

Sea Management as the Management of Complexity: The Mediterranean Case

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1. Introduction

This paper is based on the following statements: (i) the conservation and protection of the marine environment is to be regarded as a module of the sea management as a whole; (ii) sea management implies the management of webs of uses and webs of relationships between uses also on a regional scale; (iii) that it involves three levels of analysis, i.e. cognitive, prospective and propositive; (iv) as a consequence, a specific problem of complexity comes into evidence; (v) a subset of the world's seas, above all semi-enclosed seas, should be regarded as case studies, because their webs of uses and related environmental impacts grow rapidly; (vi) the Mediterranean Sea could be included in this subset.

Starting from these basic statements, the recent phases of the involvement of the Mediterranean Sea in uses and environmental impact will be recalled. This will lead us to take into account, on the one hand, a first approach-based matrix of uses and environmental impact and related methodological implications and, on the other hand, the prospects of promoting regional management in this semi-enclosed sea.

2. The Management Phases: Continuous Change (1950-1975)

On the basis of an historical phase-based reference framework one may gather that: (i) the expansive wave of neoindustrial economy has involved the Mediterranean area from the beginning of the Fifties and had its most incisive effects in the late Sixties; (ii) consequently the Mediterranean Sea has gone through a phase of continuous change for about a quarter of a century. The factors that have put an end to it arose in the second half of the Sixties and showed themselves in the early Seventies. One can place—at least as a simple reference point—the onset of a profound change in the reference framework as between the Arab-Jewish war (1973) and the reopening of the Suez Canal (1975).

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In the previous phase - especially in the Sixties - a web of parallel relations has influenced the choice of uses of the Mediterranean Sea. The economic growth of the Western World and the expansion of maritime trade have, in the context of this web, caused three related sequences of inputs, involving port and coastal industrialization, urbanization and recreational activities.

1. *Littoral industrialization.* The paleoindustrial economy had already--during the second half of the last century--brought about the installation of industries on a number of European littoral areas. In the first half of this century the neoindustrial economy reinforced the tendency to install industries in seaports: these functions were concentrated along the North Italian coasts and in the Marseilles-Fos area but other European coasts were also involved.

In the Fifties, when the first generation of Maritime Industrial Development Areas (MIDAs) invaded Western Europe, the Mediterranean Sea had two elements of differentiation with respect to the Atlantic and North Sea coasts.

- (i) A large number of cityports (Barcelona, Marseilles, Savona, Genoa, La Spezia, Naples, Marghera, Trieste) already had industrial areas mainly devoted to the first transformation of raw materials and therefore based on import oriented functions. The new industrial zones--iron and steel plants and oil refineries--were largely located more to the south, e.g. in Southern Italy, in the Tarragona area, in the larger islands such as Sicily and Sardinia. Altogether the Mediterranean has a complex typology, as shown by Verlaque's research.
- (ii) There are no wide flat areas on the Mediterranean littoral belts, so here the MIDAs are smaller than the MIDAs of the European Northern Range. In the OPEC I phase (1973-1974) the Fos MIDA extended for about 7,000 hectares, smaller therefore than Hamburg, Rotterdam and Antwerp but much bigger than any other Mediterranean MIDA.

The first, short, closing of the Suez Canal (1956) gave the idea that the Mediterranean Sea could have been deprived of its eastward access route. The second closure (1967) generated the conviction that this closure could be permanent. The consequences were noteworthy: (i) the Mediterranean situation rather increased the tendency to build bulk carriers with growing deadweight tonnage; (ii) the first container only arrived in 1969 (Genoa); (iii) the South European ports lost their, already modest, market share of transport to inland Europe through the Alps.

2. *Urbanization.* The concentration of population and conurbations along the Mediterranean littoral belts is a phenomenon too well known to be dealt with here. As for the uses of the sea it is appropriate to take a limited set

of elements into account.

- (i) In practice, all the cities with at least 100,000 inhabitants have a seaport. Other ports, above all with industrial functions, exist in smaller towns. In the first half of the Seventies 19 million people lived in the cities with more than 100,000 inhabitants with 430 Mt of port traffic. In the EEC countries (Italy and France) there was little more than 1/3 of the inhabitants with 2/3 of the port traffic. In particular, polarization processes involved littoral areas from Gibraltar to Leshorn, almost suggesting a European Southern Range.
- (ii) According to research by the Athens Centre of Ekistics, small megalopolises are forming themselves around the Mediterranean. In the late Sixties the Milan-Turin megalopolis came to light. By the mid-Nineties two other megalopolises will be formed, this time along the littoral, one between the Gulf of Genoa and the Gulf of Lyons and the other between Rome and Naples. By the end to the century others should arise along the Rhone and Garonne valleys, between Catalonia and the Gulf of Valencia, in Morocco and Algeria, Tunisia and Libya and also in Israel. It is obvious that the concentration involves the Western Mediterranean where a sort of gigantic urban circle is taking shape.

3. *Recreational uses.* Littoral belts and islands have been invaded by the expansion of international tourism. Apart from the Mashreq area, which is involved in war, the wave of expansion has never lessened, not even when the economic conditions were against it.

The expansion phase of neoindustrial economy has brought about disturbing conditions of degradation both in the coastal zone and in deep-sea and has caused, for the first time in the history of the Mediterranean, conflicts between uses of the sea. Obviously the Mediterranean communities only gave notice of the first degree of effects--that is the ecological problem--and negotiated the Barcelona Convention (1976). The agreement concerns the consequences of activities carried on in the sea and, as for sources of waste disposal, limits itself to industrial waste. Later, in 1980, waste disposal was to be entirely taken into consideration by the Athens Convention.

3. Management's Phases: Take-off of Discontinuous Change

In the early Seventies a number of historical functions weakened and the littoral industrialization, focused on raw material transformation, was halted; the importation of minerals and energy sources lost impetus in the seaport areas, littoral urbanization in the most developed areas went ahead with more moderation so much so as to make one think that the Ekistic model ought to be revised. Only recreational uses declared no truce; the whole Mediterranean continues to attract tourists. In fact, in some areas like the islands, Maghreb and Greece, it was positively reinforced.

In the mid-Seventies the Suez canal was reopened and the Mediterranean Sea returned to being as accessible as it had been in the past. Containerized traffic profited mostly from this and, especially in the Southern Range, spread very rapidly. A set of strategies, pivoted upon transshipment functions of seaports, has been applied to link deep-sea routes with feeder routes. Ports ranged between Algeciras-La Linea and Leghorn, on the west, and Trieste, on the East, have been the most involved areas.

The traditional uses change and new kinds of use spring up. Also the reference framework changes rapidly because of technological pressures, EEC policy, the strategies of developing countries and implications arising from the international law of the sea. The Mediterranean Sea enters into a discontinuous change phase whose characteristics are to appear faintly in the late Seventies and more clearly after the OPEC II (1979-1980).

It is at this point that the uses of the sea come out in more complex terms than before. Here follows a synthesis of the most significant elements of this involvement from which the present situation in the management of the sea derive, and some prospects will be evaluated.

1. *Delimitation of marine jurisdictional zones.* In the Seventies the coastal states redefined their baselines. When Suez reopened Italy agreed on the median line of a large part of the Adriatic continental shelf with Yugoslavia. This treaty (1968) was the first of a sequence of agreements by which by the mid-Eighties a large part of the Mediterranean Sea was practically shared out. All the states claimed their exclusive fishery zone; some of them even delineated the contiguous zone.

Obviously the territorial sea is redefined almost everywhere. The limited distance between coastline, opposite or contiguous, discourages states from claiming their economic exclusive zones. However the risk of some non-European Mediterranean countries doing so is latent and serious. On the other hand, this baseline definition is in itself a cause of international tensions which are acute in the Gulf of Sirte and dampened down for the Gulf of Taranto.

2. *Maritime transportation.* In relation to the uses of the sea it is useful to bear in mind, above all, the transport of hydrocarbons and coal. In the present phase the growth rates of crude oil imports into the European Mediterranean have rapidly contracted. Moreover transportation is increasingly made by MCCs (Medium-Size Crude Carriers), so there has been an inversion of the previous tendency. On the other hand, steam coal has become so important as to make one believe that the Mediterranean Sea is, together with Japan, one of the most important coal-importing areas in the last part of this century. Sea transport also has competition from pipeline transport, namely the Algerian gas pipeline from Cape Bon to

South Western Sicily.

3. *Oil and gas fields.* Up to 1975 offshore natural gas production was limited to the Ravenna area (Northern Adriatic). Drilling was taking place in various parts of the basin but large fields were only found in the Gulf of Gabes (Tunisia). Ten years later, the Central and Northern Adriatic Sea seems to be fully exploited both on the Italian side and on the Yugoslavian side; off the south eastern coast of Sicily they are preparing over 200m deep wells on the seabed for oil production; the exploitation of the Gulf of Gabes fields is in progress; off Castellon (Spain) preparations are being made to exploit a vast oil-field; in several other areas, exploration and drilling permits have been given. It is a dynamic picture, much different from that of the North Sea both for physical reasons--the configuration of the continental shelf--and for economic reasons, since the Mediterranean resources seem more modest and largely composed of natural gas.

4. *Biological resources.* The action of physical factors between the alternate glacial and interglacial phases in the Quaternary period has peopled the Mediterranean Sea, as we have said, with a great variety of fish species but without great quantities of any species. The essential features, which were brought out by FAO analysis, can be synthesized as follows.

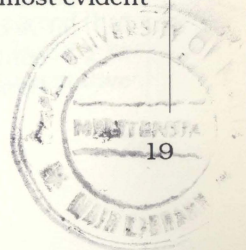
- (i) *Demersal living resources.* The central-southern section of the Balearic Basin and the Aegean Sea have high productivity - measured in t/km² - for gadoids, hake, seabream. The Aegean Sea is also noted for grey mullet, goatfish and flat fish.
- (ii) *Pelagic resources.* The Iberian side and Maghreb (Balearic Basin), plus the Central and Southern Adriatic Sea have high pilchard production, the Aegean and Black Seas have anchovies and jack mackerel. Tuna and swordfish fishing is adequate in the Balearic Basin and the Black Sea.
- (iii) *Crustacean and mollusc resources.* The central-southern section of the Balearic Basin and the Southern Adriatic have large resources of cephalopods, gastropod molluscs and lobsters as have the Central and Southern Adriatic Sea of cephalopods, the Ionian Sea of shrimps and the Aegean Sea of gastropod molluscs.

5. *Aquaculture.* The breeding of oysters and other molluscs has been carried out for a long time in the Mediterranean Sea. Some French centres, above all Sète, are well-known. The "vallicoltura" (the breeding of eels and mullets) in the Po delta has existed for a long time. On the basis of these activities, a widespread tendency to extend breeding was initiated in the late seventies with total or partial fish-breeding and experimental centres. The present situation is not very clear because initiatives and projects multiply and spread. In particular, Italy is preparing plans for breeding with the use of the cooling water discharged from littoral thermoelectric power plants.

6. *Waste disposal.* The main European rivers--Ebro, Rhone, Po--pass through urban and industrial areas and for this reason they make a considerable contribution to marine pollution both near to the coast and in deep-sea areas. On the other side, because of the Aswan Dam, the Nile has reduced its fount of nutritive substances thus reducing the phyto-plankton resources of the Central and Eastern Mediterranean Sea. Two areas are more subject to waste and sewage, namely the band between the Gulf of Valencia and Leghorn--which involves the southern part of the Balearic Basin, the Tyrrhenian Basin and the Ligurian Sea--and all the Northern and Central Adriatic Sea. UNEP has brought to light the following processes.

- (i) *Mercury and arsenic.* Mercury is the metal found in high concentrations in the most important fish species including tuna (up to 4ppm) and goatfish (up to 6ppm). High levels of mercury have been also recorded in groups of fishermen and fishmongers. Arsenic, too, has been found in quite high quantities. Both these elements come, above all, from riverine discharges.
- (ii) *Eutrophication.* This phenomenon is quite widespread in the areas of littoral industrial plants discharging cooling water into the sea. However only a few micro-areas are involved in these cases. But eutrophication has taken on vast proportions in the Adriatic Sea, above all along the Emilia-Romagna coast where there are many factors involved: the less deep-sea bottom, Po discharges, waste disposal, both urban sewage and industrial outfalls, anti-clockwise sea surface circulation.
- (iii) *Organic substances.* On the one hand, the urbanization of long stretches of the European littoral countries and, on the other hand, the temperate climate of the Mediterranean favour the diffusion of the whole spectrum of organisms expelled by the population into the sea thus producing high frequency of illnesses, caused by bacterial, viral and enteric parasites.

6. *Naval uses.* During the expansion phase of neoindustrial economy the naval uses of the Mediterranean Sea were largely confined to the confrontation between the Warsaw Pact and NATO countries. It was a manifestation of relationships along the east-west co-ordinate. At present other factors have been added: (i) military tensions, in part at least tied to the strategies of terrorism, which are shown by bilateral conflicts (e.g. USA-Libya), (ii) conflicts over territorial sea limits (e.g., Greece-Turkey) and exclusive fishery zones, (iii) tensions within the Arab area, (iv) the risks run by air transport over the sea. This situation creates a rather delicate balance between the naval and the other uses of the Mediterranean Sea. Wars, naval exercises and pollution by naval vessels are the most evident consequences.



4. Jurisdictional Framework: a Remark

As far as jurisdictional zones are concerned, it is well known that the Mediterranean Sea is affected by two original features. Firstly, it was one of the first seas in the world to be affected by agreements concerning the delimitation of continental seas between countries with opposite or contiguous coasts. Secondly, no EEZ are claimed and diplomatic efforts are being made to avoid them.

Let me pass over the present framework and to only stress some implications that the Mediterranean assessment as a whole can produce.

As far as the continental shelf is concerned complexity is produced by the gap existing between the continental margin concept and the continental shelf juridical definition. This gap reflects on the range of criteria offered by the 1982 Convention for tracing the seaward limit of the continental shelf. In this context, besides the optimum--occurring when the continental shelf overlaps the continental margin--two hypotheses occur.

Firstly, the coastal state which possesses *margins narrower than 200 nautical miles* may claim 200 nautical miles, effectively duplicating the claim to the EEZ.

Secondly, the coastal state which possesses *margins wider than 200 nautical miles* "may define the outer edge of the margin in one or two ways, both of which are subject to absolute restriction" (Prescott, 1985, 76).

These remarks are worth relating to management patterns.

- i. If the *outer edge of the continental margin extends beyond the 200 nm line* the continental shelf is prolonged to this limit. Sea planning and management, although they are limited to the seabed and subsoil, involve a quite large set of sea uses, because the resources--at least the exploitable resources--of the continental margin are more numerous than those pertaining to the abyssal area. If it is agreed that coastal planning and management concern the continental margin as a whole it must be admitted that, when the continental margin is wider than 200 nm from the baseline, a special case occurs: planning and management developed in a large coastal area.
- ii. If the *outer edge of the continental margin does not extend up to 200 nm from the baseline* the continental shelf extends up to this limit. In terms of planning and management this jurisdictional belt is to be divided into two sections.
 - (a) A *coastal section*, which extends up to the outer edge of the continental margin. In this space coastal management, (as mentioned in the item i), can be developed.

- (b) A *deep-sea section*, ranging from the outer edge of the continental margin to the 200 nm limit. In this space the framework of uses is quite different from the framework offered by the continental margin and the uses are less numerous. On the contrary, problems concerning the environmental management are nearly always less relevant and complex.

5. Mediterranean Marine Interaction

To develop sea management it is appropriate to move away from the so called "global marine interaction model". The kinds of uses should be listed and relations tying each to the other should be identified and classified. In this context a range with two limits comes to the fore. The lower limit occurs when there is no use of the sea; the upper limit occurs when all the potential sea uses are developed. Both limits are to be regarded as theoretical because, on the one hand, at the present time it is impossible to find marine spaces not involved by human behaviour and, on the other hand, it is impossible to say how many are the potential involvements of the sea by human behaviour. But what is to be stressed is that, as the number of uses grow, the relationships between uses and environment become more numerous and more and more hazardous and, as a result, the complexity of sea involvements increases.

This reasoning leads us to envisage a draft picture in which every possible real situation is included. This result can be achieved by introducing the concept of

Xi use-founded sea management

Bearing in mind that sea regionalization concerns the relationships between man and the sea, the consequence is that the case in which no use occurs is not to be taken into account. As a result, attention would be paid to this taxonomic range:

from X1 use-founded sea management
to Xn use-founded sea management.

How to list and classify sea uses is the first problem to be tackled. In fact the global marine interaction model could be assumed as a useful starting point--if reasoning is developed in a general sense, of course. However, when a specific marine space is investigated the criteria applied to formulate this model could be changed in such a way as to be consistent with this large scale analysis.

Anyway, if the methodological approach could be supported by high interaction between structuralist thought and taxonomy, it could be agreed that such models should be regarded only as reference matrices leading to approaches appropriate to the investigation of qualitative and quantitative

relationships between uses and between uses and environment. In this context, three basic concepts come to the fore: i. the *use*, regarded as specific and concrete human behaviour towards the sea; ii. the *kind of uses*, regarded as a cluster of uses which are *similar* to each other in relation to the techniques through which they are practised and *omogeneous* according to the goals achieved through them; iii. *typical use*, regarded as use endowed with such features as to be considered as a significant case of the cluster of uses which it belongs to.

This approach could offer the rationale on which to found clustering criteria. The present phase of the advancement in marine studies justifies three level-founded clusters:

- i. *Upper level*, concerning categories of uses;
- ii. *intermediate level*, concerning sub-categories of uses;
- iii. *lower level*, concerning uses.

Typical uses cannot be identified through quantitative analysis and by adopting procedures not tied to the taxonomy of uses. It is unnecessary to stress that one could single out a use which is typical of the marine space or considered as typical of a category of uses. That depends on the features of reality investigated and on the goals that research tends to achieve.

As far as clustering is concerned eight categories of uses could be listed:

1. navigation
2. mineral and energy resources
3. biological resources
4. waste disposal and pollution
5. strategy and defence
6. research
7. recreation
8. conservation

This could be regarded as an upper, or first, level cluster. To exemplify, attention could be focused on the second category, mineral and energy resources. The literature (1983, 208) lists the following kinds of use:

- 2.1 sand and gravel dredging
- 2.2 maintenance dredging
- 2.3 exploration drilling
- 2.4 production platforms
- 2.5 coastal oil installation
- 2.6 oil transportation
- 2.7 pipelines
- 2.8 ocean mining
- 2.9 tidal energy

This would be the result of an *intermediate-level clustering*. Now the sub-category "ocean mining" could be taken into account. The following list of uses--not an exhaustive list, of course--could be considered:

mineral production from:

water column

2.8.1 salt

seabed

2.8.2 manganese nodules

2.8.3 polymetallic nodules

seabed and subsoil

2.8.4 phosphorites

2.8.5 hard minerals

This could be a result of a lower level cluster.

It would be no use pointing out that sea uses could be classified in various ways according to the criteria on which the analysis is founded. For instance, when moving from technological discriminants to discriminants related to economic organization or to environmental impacts the taxonomy criteria have to be changed and this changes the approach.

Such an approach leads us to envisage a "Mediterranean marine interaction". The analysis of the two phases - continuous change (1950-1975), discontinuous change (after 1975) - illustrated in the foregoing sections, leads to the identification of 26 kinds of uses of the Mediterranean Sea in the present time, i.e. the mid-Eighties. In the recent past, i.e. during the neoindustrial expansion phase, there were 22 kinds of uses. In the mid-term, up to the Nineties, one may maintain that the kinds of uses will increase to 30 with the addition of two forms of protection (reserves and marine parks).

Bearing in mind both physical and human features of the Mediterranean Sea the relations between uses were classified as follows:

- (i) conflicting relations;
- (ii) reciprocally hazardous relations;
- (iii) relations hazardous to use *i*;
- (iv) relations hazardous to use *j*;
- (v) reciprocally beneficial relations;
- (vi) relations beneficial to use *i*;
- (vii) relations beneficial to use *j*.

The relationships between uses have been identified according to qualitative criteria, taking into account the data that can be deduced from the literature on the Mediterranean Sea. The Mediterranean uses framework not only obliges to consider the matrix as a first approach, but also could cast a shadow of confutability over the results obtained. Given these reservations, the matrix can lead to the following general deductions.

- (i) *Planning and management.* With respect to the other semi-enclosed seas, such as the North Sea or the Caribbean Sea, the Mediterranean Sea is behind in two senses. First of all, in the field of management because here the initiatives are sectoral and very different from area to area so that there is some way to go before it will be possible to take the road of global management of the uses and the environment. Secondly, inasmuch as there are few initiatives in this direction, such planning as there is has an experimental nature and concerns very limited areas.
- (ii) *Frequency of relations.* The relations between uses are numerous because of the wide range of factors, first of all the large number of inhabitants, seaports and industrial structures and recreational activities.
- (iii) *Conflicting and hazardous relations.* In respect of the general relationships framework set out in the literature, the framework of relations between the uses of the Mediterranean Sea shows noteworthy analogies, as far as conflicting relations are concerned, but is more articulated in terms of hazardous relations. For this reason, the Mediterranean Sea must be defined as a highly critical space.
- (iv) *Coastal zone.* The literature has shown how, today, the coastal zone is defined in different ways according to the countries and the coastal regions. In each case certain factors are taken into account: physical elements, particular environmental units, administrative boundaries, arbitrary distances of the coastline or of the baseline. This has not been faced for the Mediterranean Sea, neither in a systematic way by the literature nor widely by the decision-making centres. The relations between the littoral and the sea in the context of the coastal zone has been examined: (i) for particular uses such as beach defence structures, waste disposal, aquaculture, etc.; (ii) when problems have come to light which require physical interventions or jurisdictional frameworks.

After having evaluated the uses/uses matrix attention shifts to the matrix concerning the environmental impact, represented by the matrix of rela-

tionships between uses and sea environment, there is no room to go deep into this topic field. It seems enough to outline that the sea environment could be profitably disaggregated into these modules:

1. *sea surface*
2. *water column*
 - 2.1 quality
 - 2.2 ecosystems
 - 2.3 fish stocks
 - 2.4 reserves and marine parks
3. *seabed*
 - 3.1 ecosystems
 - 3.2 wrecks
 - 3.3 mineral deposits
4. *subsea*
 - 4.1 subsea minerals
 - 4.2 reserves and marine parks

As a result the uses/environment matrix has as many lines as the number of uses and as many columns as the number of environmental modules is concerned. A rather extensive environmental concept was used, inasmuch as it takes account even of the reserves and the marine parks, not to mention the wrecks which are an important part of marine archeology. In order to define the hazardous relations, it starts from the presupposition that the uses of the sea are dealt with in respect of the existing standards and with the necessary technology. This explains why sea transport and the exploitation of hydrocarbons have not been considered hazardous. Obviously the risk exists if there are accidents: in the Mediterranean Sea, up till now, there have been accidents - collisions, running aground etc. - involving sea transport but none in the field of hydrocarbon production. In spite of this, the "uses and environment" matrix for the Mediterranean Sea includes a high number of hazardous relations.

6. Mediterranean Regionalization

The analysis of the web of uses leads us to tackle sea regionalization. In a conceptual sense, moving from the sectoral analysis, i.e. the analysis of uses, to the spatial analysis, i.e. the analysis of marine areas and regions, means that attention moves from

Xi use-founded sea management

to

Xi use-founded marine area.

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To be consistent with the reasoning developed up till now, it should be concluded that the kinds of marine areas range between

X1 use-founded marine area

and

Xn use-founded marine area.

In this context it is no use distinguishing sea involvement brought about by only one use or by some uses or, lastly, by the totality of uses, but all the possible cases are considered--i.e. the sea involvement brought about by 1, 2, 3....n uses.

The more the number of categories of uses grows the more the maritime area implements its organizational assessment and, as a result, the more the assessment becomes complex. One is justified in stating that, as the number of categories of uses approaches the totality of uses which can be established in the maritime area, a real maritime region is coming to the fore or is about to be activated.

The categories of uses that can be developed in a given marine area depend on two ranges of factors: (i) physical factors and (ii) legal factors. The latter are closely tied to the jurisdictional zones claimed by the coastal state. So the role of the international law of the sea and related national policies come to the fore, offering opportunities and also producing constraints.

As far as the analysis carried out up to this point allows, certain statements can be formulated about the spatial projections of uses, the relations between uses and the relations between uses and environment, as well. *Apertis verbis*, one can outline some basic hypotheses to start from to promote research on the regionalization of the Mediterranean Sea.

The variables, and the relations between the variables considered in the two matrices, are distributed within the Mediterranean Sea so as to prefigure five areas.

A. *Western Mediterranean, high interaction levels.* This marine area includes the central and northern sections of the Balearic Basin, the Ligurian Sea and the northern part of the Tyrrhenian Sea. The tensions between industrial, residential, port and recreational uses along the coastal strip are among the highest in all the Mediterranean Sea. Here there are: (i) some of the most advanced forms of the involvement of inland waters; (ii) the considerable effects of town and industrial waste disposal; (iii) the highest frequencies of oil and refined products pollution; (iv) a lower incidence of shipping accidents than in the Eastern Mediterranean; (v) an exploitation of the sea so intense that it makes the establishment of parks and marine reserves very difficult even though these would be necessary

for the conservation of precious ecosystems; (vi) reserves of hydrocarbons in the area between the Balearic Islands and the Spanish coast.

B. *Western Mediterranean, medium interaction levels.* This area includes the rest of the Mediterranean Sea between the Strait of Gibraltar and the Sicilian channel. The effects of waste disposal into the sea is (i) less emphasized - except in the Gulf of Naples - than in the area mentioned with high interaction levels and (ii) it is more marked in the Tyrrhenian Sea than in the Peri-African marine area. The biological resources are grounds for conflicts between states (Italy and Tunisia). Oil pollution is marked along the sea routes. Economic development and coastal urbanization in the Maghreb could bring the levels of interaction in this area close to that of the other areas of the Western Mediterranean Sea. In this case between the Strait of Gibraltar and Cape Passero there could be produced a quite homogeneous marine area with critical levels in the relations between uses and environment.

C. *Adriatic Sea.* The utilization of the natural gas fields is becoming a use that draws in others in wide areas of the sea. Sea transport has less effect than in the rest of the Mediterranean Sea both in pollution and in accidents. The Italian coast north of Gargano is densely inhabited and tormented by conflicts between uses. This has negative effects on the marine environment. Eutrophication is extended and developed. Physical and human factors come together to cause subsidence. The continental shelf has been divided up for some time between opposite states thus favouring the increase in the industrial uses of the sea. It is the only Mediterranean area which, being a continental shelf, brings to mind the environments of other European semi-enclosed seas.

D. *Eastern Mediterranean* includes the area between the Sicilian channel and the Dardanelles and therefore the Ionian and the Aegean Seas. The effects of waste disposal are only intense in the Salonika Gulf. The recreational uses of the sea are among the most advanced in the Mediterranean Sea thanks to the large number of islands and archipelagos and the great cultural and environmental attractions. This area is the most important in the Mediterranean Sea for undersea archaeology, the most subject to volcanic and seismic processes and the most afflicted by shipping accidents. The ecosystems have been much damaged by the construction of the Aswan Dam. Naval uses of the sea are very advanced because of political conflicts, international terrorism and tensions hinging on juridical problems (Gulf of Sirte, Aegean Sea).

E. *Peripheral Seas (Sea of Marmara and Black Sea).* Sea transport (the Danube-Red Sea route) and naval activity (Warsaw Pact bases on the Black Sea) are very important in the framework of uses.

As can be seen, the disaggregation of the Mediterranean brings to light very different areas as one goes from west to east. The set of uses and the relations vary rapidly in time because of the action of both exogenous factors generated by the international scene and factors endogenous to the basin. In the building scenarios the following elements should be born in mind.

- (i) Interregional co-operation prevails in the Western Mediterranean while in the Eastern Mediterranean it is conflict that prevails.
- (ii) The military uses - defense and strategy - of the sea brought about by East-West relations are tending to die out while those caused by tensions in the Arab countries and by international terrorism have not decreased. At present the strip between the Gulf of Sirte and the Dardanelles is involved in tensions, because the conflicts focused upon the delimitation of jurisdictional zones are of increasing importance.
- (iii) Exploitation of hydrocarbons is diffusing as are recreational uses, undersea archeology and the management of biological webs. These uses, as they develop and spread, will be more and more frequently involved in hazardous and conflicting relations.
- (iv) In spite of all efforts, environmental management is still in the take-off phase and, in particular, is not much sustained by international co-operation.
- (v) The Mediterranean Sea in the Nineties will perhaps be affected by two waterways, namely the Rhone-Rhine and the Rhine-Danube waterways. Sea transport will be profoundly influenced by this and, in virtual terms, the North Sea and the Baltic will grow nearer to the Mediterranean Sea.

7. General Deductions

The themes expressed lead to two orders of deductions concerning the analysis criteria and the interaction that can be derived from comparative analysis, respectively.

- (i) *Analysis criteria.* The nature of the themes set out is so complex as to necessitate global analysis and to give up any reductionist approach. This means that one must move outside cartesian logic. Furthermore, it is very important to apply the teleology principle and therefore investigate the behaviour of the aggregated elements - i.e. the behaviour of sets of uses and environmental policy - rather than fall into the causality trap in the explanation process in which

analysis exhausts itself while it is looking for the relations between causes and effects. In the end, it is appropriate to give up the idea of knowing everything (exhaustive principle) and focus knowledge upon the most significant sets (aggregative principle). Diachronic analysis is not only necessary but very useful when it includes both the historical and prospective dimensions and focuses attention on structural changes, i.e. the discontinuous phase of change, marked by rapid technological advance and new patterns of management of the sea.

- (ii) *Comparative analysis.* One would hope that, both for management and for making patterns of regionalization of the sea, the research would be carried out with growing international co-operation.

On the *theoretical level* one ought to define, unequivocally, a field of fundamental concepts and assumptions, which should agree on a set of principles establishing the statutes of sea management.

On the *empirical level* analysis focused on seas provided with high complexity seem appropriate for reaching two goals: (i) to promote the development of the ocean science, regarded as a comprehensive research field endowed with a wide range of multidisciplinary approaches; (ii) to produce satisfactory explanations, scenarios and management frameworks both for international and national bodies. The second task--leading to the strengthening of links between regional decision making centres--should enable us to go on adopting behavioural patterns more and more coherent with the specific features of regional marine spaces.

Appendix: Physical Framework

As we know, in the Seventies, by carrying out research based on the plate tectonics theory, it was possible to arrive at an interpretation of the physical structure of the Mediterranean area which could offer very useful elements for the understanding of the constraints and the possibilities that this semi-enclosed sea offered for human activity. On the basis of these results it seems clear that the Mediterranean has a very complex structure which has yet to be totally explained, from which there derives a set of processes which is full of implications for human activities.

The Eastern Mediterranean may be considered as a residue of older basins originating from the African plate and subjected to subduction.

The Western Mediterranean shows traces of factors of a history rich in geological events of which the following may be recorded.

- (i) During the Eocene period, 40 million years ago, the Tethys--the small oceanic area between the Euro-Asiatic plate and the Insubric

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plate (a part of the African plate), approaching each to the other-became involved by the subduction of the oceanic lithosphere, which produced some nappes.

- (ii) Later, between the Oligocene and Lower Miocene the Western Mediterranean basin was formed by a tension process which created a new oceanic crust and shifted part of the Euro-Asiatic plate.
- (iii) During the Upper Miocene, 6 million years ago, there occurred an uprising in the asthenosphere which caused the formation of an oceanic basin in the Southern Tyrrhenian Sea.
- (iv) In recent geological times the subduction recommenced and this created an andesitic volcanic ridge in the Eolie Islands area;

As a result the Mediterranean, in its present geological phase, is undergoing considerable tensions caused by: (i) the divergence of the Arabian plate in relation to the African plate, which might cause the formation of an ocean corresponding to the Red Sea; (ii) the subduction phase of the African plate in the European plate; (iii) the anti-clockwise rotation of the Iberian and Corsica-Sardinian micro-plates; (iv) the distension which continues to involve a part of the Western Mediterranean.

In this physical context the implications for the land communities and for the archipelago and island communities are very different from those in the other two semi-enclosed European seas.

- (i) The physical processes cause vertical movements, which are very widespread and very variable in time. The risks for human settlements are not only high but also more difficult to forecast than those of a number of extra-Mediterranean areas, since they depend on a complex range of factors which are difficult to explain through models.
- (ii) The structure of the Mediterranean is compound: to the west there are basins with not very extensive abyssal plains; in the centre there are the ridges between Italy and Cyprus; to the east there are mountainous areas crossed by rift valleys up to 4000 m deep. The continental shelf is the bottom of the most part of the Adriatic Sea and it is narrow in many other parts such as in the Gulf of Sirte and in the Nile Delta.
- (iii) This structure determines that the oil and gas fields are found in the Adriatic Sea (75% of which is continental shelf), in the Ionian Sea (40% of which is continental shelf) and in the western part of the Balearic Basin. In large areas of the Mediterranean Sea deposits of evaporate rock are to be found - the deposits to the east are deeper than to the west, where in some areas they even come to the surface. They contain considerable quantities of sodium

chloride, sulphur and potassium salts.

- (iv) The recently-conducted analysis of Mediterranean circulation have led to a greater knowledge of the three principal layers: 1. surface layers, originating from the Atlantic, 2. intermediate layers from the east, 3. deep layers, composed of local water. Furthermore it has been possible to identify the rather complex model of the circulation of the Adriatic and Aegean Seas - areas which Atlantic water does not reach.
- (v) Finally, there has been an advance in knowledge of the other important factors of biological life such as the negative hydrological balance of fresh waters with high salinity as a result, the range of temperature of the surface layers, and so on. These factors, together with a detailed knowledge of the continental shelf, explain, better than they did in the past, why the zooplankton is composed of a great number of species - more than 500 - and why the biomass is so limited. The high number of species is due to the fact that, during the Quaternary, fish species from the Boreal Atlantic province were able to settle in the Mediterranean Sea, while more recently the temperate climate has fostered the arrival of species from the central Atlantic Ocean, the Red Sea and the Indian Ocean.