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TRAINING PROGRAMME IN THE MANAGEMENT OF THE MEDITERRANEAN

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REPORT

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TRAINING PROGRAMME

Annex 4

Weekly reports

WEEK 1 (2-6 October)
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The Mediterranean as a region

The first activity of the training programme was a public forum in the morning of the 3rd October 1989. The main subject of the Forum was "The Mediterranean Region, Myth or Reality?"

According to the results of this forum, it can be said that the recorded history of the Mediterranean Region shows a delicate balance between man and nature. Mediterranean societies developed a well defined ecological framework and made careful use of limited natural resources. When the Mediterranean was suddenly introduced to the technological age, the impact was tremendous.

The Mediterranean Sea is relatively small compared with other oceans of the world. Some scientists say that the Mediterranean Sea appears as an oceanic basin or in fact a miniature ocean. This miniature ocean is contained by miniature sub-continents, each of which constitutes a discrete physical world. These subcontinents in turn contain small worlds separated by coastal ranges. During 4000 years of recorded history, these separated worlds have been cris-crossed by waves of migration, trade and war. The result is a human landscape full of variety, colour and cultural diversity.

Today, the Mediterranean Sea is bordered by developed as well as developing countries, of all shades of social and economic organisation. The Mediterranean exhibits the most advanced marine uses: transportation, fishing, oil and gas, mineral mining, fresh water extraction, marine archaeology and tourism, these being among the most important.

The Mediterranean coastal states have extensive marine skills and the most advanced marine environmental programmes have been developed in the Mediterranean, in part thanks to their historic links to the sea.

It can finally be said that most marine resource management problems in the Mediterranean can only be solved on a regional basis.

Geography, physiography, geology and geophysics of the Mediterranean

From the general geographic point of view, the Mediterranean

Sea extends about 3800 km from east to west and about 800 km from north to south excluding the Sea of Marmara and the Black Sea, and covers an area of about 2.5 million km2. It has a volume of about 3.7 million km3 with an average depth of 1.500m.

Physiographically, the Mediterranean as a whole is separated from the Atlantic Ocean by the sill of Gibraltar and communicates with the Black Sea via two sills (Dardanelles - Canakkale Bogazi, and Bosphorus - Istanbul Bogazi) between which extends the Sea of Marmara. The Suez Canal has little significance for the Mediterranean. On the other hand the Siculo-Tunisian sills and sill of Messina divide the Mediterranean Sea into eastern and western basins which, in many respects, show distinct hydrographical conditions. The western basin has poorly defined compartments comprising the Tyrrhenian Sea, charecterized by volcanic activities, and the Balearic Sea charecterized by very smooth coastal areas. The eastern basin has clearly defined compartments. The Adriatic Sea is bounded by the Strait and Sill of Otranto, and the Aegean Sea opens to the eastern basin by the arched sills that support the series of islands from the Pellapones to the Anatolia. The Aegean Sea contains several sills and depressions in a region of complicated topography among the large number of islands.

From the geological and geophysical points of view, most of the deep sea Mediterranean areas were practically unknown until the sixties, mainly because of incorrect positioning in the soundings and the other measurings, except insofar as internal seas and some continental shelf areas were concerned.

Few discoveries in geophysics have contributed more to our understanding of the evolution of the earth's large-scale features (mountain belts, ocean ridges, island arcs, etc.) than the recent cumulative evidence for the fact that the Earth's crust and upper mantle are divided into a finite number of mobile, rigid plates, interacting with each other at their boundaries to produce large belts of compression and tension. "Plate tectonics" was born out of the original sea-floor spreading theory (proposed by HESS, DIETZ and others); subsequently, the symmetry of magnetic lineations over mid-ocean ridges first noted by VINE and MATTHEWS, (the theory of transformation faults as proposed by WILSON), and the improved ability to locate earthquake epicentres and determine their directions of first motion through a close network of recording seismometers, all produced a convincing amount of independent data from all parts of the world which, initially, led to the acceptance of continental drift and, eventually to the more general concepts of plate tectonics. Paleomagnetic data allowed time scales to be applied to the magnetic patterns found over most of the world's oceans and it is now known that most oceanic crust is comparatively young (less than 200 million years). On the other hand, by remote sensing techniques the evolution of existing ocean (besides their application as the images which show many significant features of the sea surface areas) is better understood now than 15 - 20 years ago. However, it is not so obvious in what manner previous oceans might have been destroyed. In this respect the Mediterranean Sea offers an attractive area of study and offers the advantages of a well-known surrounding land geology and working conditions at sea which are usually easier than the open oceans.

Very little was known on the geology of the Mediterranean Sea until very recent years, when proper marine geological and especialy marine geophysical works were undertaken. The geological knowledge was mainly extrapolated from the surrounding land areas, most of which were and are intensively studied but not always with results accepted by the totality of the geological community.

The area around the Mediterranean Sea has been the birth place for geology, but the Sea itself is yet an open area for discussions and interpretations. Geophysics is beginning to bring data, but they are not yet sufficient for answering all the geological problems.

Since 1969 when the Cooperative Investigations of the Mediterranean (CIM) was initiated by the IOC, the ICSEM and the GFCM, six major events improved drastically the geological and geophysical knowledge of the Mediterranean Sea. These are as follows:

1. The completion of the gravity and magnetic surveys;
2. The deep continuous seismic profiling;
3. The wide angle reflections;
4. The deep seismic reflections profiling, both on deep sea and in the marginal areas;
5. The deep sea drilling project;
6. The marine geological surveys.

Having the results of all these six events, the following physiogrophic, geographic and geophysical knowledge are generally accepted.

The Mediterranean Sea is divided in two parts by the Sardinia and Sicily Channels, not only from the morphological and oceanographical point of view, but also from the structural one. Basins with a very thin crust prevail in the western Mediterranean and these are almost completely continental in the eastern Mediterranean.

Seismic deep reflection and refraction, gravity and magnetic studies and measurements suggest that the bathyal part of the western Mediterranean basin is occupied by a thick sedimentary sequence overlying an ocean crust in the northern part of the bathyal plane, lying directly on a soft mantle in the southern part of that basin and in the Tyrrhenian Sea. The north Balearic and Ligurian basins and the bathyal part of the Tyrrenhian have a continental crust.

There are many indications that before the formation of the present western Mediterranean basin at least an important part of it was occupied by land. A first supposition (a) could be that this land was of continental type, with a sialic crust; a second (b) that an essential part of it was formed by upheaval of a part of the ocean floor above sea-level.

In the case of (a), a very large part of the sialic material at the site of the present western Mediterranean Sea, would have disappeared in some way or other. The conclusion for the disappearance of this sialic material is that the disruption of the sialic crust and drifting apart of its separate parts resulted in the exposure of the mantle. For instance, the Alboran and North African basins could have been formed by the southeastward drifting of the external north African domain, the Provencal basin by the southeastward drifting of Corsica and Sardinia, and the Tyrrhenian Sea by an anti-clockwise rotation of Italy.

In the case of (b), the upheaval would have affected not only oceanic upper mantle and crust material, including the overlaying sediments, but also the adjoining shelf zones of surrounding continental regions.

Seismic and gravity point to indications that the big ocean (named Tethys) liatus is not only a crustal accident but probably also implies a marked heterogenity of the mantle.

The Strait of Sicily itself is an epicontinental bridge where a thick miocenic platform has been recognised by the seismic reflection records. The central part of the Strait of Sicily is a foundered area, where narrow graben exist, delimited by steep NW-SE faults. The distension phase has been acompanied by extensive volcanism, mostly submarine and basic. The area of the Strait of Sicily is the extension of the stable Pelagian platform from the emerged African continent up to the Ragusan massif. Morover it is evident that on the central part of the Pelagian Sea there exists a rifting process, probably still at an early stage and active.

The eastern Mediterranean can be divided in a western part (Ionian Sea) and eastern part (Levantine Sea), separated by a higher zone between Crete and Cyrenaica. Connected with the Ionian Sea is the Adriatic Sea, whereas the Levantine Sea is connected to the Aegean.

Tectonically, it was thought that the eastern Mediterranean is dominated by the relative northward motions of the African plate, with subsequent sinking below the European plate, and by the motions of two microplates (the Aegean and the Anotolian, both moving southeastward). The first motion should be connected with the Calabrian and Hellenic arcs subduction (Benioff) zones and have originated the so-called Mediterranean Ridge (embryonal phase of mountain chain) and the Hellenic Trench, the latter through the very strong seismic and volcanic activity of Greece, of the Aegean Sea and Anatolia (Turkey). Both from the geological and geophysical point of view the eastern Mediterranean is not well-studied and well-known as the western Mediterranean.

<u>Climate and hydrology of the Mediterranean Region</u>

The climate of the Mediterranean region is highly diverse with desert occupying a large part of the eastern and western shores, and having well-irrigated basins in the north-western shores where the main rivers maintain a regular flow of water throughout the year. Summers are dry and winters are humid. The average precipitation on the northern shores and on the islands is 400-1000 mm/per annum, while on the southern and eastern shores it is less than 100 mm/per annum. There is much evaporation of Mediterranean Sea water.

As far as water circulation is concerned, it can be said that the Mediterranean Sea is a concentration basin. Its waters always have a higher salt concentration than those of the adjacent regions in the Atlantic Ocean and the Black Sea. Therefore, the Mediterranean Sea must have a negative water balance. That is to say that the water losses through evaporation exceed, by and large, the gains due both to precipitation and to river inflow.

Since the content of the Mediterranean Sea is constant and the incoming water is not pure water, a two-directional flow has to be established both at the Straits of Gibraltar and Bosphorus (Istanbul Bogazi), with an incoming flow of less saline water larger than the outgoing flow of more saline water. The estimated flow of water entering and leaving the Mediterranean to and from the adjacent seas is about 1.2 million m3/sec.

The mechanism by which the incoming surface Atlantic water with salinity about 36 ppt. is transformed into the outgoing deep Mediterranean water with salinity 38 ppt. is perhaps the most important oceanographical problem encountered in the Mediterranean Sea. It implies not only large horizontal displacements covering the whole basin but also a general downwards vertical movement of the water with a net increase in density. During the passage through the different basins the water is submitted to varying climatic circumstances which altogether establish, in a fairly steady state condition, the identity of several charesteristic water masses (Atlantic surface water, the intermediate Levantine water and the deep waters in each of the eastern and western basins).

The main components of the velocity field of ciruclation are due both to the wind stress and atmospheric pressure distribution and to the thermohaline forces created by the hydrographic structure.

The spatial distribution of the density suggests a general circulation of the surface Atlantic water entering the Mediterranean Sea towards the east and of the Levantine intermediate water and western deep water towards the west. Due to the rotation of the earth (coriolic effect) this general flow pattern should be deflected to give a cyclonic (anti-clockwise) general circulation in each of the basins, complicating the actual circulation pattern not only of the surface layer but also of the intermediate and deep water layers.

The main features are a number of counter-clockwise gyres (found all over the basin) especially active along the northern shores from the Alboran to the Tyrrhenian Sea. These gyres seem to carry the largest volume of the Atlantic water all the way through the Balearic Islands and into the Gulf of Lyon area. The remaining Atlantic water moves in the north African flow, generating several weak clockwise gyres, eventually crossing the Strait of Sicily, and flows towards the eastern basin with part of it entering the Tyrrhenian Sea and circling it also in a counter-clockwise direction.

Because of the strong homogeneity of the density of the deep waters of the Mediterranean, weak velocities are suspected and perhaps the vertical component is not less important. In these layers, as in the case of the intermediate water, a general east to west displacement occurs, although it is much weaker in the eastern basin than in the western one, since the deep water does not flow across the sill of the Strait of Sicily.

Basic knowledge of the circulation in most coastal regions of the Mediterranean is severely limited and fragmentary. The velocities in the coastal zones are mostly due to the transient disturbances caused by succesive gusts of wind and the corresponding waves and eddies are the dominant processes. Yet these processes are likely to vary on different shelves and with seasons.

Biological and chemical aspects of the oceanography of the Mediterranean Sea

Biological aspects of the Mediterranean

From the biological point of view, an **ecosystem** is defined as a functional unit of physical and biological organization with characteristic trophic structures and material cycles, some degree of international homogenity and recognizable boundaries.

The levels of the functional units are:

1) The organism;
2) The population (one species);
3) The community (several species);
4) The ecosystem (biotic and abiotic).

In any environment, an ecosystem has three main parts:

1) **Physical Part:**
   as energy sources including the sun, wind tides, pressure and temperature;
2) **Chemical Part:**
   including salinity, nutrients and dissolved gases;
3) **Biotic Part:**
   including producers, consumers and decomposers (as bacteria, converting organic matter into inorganic).

In order to draw a general nutrients cycle in the Mediterranean waters, it is necessary to consider the external forces (sun, tides, winds) as forcing functions to producers during photosynthesis processes, using nutrient salts as limiting factors. Then, these producers will be taken up by consumers which will also be consumed by carnivors. On death, those producers, consumers and carnivors are converted directly into organic matter, which are rapidly decomposed by bacteria into organic ones, and the cycle starts again.

Briefly, the nitrogen and phosphorous cycles in the Mediterranean Sea should be mentioned.

a) <u>Nitrogen cycle</u>

Nitrogen is one of the biologically important elements in the aquatic habitats. In addition to dissolved molecular nitrogen, the Mediterranean water contains low, but extremely important, concentrations of inorganic and organic nitrogen, the total weight of which is about a tenth of that of the dissolved gas (Martin, 1970). The most important forms of inorganic nitrogen in water, are nitrate, nitrite and ammonia. The concentrations of these forms usually lie in the range of <0.1-35ug at NO3 - N/L, < 0.01 - 3 ug at NO2 - N/L, and <0.15 - 3 ug at NH3 - N/L in oxygenated waters. Very small concentrations of inorganic nitrogen compounds, as nitrous oxide and hyponitrite ion, may also be present. The Mediterranean water also contains a wide range of organic nitrogen compounds both dissolved and particulate.

Nitrate is the final oxidation product of nitrogen compounds in sea water. It is generally considered as the only thermodynamically stable oxidation species of nitrogen in the presence of oxygen in water. Riely and Chester (1971) have pointed out that the nitrate content in the water is primarily of importance in studying the nitrogen cycle, because of its intermediate position in oxidation-reduction processes between ammonia and nitrate. The occurrence of ammonia in seawater depends mainly on the different biological and chemical processes operating in the regeneration of organic nitrogenous materials and is also a chief nitrogenous excretory product of many aquatic organisms, especially zooplankton. According to Wafer et al (1986), ammonia has been recognised as an important alternative nitrogen source for various aquatic plants and in most environments may even be assimilated in preference to nitrate.

On the other hand, dissolved organic nitrogen (DON) in the Mediterranean water is comparatively high. This is probably being assimilated by aquatic organisms at a much lower rate than inorganic forms. Of the few characterised DON compounds, amino acids are certainly used as nitrogen source by several marine phytoplankton species.

The concentrations of the various organic and inorganic nitrogen species in the Mediterranean Sea are mainly controlled by biological factors. Bacteria, plants and animals play important parts in the various inter-transformations in this cycle. Bacteria probably dominates the regenerative processes in which the organic nitrogen species eventually change to nitrate. The major biological transformations of nitrogen are nitrification, nitrogen fixation, amoniafication and uptake by living organisms. In addition, the main sink leading to disappearance of nitrogen compounds from natural waters, is the process of bacterial reduction of nitrate to nitrite to free molecular nitrogen.

b) Phosphorus cycle

Phosphorus is one of the most important nutrient elements in the Mediterranean waters. According to Liebig's law of minimum, both phosphorus and nitrogen are important factors controlling the growth and reproduction of phytoplankton.

Phosphorus is necessary to all life, where it functions in the storage and transfer of cell energy and in genetic systems. The universality of adenosine tri-phosphate (ATP) as an energy carrier and the presence of phosphate groups in nucleotides and hence nucleic acid underscore the need of living organisms for phosphorus.

Phosphorus exists in a variety of forms, as dissolved orthophosphate, dissolved organic phosphorus compounds, insoluble and absorbed phosphate in suspension.

The relation between the phosphorus and iron cycle may be of great interest especially in the ecosystem of the Black Sea. Under oxic conditions, insoluble ferric phosphate is precipitated from the medium removing phosphorus from solution. On the other hand, under anaerobic concentration most of the phosphorus is released from the sediments and the condition of dissolved inorganic phosphorus is elevated.

The phosphorus cycle in the Mediterranean waters is more simple than that of the nitrogen because the inorganic phosphorus form contains only one form.

<u>Chemical aspects and marine pollution of the Mediterranean Sea</u>

In recent years the problems of pollution of the Mediterranean Sea have become a point of national concern. Signs of pollution have already been observed in the last few years along the Mediterranean shores (Aboul-Kassim, 1987). Admittedly, the disposal of the untreated sewage, industrial and agricultural wastes in the open sea, may be harmful from a health perspective and for the fauna and flora of the Mediterranean environment. The effect is directly proportional to the quantity and quality of the pollutants discharged, as well as the capacity of the Mediterranean environment to assimilate, degrade and disperse these pollutants.

The main sources of pollution in the Mediterranean Sea include the following broad categories:

1) <u>Domestic waste sources</u>

These include many cities of a total resident population in the coastal areas of about 44 million inhabitants.

2) <u>Industrial waste sources</u>

These include four major sources along the Mediterranean coast:

a) Leather tanning and finishing;
b) Iron and steel basic industries;
c) Petroleum refineries and oil terminals; and
d) Chemical production (organic and inorganic).

Other industries of significance include:
a) textile manufacturing;
b) food processing and canning;
c) pulp and paper factories.

3) Agricultural runoff

This was considered with regard to surface runoff and the transport of sediments originating from land erosion. The role of sediment as the main carrier of nutrients from land runoff was utilized to quantify discharges from non point sources. Agricultural regions appear to produce relatively high discharges of nutrient and pesticide (insecticide, fungicide and herbicide).

4) River discharges

Rivers are located around the Mediterranean, with large differences in water quantity, ranging from very clean to heavily polluted; some areas may even be considered to be open sewers. Due to their large water discharges and the industrial and agricultural character of their drainage basins, the rivers Rhone and Po are major point sources of pollutants in the Mediterranean. In summary, the major portion of total discharge and river pollution input originates from the Northern part of the Mediterranean watershed, with only about 20% of the total flow being discharged along the Southern and Eastern shorelines.

5) Radioactive discharges

These include discharges from nuclear installations.

Generally, in the Mediterranean waters, the total amounts of biochemical and chemical oxygen demand (BOD & COD) both indicate that coastal sources and rivers contribute about equal portions of organic matter. The nitrogen and phosphorus loads are largely due to river inputs with municipalities and agricultural runoff.

The detergent discharges in the Mediterranean waters are largely due to household uses. One-third of the total load stems from coastal municipalities. Phenols and mineral oil discharges are entirely due to industrial activities.

The discharge of metals are largely due to river inputs, with considerable amounts carried naturally and from industrial sources upstream.

Estimates of radioactive discharges of the current load in the Mediterranean water, include tritium and other radionucleides from nuclear power plants in three countries around the Mediterranean (France, Italy, Spain).

Another important pollutant in the Mediterranean environment is oil, the main sources of which are the following:

a) ballasting and deballasting operations of tankers;

b) tank washing;
c) refinery effluents;
d) accidents to tankers and many vessels;
e) natural seepage;
f) accidents to pipelines and terminals;
g) offshore explorations and exploitations; and
h) discharged lubricants.

The particular topography and hydro-meteorological conditions of the Mediterranean Sea are such that, oil entering or discharged there, has little chance of leaving. It will stay and accumulate until it is degraded.

The impact of oil on the Mediterranean environment is as follows:

a) The cyclonic circulations tend to deposit the oil on the shores, or to accumulate it at certain exposed points, irrespective of whether the oil comes from offshore or from land;

b) damage to beaches;

c) fishing gear become coated with tars;

d) negative effects on some fish species and commerical fisheries;

e) death of certain organisms;

f) effects on spawning grounds and reproduction of some species;

g) negative effect of food chain; and,

h) presence of carcinogenic compounds (e.g., benzopyrene) which have been found in some fish.

What is required to control and manage oil pollution in the Mediterranean Sea? This can include the following:

a) gathering information from different areas;

b) comprehensive studies on the impact of oil on the Mediterranean environment;

c) co-operation among countries in case of emergency (accidents);

d) employment of new techniques to recover the spilled oil on water surface;

e) forecasting of water movement and currents, etc., to decrease the risk;

f) international and regional co-operation.

The heterogenity which characterizes the Mediterranean countries, cultural, historical and political factors as well as the dichotomies between north and south, developed and developing might seem to present insoluble problems and difficulties in coming to terms with the environmental degradation of the region. However, initiatives have been taken to unite the disparate nations surrounding the Mediterranean in common efforts to save their sea and to plan for a socio-ecologically correct development of the land areas around it.

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