6.2	6.2	6.8	1.25

* Dry weight averaged 11 per cent of wet weight.

The range of residue concentrations in euphausiids (9.8 to 110 ppb dry for PCB and 2.5 to 115 ppb for DDT) were similar to those measured in mixed plankton. Euphausiids from the eastern basin had higher DDT/PCB ratios than those of the central region. This is due to a greater relative decrease in DDT levels compared to PCB concentrations in going from the central to the eastern region.

Residue data in marcozooplankton and micronekton are too sparse to discern regional patterns adequately; however, some interesting observations can be made (Table XV). The pelagic tunicate, Pyrosoma atlanticum, sampled at one station in the Ionian Sea, contained far less PCB and DDT than similar-sized individuals from the Levantine basin. Different-sized mesopelagic fish, Myctophum glaciale, sampled from a single population, displayed a trend towards increasing DDT/PCB and DDE/PCB ratios with increasing size of fish. Finally, the relatively high levels of chlorinated hydrocarbons (PCB = 660 ppb; DDT = 127 ppb) found in the amphipod, Anchylomera blossevillei, may be typical for this group of organisms. It is interesting to note that amphipods are also known to accumulate certain heavy metals to very high levels (Fowler et al., 1976).

Tuna muscle contained concentrations of PCB and DDT ranging from 34 to 331 ng/g dry and 9 to 184 ng/g dry, respectively. Gut contents, which were primarily composed of euphausiids, contained levels (PCB = 67 - 383 ng/g; DDT = 57 - 198 ng/g) which corresponded to those in tuna muscle.

Levels of organochlorine compounds in selected macrozooplankton and nekton, as well as mixed microzooplankton have been compared with those in similar species from other oceanic areas (Table XVI). Although the data are sparse, PCBs in macrozooplankton and nekton do not appear to differ significantly from concentrations in similar species measured elsewhere. In the case of microzooplankton there was a trend towards slightly lower values in Mediterranean samples. PCB production has decreased since the time most of the previous surveys were made. Since no information exists on PCB concentration in plankton or water from the open Mediterranean during the early 1970s, it is impossible to ascertain whether levels may have been higher prior to our 1977 survey. Far more data need to be collected over a longer time span in order to resolve whether these lower levels in plankton are due to a global decrease in PCB input with time, or actually represent real-time geographical differences in existing PCB concentrations.

6.1.6 Vertical transport flux of chlorinated hydrocarbons

The flux of organochlorine compounds via vertical transport of contaminated particulate from the upper layers to the sediments has been assessed by analysing freshly produced biogenic particulates released from zooplankton and those collected, at depth with moored sediment traps (Fowler et al., 1979).

Sediment trap samples were composed almost entirely of intact faecal pellets and grey-green, amorphous organic matter which closely resembled the contents of faecal pellets. The latter material was categorized as faecal material. Two distinct types of faecal pellets were evident: small ovoid and cylindrical copepod pellets and longer, more fragile, cylindrical pellets presumably from larger zooplankton such as euphausiids or salps. Intact faecal pellets, sorted from a known volume of the sample, were found to comprise approximately 10 per cent of the total dry particulate trapped. Dry weight of the total particulate sample averaged about 30 per cent of the wet weight.

Table XV - Chlorinated hydrocarbon residues in zooplankton and micronekton from the open Mediterranean. Each sample was a composite sample of several individuals collected during the Hayes and the Atlantis II cruises in 1977

Organism	Region	Station+	PCB (DP-5)	µg/kg dry pp'DDT	pp'DDD	pp'DDE	ΣDDT / PCB
SIPHONOPHORA							
Abylopsis tetragona	Tyrrhenian	37	22	4.8	0.8	2.5	0.36
	Tyrrhenian	23	41	15	22	4.3	1.00
	Eastern	3a	37	9.4	5.9	3.0	0.50
POLYCHAETA							
Alciopa cantrainii	Ionian	14	96	35	5.9	19	0.63
AMPHIPODA							
Anchylomera blossevillei	Tyrrhenian	23	660	57	18 ++	52	0.19
DECAPODA							
*Sergestes arcticus**	Tyrrhenian	37	41	4.8	4.4	27	0.89
	Tyrrhenian	23	56	22	2.4	13	0.65
*Sergestes corniculum**	Ionian	4	21	4.5	1.2	9.7	0.74
Palinarus (larva)	Ionian	14	71	35	N.D.	17	0.71
TUNICATA							
Pyrosoma atlanticum	Ionian	4	6.0	1.4	0.4	1.0	0.47
	Eastern	3a	49	8.6	1.7	4.5	0.31
	Eastern	6a	150	16	8.8	10	0.23
PISCES							
Anguilla (leptocephales)	Eastern	3a	35	6.8	3.0	6.6	0.47
	Eastern	6a	48	3.9	5.2	15	0.50
*Myctophum glaciale***	Tyrrhenian	23	89	69	14	47	1.45
	Tyrrhenian	37(6-8cm)	27	20	4.5	13	1.38
	Tyrrhenian	37(4-5cm)	83	52	6.9	28	1.05
	Tyrrhenian	37(2-3cm)	50	20	10	9.6	0.81
	Eastern	6a	41	11	4.9	20	0.88

\+ Stations refer to those in Figure 2.
++ Error is ± 50%.
* Dry weight is 23% of wet weight.
** Dry weight is 27% of wet weight.

Table XVI - PCB residues in mixed plankton from different oceanic areas

Region	Date	Net mesh size (µm)	Mean (range) µg/kg wet	Reference
N.W. Atlantic shelf	1969,1971	239	*91.2 (7.1-300)	Risebrough et al.(1972)
North Atlantic	1970	"	380 (300-450)	"
South Atlantic	1971	"	200 (18-640)	"
N. & S. Atlantic	1970-1972	"	200 (=10-1000)	Harvey et al. (1974a)
N.E. Atlantic	1971	-	60 (10-110)	Holden (1972)
Firth of Clyde	1971	-	485 (40-2200)	"
Stockholm archipelago	1971	100	- ** (3-350)	Jensen et al. (1972)
Gulf of St. Lawrence	1972	73	1390 (90-3050)	Ware & Addison (1973)
"	1972	239	700 (N.D.-1860)	"
S.W. coast of Finland	1972-1973	150	190 (40-750)	Linko et al. (1974)
Gulf of Mexico - N. Caribbean	1971	239 or 750	95 (<3-1055)	Giam et al. (1973)
Gulf of Mexico	1973	333	84 (40-157)	Baird et al. (1975)
N.E. Pacific	1973-1975	333	40 (= 1-180)	Clayton et al. (1977)
Eastern Mediterranean	1977	239	7 (2-25)	Present study

* Converted at dry/wet weight = 10%.
** Converted at fat/wet weight = 1%.

Total mass flux estimates at 100 m during four months, as well as PCB concentration in the particulates, are given in Table XVII. The decrease in particulate flux during the summer months correlates well with the decrease of phytoplankton biomass and organic aggregates that are well known to occur in this region. Using PCB concentrations and the mass flux values, it can be calculated that PCB deposition rates averaged approximately 100 µg PCB $m^{-2}yr^{-1}$. Independent estimates of PCB deposition rates, calculated from PCB levels measured in the Ligurian Sea sediment, range from 80 to 125 µg $m^{-2}yr^{-1}$ and agree very closely with the measured values.

Freshly released copepod faecal pellets typically contained about 1,300 µg PCB kg^{-1} dry (Table XVIII). These levels were a factor of 10 higher than PCB concentrations (180 ppb dry) in the copepods that produced the pellets. The general similarity between PCB concentration in copepod pellets and the trapped material was not unexpected, in that faecal pellets and faecal material comprised the bulk of the particulates collected at depth. It is noteworthy that in all cases, particulates collected at 100 m contained rather less PCB than was present in faecal pellets released from surface-dwelling copepods. This observation suggests a partial release of PCBs from faecal matter as it sinks.

Table XVII - Estimates of PCB vertical flux in the Ligurian Sea

Date	Particulate PCB µg/kg dry	Mass Flux $g\ m^{-2}\ d^{-1}$	PCB Flux $\mu g\ m^{-2}\ y^{-1}$
6/78	650	0.77	183
7/78	300	0.64	70
8/78	710	0.40	104
10/78	200	0.77	56
			$\bar{X}$ = 103

Table XVIII - PCB concentrations (as DP-5) in surface produced biogenic particulate and those trapped at depth

Sample	µg/kh dry
NATURAL FAECAL PELLETS (SURFACE)	
Copepods	1300
TRAPPED PARTICULATES (100 m)	
June 1978	650
July 1978	300
August 1978	710
October 1978	200

The presence of relatively high levels of PCBs in both freshly produced copepod faecal pellets and sinking faecal metter collected in situ indicated that zooplankton defecation contributes significantly to the downward vertical transport of these compounds in the Mediterranean Sea. Measured faecal pellet sinking rates suggest that copepod pellets have the potential to reach the bottom in areas of shallow depth such as most coastal regions. However, in deep waters it is probable that only rapidly sinking, large pellets from bigger forms (e.g. large copepods and euphausiids) will prove to be the principal particulate conveyor of pollutants to depth. In this case smaller pellets would play an important role in the cycling of these compounds in the upper water layers. The fact that faecal pellets collected in traps at 2,000 m correspond in size to those of the large copepods, Acartia patersoni, used in our study, lends support to this contention. Further analyses of particle trap samples from several depths in the Mediterranean will be instrumental in testing this hypothesis.

6.2 Biokinetic studies

6.2.1 Trace element kinetics

Information on the flux of trace elements through marine organisms is vital for a complete understanding of ambient element levels measured in species which are being used in Mediterranean monitoring programmes. For this reason, the behaviour and fate of arsenic, vanadium and nickel in a variety of Mediterranean species were examined in controlled laboratory experiments utilizing both radiotracers and stable element techniques.

Bioaccumulation, tissue distribution and depuration of arsenic were studied in Mediterranean mussels (Mytilus galloprovincialis) and shrimp (Lysmata seticaudata) with the aid of the radiotracer ^{74}As (Fowler and Unlu, 1978; Unlu and Fowler, 1979). Over a concentration range from approximately 2 to 100 g As/l, uptake was dependent upon the arsenic concentration in sea-water. Most of the arsenic accumulated was located in muscle tissue. Arsenic was taken up by mussels more rapidly at higher temperatures: a temperature effect of arsenic accumulation in shrimp was more difficult to discern due to an increased rate of moulting at higher temperatures. Arsenic uptake was inversely related to salinity in both species. Animal size also affected arsenic accumulation patterns; ^{74}As concentrations on a whole-body weight basis were higher in smaller than in larger individuals.

Arsenic elimination from both species appeared to follow a double exponential function. Increased temperature enhanced the rate of depuration; however, changes in salinity had little effect on the loss rate. In addition, depuration was strongly dependent on whether arsenic was accumulated with food or directly from water (Figure 3). Mussels living in their natural environment lost arsenic at a much greater rate than did inidividuals maintained in the laboratory. Increased arsenic loss from these individuals was correlated with increased byssus production and it appears that rapid turnover of arsenic in byssus is one mechanism by which contaminated mussels can rid themselves of excess arsenic.

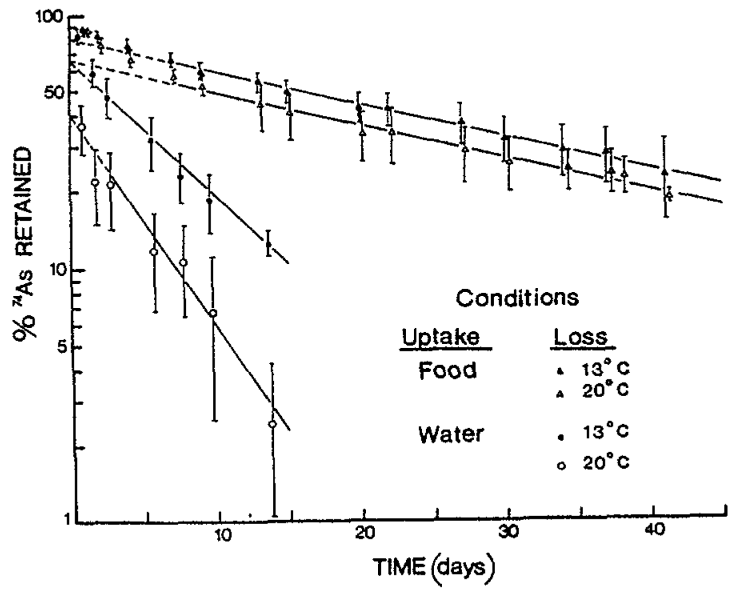

Figure 3. Loss of As from Mediterranean shrimp (Lysmata seticaudata) at two different temperatures following uptake either from water or food

Preliminary studies with the phytoplankton Dunaliella marina have shown that arsenate is rapidly metabolized to a form extractable with the lipids. Using Dunaliella as the primary producer in a three component food-chain it has been shown that this lipid arsenic is transferred efficiently to a herbivore (Artemia salina), and subsequently to a carnivorous shrimp (Lysmata seticaudata). It also appears that Artemia and Lysmata cannot mobilize inorganic arsenic into the lipid fraction; arsenate absorbed directly from sea-water by these organisms is converted largely to arsenite (Wrench et al., 1979).

Vanadium-48 and stable vanadium were used to study the uptake from water and elimination of vanadium in four benthic invertebrates - mussels (Mytilus galloprovincialis and M. edulis), worms (Nereis diversicolor), shrimp (Lysmata seicaudata) and crabs (Carcinus maena). The highest concentration factor (≈ 30) was noted in mussels after three weeks exposure. Over a concentration range from approximately 2 to 100 µg V/l, uptake in mussels and shrimp was dependent upon the vanadium concentration in sea-water. Uptake in mussels and shrimp appeared to be independent of temperature over a range of 13°C to 24°C but was slightly increased at low salinity (19°/oo). Vanadium behaves differently from arsenic in that the majority of vanadium (> 90 per cent) becomes fixed to shells of mussels and crustaceans suggesting that surface adsorption plays a strong role in the bioaccumulation of this element (Ballester, 1979; Miramand et al., 1980). Both radiotracer experiments and stable element data showed that byssus rapidly accumulated vanadium to high levels (Figure 4). Because of the remarkable ability of byssal threads to take up this element, some consideration might be given to using this tissue as a biological monitor for measuring changes in vanadium levels in the natural environment.

Elimination of ^{48}V from mussels, shrimp and crabs was biphasic and could be best fitted to a double exponential excretion model. Contaminated worms, on the other hand, lost the isotope from their tissues at a rate which was best described by a single exponent. Crustacean moulting was found to play an important role in vanadium depuration as well as in the overall biogeochemical cycle of this metal in the marine environment.

In similar experiments with the mussel Mytilus edulis, it has been shown that Ni is assimilated to a much greater degree than V (Ballester, 1979). Enhanced bioavailability of Ni compared to vanadium was also noted in bioaccumulation experiments using bacteria and phytoplankton. Other studies in which fish and shrimp ingested food contaminated with V have demonstrated the generally low assimilation efficiency or this element in marine biota (Ballester, 1979).

6.2.2 Chlorinated hydrocarbon biocycling

Several different experiments were designed to assess the bioaccumulation potential, tissue distribution and depuration of PCB available from water, food and sediments (Polikarpov et al., 1979). In order to test the bioavailability of sediment-bound PCB, comparisons were made of the accumulation of a PCB mixture from sediments and from water by the benthic worm Nereis diversicolor (Fowler et al., 1978; Elder et al., 1979). Uptake from sediments was dose-dependent, attaining equilibrium concentration factors

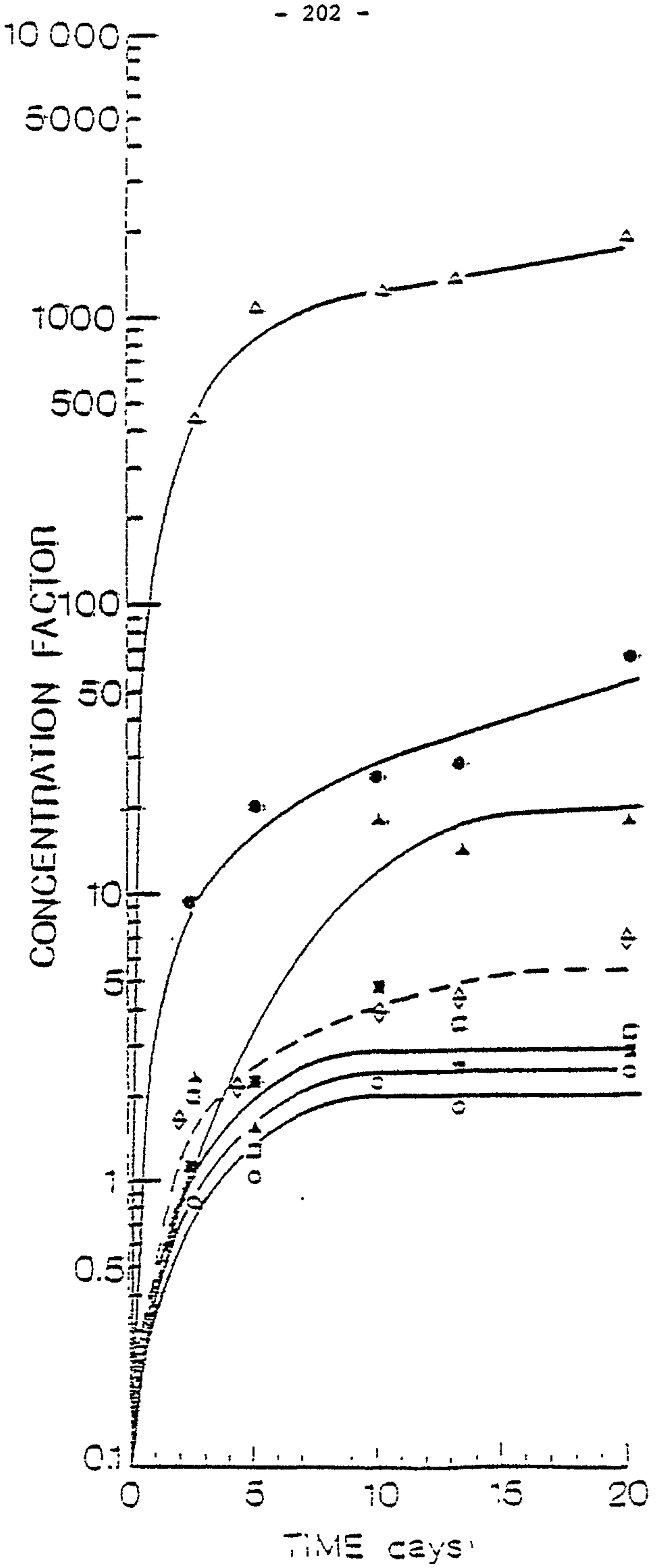

Figure 4. Mytilus galloprovincialis. Accumulation of ^{48}V in tissues after uptake from water. Each point represents mean value of 2 individuals. Mean weight of 10 individuals = 5.3 + 0.2 g; temperature = 13°C. Filled circles: shell; diamonds: whole soft parts; filled triangles: viscera; open circles: muscle; filled squares: gills; open squares: mantle; open triangles: byssus

of approximately 3 to 4 after two months (Figure 5). Subsequent PCB elimination rates were concentration-dependent, with higher initial loss rates evident in the worms containing higher levels of PCBs. Accumulation of PCBs from water was much more rapid: concentration factors reached approximately 800 after only two weeks. Estimates were made of the relative importance of sediments and water as a source of PCBs to worms exposed to these contaminants in the natural environment. Calculations based on experimentally derived PCB concentration factors and ambient PCB levels in sediments and water suggest that, compared to water, sediments contribute the bulk of these compounds to the worms.

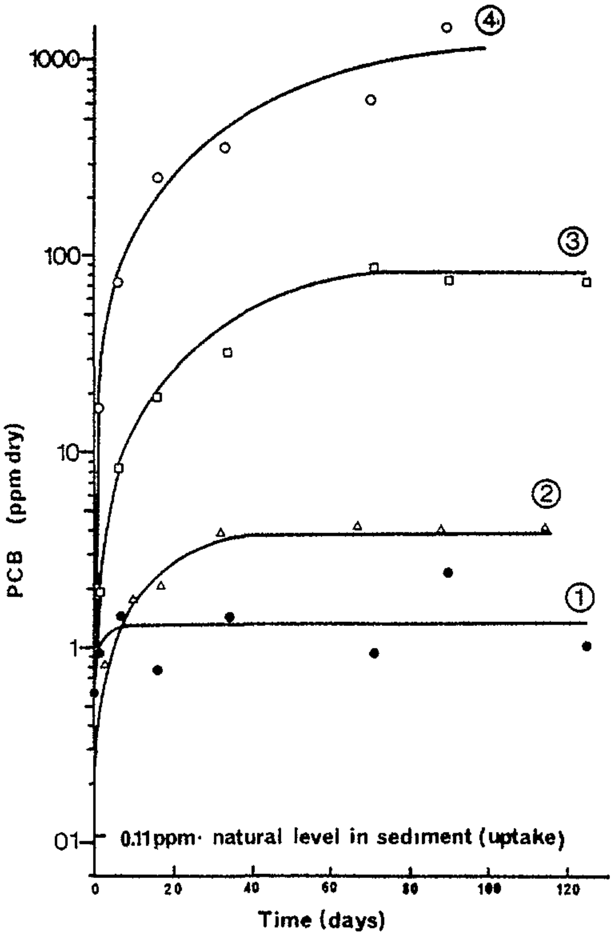

Figure 5. Nereis diversicolor. Accumulation from PCBs from sediments spiked with 0.65 ppm (Curve 2, triangles: after Elder *et al.*, (1979), 9.3 ppm (Curve 3, squares), and 80 ppm (Curve 4, open circles) dry weight. Curve 1 (filled circles) represents PCB levels in worms living in unspiked sediments. Background level of PCB in sediments used by Elder *et al.* was 0.20 ppm dry weight. Wet weight to dry weight ratios are 5.6 for worms and 2.2 for sediments

Using the typical filter-feeding mussel *Mytilus galloprovincialis*, the influence of natural off-shore water and laboratory (running sea-water system) conditions on PCB loss from mussel tissues was studied. Before beginning the depuration phase, mussels had reached 160 ± 67 ppm PCB following a long-term accumulation from running sea-water. During depuration, the ratio of PCB in laboratory mussels to those maintained *in situ* increased from 1.0 at the start to 10 at 71 days, indicating a much more rapid loss of PCBs from mussels maintained under natural condition. These results suggested that mussels living in the natural environment turn over PCB compounds at much more rapid rates than those maintained under laboratory conditions; however, the significance of this finding was questionable, since the PCB concentrations in offshore waters (1.3 ng/l) and laboratory sea-water (20 ng/l) varied by approximately a factor of 15. Therefore a controlled experiment was designed in which PCB-spiked mussels were allowed to depurate in two laboratory sea-waters with PCB concentrations averaging 40 and 190 ng/l. The results in Figure 6 show that mussels do indeed depurate PCBs more rapidly in water of lower PCB concentration. This effect partially explains the observations noted in the laboratory-field experiment and, thus, it is evident that PCB flux comparisons between organisms living in the environment and those living under conditions simulating the environment must take into account the effect of ambient PCB concentration even when it varies by as little as a factor of five. Nevertheless, some increase in PCB depuration rate might be expected in healthy, growing mussels living under natural conditions, but this will be difficult to determine experimentally unless PCB concentrations in laboratory sea-water and in the sea are similar.

The influence of uptake pathway on PCB accumulation and tissue distribution was examined by allowing shrimp to accumulate DP-5 from either food or sea-water and analysing their tissues during a period of one month. Regardless of the uptake pathway, the relative tissue distribution was similar (Figure 7). The viscera which include the hepatopancreas reached the highest levels. Concentrations of PCB in viscera were over an order of magnitude higher than those in exoskeleton and muscle, suggesting that surface sorption plays a minor role in the accumulation of PCB from water by shrimp. Despite the fact that PCBs were rapidly absorbed into internal tissues, moulted exoskeletons contained significant amounts of these compounds. Concentration factors in moults as high as 10^3 to 10^4 clearly illustrate the importance of crustacean moulting as a process for redistributing PCBs in the marine environment. These experiments demonstrate the ease with which PCBs are transferred from the environment to benthic shrimp.

7. OTHER RESULTS

Research agreements were successfully negotiated with research centres and signed by all of them.

The periodic reporting to the IAEA Monaco Laboratory by the research centres was generally satisfactory.

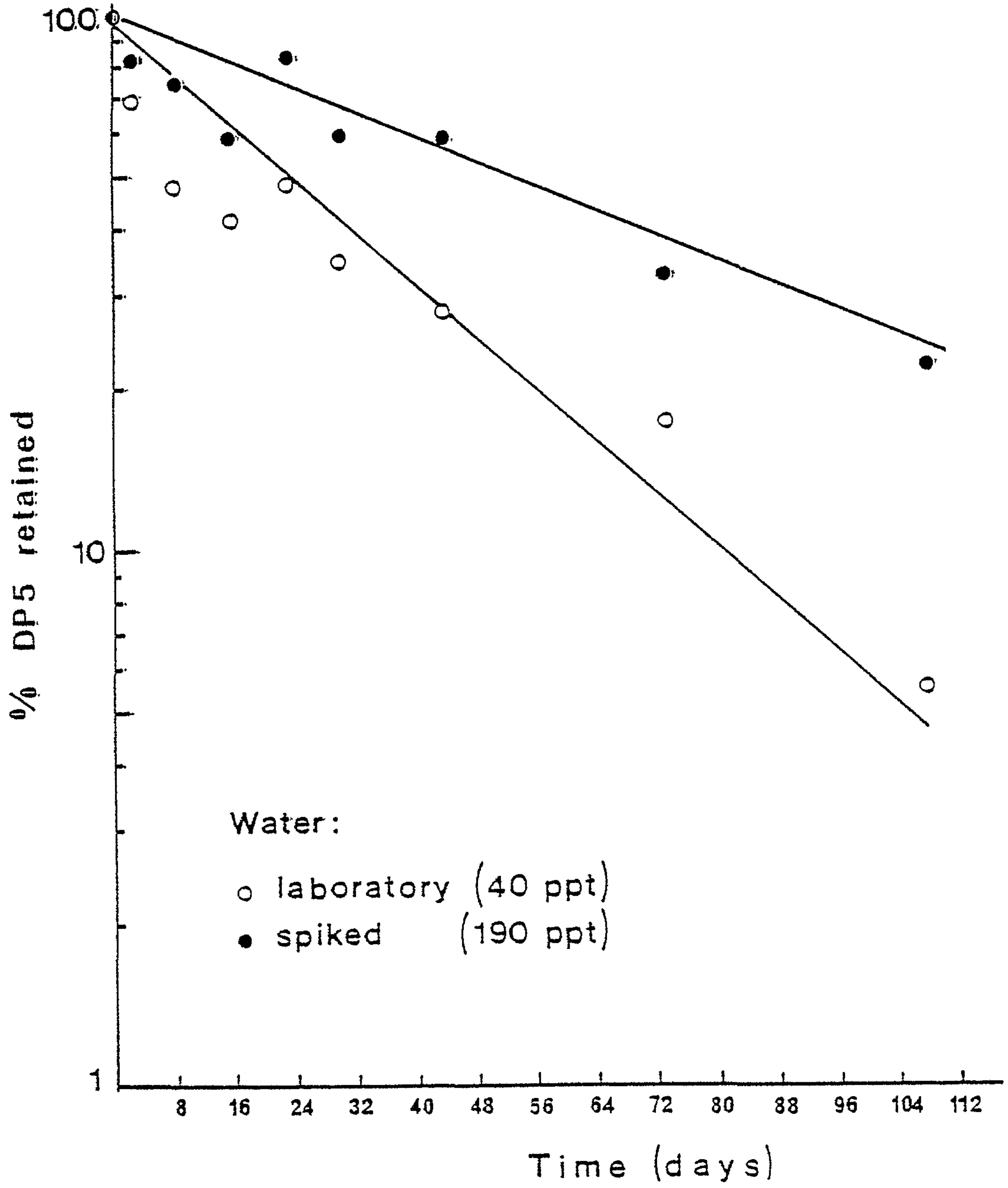

Figure 6. Mytilus galloprovincialis. Loss of PCBs from mussels living in seawater containing two different levels of PCB

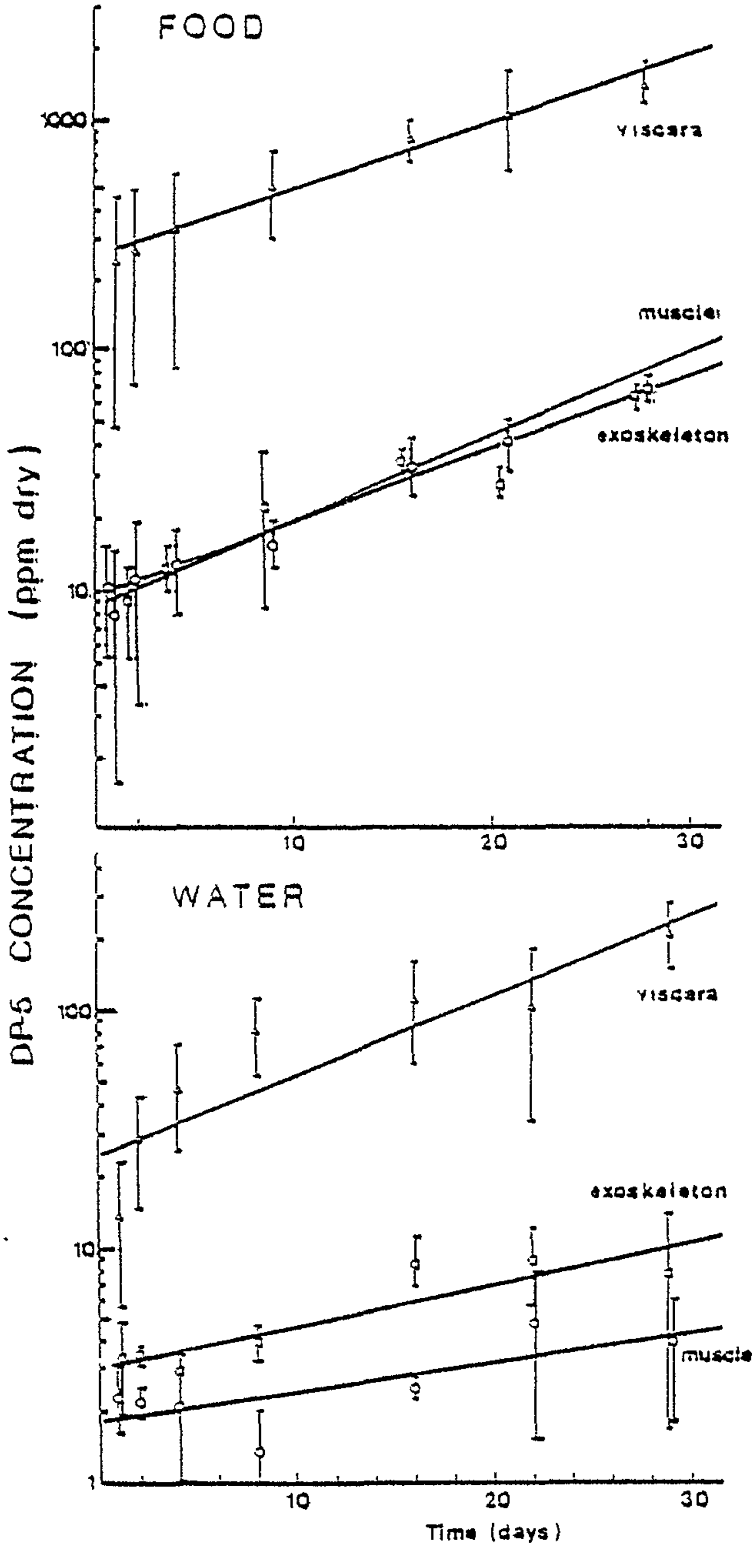

Figure 7. Lysmata seticaudata. Uptake of PCBs from food or water in shrimp tissues

According to the information received from all the research centres, the project was of great value for them in that it:

- enabled widening of the scope of their research and monitoring activities;
- contributed to the efficiency of their work and to the quality of their results;
- introduced new techniques and harmonized their research with other research centres in the region;
- provided for exchange of data and for their comparison with those obtained in other research centres in the Mediterranean.

All research centres expressed their strong wish to continue their collaboration on this or similar marine pollution research and monitoring programmes.

No formal training activities were taken and no specific documents were developed under the project.

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MED POL IX : ROLE OF SEDIMENTATION IN THE POLLUTION OF THE MEDITERRANEAN SEA (UNESCO/UNEP)

1. INTRODUCTION

A comparison between dissolved and particulate elemental concentrations of most metals and organic pollutants in the aquatic environment indicates that they are relatively higher in the solid phase than in the dissolved phase. As a result, the total relative amount of pollutants transported by river water in the dissolved phase compared to that on suspended sediments clearly shows the importance of the latter in any waste load assessment, especially where a high sediment load is present.

In addition to natural particulates from various origins, secondary enriched particulates, such as pesticides fixed on clay minerals and organic matter eroded and carried by rivers, increase the contaminant load. Pollutants from sewage and industrial wastes may be adsorbed on suspended particles or directly discharged in particulate form into receiving waters.

The long-term aim of this project was to provide the Governments of the Mediterranean coastal States with an assessment of the quantity of pollutants entering the Mediterranean Sea through the particulate load carried by the rivers.

The following tasks were identified as the immediate objectives of project MED POL IX:

i) to review the role of river sediments in pollutant transfer;

ii) to review the present knowledge on the quantity and quality of river particulate load discharged into the Mediterranean;

iii) to co-ordinate the actions of the Mediterranean countries and help them to survey the pollutant load carried by suspended particles in rivers.

Development of common procedures for representative sampling of river-suspended sediments was carried out under this project. This included methods for separation of suspended solids, extraction procedures and analytical methods for selected organics and heavy metals.

A selection was made of Mediterranean rivers to be sampled and analysed for substances carried by suspended sediments. Results were to be used in the overall assessment of pollutants contributed by major rivers being carried out in the MED POL X project.

The project was initiated in October 1975 and was later (1978) partly integrated into the activities carried out under project MED POL X.

2. PARTICIPANTS

National institutions in 17 Mediterranean States, selected through UNESCO country focal points, participated in the project.

3. CO-ORDINATING ARRANGEMENTS

UNESCO maintained the operational contacts with national institutions participating in the project.

4. FINANCIAL ARRANGEMENTS

Specific financial support to the project was provided through project document FP/1106-75-06. Costs (in US dollars) were shared between the co-sponsors of the project as follows:

	1976	1977	1978	Total	Percentage
UNESCO	6,000	9,500	1,500	17,000	25.1
UNEP	13,515	13,923	23,198	50,636	74.9
TOTAL	19,515	23,423	24,698	67,636	100.0

These costs included:

- US $ 9,000 for project personnel;
- US $ 15,000 for consultants;
- US $ 1,500 for administrative support;
- US $ 34,000 for the organization and attendance at meetings.
- US $ 5,000 for reporting costs;
- US $ 3,136 for miscellaneous expenses.

No attempt was made to estimate the size of national contributions to the project through the participation of national institutions in its execution.

5. OPERATIONAL DOCUMENT

The technical details of the project were identified at the UNESCO/UNEP Meeting of Experts on Pollutants Entering the Mediterranean through Rivers (Paris, 17 - 21 May 1976).

This meeting developed common methodology to ensure a uniform approach for the collection of a first set of water pollution data relevant to river discharge into the Mediterranean, within the framework of MED POL X. This report was subsequently prepared by the Secretariat of the Division of Water Sciences, in order to review: (i) the role of sediments in pollution studies; (ii) the sediment-pollutant interactions; (iii) the particulate pollutant distribution and the sampling procedures, and (iv) references for analytical procedures. The meeting also proposed a list of pollutants to be monitored in the Mediterranean rivers. Finally a complete list of all major and secondary rivers in the Mediterranean was given including their water discharge, drainage area, average turbidity and information on the quality of the suspended load, if there was any such load.

The report of the above-mentioned meeting was extensively discussed by the experts who met in Rome for discussion on projects MED POL IX and MED POL X.

The meeting recognized the importance of pollutants carried by suspended particles for the assessment of the total pollutant contribution by rivers, especially as far as heavy metals and organochlorinated compounds are concerned.

Taking into account the short time available for the assessment and the present lack of data on the Mediterranean rivers, the Meeting recommended that an action should be taken to obtain a general picture of the order of magnitude of the present level of pollutants based on a limited number of selected rivers and a very restricted number of samples (at least one between January and June 1977).

The meeting agreed on a list of pollutants and a suitable frequency of sampling (Tables I, II and III).

Table I - List of pollutants for the inventory of particulate pollutants

1.	Extremely hazardous pollutants (black list)
	Arsenic Mercury Lead Cadmium PCB Other chlorinated organic compounds
2.	Certain other significant pollutants (grey list)
	Copper Chromium Nickel Zinc

Table II - Major rivers surveyed for particulate pollutants

Albania	Not determined
Algeria	Cheliff, Seybouse
Egypt	Nile and coastal lakes
France	Aude, Hérault, Rhône (to be confirmed)
Greece	Evros
Israel	-
Italy	Adige, Arno, Pescara, Po, Tevere
Lebanon	Not determined
Morocco	Moulouya
Spain	Ebro, Llobregat
Tunisia	Medjerda
Turkey*	Seyhan, Ceyhan, Buyak, Menderes
Yugoslavia	Neretva

* Rivers suggested by the Secretariat.

Table III - Proposed Sampling Frequency for Particulate Pollutants

Type of parameters	Sampling Frequency	
	Large rivers $Q > 100\ m^3/s$	Small rivers $Q < 100\ m^3/s$
Black list	Monthly during the first year Monthly or 4-6 times during the subsequent four years	4 times each year (occasionally)
Grey list	Same as above	One year every five years (four times in that year)
Environmental parameters	To be measured at the time of each sampling	

6. RIVERS STUDIED

Thirty-seven rivers were regularly monitored for some of the determinants of the black and/or grey lists of annexes I and II of the Protocol for the Protection of the Mediterranean Sea against Pollution from Land-based Sources. UNESCO received results on 30 rivers, and data were expected from the remaining seven later.

These 30 rivers represent about 5,800 m^3/s, i.e. about 43 per cent of the total water discharge by rivers to the Mediterranean, estimated to be approximately 14,000 m^3/s, after the Asswan Dam completion and Nile Rosetta Branch closure.

Eight rivers among the most important ones, were regularly monitored with regard to their water discharge. They were:

Country	River	Flow rate (m^3/s)	% of total input
France	+ Rhône	1712	17.6
Italy	+ Po	1550	16.0
Spain	+ Ebro	570	5.9
Egypt	+ Nile + Delta Lakes	540	5.6
Yugoslavia	++ Neretva	378	3.9
Albania	* Drin	342	3.5
Greece-Turkey	++ Evros	311	3.2
Italy	+ Tevere (Tiber)	234	2.4
Italy	+ Adige	231	2.4
Turkey	* Ceyhan	215	2.2
	TOTAL:	6083	63

\+ Monitored (results at UNESCO).
++ Monitored.
* Estimate.

7. MATERIAL AND METHODS

A manual was prepared by UNESCO in co-operation with the International Laboratory for Marine Radioactivity of the IAEA in Monaco, containing the basic methods followed for sampling and pre-treatment of river water samples and for chemical analysis of suspended matter in river water.

8. SCIENTIFIC RESULTS AND DISCUSSION

8.1 Importance of sediments in pollution studies

8.1.1 Relative importance of particulate pollutants

The possibility of quantifying the flux of pollutants through the aquatic ecosystem depends upon the identification of the various phases that act as reservoirs of chemical substances. There are basically three major reservoirs: i.e. dissolved reservoir (water and dissolved load), particulate reservoir (suspended and bottom sediment) and biological reservoir (plankton, benthos, nekton).

The assessment of pollutant behaviour within these reservoirs, as well as the flux of material from one to the other, and the boundary conditions of the system, are the prerequisites of a holistic knowledge of pollutant pathways in the aquatic environment. Moreover, this will help to implement a monitoring programme and to provide a basis for prevention and eventual control of pollution.

In this connexion, the particulate reservoir is one of the major sub-systems of the aquatic environment, and requires special attention. The comparison between dissolved and particulate elemental concentrations shows that most heavy metals and organic pollutants are enriched in the solid phase by two or three orders of magnitude. When the relative amount of pollutants transported in river waters and in the suspended sediments are compared, the importance of sediment is clearly seen.

8.1.2 Principal interaction processes between pollutants and particulates

(1) Particle size

Decrease in grain size of natural suspended particles (sand → silt → clay → colloids) is accompanied by mineralogical variations, i.e. an increase in the clay mineral content, and by physical property changes, the greater importance of surface processes (ion exchange capacities, specific surface) with decreasing grain size.

According to these variation in size and/or mineral nature, smaller particles generally exhibit the highest pollutant concentrations. This is the general case for heavy metals and radionuclides, and also for pesticide residues that are adsorbed on clay particles.

(2) Types of association processes

As a first approximation, association processes between pollutants and particulates can be classified as follows:

- physico-chemical sorption on smallest particles (clays, colloids, hydroxides) and on particulate organic matter;

- co-precipitation with oxides and/or hydrous oxides, hydroxides, especially with iron and manganese, causing coatings on sand grains;

- insoluble organic compound formation;

- incorporation in mineral lattice.

(3) Stability of the association processes

Any change in the chemical composition or in the physical parameters of a water body may cause a pollutant to be released from the particles. Among the variations of chemical parameters able to affect the pollutant-particle association, pH variation plays a significant role. Diagrams of the solubility of metals as a function of pH indicates that, in acid waters, hydroxides, carbonates and sulphides become unstable and metals may pass into ionic form. Such pH variations can be caused by bacterial decomposition of organic matter or by release in the rivers of industrial acid effluents.

Disposal of certain organic substances, especially complexing agents and detergents, can also result in complete solubilization of metals, the toxicity of which is sometimes higher than the ionic dissolved form (e.g. mercury, cadmium).

8.1.3 Problems of particulate pollutant load assessment

(1) Separation of particulate and dissolved phases

The most popular method of separation currently in use is the microfiltration on cellulose filter (such as Millipore, Nucleopore, etc.). The phase passing through the filter is the so-called dissolved fraction while the fraction retained on the filter is regarded as suspended sediment.

This criterion of separation is still an open question. In fact, the separation between various particle sizes is arbitrary, and colloidal or macromolecular material will pass through the filter (usually a 0.45 micron/ pore size). If we consider the various specific forms of metals in natural waters, there is obviously a continuous range of metallic species between soluble and particulate phases (e.g. colloidal ferric hydroxide which is able to pass through a 0.45 μ filter will be retained by a 0.01 μ filter). The importance of particulate ferric hydroxide as a scavenger of many heavy metals could then be under-estimated by using a 0.45 μ pore-size filter. On the other hand, the so-called supersaturation of water with respect to many trace metals is possibly an artefact due to inadequacy in filtration procedure in many cases.

Geochemists are very much aware of this problem but there is still no consensus in how to solve it. Intercomparison of data with those obtained in most of the world's hydrological and chemical laboratories will require the use of 0.45μ pore-size filter in the Mediterranean project, although there is now evidence that this limit is rather arbitrary and sometimes misleading.

(2) Background value estimates of heavy metals

For determining quantitatively the amount of heavy metals introduced by human activities it is necessary to have some idea of the natural background concentrations of these elements, i.e. if a rough estimate of heavy metal supplied to the Mediterranean Sea were to be achieved through analyses of bulk sediment, it must be kept in mind that natural particulates contain an appreciable amount of heavy metals. Various solutions to this problem have been proposed:

(a) Use of a world standard of reference: Mean values of metal concentrations in fine sediments excluding anthropogenic contamination have been estimated by Turekian and Wedepohl (1961) for clay minerals. This composition may be assumed to approximate those of suspended sediments in streams.

(b) These values must be subtracted from the measured concentrations, assuming the difference is related to pollution, but such a procedure does not account either for local natural geochemical variations which can be important, or for possible natural enrichment of river-suspended materials.

(c) Comparison with old unpolluted river sediments: In this case difficulties may arise from different quaternary depositional environments (not comparable with present situation), secondary contamination by polluted groundwaters and unknown post- depositional mobilization processes occurring in sediments.

(d) Reference to present sediments in non-industrialized areas: It is difficult to find virgin aquatic systems free of industrial pollution. Vanadium, lead and cadmium contamination of atmospheric dust is well known especially in the northern hemisphere. Moreover, regional geochemical anomalies may again result in a false estimate of the natural level existing in the polluted systems to be compared.

(3) Preferential leaching of heavy metals

Preferential leaching of heavy metals by various chemical reagents is often used to estimate the amount of particulate-bound metals that are potentially released to the environment and/or available to aquatic organisms.

This preferential leaching method is probably adequate for pollutant flux studies, but one must be aware that heavy metals in adsorption sites and natural coatings will also be dissolved. Moreover, it is difficult to be sure that none of the metallic species incorporated within the mineral lattice is unleached. Finally, the amount of metallic elements leached from the suspended sediment is largely dependent upon their mineralogical and chemical composition.

(4) Post-depositional mobilization

Once the suspended particles are deposited, several mechanisms may alter the water and sediment quality. Various metallic elements can be trapped as insoluble sulphide compounds, while there is often an increase in dissolved concentrations in interstitial waters, caused by solubilization processes, which generate an upward diffusive flux of pollutants through the benthic boundary layer.

An important increase of pollutant concentrations in the water body is more likely to occur through recycling of bottom deposits either by natural phenomena, e.g. floods or bioturbation, or by anthropogenic action, e.g. dredging activities. Ingestion of polluted particles by benthic organisms can change their chemical speciation and cause a new availability of the pollutant.

(5) The estuarine problem

The estuary is the meeting place of river waters (salinity usually ranging from 50 to 500 mg/l) with sea-water of much higher ionic strength (salinity close to 36 g/l). In this zone pollutants are subject to new physicochemical, dynamical, sedimentological and hydrological conditions which may alter their speciation and modify their flux to the ocean. Furthermore, as industrial settlements are often found in the estuarine zone of rivers, additional sources of pollutants are likely to occur. From these observations we can see that any balance based on upstream data could not represent the actual flux of pollutants entering the ocean.

8.2 Particulate pollutant load in Mediterranean rivers

Owing to great technical difficulties in sampling, pre-treatment and analysis and to the short time available to collect new data, very few results on river particulate matter composition are currently available.

At the present time, we have some information on the heavy metal composition of bulk suspended sediment of the Adige, Po, Rhône and Aude rivers (Table IV).

Table IV - Total pollutants content in some river suspended sediment from Mediterranean countries (10^{-6} g.g^{-1})

River / pollutant	Adige (a)	Po (a)	Rhône (b)	Aude (c)	World average (d)	Rhine (1970) (e)
Arsenic	-	-	-	-	5	220
Mercury	-	-	0.5-1.5	1.2	-	23
Lead	203	185	270	-	150	800
Cadmium	-	-	-	-	1	45
Copper	93	112	50-250	-	100	600
Chromium	76	112	70-200	173	100	1240
Nickel	-	-	60	-	90	100
Zinc	1310	2100	760	318	350	2900
PCB	-	-	15	-	-	-
DDT	-	-	-	-	-	-

(a) C.N.R., Italy, average of 3 and 6 analyses.
(b) Martin, J.M. (1971), Vernet et al. (1977).
(c) Monaco A. (1977).
(d) Martin, J.M., M. Meybeck, (1979).
(e) De Groot, A.J., E. Allersma (1973).

For comparison, the global average heavy metal concentrations in river suspended sediment and the composition of the heavily polluted Rhine river are given. All these data refer to the bulk composition of suspended sediment.

Moreover, and following the recommendations of the Rome meeting and the recommended sampling and pre-treatment procedures for particulate pollutant analysis prepared jointly by the International Laboratory of Marine Radio-activity (IAEA, Monaco) and the Division of Water Sciences of UNESCO, some rivers were sampled and their sediment analysed. They include the Ebro and Llobregat (Spain). Rivers A and B (country not identified) were analysed by the IAEA (Table V).

Tunisia also sent a sample to IAEA but the data are not yet available. For comparison, literature data from Israel's rivers have been included.

The following remarks can be made on these preliminary results.

If we consider Table V, the four Mediterranean rivers do not appear as heavily polluted in comparison to the Rhine river. However, there is good evidence of contamination for the following rivers: Adige (zinc), Po (zinc), Rhône (zinc, lead, locally copper, chromium, mercury), Aude (chromium).

From Table V it is obvious that the rivers listed are subjected to some degree of pollution with the consequent liability of contamination by trace metals. The Ebro, Llobregat, river A, Ayyalon, Gadura and Qishon carry sediments exhibiting pollution effects.

It is interesting to compare the relative importance of the dissolved and suspended pollution loads in these rivers. On the basis of the average contents in the dissolved and particulate phases, and of the average long-term turbidity, we have computed the ratio of dissolved transport over total river transport (i.e. dissolved + particulate) (Table VI). Data from the Rhine and Mississippi rivers are given for comparison.

For the more turbid rivers (Adige, Po) and to a lesser extent the Rhône, the suspended phase plays a major role.

This importance of the particulate phase is a world-wide phenomenon that is observed in highly polluted rivers such as the Rhine or in very turbid rivers such as the Mississippi. On a world scale the following proportions of trace metals carried by rivers are in the dissolved form: (in percentages) chromium 2.5, copper 19, nickel 5, lead 7, and zinc 17. It is most likely that for the Mediterranean rivers that are generally highly turbid, the suspended phase has a similar importance.

However, in the Llobregat and Ebro rivers, the dissolved phase appears as the major phase of transport; this is most likely attributable to the analytical method used, i.e. "preferential leaching" instead of "total content", and in the case of the Ebro river it is also attributable to the existence of upstream dams which trap a large percentage of the river sediment.

Table V - Leachable contents of heavy metals in suspended and deposited sediments from mediterranean countries

River / pollutant	SPAIN		IAEA		ISRAEL (3) (b)						
	Llobregat (1) (a)	Ebro (1) (a)	River A (2) (a)	River B (2) (a)	Yargon	Ayyalon	Alexander	Madera	Qishon	Gadura	Ha'aman
Arsenic	1.1	4.1	-	-	-	-	-	-	-	-	-
Mercury	0.4	1.6	1.7	0.8	N.D.	P.D.	.15(.07-.30)	.56	(0-0.1)	(0-0.3)	(0-0.3)
Lead	53	159	60	8	28(20-48)	81 (12-266)	13 (7-22)	14(5-25)	28(9-72)	158(93-275)	12(10-16)
Cadmium	7	5	2.3	0.4	N.D.	7.9(.1-16)	N.D.	N.D.	(0-4)	55(7-123)	N.D.
Copper	43	16	50	8	2.8(1.6-3.3)	6.7(2.3-16)	1.7(2.1-3.0)	7(3-13)	14(3-48)	17(6-43)	4(3-6)
Chromium	55	16	20	4	2.8(1.9)	35(12-124)	13 (11-17)	14(12-17)	18(3-56)	294(62-610)	15(4-26)
Nickel	-	-	30	6	1.0(1-4)	17(8-60)	6.3 (6-7)	9(6-12)	15(11-19)	22(17-31)	7(4-14)
Zinc	787	174	180	40	52(12-83)	196(49-323)	45 (48-72)	87(42-176)	130(20-325)	931(365-1500)	46(9-136)

(1) Centro de Estudios Hidrográficos, Spain, 1977 (one analysis).
(2) IAEA Monaco Laboratory, average of 3 analyses, Northwestern Mediterranean rivers.
(3) Kronfeld, J. and J. Navrot (1975), average of 3-9 analyses.
(a) suspended sediment, leaching with diluted HCl acid.
(b) deposited bank sediment ($<$ .17 mm, leaching with hydroxylamine-hydrochloride in 25% acetic acid).

Table VI - Trace metal transport by Mediterranean rivers.
Ratio of dissolved transport over total transport (in %)

	Adige	Po	Rhône	Llobregat	Ebro	Rhine	Mississippi
Turbidity mg/l	220	245	84	165	20	32	530
Arsenic	-	-	-	94	93	44	-
Mercury	-	-	-	-	-	-	-
Lead	10	17	30	57	56	13	0.8
Cadmium	-	-	-	76	96	72	11
Copper	14	53	32	93	99	50	8.4
Chromium	20	-	39	87	97	20	1.5
Zinc	-	9	36	85	96	56	10

8.3 Conclusions

(i) With regard to the first objective (review of contribution of suspended material transported by rivers to the pollution of the Mediterranean Sea), a review of scientific publications and reports from countries surrounding the Mediterranean Sea clearly showed that at that moment, no data on particulate pollutants were being collected on a routine basis. The preliminary analyses that had been performed did not permit a mass balance statement of particulate pollutants discharged by rivers into the Mediterranean Sea. This gap was mainly due to the technical difficulties in pre-treatment, i.e. the separation of a sufficient amount of suspended sediment, and to the fact that sediments are usually considered as a trap for pollutants and consequently improve the quality of the river water. If their self-purification capacity is high, they could be important sources of contaminants to marine organisms (i.e. filter feeders). Moreover, there is a complex equilibrium governed by various chemical physical and biological factors between the sediments and the surrounding water, the result being possibly the desorption of an important amount of pollutants. This is likely to occur at the benthic boundary layer and within the estuarine system.

The preliminary results obtained in a restricted number of rivers did not point to contamination as being as important as in some highly polluted rivers like the Rhine. However, some metals, e.g. cadmium and zinc, were already present at a high level compared to the natural values.

(ii) The second objective (to identify research and information needs on critical pathways and methodology) was achieved in a paper prepared by the secretariat. This paper was extensively discussed at the expert meeting held in Rome. The paper included a review on the role of sediments in pollution studies, sediment-pollutant interactions, pollutants to be monitored, particulate pollutants, sampling and analytical procedures, and finally a catalogue of Mediterranean rivers to be monitored. This paper clearly emphasized that most heavy metals and organic pollutants are carried in the suspended matter, e.g. 75 - 99 per cent of heavy metals are carried by rivers in the particulate form.

Further, a paper on "Recommended sampling and pre-treatment procedures for particulate pollutant analyses" was prepared by the secretariat after consultation and advice from the staff of the International Laboratory on Marine Radioactivity of IAEA. However, it should be clearly understood that this paper describes methods which may not be the best scientifically; they were chosen for their simplicity in order to obtain the necessary data.

(iii) The third objective (evaluation of the possible role of the International Association of Hydrological Sciences (IAHS) and the International Hydrological Programme (IHP) in this project) was achieved in collaboration with the IHP and IAHS.

Of special interest were the IHP 3.8.5 and IHP 6.1 projects. Project 3.8.5 dealt with the relation between water quality and sediment transport, whereas project 6.1 reviewed the state of knowledge on processes affecting water quality in rivers, lakes and estuaries.

8.4 Documentation

Documents prepared for, or through, this project include:

- UNEP/WG.18/INF.4. Pollutants from land-based sources in the Mediterranean - Monaco Conference 9-14 January 1978.
- UNESCO/UNEP/MED IX. Final report. Role of sedimentation in the Pollution of the Mediterranean Sea - August 1977.
- IHP/MED/INF/1. Catalogue of major rivers discharging into the Mediterranean. IHP Regional Meeting, Rome, October, 1978.
- IHP/MED/INF/2. Catalogue of water quality data of Mediterranean rivers. IHP Regional Meeting, Rome, October 1978.
- IHP/MED/INF/5. Discharge of dissolved and particulate substances into the Mediterranean by rivers. IHP Regional Meeting, Rome, October 1978.
- UNESCO(GEMS/WATER; MED-IX)BUD/Rep.1. Recommendations on the assessment of particulate matter quality in rivers and lakes. Budapest Workshop, November 1978.
- Role of Sedimentation in the Pollution of the Mediterranean Sea: Assessment of Knowledge and Development of Guidelines. Report of UNESCO/UNEP Meeting of Experts (Rome, 20 - 23 December 1976). UNESCO 1976.

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MED POL X : POLLUTANTS FROM LAND-BASED SOURCES IN THE MEDITERRANEAN (WHO/ECE/UNIDO/FAO/UNESCO/IAEA/UNEP)

1. INTRODUCTION

The main land-based sources of pollution of Mediterranean coastal waters are municipal sewage and industrial effluents discharging through rivers or directly to the sea. Pollution is aggravated in the Mediterranean, which is an almost entirely enclosed area, by very small tidal effects, long periods of calm weather and relatively high ambient temperature.

In order to obtain comprehensive information on most major pollution inputs into the Mediterranean from land-based sources, the following tasks were undertaken within this project:

- preparation of an inventory of land-based sources of pollutants discharging directly into the Mediterranean;
- assessment of the nature and quantity of pollutants from coastal sources;
- assessment of the nature and quantity of pollutants carried by major rivers;
- review of present waste disposal and pollution management practices.

The project covers those coastal zones of the Mediterranean Sea that directly influence the quality of the marine waters by the discharge of liquid, dumping of solid or emission of gaseous wastes.

This project is closely linked to the other MED POL projects and to the legal component of the Mediterranean Action Plan. In particular, it provides technical information relevant to the implementation of the protocol on the protection of the Mediterranean from land-based sources of pollution and of the project on coastal water quality control (MED POL VII).

The ultimate objective of the project is to provide the Governments of the Mediterranean coastal States with appropriate information on the type and quantity of pollution inputs from major land-based sources and rivers, and on the present status of waste discharge and management practices which affect marine pollution.

The project was initiated in early 1976.

2. PARTICIPANTS

Concurrence of the countries' participation was secured by UNEP and the majority of Mediterranean Governments (11 out of 18) designated a specific contact point for this project in 1976. In other countries the UNEP focal point and the agencies' regular contacts were approached. Data were largely collected by the national authorities themselves, in some cases assisted by international consultants. In addition, national and international statistics and other reports were used to complete the information. Based upon sectorial reports on each waste source category, the present summary report was then compiled.

3. CO-ORDINATING ARRANGEMENTS

The project was a joint undertaking of six co-operating United Nations bodies (EEC, UNIDO, FAO, UNESCO, WHO and IAEA) each contributing in its specific field of competence and with WHO acting as the technical co-ordinator of the work.

During the preparatory phase of project MED POL X, a co-operative mechanism among the secretariats of the six United Nations bodies executing the project was established which ensured adequate coverage of all pollution source categories. Responsibilities were assumed as follows:

(i)	inventory and assessment of municipal sources	WHO
(ii)	inventory and assessment of industrial sources	ECE/UNIDO
(iii)	inventory and assessment of agricultural run-off	FAO
(iv)	inventory and assessment of river discharges	UNESCO
(v)	inventory and assessment of radioactive discharges	IAEA
(vi)	review of municipal waste disposal and management	WHO
(vii)	review of industrial waste disposal and management	ECE/UNIDO
(viii)	project co-ordination	WHO

During the early stages of the project, technical guidelines and a number of questionnaires were prepared by all participating agencies. These data reporting forms were to ensure a harmonized approach to the establishment of source inventories and also to allow for a comparative assessment of pollutants stemming from different waste source categories.

Specific meetings held in connection with this project included:

- UNEP/WHO/ECE/UNIDO/FAO/UNESCO/IAEA Meeting of Experts on Pollutants from Land-Based Sources (Geneva, 19 - 23 September 1977), attended by 22 participants from 13 Mediterranean States.

4. FINANCIAL ARRANGEMENTS

Specific financial support to the project was provided through project FP/0503-76-01. Costs (in US dollars) were shared between the seven co-sponsors of the project as follows:

	1976	1977	1978	1979	Total	Percentage
WHO	15,500	52,500	12,000	-	80,000	16.3
ECE	-	12,000	4,000	-	16,000	3.2
FAO	1,000	9,000	6,000	-	16,000	3.2
IAEA	200	800	-	-	1,000	0.2
UNESCO	800	8,000	3,000	4,200	16,000	3.2
UNIDO	-	14,000	2,000	-	16,000	3.2
UNEP	24,862	281,561	34,212	6,957	347,592	70.7
TOTAL	42,362	377,861	61,212	11,157	492,592	100.0

The national financial contributions to the project are not known but, judging from the large input from national institutions into the project, the size of this contribution (in kind and services) is estimated as equivalent to US $ 500,000.

5. OPERATIONAL DOCUMENT

The document specifying all project operations was prepared by a series of interagency consultations and agreed upon among the six co-operating agencies and UNEP.

The unprecedented task of compiling a waste source inventory over a large geographical area involving the collaboration of 18 individual countries required the development of new approaches. In addition, the different nature of pollution sources considered made harmonization of methods a prerequisite to any data collection efforts at the country level.

In view of the complex nature of the problem, a two-step approach was chosen which allowed for an intermediate adjustment of implementation methods. In a first phase, sectorial inventories were established which were intended to register all activities in the coastal area of the Mediterranean which might involve the discharge of waste waters. In the second phase, this inventory, together with other information, was used to assess and quantify the pollution input from the various sources. The methods applied are elaborated in greater detail below.

Harmonization of approaches to the different waste source categories was achieved primarily through the establishment of a common list of selected pollutants. On the basis of this list, a set of questionnaires was prepared by the responsible organizations which provided for a comparable data collection format. The questionnaires in draft form were circulated to the interested countries for comment. Following this exercise the questionnaires were finalized and distributed.

These questionnaires were completed by national authorities, frequently in collaboration with consultants, indicating the location and magnitude of pollution sources or groups of sources. Wherever the information obtained was incomplete, additional data were utilized from statistics and other reports.

The assessment of pollution loads was made for each pollutant individually. To this end, the major contributing sources had to be identified by category. Insignificant contributions or uncertainty of estimate reduced the range of sources considered in most cases.

The assessment of the pollution loads discharging into the Mediterranean from different waste sources was undertaken largely on the basis of an indirect estimate which took into account original country survey data as well as statistical information and other data sources. The estimated annual loads may be considered accurate within an error range of about one order of magnitude.

A review of waste disposal and management practices was undertaken on the basis of questionnaires for domestic sewage and industrial waste waters. Additional information was available from international reviews, project reports, national statistics and data collected during consultant visits.

6. AREAS STUDIED

The geographical distribution of pollution loads was evaluated on the basis of 10 regional entities into which the Mediterranean Sea was subdivided according to UNEP's pollution monitoring and research programme. In the present project only these 10 parts of the Mediterranean proper were considered while the 3 adjacent areas were excluded. Table I provides for a list of these areas and the countries bordering on them. The map in Figure 1 shows their extent and boundaries.

7. MATERIAL AND METHODS

7.1 Sectorial study methods

7.1.1 Domestic sewage

Information on municipal waste sources was collected by means of questionnaires providing data on resident population, tourists and industry discharging into municipal sewers. Population centres of 10,000 inhabitants and above were considered in this study. In addition, maps and demographic year-books as well as tourist organization reports were consulted.

Direct data on domestic waste water discharges and related pollution loads were provided only in some cases. Additional information was, therefore, required on unit human waste production and other domestic sources which were taken from research studies, country project reports and other statistical sources. On this basis, annual sewage loads per capita were estimated for each country.

Table I - Mediterranean Sea areas and countries bordering on them

A. Mediterranean proper	Sea area	Bordering countries
I	Alboran	Spain, Morocco, Algeria
II	North-Western	Spain, France, Monaco, Italy
III	South-Western	Spain, Italy, Algeria, Tunisia
IV	Tyrrhenian	Italy, France, Tunisia
V	Adriatic	Italy, Yugoslavia, Albania
VI	Ionian	Italy, Albania, Greece
VII	Central	Italy, Tunisia, Libya, Malta
VIII	Aegean	Greece, Turkey
IX	North-Levantin	Turkey, Cyprus, Syria, Lebanon
X	South-Levantin	Lebanon, Israel, Egypt, Libya
B. Adjacent areas	Sea area	Bordering countries
XI	Atlantic	Spain, Morocco
XII	Sea of Marmara	Turkey
XIII	Black Sea	Turkey, USSR, Roumania, Bulgaria

Industrial sources within the municipal sewerage system, which were initially included in the country surveys, were subsequently transferred to the industrial waste load assessment section. Tourist augmentation of the resident population during the holiday season was, however, taken into consideration when calculating the total annual production of domestic sewage.

The gross domestic waste load was then subject to three reductions for the assessment of actual waste discharges into the sea. As a first step, the percentage of population connected to public sewerage systems was determined. It varies between 10 and 100 per cent but remains in most cases at 50 per cent and above. The assumption was made that the non-sewered population uses individual sewage disposal methods not resulting in direct discharges to the sea. The second reduction provides for the exclusion of sewered portions which are not discharged to the sea but rather disposed elsewhere. The percentages reaching the sea vary between 50 and 100 per cent in most cases. The third step allowed for the reduction of waste loads due to sewage treatment. The resulting amounts of domestic waste water and its constituents were then entered into the overall assessment procedure.

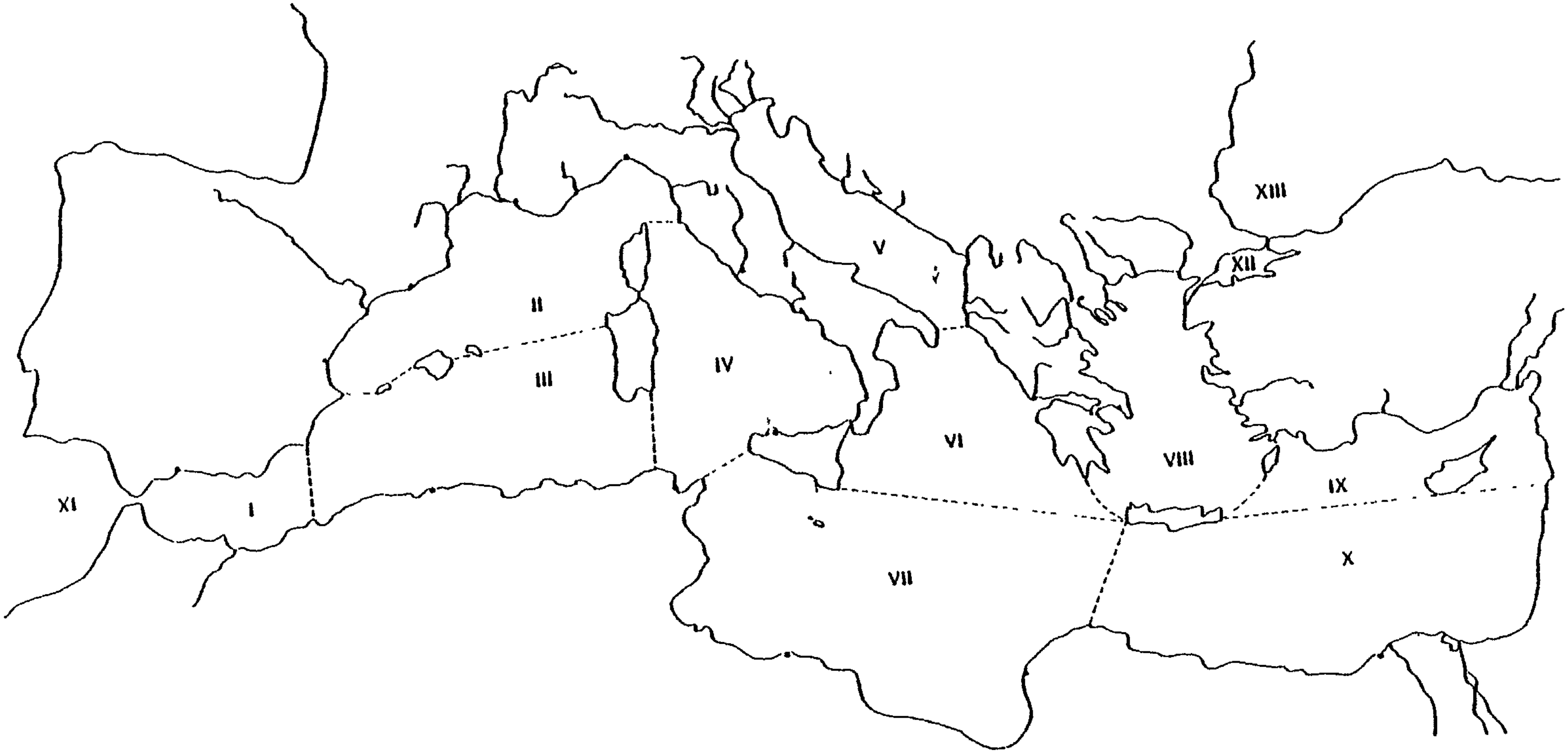

Figure 1. Regional entities of the Mediterranean proper and adjacent sea areas

7.1.2 Industrial waste water

An inventory of major industrial areas around the Mediterranean coastline was prepared which identifies their general location as well as the type and magnitude of industrial activities. Less industrialized and small countries permitted a rather detailed consideration of individual industries or complexes of factories. In some cases, even consultant visits to factories were possible. The large number of individual enterprises along the coastline of the highly or partly industrialized countries prevented a factory-by-factory approach.

Information on industrial waste sources was collected by means of a questionnaire providing for data on waste water flows and constituents as well as on industrial production figures, raw materials used or number of employees. A certain amount of direct information was obtained. Since the data collected were not always complete, and in general not comparable at a basin level, it was necessary to use, in addition, other sources of information.

The assessment study required a rather flexible approach ranging from direct analytical results to pure desk studies. Largely, an indirect method was applied which made use of the best information available from each country even though the basic data varied from country to country. Subsequently, these data were subjected to a computation process which made use of specific waste coefficients obtained from experience. As basic data, the following variations were considered: (i) waste water flow data and accompanying analytical results; (ii) daily or yearly production figures; (iii) water consumption figures, and (iv) number of employees working within a given plant or an industrial sector.

Wherever an indirect estimation of industrial waste loads was necessary, production figures or numbers of employees were mainly used. For this purpose, an elaborate scheme of specific coefficients of industrial waste generation was developed which provided the necessary basis for computation. Their preparation was largely based on published investigations, various national guidelines, local reports, country project reports, on-site consultant findings during the project as well as other expert experiences.

Problems with the indirect method, as described above, frequently encountered were: (i) lack of information on the location of industrial plants relative to the coastline; (ii) inconsistent classification of industries; (iii) insufficient differentiation of production and employee figures; (iv) sparse experience on trace contaminants in industrial waste waters, and (v) non-comparable reporting systems from country to country. Despite the limitations of such an indirect method of evaluation, the results obtained are quite homogeneous and complete. Under the prevailing conditions, this indirect method together with the basic data available, provided for an adequate coverage of the industrial waste component of the total pollution load assessment.

7.1.3 Agricultural run-off

Estimation of pollutant amounts stemming from land run-off in the coastal zone was undertaken in two groups separately: (i) sediments as total suspended solids together with phosphorus and nitrogen as well as organic matter determined as total organic carbon, and (ii) various types of pesticides.

As far as the estimation of nutrient wash-out rates was concerned, only scanty analytical data on the chemical composition and sediment content of run-off waters were available. An indirect scientific assessment procedure was therefore developed which was calculated to allow for relevant estimates to within at least one order of magnitude. Various studies support the assumption made that nutrients in run-off are largely attached to sediments as carriers. As a first step, this sediment yield was computed and subsequently used for nutrient load calculations. Four basic factors affecting run-off and erosion were taken into consideration: climate, soil, topography and vegetation cover. These factors were quantified when applying a sediment yield formula developed by Gavrilovic (1962). By comparison of test drainage areas with monitored river discharges, the formula was calibrated and adjusted to the conditions prevailing in the different parts of the Mediterranean basin.

For the application of this method to the Mediterranean basin, this was subdivided into 144 individual drainage areas employing available land use maps and national statistics. Subsequently, run-off and sediment yield were computed for each area. An empirical classification of five different degrees of erosion was established into which the above 144 entities were subdivided.

The amounts of phosphorus, nitrogen and organic matter were then calculated by using the sediment yield as the basis and applying an estimated enrichment ratio for each of them. Increases of nutrient loads (P and N) due to fertilizer application were taken into consideration. Other factors included natural soil fertility, land use, topography and erosion intensity.

As far as the estimate of pesticide loads from agricultural run-off is concerned, insufficient measurements on the level of pesticide residues in soils were carried out in the Mediterranean drainage basin. A scientific assessment approach was needed, therefore, largely relying on experience gained elsewhere. This led to a first assumption that, apart from improper practices and accidental releases, removal in run-off water and associated suspended material probably constitutes the major pathway of agricultural pesticides into the aquatic environment. Air-borne sources of pesticide pollutants were not considered and the study concentrated on the surface run-off component.

The establishment of an inventory on pesticide usage in the countries bordering the Mediterranean was attempted by means of a guideline and questionnaire. Sparse response required the additional utilization of information sources from FAO and the European Mediterranean Plant Protection Organization (EPPO). Pesticide applications as insecticide, fungicide, herbicide and for other purposes were verified in each case. Data on the size of the area treated were seldom reported and relevant estimates had to be made.

In the absence of field measurements, the assessment of possible pollution loads had to be made by analogy with research studies which carefully followed the fate of known amounts of pesticide applied under practical field conditions. As an approximation, a run-off portion of 1 per cent of the pesticides applied was chosen and the most likely pollution load for the organochlorine compounds calculated. The other pesticides were considered of less importance in this respect.

7.1.4 River discharges

Methodology for the estimate of pollution loads carried by rivers into the Mediterranean was developed through expert meetings in Paris (Meeting of experts of Mediterranean countries, UNESCO, Paris, 17-21 May 1976), and Rome (Meeting of experts of Mediterranean countries, Rome, 20-23 December 1976). The latter also afforded a close linkage with project MED POL IX on the role of sedimentation in the pollution of the Mediterranean Sea. Data on river discharges and water quality as well as particulate pollutants were collected by means of questionnaires.

Among the 68 rivers included in the inventory, only about 30 were adequately covered by monitoring data. Sampling frequencies were very variable ranging from less than 1 sample to 12 samples per year. Three countries initiated intensive surveys particularly for project MED POL X. In the other cases, past and current data were utilized as made available.

Various problems were encountered when collecting data. Metals, specific organics and organochlorine compounds were rarely monitored and, if sought for, were not detected. In addition, sample pre-treatment and analytical methods varied widely from country to country. Sample filtration influences considerably metal and pesticide determination which are strongly bound to suspended particles. In view of all the limitations encountered, the results must be considered as a rough estimate for which the reliability is no more than an order of magnitude.

For the assessment of pollution carried by adequately monitored rivers, loads were computed on the basis of the average pollutant concentrations and the mean water discharge. Results were achieved for 30 rivers representing a total flow of 5,800 m^3/s or 43 per cent of all freshwater discharges into the Mediterranean.

For selected rivers without data available, which represent 3,500 m^3/s or 26 per cent of the total freshwater inflow, and for the rest of rivers not included in the inventory covering about one-third of the total discharge, the assessment was achieved by extrapolation. Concentrations ranging from a typical unpolluted river to a typical polluted river draining an industrialized region were used for this purpose.

Annual loads were estimated for each of the ten regional seas areas including all rivers with available data as well as those computed indirectly. Also, natural background levels of substances were taken into account providing for an estimate of the man-made pollution loads carried by rivers.

7.1.5 Radioactive discharges

An inventory of nuclear installations was undertaken by means of questionnaires and national and international reports on nuclear power production as well as information on radioactive wastes from nuclear power stations. For each country, the relevant installations were listed in chronological order including those in operation and under construction.

The inventory specified reactors of different type (gas cooled, fast breeder, light water reactors), research centres, reprocessing plants and one planned enrichment plant. Each source was quantified by its nominal size in electrical megawatts (MWe) for reactors and in uranium handled per year (tU/a) for reprocessing plants. Other radioactivity sources, such as medical applications, were considered to be insignificant for the purpose of the survey.

Much information was available on the release of radioactivity from nuclear installations already in operation. Based upon such data, a set of standard discharge values was developed which allowed for an estimate of releases from installations under construction. Plant availability and allowance for variations in the operational behaviour were taken into consideration.

Very few nuclear installations are located on, or near, the Mediterranean coast. However, many are located on major rivers which flow into the Mediterranean Sea. The magnitude of each radioactive release was computed at the source and at the point of discharge into the sea. Reduction factors according to length of river transport to the sea were applied for the radionuclides other than tritium. The full tritium values were taken into account. Based upon the inventory of individual sources, the current radioactivity discharged to the Mediterranean Sea was estimated.

8. SCIENTIFIC RESULTS AND DISCUSSION

The primary purpose of the inventory section of the project was to identify all major waste sources either individually or in groups by geographical location and to determine the nature and magnitude of each as far as possible. The mode of identification and quantification varied according to the different types of pollution sources. The basic units ranged from number of inhabitants or production figures to land area and other ways of measurement.

The source inventory covered the coastal area. In this area a certain overlap of waste source categories is inevitable. For example, industry discharges either directly or through municipal sewerage systems to the sea and a distinction is not always possible. Similarly, some coastal municipalities discharge their sewage into near-shore rivers which are also included in the river component of the project. The sectorial inventories list all of them while in the subsequent pollution load assessment, a careful delineation has been observed in each individual case.

8.1 Domestic waste sources

The study revealed a total resident population in the coastal area of about 44 million inhabitants. In addition, a considerable number of tourists were encountered during the season, and they were taken into consideration when assessing the total domestic waste load.

8.2 Industrial waste sources

An inventory of industrial activities contributing significant pollution loads inevitably covers a large variety of production sectors. An attempt was made to summarize within broad categories of industrial activities as well as to identify industrial concentration areas by their geographical location. Thus, data on individual units were not lost but incorporated in larger entities.

The geographical distribution of the more heavily polluting industrial sectors along the Mediterranean coastline is mapped in Figure 2. Four major categories were included: (i) leather tanning and finishing; (ii) iron and steel basic industries; (iii) petroleum refineries and oil terminals, and (iv) chemical production (organic and inorganic).

Other industries of significance include textile manufacturing, food processing and canning, and pulp and paper factories. In addition, there are several other activities of importance but their size in most cases was too small to justify listing and mapping them individually.

8.3 Agricultural run-off

Erosion susceptibility within the Mediterranean watershed and its geographical variability was estimated through the delineation of four different classes indicating slight, weak, moderate and high degrees of soil erosion. The actual amount of sediments reaching the sea is, however, much smaller than the classification indicates. It is influenced by dams and other natural man-made structures acting as sediment traps and thus considerably reducing the discharged amounts.

The 144 sub-basins into which the Mediterranean watershed was divided are summarized in Figure 3 which also indicates their erosion classification. Some large rivers, e.g. the Ebro, Rhône and Po, were not subject to this procedure since their sediment discharges were already covered by the river component of the project. Because of the lack of suspended sediment determinations at many river monitoring sites, the agricultural run-off computation was also used to estimate their sediment yield.

The pesticide inventory was prepared in the form of a summary of the consumption of pesticides by agriculture specifying their types and quantities and their use as insecticide, fungicide or herbicide. It became evident that the amounts of pesticides used in the respective countries ranged fairly widely.

8.4 River discharges

All major rivers around the Mediterranean are identified by country and by sea area into which they discharge. Average flow and drainage area are also given. Their exact location is mapped in Figure 4 according to three discharge categories.

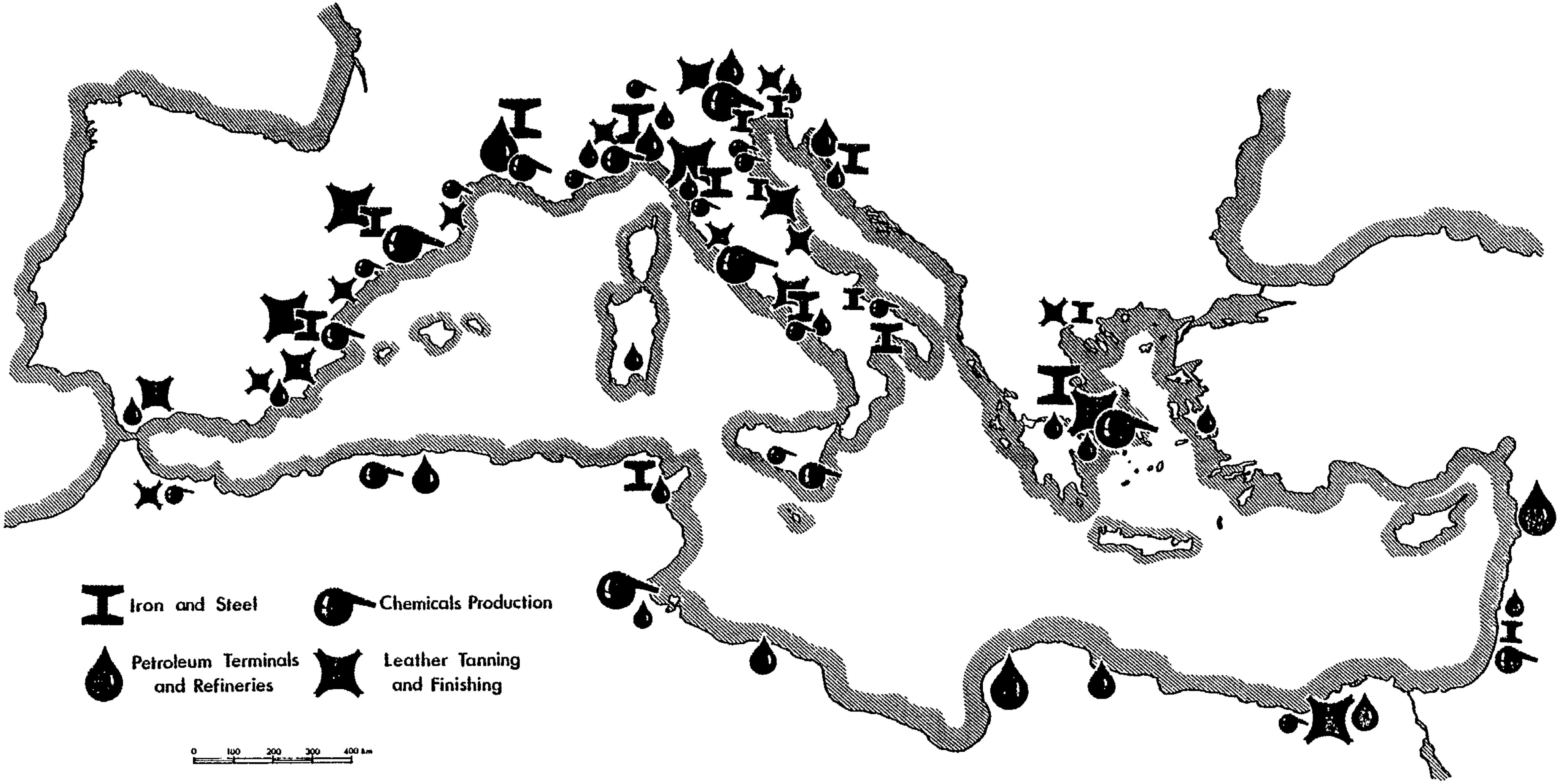

Figure 2. Location of major industrial areas along the Mediterranean coastline

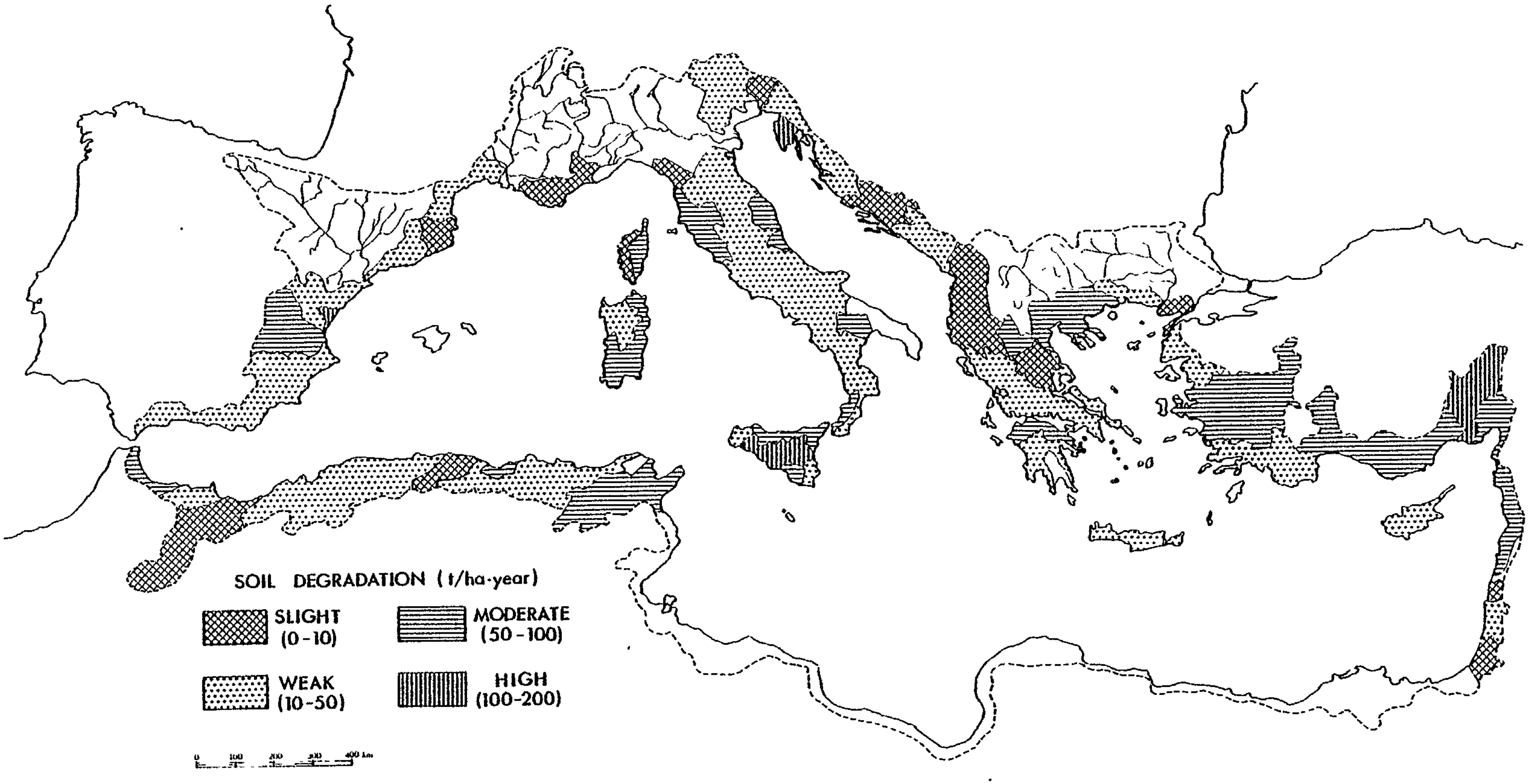

Figure 3. Distribution of erosion potentials within the Mediterranean watershed basin

Figure 4. Situation of rivers included in the pollution source inventory

As expected, there is a large variety of water quality ranging from very clean to heavily polluted while some watercourse may even be considered as open sewers. A clear distinction must, however, be made between flux and concentration. Large rivers may result in a considerable flux of substances due to background concentrations only, while others may carry significant loads due to man-made pollution. Consequently, discharge volume and character of the drainage basin have to be taken into equal consideration. Due to their large water discharges and the industrial and agricultural character of their drainage basins, the rivers Rhône and Po are major carriers of pollution. Other significant contributions are from the Ebro, Llobregat, Nile, Adige and Tevere rivers.

In summary, the major pollution carriers among the rivers are situated along the northern coastline and the major portion of the total discharge originates from the northern part of the Mediterranean watershed. Only about 20 per cent of the total flow is discharged along the southern and eastern shoreline.

8.5 Radioactive discharges

An inventory of nuclear installations in chronological order was established for each country. Their location is shown on the map in Figure 5. In this inventory, all major nuclear plants located on rivers flowing into the Mediterranean were included. Reduction factors to take account of the time of decay were applied for the discharge assessment of installations remote from the sea.

In addition, there is nuclear research work going on in a number of countries, together with a widespread use of radioisotopes in medicine. Because the radioactivity discharged from these sources to the Mediterranean is limited, they are not included in the present inventory and assessment.

8.6 Results of pollution load assessment

Following the selection of major pollutants and waste source categories, a comprehensive assessment of the total pollution load of the Mediterranean was undertaken. The waste discharges of each country into the different sea area were computed individually and then assembled for each pollutant by source and by regional sea area.

The results of the estimate of annual pollutant loads are presented in summary form below. When considering the figures that are given, it has to be borne in mind that the results are likely to have a range of error of approximately one order of magnitude.

A. Estimated pollutant loads from different sources

Relevant data are summarized in Table II providing for total loads in tons per annum (or equivalent) as well as by percentages for each pollutant source. To this end the total annual load has been subdivided into pollution loads originating in the coastal zone and loads carried by rivers. The first group covers all pollution sources located in the coastal area, including domestic sewage, industrial waste waters and direct surface run-off from agricultural areas. Loads carried by rivers are differentiated according to man-made pollution and background flux. Ranges have been indicated, as they are considered more reliable than average figures in view of the uncertainty inherent in making estimates for rivers.

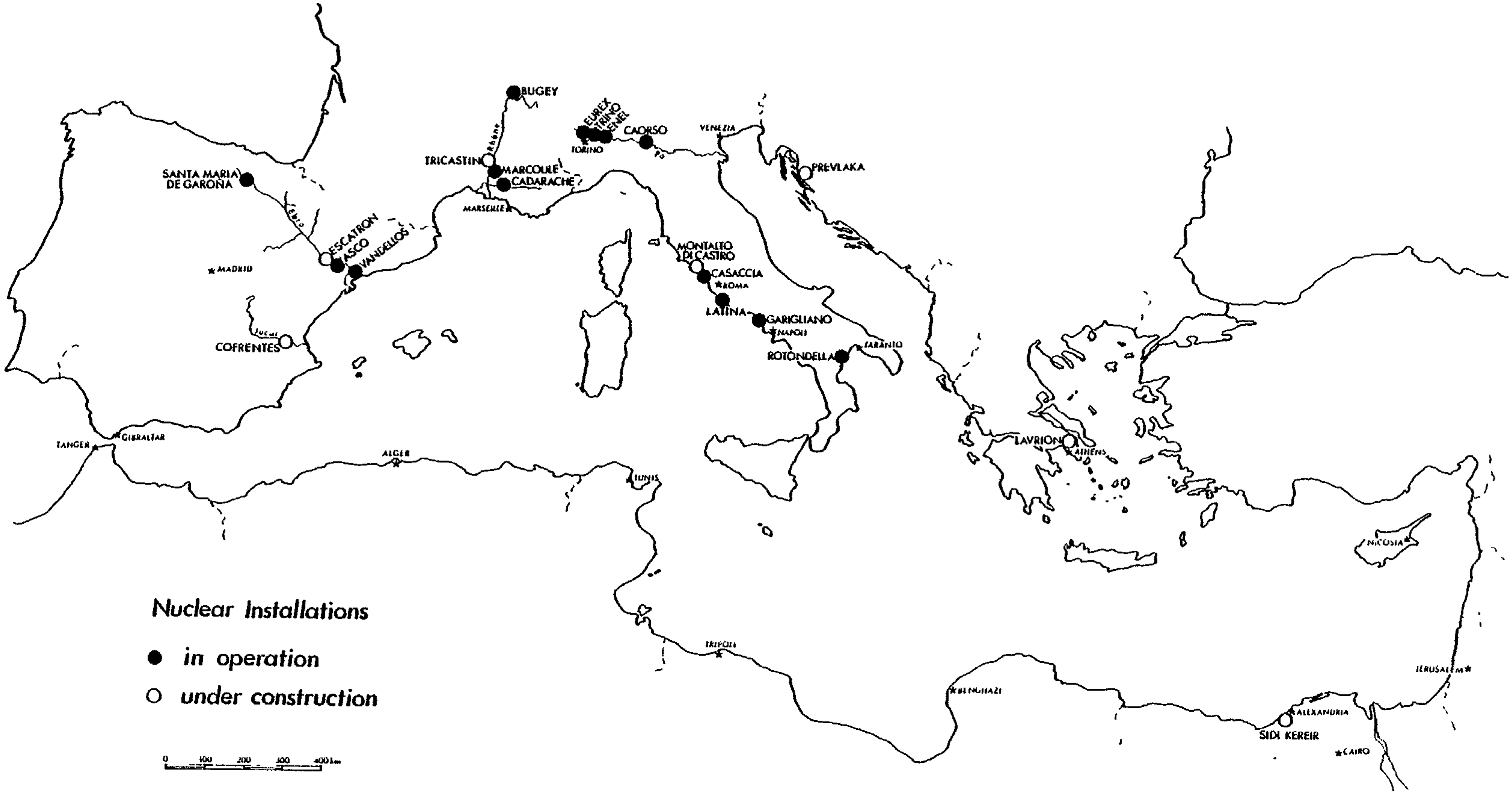

Figure 5. Location of nuclear power plants in the Mediterranean basin

Table II - Estimated pollution loads of the Mediterranean from Land-based Sources

Pollutant	Pollution loads originating in the coastal zone				Loads carried by rivers into the Mediterranean				Total Mediterranean Loads		
	Domestic t/a	Industrial t/a	Agricultural t/a	Sub-total t/a	Pollution t/a	Background t/a	Sub-total t/a	Sub-total (range)	Pollution	Total (including background) t/a	Total (including background) (range)
1. Volume:											
Total discharge $x10^9$	2	6	-*	(8)	(-)	420	420	(400-500)	(-)	430	(400-500)
2. Organic matter:											
BOD $x10^3$	500	900	100	1 500	1 000	(800)	1 800	(1200-2300)	2 500	3 300	(2700-3800)
COD $x10^3$	1 100	2 400	1 600	5 100	2 700	800	3 500	(2300-4700)	7 800	8 600	(7400-9800)
3. Nutrients:											
Phosphorus $x10^3$	22	5	30	57	260	40	300	(200-400)	320	360	(260-460)
Nitrogen $x10^3$	110	25	65	200	600	200	800	(600-1000)	800	1 000	(800-1200)
4. Specific organics:											
Detergents $x10^3$	18	-	-	18	42	0	42	(9-75)	60	60	(30-90)
Phenols $x10^3$	-	11	-	11	1	0	1	(0.5-1.8)	12	12	(6-18)
Mineral oil $x10^3$	-	120	-	120	(-)	0	(-)		(120)	(-)	
5. Metals:											
Mercury	0.8	(7)	-	(8)	90	30	120	(40-200)	100	130	(50-200)
Lead	200	1 400	-	1 600	2 200	1 000	3 200	(2700-3800)	3 800	4 800	(4300-5400)
Chromium	250	950	-	1 200	1 200	400	1 600	(500-2700)	2 400	2 800	(1700-3900)
Zinc	1 900	5 000	-	6 900	14 000	4 000	18 000	(14000-22000)	21 000	25 000	(21000-29000)
6. Suspended matter:											
TSS $x10^6$	0.6	2.8	50	53	-	300	300	(100-500)	-	350	(100-600)
7. Pesticides:											
Organochlorines	-	-	-*	-	90	0	90	(50-200)	90	90	(50-200)
8. Radioactivity:											
Tritium Ci/a	-	400	-	400	2 100	(-)	2 100	(1600-3100)	2 500	(-)	
Other radio-nuclides Ci/a	-	25	(-)	25	15	(-)	15	(10-25)	40	(-)	

Legend: - Contributions from this source negligible.
(-) Insufficient data base for estimate.
-* Included in river assessment.

B. Regional contributions to pollution loads

A summary of annual loads for each pollutant according to the 10 sea areas is provided in Table III of this report. As could be expected, it shows marked differences up to one order of magnitude between the regions. The particular waste source category largely responsible for dominant contributions varies, however, from region to region.

Heaviest pollution loads are discharged into the North-Western basin (region II) which is not only bordered by three industrialized countries, but also receives major river pollution loads. This sea area has to absorb almost one third of the total pollution load of the Mediterranean. The Adriatic Sea (region V) is also severely affected and receives about one quarter of the total load, likewise due to large rivers and major coastal sources.

Moderate pollution loads are encountered in the Tyrrhenian and the Aegean Sea (regions IV and VIII). They each receive about 10 per cent of the total Mediterranean pollution load.

The other six Mediterranean sea areas (I, III, VI, VII, IX and X) each account for no more than 5 per cent of the total load. Mineral oil pollution is, however, an exception to this general rule. Owing to the presence of large oil terminals and some refineries, more than half of the total mineral oil discharges are located in the central and northern Levantine basin (areas VII and IX). Additional mineral oil contributions. are located in three other regions.

Taking geographic distribution of the waste loads into consideration, Mediterranean pollution problems can largely be attributed to a limited number of significant point sources along coastlines. Industrial centres, municipalities and several rivers are the major sources in this respect. In the case of rivers, a distinction has to be made, however, between man-made pollution and background loads carried naturally into the sea. Agricultural pollution loads are, in addition, contributed by direct surface run-off from the coastal area.

8.7 Waste disposal and management practices

As part of the MED POL X project's activities, current practices in the Mediterranean countries concerning the disposal of waste and relevant management procedures were studied. This review largely concentrated on the legislation basis of waste management but also attempted to consider the situation with regard to particularly hazardous pollutants.

8.8 Conclusions

The relatively short time period of one and a half years provided for project development and implementation did not allow for an in-depth study of each individual pollution source along the Mediterranean coastline. It was possible, however, to achieve a comprehensive overview as well as a comparative evaluation of major point and non-point sources. Such information was requested by mid-1977 in order to assist in the critical stages of the preparation of the draft protocol on land-based sources.

Table III - Estimated annual pollution loads of the Mediterranean sea areas (all figures in tonnes per annum or percentages)

Sea area / Pollutant	I		II		III		IV		V		VI		VII		VIII		IX		X		TOTAL
	t/a	%	t/a	%	t/a	%	t/a	%	t/a	%	t/a	%	t/a	%	t/a	%	t/a	%	t/a	%	t/a
1. Volume:																					
Total discharge $x10^9$	7	2	99	23	9	2	33	8	151	35	33	8	6	1	47	11	25	6	18	4	428
2. Organic matter:																					
BOD $x10^3$	90	3	950	29	120	4	370	11	800	25	230	7	70	2	330	10	140	4	150	5	3 250
COD $x10^3$	300	3	2400	28	400	5	1100	13	1700	20	600	7	300	3	950	11	550	6	300	3	8 600
3. Nutrients:																					
Phosphorus $x10^3$	7	2	126	35	9	3	29	8	85	24	23	6	7	2	33	9	19	5	20	6	358
Nitrogen $x10^3$	25	2	387	37	27	3	62	6	273	26	61	6	20	2	90	9	51	5	46	4	1 042
4. Specific organics:																					
Detergents $x10^3$	1.5	3	14.8	25	1.8	3	8.2	14	16.2	27	3.8	6	1.2	2	6.0	10	2.7	5	3.5	6	59.7
Phenols $x10^3$	1.2	10	3.9	31	0.6	5	1.0	8	1.6	13	1.5	12	1.1	9	0.9	7	0.2	2	0.4	3	12.4
Mineral oil $x10^3$	2	2	10	7	1	1	3	3	4	4	10	9	41	36	4	4	27	23	13	11	115
5. Metals:																					
Mercury	2	2	33	25	3	2	11	8	41	32	10	8	2	2	14	11	7	5	7	5	130
Lead	90	2	1360	28	120	2	630	13	1440	30	230	5	100	2	440	9	180	4	230	5	4 820
Chromium	100	4	1000	36	120	4	380	14	200	7	210	8	50	2	290	11	150	5	260	9	2 760
Zinc	300	1	5200	21	700	3	3000	12	8600	35	1600	6	500	2	2500	10	1100	4	1200	5	24 700
6. Suspended matter:																					
TSS $x10^6$	(-)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)	-	(-)
7. Pesticides:																					
Organochlorines	6.4	7	14.9	17	10.4	12	12.1	13	14.0	16	6.1	7	2.9	3	7.4	8	6.7	7	9.1	10	90
8. Radioactivity:																					
Tritium Ci/a	-	0	1100	44	-	0	120	5	1260	51	1	0	-	0	-	0	-	0	-	0	2 480
Other radionuclides Ci/a	-	0	16	42	-	0	14	37	7	18	1	3	-	0	-	0	-	0	-	0	38

Legend: (-) Insufficient data base for estimate.

All the various sectorial studies revealed without exception the limited availability of relevant data in all Mediterranean countries. Particular data deficiences were encountered for hazardous pollutants such as heavy metals, specific organics and pesticides. Furthermore, the available statistical documents frequently did not provide for a more detailed analysis of data according to industrial activities or geographical locations.

Collection of the required data in the countries faced various difficulties: data collection and reporting formats varied from one country to another; a large number of different data sources had to be included in each study; certain sectorial data were not readily available; in some cases the required data were not obtained due to confidentiality restrictions which could not be overcome in the short time provided for the project.

In view of the limitations and difficulties encountered, the pollution load assessment for all waste source categories has been, to a great extent, estimated indirectly. It has been worked out taking into consideration demographic statistics, industrial production and employee figures, and agricultural consumption data in addition to the data provided by the questionnaires. Similarly, extrapolations from known sources were made in the case of rivers and of nuclear power stations. Despite the short-comings of such an indirect method of evaluation, the results obtained are homogeneous and fairly complete and cover the entire Mediterranean region. The quality of calculated estimates may be considered accurate within an error range of about one order of magnitude.

Compilation and comparison of the sectorial results achieved revealed a number of interesting facts which could assist in the improvement of present pollution control efforts of the countries bordering the Mediterranean Sea.

Domestic sources largely contribute organic matter (BOD or COD), microbial pollution and nutrients as well as detergents from household uses. Some of the metals are also derived from municipal sewage discharges.

Industrial waste discharges are responsible for considerable amounts of organic matter and suspended solids. Various industrial processes result also in phenol and metal releases while mineral oils are largely introduced from refineries and crude oil terminals.

Agricultural run-off is responsible for a considerable portion of the nutrient input to the sea. Suspended solids and pesticide discharges are largely due to soil erosion in the Mediterranean watershed. However, the contribution from agricultural run-off within the coastal area is but a fraction of the pollution loads carried by rivers into the sea. The airborne load of pesticides could not, however, be included in the study.

Major rivers and drains transport an integrated load of domestic, industrial and agricultural pollutants from the entire drainage basin into the sea. Their contribution is therefore very high in suspended solids, nutrients, metals and organic matter. They also carry most of the pesticide residues from agricultural areas into the Mediterranean watershed.

The total discharge of radioactivity into the Mediterranean from nuclear installations is fairly low in comparison to the radioactive contaminants in other materials discharged (particularly phosphates) and in fall-out from earlier weapon tests.

9. OTHER ACHIEVEMENTS

The results of the project were of primary importance for the successful negotiation of the Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources.

In spite of logistic problems involved in the execution of a project of such a complex nature, the co-ordinating arrangements between the co-sponsors of the project and the relevant national authorities were very efficient and indeed exemplary.

10. DOCUMENTATION

Documents specifically developed for and by this project include:

- Pollutants from Land-Based Sources in the Mediterranean. UNEP Regional Seas Reports and Studies No. 32. UNEP 1984.
- Waste discharge into the Marine Environment. Principles and Guidelines for the Mediterranean Action Plan. WHO/UNEP. Pergamon Press, 1982.

10. REFERENCES

Gavrilovic, S. (1962), Proracun srednje kolicine nanosa prema potencijalu erozije (Calculation of the mean amount of sediment according to the potential of the erosion). Glasnik Sum. Fakulteta Beograd, No. 26.

MED POL XI : INTERCALIBRATION OF ANALYTICAL TECHNIQUES AND COMMON MAINTENANCE SERVICE (IAEA/FAO(GFCM)/IOC/UNEP)

1. INTRODUCTION

The primary objective of the MED POL XI was to give specific assistance to Mediterranean laboratories participating in the pilot projects on baseline studies and monitoring heavy metals and halogenated hydrocarbons in marine organisms (MED POL II and MED POL III), by organizing intercalibration exercises for their measurements.

The original project was revised in July 1976 to include the establishment of common maintenance services for the analytical instruments to be distributed to the above-mentioned Mediterranean laboratories. In 1978 the analytical work on sea-water and sediment samples collected by the R/V Calypso in the course of its circum-Mediterranean cruise in summer/autumn 1977 was entrusted to IAEA International Laboratory in Monaco and a number of measurements of trace metals in sea-water and of chlorinated hydrocarbons in sediments were carried out. The report presents the overview of the achievements of the Mediterranean intercalibration programme and in the instrument maintenance services from the start of the project in January 1976 to December 1980. The results obtained from the Calypso samples are also reviewed.

2. FINANCIAL ARRANGEMENTS

Specific financial support to the project (excluding the costs of intercalibration for petroleum hydrocarbons) was provided through projects FP/1301-74-07 and FP/0503-75-04. Costs (in US dollars) were shared between the three co-sponsors of the project as follows:

	1975	1976	1977	1978	1979	1980	Total	Percentage
IAEA	20,000	50,000	50,000	50,000	50,000	32,000	252,000	32.5
IOC	2,000	4,000	3,000	3,000	-	-	12,000	1.5
UNEP	88,673	33,714	150,707	7,791	193,000	37,073	510,958	66.0
TOTAL	110,673	87,714	203,707	60,791	243,000	69,073	774,958	100.0

3. NATIONAL CONTRIBUTION

The financial contributions of national research centres to the activities covered by MED POL XI are included in the estimates given in the sections dealing with MED POL I, II and III.

4. CO-ORDINATING ARRANGEMENTS

The intercalibration of analytical methods relevant to metals and chlorinated hydrocarbons was co-ordinated by the IAEA Monaco Laboratory in co-operation with FAO(GFCM). The intercalibration of analytical methods relevant to petroleum hydrocarbons was co-ordinated by IOC.

The provision of common maintenance services was co-ordinated by the IAEA Monaco Laboratory in co-operation with FAO(GFCM) and IOC.

The co-ordination of the Calypso cruise was carried out by ICSEM with financial support from UNEP as well as from the EEC.

5. MEDITERRANEAN INTERCALIBRATION EXERCISE

Trace metal measurement

The following homogeneous samples used for the intercalibration exercises on trace metal measurements were prepared under the previous UNEP project (No. 0800-73-007) as well as the present project:

- oyster homogenate (MA-M-1);
- sea plant homogenate (SP-M-1);
- copepod homogenate (MA-A-1);
- fish flesh homogenate (MA-A-2).

The homogeneity of these samples was tested at the same time on a number of trace elements in three places: IAEA's Monaco and Seibersdorf laboratories in Vienna as well as at Battelle Pacific Northwest Laboratories, Richland, Washington, USA. The results of these tests demonstrated that the bottle-to-bottle variations of trace element content did not exceed $\pm$ 10 per cent in terms of 1σ standard deviation and, for a number of trace elements measured, the variations remained at a level of a few per cent. After verification of the homogeneity, the samples were sent to the Mediterranean research centres participating in the MED POL II project. Participation in the intercalibration of analytical methods was considered mandatory for all participating research centres. At the same time as the Mediterranean intercalibration was under way, the programme was extended to incorporate laboratories on a world-wide basis by using the same samples. Altogether, about 100 laboratories from approximately 30 countries participated in the intercalibration exercises organized. Among these laboratories were 32 research centres from 14 Mediterranean countries.

The MA-M-1 (oyster) sample was distributed in 1976; the SP-M-1 (sea plant) and MA-A-1 (copepod) samples in 1977 and MA-A-2 (fish) samples in 1978.

In general, the policy was that, until a laboratory sent in the results of measurements, it did not receive the next sample(s). Thus the intercalibration exercise on the MA-M-1 (oyster) samples was completed in 1977, and that on SP-M-1 (sea plant) and MA-A-1 (copepod) in 1978 and that on MA-A-2 (fish) in 1979, except for some laboratories which had not sent their results by then.

The reported results were compiled on a world-wide basis and the average values for the elements measured were calculated after rejecting outliers by applying statistical tests. These average values were considered as the "consensus values." Since the statistical treatment of the data does not always guarantee reasonable estimations of true concentrations of the elements cncerned, the "probable concentrations" of the elements were estimated on the basis of the data reported by about 20 laboratories selected on the basis of their analytical reputation and performance, as well as their geographic location. The comparisons between the "consensus values" and the "probable concentrations" showed that, in general, these two sets of values were in agreement. Based on the uncertainties associated with the "probable concentrations" of the elements concerned, the 2 standard deviations (2σ) range and the 1 standard deviation (1σ) range were respectively regarded as "acceptable range" and "good range". The "probable concentrations" as well as these two ranges for Cu, Zn, Cd, Hg and Pb in each intercalibration sample are given in Table I. Based on the "acceptable range" and "good range" estimated for each element for each sample the results reported by the Mediterranean research centres on Cu, Zn, Cd, Hg and Pb were evaluated and the results of the evaluations are given in Table II.

Table II shows that the comparability of the mesurements on the trace metals listed is generally satisfactory. However, it became apparent that some laboratories continued to have difficulties in reporting the results as scheduled and that the comparability of the measurements of low concentration of Pb in some samples is poor. During the intercalibration operations, major difficulties have been encountered in the covering reports of the analytical results from some research centres. While most of the participating laboratories reported their results punctually within specified deadlines, the result-reporting of some laboratories was much slower, so that the statistical tratment of the reported results as well as the feedback processes of the result-survey to individual laboratories tended to be delayed. From some laboratories the reports were not received, despite the fact that they had been equipped with the necessary instruments and these instruments have been proved to be functioning. Except for a limited number of laboratories, the intercalibration exercises have proceeded very effectively and the participating laboratories received the necessary feedback for their analytical quality control.

Table I - "Probable concentrations", "good ranges" and "acceptable ranges" for Cu, Zn, Cd, Hg and Pb in the intercalibration samples, MA-M-1 (Oyster), SP-M-1 (sea plant), MA-A-1 (copepod) and MA-A-2 (fish), estimated on the basis of the results obtained by selected laboratories

Element		Cu	Zn	Cd	Hg	Pb
MA-M-1 (oyster)	Probable concentration* (µg/g-dry)	325 ± 9	2880 ± 40	2.3 ± 0.1	0.18 ± 0.01	1.2 ± 0.2
	Good range (µg/g-dry)	285 - 365	2680 - 3080	1.8 - 2.8	0.13 - 0.23	0.8 - 1.8
	Acceptable range (µg/g-dry)	245 - 405	2480 - 3280	1.3 - 3.3	0.08 - 0.28	0.3 - 2.3
SP-M-1 (sea plant)	Probable concentration* (µg/g-dry)	12.1 ± 0.6	61 ± 2	0.42 ± 0.03	0.31 ± 0.02	18 ± 2
	Good range (µg/g-dry)	9.4 - 15.2	53 - 68	0.31 - 0.53	0.24 - 0.38	13 - 23
	Acceptable range (µg/g-dry)	6.5 - 18.1	46 - 75	0.20 - 0.64	0.17 - 0.45	8 - 28

* Uncertainties are expressed in standard errors

continued

Table I - "Probable concentrations", "good ranges" and "acceptable ranges" for Cu, Zn, Cd, Hg and Pb in the intercalibration samples, MA-M-1 (Oyster), SP-M-1 (sea plant), MA-A-1 (copepod) and MA-A-2 (fish), estimated on the basis of the results obtained by selected laboratories (continued-2)

Element		Cu	Zn	Cd	Hg	Pb
MA-A-1 (copepod)	Probable concentration* (µg/g-dry)	7.5 ± 0.3	161 ± 3	0.70 ± 0.03	0.27 ± 0.01	0.88 ± 0.07
	Good range (µg/g-dry)	6.2 - 8.8	145 - 177	0.60 - 0.80	0.24 - 0.30	0.67 - 1.09
	Acceptable range (µg/g-dry)	4.8 - 10.2	129 - 193	0.50 - 0.90	0 21 - 0.33	0.46 - 1.30
MA-A-2 (fish flesh)	Probable concentration* (µg/g-dry)	3.9 ± 0.1	33.6 ± 0.9	0.081 ± 0.007	0.52 ± 0.22	0.64 ± 0.10
	Good range (µg/g-dry)	3.3 - 4.5	29.3 - 37.9	0.05 - 0.11	0.43 - 0.61	0.26 - 1.0
	Acceptable range (µg/g-dry)	2.7 - 5.1	24.9 - 42.3	0.02 - 0.14	0.34 - 0.70	0 - 1.4

* Uncertainties are expressed in standard errors

Table II - Evaluation of the intercalibration results of trace metal measurements reported by Mediterranean laboratories

		MA-M-1 (oyster)	SP-M-1 (sea plant)	MA-A-1 (copepod)	MA-A-2 (fish flesh)
Cu	No. of results	13	14	18	15
	within "good range"	10 (77%)	8 (57%)	13 (72%)	6 (40%)
	within "accept. range"	12 (92%)	13 (93%)	15 (83%)	12 (80%)
Zn	No. of results	12	13	15	13
	within "good range"	6 (50%)	6 (46%)	5 (33%)	6 (46%)
	within "accept. range"	9 (75%)	7 (54%)	10 (67%)	10 (77%)
Cd	No. of results	18	18	20	15
	within "good range"	13 (72%)	5 (28%)	6 (30%)	8 (53%)
	within "accept. range"	17 (94%)	12 (67%)	13 (65%)	11 (73%)
Hg	No. of results	14	22	24	17
	within "good range"	8 (57%)	11 (50%)	5 (21%)	4 (24%)
	with "accept. range"	12 (86%)	15 (68%)	12 (50%)	7 (41%)
Pb	No. of results	12	14	17	11
	within "good range"	5 (42%)	9 (64%)	4 (24%)	5 (45%)
	within "accept. range"	8 (67%)	11 (79%)	7 (41%)	6 (55%)

Chlorinated hydrocarbon measurements

Four intercomparison samples were prepared for distribution within the framework of the Mediterranean monitoring programme. The samples were all derived from natural sources and were not spiked with chlorinated hydrocarbons. Therefore, unlike several previously conducted intercalibration exercises, the samples involved represented very closley the levels an analyst is likely to encounter in his own environmental monitoring programme. The four samples consisted of Mediterranean near-shore sediment (SD-M-1), copepod homogenate (MA-A-1), oyster homogenate (MA-M-1) and fish fillet homogenate (MA-A-2). These represented a diversity of sample types which presented the analyst with most of the kinds of analytical difficulties he was likely to encounter while participating in the Mediterranean monitoring programme.

By using these samples, a series of intercalibration exercises was organized in the course of 1976 - 1980. Although there were several laboratories which did not report any results, altogether, 26 research centres from 12 Mediterranean countries participated in these intercalibration exercises.

As in the case of trace metal measurements, the "probable concentrations" as well as "acceptable" and "good" ranges were computed for various chlorinated hydrocarbons and their derivations contained in each sample, on the basis of the results obtained through the world-wide intercalibration exercises using the same samples. The evaluation of the results reported by Mediterranean research centres on the oyster homogenate (MA-M-1) are compared in Table III with those of the world-wide intercalibration exercises. Table III shows that the percentages of "acceptable" as well as "good" results are generally higher for Mediterranean laboratories than for laboratories from world-wide intercalibration. Although the standard deviations for the average values are still large ($\sim\pm$ 30 per cent), the evaluation shown in Table III indicate that the results obtained through these intercalibration exercises are encouraging, since the samples used contained environmental levels of chlorinated hydrocabon residues which are much lower than the levels that have ordinarily been produced in spiked intercalibration samples.

Table III - Evaluation of the intercalibration results for chlorinated hydrocarbon measurements on the oyster homogenate (MA-M-1) reported by the Mediterranean research centres

	Mediterranean			World-wide		
Compound	No. of results received	No. of "acceptable" results	No. of "good" results	No. of results received	No. of "acceptable" results	No. of "good" results
Ar 1254	15	14 (93%)	14 (93%)	26	22 (85%)	15 (58%)
DDT	15	14 (93%)	11 (73%)	34	32 (94%)	20 (59%)
DDD	14	13 (93%)	13 (93%)	30	20 (67%)	7 (23%)
DDE	15	15 (100%)	9 (60%)	36	31 (86%)	24 (67%)
Dieldrin	8	7 (88%)	7 (88%)	22	20 (91%)	18 (82%)
γ-BHC	6	6 (100%)	5 (83%)	25	14 (56%)	9 (36%)

6. INSTRUMENT MAINTENANCE SERVICE

Through the services of the maintenance engineer of the IAEA Monaco laboratory, efficient assistance was provided to a large number of research centres in installing, maintaining and repairing atomic absorption spectrophotometers, gas chromatographs, fluorimeters, current meters and similar equipment.

Maintenance services, accomplished during visits of the maintenance engineer, consisted of:

- installation of equipment (frequently in co-operation with an expert provided by the supplier of the equipment);
- regular maintenance services (cleaning, adjustments, etc.);
- repair or replacement of faulty components;
- instruction of local expert on maintenance procedures.

Visits to the research centres were undertaken:

- on the installation of the larger equipment provided to the research centre through MED POL;
- at regular intervals for routine services of earlier-installed equipment;
- on emergency calls when an instrument broke down or did not perform satisfactorily.

The services of the maintenance engineer were, in principle, available only for the maintenance of instruments provided to the research centres through MED POL but, in exceptional cases, equipment used for, but not provided through, MED POL, was also repaired.

In Tables IV and V, respectively, the names of the research centres visited during 1976 - 1980, as well as a list of instruments purchased and installed at these centres through the UNEP fund are given.

By the end of 1980, through the duration of the MED POL - PHASE I, 46 maintenance visits had been paid to 17 research centres in 10 Mediterranean States. A list of the maintenance visits is given in Table VI. The reports on these visits indicate that the services provided were very efficient and of high professional quality. In view of the prevailing conditions in most of the Mediterranean States, the project should be considered as an essential contribution to the successful work of many national research entres. Judging from the result-reporting of the intercalibration samples distributed, however, the lack of experience in some research centres in the use of the instruments for the required measurements is considered to have been a primary cause of the delay of the intercalibration measurements as well as scheduled baseline and monitoring measurements. This was especially true of the measurements of chlorinated hydrocarbons by GC.

Table IV - Name and location of laboratories visited

1. Marine Biological Station, Institute of Biology, University of Ljubljana, Portoroz, Yugoslavia
2. Centre for Marine Research, "Rudjer Boskovic" Institute, Zagreb/Rovinj, Yugoslavia
3. Marine Sciences Department, Middle East Technical University, Erdemli/ Içel, Turkey
4. General Chemical State Laboratories, Division of Research, Athens, Greece
5. Institute of Oceanographic and Fisheries Research, Athens, Greece
6. University of Thessaloniki, Analytical Chemistry Laboratory, Thessaloniki Greece
7. Centre de Recherches Océanographiques et des Pêches, Alger, Algeria
8. Fisheries Department, Ministry of Agriculture and Natural Resources, Nicosia, Cyprus
9. Israel Oceanographic and Limnological Research Ltd., Haifa, Israel
10. Hydrobiological Research Institute, Faculty of Science, University of Instanbul, Turkey
11. Institute of Hydrobiology, Faculty of Science, Ege University, Izmir, Turkey
12. University of Malta, Msida, Malta
13. Institut Scientifique des Pêches Maritimes, Casablanca, Morocco
14. Institut National Scientifique et Technique d'Océanographie et de Pêche, Salambo, Tunisia
15. University of Athens, Athens, Greece
16. Institute of Oceanography and Fisheries, Alexandria, Egypt
17. Centre for Post-Graduate Studies and Research, Alexandria, Egypt

Table V - List of instruments installed

Location of Research Centre		AAS	GC
1.	Msida, Malta	+	+
2.	Portoroz, Yugoslavia	+	+
3.	Rovinj, Yugoslavia	+	+
4.	Haifa, Israel	+	
5.	Erdemli/Içel, Turkey	+	+
6.	Alger, Algeria	+	+
7.	Nicosia, Cyprus	+	+
8.	Izmir, Turkey	+	
9.	Salammbo, Tunisia	+	
10.	Casablanca, Morocco	+	+
11.	Barcelona, Spain		+
12.	Istanbul, Turkey		+
13.	Alexandria (Fisheries), Egypt	+	+
14.	Alexandria (University), Egypt	+	
15.	Beirut, Lebanon		+

Table VI - Maintenance service programme
(list of visits Nov. 1976 - Dec. 1980)

Location	Date	Purpose of Visit
1. Portoroz-Yugoslavia	22-25 Nov. 76	Installation of AAS and GC
2. Rovinj-Yugoslavia	11-14 Jan. 77	Installation of AAS and GC
3. Erdemli/Içel-Turkey	9-13 May 77	Installation of AAS and GC
4. Athens-Greece	5 July 77	Adjustment of Mercury Analyser/ General Chemical State Laboratory
5. Athens-Greece	5 July 77	Discussions on maintenance problems/University of Athens
6. Athens-Greece	6 July 77	Current meters maintenance (Aanderaa)/Fisheries Department
7. Thessaloniki-Greece	7 July 77	Maintenance of different types of GC and AAS
8. Rovinj-Yugoslavia	9-12 July 77	1st service GC/repair of AAS/ repair of gasmaspectrometer NCC

Table VI - Maintenance service programme
(list of visits Nov. 1976 - Dec. 1980) (continued)

Location	Date	Purpose of Visit
9. Portoroz-Yugoslavia	9-12 July 77	lst service AAS and GC
10. Alger-Algeria	7-9 Aug. 77	Installation of AAS
11. Nicosia-Cyprus	15-18 Aug. 77	Installation of AAS
12. Haifa-Israel	19-23 Aug. 77	lst service of AAS and repair/ repair of GC/maintenance of current meter
13. Rovinj-Yugoslavia	24-26 Aug. 77	Emergency service-repair of AAS
14. Portoroz-Yugoslavia	5-7 Oct. 77	Emergency service-repair of AAS
15. Rovinj-Yugoslavia	7 Oct. 77	2nd service-replacement of H2 lamp
16. Istanbul-Turkey	25-26 Oct. 77	Installation of GC
17. Izmir-Turkey	27 Oct. 77	Installation of AAS
18. Erdemli/Içel-Turkey	28 Oct. 77	lst service of AAS and GC-repair of AAS
19. Portoroz-Yugoslavia	19-21 Dec. 77	lst service of AAS and GC/repair of AAS
20. Msida-Malta	6 Feb. 77	2nd service of AAS/arrangement for repair of Hewlett-Packard GC
21. Haifa-Israel	7-9 Feb. 78	2nd service and repair of AAS and GC
22. Nicosia-Cyprus	10-11 Feb. 78	lst service of AAS/repair of Turner spectrophotofluorimeter
23. Casablanca-Morocco	17-20 Sept. 78	lst service and repair of AAS
24. Salambo-Tunisia	21-22 Sept. 78	lst service of AAS
25. Alger-Algeria	12-14 Nov. 78	lst service of AAS
26. Rovinj-Yugoslavia	21-24 Nov. 78	Emergency service of AAS
27. Alexandria-Egypt	16-20 Jan. 79	Installation of AAS and GC/ Fisheries
28. Salammbo-Tunisia	9-12 Apr. 79	2nd service of AAS

Table VI - Maintenance service programme
(list of visits Nov. 1976 - Dec. 1980) (continued)

Location	Date	Purpose of Visit
29. Instanbul-Turkey	26-27 Jun. 79	1st service of GC
30. Erdemli/Içel-Turkey	28 Jun-1 Jul.79	2nd service AAS/GC/AA-6/two chart recorders/GC Becker-Packard
31. Izmir-Turkey	1-3 July 79	1st service of AAS
32. Portoroz-Yugoslavia	4-7 July 79	Emergency service GC
33. Nicosia-Cyprus	9-11 Oct. 79	2nd service AAS/installation GC 3700
34. Alexandria-Egypt	13-16 Oct. 79	Installation of AAS Mod 175/ University
35. Alexandria-Egypt	15 Oct. 79	1st service AAS/GC service of Turner spectrophotofluori-meter/Fisheries
36. Msida-Malta	16-19 Oct. 79	Installation of GC 3700/service of AAS/inspection of 2 current meters
37. Casablanca-Morocco	3-7 Dec. 79	Installation of GC 3700/2nd service of AAS
38. Alger-Algeria	31 Mar.-2 Apr.80	2nd service of AAS
39. Rovinj-Yugoslavia	9-11 Apr. 80	Service of Aanderaa current meters
40. Portoroz-Yugoslavia	14 Apr. 80	Service of AAS and GC
41. Alexandria-Egypt	28-30 May 80	Emergency service of AAS/ Fisheries
42. Alexandria-Egypt	30 May 80	1st service of AAS Mod 175/ University
43. Msida-Malta	22-24 Oct. 80	1st service GC 3700/service of Aanderaa current meter
44. Alexandria-Egypt	25-26 Oct. 80	Emergency service of AAS/ Fisheries
45. Alexandria-Egypt	27 Oct. 80	2nd service of AAS Mod 175/ University
46. Nicosia-Cyprus	28-31 Oct. 80	1st service of GC 3700/service of AAS and Aanderaa current meters

7. MEASUREMENTS ON CALYPSO SAMPLES

During the period July - December 1977 a circum-Mediterranean cruise was organized using the R/V Calypso under the auspices of ICSEM, and a number of samples of surface sea-water and coastal sediment were collected. The Monaco laboratory was asked to take up the analyses of these samples. Based on an agreement concluded between ICSEM, UNEP and IAEA, the meassurements of trace metals in sea-water samples and of chlorinated hydrocarbons in sediment samples were performed in the Monaco laboratory in the course of 1978.

The analyses of selected trace metals, such as copper, zinc, cadmium and mercury on 127 sea-water samples as well as those of chlorinated hydrocarbons (PCB, DDE, DDD and DDT) on 117 sediment samples were completed. Although advice on sampling of sea-water and sediments was given by the Monaco staff at the outset of the Calypso cruise, their role in reality was limited to laboratory work. A review of the present pollution in the coastal waters of the Mediteranean Sea was drawn up by an expert group of ICSEM on the basis of data and presented at the ICSEM/UNEP Workshop on Pollution of the Mediterranean, held at Antalya in November 1978. The data showed that the concentration levels of trace metals in coastal waters as well as chlorinated hydrocarbons in coastal sediments tend to be similar to, or even lower than, those found in corresponding areas in other regions. Some "hot spots" were, however, found at a limited number of stations notably close to industrialized areas. It seems reasonable to consider that pollution of the coastal areas of the Mediterranean by these substances, as a whole, is not far different from that of other coastal regions with small or moderate anthropogenic input.

8. DOCUMENTATION

Documents specifically developed in the frame-work of this project:

- Intercalibration of Analytical Methods in Marine Environmental Samples. Progress Report No.13 (IAEA 1975), No.15 (IAEA 1977), No.16 (IAEA 1978), No.18 (IAEA 1978), No.19 (IAEA 1978), No.20 (IAEA 1980).
- Intercalibration of Organochlorine Compound Measurements in Marine environmental Samples. Report No.1 (IAEA 1977), No.2 (IAEA 1979).
- Intercalibration of Analytical Methods on Marine Environmental Samples. UNEP/WG.46/INF.7, IAEA/UNEP 1981.

Specific meetings held in connection with this project:

- Meeting of Consultants on Organochlorine Intercalibration Measurements (Monaco, 3-5 November 1976), attended by 8 participants from 8 research centres.

MED POL XII : INPUT OF POLLUTANTS INTO THE MEDITERRANEAN SEA THROUGH THE ATMOSPHERE (WMO/IAEA/WHO/UNIDO/ECE/UNEP)

1. INTRODUCTION

At present, it appears that practically no data are available on the atmospheric contribution to the pollution of the Mediterranean, although the input of airborne pollutants may turn out to be one of the major parameters needed to assess the state of pollution in the Mediterranean basin.

The first phase of the project would develop the scientific criteria and methods for measuring airborne pollutants. The second phase would include field measurements on the transport of pollutants through the atmosphere, exchange of pollutants through the air/sea interface and modelling of these processes.

The objective of the project is to provide information on the relevance of airborne pollution to the present state of pollution of the Mediterranean Sea and thus contribute to the understanding of the biogeochemical cycle of pollutants in the Mediterranean basin. As the airborne transport of pollutants may be one of the major mechanisms contributing to transboundary pollution, the results of this project could eventually lead to the negotiation of a legal instrument designed to control airborne pollution of the region.

2. RESULTS ACHIEVED

This project, suggested by several Mediterranean expert groups and by an intergovernmental meeting remained in the planning phase only.

The first outline of a possible approach to the problem was formulated by the World Meteorological Organization (WMO) in consultation with IAEA, ECE, UNIDO, WHO and UNEP.

No specific expenses were incurred by UNEP in connection with this project.

MED POL XIII: MODELLING OF MARINE SYSTEMS IN THE FRAMEWORK OF MED POL (UNESCO/FAO/IOC/UNEP)

1. INTRODUCTION

Modelling is an essential component of any overall plan designed to assess the impact of pollutants on natural systems and to provide information needed by those in charge of the rational management of these systems. Modelling is, in particular, one of the most effective scientific tools to explore the functioning of marine ecosystems and their response to environmental stresses.

The project included the development of two- and three-dimensional hydrodynamic circulation models, models of biogeochemical cycles of pollutants and models of ecosystems' response to pollutants.

The objective of the project was to provide information needed for the design, co-ordination and balance of sampling programmes carried out under MED POL monitoring projects, and for a better understanding of the complex relationship between the sources of pollution and their effects on marine ecosystems, human health and socio-economic development. Such models would provide the means by which the results of the individual projects of the Mediterranean Action Plan, and of MED POL in particular, could have been synthesized and better understood.

These models, having predictive capabilities, could be used by the Governments of the Mediterranean coastal States as management tools in the prevention and control of marine pollution affecting the Mediterranean Basin.

2. RESULTS ACHIEVED

Several scientific and expert group meetings on ecosystem model were convened after 1973 by UNESCO and this activity was expanded after 1976 with assistance from UNEP. At the Expert Consultation in Paris in 1976, the establishment of working groups was proposed, each concerned with one specific region in the Mediterranean. The group for the north-western Mediterranean gathered at Banyuls-Sur-Mer, January 1977, and elaborated the framework in which studies of marine processes would have to be undertaken.

At the Mid-term Review Meetings on individual MED POL pilot projects in Dubrovnik (May 1977), Barcelona (May 1977) and Monaco (1977) it was recommended that an interdisciplinary task team should be created to formulate conceptual models for the most critical pollutants in the Mediterranean, to advance these to the level of mathematical models for certain Mediterranean areas by using data generated in the various pilot projects of the Mediterranean Action Plan, and to test their predictive capabilities as a management tool.

Based on the guidance received at the Intergovernmental Review Meeting of Mediterranean Coastal States on the Mediterranean Action Plan (Monaco, 9-14 January 1978), an outline of a project focusing on hydrodynamic, biogeochemical and ecosystem modelling, was drawn up jointly with UNESCO.

However, due to budgetary constraints, the project remained in the planning phase only.

SUPPORTING ACTIVITIES TO THE MED POL - PHASE I

1. INTRODUCTION

As preparatory activities for the adoption of the Mediterranean Action Plan, and MED POL as its scientific component, the following two projects were carried out:

International Workshop on Marine Pollution in the Mediterranean

With the co-operation of IOC, FAO(GFCM) and ICSEM, the Workshop was organized in Monaco (9 - 14 September 1974). It was attended by 27 experts, 19 of them from 11 Mediterranean States.

The Workshop:

- reviewed the main problems of marine pollution in the Mediterranean and the state of pollution studies and monitoring carried out in the Mediterranean;
- identified high priority studies and the needs for co-ordinated activities;
- outlined several pilot projects and recommended their initiation.

The Workshop was co-sponsored by UNEP. The costs of the Workshop (in US dollars) were shared by co-sponsors as follows:

	1974	1975	1976	Total	Percentage
IOC	4,000	-	-	4,000	11.1
FAO (GFCM)	1,000	-	-	1,000	2.8
ICSEM	6,000	-	-	6,000	16.6
UNEP	-	25,040	69	25,109	69.5
TOTAL	11,000	25,040	69	36,109	100.0

These costs included:

- US $ 13,800 for the organization of the meeting;
- US $ 17,400 for attendance of experts;
- US $ 3,000 for reporting costs;
- US $ 1,909 for miscellaneous expenses.

The project successfully accomplished its goal in that it resulted in the first outline of projects which later became parts of MED POL.

Evaluation of Institutional Programmes

Through IOC a study was sponsored by UNEP to evaluate the institutional capabilities of the Mediterranean research centres, their programmes relevant to marine pollution monitoring and research and their readiness to participate in MED POL - related activities.

The costs of the study (in US dollars) were shared by the two co-sponsors as follows:

	1974	1975	1976	Total	Percentage
IOC	1,500	-	-	1,500	10.2
UNEP	-	12,838	337	13,175	89.8
TOTAL	1,500	12,838	337	14,675	100.0

These costs included:

- US $ 1,500 for consultants;
- US $ 9,575 for travel;
- US $ 2,000 for reporting costs;
- US $ 1,600 for miscellaneous expenses.

The project resulted in a comprehensive survey of the institutional infrastucture which could underly MED POL - related activities and was later used as the basis for the first issue of the Directory of Mediterranean Marine Research Centres (Directory of Marine Research Centres, UNEP, Geneva (1977)).

2. CO-ORDINATION

MED POL - PHASE I activities were organized in close collaboration between UNEP and the specialized United Nations bodies (ECE, UNIDO, GFCM of FAO, IMO, UNESCO, WHO, WMO, IAEA and IOC of UNESCO) and selected international organizations (IUCN, ICSEM), which had a major role in their implementation. Throughout the planning period, and during the whole of the pilot phase, a high degree of co-operation was maintained by UNEP, acting as the overall co-ordinator, and those specialized organizations who were responsible for the technical implementation of individual projects. The overall co-ordination of MED POL - PHASE I was carried out, on UNEP's behalf, by the UNEP Regional Seas Programme Activity Centre (RS/PAC) and was achieved through frequent contacts and consultations between RS/PAC and the relevant specialized organizations. In order to facilitate the co-ordination of the original seven MED POL pilot projects, an Inter-Agency Advisory Committee (IAAC) was established in 1975.

The co-ordination of MED POL with similar ongoing and planned programmes in the other regions of the globe (Caribbean, Kuwait Action Plan Region, South-East Pacific, Red Sea, West Africa and others) was performed by UNEP's Regional Seas Programme Activity Centre (RS/PAC).

Apart from the specific contributions to the individual projects, additional support was provided to initiate and assist the implementation of MED POL - related activities through the RS/PAC. This assistance was related to general MED POL - related activities or to activities involving more than one of the MED POL projects and the overall costs (in US dollars) were:

1975	1976	1977	1978	1979	1980	Total
95,000	245,000	247,000	318,000	370,000	390,000	1,665,000

3. DATA HANDLING

The rough estimate of the total number of primary data collected through MED POL - PHASE I was 1.5 million data items per year.

The first evaluation of the primary data was the task of the research centres who collected it. Secondary (reduced) data were reported periodically to the specialized United Nations body having the technical responsibility for the implementation of the project. The processing of the secondary data, including their validation and analysis was accomplished by the relevant specialized United Nations organizations which reported them to RS/PAC.

The facilities of the Geneva-based United Nations International Computing Centre (ICC) were selected to be used on a trial basis as the central data repository and processing facility for the entire Mediterranean Action Plan. Approximately 60,000 items of reduced data were reported to the Co-ordinating Centre.

Data were collected, handled and disseminated according to existing standard formats and pactices, making full use of the existing mechanisms for data exchange. Progress made in this area were rather slow due to the following problems:

(a) Many of the data forms were incorrectly or inadequately completed and therefore unusable. The missing items could not easily be completed due to the long time interval between data generation and the detection of errors.

(b) Major financial contributions to the Mediterranean Trust Fund were delayed and this caused delays in the recruitment of computer staff and the purchase of essential computer equipment for the Co-ordinating Unit.

(c) Much of the data were of strictly local relevance and could not be used in presenting a coherent and composite picture of Mediterranean conditions.

In spite of the above problems, MED POL - PHASE I data greatly contributed to the formulation of the first assessments of pollution by mercury and microorganisms. The two assessment documents (UNEP/WG.91/5 and UNEP/WG.91/6) were lately updated by using the data obtained through MED POL - PHASE II.

OVERALL EVALUATION OF THE MED POL - PHASE I

The large number of national research centres designated by their Governments to participate in MED POL (83 research centres from 16 Mediterranean States, and the EEC, Table I), the diversity of the programme and its geographic coverage, the impressive number of Mediterranean scientists and technicians (about 200) and the number of co-operating agencies and supporting organizations involved in it, qualifies MED POL as certainly one of the largest and most complex co-operative scientific programmes with a specific and well-defined aim ever undertaken in the Mediterranean basin.

The selection of national research centres, made by national Government authorities, was in most cases fully justified, although some of the centres were, at the time of their nomination, not able to contribute effectively to the programme. The remarkable progress made by some centres in developing their ability to analyse the state of pollution in the Mediterranean and to embark on independent scientific research was made possible only by "risky" and "unsafe" investments in their instrumentation and in training of their experts.

Contacts between the national research centres and the specialized organizations responsible for the day-to-day organization and supervision of the various projects was, in general, satisfactory, although many of the research centres did not respect the deadlines for reporting of results or the formats in which it was agreed data would be reported. This caused considerable problems in the consolidation of the results obtained through MED POL and in the evaluation of their significance by the secretariat.

The training of 82 national experts and technicians (87 man/months), the deployment of capital equipment (Table II) and the donation of expendable material was of great value to research centres participating in MED POL. Problems encountered in organizing an effective training programme, that used almost exclusively research centres participating in MED POL as training centres, were more than offset by the benefits derived from the strengthened co-operation of Mediterranean scientists through their direct contacts during the training period.

As direct assistance, US $ 1,465,181 was distributed through UNEP and the relevant specialized agencies to the national research centres participating in the various projects (Table III) in the form of equipment, expendable material, training and experts (only on request of the centres).

Indirect assistance to the participants in MED POL was provided through the organization of the data quality control programme (intercalibration of analytical techniques) which ensured the Mediterranean-wide comparability of data; through the common maintenance services which kept the expensive analytical equipment functioning even under most difficult local conditions; through the preparation of numerous guidelines, manuals, surveys, bibliographies and directories; and through the organization of meetings of experts which provided a required forum for free exchange of ideas, comparison of results and harmonization of the approach for further work.

Total expenditures through UNEP and specialized organizations by projects and by year for MED POL - PHASE I are presented in Tables IV and V, respectively.

The reported cost to the national research centres (US $7.2 million) for the participation of their staff and use of their equipment in the work, should be considered as grossly understimated, as it is based on information received only from some of the principal investigators (from MED POL II, III, IV, V, VII and X) and on uneven estimates for the actual cost of the experts/ technicians per month in the view of the secretariat, an estimate of at least US $ 12 million would seem more realistic.

As a result, total contributions to the MED POL - PHASE I were:

-	from the Environment Fund (UNEP)	US $ 4,775,362
-	from the Mediterranean Trust Fund	US $ 619,540
-	from the specialized organizations	US $ 1,425,684
-	from national research centres	US $ 12,000,000 (estimate)
		US $ 18,820,586

The total figure might appear high, but should in fact be considered, when compared with values at stake, a very modest investment in the future of the Mediterranean basin.

A programme as large-scaled and diversified as MED POL is, inevitably requires a complicated co-ordinating mechanism to cope with logistic problems that, from time to time, seemed unsurmountable. Taking into account that there was no model to be followed and that the co-ordinating mechanisms had to be built as the programme was developing, the effectiveness of this mechanism can be assessed as satisfactory.

The experiment of establishing MED POL Regional Activity Centres proved that the creation of functional centres of excellence is not an easy task. Only two, out of seven, justified the expectations and made a real impact on the development of MED POL. Surprisingly enough, one of these was probably the weakest at the moment of its selection (1976) but with great efforts by its staff remarkable progress was made under relatively unfavourable local conditions, thus proving that there were no "objective" reasons for the inactivity of those centres whose performance was assessed as inadequate.

Before the beginning of MED POL, in many Mediterranean States there were no national centres capable of providing the scientific information required for the implementation of the Barcelona Convention and its Protocols. In spite of some initial doubts about its effectiveness, the policy followed by UNEP was to give an equal chance to all participants in MED POL by channeling most of the resources to those who needed them most. Although this approach did not yield the same results in every case, the programme as a whole was more than successful with the general upgrading of the technical/scientific capabilities of the Mediterranean developing countries, the initial collection of reliable data and the creation of a Mediterranean network which allowed the formulation of the Long-term Programme for Pollution Monitoring and Research (MED POL - PHASE II), which has been ongoing since 1981.

Table I - Distribution of research centres participating *in* MED POL - related projects and (*in* brackets) the number of signed research agreements (as at December 1980)

Country	MED I	MED II	MED III	MED IV	MED V	MED VI	MED VII	MED VIII	RAC	Total*
Algeria	-	1 (1)	1	-	1 (1)	-	1 (1)	-	1 (1)	1 (4)
Cyprus	1 (1)	1 (1)	1 (1)	1	1 (1)	1 (1)	-	-	-	1 (5)
EEC	-	-	-	-	-	-	-	-	-	1
Egypt	2 (1)	2 (2)	2 (2)	2 (2)	2 (2)	2 (1)	1 (1)	-	1 (1)	2 (12)
France	5 (2)	3 (3)	2 (2)	1 (1)	1 (2)	3 (1)	2 (2)	1 (1)	1 (1)	12 (15)
Greece	3 (3)	5 (5)	5 (4)	3 (2)	3 (4)	3 (2)	3 (3)	1 (1)	-	13 (24)
Israel	1 (1)	1 (1)	1 (1)	3 (3)	-	1 (1)	4 (4)	1 (1)	-	7 (12)
Italy	3 (1)	5 (5)	2 (2)	3 (2)	-	3 (2)	7 (6)	-	1 (1)	17 (19)
Lebanon	1 (1)	1 (1)	1 (1)	1	1	-	1 (1)	-	-	1 (4)
Malta	1 (1)	1 (1)	1 (1)	1 (1)	-	1 (1)	1 (1)	1 (1)	1 (1)	2 (8)
Monaco	-	-	-	-	-	1	1 (1)	-	-	1 (1)
Morocco	1	3 (1)	3 (1)	3 (1)	2	1	2 (2)	-	-	3 (5)
Spain	4 (2)	3 (3)	3 (2)	2 (2)	2	3 (1)	3 (2)	1 (1)	-	8 (13)
Syria	1	1	1	-	-	-	-	-	-	1
Tunisia	1 (1)	1 (1)	1 (1)	1	1	1 (1)	1 (1)	-	-	3 (5)
Turkey	1 (1)	4 (3)	3 (2)	3 (2)	2 (1)	1 (1)	1 (1)	-	1 (1)	5 (12)
Yugoslavia	3 (2)	4 (4)	4 (4)	3 (3)	4 (4)	2 (2)	3 (3)	-	1 (1)	5 (23)
Total	28 (17)	36 (32)	31 (24)	27 (19)	20 (15)	23 (14)	31 (29)	5 (5)	7 (7)	83*(162)

* Institutions participating *in* more *than* one pilot project are counted only once.

Table II - Major analytical instruments installed in Mediterranean States through MED POL (until December 1980)

Country and city	Atomic Absorption Spectrophotometer (VARIAN 1250 or 175)	Gas Chromatograph (VARIAN 2750 or 3700)
Algeria (Alger)	1	-
Cyprus (Nicosia)	1	1
Egypt (Alexandria)	2	1
Greece (Athens)	1	-
Israel (Haifa)	1	-
Lebanon (Beirut)	-	1
Malta (Msida)	1	1
Morocco (Casablanca)	1	1
Spain (Barcelona)	-	1
Tunisia (Salammbo)	1	-
Turkey, (Erdemli-Içel, Istanbul, Izmir)	2	2
Yugoslavia (Rovinj, Portoroz)	2	2
Total	13	10

Table III - Direct financial assistance (in US dollars) to the participants in MED POL for training, equipment, material and experts (as at December 1980)

Country	MED I	MED II	MED III	MED IV	MED V	MED VI	MED VII	MED VIII	RAC	Other	Total
Algeria	-	28,125	-	-	22,500	-	2,280	-	50,000	-	102,905
Cyprus	10,000	30,225	19,500	-	8,500	9,700	-	-	-	-	77,925
Egypt	11,500	62,825	33,925	12,700	15,700	18,200	5,315	-	40,000	1,401	201,566
France	2,000	-	1,000	-	-	-	4,560	8,000	10,000	-	25,560
Greece	12,000	41,225	4,500	6,500	6,300	11,000	10,760	9,200	-	561	102,046
Israel	30,000	30,525	1,000	24,300	-	7,000	26,450	9,000	-	-	128,275
Italy	2,500	19,800	6,000	3,000	-	14,100	25,300	-	10,000	-	80,700
Lebanon	9,500	8,100	14,500	-	-	-	4,740	-	-	1,370	38,210
Malta	6,000	24,525	21,878	15,000	-	12,500	7,980	10,000	10,000	-	107,883
Monaco	-	-	-	-	-	-	6,635	-	-	-	6,635
Morocco	-	29,525	17,000	-	-	2,500	4,560	-	-	-	53,585
Spain	2,500	4,500	18,053	4,500	-	-	9,560	10,000	-	-	49,113
Tunisia	12,500	30,725	5,500	-	-	3,500	2,280	-	-	-	54,505
Turkey	10,000	75,970	46,350	10,900	11,200	10,500	10,900	-	10,000	837	186,657
Yugoslavia	7,000	67,050	34,156	32,200	41,100	16,000	41,335	-	10,000	775	249,616
Total	115,500	453,120	223,362	109,100	105,300	105,000	162,655	46,200	140,000	4,944	1,465,181

Table IV - Total Expenditures by Project (in US dollars), as at December 1980

Activity	UNEP	ECE	UNIDO	FAO	UNESCO	WHO	WMO	IAEA	IOC	ICSEM	Total
Prep. Activity 1/	25,109	-	-	1,000	-	-	-	-	4,000	6,000	36,109
Prep. Activity 2/	13,175	-	-	-	-	-	-	-	1,500	-	14,675
MED POL I	223,862	-	-	-	-	-	19,600	-	92,000	-	335,462
MED POL II	703,085	-	-	86,345	-	-	-	-	-	-	789,430
MED POL III	421,851	-	-	66,149	-	-	-	-	-	-	488,000
MED POL IV	228,752	-	-	52,237	-	-	-	-	-	-	280,989
MED POL V	230,278	-	-	41,353	-	-	-	-	-	-	271,631
MED POL VI	215,358	-	-	-	-	-	-	-	54,500	-	269,858
MED POL VII	538,710	-	-	-	-	213,000	-	-	-	-	751,710
MED POL VIII	220,536	-	-	-	-	-	-	342,000	20,000	-	582,536
MED POL IX	50,636	-	-	-	17,000	-	-	-	-	-	67,636
MED POL X	347,592	16,000	16,000	16,000	16,000	80,000	-	1,000	-	-	492,592
MED POL XI	510,958	-	-	-	-	-	-	252,000	12,000	-	774,958
General Assistance	1,665,000	-	-	-	-	-	-	-	-	-	1,665,000
Total	5,394,902	16,000	16,000	263,084	33,000	293,000	19,600	595,000	184,000	6,000	6,820,586

1/ International workshop on marine pollution in the Mediterranean (Monaco, 9-14 September 1974).
2/ Evaluation of institutional programmes (1974-1976).

Table V - Financial contributions to the MED POL - PHASE I from its beginning to the end of 1980 (expressed in US dollars)

Year	UNEP		ECE	UNIDO	FAO	UNESCO	WHO	WMO	IAEA	IOC	ICSEM	TOTAL
	EF	MTF										
1974	11,284	-	-	-	1,000	-	5,000	-	-	5,500	6,000	28,784
1975	293,719	-	-	-	24,000	6,000	18,000	4,000	20,000	11,900	-	377,619
1976	643,098	-	-	-	46,110	800	35,500	3,500	52,200	34,900	-	816,108
1977	1,485,427	-	12,000	14,000	57,084	17,500	142,500	3,600	200,800	36,750	-	1,969,661
1978	959,077	-	4,000	2,000	54,390	4,500	59,000	2,800	145,000	49,350	-	1,280,117
1979	1,008,297	178,000	-	-	45,400	4,200	21,000	4,200	145,000	34,500	-	1,440,597
1980	374,460	441,540	-	-	35,100	-	12,000	1,500	32,000	11,100	-	907,700
TOTAL	4,775,362	619,540	16,000	16,000	263,084	33,000	293,000	19,600	595,000	184,000	6,000	6,820,586

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No. 1 UNEP/IOC/WMO: Baseline studies and monitoring of oil and petroleum hydrocarbons in marine waters (MED POL I). MAP Technical Reports Series No. 1. UNEP, Athens 1986.

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