EP

United Nations
Environment
Programme

UNEP/(DEC)/MED WG.190/Inf.11
10 July 2001

ENGLISH
ORIGINAL: FRENCH

MEDITERRANEAN ACTION PLAN

Meeting of MAP National Focal Points

Athens, 11-14 September 2001

GUIDELINES FOR IMPACT ASSESSMENT ON SEAGRASS MEADOWS

UNEP
Athens, 2001

Contents

Foreword

Today the coast is seen as an "eco-sociosystem", i.e. a complex system where natural environment and human activity interact (COI, 1997). An area where sky, land and sea meet, a mosaic of terrestrial and aquatic ecosystems, the coastline is seen as an area that is particularly fragile and coveted because the coastal strip is narrow and is a favourite site for a number of economic activities (e.g. urbanization, fishing, aquaculture, boating and tourist activities). The coexistence of these various activities, where one frequently excludes the other, gives rise to a host of problems and clashes of interests. They disturb the functioning and stability of the coastal ecosystems, particularly the marine phanerogam meadows, and put at risk their future existence. And the meadows seem to be key plant formations in terms of biodiversity, at planetary level.

Thus, in the context of the Mediterranean Action Plan, the Contracting Parties to the Barcelona Convention in 1999 adopted an Action Plan for the conservation of marine vegetation in the Mediterranean Sea. This plan aims at enabling macrophytes and the marine vegetation formations to be preserved by introducing suitable management tools. This must, via the steps adapted (e.g. the law) ensure that these formations are protected, prevent their degradation, and allow them to be maintained in a satisfactory state of conservation.

To carry out this task successfully, it is first necessary to gain a better knowledge of the Mediterranean meadows (e.g. their features, their distribution) and the stresses to which they may be subjected, in order to attempt, in a second phase, to reduce these. Achieving this second point means (i) introducing laws to protect species, (ii) setting up specially protected areas permitting the meadow habitats to be protected, and (iii) strengthening existing regulations, particularly as regards impact studies. Impact studies in fact aim at making a prospective analysis when a development that could harm the marine environment is under consideration. Insofar as up to now few Mediterranean countries seem to have specific regulatory frameworks that allow these plant formations to be taken into account (RAC/SPA, 2000), it is necessary to draft guidelines enabling all the Mediterranean countries together to carry out these impact studies.

The RAC/SPA is responsible for drafting these guidelines for carrying out impact studies. The present study comes within the context of this approach. It aims at:

- grasping the main features of the meadows and identifying the main dangers to which they are subject,
- clearly stating the present state of the regulations on impact studies in the marine environment,
- suggesting the elements which should be taken into account when carrying out an impact study, to reduce the threats to the meadows and permit their conservation.

The first part of this document frequently refers to the report of synthesis of data on meadow habitats in the Mediterranean Sea, drawn up by the RAC/SPA (2000). This report has been amended and expanded, according to the objective set.

The second and third part have been made possible by the effective collaboration of several partners (administrative and/or scientific) who are in their own countries taking part in managing or monitoring the coastline. The regulations on impact studies have indeed been established from answers to a standard questionnaire (Appendix A), and from the few legislative texts to which it was possible to have access. We should clearly state that not all the people contacted were able, by reason of their professional duties, to answer the questionnaire within the given time. The suggested synthesis does not therefore claim to be an exhaustive, detailed analysis of present legislation in each of the Mediterranean countries as regards the environment. Moreover, the analysis is not that of a legal expert specializing in environmental law, but of a biologist who is basically concerned by phanerogam meadows and their conservation.

Similarly, the elements to be taken into account in the context of meadow impact studies have been discussed by specialists. There too, the suggested elements do not claim to reflect the diversity of the analysis used by each research team working on meadows. The parameters offered were chosen according to the ease of their implementation and because these were classical parameters and/or had been standardised. But, in the interests of efficacity, a consensus should be reached on the choice of these parameters by the scientists responsible for monitoring meadows. The suggested list must therefore be seen as a rough draft and must be further and more widely debated before being finalised.

The main elements more directly related to the planning out of the impact assessment are summarised in Appendix B.

Marine phanerogam meadows

I. Introduction

Marine phanerogams are continental monocotyledonous angiosperms which, at the end of the Secondary (some 120 million years ago), returned to the marine environment. Like the terrestrial 'herbaceous plants' from which they spring, they possess an erect foliar system, borne on stems or rhizomes. Unlike other immersed vegetation (e.g. algae) they flower, fruit and produce seeds. They also have a true root system and an internal system for transporting gases and nutriments. They constitute an ecological group formed by a small number of families and species (Kuo & Den Hartog, 2000). Today, marine phanerogams give rise to dense formations called 'meadows', met with in practically all the coastal areas of the world (Short *et al.,* in press). These meadows are a feature of the infralittoral level, where they prefer to colonise the crumbly substrata.

All marine phanerogams share a set of characteristics (Kuo & Den Hartog, 2000), such as:

- they are able to live totally emerged (e.g. absence of stomata within the foliar tissues);
- they have an effective system for fixing themselves to the sediment;
- they are adapted to life in a salty environment;
- they have a hydrophilous pollination system (pollen transported by water);
- they are able to successfully compete with other marine vegetation (e.g. algae).

Marine phanerogams have several biological functions. We know that they play a part in managing fish stocks in the coastal environment and constitute a place for nurseries, shelter and food for a large number of animal species (Boudouresque & Meinesz, 1982). By regulating hydrodynamism, the meadows help maintain the coastal balance (Clarke & Kirkman, 1989).

Seven species of marine phanerogam have been signalled in the Mediterranean (Short *et al*., in press). They are *Cymodocea nodosa, Halophila stipulacea, Posidonia oceanica, Ruppia cirrhosa, Ruppia maritima, Zostera marina* and *Zostera noltii.* The two most widespread species are *Posidonia oceanica* and *Cymodocea nodosa. P. oceanica* forms vast meadows in the littoral area and very greatly affect benthic biotopes; *C. nodosa* meadows are often situated on one or other side of *P. oceanica* meadows. The mode of reproduction of these two species differs basically, for studies done in the Island of Ischia (Gulf of Naples, Italy) show that *C. nodosa* almost exclusively favours sexual reproduction whereas *P. oceanica* practically always uses asexual reproduction (Procaccini & Mazzella, 1996). This differing behaviour is perhaps not without consequence for the maintenance of both species in the face of anthropic activity. Sexual reproduction (permitting genetic mixing) increases the species' adaptability and gives it greater tolerance to environmental disturbance.

Apart from these two species, we notice the rarer presence of the *Zostera* genus (*Z. marina* and *Z. noltii*) and the introduced species *H. stipulacea,* which essentially

remains confined to the eastern part of the Mediterranean (Verlaque, 1994). Finally, in certain euryhaline lagoons, we notice the development of *Ruppia* genus (*R. cirrhosa* and *R. maritima*), which can develop even in the estuaries and graus.

A country-by-country statement of knowledge on these marine phanerogam meadows is given in RAC/SPA's report (2000). It shows that in certain sectors the data still remains very fragmentary.

II. Marine phanerogams of the Mediterranean[1]

1. Posidonia oceanica

Posidonia cretacea seems to be the oldest species. From the Tertiary (some 60 million years ago) the *Posidonia* genus seems to have invaded the seas and played a considerable part therein. *Posidonia* genus belongs to the Posidoniaceae family, an exclusively marine family that only contains the *Posidonia* genus (Kuo & Den Hartog, 2000). Today we know 9 *Posidonia* species: *P. angustifolia, P. australis, P. sinuosa, P. coriacea, P. denhartogii, P. kirkmanii, P. ostenfeldii, P. robertsonae* and *P. oceanica*. This last species alone is present in the Mediterranean (Figure 1).

<u>Morphological features</u>

The leaves of *P. oceanica* are ribbon-shaped, 40 to 140 cm long, 7 to 11 mm wide, with 13 to 17 veins set in distichous manner. A section of the petiole of a leaf shows a true network of lacunae throughout the plant from the tip of the leaf to the end of the roots, called the aerarium, and all the tissues are steeped in gas. This is the main difference between the marine phanerogams and the marine vegetation, which never left the sea. The base of the leaves or petiole is like a sheath and continues on the rhizomes after the limb has dropped off. These petioles, which cover the aged parts of the rhizomes in a characteristic way, are incorrectly called "scales". The leaves, gathered together in fascicles (from 5 to 8 leaves) at the tips of the stems, have a life of between 5 and 13 months (Pergent & Pergent-Martini, 1990) and are formed and fall throughout the year (Caye, 1989).
The woody stems, totally or partially buried in the sediment, are called rhizomes. They may be plagiotropic (horizontal) or orthotropic (vertical), measuring up to 1 cm in diameter.

The plagiotropic rhizomes may change into orthotropic, and vice versa. Horizontal growth allows colonization of empty spaces around the meadow, while the rhizomes' vertical growth allows the plant to struggle against being buried and causes a slow rising of the bottom. The root system is made up of thick (over 2 mm) roots that are relatively short, woody and few in number.

This web of rhizomes and sediment, which seals off the interstices, forms a very characteristic whole, called "matte". Over time, when the growth/sedimentation balance is achieved, the meadow and the underlying matte slowly rise to the surface and may be several metres in extent. The speed at which the matte rises varies according to sectors studied. Long thought to be on average 1 metre per century

[1] Data taken from RAC/SPA's report (2000)

(Molinier & Picard, 1952), it seems in the light of more recent work to be slower (from 34 to 86 cm, in Pergent & Pergent-Martini, 1990).
At the bottom of sheltered bays, the rising of the matte allows the meadow to reach the surface and the leaves spread out over the surface. Then we speak of a "fringe-reef".

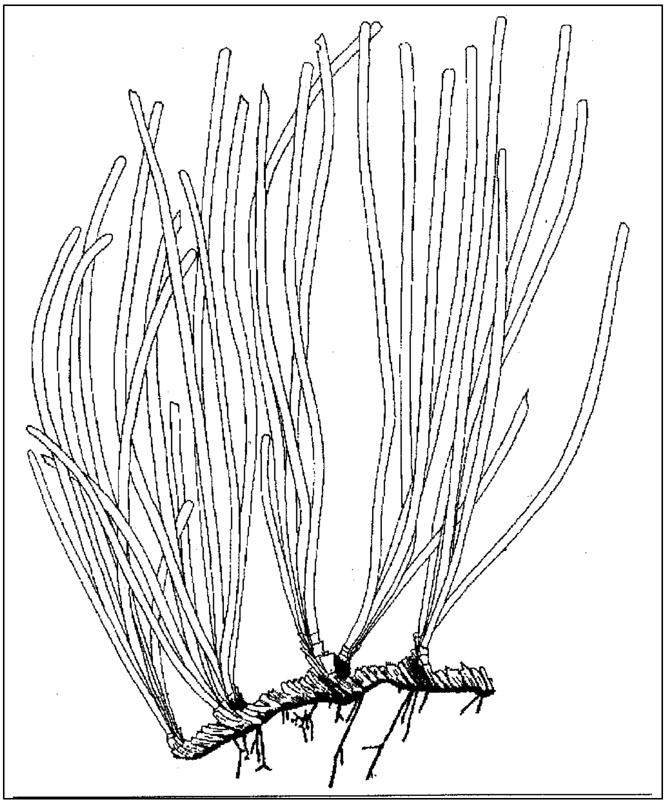

Figure 1: General view of *Posidonia oceanica* (Boudouresque & Meinesz, 1982)

Between the emersion area and the coast, water circulates with difficulty, warming up in summer, becoming less salty during storms, and this brings about the death of *P. oceanica.* At the same time, the upwards growth of the meadow continues and leads, on the sea side, to the emersion of new individuals, which mark off a kind of "lagoon", separated from the open sea by a "barrier reef" (Molinier & Picard, 1952; Boudouresque & Meinesz, 1982).

P. oceanica flowers in the autumn. The inflorescences, carried by a 10 to 25 cm long peduncle, contain 3 to 5 hermaphrodite flowers; the ovaries end in very jagged stigmata; the stamens have basal anthers and a frenum that extends beyond (Den Hartog, 1970). The flowers have no petals, the pollen being spread in the form of viscous filaments, which float along on the currents, and the ovaries are equipped with denticles, which catch the pollen as it floats past. The flowering of *P. oceanica*, about which we still know very little, is a relatively rare phenomenon. Fertilization usually produces fruits, called "sea olives". At maturity, these detach themselves from the mother plant and go off to ensure the broadcasting of the species via their ability to float. Later they sink to the sea bed and, if the nature of the substratum and the physico-chemical factors are favourable, germination of an embryo, freed by the fruit's dehiscence, may occur. Only very rarely does germination result in the existence of young individuals. This is perhaps the result of the mechanism whereby the seeds are dispersed, which causes the loss of many fruit along the coast.

The *Posidonia* thus have sexual reproduction via germination and asexual reproduction via the plant propagation of the underground rhizomes and the natural propagation when rhizomes are pulled off the plant during storms. But a comparison of the DNA and the genetic proximity observed in the various Mediterranean stocks confirms the fact that asexual reproduction is this species' favourite way of reproducing itself (Procaccini & Mazzella, 1996).

Ecological features

The *P. oceanica* meadow constitutes the most important Mediterranean ecosystem, given its major ecological role: it is a pole of biodiversity, sheltering 20 to 25% of Mediterranean species and encouraging the recruitment of economically important species (for spawning grounds and nurseries; Boudouresque & Meinesz, 1982). The meadow is a biocenotic complex, a superpositioning of three biocenoses:

-a biocenosis with sciaphilic affinity linked to the rhizomes,
-a biocenosis with photophilic affinity linked to the leaves,
-and the endogenic biocenosis of the mattes.

The meadow has a high primary production (from 130 to 1,280 g dry weight per square metre per year, i.e. 2 to 10 tons per hectare per year; Pergent-Martini *et al*., 1994). These values are to be compared with the two tons produced by a tropical forest or the 4 to 6 tons produced by a field of cereal (Boudouresque & Meinesz, 1982). As with many marine phanerogams, the *in situ* way of assimilation of the primary production is by detritus-eaters (Pergent *et al*., 1997). In fact, little (3 to 10%) of the primary production is directly consumed by herbivores. Most of this foliar production remains inside the meadow and supplies the bed or is sent off to other ecosystems (about 30%; Pergent *et al*., 1997). This exporting is done both towards new heights and possibly deposited on the beaches as cushions, and at depth. It then represents a considerable source of food for organisms at the circalittoral level or at greater depths, when the continental shelf is sufficiently narrow.

One of the consequences of plant photosynthesis is the production of oxygen. *P. oceanica* meadows are thus an important factor for oxygenating water. For example, at 10 metres depth, in Corsica, one square metre of meadow gives off up to 14 litres of oxygen a day (Bay, 1978 in Boudouresque & Meinesz, 1982).

Finally, the meadow plays a part in stabilizing the sea beds, slowing down the swell and waves and encouraging the depositing of sedimentary particles (Boudouresque & Meinesz, 1982).

Distribution

Despite rather suspicious sightings in the last century, in Portugal and the Basque coast (Den Hartog, 1970), the species is absent from the Black Sea and the Atlantic. The sighting of *P. oceanica* in Texas by American authors is probably due to confusion with *Thalassia testudinum* Banks ex Konig (McMillan *et al*., 1975). *P. oceanica* is a strict endemic of the Mediterranean. The meadows cover between 1 and 2% of the sea beds, i.e. 35,000 sq. km (Pasqualini *et al*., 1998), and constitute the main climax population. They are widespread in most of the Mediterranean, with the exception of the waters around Gibraltar (Molinier & Picard, 1956), the Sea of Marmara and the coasts of Israel (Lipkin, 1977). On the Syrian-Lebanese coasts, the *P. oceanica* meadow has only been found in two places (north-west of the Island of

Rouad and near Ras-Ibn-Hani; Thiebault, 1953), where it appears to be much threatened (Mayhoub, 1976).

The maximum bathymetric extension of *P. oceanica* meadows (or lower limit) is between 30 and 40 metres deep in clear water. When the water is particularly transparent, the species can exist up to 45 metres deep (e.g. Corsica, Malta). The meadows are rare on the Languedoc coastline, from the Camargue to the Pyrenees (France) and off the Nile delta (Aleem, 1955), doubtless because of the fact that the sedimentary movement is too great and because of the lack of saltiness. *P. oceanica* is extremely stenohaline, disappearing when the salinity is under 33‰, which explains its total absence from the brackish ponds of Languedoc, of the eastern coast of Corsica and of Tunisia. But the species can stand relatively large heat variations (from 9 to 29°C) and can be seen on very varied substrata (silt, fine sand, average and coarse sand, rocks), even if it prefers crumbly substrata, rich in organic matter.

2. Cymodocea nodosa

Its frequency, density and geographical range make *C. nodosa* the second species of marine phanerogam in the Mediterranean (Boudouresque *et al*., 1994; Figure 2). *C. nodosa* belongs to the Cymodoceaceae family, an exclusively marine family, which includes the genera *Amphibolis, Cymodocea, Halodule, Syringodium* and *Thalassadendron* (Kuo & Den Hartog, 2000). The *Cymodocea* genus is represented by 4 species widely distributed in tropical and subtropical seas, except for the American continent (Den Hartog, 1970).

Morphological and ecological features

The leaves of *C. nodosa* are ribbon-shaped and 10 to 30 cm long, denticulated at the tip. They have 7 to 9 parallel veins and are rich in cells with tannin. Rhizomes are delicate, orthotropic and plagiotropic. The rhizomes and roots are usually buried in the first centimetres of the sediment.

The plagiotropic rhizomes may grow 2 metres a year (Boudouresque *et al*., 1994). It is a pioneer species, appreciating sandy bottoms that are rich in organic matter (Mazzella, 1990). The species is perennial (one rhizome may live some ten years), but after death the rhizomes decompose much more rapidly than those of *P. oceanica.*

This gives rise to either superficial mixed meadows in association with the marine phanerogam *Z. noltii* and the alga *Caulerpa prolifera,* or to monospecific meadows which precede or follow on *P. oceanica* meadows. It also colonises dead *P. oceanica* mattes.

Like *P. oceanica*, it has an efficient asexual reproduction, but unlike *P. oceanica* sexual reproduction is frequent (Caye, 1989). The flower is not a hermaphrodite one; the male flowers are reduced to a stamen and the female flowers bear two free ovaries. As in *P. oceanica*, the flowers are borne on orthotropic axes (Caye, 1989). Each of the two ovaries may bear a flattened, semicircular fruit. In dense meadows, the rate of fruiting may be as high as 50% (Caye, 1989). The seeds are found in abundance in the sediment all year round.

The species seems to play an important part in *P. oceanica's* colonisation dynamics, particularly by encouraging the humification of the substratum and helping create a soil (Molinier & Picard, 1952). In the parts of the eastern Mediterranean where *P. oceanica* is absent, *C. nodosa* seems to play the same part. And Drew (1978) remarks that in shallow water *C. nodosa* seems to grow and produce better than *P. oceanica*. Moreover, the species is well liked by grazers, especially the sea urchin *Paracentrotus lividus* and the fish *Sarpa salpa*. But as regards this latter species, *C. nodosa* meadows are often confined to refuge areas, which are difficult for it to reach.

Distribution

C. nodosa is essentially found in the Mediterranean, even if it is also present in the eastern Atlantic, from south Portugal to Senegal and round the Canary Islands. In the Mediterranean, it develops in the open sea where it prefers to colonise relatively sheltered biotopes, port areas, the interior of sea walls and superficial sandy beds between the coast and the upper limit of the *P. oceanica* meadows (Buia *et al*., 1985a). It may also give rise to vast meadows between the surface and about thirty metres down (Mazzella, 1990). More tolerant to desalinated water, in a lagoon environment, *C. nodosa's* bathymetric extension is smaller (-2 to -3 m.), but it colonises large areas, particularly in the lagoons, which offer sufficient salinity.

3. Zostera noltii

Z. noltii seems to be often associated in the Mediterranean with *C. nodosa* (Figure 3). It belongs to the third family of exclusively marine monocotyledons, the family of the Zosteraceae, which includes the genera *Heterozostera, Phyllospadix* and *Zostera*. Originally called *Zostera nana* (Cavolini, 1792 in Caye, 1989), this species was given its present name in 1965.

Morphological and ecological features

Morphologically speaking, *Z. noltii* seems close to *C. nodosa*, but a great heterogeneity as to the size of the vegetative system (from 4 to 20 cm) can be noticed. Its ribbon-shaped leaves are narrow and have 1 to 3 veins. The foliar fascicle is made up of 2 to 5 leaves. The leaves are wrapped at their base in a 1 to 4 mm sheath that is split all the way along. The rhizomes essentially show horizontal growth (Den Hartog, 1970). The rhizomes generally run along the surface of the sediment and have a well-developed root system. The fine roots are buried up to over 10 cm in the sediment.

It is well adapted to strong light but can bear relatively turbid water. It is a euryhaline species, which can bear low salinity levels (9 to 10‰; Den Hartog, 1970), which explains its presence in lagoons behind *P. oceanica* barrier reefs (Molinier & Picard, 1952).

Z. noltii depends on areas where the motion of the tides is present and prefers fairly coarse sediments. Its bathymetric distribution is generally restricted (up to 4 metres deep; Loques, 1990).

This phanerogam is able to reproduce sexually or asexually. The inflorescence is composed of mono-sexual flowers. Flowering has been recorded from April to late August (Loques *et al*., 1988). Fertilization gives rise to a smooth black ellipsoidal fruit 1 to 2 mm long. The seed is reddish-brown, the same size as the fruit (Den Hartog,

1970). Low salinity levels encourage germination of the seeds (Loques *et al*., 1990). Despite a sizeable reproductive effort and considerable production of seeds, the species is mainly propagated by in vegetative manner (Loques, 1990; Harrisson, 1993).

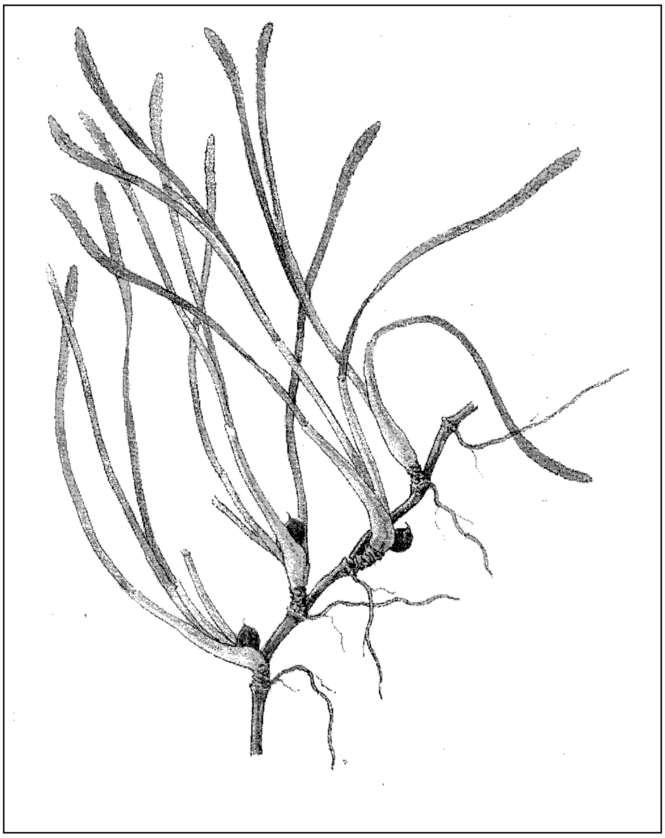

Figure 2: Representation of *Cymodocea nodosa* (Bonnier & Douin, 1990).

Figure 3: Representation of *Zostera noltii* (Bonnier & Douin, 1990).

It plays an important part in littoral lagoons and in certain sheltered bays with large variations in salinity, where it replaces the other marine phanerogams. It is generally considered to be a pioneer species (Laugier, 1998).

Distribution

Z. noltii is widely distributed over the European coasts of the Atlantic Ocean from Sweden to Mauritania but is rarer in the Mediterranean and in the Black Sea. It is the only marine phanerogam to colonise the relic continental seas such as the Caspian Sea or the Aral Sea (Bellan-Santini *et al*., 1994).

In the Mediterranean, it develops in the open sea in superficial infralittoral biotopes, where it can give rise to vast monospecific or mixed meadows, on sandy-silty bottoms, from the surface down to 10 metres deep. But it is especially dependent on poikohalinic environments such as coastal lagoons and estuaries. It has been sighted in the Adriatic Sea, in Greece, in Egypt (Molinier & Picard; 1952: Bellan-Santini *et al.,* 1994) and in Tunisia (Cap Carthage, Salammbo, from Hammam-lif to Ras El Fartass, Sidi Rais, Gulf of Gabès, Bou Grara Sea, Bizerta lake, Bou Grara lagoon and the northern lake of Tunis).

4. *Zostera marina*

Zostera marina is the second species of the genus present in the Mediterranean (Figure 4).

Morphological and ecological features

Z. marina differs from *Z. noltii* in being bigger. It has creeping rhizomes that are from 2 to 5 mm thick, with many roots and a leaf at each joint. Short, erect branches bearing a fascicle of 3 to 8 leaves are born at the axil of the rhizome's leaves. The ribbon-shaped leaves are from 2 to 12 mm wide and up to 120 cm long, with 5 to 11 veins (UNEP *et al.,* 1990). At their base, the leaves are enclosed in a membraneous tubular sheath measuring between 5 and 20 cm long, generally wider than the leaves.

This eurythermic species can bear water from 0° to above 30°C. Like *Z. noltii*, it also tolerates wide variations of salinity (from the open sea to almost fresh water) but seems more ubiquitous than that species as regards the nature of the substratum (coarse sand to silt). Light seems to be the main factor limiting this species' bathymetric extension. It develops in sub-tidal areas but can also make incursions into the inter-tidal area. Although it is found between 3 and 7 metres deep in the Atlantic and up to 10 metres deep in Mediterranean waters, it is found at depths of up to 18 to 30 metres along the Pacific coasts of the U.S. (Den Hartog, 1970; Duarte, 1991). It tolerates heavy hydrodynamic stress. An increase in the speed of the currents gives rise to a decrease in the leaf canopy and greater development of the root system (Laugier, 1998).

Able to reproduce both sexually and asexually, this species is able to reproduce at low temperatures (5°C). The full flowering process takes from 30 to 60 days and the seeds are set free between May and August. The monosexual flowers are contained in a terminal spike. After fertilization, they give rise to ellipsoidal or ovoid fruits that are from 2.5 to 4 mm long. The seeds are the same shape. They may germinate in early August until September, but germination continues, though at a low rate, during the winter and spring. The reproductive effort varies according to the habitat, but the populations are essentially maintained through vegetative reproduction (Harrisson, 1993).

Distribution

Z. marina is widespread in the northern hemisphere (Den Hartog, 1970), whether in the Pacific (U.S., Mexico), or the northern Atlantic (U.S., Canada, Baltic Sea, Denmark, Germany, U.K., Ireland, Holland, France, Spain, Portugal; UNEP/IUCN/GIS Posidonie, 1990). This is a species with cold affinity, the only marine phanerogam to reach the Arctic Circle (it is found under 1 metre of ice in the Arctic). It has also been sighted in the Black Sea (Romania, Turkey).

In the Mediterranean, it is especially confined to very superficial and sheltered infralittoral biotopes (mainly coastal ponds) where it may constitute little meadows. Extremely localised in the open sea, it has been sighted:

- In Algeria, in the Bou-Ismail station in the open sea (Molinier & Picard, 1953; Peres & Picard, 1958).
- In Spain, *Z. marina* is only known in the Port Lligat (Cap Creus) and Els Alfacs (Ebro delta) bays, where this species constitutes very localised populations

inside *Z. noltii* and *C. nodosa* meadows. It is possible that the species does not exist anywhere else on the Spanish Mediterranean coasts; other sightings could be due to its being confused with *C. nodosa.*

- In France, this species is abundant in a certain number of brackish coastal lagoons (Salse, Thau; *in* UNEP *et al*., 1990); out at sea its stations are rarer: Fos Gulf (big meadow), Toulon harbour (very localised station; Verlaque & Tine, 1979 *in* UNEP *et al*., 1990).
- In Greece, *Z. marina* is only certainly present in the Gulf of Amvrakikos (Panayotidis, unpublished *in* RAC/SPA, 2000), and other sightings are doubtful.
- In Italy, it has been sighted in the northern Adriatic (Techet, 1906 *in* UNEP/IUCN/GIS Posidonie, 1990), the Venice lagoon (Rismondo *et al*., 1995), and the Gulf of Naples (Funk, 1927; Parenzan, 1956 *in* UNEP *et al*., 1990).
- In Malta, the only sighting (Gulia, 1873 *in* RAC/SPA, 2000) certainly springs from confusion with *C. nodosa.*
- In Syria and Lebanon*, Z. marina* is present (Thiebault, 1953; Mayhoub, 1976).
- In Tunisia, it is abundant in the Bizerta lake (Zaouali, 1980).
- In the Federal Republic of Yugoslavia, this species has been sighted, in particular by Zavodnik (1965 *in* RAC/SPA, 2000) and Avcin *et al*. (1974 *in* UNEP *et al*., 1990).

5. Halophila stipulacea

H. stipulacea belongs to the Hydrocharitaceae family. This family contains 17 genera, only three of them marine: the genus *Enhalus*, the genus *Halophila* and the genus *Thalassia* (Kuo and Den Hartog, 2000). The genus *Halophila* is made up of 10 species, which colonise the tropical areas of the world.

Morphological and ecological features

Unlike the marine phanerogams mentioned above, the leaves of *H. stipulacea* are oval, with petioles that are from 30 to 50 mm long and from 4 to 6 mm wide, with a jagged edge (Figure 5). The well-developed petioles widen at the base in a dissymmetrical sheath.

The genus *Halophil*a is alone in being able to constitute meadows at depths ranging from surface level to nearly 100 metres down in tropical regions (Duarte, 1991).
The flowers are solitary. The male flowers are pedicellate and made up of 3 stamens. The sessile female flowers have a reduced perianth.

Distribution

H. stipulacea is a species that is widespread in the Red Sea, which penetrated into the Mediterranean via the Suez Canal. It is also present in the Indian Ocean along the Saudi coasts (Kenworthy *et al*., 1993) and the eastern coast of India (Jagtap, 1996). Colonies of *H. stipulacea* have been sighted on the coasts of Lebanon, Turkey and Greece. The species is also present around the islands of Cyprus, Rhodes, Crete and Malta (Verlaque, 1994). The species progresses by following the dominant sea currents. Although *H. Stipulacea* is fairly well represented in the eastern Mediterranean, it is slowly moving towards the western basin and can now be found along the coasts of Sicily (Verlaque, 1994).

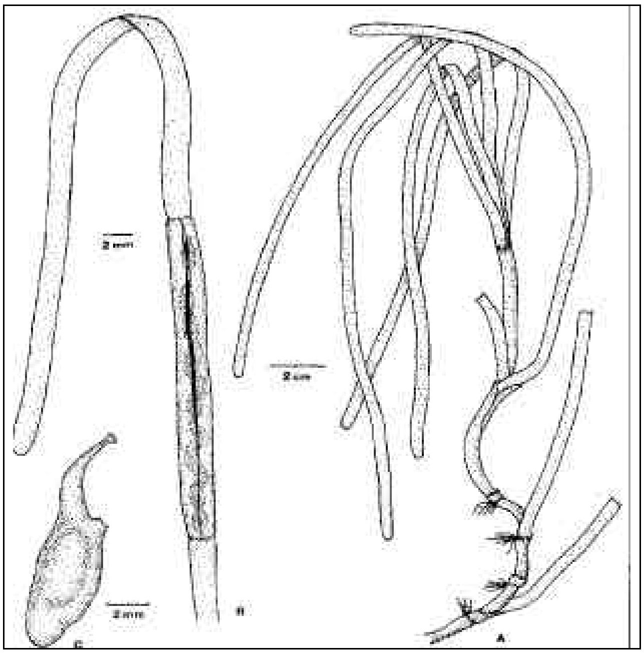

Figure 4: Representation of *Zostera marina* (A); detail of leaf (B) and fruit (C). From Phillips & Meñes (1988)

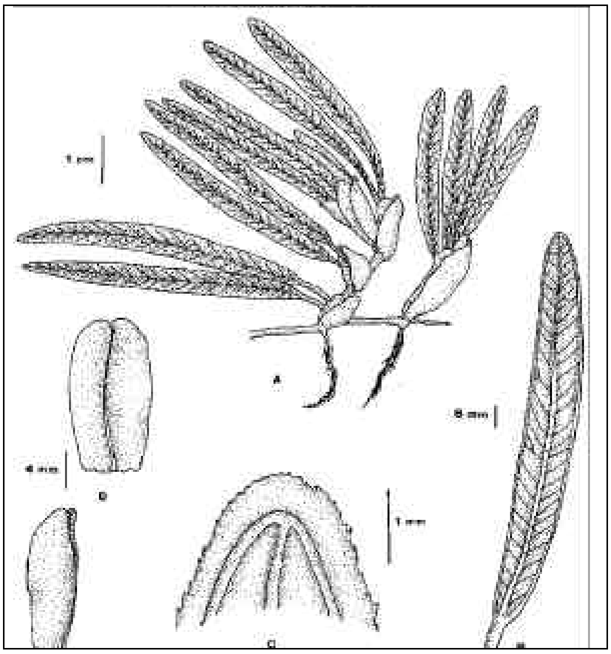

Figure 5: Representation of *Halophila stipulacea* (A); detail of leaf (B) and jagged edge (C); and fruit (D). From Phillips & Meñes (1988).

6. *Ruppia cirrhosa* and *Ruppia maritima*

R. cirrhosa ex spiralis, like *R. maritima,* belongs to the family of the Ruppiaceae. Within the *Ruppia* genus, only the species *Ruppia. aff. tuberosa* may be considered as a strictly marine species (Kuo & Den Hartog, 2000).

Morphological and ecological features

R. cirrhosa (Figure 6) and *R. maritima* (Figure 7) present a herbaceous rhizome with an extremely large number of branches, with very narrow, single-veined leaves with pointed tips. Both species are remarkable for their morphological criteria as regards fertile tips, number of chromosomes and pollination mechanism. Also, outside the flowering period, it seems hard to distinguish them *in situ.*

Eurythermic and euryhaline, both species develop in superficial biotopes (Verhoeven, 1975). They constitute vast monospecific meadows on mud, in coastal lagoons, which are not too salty. They can also give rise to mixed meadows in association with *Z. noltii* or *C. nodosa.*

Experiments have shown that *R. maritima* grows quickly and can be used successfully to restore meadows (Hammerstrom *et al.,* 1998).

For *R. maritima*, the inflorescences are formed by alternate hermaphrodite flowers. After fertilization, the green fruit has an asymmetrical ovoid shape (Buia *et al.,* 1985b). Sexual reproduction is usually efficacious and gives numerous seeds. Many birds eat the seeds (Powell *et al*., 1991).

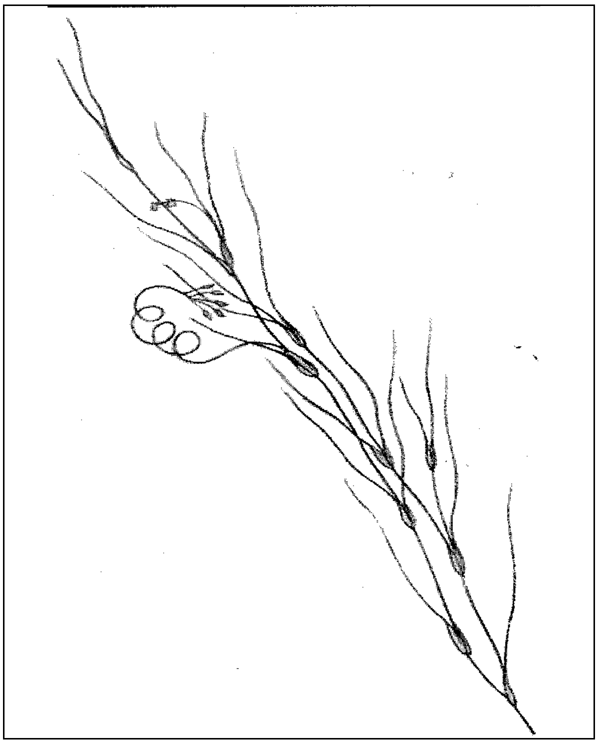

Figure 6: Representation of *Ruppia cirrhosa* (Bonnier & Douin, 1990).

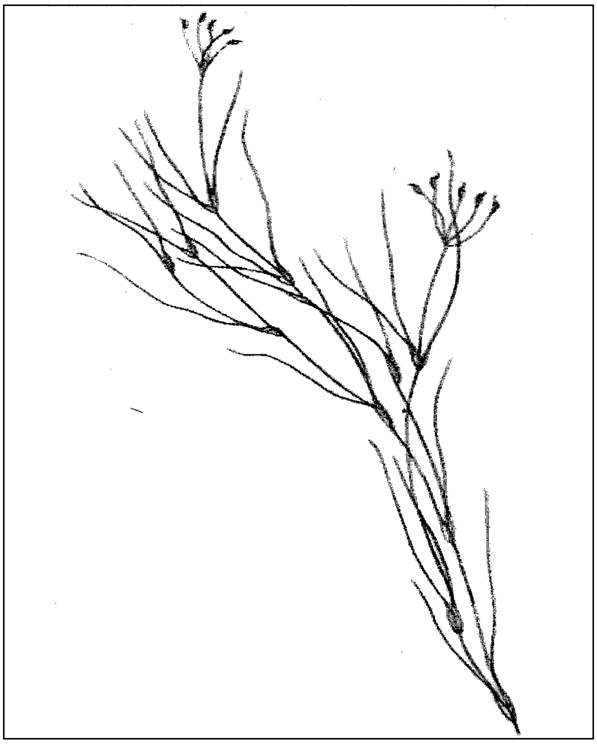

Figure 7: Representation of *Ruppia maritima* (Bonnier & Douin, 1990).

Distribution

R. cirrhosa and *R. maritima* are cosmopolitan species, present in many parts of the biosphere. Very frequent in the coastal lagoons of the western Mediterranean (Buia *et al.,* 1985b), the genus has even been sighted in open sea, in the Balearics (Ribera *et al*., 1997) and in Tunisia (G. Pergent, personal observation).

III. Threats to marine phanerogam meadows

Destruction or regression of the meadows have been reported at planetary level (Short & Wyllie Escheverria, 1996). This destruction may be caused (i) naturally, as the “wasting disease”, which affected *Z. marina* meadows between 1930 and 1933 and caused the destruction of about 90% of the Atlantic populations (Den Hartog, 1987) or by storms and cyclones regularly affecting formations in the inter-tropical areas (Short & Wyllie Escheverria, 1996) or (ii) by man. Because of their geographical siting (e.g. coastal shallows), marine phanerogam meadows are directly subject to impacts caused by human activity. This is usually expressed in the reduction of the area occupied by the meadows, particularly near big urban centres (Boudouresque, 1996). Thus, for *P. oceanica*, even if the regression does not imperil the future of the species, as regards the areas occupied (Pasqualini *et al.,* 1998) it is especially worrying because of the low speed of regeneration inherent to the species (Caye, 1989) and the size of the area lost since the 20^{th} century began:

- 10 to 30% in the Ligurian area (Bianchi & Peirano, 1995),
- 52% in the Alicante area (Ramos-Espla *et al*., 1995),
- 45% in the area round Marseilles.

The threats hanging over the meadows are manifold (e.g. excessive urbanization, over-frequenting by tourists, pollution, exploiting of marine resources). The last few years have seen many well-documented, exhaustive inventories made of them

(Boudouresque *et al*., 1994; Boudouresque, 1996; 1997). These syntheses show that both the marine phanerogams (as individuals) and their habitats are directly threatened.

Even if it is difficult to say which of the two phenomena is the more serious, use of the Meinesz classification (*in* Boudouresque, 1996; 1997), which suggests rating the impact according to the time needed for it to become reversible, shows that the destruction of habitats is by definition always irreversible and that the disappearance of individuals at best occurs over the long term, for annual species (e.g. *R. cirrhosa, R. maritima*) or pioneer species (e.g. *C. nodosa, Z. noltii*), and at worst is irreversible on a human scale for rare species (e.g. *Z. marina*) or climax species (e.g. *P. oceanica*).

1. Reasons for the disappearance of meadow habitats

The disappearance of meadow habitats is basically due to coastal development. This can be generated by the rise in coastal populations (e.g. building accommodation and communications routes, laying underwater cables) or the development of leisure activities such as boating or bathing (e.g. extending or creating ports, jetties and nautical bases, building alveolar beaches, constructing dykes).

Whatever the nature of the development, it results in a reduction of the coastal strip where meadows are likely to develop (Meinesz *et al*., 1993). This is especially problematic when the continental shelf is small, which is frequently the case in the Mediterranean. It is thought that sea beds of less than -50 metres, where the development is concentrated, only represent 5% of beds (Boudouresque, 1996). Thus, 16% of the Provence-Alpes-Côte d'Azur coast in France will become a man-made one (Boudouresque, 1996). This phenomenon also concerns the Balearics and the Catalan coast in Spain, Liguria and Sardinia in Italy, the Aegean coast in Turkey, and also the south of the island of Cyprus. Adding up all this development, it is thought that on a Mediterranean scale 2,000 km have become man-made over twenty years (Boudouresque, 1996).

2. Reasons for the disappearance of species[2]

The disappearance of species because of the deaths of individuals may be due to a multitude of causes (direct or indirect) that are of variable importance.

<u>Direct causes</u>
Direct causes are usually easily shown and generally only affect localized sectors of the shore. Thoroughly described in the literature (see the synthesis in Boudouresque, 1996; 1997), they are succinctly stated.
Direct causes consist in plants being pulled out by fishing gear or when boats cast anchor or when fascicles are destroyed by the use of explosives (e.g. fishing with grenades).

The use of bottom trawls or dragnets constitutes the main direct threat to the Mediterranean meadows. Although the law forbids the use of this gear on beds of under 50 m, or near the coasts, they remain in use (Relini, 1992 *in* Boudouresque, 1996). Trawls are abrasive to the sea bed, stir up sediment, unintentionally destroy

[2] Data taken from the RAC/SPA report (2000).

non-commercial species and thus cause long-term changes for benthic communities (Boudouresque, 1996). The damage done is thus considerable, all the more so in that a study done along the Corsican coast, where fishing constitutes a little-developed, marginal activity (with only 250 boats), shows that in certain sectors, meadows destroyed by dragnets represent up to 23% of the areas studied (Pasqualini *et al*., 1999).

Mooring boats can also harm the meadows. There are several kinds of mooring (e.g. anchors, isolated moorings and mother chains, moorings and floating landing stages). The immersion of moorings pulls off the fascicles and may cause the mattes to be abraded, immersed structures undermined and the substratum modified (Porcher, 1984). The boats' anchors give rise to similar phenomena, although to a lesser extent. Nonetheless, Francour *et al*. (1999) show that every anchoring causes an average 20 fascicles to be pulled out, which has its effect in sectors where an excessive number of tourists arrive in the summer season (e.g. up to 9,000 moorings recorded in three months around the Lavezzi islands in Corsica; Richiez, 1995).

Finally, destruction linked to the **use of explosives** as part of fishing activities seems at present to be anecdotal. These practices are forbidden in the national law of all the countries because of how they affect stocks and the environment (Boudouresque, 1996) and, when they continue to be practised, only affect small areas (generally less than one hectare; Pasqualini *et al.,* 1999).

<u>Indirect causes</u>

Any introduction into the marine environment may constitute an indirect cause of meadow mortality insofar as it modifies the chemical, physical or biological parameters of that environment.

Thus, (i) modification of the currents or rheological system of masses of water when the coast is being developed, (ii) the pouring out of various substances (e.g. nutriments, detergents, pesticides, hydrocarbons, trace metals) by rivers, the leaching of soils, or coastal discharge, (iii) the introducing of sedimentary particles during building in the maritime area and enlargement of beaches or by erosion, and (iv) the introduction of new species (e.g. micro-organisms, viruses, bacteria, invasive species) may constitute a real threat to marine phanerogams. However, the cause/effect relationship is often hard to prove, particularly since the geographical area affected may be extensive, and each of the factors taken separately does not cause death but only a lowering of vitality in individuals. Often it is only the conjunction of several of these factors, which by increasing the individuals' vulnerability, finally provokes a sizeable mortality.

Bearing in mind the whole set of observations carried out on a Mediterranean scale, it seems possible to set out a few principles:

Concerning temperature

Discharge of hot water can change the temperature of the sea water, and this can threaten organisms. But no convincing proof has so far been supplied about the true harm done by a marked difference in temperature; on the contrary, variations of 20°C have been recorded for *P. oceanica* (Augier *et al*., 1980) without the plant's vitality seeming to be affected.

Concerning salinity
Discharge of fresh water (e.g. rivers, urban discharge pipes) into the marine environment does, at least near the spot where this discharge takes place, modify the environment's salinity. This decline in salinity only ought, it seems, to affect *P. oceanica*, insofar as this is the only Mediterranean species that is relatively stenohaline. Although no specific study has been devoted to this problem, with the exception of Ben Alaya's observations (1972), this is doubtless because it seems rather minor, at least as an anthropic factor causing meadows to regress. But, as a natural-origin factor, one only has to look at the way meadows are retreating along the mouths of the coastal rivers of the eastern coast of Corsica to recognise its importance (Pasqualini *et al*., 1999).

Concerning turbidity
The increase of the water's turbidity often looks like an aggravating factor when added to another disturbance, such as an influx of nutriments, sediment or toxic substances. Doubtless, this is a major parameter of meadow regression, at least as regards their lower limit. In fact, any increase in the amount of dissolved particles gives rise to a quantitative and qualitative change in the light (phenomena of absorption and reflection) which affect photosynthesis, and can cause the lower limit to rise (see synthesis *in* Peres & Picard, 1975; Peres, 1984).

Concerning influx of nutriments
Some addition of nutrients is normal and necessary. But the general increase in these additions over the last few decades (Bethoux *et al*., 1990 *in* Boudouresque, 1996) in an environment that is usually thought to be oligotrophic will have certain consequences. Indeed, this enriching firstly helps planktonic organisms, whose massive development can reduce the water's transparency (e.g. phytoplanktonic bloom). The impact of this enriching then differs from one phanerogam species to the next. It seems that pioneer species like *C. nodosa* are very rapidly able to make use of these nutrients, which are frequently restrictive factors (e.g. phosphorus) for their own growth (Peres *et al*., 1991). Inversely, for climax species such as *P. oceanica*, a massive development is recorded for epiphytes, which compete with the host plant for light. This rivalry may be expressed in a decrease in foliar growth, even, when the nutritive additions are maintained for several weeks, a death of the fascicles. And many authors mention these massive developments of epiphytes to explain the way meadows are retreating in anthropised sectors (see synthesis *in* Shepherd *et al*., 1989).

Concerning influx of pollutants
Pollutants are added by reason of the existence of big industrio-port and petrochemical complexes and shipyards. They are expressed both in the direct discharge of untreated waste and the accidental introduction of pollutants or non-toxic substances whose combination gives rise to toxic elements. Experiments carried out in this field most often concern *P. oceanica* and often conclude that the plant's vitality is diminished, whether by trace metals (see synthesis *in* Pergent-Martini & Pergent, 2000), industrial waste (e.g. phospho-gypsums; Darmoul *et al*., 1979) or detergents (Monnier-Besombes, 1983).
However, it should be said that many measures have been carried out in aquariums with concentrations higher than those recorded in the natural environment, and that the sensitivity to pollutants taken separately to the concentrations that are actually

naturally present has not been clearly demonstrated, at least as regards *P. oceanica* (UNEP *et al*., 1990). Thus, studies concerning mercury and other trace metals show a sizeable accumulation by the plant, which does not (in the present state of our knowledge) harm its development (Pergent-Martini & Pergent, 2000). This seems also to be the case for radio-isotopes like Cesium 137 (Calmet *et al*., 1991). As for hydrocarbons, after the accident of the "Haven" in the port of Genoa (Italy), Sandulli *et al*. (1992 *in* Boudouresque, 1996) have not managed to demonstrate a significant impact of hydrocarbons on *P. oceanica*.

Concerning addition and deficit of sediment
A medium- or long-term change in the amount of sediment causes the vegetative tips to be buried or the rhizomes loosened, which can in the long run cause the death of *P. oceanica* fascicles (Boudouresque & Meinesz, 1982).

Concerning the introduction of alien species
The introduction of invasive species that are likely to compete directly with marine seagrasses is a relatively recent phenomenon. Even if we have at our disposal increasingly precise information on the mechanisms operating during these interactions, namely with regard to *Caulerpa* species (Villèle and Verlaque, 1995; Ceccherelli *et al*, 2000) it is still too early to evaluate the real impact of introduced species on seagrass meadows. In fact, if this competition phenomenon does not appear to lead to a drastic regression in *Posidonia* meadows, the modifications caused, namely with regard to energy allocation and mobilization of the plant's reserves, must be studied over a long period of time. Likewise, it is necessary to consider the meadow as a biocoenosis, notably in terms of its spatial structure (micro habitats) and the diversity of the associated flora and fauna. In addition, it seems judicious to apply the precautionary principle and to consider invasive species as factors that are likely to cause a threat for marine seagrass meadows.

Impact studies in the marine environment

I. Introduction

An impact study is a regulatory approach which aims at getting information about the environment and assessing the impact of a planned development before it is put into effect so that it can be decided in the light of the knowledge available whether this project should really be carried out (UNEP, 1996). Information consists of (i) a prediction of the possible changes to the environment after the development is put into effect, and (ii) opinions on how the development should be carried out so that the disturbance it causes will be as slight as possible.

The impact study idea appeared in 1970 in the U.S., in the law on environmental protection (NEPA). The need to make a report on the impact on the environment for bills and other action, which could significantly affect the quality of the environment, is clearly stated. Environmental considerations must be studied at each important stage of the decision-making process and the impact report is always published (UNEP, 1996). This concept is rapidly being adopted internationally; we have seen it appear in Canada from 1973 and in Europe from the late 1970s.

An impact study usually contains several parts:

- a precise description of the envisaged development (e.g. the project's aims, the site where it will be put into effect, the size, the operational techniques envisaged for its completion);
- a detailed analysis of the original condition of the area where it will be put into effect (e.g. state of reference, or "zero" state);
- an exhaustive inventory of the effects linked to the development or engendered by its future exploitation;
- a suggestion about measures to be taken to mitigate the impact on the environment, integrating possible compensatory measures. These aim at compensating as far as possible the harm done by the development.

Today, impact studies are a tool for helping development, accompanied by technical advice, for an optimum result (UNEP, 1996). They encourage coordination between bodies responsible for the environment, and also associate local people and non-governmental organizations (Galloway & Fordham, 1995). Public consultation is increasingly being encouraged and an ever-growing part of the studies devoted to an analysis of alternative solutions to the project under discussion (Galloway & Fordham, 1995). Impact studies aim to become a tool for "sustainable development", and are seeing their field of application expanding. They should in the long run be integrated in any drafting of management plans, or any definition of the regulatory processes (UNEP, 1996).

Although they are common to several states, making impact studies still remains for most countries an approach that is original and innovative but essentially academic and a recent regulatory procedure, especially in the Mediterranean.

II. Impact studies in Mediterranean countries

This section does not pretend to give a description of the laws in all the Mediterranean country. The information presented in this section have been finalised taking into account the data provided by the SPA National Focal Points, when furnished, as regard the state of impact studies in their countries.

Although the idea of an impact study is familiar to many Mediterranean countries, it does not appear systematically in their national law. Four countries belong to the European Community (e.g. Spain, France, Italy and Greece) and thus are bound to apply the Community Directives.

1. European regulations

The idea of impact studies appears in the Directive on assessing the effects on the environment of certain public and private projects (EEC Directive 85/337).

Studies must be done for all building work or other installations or work or operations in the environment, including the exploitation of soil resources. Only projects for national defence, or which are adopted by a particular national law, are excluded from this. Projects which systematically give rise to impact studies (excluding particular exemption) are those which concern:

- oil refineries (excluding the production of lubricants), large-scale gasification or liquification installations (minimum 500 tons of coal or bituminous schists per day);
- thermal power stations (at least 300 MW) or nuclear power stations (excepting those research structures whose maximum power is under 1 kW of permanent thermic duration);
- installations for stocking or processing radioactive waste;
- steelworks;
- installations where asbestos is extracted and, according to production level, processed;
- chemical installations;
- heavy-use communication routes and airports (with runways of over 2.1 km);
- port infrastructures or maritime routes concerning buildings of over 1,350 tonnes, and
- installations for eliminating, processing or stocking toxic waste.

However, many developments may require an impact study if the states believe that their features require this. This concerns projects affecting agriculture, mining, the power industry, metalwork, glass-making, the chemical industry, the food industry, the textile, leather, wood and paper industries, the rubber industry, infrastructure projects and other projects.

In the context of an impact study, both direct and indirect effects on man, the fauna, the flora, the soil, the air, the climate, the countryside, material property and the cultural heritage must be anticipated. The information which must be provided is (a minimum):

- A description of the project, its site, its design and its size;

- A description of the steps to be taken to reduce the major negative effects and, if possible, provide a remedy for them;
- Data for identifying and assessing the probable effects on the environment;
- A summary of the three preceding points.

The whole of the file must be made available to (i) the public, for it to be able to express an opinion, and (ii) the administrative structures responsible for authorizing all or part of the project. Similarly, the decision to give permission and the appended conditions, which authorize the project's being put into effect, must be made available to the public. If national law so permits, the elements, which justified the agreement, may be made known to the public.

2. Regulation in Albania

There does seem to be regulation in Albania concerning impact studies, in the context of coastal development. But so far no, or few, studies of this type have been made.

3. Regulation in Bosnia-Herzegovina

There exists a law in Bosnia-Herzegovina concerning development (e.g. Law on Physical Planning, Official Gazette no. 9/87). This is an adaptation of the former Yugoslavian law, in accordance with the Dayton peace treaties. In this law there is no mention of how to make an impact study, but the idea is mentioned in the regulatory text. Thus, building work must not endanger organisms and must enable the conditions of use of the site to be maintained. Development work must not give rise to any disturbance greater than that which the environment can regulate, or affect people's health and safety.

These studies are carried out by public or private bodies or organizations, which have to be accredited by the administrative authorities. On the other hand, these bodies do not have to prove their competence in the field of the marine environment, particularly since no reference is made to marine plant formations. The studies are made by the enterprise, which wishes to undertake the development.

It should be said that new laws will be coming into force in 2001. In the new texts, the structure of impact studies should be stated in detail (what should be taken into account, and how?). Adopting these new regulations should permit the situation to be improved.

4. Regulation in Croatia

Regulations on impact studies in Croatia appear in Decree no. 1324/59/2000.
The responsible body is the Ministry of Environmental Protection and Physical Planning.

The elements which have to appear in the impact study are a description of the original condition, the suggested development, the impacts and harm envisaged and the steps suggested to reduce this harm, plus monitoring after the completion phase. The law makes no reference to marine plant formations.

Studies are made by private or public bodies, which have to prove marine experience, and have to be accredited by the administration concerned with

environment management. The body responsible for the development finances the impact study.

5. Regulation in Egypt

The Law on the Environment (Law no. 4/1994) makes carrying out an impact study obligatory. The Egyptian Environmental Affairs Agency (EEAA) is responsible for putting this law into effect.

In the context of an impact study, the envisaged project must be described, as well as the natural resources present and the steps likely to attenuate the impacts, or alternative suggestions. The package of elements is sent by the developer to the EEAA, more precisely the Environment Development sector (EMS). The EMS works with university professors and experts in each of the disciplines to assess the study that has been made.

Over the period 1992-1994, projects requiring an impact study have essentially been tourist development projects (84%; e.g. the creation of marinas, jetties), installation of electric power stations (3%) and desalination stations (3%).

In the main, developers are showing real involvement in environment protection and have come up with interesting alternative suggestions or have included in their studies additional parameters with respect to what is set out at regulatory level.

6. Regulations in Greece

The assessment of environmental impacts (E.I.A.) is obligatory for two major categories of projects, in accordance with the European Directive 85/337/EEC as modified at present (Joint Ministerial Decision 69269/5387/1990 and JMD 75308/5512/1990). For a third category of projects, not foreseen in the E.U. Directive, there is obligation of E.I.A, in cases the authorities consider that they might have significant negative effects on the environment.

The process introduced by the above mentioned legislation applies to both private and public investments and projects, the cost is covered by the interested party, be it private or public and the Environmental Statements are accepted for public administration control only if they are elaborated by scientists who are accredited and enrolled in a specific Register of the Ministry of Environment, Physical Planning and Public Works.

The Greek E.I.A. process for the two major categories is integrated into a two – cycle approach, linked first to a Preliminary Environmental Statement and a decision for authorization of the type of project in this location (putting the project into scope) and then to a full Environmental Statement and the decision granting final environmental terms for its implementation. This process has had a positive effect on the conservation of the natural environment as it allows for intervention in the design of the project and a better application of the precautionary principle.

The information presented in each case depends on the type and size of a project, as well as on the location it is proposed. Administrative circulars have been issued with regard to specifications set for certain categories of projects and work has been finalised in preparing specifications for all categories, the remaining relevant circulars

pending. Depending on the type and size of the projects, authorisation lies with the competencies of Prefecture or Regional or central Environmental Services of the country.

Generally, the impact study has to include the following points:

- Description of the original state
- The accomplishments foreseen
- Envisaged impacts and harmful effects
- Measures envisaged to reduce the harmful effects

In case where the project is likely to affect protected areas or protected species and habitat types (including sea grass meadows), the opinion of the Section of Nature Management of the Ministry of Environment is sought.

7. Regulation in Spain

In questions of impact studies, the Spanish regulation follows the European Directive. Several laws exist, at state level (Decree 1302/1986, BOE 155; Decree 1131/1988, BOE 239) and Catalan regional level (Decree 114/1988, DOGC 1000).

In the context of these texts, interventions in the environment that imperatively require impact studies are identified. These are projects defined in Appendix I of EEC Directive 85/337 and all intervention likely to harm the value of protected natural areas, as defined by Spanish law. The 1986 Decree supplements the existing decrees on industry (1976) and water (1985) and standardises impact study procedure.

In addition to the elements of the European Directive, in Spain the study has to integrate:

- an assessment of the nature and quantities of waste or the energy resulting from carrying out the development ;
- the environment’s ability to recuperate, and
- an environment-monitoring programme.

Moreover, regional regulations (Catalonia) state clearly that an analysis of the ecological systems of the area must include a study of the benthic communities and the organic elements in the sediments, on the same scale as the general bathymetry. Quantitative studies of the populations of the most representative species must also be included. Lastly, the methodology used must be meticulously described to make possible a future comparison with similar studies in the future, which will help establish the major lines of the area’s biological evolution, after the development. The impact studies required fall particularly within the scope of a description of the area’s present biological state (zero state), on the basis of which a forecast is made of the evolution of the biological systems according to the expected impact.

Moreover, the Decree states that any development imperatively requiring an impact study and carried out without this being done will be suspended. Similarly, any omission or falsification of data in the impact procedure or any infringement of the conditions imposed for putting the project into effect may bring about the stoppage of the work. Similarly, when, after an illegal intervention, the environment is seen to be disturbed, the person/s responsible for the work must repair the state of the environment in the form requested by the administration.

8. Regulation in France

Regulation as to impact studies appeared in France in 1976, with the law on nature protection (J.O. of 13 July P.4203). France was thus the first Mediterranean country to adopt the North American idea.

The Decree of 12 October 1977 (Decree no. 77-1141) defines the general terms of the impact study. It states that the content of the study has to be related to the size of the envisaged work and its foreseeable effect on the environment. The 1993 Decree (Decree no. 93-245 of 25 February 1993) supplements and makes more clear the impact study procedure; the impact study must provide:

- an analysis of the original condition of the site and of its environment in terms of natural riches and areas affected by the development ;
- an analysis of the direct and indirect, temporary and permanent effects of the development on the environment, particularly on sites and landscapes, fauna, flora, soil, water, air, natural environments and biological balance, protection of property and the cultural heritage and possibly the environmental comforts (noise, vibration, smell…), hygiene, public health or safety ;
- an analysis of the methods used to assess the effects of the project on the environment, mentioning possible difficulties (technical or scientific) for making the assessment ;
- the reasons why the suggested project has been accepted, particularly as regards the environment ;
- the steps envisaged by the entrepreneur to suppress, reduce and where possible compensate for the project's harmful consequences for the environment, and an assessment of the corresponding expenditure ;
- a non-technical summary to make consultation with the public easier.

Unlike the regulations of other states, not only those kinds of installation requiring an impact study are appended to the decrees but also work for which the procedure is not obligatory. This means that the impact study must constitute the rule, and the exemption the exception. Specifically excluded are maintenance work and big repair jobs. Technical, or, failing this, financial thresholds are defined as application limits for an impact study. Thus, developments costing less than twelve million francs (a sum regularly updated) are not subject to an impact study.

However, for work costing less but whose environmental impact cannot be seen as negligible, a slighter impact note procedure is set out.

If there is a public inquiry, the impact study is included in the file, and if there is not, the study is made available to the public, at the latest when the decision to implement the development is taken, and imperatively before work starts. Beforehand, the existence of the impact study has to be published in the regional and national press. Not less than fifteen days must be set aside for consultation on the study. However, the fact that an impact study has not been made public does not affect the legality of the permission given.
The Minister of the Environment may take on or have referred to him any impact study for his opinion. The Minister has 30 days from the time he receives the file to make his decision known, and no decision to start work, nor opening of public inquiry, can occur before this time has expired. Where a public inquiry is necessary, it is advisable for the Minister's opinion to be known before the inquiry starts.

The impact study is usually elaborated by the entrepreneur or ‘petitioner’. It is therefore he who is responsible if an incomplete or insufficient study has been made, but he is not obliged to make the study himself. He is even recommended to call on specialists for all or part of the study.

Where there is no impact study concerning a development for which this procedure is required, a stay of execution may be pronounced, causing the work to be stopped.

Since 1983, the law has tried, in order to (i) permit the public to be better informed and (ii) provide the competent authority with all the necessary elements for information, to make a public inquiry obligatory for any development which by its nature or the character of the area concerned is likely to affect the environment (Law no. 86-630 of 12 July 1983). Fifteen days before the public inquiry starts, the public must be informed about it and the inquiry must last not less than one month. The inquiry must permit the public to hear its suggestions, observations and counter-proposals, and the well-founded conclusions of the investigating commissioner or of the commission of inquiry are made public. The results of the inquiry have a five-year validity. The costs of the inquiry are to be borne by the entrepreneur, except for the allowance paid to the investigating commissioner or members of the commission of inquiry, which is borne by the state. The public inquiries’ field of application (Decree no. 85-453 of 22 April 1985) is almost exactly that defined by the 1977 Decree on impact studies. But the two elements remain separate, since a public inquiry can take place without an impact study or impact note, and vice versa.

The 1993 Decree sets out to:

- help the entrepreneur design a better project ;
- make decision-makers better informed on the nature and content of the decision to be made ;
- make the public better informed ;
- extend the impact study’s field of application (e.g. town planning and tourist projects, excluded from the 1977 text) and the impact note (e.g. work to protect the land against the sea) ;
- integrate in French law certain provisions of the 1985 European Directive which did not appear therein, and
- make the tool more efficacious.

In the 27 September 1993 circular from the Ministry of the Environment, the Minister explicitly mentions by name the elements which must be borne in mind in the context of an impact study. He requests that action accompanying the project, i.e. the steps to suppress, reduce and compensate, be taken up again in the decision of approval, and that these commitments be monitored. He also stresses the need to set up, where necessary, follow-up of the completion or functioning of the work.
Although the idea of a meadow does not explicitly appear in the regulation about impact studies and notes, except for the assessment of the effect on flora, it is clearly stated in the 1989 Decree concerning the provisions of the Town Planning Code that particularly concern the coast (Decree no. 89-694 of 20 September 1989). This permits the regulating of development activity carried out after a public inquiry in areas and environments where the formations constitute a remarkable site or landscape.

9. Regulation in Israel

The law on buildings on the maritime domain comes under the Ministry of the Interior and the 1965 Law on development and construction. This Law, as well as providing development outlines, has enabled a Territorial Waters Committee (TWC) to be set up, dealing with planning and building on the maritime territory and the coastline. Before any development is permitted it has to be approved by the TWC. The TWC's decision is based on a general national plan for the coastal areas that essentially takes into consideration the use of the terrestrial area as regards the shoreline and a few hundred metres back.

10. Regulation in Italy

For more than fifteen years, all sea development must lead to an environmental impact assessment study (VIA). The Sicily region, which has autonomous status, has always included an environmental impact assessment for all operations carried out at sea, not just those included in the European Directive (EEC Directive no. 11/1995). This Directive is adapted in Italy in a 1999 Decree (Decree no. 152/1999) concerning 'Provisions on protection of waters against pollution…'. Article 3.4.1.2. of this Decree explicitly refers to marine phanerogams, stating that in the light of their major heritage interest, these species must be mapped and given specific monitoring.

The impact study includes the elements of the European Directive plus a period during which the site is monitored after the development has been implemented.

The study is always done over a wide geographical area, depending on the preliminary project. It is possible in the project's preliminary phase to just establish a note on the environmental impact, based on the kind of intervention, the environmental and biological features of the concerned part of the ecosystem, and on the habitual and potential uses deduced from the sector reference context (e.g. development plan, particular plan).

In the VIA procedure, each site's natural and anthropic elements must be borne in mind, as well as the interaction between these elements and the environment taken as a whole. The elements, which have to be more especially taken into account are those set out in Appendix II, i.e.:

- The air quality; it is advisable to establish the pre-existing situation, to foresee the project's impact on the water/air interface and on marine organisms, and to state the site's meteorological features.
- The hydric environment; the marine waters must be seen as elements of the environment and as resources. An analysis of the water as an environment includes an analysis of the various physico-chemical parameters, which must be done at 3 depths, each month. As for water as resource, the measurements concern plankton (to grasp the biological importance of the water column and the efficiency of the first trophic levels) and the nekton (to grasp its value as resource that can be removed by fishing and can renew itself). This study is done by quantitative and qualitative measurements, using synecological indices, which permit the quality, biodiversity, and functioning of the environment to be assessed.
- The soil's and subsoil's geological and geomorphological nature; the soil's character and its physico-chemical make-up must allow the oxidoreduction

processes, substratum/organism interaction and the substratum's receptive capacity to be determined.
- Vegetation; this item represents the most important part of the study. Vegetation may be mapped to show the dominant species and bathymetric zoning. Rare and/or protected species must be mentioned and a floristic inventory made. If necessary, a phyto-sociological record may supplement the preceding observations.
- Ecosystems; all the above parameters must allow an understanding of the ecosystems and how they function. A 1:10,000 cartographical report of the ecosystemic units must be made showing possible anthropic pressure. As well as calculating the synecological indices, bio-tests may be carried out to better grasp the way the ecosystem functions. The site's ability to self-purify must be assessed as well as the degree of maturity and the quality of the ecosystem (e.g. biodiversity, presence of endemic species).
- Public health;
- Noise and vibration;
- Ionizing and non-ionizing radiation; (for these three parameters the approach is exactly the same as for impact studies on land).
- Landscape; it expresses the ecosystem's aesthetic side, including topography of the seabeds, vegetation and man as observer. An appreciation of the landscape can be made with the help of photographs or films.

The company wishing to carry out the development is responsible for financing the impact study. There are many private expert evaluation agencies, which use scientists to make a successful environmental assessment. The impact study can be made by public or private bodies but these must have experience in the marine field.

11. Regulation in Slovenia

Slovenia possesses special laws on impact studies (Off. Bull. no. 66/1996 and no. 12/2000, Ministry of the Environment).

It is obligatory that the study contain a description of the original condition, projected development, the impacts and harm envisaged and measures suggested to reduce this damage. The Ministry of the Environment then sets out case by case the criteria which must be borne in mind, but in the regulatory text no reference is made to meadows.

It is obligatory to carry out an impact study for any aquaculture structure that is bigger than 0.5 hectares, for building ports or marinas of over 100 mooring rings and for 'reclamation', i.e. land reclaimed from the sea by filling-in.

The study is made by bodies empowered by the Ministry of the Environment, but financed by the enterprise, which wishes to carry out the development.

12. Regulation in Tunisia

There is regulation of impact studies in Tunisia, stating the elements, which must appear, i.e. the original condition of the sector for development, information concerning the phases of the project, supposed impacts of the development and steps to be taken to reduce threats to the environment.

These studies are usually done by the body made responsible for carrying out the development, and the scientific part may be entrusted to any private body.

No reference to meadows is made in the regulation of impact studies.

13. Regulation in Turkey

Turkey has introduced regulation of impact studies. The idea appears in the Law on the Environment (Law no. 9.8.1983). This very general Law on the Environment indicates that organisations and establishments, which via some projected activity may create environmental problems, must draft a report on these expected impacts. The text sets out a list of projects, which may give rise to an impact study and the elements, which must appear in it, and describes the procedures and authorities responsible for the decision.

Projects, which require an impact study, are the building of thermal power and nuclear power stations, refineries, ports (for handling boats of over 1,350 tons), pipelines, storing facilities, industrial or naval repair units. It is advisable to add offshore rigs and dredging and filling-in activities over large areas. For smaller developments, such as building reservoirs used as ballast tanks, fishing ports, marinas or breakwaters, only a (smaller) preliminary study is needed. If this preliminary note concludes that there is sizeable harm, the full procedure of an impact study must be gone through.

The full procedure is also necessary in all ‘sensitive’ areas (e.g. national parks, protected areas, marine resource production sectors).

III. Synthesis

An analysis of the situation in terms of developments in countries, which have for several years possessed laws on impact studies, shows that these procedures are in the main efficacious.

But it does seem to be difficult to pronounce as to their efficacity regarding meadows. In fact, impact studies concern the protection of the land rather than the marine environment. A glance at the regulatory appendices of impact studies procedures shows few developments concerning the marine domain. These are essentially port infrastructure and work on maritime traffic routes. Some countries do also include therein work to protect the land from the sea, aquaculture installations, filling-in in the maritime domain and sea discharge pipes. Moreover, a reading of the texts shows that the coastal environment is never specifically mentioned, still less the plant formations developing there.

But despite this apparent lack of interest in meadows, their presence in the countries of the northern part of the Mediterranean usually prevents the development’s being carried out. Indeed, several species (e.g. *C. nodosa, P. oceanica, Z. noltii*) are protected either directly by national law (e.g. France) or regional law (e.g. the Catalonia and Valencia regions in Spain) or indirectly via international agreements signed by the state (e.g. Italy; see the synthesis in RAC/SPA, 2000).

In particular, concerning the countries of the European Union, it is important to mention the Directive no 92:43 of 21 Mai 1992, labelled “Habitat Directive”. In the Annex I, which determines the coastal habitats, *P. oceanica* meadows are considered as priority Site of Community Interest (SIC).
Effectiveness in terms of conservation of meadows is not therefore gained via the impact study but by the protection of the species or its habitat. Thus, in France no coastal development involving the destruction of a *P. oceanica* meadow has been carried out since 1988. It has however been considered that dead mattes with a few isolated fascicles or residual spots of *P. oceanica* do not constitute a meadow, which is an acceptable interpretation of the protection texts (e.g. development of the Corbière beach in Marseilles; Crebassa, 1992).

The various regulatory texts show a few strong and a few weak points concerning these impact study procedures, where they exist.

Strong points
Impact studies are a means of improving and rationalising decision-making on developments. They permit the environment to be taken into account in the same way as the interest for local people or hoped-for economic profit.

Another element, which appears in certain countries, but would deserve extending to the entire Mediterranean, is the fact that the impact study procedure, in a perhaps slighter version, is the rule for developments, and the lack of procedure the exception.

A certain number of countries have also set up in a regulatory manner a monitoring and checking system for the phases of the development, and then, a posteriori. This analysis allows verification of how well the recommended techniques fit the objectives aimed at, in terms of reduction of impacts.

Weak points
Several elements can reduce the efficacity of the impact procedure:

One of the important points is linked to the fact that it is always the entrepreneur who finances the study. If this is consistent, from an economic point of view, in practice it can lead to difficulties. In fact, there is a risk that the study carried out is, for reasons of cost, only superficial or entrusted to inexperienced people. This risk is all the greater in that the study may be entrusted to anybody at all, insofar as few countries exercise a check via accreditation on the people or bodies able to make an impact study. This can give rise to very varied results (in terms of quality and competence), all the more reason when the guidelines of the procedure are not given in detail and when the elements to be taken into account are not explicitly stated.
This type of approach can also lead to a systematic underestimation of the development’s potential harm. Indeed, the body made responsible by the entrepreneur for the environmental appraisal may be tempted – to keep his custom – to conclude that the development as proposed by the said entrepreneur is feasible.

A second point is linked to the fact that even when a regulatory text exists, it is not necessarily accompanied by precise directives on how the study should be done. This often leads to rather superficial studies being made, or made by teams whose

competence is rather suspect and for whom there is no standardised protocol. This absence of standardisation makes all medium-term follow-up of the development's real impact difficult, and does not permit the results obtained to be compared within one country.

Impact studies as a tool for the conservation of marine phanerogam meadows

According to the threats we first identified concerning the conservation of meadows, any development on the maritime domain may justify an impact study procedure. The carrying out of a development project implies at least, both during the work and afterwards, a modification of the sea currents and thus turbidity and/or sedimentary phenomena, even a dwindling of the meadow habitats (e.g. filling-in, dyking) and a change in the topography of the sea beds. Moreover, if the development is an aquaculture production structure, to these disturbances should be added a localised increase of nutriments, or non-negligible additions of various chemical substances (e.g. antibiotic treatments, micro-nutriments, trace metals). Similarly, the building of discharge pipes out into the sea gives rise to temperature and salinity changes and even increased discharge of pollutants.

Given that many developments can cause the meadows to retreat, and that impact study procedures seem able to limit the harm caused by such developments, we may wonder which elements deserve to be taken into account when there is a wish to make an impact study in a meadow area, and how efficacious they will be.

I. Elements to be borne in mind for impact studies on meadows

Optimum management of the environment increasingly requires the possession of tools that enable quick, reliable understanding of the general condition of an environment and then follow-up of its evolution over long periods of time. Assessing impacts on the environment is often difficult since one must distinguish between natural variations in time and space and those brought about by human agency. Only a pluri-disciplinary approach (ecological risk assessment) coupled with medium-term monitoring programmes can enable us to guard against the damage before it happens (Cuschnir, 1995).

The speed of execution demanded for impact studies forces us to direct research to relatively stable biological sets, which integrate environmental variations well and have been recognised as indicators of water quality and environment quality. Benthic populations satisfy these conditions, especially assemblages on hard substrata and phanerogam meadows.

Any impact study concerning meadows must therefore enable the overall functioning of these formations to be grasped. For this, it is advisable to:

- identify the assemblages presumed to be subject to the impact;
- map these assemblages as precisely as possible;
- make a quantitative study of the species whose biomass is biggest;
- draw up a statement of the existing biological biodiversity;
- identify the descriptors which enable the state of the environment to be

grasped by taking into account the meadows’ vitality parameters.

As regards the last point, several studies have enabled us to grasp the meadows’ response to a disturbance of environmental conditions (e.g. industrial discharge, urban effluent discharge, aquaculture activities). Whatever their origin, these disturbances are expressed in a modification of certain parameters related to the meadows’ vitality. Some of these parameters, concerning *P. oceanica*, are set out in detail below (Table 1).

The very marked seasonal character of certain parameters (e.g. cover, foliar biometry), the difficulty of getting others which require great systematic knowledge (e.g. diversity of the epiphytic community), or the partial knowledge of their limits of use (e.g. compactness of the substratum) make them hard to interpret and restrict their use. However, some parameters, easily measured and having been standardised, may be taken into consideration. Thus, the position of the species’ bathymetric extension limit is an interesting parameter, because while it can exceed -40 metres in clear water, near where urban or industrial pipelines discharge their waste into the sea it hovers between -10 and -15 metres (see synthesis *in* Pergent *et al*., 1995). It will thus be possible to link the depth of the lower limit of the meadows to the turbidity or transparency of the water. Similarly, for *P. oceanica*, it is possible to analyse the density of the fascicles according to the depth and condition of the meadow. Thus, for a given depth, four classes can be made out (Table 2):

- The supra-normal class, corresponding to particularly exceptional situations in terms of *P. oceanica’s* vitality or the meadow’s bathymetric extension.
- The normal class, corresponding to satisfactory *P. oceanica* vitality values, which should be observable when there is no marked anthropic pressure.
- The subnormal class, corresponding to a reduction in the meadows’ vitality (diminished density, slower growth, contamination), and must be an alarm signal indicating that the environment is sufficiently disturbed to affect the meadow.
- The abnormal class, corresponding to critical situations where the meadow’s vitality is extremely low.

Table 1: Main *Posidonia oceanica* meadow descriptors and the protocols permitting their operation

Descriptors	Definition	Implementation
Lower limit		
☆Position ☆Type ☆Evolution	Bathymetric extension	The position is measured by diving, helped by an electronic depth-gauge (precision ± 10 cm). It is advisable to take several measurements several metres apart (average value). The type (e.g. abrupt, progressive, regressive) is established by *in situ* observations. The evolution may be checked by setting up fixed markers (10 to 12 markers each 5 metres apart) in contact with the meadow and photographed every three years, with regular repairs done (once a year).
Quantitative and qualitative assessment		
Density	Number of fascicles per m²	Measurements are taken inside 40 cm sided, or at the lower limit, 20 cm sided, squares. Measurements (at least ten) are taken at random in the meadow; the squares are dropped from one metre and the count is done where they fall.
Cover	Percentage of substratum covered by *P. oceanica*.	Measurements (5 to 10) are taken either by vertically-taken underwater photographs (Cristiani, 1980) after marking off a known area (16 to 20 cm²), or by counting the number of (10 cm²) squares occupied by the meadow on a (1 m²) transparent frame looking vertically down from 3 metres above the sea bed (Francour *et al*., 1997).
Sedimentary parameters		
Exposure	Distance between the plant's vegetative point and the sediment.	This is done by diving, with at least 20 fascicles. Three cases are identified: - hyper-sedimentation: vegetative point in the sediment - balanced: vegetative point at sediment level - sedimentary deficit: vegetative point very much above the sediment
Compactness	Resistance of the matte to breakage.	This is done by driving a graduated shaft into the meadow under the action of a big hammer (Francour *et al.,* 1997).
Foliar biometry		
☆Number and type of leaves ☆Length and width ☆Leaf Area Index (LAI) ☆ Coefficient A	Adults – leaves + petioles, Intermediary – leaves without petiole > 50 mm, Juvenile – leaves without petiole < 50 mm, LAI = leaf area/m² Coef. A = % of broken leaves.	Dissection and measurement of at least 10 fascicles in the laboratory. It is advisable to take the measurements during an annual cycle, or to only compare samples gathered at the same period.
Epiphytic cover		
☆ Diversity ☆ Biomass	Colonisation of the leaf by animal or plant species.	Inventory of flora and fauna in the laboratory, on 10 fascicles. The biomass is measured by scratching the epiphytes, and weighing after drying (72 hours at 60°C).
Lepidochronological parameters		
☆ Number of leaves per year ☆ Growth of rhizomes per year		Samples of 15 fascicles at least one metre apart. After dissection (Pergent, 1990), identification of minimum and maximum thickness and measurement of number of scales and size of each section of rhizomes, then weighing after drying (72 hours at 60°C).

Table 2: Scale for assessing density (fascicles per m²) of *P. oceanica* meadows according to depth. A: Abnormal; S-: Subnormal; N: Normal; S+: Supra-normal

Depth	A		S-	N			S+	Depth	A		S-	N			S+
1	←	822	↔	934	↔	1158	→	21	←	48	↔	160	↔	384	→
2	←	646	↔	758	↔	982	→	22	←	37	↔	149	↔	373	→
3	←	543	↔	655	↔	879	→	23	←	25	↔	137	↔	361	→
4	←	470	↔	582	↔	806	→	24	←	14	↔	126	↔	350	→
5	←	413	↔	525	↔	749	→	25	←	4	↔	116	↔	340	→
6	←	367	↔	479	↔	703	→	26			←	106	↔	330	→
7	←	327	↔	439	↔	663	→	27			←	96	↔	320	→
8	←	294	↔	406	↔	630	→	28			←	87	↔	311	→
9	←	264	↔	376	↔	600	→	29			←	78	↔	302	→
10	←	237	↔	349	↔	573	→	30			←	70	↔	294	→
11	←	213	↔	325	↔	549	→	31			←	61	↔	285	→
12	←	191	↔	303	↔	527	→	32			←	53	↔	277	→
13	←	170	↔	282	↔	506	→	33			←	46	↔	270	→
14	←	151	↔	263	↔	487	→	34			←	38	↔	262	→
15	←	134	↔	246	↔	470	→	35			←	31	↔	255	→
16	←	117	↔	229	↔	453	→	36			←	23	↔	247	→
17	←	102	↔	214	↔	438	→	37			←	16	↔	240	→
18	←	88	↔	200	↔	424	→	38			←	10	↔	234	→
19	←	74	↔	186	↔	410	→	39			←	3	↔	227	→
20	←	61	↔	173	↔	397	→	40			←		↔	221	→

II. Practical measures to mitigate impacts on meadows and comments on their efficacy

It is obvious that there is no efficient alternative to reduce impacts on meadows when developments are envisaged at their expense. Insofar as building causes a reduction in the meadow habitats, only the pure and simple banning of the development can constitute a solution, particularly for species with low colonisation (e.g. *P. oceanica*) or that are infrequently found (e.g. *Z. marina*). Indeed, a study of recolonisation of *P. oceanica* meadows after the halting of anthropic disturbance (Pergent-Martini *et al*., 2000) shows that although natural recolonisation may appear, restoration mechanisms remain very slow (several decades to restore one single hectare).

Nonetheless, in many cases this kind of solution is ruled out, and the development has to be carried out in the light of its interest for the local people (e.g. laying down drinking water pipes, linking up to the electricity supply, laying down telecommunication cables, building discharge pipes out to sea). In this kind of case, making precise maps may constitute an effective way of reducing the impacts on the meadow by optimizing the chosen layout to spare these formations as far as possible. Thus, when an electric cable linking the Port-Cros island (Var) to the continent was to be laid down, the meadows in the area were mapped (Meinesz & Bellone, 1989) and the underwater passage of the cable then determined so as to cross the meadow as little as possible. Similarly, in Catalonia, the Direccion General de Pesca Maritima required in 1992 a general (1/50,000) map to be made of the marine phanerogam meadows (and other types of beds) of the whole Catalan coast (700 km) in order to manage implementing the law protecting marine phanerogams. Finally, mapping populations and types of beds of the Girolata (Haute-Corse) and Tizzano (Southern Corsica) bays has made it possible to identify areas likely to

accept planned moorings while minimising these structures' impact on *C. nodosa* and *P. oceanica* meadows.
Even if it is advisable to bear in mind that no technique can compensate for the loss of all or part of a meadow, several operational techniques may be used to reduce impacts on meadows (e.g. compensatory measures).

As for indirect threats to meadows, it seems possible to act on water turbidity and/or addition of fine particles. These threats, which happen during dyking or filling-in work, can be minimised by using materials that have previously been washed. This is an effective way of reducing the addition of fine particles over meadows. Similarly, the use of geotextile nets enables the impact to be confined to the development area alone, by preventing the fine particles being dispersed by currents. As regards other indirect threats (e.g. addition of nutriments, sedimentary deficit), these must be identified and quantified. The necessary measures are not specified.

It seems to be easier to reduce threats linked to the direct destruction of phanerogams. Thus**,** concerning the improper use of bottom trawls or dragnets, which are a significant source of degradation of meadows, first of all the existing laws should be respected. And recourse to anti-trawl reefs may be an additional means of facilitating the implementing of bans on fishing in certain sectors. Several 'sea-rocks' have already been introduced either in protected areas (Ramos, 1990 *in* Boudouresque, 1996) near coasts (3 mile zones or 50 metre isobath zones; Relini, 1992, *in* Boudouresque, 1996) or areas reserved for traditional fishing with trammels or palangre fishing (Francour *et al*., 1991; Tocci, 1996 *in* Boudouresque, 1996).

Similarly, concerning mooring, it is often possible to restrict this to specially developed geographical sectors and especially to exclude it from areas where the meadows have been made less robust. Because of the higher risk of mortality it is sensible to forbid mooring in sectors characterised by mattes that are not very compact and where the rhizomes are exposed. To permit the restoring of these sites, the ban on mooring must be maintained for at least five years (Francour *et al*., 1999). As exists already for coral reefs, a code of behaviour for mooring over meadows must be created and the general public, especially amateur sailors, made aware of this harm. Finally, all technical innovations that allow pleasure mooring to be optimised, such as mooring with reduced contact with the soil (e.g. Harmony system), must be encouraged.

Over the last few years several replanting techniques have been improved, particularly as regards *P. oceanica* (Cinelli, 1980; Meinesz *et al*., 1992; Molenaar *et al*., 1993; Genot *et al*., 1994), but some problems are still present. Concerning that it is important to continue the research with the aim of further improving the replantation techniques.
It is advisable to make sure that replanting techniques are not hijacked to serve as an excuse for new destruction. Experience has shown that in many sectors planting has been done for planting's sake, with no overall strategy. Thus, *P. oceanica* has been planted in sectors where it does not naturally exist and seems never to have existed, or in areas where the meadow is speedily retreating. At Cannes, part of the replanting of *P. oceanica* was done in an old, stable *C. nodosa* meadow; now destroying one phanerogam to replace it with another is not a very coherent strategy. It has been suggested that *P. oceanica* be replanted as a compensatory measure in

the context of projects to build or enlarge pleasure boating ports. The 6 August 1992 decision of the Sanary-sur-Mer Municipal Council approving this project was later annulled by the Nice Administrative Tribunal (3 December 1992 decision; Boudouresque, personal communication).

References

Aleem A.A., 1955. Structure and evolution of the seagrass communities *Posidonia* and *Cymodocea* in the southeastern Mediterranean. *Essays in the natural sciences in honor of Captain Allan Hancock, on the occasion of his birthday, July 26*, 279-298.

Augier H., Robert P., Maffre R., 1980. Etude du régime thermique annuel des eaux au niveau des peuplements de Phanérogames marines de la baie de Port-Cros (Iles d'Hyères, Méditerranée, France). *Trav. sci. Parc nation. Port-Cros*, 6 : 69-131.

Bellan-Santini D., Lacaze J. C., Poizat C., 1994. Les biocénoses marines et littorales de Méditerranée, synthèse, menaces et perspectives. *Muséum National d'Histoire Naturelle publ.* : 246 p.

Ben Alaya H., 1972. Répartition et conditions d'installation de *Posidonia oceanica* Delile et *Cymodocea nodosa* Ascherson dans le Golfe de Tunis. *Bull. Inst. Océanogr. Pêche Salammbô*, 2 (3) : 331-416.

Bianchi C.N., Peirano A., 1995. Atlante delle fanerogame marine della Liguria : *Posidonia oceanica* e *Cymodocea nodosa*. *ENEA, Centro Ricerce Ambiente Marino, La Spezia* : 1-146.

Bonnier G., Douin R., 1990. La grande flore en couleur de Gaston Bonnier, France, Suisse, Belgique et pays voisins. *Réédition de la flore complète illustrée en couleur de France, Suisse, Belgique, de G. Bonnier et R. Douin, Belin édit.*, 4 tomes.

Boudouresque C.F., 1996. Impact de l'homme et conservation du milieu marin en méditerranée. *2ème édition. GIS posidonie publ., Marseille* : 1-243.

Boudouresque C.F., 1997. Situation de la biodiversité marine et lagunaire en Tunisie. Recommendations. *CAR/ASP Tunis et GIS Posidonie publ.* : 1-154.

Boudouresque C.F., Meinesz A., 1982. Découverte de l'herbier de Posidonies. *Cahier Parc nation. Port-Cros*, 4 : 1-79.

Boudouresque C.F., Meinesz A., Ledoyer M., Vitiello P., 1994. Les herbiers à phanérogames marines. *In* « Les biocénoses marines et littorales de Méditerranée, synthèse, menaces et perspectives », Bellan-Santini D., Lacaze J. & C. Poizat, *Muséum National d'Histoire Naturelle publ.* : 98-118.

Buia M.C., Casola E., Mazzella L., Russo G.F., 1985b. Osservazioni sulla fioritura di *Ruppia maritima* L. nello stagno di Marceddi (Sardegna Sud-Occidentale). *Oebalia*, N.S., 11(3) : 857-859.

Buia M.C., Mazzella L., Russo G.F., Scipione M.B., 1985a. Observation on the distribution of *Cymodocea nodosa* (Ucria) Aschers. prairies around the island of Ischia (Gulf of Naples). *Rapp. Commiss. internation. Explor. sci. Médit.*, 29(6) : 205-208.

Calmet D., Charmasson S., Gontier G., Meinesz A., Boudouresque C.F., 1991. Chernobyl radionuclides in the Mediterranean Seagrass *Posidonia oceanica*, 1986-1987. *J. Environ. Radioactivity*, 13 : 157-173.

CAR/ASP, 2000. La protection des habitats aux herbiers en Méditerranée (Platini F.). *Rapp. PNUE, PAM, CAR/ASP édit.* : 65p.

Caye G., 1989. Sur la morphogénèse, le cycle végétatif et le reproduction de deux phanérogames marines de Méditerranée : *Posidonia oceanica* (Linnaeus) Delile et *Cymodocea nodosa* (Ucria) Ascherson*. Thèse habilitation, Univ. Nice* : 1-229.

Ceccherelli G., Piazzi L., Cinelli F., 2000. Response of the non-indigenous *Caulerpa racemosa* (Forsskal) J. Agardh to the native seagrass *Posidonia oceanica* (L.) Delile: effect of density of shoots and orientation of edges of meadows. *Journal of Experimental Marine Biology and Ecology*, 243 : 227-240.

Cinelli F., 1980. Le Fanerogame marine : problemi di trapianto e di riforestazione. *Mem*. *Biol. mar. Oceanogr., N.S. suppl*, 10 : 17-27.

Clarke S.M., Kirkman H., 1989. Seagrasss dynamics*. In* : *Biology of Seagrasses*, A.W.D. Larkum, A.J. McComb & S.A. Shepherd. (Eds.) *Aquatic Plant Studies, Elsevier Publ. 2* : 610-634.

COI, 1997. Guide méthodologique d'aide à la gestion intégrée de la zone côtière. Commission océanographique intergouvernementale, UNESCO, *Manuels et Guides*, 36 : 47p.

Crebassa P., 1992. Evaluation des mesures de protection des herbiers à *Posidonia oceanica. Mém. Stage Ecole Polytechnique* : 1-52.

Cuschnir A.A., 1995. Coastal development : a suggested approach to environmental impact assessments. *Proc II International Conference on Mediterranean Coastal Environment, MEDCOAST 95, October 24-27, 1995, Tarragona Spain, E. Ozhan edit., Medcoast publ.* : 1247-1260.

Darmoul B., Hadj-Ali M., Vitiello P., 1980. Effets des rejets industriels de la région de Gabès (Tunisie) sur le milieu marin récepteur. *Bull. Inst. nation. sci. tech. Océanogr. Pêche Salammbô*, 7 : 5-61.

Den Hartog C., 1970. The seagrasses of the world. The seagrasses of the world. Verhand. *Koninklijke Nederl Akad. Wetenschap Afd. Nat. Tweede reeks, North-Holland Publ. Amsterdam*, 59 (1) : 1-272.

Den Hartog C., 1987. "Wasting disease" and other dynamic phenomena in *Zostera* beds. *Aquatic Botany*, 27 : 3-14.

Drew E.A., 1978. Factors affecting photosynthesis and its seasonal variation in the seagrasses *Cymodocea nodosa* (Ucria) Aschers., and *Posidonia oceanica* (L.) Delile in the Mediterranean. *J. Exp. Mar. Biol. Ecol*., 31 : 173-194.
Duarte C.M., 1991. Seagrass depth limits. *Aquat. Bot*., 40 : 363-377.

Fawzi M.A., Abul-Azm A.G., El-Sayed M.K., 1996. ICZM : An Egyptian experience. *In* Proc. International Workshop on MED & Black sea ICZM, November 2-5, 1996, Sarigerme, Turkey, *E. Ozhan edit., Medcoast Publ* : 263-274.

Francour P., Ganteaume A., Poulain M., 1999. Effects of boat anchoring in *Posidonia oceanica* seagrass beds in the Port-Cros National Park (north-western Mediterranen sea). *Aquatic Conserv. Mar. Freshw. Ecosyst*., 9 : 391-400.

Galloway J., Fordham T., 1995. A recommended framework for coastal environmental impact assessment. *In* “Proc II International Conference on Mediterranean Coastal Environment, MEDCOAST 95”, October 24-27, 1995, *Tarragona Spain, E. Ozhan edit., Medcoast publ*. : 1261-1271.

Genot I., Caye G., Meinesz A., Orlandini M., 1994. Role of chlorophyll and carbohydrate contents in survival of *Posidonia oceanica* cuttings transplanted to different depths. *Mar Biol*, 119(1) : 23-29.

Giaccone G., 1970. The climax problem in the deep regions of the Mediterranean sea. *Thalassia Jugoslavica*, 6 : 195-199.

Hammerstrom K., Sheridan P., McMahan G., 1998. Potential for seagrass restoration in Galveston Bay, Texas*. Texas Journal of Science*, 50(1) : 35-50.

Harrison P.G., 1993. Variations in demography of *Zostera marina* and *Z. notlii* on an intertidal gradient. *Aquat. Bot*., 45 : 63-77.

Jagtap T.G., 1996. Some quantitative aspects of structural components of seagrass meadows from the southeast coast of India*. Bot. Mar.,* 39(1) : 39-45.

Kenworthy W.J., Durako M.J., Fatemy S.M.R., Valavi H., Thayer G.W., 1993. Ecology of Seagrasses in Northeastern Saudi-Arabia One Year After the Gulf-War Oil Spill. *Mar Pollut Bull*, 27 : 213-222.

Kuo J., Den Hartog C., 2000. Seagrasses: A profile of an ecological group. *Biol. Mar. Médit*., 7(2) : 3-17.

Laugier T., 1998. Ecologie de deux phanérogames marines sympatriques - *Zostera marina L.* et *Z. noltii Hornem.* - dans l’étang de Thau (Hérault, France). *Thèse "Biologie des Populations et Ecologie", Univ. Montpellier II* : 142p. + Ann.

Lipkin Y., 1977. Seagrass vegetation of Sinai and Israel. *In* "*Seagrass ecosystems, a scientific perspective*", *Mc Roy P. & Helfferich C. edit., Dekker publ., USA* : 263-293.

Loques F., 1990. Biologie de la phanérograme marine *Zostera nolteii* Hornemann sur le littoral méditérranéen français*. Thèse de doctorat, Université de Nice Sophia Antipolis*, 158 pp.

Loques F., Caye G., Meinesz A., 1988. Flowering and fruiting of *Zostera noltii* in golfe Juan (French Mediterranean). *Aquat. Bot*., 32 : 341-352.

Loques F., Caye G., Meinesz A., 1990. Germination in the marine phanerogan *Zostera noltii* Hornemann at golfe Juan, French Mediterranean. *Aquat. Bot*., 38 : 249-260.

Mayhoub H., 1976. Recherches sur la végétation marine de la côte syrienne. Etude expérimentale sur la morphogenèse et le développement de quelques espèces peu connues*. Thèse Doctorat d'Etat, 26 oct. 1976*, 286 p, + 1 carte, + Pl. 1-16 h.t.

Mazzella L., 1990. Il ruolo dei sistemi a fanerogame marine nell'economia delle communità costiere ed i problemi causati dal distrubo antropico. *In* "Inquinamento ed ecosistemi acquatici", *Atti Congresso Ordine Nazionale dei Biologi (ed. S. Dumontet & E. Landi)* : 103-116.

Mc Millan C., Lipkin Y., Bragg L., 1975. The possible origin of peculiar *Thalassia testudinum* reported from Texas as *Posidonia oceanica*. *Contrib. mar. Sci*., 19 : 101-106.

Meinesz A., Bellone E., 1989. Localisation des herbiers à *Posidonia oceanica* sur le parcours du câble EDF à immerger dans les eaux du Parc National de Port-Cros. Contrat EDF/GIS Posidonie, *GIS Posidonie édit., Fr.* : 1-6, + 2 fig. h.t.

Meinesz A., Molenaar H., Caye G., 1992. Transplantation de phanérogames marines en Méditerranée. *Rapp. Comm. int. Mer Médit*., 33.

Molenaar H., Meinesz A., Caye G., 1993. Vegetative Reproduction in *Posidonia oceanica* - Survival and Development in Different Morphological Types of Transplanted Cuttings. *Botanica Marina*, 36(6) : 481-488.

Molinier R., Picard J., 1952. Recherches sur les herbiers de Phanérogames marines du littoral méditerranéen français. *Ann. Inst. océanogr*., Paris, 27 (3) : 157-234.

Molinier R., Picard J., 1953. Etudes biologiques sur les herbiers de Phanérogames marines à l'Ouest d'Alger. *Bull. Stn. Aquicult. Pêche Castiglione, Alg*., 4 : 7-34.

Molinier R., Picard J., 1956. Aperçu bionomique sur les peuplements marins littoraux des côtes rocheuses méditerranéennes de l'Espagne. *Bull. Trav. Stn. Aquicult. Pêche Castiglione*, N.S., 8 : 251-268.

Monnier-Besombes G., 1983. Etude de la contamination de la Posidonie (*Posidonia oceanica* L. Delile) et de son milieu par des composants de détergents synthétiques. *Thèse Doct. 3ème cycle Ecol., Univ. Aix-Marseille II, Fr.* : 1-162.

Ozhan E., Uras A., Aktas E., 1993. Turkish legislation pertinent to coast zone management. *In* Proc. First International Conference on Mediterranean Coastal Environment, November 2-5, 1993, Antalya, Turkey, *E. Ozhan edit., Medcoast Publ.* : 333-346.

Pasqualini V., Pergent-Martini C., Clabaut P., Pergent G., 1998. Mapping of *Posidonia oceanica* using aerial photographs and side-scan sonar : Application of the island of Corsica (France). *Estuarine, Coastal Shelf Science*, 47 (3) : 359-367.

Pasqualini V., Pergent-Martini C., Pergent G., 1999. Environmental impacts identification along Corsican coasts (Mediterranean sea) using image processing. *Aquatic Botany*, 65 : 311-320.

Peres J.M., 1984. La régression des herbiers à *Posidonia oceanica*. *In* "International Workshop on *Posidonia oceanica* Beds", Boudouresque C.F., Jeudy de Grissac et Olivier J. *édit., GIS Posidonie publ., 1* : 445-454.

Peres J.M., Picard J., 1958. Manuel de bionomie benthique de la mer Méditerranée. *Rec. Trav. Stn. mar. Endoume*, 14 (23) : 7-122.

Peres J.M., Picard J., 1975. Causes de la raréfaction et de la disparition des herbiers de *Posidonia oceanica* sur les côtes françaises de la Méditerranée. *Aquat. Bot*., 1(2): 133-139.

Perez M., Romero J., Duarte C.M., Sand-Jensen K., 1991. Phosphorus limitation of *Cymodocea nodosa* growth. *Marine Biology*, 109 : 129-133.

Pergent G., Pergent-Martini C., 1990. Some applications of lepidochronological analysis in the seagrass *Posidonia oceanica*. *Botanica marina*, 33 : 299-310.

Pergent G., Pergent-Martini C., Boudouresque C.F., 1995. Utilisation de l'herbier à *Posidonia oceanica* comme indicateur biologique de la qualité du milieu littoral en Méditerranée : Etat des connaissances. *Mésogée,* 54 : 3-29.

Pergent G., Rico-Raimondino V., Pergent-Martini C., 1997. Estimation and fate of primary production of *Posidonia oceanica* meadow in the Mediterranean. *Aquatic Botany*, 59 (3,4) : 307-321.

Pergent-Martini C., Pergent G., 2000. Are marine phanerogams a valuable tool in the evaluation of marine trace-metal contamination : example of the Mediterranean sea ? International Journal *Environmental Pollution*, 13(1-6) : 126-147.

Pergent-Martini C., Rico-Raimondino V., Pergent G., 1994. Primary production of *Posidonia oceanica* in the Mediterranean basin. *Marine Biology*, 120 : 9-15.

Phillips R.C., Meñez E., 1988. Seagrasses. Smithsonian Contributions to the Marine Sciences, 34.

Pisanty S., 1996. ISRAEL – Country review of coastal Management. *In* Proc. International Workshop on MED & Black sea ICZM, November 2-5, 1996, Sarigerme, Turkey, *E. Ozhan edit., Medcoast Publ* : 257-262.

PNUE, 1996. Environmental Impact assessment : issues, trends and practice. Scott Wilson Resource Consultants & UNEP International Working group on EIA, *UNEP publ.* : 96p.

PNUE/UICN/GIS Posidonie, 1990. Livre rouge "Gérard Vuignier" des végétaux, peuplement et paysages marins menacés de Méditerranée. *MAP Technical Reports*, 43 : 1-250.

Porcher M., 1984. Impact des mouillages forains sur les herbiers à *Posidonia oceanica*. International Workshop *Posidonia oceanica* Beds, Boudouresque C.F., Jeudy de Grissac et Olivier J. *édit., GIS Posidonie publ., 1* : 145-148.

Powell G.V.N., Fourqurean J.W., Kenworthy W.J., Zieman J.C., 1991. Bird colonies cause seagrass enrichment in a subtropical estuary : Observational and experimental evidence. *Estuarine Coast. Shelf Sci*., 32 : 567-579.

Procaccini G., Mazzella L. , 1996. Genetic variability and reproduction in two Mediterranean seagrasses*. In* « Seagrass Biology : Proceedings of an International Workshop », J. Kuo, R.C. Phillips, D. I. Walker & H. Kirkman eds., *Univ. Western Australia publ*. : 85-92

Ramos-Espla A.A., Aranda A., Gras D., Guillen J.E., 1995. Impactos sobre las praderas de *Posidonia oceanica* (L.) Delile en el S.E. espanol : necesidad de establecer herramientas de ordenamiento y gestion del litoral*. In* " Pour qui la Méditerranée au 21ème siècle - Ville des rivages et environnement littoral en Méditerranée " OKEANOS 94, *Maison de l'Environnement de Montpellier Edit.* : 64-69.

Ribera G., Coloreu M., RodriguezPrieto C., Ballesteros E., 1997. Phytobenthic assemblages of Addaia Bay (Menerca, western Mediterranean): Composition and distribution. *Botanica Marina*, 40(6) : 523-532.

Richez G., 1995. Réserve naturelle des Iles Lavezzi : la fréquentation touristique et récréative de l'île Lavezzu durant l'été 1994 et évolution 1991 - 1994. *Trav. sci. Parc nat. rég. Rés. nat., Corse*, 55 : 45-92.

Rismondo A., Curiel D., Marzocchi M.,Micheli C., 1995. Autoecology and production of *Zostera marina* in Venice Lagoon. *Rapp. Comm. int. Mer Médit*., 34 : 42.

Shepherd S.A., Mc Comb A.J., Bulthuis D.A., Neverauskas V., Steffensen D.A., West R., 1989. Decline of seagrasses*. In* A.W.D. Larkum, A.J. McComb & S.A. Shepherd (Eds.) *Biology of seagrasses, Aquatic Plant Studies 2, Elsevier Publ*. : 346-393.

Short F.T., Coles R., Pergent-Martini C., *in press*. Global seagrass distribution. *In* "Seagrass Method books", Short F.T & R. Coles edit., *Elsevier publ*.

Short F.T., Wyllie-Echeverria S., 1996. Natural and human-induced disturbance of seagrasses. *Environmental Conservation*, 23(1) : 17-27

Thiebaut J., 1953. Flore libano-syrienne. Troisième partie. *CNRS édit*. : 1-360, 7 pl. h.t.

Verhoeven J.T.A., 1975. Ruppia-communities in the Camargue (France) : Distribution and structure in relation to salinity and salinity fluctuations. *Aquatic Botany*, 1 : 217-241.

Verlaque M., 1994. Inventaire des plantes introduites en Méditerranée: origines et répercussions sur l'environnement et les activités humaines. *Oceanol. Acta*, 17(1) : 1-23.

Villèle X., Verlaque M., 1995. Changes and degradation in a *Posidonia oceanica* bed invaded by the introduced tropical alga *Caulerpa taxifolia* in the north western Mediterranean. *Bot. Mar.*, 38(1) : 79-87.

Annex A : Model Questionnaire

Name:

A : Is there any legal obligation to carry out an impact study before construction of a port or establishment of a fish farm ? Can you specify the referent text (N° of the decree) and the responsible body (Ministry, council ?)

Country/Region	Yes	No	N° of ref. text

B: If there is a legal obligation, does the impact study include the following points?

I/ Description of the original state
2/ The accomplishments foreseen
3/ Envisaged impacts and harmful effects
4/ Measures envisaged to reduce the harmful effects

YES or NO. If NO, what are the points that are not included (N°)?

What supplementary criteria exist?

C: Who is carrying out the impact study?

1/ Public bodies (administration, university) YES NO
2/ Private bodies YES NO
3/Bodies authorized by the Ministry
of the Environment or other Ministry YES NO
4/ Bodies with proven marine experience YES NO
5/ Anyone YES NO

D: Who will assume the cost (financial) of the impact study?

1/ An administrative body YES NO
2/ The enterprise carrying out the development YES NO
3/ An independent body YES NO

E: In the impact study(legal text) is there a reference to seagrass meadows?
YES NO

F: If there is a reference to meadows, are there particular criteria referring to them? YES NO

G: Which criteria?

H: Which criteria would you like to see appear?

Annex B: Schematic draft guidelines for the portion of environmental impact assessment dealing with meadows

First it is important to specify that dead mattes with a few isolated fascicles or residual spots of *Posidonia oceanica*, as well as thin and occasional plants of *Cymodocea nodosa*, do not constitute a meadow.
Furthermore, concerning precautionary measures, differences among seagrass species and their geographic distribution must be considered: climax or rare species like *P. oceanica* and *Zostera marina* request stronger care than annual or pioneer species (*C. nodosa, Z. noltii, Ruppia cirrhosa, R. maritima*).

In addition to general impact studies procedures, the assessment of impact on meadow request some specific information regarding different parameters. At this regard, many elements are in the section III "Threats to marine phanerogam meadows", of the first chapter of the document, below summarised:
- Information concerning coastal currents in order to understand the impact of possible sediments and pollutants from the envisaged development;
- Information concerning possible increasing in water's turbidity, which has negative impact on all the seagrass and in particular on *P. oceanica*. Doubtless, this is a major parameter of meadow regression, at least as regards their lower limit.
- Information concerning possible decline in salinity; this is a problem for *P. oceanica*, which disappearing when the salinity is under 33‰,. The other species are more tolerant.
- Information concerning possible addition of nutrients; the impact of this enriching then differs from one phanerogam species to the next. It seems that pioneer species like *C. nodosa* are very rapidly able to make use of these nutrients, which are frequently restrictive factors (e.g. phosphorus) for their own growth. Inversely, for climax species such as *P. oceanica*, a massive development is recorded for epiphytes, which compete with the host plant for light. This rivalry may be expressed in a decrease in foliar growth, even, when the nutritive additions are maintained for several weeks, a death of the fascicles. And many authors mention these massive developments of epiphytes to explain the way meadows are retreating in anthropised.
- Information concerning possible addition and deficit of sediment; *P. oceanica* is again the more sensitive species. The a medium- or long-term change in the amount of sediment causes the vegetative tips to be buried or the rhizomes loosened, which can in the long run cause the death of *P. oceanica* fascicles.
- information possible concerning increasing of mooring boats. There are several kinds of mooring (e.g. anchors, isolated moorings and mother chains, moorings and floating landing stages). The immersion of moorings pulls off the fascicles and may cause the mattes to be abraded, immersed structures undermined and the substratum modified. The boats' anchors give rise to similar phenomena, although to a lesser extent. Every anchoring causes an average 20 fascicles to be pulled out.

An impact study usually contains several parts, for each of these parts some suggestions regarding the impact on meadow are presented.

Phase 1) Description of the envisaged development. In this first phase the project and the operational techniques for the completion of the project should be described taking into account possible increasing of water turbidity, decline of salinity, addition of pollutants, presence of mooring boat on the meadow.

At this first level some measures to mitigate the impact on meadow could be:

- Detailed mapping in order to safeguard meadow avoiding to build on it;
- using materials that have previously been washed to reduce the addition of fine particles;
- using of geotextile nets to confined the impact to the development area and to reduce the addition of fine particles;
- to forbid mooring in sensitive sectors;
- to create a code of behaviour for mooring over meadows;
- to optimise technical innovation in mooring.

Phase 2) Detailed analysis of the original condition ("zero state"). Any impact study concerning meadows must enable the overall functioning of these formations to be grasped. For this, it is advisable to:

- identify the assemblages presumed to be subject to the impact;
- map these assemblages as precisely as possible;
- make a quantitative study of the species whose biomass is biggest;
- draw up a statement of the existing biodiversity;
- identify the descriptors which enable the state of the environment to be grasped by taking into account the meadows' vitality parameters (see Table 1 and 2 in the document).

Phase 3) Exhaustive inventory of the effects linked to the development or engendered by its future exploitation. At this level the possible addition of pollutants, increasing of water turbidity, decline of salinity, possible addition of nutrients, presence of mooring boat on the meadow should be considered. A detailed description of the maintenance operations of the new facilities should be given.

Suggestions about measures to be taken to mitigate the impact on meadow, in part, are the same suggested in the first phase, but as concern the prohibition of mooring in sensitive sectors, it is useful to add that the goal is to permit the restoring of these sites and to this end the ban on mooring must be maintained for at least five years.

Phase 4) Environment-monitoring programme. This analysis allows verification of how well the recommended techniques fit the objectives aimed at, in terms of reduction of impacts. It is advisable to carry out the same or comparable analysis executed during the phase 2.

Over the last few years several replanting techniques have been improved, but some problems are still present. Concerning that it is important to continue the research with the aim of further improving the replantation techniques. It is however important to prevent that replanting serve as an excuse for new destruction.