United Nations Environment Programme

UNEP(OCA)/WG.2/5
May 1988

ENGLISH
Original: FRENCH

Joint Meeting of the Task Team on Implications of Climatic Changes in the Mediterranean and the Co-ordinators of Task Teams for the Caribbean, South-East Pacific, South Pacific, East Asian Seas and South Asian Seas regions

Split, 3-8 October 1988

EFFECTS OF THE SEA LEVEL RISE ON COASTAL ECOSYSTEMS INCLUDING THOSE UNDER SPECIAL PROTECTION AND THREATENED AND MIGRATORY SPECIES

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FIRST DRAFT

NOT TO BE CITED

UNEP
Athens, 1988

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INTRODUCTION

On UNEP's initiative, an international conference on sea level rise variations was held in Villach (9-15 October, 1985); one of the conclusions adopted was the possibility that by the end of the 21st century there would be a warming of mean temperature of 1.5 to 4.5°C and a sea level rise of 20 to 140 cm.

This document examines the probable impact of the following changes:

- a rise in temperature of 1.5°C
- a 20 cm sea level rise,

both predicted for the year 2025, as agreed by the experts convened in Geneva (May 11-13, 1987).

The implications concern the coastal Mediterranean ecosystems, including those under special protection as well as the threatened and migratory species.

The Specially Protected Areas Protocol, one of the Protocols of the Convention on the Protection of the Mediterranean Sea against Pollution takes into consideration both coastal and marine areas (Art. 3). The Specially Protected Areas created in the Mediterranean region aim at protecting especially:

a) - sites of a biological and ecological value;
   - the genetic diversity of species, as well as satisfactory population levels, breeding areas and habitats;
   - representative ecosystems and ecological processes;

b) - sites that are especially important because of their scientific, esthetic, historical, archeological, cultural or educational interest.

This report will examine both aspects in turn.

Even one ecosystem, if its balance is disturbed or destroyed can bring about the disturbance or the destruction of the whole system. This ecosystem (or ecosystems since they may be more than one) which safeguards the quality of many other ecosystems or of the environment as a whole, is called "key ecosystem". All protection priorities must aim at maintaining the balance of this ecosystem (or ecosystems).

A natural arrangement by geological and biological zones exists in each large sector of the hydrosphere. In the marine areas depth is undoubtedly the essential parameter; the other parameters simply modulate its decisive influence. In the land areas (marshy or not) latitude, which influences temperature and photoperiodicity, seems to be the fundamental parameter.

If we look at production results, we see that two sets, located at the interface of marine and coastal systems, predominate. They are:

- in the marine areas, it is reefs and water plant communities that are the most productive. Because they are near the coast and thus readily accessible, they are placed under human pressure (predation, occupation);

- at the juncture of the marine and land spheres, wetlands (estuaries, deltas, marine saltmarshes, lagoons) and the water plant communities that occupy them are even more productive. This system is also under human pressure, not only for production purposes, but also for the available and readily usable space it represents (storage facilities, dumps, construction, etc.).

In the Mediterranean, water plant communities and wetlands form very large sets, whereas the bio-constructed formations connected with reefs are a lot smaller; we will examine in turn these sets, the role they play in environmental quality, protection and development, as well as the likely scenarios in the event of a sea level rise.

Concerning the sites of a scientific, esthetic, historical, archeological, cultural or educational interest, the impact of the sea level rise is more difficult to evaluate. For instance, the possible effects on the traditional fishing techniques or on the historical and archeological sites must also be studied.

1. FACTORS BEARING ON ECOSYSTEM QUALITY AND POSITION

In a marine or coastal environment under marine influence, the factors that are likely to have an impact on the quality and position of ecosystems can be classified in three categories:

- climatic
- hydrodynamic
- physical

There is also the combined action of these three groups of factors.

1.1. Climatic factors

They depend directly on solar radiation. The main ones are the following:

- temperature, on the basis of which the great climatic regions and their subdivisions are defined;

- illumination, which is the basis for the delimitation of bionomic, underwater tiers;

- moistness, which is the basis for the delimitation of those bionomic tiers which can, to a greater or lesser degree, emerge from the high marine levels and from the tiers of coastal land vegetation.

1.2. Hydrodynamic factors

In the marine environment and at the land-sea interface these are the essential factors. They can be represented by three basic pairs (balances):

- strong water circulation -- stagnation, confined waters
- rough waters -- quiet or sheltered waters
- large range of tides -- small range of tides

These hydrodynamic balances control directly or indirectly other factors, such as:

- the chemical characteristics of the water (salinity, oxygen);
- water turbidity;
- the granulometry of loose substrata;
- the physical or chemical erosion of hard substrata;
- the modifications which are linked to human activity.

The same hydrodynamic balances also control directly or indirectly the distribution in space of the impact of the climatic factors, i.e.:

- temperature, which is a function of circulation;
- illumination, which is a function of turbidity;
- moistness, which is a function of the degree of exposure and of the tides.

In many places, the hydrodynamic factors prevail over the climatic factors and influence the quality and position of ecosystems.

1.3. Physical factors

The main physical factors, which at a given time "t" influence ecosystem position and quality are:

- underwater and coast topography;
- substratum quality (rigid or loose).

2. GENERAL METHODOLOGY

One should take into consideration on the one hand the factors bearing on the ecosystems already established when the sea level rises and on the other the impact of these factors on these same ecosystems. For the purposes of this study, an ecosystem is defined as the association of a biotope (base) and of a biocenosis (population). Depending on the case we shall consider the former or the latter.

2.1. Factors having an impact

In order to assess the effects of a sea level rise on the various ecosystems, one must firstly take into account the following elements and their possible modifications:

- the topographic profile;
- substratum quality;
- the range of tides, and the degree of exposure (mode);
- the existing benthic populations.

2.1.1. Topographic profile

In a simplified manner, the topographic profiles can be grouped in 3 categories:

A: Vertical or pseudo-vertical
B: Association: vertical and horizontal (plateau)
C: Horizontal or pseudo-horizontal.

If the sea level rises 20 cm over a 35-year period, the expected effects will be different:

A: there will be a lag in the effect on 20 cm in height.

B: the effect will be a function of the position of the plateau, depending on whether the latter is:

- mostly above the present level zero: in which case there will be occupation of a new substratum,

- at the level of the greatest depth where light can enter: in which case the photophilic biocenoses may disappear.

C: the effects will be smaller or greater as a function of the gradient, 2%=10 cm, 2‰=100 m and will be more noticeable:

- at the level of the coast, there will be marine environment penetration and transgression;

- at the level of the depth-limit for illumination: there will be disappearance of photophilic biocenoses.

2.1.2. Substratum quality

The original quality of the substratum and its modifications are one of the main elements influencing the presence of benthic biocenoses. Three general types of substratum can be distinguished:

A: Rigid substratum (rocky sea-bed);
B: Mixed substratum combining rocky and sandy beds;
C: Unstable or loose substratum (muddy or sandy sea-bed).

If the sea level rises by 20 cm over a 35-year period, the implications will be different, depending on the type of substratum, but to put it simpler, we can predict the following prevailing actions:

A: erosion phenomena are displaced and increased for a certain period of time (decompression of banks, falling-in of sea cliffs);

B: sediment erosion and transport phenomena will be predominant (erosion, transport);

C: erosion, transport and sedimentation phenomena act in conjunction and bring about great changes in the structure of the coast and in the underwater sedimental matter.

Erosion, transport and sedimentation will bring about changes in the substrata, the turbidity and thus in the populations.

2.1.3. Tides and exposure degree (mode)

The range of the tide and of the degree of exposure of the coast is one of the factors which affect the presence of ecosystems. The changes will be different, depending on the various types encountered:

A: Strong tides;
B: Normal tides.

In the Mediterranean, the astronomic tides are generally weak (0.60 m), except in certain specific places, like the Gabès Gulf in Tunisia (2.40 m) and the Adriatic Sea. To the astronomic tides one must add the barometric tides and the positive impact of the wind. These two elements combined can increase a normal tide by 0.60 to 0.80 m.

A sea level rise of 0.20 m will make this set of phenomena move up and the effects, among which erosion, will be felt in the sector concerned.

1. Strong degree of exposure or mode battu;
2. Medium degree of exposure or mixed mode;
3. Weak degree of exposure or calm mode.

The level of the degree of exposure (mode) and its modifications will have an impact on the conditions of deposition, on the nature of the substratum and on the populations associated with it.

Note: If we consider at this point all the parameters cited above, we will have 54 possible figure sets. The low wetlands generally concern horizontal or pseudo-horizontal profiles (A), loose sediments (C), and taking into consideration the various profiles, the strong or normal tides and the calm or medium modes, we end up with 8 sets of figures out of the possible 54, or approximately 15%.

2.1.4. Existing (benthic) populations

Before the sea level rises, one of the main factors that can influence the impact of the rise is the presence of benthic populations, especially underwater plant communities. We will examine later the role of these communities as concerns sediment holding, breaking of waves and currents, biomass and productivity. Their weakening or destruction plays an important role, even from an economic point of view.

2.2. Main effects of the above mentioned factors

We must then examine the effects of these 3 elements and their interactions in terms of their bringing about modifications in the following elements:

- light penetration/turbidity;
- nutrient content;
- biomass present and annual productivity.

2.2.1. Light penetration/turbidity

Erosion phenomena linked to a sea level rise may bring about an increase in turbidity, which in turn will bring about a decrease (temporary or permanent) in light penetration which then will cause the disappearance of photophilic populations, especially the plant communities in deeper waters.

2.2.2. Nutrient content

For the same reasons, increased nutrient content may very well occur in the marine environment, destroying the balance of certain ecosystems and causing the disappearance or the replacement of certain species.

2.2.3. Biomass present and annual productivity

For the marine area, the major effects of these modifications can be of two types (for the short, medium and long term):

- modification of existing biomass, because of the disappearance or thinning of populations, or on the contrary through exceptional development, in a very short time, of certain replacement species adapted to the new conditions;

- modification of annual productivity, related to the presence or absence of certain species. The underwater plant communities are the most productive sites in the Mediterranean. If they disappeared, production would fall dramatically in many areas, especially production of species edible by man (fish, crustaceans).

For the land area, changes in underground water position can bring about a modification of the plant populations, hence the departure of animal species, because of increased erosion phenomena and loss of territory.

3. MEDITERRANEAN CASE STUDIES

The following cases will be examined in turn as to: presence, actual status, role and impact of sea level rise (directly or indirectly through the implications described above):

I Water plant communities
II Benthic biocenoses
III Biogenic constructions
IV Wetlands
V Threatened species
VI Threatened heritage

I. Water plant communities

Posidonia meadows

Types of plant communities

In the Mediterranean, the communities with well developed vegetation may be constituted of populations based on marine phanerogams or alternatively on algae. For the former we can distinguish:

- the biocenosis of the Posidonia oceanica bed,
- the biocenosis of the Cymodocea modosa meadow,
- the biocenosis of the Zostera noltii bed,
- the biocenosis of the Halophila stipulacea bed.

As for algae, the main populations are the following two:

- the Caulerpes populations (with Caulerpa prolifera, C. scapelliformis, C. racemosa, C. crassifolia and C. olivieri)
- the Arthrocladia villosa and Sporochnus pedunculatus population.

Of all these biocenoses and populations, the present study will only consider the Posidonia beds that are the most numerous around the Mediterranean; furthermore, their role and impact are felt at various levels.

Posidonia oceanica: Biology

Posidonia: Posidonia Oceanica (L) Delisle is a marine phanerogam (a flower and fruit producing plant), with creeping or upright stalks (rhizomes) which end in bundles of leaves or heads. Each head has 4 to 8 leaves (approximately 1 cm wide and 20 to 80 cm long - maximum 142 cm). Flower time is the end of summmer or more generally fall. Flowers are hermaphrodite; 4 to 10 flowers are grouped together in an inflorescence at the top of a peduncle. For the fruit of the Posidonia to mature, 6 to 8 months are needed. Between May and July they break off and float, carried by the currents, at times ending up on beaches. They have the shape and the dimensions of an olive; their colour is dark brown to black. In many areas of the Mediterranean, reproduction through fructification is less important than that carried out by planting cuttings, i.e. through pieces of rhizomes torn off during storms.

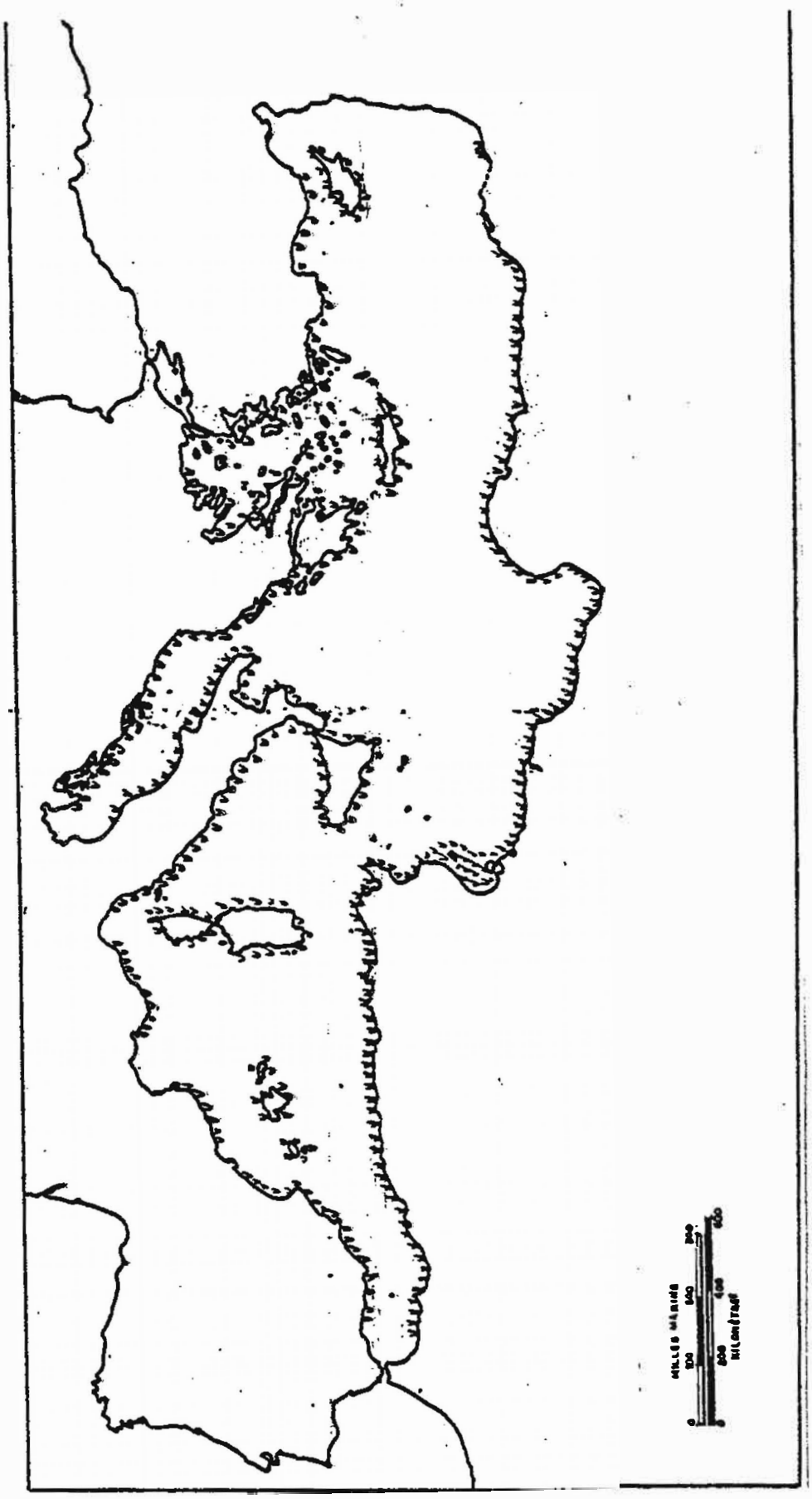


Fig. 1 - Location of meadows around the Mediterranean mostly Posidonia oceanica

The biocenosis of the Posidonia oceanica beds

More commonly referred to as Posidonia beds, the biocenosis of the Posidonia oceanica bed occupies, in many places in the Mediterranean Sea, an important part of the infralittoral range. Posidonia beds have special characteristics and play important roles, of which we will deal with the following:

- the Posidonia bed as a factor stabilizing and building up the sea bed;
- the Posidonia bed as an oxygen supplying factor;
- the Posidonia bed as a production, exportation, gathering and fishing area;
- the Posidonia bed as a habitat, spawning ground, nursery, shelter and feeding ground;
- the Posidonia bed as a beach protecting factor.

The Posidonia bed as a factor stabilizing and building up the sea bed.

Posidonia plants have rhizomes hidden in the sediment: at the top of these rhizomes there are leaves gathered in clusters. Posidonia rhizomes can grow both horizontally (creeping of plagiotropic rhizomes) to colonize the substratum, and vertically (orthotropic rhizomes); this latter property makes them resist being buried in the sediment. The rhizome network formed thus, is called "la matte".

The installation of a Posidonia bed on a sandy bed is carried out progressively; the sediment may have previously been stabilized and enriched with organic matter by other species, such as the Cymodoceans. The succession of species on the same site is called "evolutionary series" and is carried out along the lines of environmental condition changes. Once established, the Posidonia bed, can both colonize the sea-bed horizontally and grow vertically. Vertical growth can be speeded up through sediment which comes from the coast and gets trapped in the Posidonia bed. The leaves act as brakes to the currents transporting sediment and the particles are deposited first between the leaves and then in the tangle of rhizomes. In certain bays and protected coves, the Posidonia plants, by growing in height, can come near the surface of the water, thus cutting off a lagoon from the open sea. This biological construction is called "barrier reef"; both its formation and function are similar to those of coral reefs; however, the former is more fragile, because of its plant origin. The installation of barrier reefs is very slow (vertical growth of Posidonia is on an average calculated at 1 m century^{-1}), but their destruction can be very rapid. The lagoon which is cut off from the open sea by a Posidonia construction, has features which bring it closer to the coastal environment (wealth of organic matter, confinement, large production). The most important barrier reef type of construction in the Mediterranean is located in Tunisia, around the Kerkennah islands.

2. The Posidonia bed as oxygen supplier

The Posidonia bed, like other plants and certain bacteria, can with the help of very simple elements (water, carbon dioxide and mineral salts) and a sunlight caught by the green chlorophyll molecules, ensure the synthesis of living matter. Through this process called photosynthesis, oxygen is produced. Thus, protection of all the Posidonia beds is the most crucial element for the survival of the Mediterranean.

3. The Posidonia bed as a production, exportation, gathering and fishing area

The weight of the living matter created annually through photosynthesis is called primary production (unit expressed in kg of dry weight hectare^{-1} year^{-1}). Various authors, on the basis of measures and estimates for primary production give a total of approximately 21 tonnes of dry matter per hectare, per year for a Posidonia bed broken down as follows:

- 11,800 kg ha^{-1} year^{-1} Posidonia leaves;
- 280 kg ha^{-1} year^{-1} Posidonia rhizomes;
- 9,000 kg ha^{-1} year^{-1} approximately for the epiphytes of leaves.

These values are a rough estimate, since measurements carried out at different sites give varied results. It is a fact however, that the Posidonia bed has the greatest primary production of all Mediterranean populations. For comparison, we can point out that the Posidonia primary production is in the same order of magnitude as that of the forests of Europe, of cereal farming and of the fields of large marine algae in the Atlantic Ocean.

That part of the production which is exported, mainly in the form of dead leaves carried away by the waves and currents, is estimated at about 30%. It is consumed by many species: edible sea urchins, bacteria, fungi, sea squirts; sea squirts constitute the first link of a trophic chain which goes all the way up to species edible by man.

The importance, therefore, of Posidonia beds by far exceeds the surfaces covered, which are rather modest on a Mediterranean scale (30,000 ha on the continental façade of the Mediterranean coast of France - Golfe de Gabès, cf. map). Posidonia plays a crucial role in the alimentary budget of the Mediterranean as a whole.

4. The Posidonia bed as a habitat, spawning ground, nursery, shelter and feeding ground

The Posidonia bed as a high density habitat, with plant and animal populations which occupy all available spaces or swim in the vicinity: photophilic species of the foliage, shade-loving species of the rhizomes, soil-dwelling species of the "matte", species moving about near by.

Some of the species belonging to the last category form an important part of the coastal fishing catch of the Mediterranean. Whether there is or isn't a Posidonia bed, whether it is exploited in a rational manner, whether it is taken into consideration when planning construction or selecting sites for effluent disposal, are all factors affecting the daily catches along certain parts of the coast and the preservation of this type of resource for the coastal populations. The presence of a Posidonia bed can by itself increase by 5, or even by 10, local production of edible species.

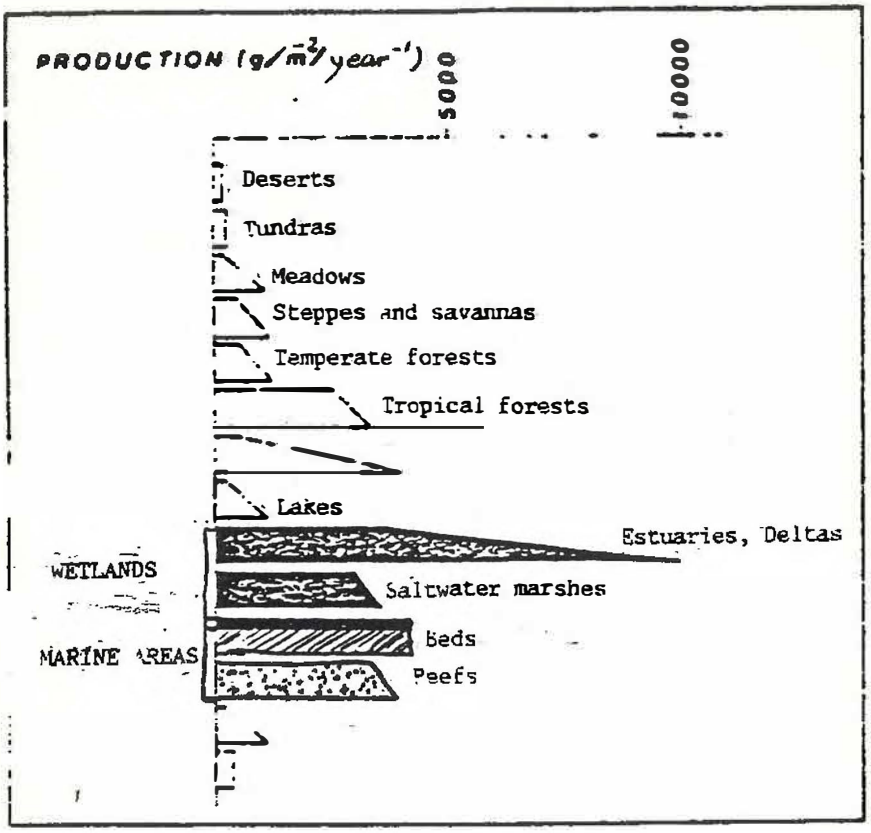


Fig. 2 - Comparative production of some terrestrial and marine ecosystems (adapted from Basson et al., 1977 and Allen et al., 1979)

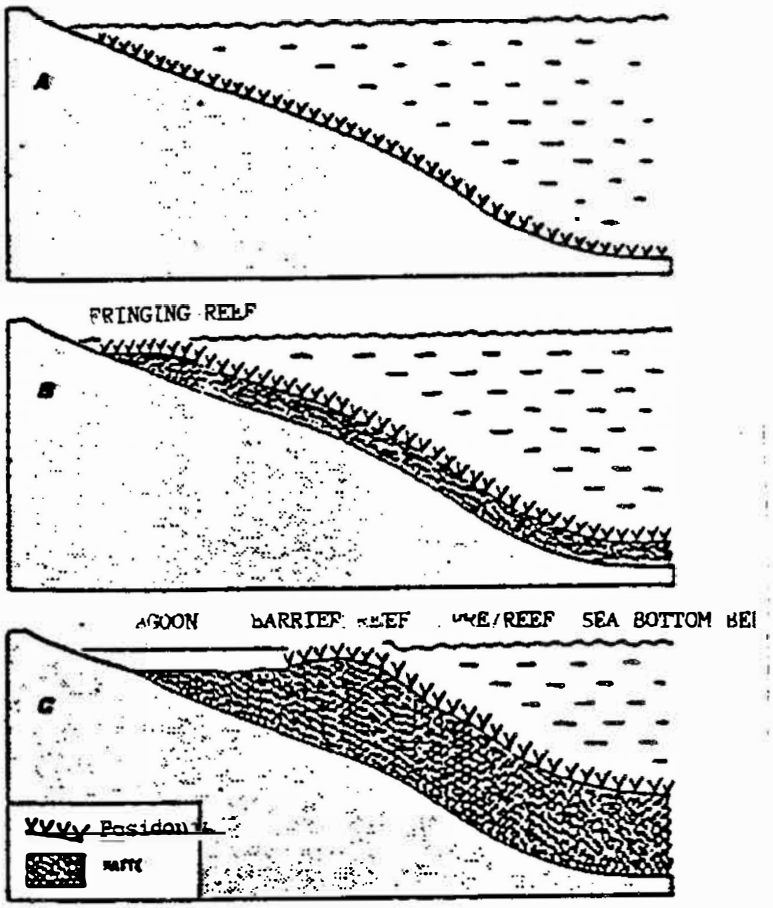


Fig. 3 - Vertical growth of "mattes" of a Posidonia bed in calm mode: a fringing reef is formed first (B) which then develops into a barrier reef (C) cutting off the lagoon behind it

5. The Posidonia bed as a beach protection factor

In addition to the importance of Posidonia beds for the quality of the Mediterranean marine environment, one should keep in mind the role these beds play for the protecting of coasts and their being maintained in place. Indeed, a Posidonia bed can impact upon the local hydrodynamic conditions (currents, waves) and thus attenuate their respective action on coasts in various ways, i.e.:

- leaves are a brake to currents (up to 60% absorption half-way up the leaves) thus triggering the deposition of sedimental particles;

- sediment preservation is assured by rhizome entanglement. During heavy storms, part of this sediment can be transported to the coast;

- softening of the wave action can take place on the "matte" which is a structure both rigid and flexible at the same time. Field and laboratory measurements have

shown that in the presence of a Posidonia bed, the wave characteristics decrease by 40%;

some of the Posidonia leaves after they fall off are carried to the beaches where they form accumulations called "banks"; these may exceed 1 m in height and they protect beaches during winter storms in two ways: the accumulation itself forms a shield, and the water adjacent to the beach acquires increased viscosity due to the floating leaves and fibres.

If we take all of the above elements into consideration, we can understand the crucial role played by the Posidonia beds in protecting the coast and maintaining the coast line. It follows therefore, that if we respect the beds we protect the quality of the Mediterranean marine environment and safeguard the existence of sandy coasts and lagoons protected by those same Posidonia beds; seen from this angle, the survival of wetlands is closely linked with that of Posidonia beds.

Impact of sea level rise

At the present time, a certain number of anthropogenic activities on the coasts brings about damage to the Posidonia beds. Sea level rise may increase the rate of damage and lead to a true desertification of the environment.

The main implications of sea level rise are the following:

- increased erosion of coast and of the sea-bed near the coast through hydrodynamic changes which would soon lead to:

- increased turbidity, raising of the lower level where light can penetrate and thus loss of deep areas covered with Posidonia beds;

- death of Posidonia beds because of excessive sedimental inputs covering the plants;

- difficulty of the beds to colonize quickly new available areas.

The present trend, when problems occur on sandy beaches, is to use rockfill which brings about increased agitation of the waters and general regression of the beds.

New types of protection should be sought (either in the open sea and/or flexible structures); furthermore, techniques for replanting the beds should be developed.

II Benthic biocenoses

Biocenoses are of different types depending on depth, degree of water agitation and thus on the nature of sediment (Fig. 4). The main biocenoses encountered on loose substratum are the following (Péres and Picard, 1964 classification):

1. Well calibrated fine sand (SFBC)
2. High-level fine sand (SFHN)
3. Muddy sand, calm mode (SVMC)
4. Unstable loose bed (FMI)
5. Sand and gravel under the influence of bottom currents (SGCF)
6. Coastal detrital beds (DC)
7. Silted-up detrital beds (DE)
8. Coastal terrigenous mudd (VTC)

Impact of sea level rise

All the biocenoses mentioned above are likely to change positions, if there is a sea level rise and if there is a change in coast exposure. In such a case, species competition for space can be fierce. The potential existence of Posidonia beds on the same sites can, depending on the case, accelerate or slow down these changes.

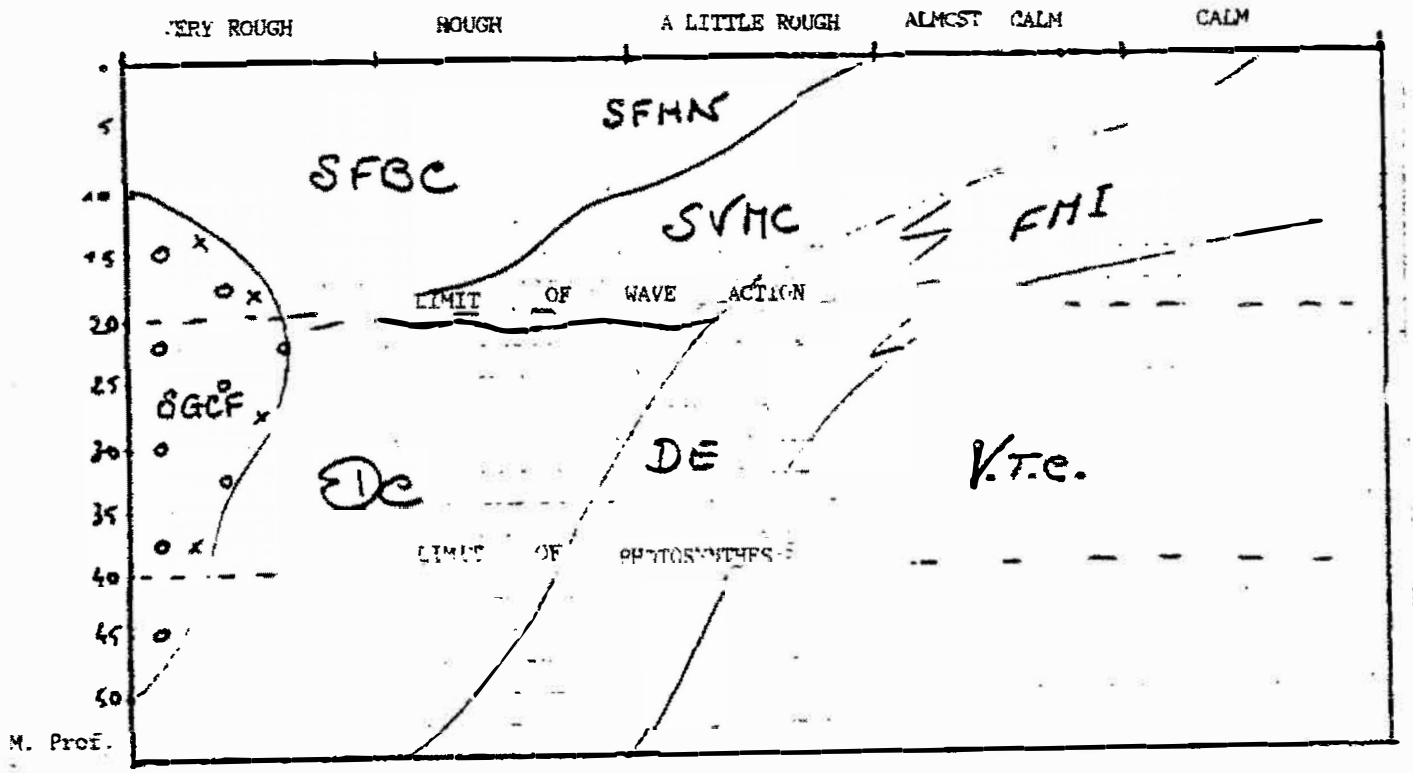


Fig. 4 - Position of benthic biocenoses of loose substrata as a function of degree of roughness and depth

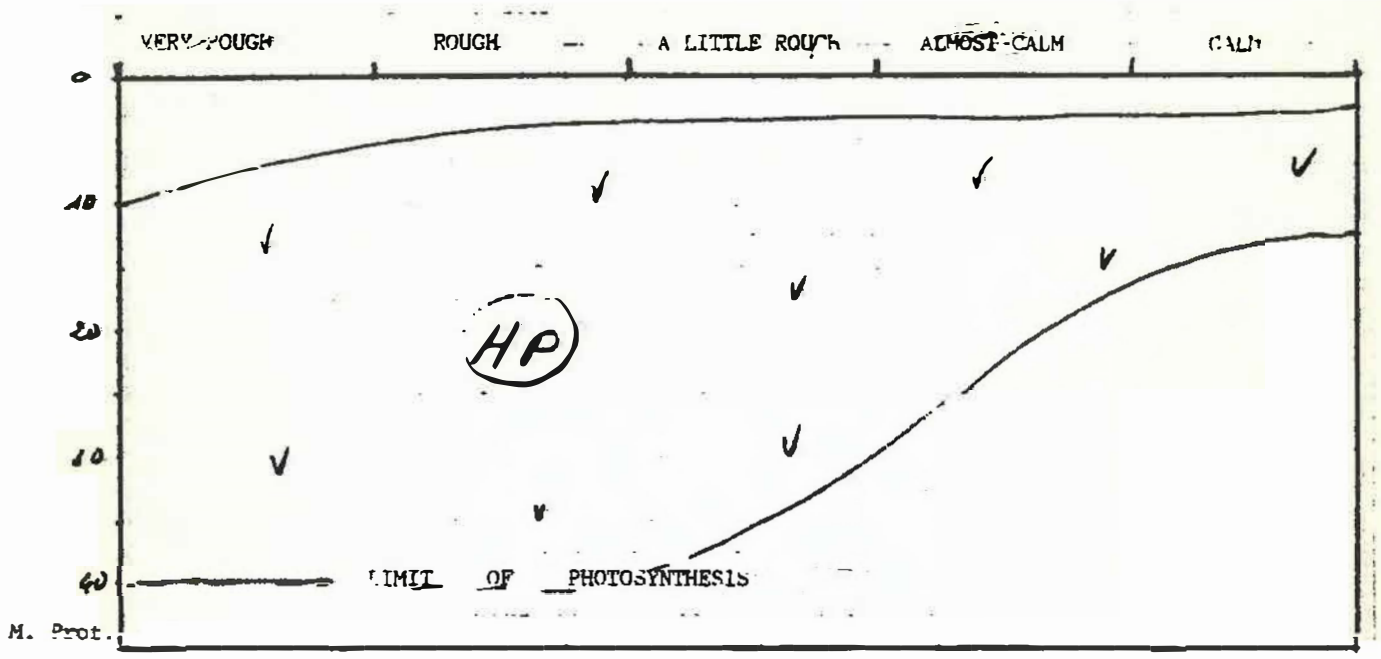


Fig. 4 - Potential position of Posidonia beds (HP=V)

III Biogenic constructions

The formations called "biogenic constructions" may be linked to the growth and accumulation of plants (V), animals (A), or true coral (C). The following constructions have been studied:

1. Lithophyllum lichenoides (V)
2. Vermetid-algal (V+A)
3. Corallina (V)
4. Lithophyllum incrustans (V)
5. Serpulid (A)
6. Cladocora (C)
7. Coralligenous algal (V)

The biogenic constructions found in the Mediterranean are generally on rocky substratum on the coast or near it, at sea level or at depths not exceeding 25 m. Only one formation is found at a depth of between 12 and 120 m (Fig. 5).

Impact of sea level rise

Sea level rise will be extremely serious for the formations which, in order to survive, must stay close to the present sea level (1,2); however the implications of light penetration and turbidity can be serious for all formations. Moreover, the competition for the occupation of spaces which will have become available when the level rises can lead to the disappearance of the least mobile species, or those that grow slowly.

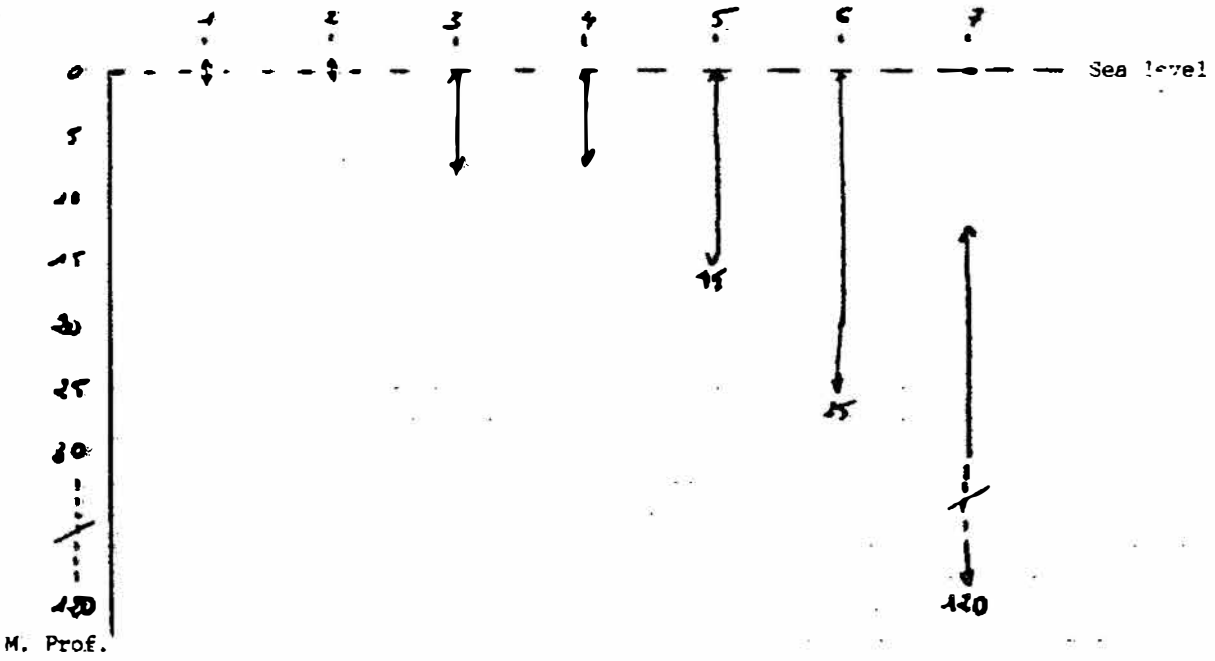
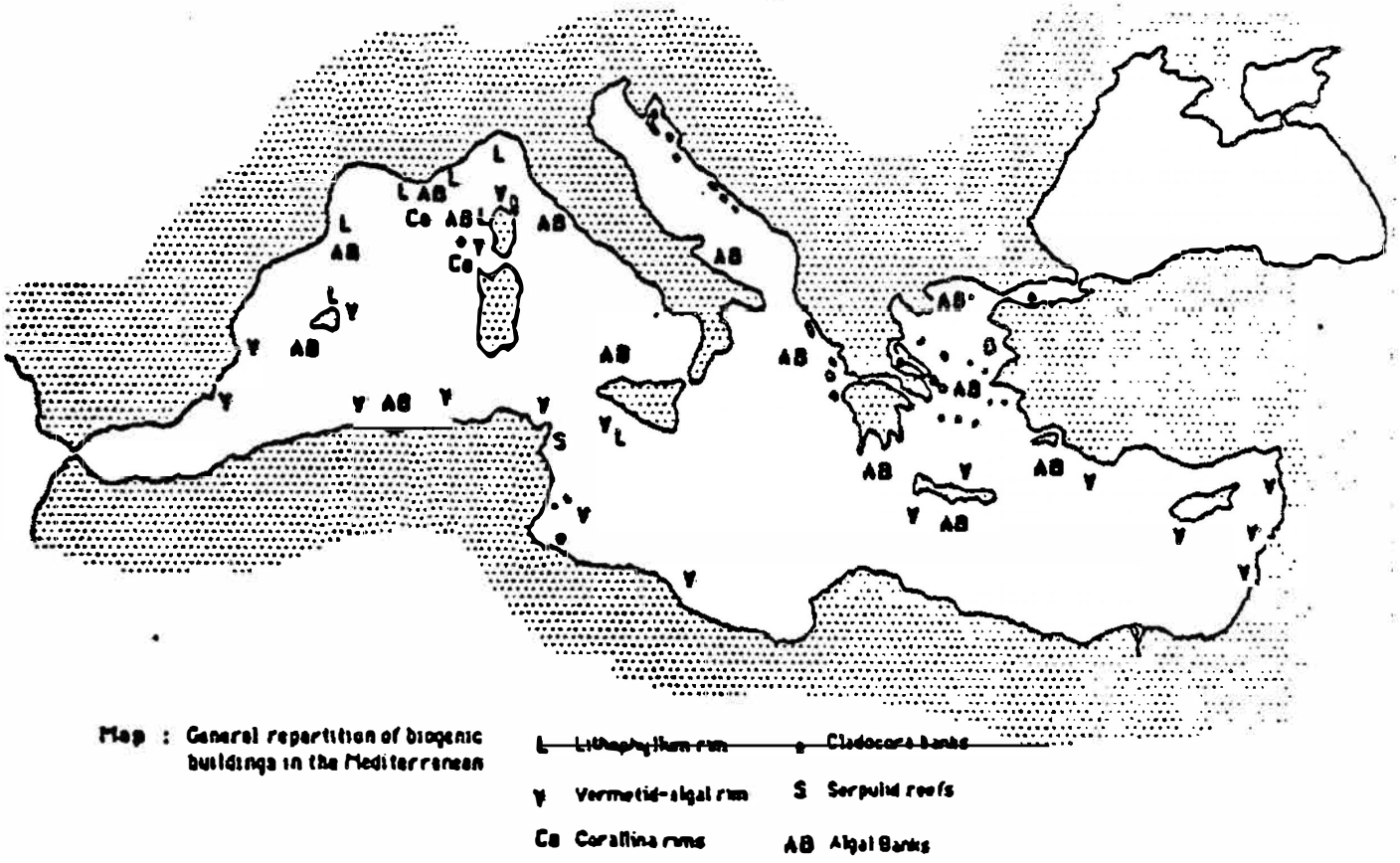


Fig. 5 - Position of the various types of biogenic constructions as a function of depth (1-7)



From: J. Laborel: Biogenic constructions in the Mediterranean, a review, 1986

IV Wetlands

All the case studies included in the general programme all concern areas of this type; the predicted results are therefore similar. In each of these sites there are protected areas at the local, national or regional level. A summary description of each is given in the Annex.

Study area	Existing protected areas
Ebro	1) Delta of the Ebro
Nile	2) Bardawil - 3) El Arish-Rafal
Po	4) Comacchio-Sacco di Bellochio
Rhône	4) Camargue
Medjerda	5) Ichkeul

A detailed descriptive data sheet, from the files of the Centre for Specially Protected Areas (SPA/RAC, UNEP) or from those of the Conservation Monitoring Centre (CMC, IUCN), on each of these areas is given in the Annex. On the basis of these descriptions, it is possible to predict a certain number of implications of sea level rise; however it appears that in order to determine, on the basis of figure patterns, the real predictable impact, a lot of additional information is needed, and especially:

- topographical maps of the marine and coastal areas showing clearly which surfaces would be affected by a small rise of the sea level;
- the amplitude of existing tides;
- variations in marine level during very severe storms;
- the sedimentological nature of the littoral fringe;
- existing biocenoses, etc.

Impact of sea level rise

When we consider a sea level rise, we must first analyze each area separately and then carry out a synthesis which would bring to light those problems which are of regional importance and which can have implications for all Mediterranean sites.

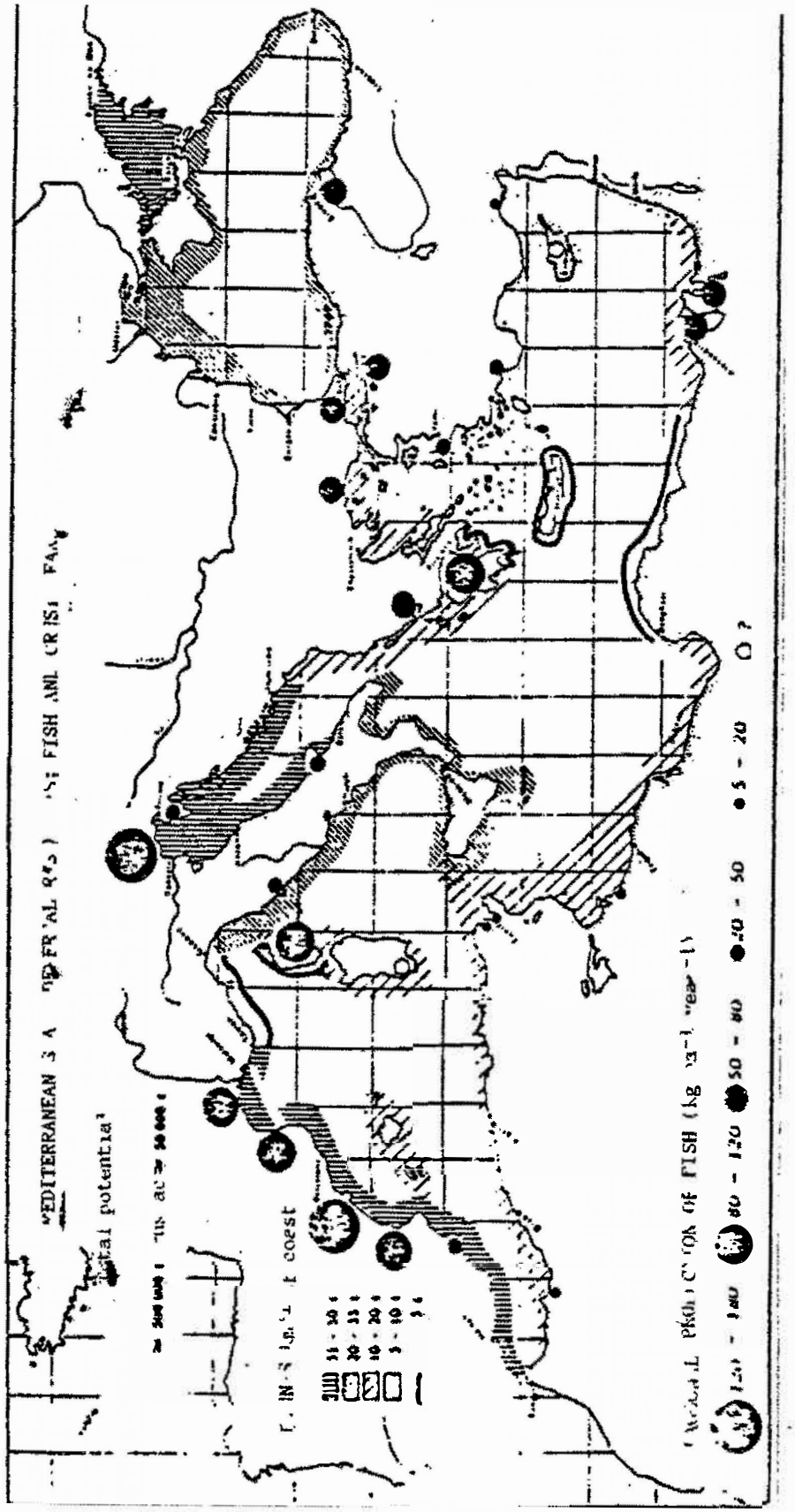


Fig. 6 - Comparison between demersal and lagoonal fish production along the Mediterranean coasts (adapted from FAO Atlas, 1972 and Amanieu and Lasserre (1981), modified. Guelorget and Perthisot (1983)
The coasts with important demersal production are always adjacent to large areas of wetlands or estuaries

V. Threatened species

In addition to the aspects already examined, a sea level rise can have an impact on the survival of those species that are already threatened at Mediterranean level and especially:

- certain bird species, through loss of breeding and feeding habitats;
- marine turtles, through loss of breeding places;
- terrestrial plant species of the littoral fringe, through changed impact of the sea (underground water, spray);
- several species that can be threatened through increased migration of species from either the Atlantic or the Indian Ocean (competition problem).

VI. Heritage threatened

A sea level rise can negatively affect the Mediterranean marine heritage in the following ways:

- traditional and cultural activities (such as fishing and fishing techniques) can be threatened;
- the preservation of coastal sites of archeological or historical interest can be impeded;
- coastal and marine ecosystems may be threatened.

EGYPT

* BARDAWEEL (Zarinfck)

MANAGEMENT CATEGORY Nature Reserve

TYPE Wetland

ANNOTATED DESCRIPTION Very important site for the passage of migratory birds.

GEOGRAPHICAL LOCATION The reserve covers the eastern end of the Bardaweel lagoon. This lagoon lies along the northern shore of the Sinai Peninsula, occupying more than half the length of its Mediterranean coastline. It is 95 km long and 25 km wide at maximum. N 31° 10'-E 33° 15'.

AREA 60,000 ha (lagoon)

DATE ESTABLISHED 1985

LEGAL PROTECTION Established as a Nature Reserve in 1983 based on law 102 concerning natural protectorates. Ministerial decree No. 472 issued 5 March 1980 prohibits hunting of all birds and animals in the area.

LAND TENURE No information. Presumably state owned.

CLIMATE A typical mediterranean arid climate with winter temperatures between 7°C and 20°C and Summer temperatures between 18°C and 33°C. The annual rainfall averages 80-100 mm.

PHYSICAL FEATURES A saline lagoon separated from the sea by a narrow strip of land forming a barrier 300-1000 m wide, its height varying from a few metres to over 60 m. Three man-made entrances permit free exchange of water from the sea. The lagoon is a vast area of shallow water with peninsulae and small islands, marshes and saltflats. Maximum water depth 3m; average water depth 1m.

VEGETATION Vegetation on foreshore and islands consists mainly of halophytes and is of varying density.

FAUNA The lagoon is a permanent habitat for about 1500 Flamingos (Phoenicopterus ruber), a maximum of 8,000 being recorded in 1973. During the autumn, huge numbers of migrating birds pass along the length of the lagoon including Pelecanus onocrotalus (1460), Anas querquedula (203,000), Calidris minuta (15,500), Chlidonias leucopterus (8,800), Alcedo atthis (1,200) and Coturnix coturnix.

MANAGEMENT Hunting is prohibited.

USES Some parts of the lagoons are used for sand extraction.

PROBLEMS Alteration of the habitat due to the construction of irrigation canals and the expansion of agriculture, severe hunting pressure. Eggs and fledglings of breeding waterbirds are gathered extensively by the local fishermen for food and probably sale. Excessive sand extraction.

PRINCIPAL REFERENCE MATERIAL

Carp E., 1980. A Directory of Western Paleartic Wetlands. IUCN, Gland.

EGYPT

EL ARISH-RAFAH

MANAGEMENT CATEGORY Nature reserve.

TYPE Coastal.

ANNOTATED DESCRIPTION This is a wooded coastal region stretching from El Arish to Rafah at the border with Israel. The site is an extension to the Bardaweel reserve. The shore consists of series of dunes supporting typical vegetation.

GEOGRAPHICAL LOCATION Situated between the town of El Arish and Rafah on the Israel border. E 34° 02', N 31° 13'.

AREA No information, approximately 40 km of coastline.

DATE ESTABLISHED 1985

LEGAL PROTECTION Established by Prime Ministers decree No. 1429.

LAND TENURE State owned.

CLIMATE A typical mediterranean arid climate with winter temperatures between 7°C and 20°C and summer temperatures between 18°C and 33°C. The annual rainfall averages 80-100 mm.

PHYSICAL FEATURES No information.

VEGETATION Fixed sand dune vegetation is represented by Ammophila arenaria, Pancratium maritimum and Crucianella maritima. The vegetation of the mobile dunes is largely of Sahara-Sindic origin and includes Euphorbia paralias, Cyperus conglomeralis, Cakile maritima and Silene succulenta.

FAUNA Mammals such as the dorcas gazelle (Gazella dorcas) have been recorded in the area. The Monk seal was last sighted in the marine areas of the park in 1940.

CULTURAL/HISTORICAL FEATURES El Arish, the administrative capital of Sinai, was founded by an Ethopian King of Egypt and was built on the ancient 'Route Maris' constructed 3,000 years ago.

MANAGEMENT The area is administered by the Executive council with representation from the ministries of tourism, agriculture, defence, interior, the ACRT, the AEA and the Sinai development authority.

USES El Arish has a population of 30,000 (1973). Sand is extracted from the area.

PROBLEMS No information.

PRINCIPAL REFERENCE MATERIAL

Brunn, B. (1986). Two new protected areas in Northern Sinai. Sinai Newsletter, 4.

CONTACT ADDRESS No information.

FRANCE

CAMARGUE NATIONAL RESERVE

MANAGEMENT CATEGORY Strict Nature Reserve and Biosphere Reserve. European Diploma Award 1966

TYPE Coastal Wetland

ANNOTATED DESCRIPTION The most important wetlands site in the Mediterranean. The Reserve lies entirely within the Camargue Regional Natural Park of 85,000ha extending between the Grand Rhône in the East and the Petit Rhône in the West and including a beach of fine sand.

GEOGRAPHICAL LOCATION The area is situated on the Rhône Delta, south of Arles, Bouches-du Rhône and near the townships of Arles and Saintes-Maries. 43°30'N, 04°30'E.

AREA 13,117 ha of which 3,500 ha are terrestrial. 11 km of coastline

DATE ESTABLISHED 1975 as National Reserve, January 1977 as Biosphere Reserve.

LEGAL PROTECTION . Protection of the area started in 1927 and resulted in the creation of the National Reserve in 1975 by ministerial decree (Ministry of Environment) of 24 April 1975. The Reserve is part of the Regional Natural Park of Camargue established in 1972.

LAND TENURE State property

CLIMATE The area has a typically Mediterranean climate with hot, dry summers and mild rainy winters. Mean annual rainfall of around 571 mm (winter month average 150 mm.; summer month average 110 mm). Mean annual temperature 14.5°C (winter average 7°C; summer average 22°C). The prevalent winds are from NW (50-100 km/h) and SE (30-70 km/h). Mean water temperature 15 o C; water salinity in winter 30 mg/l, in summer 30-60 mg/l.

PHYSICAL FEATURES The Reserve occupies the centre of the depression formed by the Rhône Delta and is a natural wetland of low-lying salt steppe and brackish, high concentration saltwater lagoons connected by shallow channels and dunes. Submerged land varies from 60% in summer to 95% in winter. The major water bodies or ítangs are Vaccares (6,500ha) and the southern group of Fournelet, Monto, Malagroy, Impíriaux, Dame and Lion. Salinity ranges from an average 7g per litre in the Vaccarès to 30g per litre in the "lesser" lakes and ponds. 10% of the area has sandy soil associated with fossil and recently formed dunes, and sub-soil consists of a layer of mud up to 50m thick. Altitude ranges between -1.50m in the center of the lagoons to 4m in the sand dunes.

VEGETATION The main landscapes represented in the Reserve are: fresh or brackish marshes with Typhaceae, reed-beds and other fresh water or slightly brackish formations; lagoons with aquatic vegetation; temporary seaponds connecting with the sea, with saltbush vegetation; and littoral dunes with herbaceous formations of psammophytes. The main saline-tolerant species are Salicornia spp. and Statice limonium with Tamarix gallica on less saline but still waterlogged soils. The drier, less saline soils are covered by tall, thick "maquis", dominated by a Phillyrea angustifolia association. The most saline flats support Arthrocnemum macrostachya and the dunes an Agropyron-Ammophila association, while the very old dunes (once sea-bank) have particularly good stands of climax Juniperus phoenicea.

FAUNA This is an important waterfowl breeding, resting and wintering place for large numbers of migratory birds, with some 323 different species being recorded. It is the only regular breeding place in France for several species, including Phoenicopterus ruber, Ardeola ralloides, cattel egret (Bubulcus ibis), Sterna nilotica and Glareola pratincola. About 200,000 members of the family Anatidae live here during winter. Mammals include wild boar (Sus scrofa), foxes (Vulpes spp.), coypu (Myocastor coypus) and many species of small mammals including shrew and weasels (Mustela). The European beaver (Castor fiber) is found on the Rhône within the Natural Park zone. Nine of the 13 species of reptiles in the Rhône Delta, and all six species of batrachians, have been found in the Reserve.
Two different fish habitats can be distinguished often with overlapping geographical bounds: the saline lesser lakes and ponds, and the Vaccarès with freshwater fish able to tolerate the low salinity. The eel is abundant and widely fished in surrounding waters. The invertebrate distribution reflects the "mosaic" of environments; some noteworthy for their rarity are those dependent on Juniperus phoenicea.

CULTURAL/HISTORIC FEATURES
Archeological remains of the I century BC, and of IV and VI century AD are present in the reserve.

MANAGEMENT The administration and management of the reserve are under the responsibility the Director of the Societe National de Protection de la Nature, assisted by a management committee and a scientific committee. The personnel is composed of 7 people: 2 in the administrative service and 5 guards who are also acting as technicians. The annual budget in 1985 was 1,167,000 French francs provided by the State for running costs and 200,000 French francs for investments (from self-funding, region).
Hunting, fishing, commercial activities are prohibited. Public access is permitted only on a 20 km trail and on the beach. Grazing is allowed in an area of approximately 1000 ha.
Tourist facilities are offered at Arles and Saintes Maries de la Mer. Educational facilities include a visitor orientation center at Salin de Badonan and an information center with permanent exhibition, audio-visual shows, nature trials at La Capelière. Training stages on ornithology, interpretation, drawing and other as well as guided tours are organized.

USES There are no permanent residents in the Reserve. Of 1 million persons visiting the Camargue, 150,000 visit the accessible sites of the Reserve between April and November for bird watching, bathing and cultural reasons. Permanent research programmes have been conducted since 1954 by the Station Biologique de la Tour du Valat, a privately run research station in cooperation with Centre Nationale de la Recherche Scientifique, and since 1970 by CNRS themselves. The present focus is on the gradual establishment of a permanent system for collecting data in research fields which have already been well-analysed, and on the study of new links in food chains. In addition, there has been an attempt to combine the efforts of many research workers in multidisciplinary programmes (Délégation Générale à la Recherche Scientifique et Technique, DGRST). These projects may be fundamental research (the productivity of saltbush flats, the behaviour of teal), and yet provide practical data such as on grazing activity or the effects of hunting. The diversity of research undertaken represents over 10 organizations working in the Camargue.

PROBLEMS The Reserve has only been slightly altered by human action including grazing and salt extraction from 150 ha over a hundred years ago, however, the same is not true for the Delta as a whole. The geomorphological evolution of the Delta was arrested in 1860, when it was dyked and since then, man has harnessed the water to his use (pumping it or discharging it into the Rhône) and therefore has some influence over nature conservation in the centre of the Delta. Changes in rice-growing have had a special impact, with the introduction of large volumes of fresh water (1950-1960) and then the gradual abandonment (1960-1976) of this type of cultivation. Tourists and campers are causing increasing disturbance and sometimes invade the coastal part of the reserve. Air pollution from nearby industry is increasing, and there is an inflow of excess water from agricultural land, which has washed out part of the salt content from some of the ponds and introduced increasing amounts of toxic chemicals. Hunting close to the reserve threatens some game species.

PRINCIPAL REFERENCE MATERIAL

For over 50 years numerous scientific papers have been published on ornithology in the reserve, and more recently on botany, hydrobiology, hydrology, parasitology and general ecology. The best general view is in Actes de la Réserve de Camargue, appearing biannually in La Terre et La Vie.

- Biber O., 1975. Bibliographie de Camargue. 19th and 20th Comptes Rendus de la Station Biologique de la Tour du Valat. pp 16-53.
- Conseil de l'Europe. Octroi du Diplome Europeen pour la Sauvegarde de la Nature. Reserve Naturelle de Camargue, France. Strasbourg, 1966.
- Le Courrier de la Nature. Special Reserve de Camargue. No 35, January-February 1975.
- Biosphere Reserve nomination submitted to Unesco.

CONTACT ADDRESS

- Réserve Nationale de Camargue, La Capelière, 13200 Arles, France.
- Société Nationale de Protection de la Nature (manager), 57 rue Cuvier, 75005 Paris, France.

TUNISIA

ICHKEUL

MANAGEMENT CATEGORY National Park, Biosphere Reserve, World Heritage Site.

TYPE Wetland

ANNOTATED DESCRIPTION Ichkeul lake is almost the only remaining example of a number of large, shallow lakes which once occurred in North Africa. It is also one of the principal sites in the entire Mediterranean region for the wintering of waterfowl.

GEOGRAPHICAL LOCATION The Park is situated on the Mateur plain in the Gouvernorat of Bizerte, northern Tunisia. It lies 20 km south-west of Bizerta and 60 km north-west of Tunis. 37°10'N- 09°40'E.

AREA 12,600 ha

DATE ESTABLISHED 1980

LEGAL PROTECTION The National Park was established on 18 December 1980 by Presidential Decree No. 80-1608. It was accepted as a Biosphere Reserve on March 77 and as a World Heritage Site in 1979.

LAND TENURE Government owned

CLIMATE Average annual temperature is 18°C (11.3°C in winter, 25.2° in summer). Average annual rainfall is 625 mm (103mm in winter, 30 mm in summer). About 300 million cubic metres of rainwater pour into the lake each year. The dominant winds are from north and west.

PHYSICAL FEATURES The Park consists of an isolated, wooded massif or Djebel (511m), probably a lake island at one time, located on an alluvial plain, and a permanent lake, lake Ichkeul (8,700 ha in summer), connected to the sea via Lake Bizerta and the Tindja Canal. Lake Ichkeul (some 1.5m below sea level) is fed by four fresh water rivers which dry up in summer, causing the level of the lake to fall and salt water from Bizerta lake to flow in. The following geological elements can be distinguished: the Djebel Ichkeul composed of Triassic and Jurassic formations (matamorphosed limestones with pseudo-Dolomitic aspects - marbles); the northern fringe, with its late Tertiary and Quaternary outcrops, which contain a valuable paleontological fauna (Anancus osiris, Elephas planifrons, Stylohipparion libycum, Libytherium maurusium, Testudo gigans, T. emys) of the Villafranchian (late Pleistocene) age ; the endorheic basin of the lake and the marshes composed of Quaternary alluvia.

VEGETATION The vegetation of the Park is representative of the thermo-Mediterranean belt with north-African affinities. The Djebel is covered with a grouping of Olea europaea, Pistacia lentiscus and Smilax aspera. It forms an ecosystem varying from fairly dense pure olive groves, to associations in which other species co-dominate, especially Euphorbia dendroides on the south-east versant and Juniperus phoenicea on the northern versant. The Djebel has a rich variety of northern Tunisian plant species including Teucrium shoenenbergeri (a species endemic to Tunisia), Notholena velleae, Ceratonia siliqua and Tetraclinis articulata. The marsh vegetation is dominated by Scirpus maritimus, S. lacustris, S. litoralis, Typha angustifolia, and Tamarix africana. Lake vegetation is mainly composed of Potamogeton pectinatus, Phragmites communis and Ruppia ssp.

FAUNA The Ichkeul wetland plays an essential role in the Paleoarctic waterfowl cycle hosting about 200-300,000 birds. The most numerous species are Anas penelope, Aythya ferina and Fulica atra. Ichkeul is the most important wintering station in the Maghreb for Aythya ferina (100,000) and Anser anser (7,000). More than 185 different bird species are found in Ichkeul including Casmerodius albus, Plegadis falcinellus, Ciconia nigra, Phoenicopterus ruber, Hieraaetus pennatus, H. fasciatus, Falco peregrinus, Neophron pernopterus, and Plyonoprogne rupestris. The otter (Lutra lutra) is rather rare on the shore of the lake, whereas porcupine (Hystrix cristata), mongoose (Ichneumon herpestes), Genetta genetta and wild cat (Felis sylvestris lybica) are commonly found on the Djebel. The Ichkeul water buffalo, (Bubalis bubalis), is being reintroduced into the marshes. No other buffalos exist in Tunisia at the present time. The principal fish species are Anguilla anguilla, Mugil cephalus, M. ramada, Dicentrarchus labrax, Barbus barbus, Solea solea and Alosa fallas.

MANAGEMENT Hunting is prohibited, fishing and grazing are controlled. There is a locally based park director and two wardens. Patrolling activities are carried out by the National and Regional Brigades. A museum is under construction and exhibits are in preparation. The Park has no budget at present but financial support for conservation activities has been provided by international organizations and bilateral cooperation programs. A management plan was produced by the University College London and a conservation program was approved by a Co-ordinating Committee formed by various Tunisian authorities. The principal management objectives are to control water-level and water salinity of the lake in order to maintain and develop areas of Potomogeton and Scirpus vegetation which is the major food source for migrating birds. This is to be achieved through the construction of a sluice on the Tindja Canal to exclude sea water from the lake and retain winter flood water and the filling of the drainage canal across the Djoumine marshes.

USES About one hundred families live in the Park area and some controlled grazing is allowed. Aquaculture is carried out by the Office National de la Pêche. Several warm water springs around the foots of the Djebel are much visited during the spring. Some bird watching and recreation by local and foreign tourists take place especially in the winter. Studies on the biological environment of Lake Ichkeul and its hydrology have been carried out by the Ministry of Agriculture, the Salammbo Oceanographic Institute and University College London. Waterfowl counting is undertaken by the "Station Biologique de Tour du Valat", Camargue, and the University College of London.

PROBLEMS

The construction of dams in the rivers which feed the lake with freshwater is endangering the Ichkeul ecosystem. Major habitat loss as a wintering, feeding and roosting place for waterfowl would eventually result from the salinization of the lake and dessication of the marsh vegetation. Some reclamation of land for agriculture and overgrazing by domestic stock also coming from the surrounding areas occur in the marshes. The death of 18 of the water buffaloes reintroduced in 1980 has been ascribed to malnutrition caused by overgrazing by domestic stock on the marshes. The massive use of fertilisers and herbicides in the cultivated lands around the marshes might cause eutrophication and disrupt the benthic food-chains. Open-cast stone quarries are found on the southern versant of Djebel Ichkeul.

PRINCIPAL REFERENCE MATERIAL

- Hollis G.E. 1983. A Faisability Study for Sluice on the Oued Tindja in the Ichkeul National Park, Tunisia. A Report on Aspects of Hydrology, Sedimentology and Ecology of the Project. Prepared for the Commission of European Communities.
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CONTACT ADDRESSES

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TUNISIA.

EBRO DELTA

Regional National Park

TYPE — Coastal wetland

ANNOTATED DESCRIPTION — The regional park covers the most valuable localities for waterfowl left of the wide Ebro delta area (64,000 ha) which is now under cultivation, mostly for the production of rice.

GEOGRAPHICAL LOCATION — 70 km south-west of Tarragona. 0° 30' E- 41° 09' N

AREA — 15,000 ha. 6.5 km of coastline

DATE ESTABLISHED — No information

LEGAL PROTECTION — Natural park established by Decree of the Catalu a region.

LAND TENURE — Private property

CLIMATE — Average annual temperature 20.5° C (winter average - 3.2° C, summer average 37.8° C). Average annual precipitation 500 mm.

PHYSICAL FEATURES — The park includes the sandy or dune areas at the northern and southern tips of the delta (Punta del Fangar and Punta del Alfaques), several saline brackish lagoons (Goleta, Canal Vell, Platc hola, Anfacada, Zancada, Enca izada) and the islands of Buda (1,300 ha) and San Antonio.

VEGETATION — Rests of white poplar wood Populus albae and Tamarix africana. In places, there are fairly extensive patches of dense reedbed.

FAUNA — The delta is still very important for wintering coots Fulica atra and duck especially Wigeon Anas penelope and Shoveler A. clypeata but also Mallard A. platyrhynchos, Teal A. crecca, Pochard Aythya ferina, in numbers up to 35,000. Flamingos Phoenicopterus ruber are often present in the saltpans on the south of the Los Alfaques peninsula, which also attracts waders, gulls and terns. Quite a number of species stay to breed, including Purple Heron Ardea purpurea, Mallard, Red-crested Pochard Netta rufina, Coot Fulica atra (c. 1000 pairs), Kentish Plover Charadrius alexandrinus, Herring Gull Larus argentatus, Common Tern Sterna hirundo and Whishered Tern Chlidonias hybrida.

MANAGEMENT — Managed by the General Directorate of Medio Rural de la C.A. de Cataluna. Shooting on the lagoons La Enca izada and Zancada is under ICONA control.

USES Within the Regional Park area there are 1500 permanent residents (villages of Amposta, Rosella, San Carlos de la Rapita, Tortosa) and 25,000 temporary residents. 250,000 persons visit the area each year for bird-watching and cultural reasons.
Fishing with traditional techniques is carried out in the lagoons.
The avifauna of the delta has been well studied by the Institucio Catalana in Barcelona.

PROBLEMS The area is threatened by urbanization and drainage projects, and the possibility of oil exploration within the delta. Heavy tourist pressure and massive use of pesticides for agriculture also constitute a problem.

PRINCIPAL REFERENCE MATERIAL

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CONTACT ADDRESS Don Juan del Peso Diaz, Servicio del Medio Natural de la Comunidad Autonoma de Cataluna, C/ Corcega 329, 5 Planta, 08037 Barcelona, Spain. Tel. (93) 2372991.

NAME Remaining 'valli' in the Comacchio district and Sacca di Bellochio

GEOGRAPHICAL LOCATION 44°35'-38'N, 12°10'-16'E. Situated about 14 km due north of Ravenna in Ferrara Province, Emilia Romagna.

AREA Contiguous Ramsar sites: Comacchio dam 13,500ha; Sacca di Bellochio 223ha.

DEGREE OF PROTECTION Azienda Valli Comacchio and Orsi-Mangelli Preserve are privately owned and the wetland complex contains several private bird sanctuaries and hunting reserves in which hunting is controlled. The remaining area (Ente Delta Padano) is state owned. The complex also includes a Landscape Reserve and Hydrological Reserve in which the water regime is regulated. 1,000ha of bird refuges with adequate protection have been established. The competent administrative authority in charge of implementing the convention is the Ministry of Agriculture and Forests (General Direction of Mountain Economy and Forests). Sacca di Bellochio was designated as a Ramsar site after August 1979. The residual plains of Comacchio were designated as a Ramsar site in August 1981.

SITE DESCRIPTION The designated sites comprise the residual Valli di Comacchio and the adjacent Vene Bellochio which extend from the Reno River estuary on the Adriatic to Agosta dam on the western boundary and from Comacchio township in the north to the banks of the Reno River in the south. Valli di Comacchio are the remnants of a large coastal and inland complex of lagoons and marshes which were extensively drained since the 1850s for agricultural purposes. The valli: Fossa di Porto, Campo and Lido di Magnavacca constitute a lagoon (maximum depth 2.5m) fed by inflow from the sea and freshwater rivers, particularly the Reno. They are partially separated from one another by sand and shell banks and small islands which indicate historial shorelines. Sacca di Bellochio is part of the Vene Bellochio which are a complex of saltmarshes and parallel basins bordering the Adriatic. The submerged vegetation comprises mainly Chara spp., Lamprothamnium papulosum (Vene Bellochio and Valle Lido di Magnavacca) and tassel pondweed Ruppia spiralis (Valle Fossa di Porto). Halophytic vegetation includes pure stands of shrubby glasswort Salicornia fruticosa and associations in which dominant species include A. herbacea or sea blit Suada maritima and saltwort Salsola soda or couchgrass Agropyron elongatum and golden samphire Inula Crithmoides. Occasional freshwater bodies support reedbeds of Phragmites communis and glasswort Salicornia. Orsi-Mangelli hunting preserve is the only uncontimated area at the northern end of the marsh and is partially covered by woods of stone pine Pinus pinea.

CRITERIA FOR INCLUSION

INTERNATONAL AND NATIONAL IMPORTANCE The wetland complex supports a rich avifauna including breeding and winter migrant populations. Breeding birds include black-winged stilt Himantopus himantopus, avocet Recurcirostra avosetta, purple heron Ardea purpurea, mallard Anas platyrhynchos, garganay A. querquedula, northern shoveler A. clypeata, pochard Aythya ferina, white-eyed pochard A. nyroca, shelduck Tadorna tadorna, redshank Tringa totanus, collared pratincole Glareola pratincola, least tern Sterna albifrons, Caspian tern S. caspia, sandwich tern S. sandvicensis, common tern S. hirundo, gull-billed tern A. nilotica, Mediterranean gull Larus melanocephalus, slender-billed gull L. genei, herring gull L. argentatus and bearded tit

Panurus biarmicus. Hundreds of thousands of passage and wintering wildfowl visit the wetland complex including pochard (over 20,000), coot Fulica atra (about 40,000), bean goose Anser fabalis, white-fronted goose A. albifrons, Eurasian wigeon Anas penelope, gadwall A. strepera, teal A. crecca, mallard, northern shoveler, white-eyed pochard and tufted duck Anas fuligula. The otter Lutra lutra (V) is thought to still be present in Orsi-Mangelli preserve.

CHANGES IN ECOLOGICAL CHARACTER Traditional fishing practices are being replaced by fish farming projects with associated excessive clearing of Salicornia vegetation to enlarge the fish ponds. The northern area of the marshes is completely degraded and the wetlands are slightly contaminated by cropspray and water pollutants carried in by the River Reno. Since the mid 1950s some 25,000ha of Valli di Comacchio have been drained for cultivation. The reclamation programme has been suspended but there is still some degree of threat from agriculture in Orsi Mangelli as well as in the rest of the Comacchio Valley.

MANAGEMENT PRACTICES The inflow to the Valli from the sea and the Reno River is fully controlled. Orsi-Mangelli hunting preserve is well managed with shooting maintained at a moderate level.

SCIENTIFIC RESEARCH AND FACILITIES Hydrobiological research projects by the Universities of Bologna and Ferrara. Studies have been undertaken concerning the establishment of a regional park.

PRINCIPAL REFERENCE MATERIAL

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Additional references:

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