

# The role of seagrass beds on the conservation of littoral fish

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There are 49 species of grass-like flowering plants in the shallow-water coastal areas of the world.

The study of seagrass beds have been incremented after an epidemic disease responsible for the disappearance of about 90% of *Zostera marina* in the years 1931-34 in the USA and the West coast of Europe (Tutin, 1942).

Until 1970 only 540 papers about seagrass were published and most of them concerning botanic aspects. Eight years after, the number of published raised to 1400, with a total of 3150 nowadays.

This increment of papers is a reflection of the importance of these biocenosis in the marine environment.

From the 11 known genera of seagrass, seven are tropical and four are present in temperate waters. Two of them are bipolar (*Zostera* and *Posidonia*), being present both north and south of the tropics.

Some of these species have a wide distribution, such as *Zostera marina*, which is present in the whole temperate region of the northern hemisphere. Others are restricted to limited regions of the world, like the six species that are only found in Australia (*Posidonia australis*, *P. ostenfeldii*, *Zostera muelleri*, *Z. mucronata*, *Amphibolis antarctica* and *A. griffithii*).

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In the Mediterranean region, five species are present, in which four had their origin there (*Zostera marina*, *Z. noltii*, *Posidonia oceanica* and *Cymodocea nodosa*) and one was introduced from the Red Sea and is now considered an infestation (*Halophila stipulacea*).

In other world regions sometimes only a single species is found, like in Chile (a monospecific distribution of *Heterozostera tasmanica*), or on the contrary, as many as 12 species of seagrass can be found (Phillips & Meñez, 1988).

The depth limit in which these plants can be found depends directly on the water transparency. Thus, in temperate and high latitude regions, the depth limit is around 15m, whereas in the tropics is around 75m.

The increase in habitat diversity provided by Zosteracea seagrass relates to the possibility of a higher fauna biodiversity present in a given region. This is because in the upper parts of the plant, light is abundant near the leaves, while near the basal region and rizoma one can find organisms adapted to dim light and debris of dead leaf parts, which in conjunction with algae and other dead organisms make part of the so called "manta morta". This leaf debris are very important in zosteracea beds, since many times they have up to 4 times more plant material then the bed itself.

The processes by which the leaf debris originate includes: (I) fragmentation by physical and biological action (22-70% due to the macrofauna), (II) autolyse with the liberation of cellular contents by enzymatic action through osmotic processes of the solvent components, (III) bacterial action, with the digestion of the debris by bacteria and extracellular fungi. It is the combination of all these processes that allow the debris formation from the seagrass leaves.

The action of the benthic habitat in the decomposition process of the leaves and in the debris absorption by many organisms (e.g. polychaets) is in many cases vital. Some crustaceans (e.g. amphipods and isopods) also contribute to leaf decomposition by bracking and reducing leaf dimension. This also allows the raise in oxygen consumption by the debris, which

*per se* contribute to the acceleration of the decomposition process (c.a. 2.7 times fold).

A great amount of organisms like Bryozoa and Hydrozoa which live directly on the leafs of the seagrasses can (and many time do) cause the asphyxiation of the leaf since they do not allow enough light to get on the surface, blocking the photosynthetic process. In this case, the role of animals like some gastropods and isopods is extremely important, since having grazer feeding behaviours they keep the leaf surface clean. As endofauna, and directly dependent on the substrate, several species of polychaets and bivalves can be found; some species of sponges and ascidians live on the rhizoma due the dim conditions of light.

The seagrass species that live in the intertidal zone play an important role as ecological regulators, since their leafs act as temperature and moisture buffers during low tide, avoiding great changes in temperature and salinity.

Being in general large and dense, these seagrass beds contribute to an enrichment of oxygen in the water, and sometimes oversaturation levels of oxygen can be found. Due to this situation large amounts of gastropods feed on their leafs or on small organisms living on them.

Also through their leafs marine angiosperms have an important role in the ecological regulation of carbon, nitrates and nitrites, since they are able to absorb or release this elements depending upon the environmental levels.

Echinoderms, cephalopods and fish are also important groups of animals that may be found in the seagrass beds.

Seagrass beds of marine angiosperms in Portugal are generally found in estuaries in sand-mud substrates. In the West coast, *Zostera noltii* and *Zostera marina* occur, and in the South (Ria Formosa) also *Cymodocea nodosa*. Both *Zostera noltii* and *Z. marina* occur, are euryhaline species since they tolerate water salinity between 5 and 37‰.

*Zostera noltii* occurs at depths shallower than 4m, and on organic substrate.

It is known that high productivity regions have high levels of biodiversity and that some of them have commercial value, such as fish does.

There are many regions in the world in which fish species of commercial value depend on these marine angiosperms ecosystems, which have an important role in the coastal marine environment since they are the substrate for a large number of organisms and have a special importance as nursery grounds for fish and crustaceans, that latter disperse to other marine environments.

Studies in the West coast of Portugal in the estuary of the Mira river (Vila Nova de Mil Fontes) showed that seagrass beds of *Zostera noltii* and *Z. marina*, with an average area of 13000 m<sup>2</sup>, are of extreme importance for the recruitment of littoral fish (mainly of the family Sparidae), and shrimp and crab species (Almeida, 1988, 1992, 1994). Of the 47 species of fish, nine were of commercial value (*Anguilla anguilla*, *Conger conger*, *Boops boops*, *Diplodus annularis*, *D. sargus*, *D. vulgaris*, *D. puntazzo*, *Sarpa salpa* e *Spondyliosoma cantharus*).

For this studied area of seagrass beds the average diversity index was 2.55 nats with a density of 0.175 fish per square meter (Almeida, 1988), and outside the area a diversity of 2.02 nats and a density of 0.011 fish.m<sup>2</sup> was found (Costa *et al.*, 1987, 1994).

In south Portugal (Ria Formosa), Monteiro (1989) studying seagrass beds of *Cymodocea nodosa*, *Zostera noltii* and *Z. marina* with an average area of 8200 m<sup>2</sup> obtained for the average diversity index a value of 2.44 nats for a total of 55 species, while outside this beds and without any vegetation a diversity index of 1.28 nats with a total of 51 species was recorded.

On the other end, Sogard and Able (1991) working in the New Jersey coast (USA) showed that in areas where *Zostera marina* and *Ulva lactuca* were present, the abundance of fish was higher when compared with areas with no vegetation cover of the substrate, and that when compared with each other the vegetation areas of *Zostera marina* had a higher biodiversity with 20 ind./m<sup>2</sup>.

Our work in the Inhaca Island, Mozambique, during 1993-95 (Almeida et al., in press) revealed that in mixed seagrass beds of *Thalassodendron ciliatum*/*Halodule wrightii* present till the depth of 5-6m, 73 species of fish of 30 different families could be found, with a diversity index of 2.45 nats. The Labridae (7 species), Lethrinidae (6 species), Scorpaenidae (5 species), Apogonidae, Mullidac and Syngnathidae (4 species) were the families with the great number of species.

Both in the Inhaca Island and the estuary of the Mira river, the percentage of the total number of juvenile fish is high being near 50% of the number of individuals present (Almeida, 1998; Almeida et al., in press). Other authors found similar results in fish communities occurring in marine angiosperms, with a large number of juvenile or small adults being found (Monteiro, 1989; Heck et al., 1989).

It is important to note that some fish families are present in almost every seagrass beds of marine angiosperms. For example, the families Syngnathidae and Gobiidae were present in 24 of the 25 studied areas around the world (Howard & Kohn, 1985). Also the families Monacanthidae, Sparidae, Labridae, Gerreidae, and Tetradontidae are present in many of the areas (Bell & Pollard, 1989).

The highest number of fish species found in this type of habitats were in a mixed seagrass bed in Madagascar with 189 species recorded, while in Australia the seagrass bed (*Posidonia*) with the smallest diversity of fish species (only 19 species) was recorded.

Having this in mind one must always be careful when doing isolated studies in seagrass bed ecosystems since the type of bed, and specially the main species present, as well as the time of the year and if is a diurnal or a night study is of extreme importance (Harmelin-Vivien, 1983).

For the reasons stated above, the destruction of seagrass beds can be compared to the destruction of terrestrial forests. During the degradation process all the fauna present will disappear leading to an overall

impoverishment of the surrounding environment in a short and medium time scale, due to the reduction of the nesting, breeding and nursery areas.

As an example, one can mention the drag works done in Florida (USA) where 1100 tons of *Thalassia* seagrass beds were destroyed, and where studies showed that 1800 tons of associated fauna were destroyed as well (see Thayer et al., 1975), being the annual lost of fauna ever since around 73 tons of fish and 1100 tons of macroinvertebrates.

This is even more serious if we think that seagrass beds of marine angiosperms when destroyed can take up to 30 years to get to its initial stages, that is if the environmental condition allow to. This was the time length needed for the seagrass beds of West Europe and the USA to recover themselves after being infested by *Labyrinthula macrocystis* in the years 1931-34.

Reintroduction programs seems to be a good solution in these cases (the first experiments were done in 1947: Phillips & McRoy, 1990). Studies in Florida in 1988/89 (Brown-Peterson et al., 1993) in places of artificial recolonization by *Halodule wrightii* and *Syringodium filiforme*, showed that after 4 years of observation in these areas they had an ichthyofauna no different then the original (31 years ago) specially in what concerns juveniles and small adults.

In our days the Mediterranean have a huge problem which is in the hands of the scientific community. In Monaco, near the Oceanographic Museum, in 1984 a colony of *Caulerpa taxifolia*, a tropical algae, was detected (Francour et al., 1995). It seems that this algae had its origins from water of the Museum itself, and now it is expanding very rapidly not only in the French coast where it covers already an area of 3000ha, but also to other coasts in the Mediterranean Sea (as in Italy, and some of the Spanish and Croatia Islands). It forms small clusters that are destroying not only biotopes but also the original vegetation in those areas. Also *Posidonia oceanica* is being affected by it.

The problem with this algae is that they do not have natural predators in the Mediterranean and it is toxic to many organisms.

Many studies are taking place in several laboratories with a small opisthobranch which feeds on this algae becoming toxic itself and not having natural predators because of that. It is with this method that researchers are trying to reduce or even stop the rapid growing and expansion of the *Caulerpa taxifolia* population in the Mediterranean.

In this fight for the preservation of the original vegetation (of algae and *Posidonea oceanica*) 30 research institutes (French, Spanish, Italian and Croatian) and more than 200 researchers are involved.

For all this reasons it is essential that each country has or develops a conservation/preservation program for these habitats. For this to happen it is vital to know locally the areas where in the past this seagrass beds existed to assess its importance in the ecosystem. The limits of the beds should be charted (through remote detection, photo/video, in situ markings, etc.), as was done recently in northern Spain for *Zostera noltii* (Laborda et al., 1977).

At the same time, the increase or decrease in density of the beds should be assessed (through transects for biomass evaluation). These observations should be made monthly (in the summer) and bimonthly (in the winter), since the biomass values can have major seasonal variations (Harrison, 1982; Teles-Ferreira et al., 1996).

A reimplantation program should be implemented, not only to keep the present distributional areas, but also to increase those areas where in the near past these beds occupied large areas of the coast, as is the case of the coast of Arrábida (Portugal) where most seagrass beds are now extinct.

The first reimplantation experiments were done in 1947 and were already aimed at the restoration of these natural habitats.

It is essential to preserve these marine plants avoiding them to the presence and contact with chemical and organic pollution, and the devastating processes of dragging of the seagrass beds as well as the adjacent areas, since the increase of turbidity caused by these works can lead to the death of the plants due to the block of the solar energy.

## REFERENCES

- Almeida, A.J. (1988). *Estrutura, dinâmica e produção da macrofauna acompanhante dos povoamentos de Zostera noltii e Zostera marina do estuário do Rio Mira*. Unpublished Ph.D. Thesis, University of Lisbon.
- Almeida, A.J. (1992). L'importance des Zosteres dans la conservation des ressources marines. *Publicações Avulsas do I.N.I.P.*, 17, 447-460.
- Almeida, A.J. (1994). *Macrofauna acompanhante de Zosteraceas. Importância na conservação do meio marinho*. In Professor Germano da Fonseca Sacarrão (1914-1992) (pp. 125-144). Lisboa: Muscu Bocage.
- Almeida, A.J., Amoedo, L., & Saldanha, L. (in press). Fishes assemblages in the seagrass beds at Inhaca Island (Mozambique) – Cold season. *Boletim Museu Municipal Funchal*.
- Bell, J.D., & Pollard, D.A. (1989). Ecology of fish assemblages and fisheries associated with seagrasses. In A.W.D. Larkum, A.J. McComb, & S.A. Shepherd (Eds.), *Biology of Seagrass – A Treatise on the Biology of Seagrasses with Special Reference to the Australian Region* (pp. 565-609). Netherland: Elsevier.
- Brown-Peterson, N.J., Peterson, M.S., Rydenc, D.A., & Eames, R.S. (1993). Fish assemblages in natural versus well-established recolonized seagrass meadows. *Estuaries*, 16, 177-189.
- Costa, M.J., Bruxelas, A., & Rosado, D. (1987). Ictiofauna do Estuário do Mira, abundância e diversidade. 2º Congresso sobre o Alentejo. *Semeando Novos Rumos, Beja*, 1987, 2, 225-230.
- Costa, M.J., Costa, J.L.C., Almeida P.R., & Assis, C.A. (1994). Do eelgrass beds and salts marsh borders act as preferential nurseries and spawning grounds for fish? An example of the Mira Estuary in Portugal. *Ecol. Eng.*, 3, 187-195.
- Francour, P., Harmelin-Vivien, M., Harmelin, J-G., & Duclerc, J. (1995). Impact of *Caulerpa taxifolia* colonization on the littoral ichthyofauna of north-western Mediterranean sea: preliminary results. *Hydrobiologia*, 300/301, 345-353.
- Harmelin-Vivien, M.L. (1983). Étude comparative de l'ichtyofaune des herbiers de phanérogames marines en milieux tropical et tempéré. *Rév. Écol. (Terre Vie)*, 38, 179-210.



- Harrison, P.G. (1982). Spatial and temporal patterns in abundance of two intertidal seagrass, *Zostera americana* den Hartog and *Zostera marina* L. *Aquat. Bot.*, 12, 305-320.
- Heck, C.T., Able, K.W., Fahoy N.P., & Roman C.T. (1989). Fishes and decapod crustaceans of Cape Cod eelgrass meadows: species composition, seasonal abundance patterns and comparison with unvegetated substrates. *Estuaries*, 12, 559-265.
- Howard, R.K., & Koehn, J.D. (1985). Population dynamics and feeding ecology of pipefish (Syngnathidae) associated with eelgrass beds of Western Port, Victoria. *Aust. J. Mar. Freshw. Res.*, 36, 70-361.
- Laborda, A.J., Cimadevilla, I., Capdevila L., & Garcia, J.R. (1997). Distribución de las praderas de *Zostera noltii* Hornem., 1832 en el litoral del norte de España. *Publ. Especiales Inst. Español Oceanogr.*, 23, 273-282.
- Monteiro, C.C. (1989). *La Faune Ichtyologique de la Lagune Ria Formosa (sud Portugal). Répartition et Organisation Spatio-Temporelle des Communautés: Application à l'Aménagement des Ressources*. Unpublished Ph.D. Thesis, Université des Sciences et Techniques du Languedoc (Montpellier II).
- Phillips R.C., & McRoy, C.P. (1990). *Seagrass Research Methods*. Paris: UNESCO.
- Phillips R.C., & Meñez, E.M. (1988). Seagrass. *Smithsonian Contrib. Mar. Sci.*, 34, 1-104.
- Sogard, S.M., & Able, K.W. (1991). A comparasion of eelgrass, sea lettuce macroalgae, and marsh creeks as habitats for epibenthic fishes and decapods. *Estuar. Coast. Shelf Sci.*, 33, 501-519.
- Teles-Ferreira, C., Marques, J.C., Guerreiro da Silva, J., & Almeida, A.J. (1996). Estrutura trófica dos povoamentos macrobentónicos das Zosteraceas do Estuário do rio Mira (Portugal). *IX Simposio Ibérico de Estudios del Bentos Marino, Madrid 1996*, 60-61.
- Thayer, G.W., Wolfe, D.A., & Williams, R.B. (1975). The impact of man on seagrass systems. *Amer. Sci.*, 63, 288-296.
- Tutin, T.G. (1942). *Zostera* L. *J. Ecol.*, 30, 217-226.