

THREATS AND CHALLENGES TO THE MARINE ENVIRONMENT IN THE MEDITERRANEAN SEA

OGROŽENOST IN IZZIVI MORSKEGA OKOLJA V SREDOZEMSKEM MORJU

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ABSTRACT

Marine environments are exposed to many threats, mostly deriving from direct human impact through manifold activities. Environmental protection should be accomplished by identifying the source of disturbance and by removing it. This is particularly possible when disturbance is direct and limited in space and time. The Habitat Directive of the European Union aims at identifying relevant habitat types that merit protection (even though the list does not reflect the diversity of Mediterranean habitat types), and a network of Marine Protected Areas has been instituted just to protect particular environments from direct threats. However, there are many forms of disturbance (one for all: global warming) that are acting at very large scale, if not global, and cannot be eliminated by local measures. The stopping of deep water formation in the Northern Adriatic led already to an altered situation (the Eastern Mediterranean Transient) that should be a source of the greatest concern in the light of the impact of global warming on the state of the Mediterranean Sea. The role of the scientific community, within this framework, is not only to evaluate the state of the environment and to propose measures of restoration, but also to enhance public awareness about a proper relationship between our species and the rest of nature.

IZVLEČEK

Morska okolja so izpostavljena neštetim grožnjam, večinoma zaradi neposrednih antropogenih vplivov, ki so posledica različnih človekovih posegov v ta prostor. Varovanje okolja bi se morali lotiti z ugotavljanjem vira motenj in njihovim odpravljanjem. To je še posebej mogoče, kadar je motnja neposredna in omejena v prostoru in času. Namen Direktive o habitatih Evropske unije je opredeliti pomembne habitatne tipe, ki so potrebni ustrezne zaščite (čeprav njihov seznam ne odseva pestrosti sredozemskih habitatnih tipov), medtem ko je bilo omrežje morskih zavarovanih območij osnovano le za zaščito določenih okolij pred neposrednimi grožnjami. Toda dejstvo je, da se moramo spopadati z mnogimi oblikami motenj (predvsem kot posledico globalnega segrevanja), ki delujejo v zelo velikem obsegu (če že ne v globalnem) in jih ni mogoče odpraviti z lokalnimi ukrepi. Že zastoj v formiranju (pridnenih) hladnih vodnih mas v severnem Jadranskem morju vodi v precej spremenjene razmere (vzhodni sredozemski klimatski odziv), ki bi jim morali zaradi učinkov globalnega segrevanja na stanje Sredozemskega morja posvetiti vso pozornost in skrb. Vloga znanstvene skupnosti v tem okviru ni le oceniti stanje okolja in predlagati ukrepe za vzpostavitev nekdanjega stanja, marveč tudi okrepiti ozaveščenost javnosti o pravem odnosu med našimi vrstami in preostalo naravo.

1. INTRODUCTION

The Mediterranean Sea has a paramount role in both natural and human domains. In fact, it is both a hot spot of biodiversity and the cradle of western civilization, being a crossroad of three continents, having more than 380 million people living in the countries that form the basin, 146 million living directly on its shores. Its nature, climate and culture have greatly contributed to the fact that the Mediterranean area has become the most visited part of the entire world, with a tourist flux that is the first source of income for the area, leading to the doubling of the population living along the shore, due to tourist fluxes.

Human pressure is a threat to this beauty, and to the ecological systems that allow for it. The main threats are the usual ones, affecting the whole world: industrial pollution, urban pollution, coastal development (often triggered by tourist presence), industrial fisheries, poaching, human-promoted arrival of alien species. It is in the interest of the Mediterranean people that the reasons for visiting the area remain valid, and that the goods and services provided by the sea remain available for future generation. It is imperative, therefore, to protect the Mediterranean Sea. Marine Protected Areas are one of the tools to achieve this goal.

2. THE MEDITERRANEAN: A BEAUTIFUL PLACE

In recent times, many Marine Protected Areas throughout the Mediterranean area have been instituted for a very precise reason: to defend beauty. It seems a very naive reason, but let us not forget that terrestrial National Parks have been designed for the very same reason as well. Beauty can be a landscape, like a rocky shore with many caves, continuing underwater with steep cliffs that dive into the blue water. Or it can be a single or a group of flagship species, like the monk seal, or cetaceans in general. There are places in which Nature is particularly generous, and we can feel it, even with no aid from science. These places are sacred to all humans, and it is not by chance that sometimes the word “sanctuary” is used for them.

Mediterranean MPAs are essentially sanctuaries. They protect unique places that have no counterpart anywhere else. These locations, and the species that inhabit them, are irreplaceable because they occur only at THAT place, and THAT place is to be preserved. It is not by chance that almost all Mediterranean MPAs are situated on rocky shores, and it is not by chance that many are islands.

So, the aim is clear: beautiful places must continue to be beautiful.

The very beauty of a given place is source of the main threat. Beautiful places are usually not exploited by humans. They are beautiful because they are as pristine as possible and pristine means with no sign of human activities. The threats to the beauty of these places start when somebody discovers it, and few illuminated people go and take advantage of it for some time, to enjoy it. Then other people realize the potential of the place, and they work to “develop” it. They build facilities that will allow more and more people enjoying the direct

contact with a beautiful place. The place becomes rich, hotels are built, and marinas, maybe even airports. The best places, the most beautiful ones, become parks of villas of very rich people. After this treatment, the beauty of the place is gone. The features that made that place beautiful were linked to the absence of human signs. After “development”, human signs become very evident, and beauty is spoiled. This treatment has been inflicted to too many parts of the Mediterranean coast, and it is our duty to defend the few places that are still untouched. Is this enough to “save the sea” from all threats? The answer is simple: no, it is not.

3. SAVING THE MEDITERRANEAN

The most important habitat of the Mediterranean is not a habitat, it is the result of the presence of a habitat-forming species: *Posidonia oceanica*, the seagrass that forms extensive meadows along the greater part of the Mediterranean coast, changing the primary habitat that hosts it (from sand to rock) into a secondary habitat with vital functions for the rest of the Mediterranean biota. *Posidonia* meadows are threatened by coastal development and illegal fisheries throughout the basin; their protection is urgent and badly needed. Can we save them with Marine Protected Areas? There are too many people on the coast, and we cannot propose a MPA for every spot where *Posidonia* occurs, i.e. a great part of the coast of the whole basin. There have to be other tools. Luckily, for *Posidonia* there is one: the Habitat Directive of the EU. The other side of the coin is that the Directive is valid only in the EU, but the Mediterranean is much more than the EU. A shared legislation is needed to prevent all countries from depleting their natural capital, in this case: the capital represented by *Posidonia* meadows.

The presence of *Posidonia* meadows, thus, is a reason for stopping coastal development, so that meadows remain untouched by direct impact, like the construction of harbours, the passage of pipelines, the discharge of materials. A more general legislation than that ruling Marine Protected Areas is aimed at protecting an ecologically valuable habitat of the Mediterranean.

Seagrass meadows, however, are just one of the important habitats of the Mediterranean. And we are very far from having explored the basin. How can we dream of protecting something if we do not know our capital?

The other marine habitats covered by the Habitat Directive are:

11. Open sea and tidal areas

1110 Sandbanks, which are slightly covered by seawater all the time

1120 * *Posidonia* beds (*Posidonion oceanicae*)

1130 Estuaries

1140 Mudflats and sand flats not covered by seawater at low tide

1150 * Coastal lagoons

1160 Large shallow inlets and bays

1170 Reefs

1180 Submarine structures made by leaking gases

The list of marine habitat types comprises also:

8330 Submerged or partially submerged sea caves

It is very evident that the Habitat Directive did not consider the diversity of habitat types that characterizes the Mediterranean Sea. Coralligenous formations are not covered and, furthermore, the spectacular diversity of Mediterranean biota found on capes and promontories is ignored, with the enhancement of mudflats and shallow inlets and bays! These habitats might fall under the Reefs category which, in fact, is too generic, comprising too many different habitat types.

Habitats have to be listed and mapped, in order to identify the most valuable ones, and their distribution. At present, there are far too many lists of Mediterranean habitats, and it is urgent to merge them under a robust rationale. Then we must try to identify the main threats on each of them, wherever they do occur. The exploratory phase, which is very far from being accomplished, might lead to the discovery of valuable sites that are still unknown, especially on the southern shore of the Mediterranean, not to speak about the deep sea.

Of course, we cannot wait for the complete exploration of the basin and we must act now, but the ultimate objective should be the proper knowledge of the Mediterranean biota. Whenever an area is sufficiently explored, and we know the features of its biota, for some places, we might say: at this place there is something really unique, and beautiful. This will be a Marine Protected Area. Probably, all countries have already identified all these places in their own territories. Some are MPAs already; some will be, sooner or later.

There are other places, however, that might be extremely important not for the way they look, but for what they do, just as *Posidonia* meadows.

Such places might be important for the functioning of ecosystems, like marine canyons, leading to the formation of upwelling currents, the currents that bring nutrients from the deep sea to the shallow waters of the shore. If marine canyons become the recipients of dumping, their ecological role might become impaired. The Pelagos Sanctuary for Mediterranean Marine Mammals, for instance, hosts a huge number of whales owing to the presence of large populations of the euphausiacean *Meganyctiphanes norvegica*. These are concentrated in accordance with the upwelling currents that are generated by the large system of marine canyons that characterizes the deep bottoms of the sanctuary. Whales are there simply because the canyons “pump” their food and concentrate it. Protection of whales passes through the protection of marine canyons!

There are places that are important for the reproduction of species. Some are used by the reproductive adults (spawning areas), others are important for the initial growth of larvae and juveniles (nursery areas). The existence of widespread species throughout the basin might be linked to a few places where the representatives of that species concentrate during some part of their existence. If that or those places are degraded, the species is in peril. Maybe there is nothing so special there, in our eyes, and we just need to say that the integrity is to be preserved by prohibiting the most destructive activities, usually fisheries.

Once we have made the list of the places that are beautiful and of the places that are important for ecosystem functioning, we have an inventory of the most valuable natural items. Once we know that these valuable places exist, we must identify their vulnerabilities.

4. STATING OBJECTIVES

Protection implies the presence of a threat. If a place is protected, one should ask: protected from what? And what are the expected results of protection? It is too easy to make a generic list of threats and of possible improvements, and then to apply it to all Protected Areas. This would make it too difficult to evaluate the efficacy of the measures of protection: if we list every positive goal for each MPA, then some results will be surely obtained. But are they relevant for the objectives of that particular MPA? Or, if beauty is not involved, for the area that we wanted to defend due to its ecological importance?

So, stating the threats and the ways to avoid them is a prerequisite for the good management for any place, and this is even truer for Marine Protected Areas.

The test of efficacy, however, is rather difficult. To decide whether management has been effective, in fact, one should compare the managed area with a series of similar areas (the controls, and they have to be more than one) that have not been managed. Because the obtained results might not be the fruit of good management but of chance. So, management is effective when the managed area has more positive features in a series of indicators (decided in function of the identified threats) than similar but not managed areas in its vicinities. The procedure is very simple, in theory, but it is often impossible in practice. Unicity, in fact, is one of the main reasons for the institution of Marine Protected Areas, and if a place is unique then there will be no other places like it, and this makes the finding of adequate controls impossible.

A different way of evaluation might be trend analysis. Once the feature to protect has been identified and the possible threats to it have been removed by protection, one might monitor the descriptors of that feature in order to evaluate if any improvements have been made. The presence of improvements, without proper controls, might not be unambiguously ascribed to management, but this might become irrelevant. As long as the situation improves, or at least does not undergo further degradation, management might be considered as effective. If the trend is showing a decrease in the indicators of quality, then we are most likely that we have a case of mismanagement on our hands.

5. WHAT MPAS CANNOT DO

A Marine Protected Area, however, cannot stop an alien species (like *Caulerpa racemosa*) and one cannot blame the manager if the bottoms of its area are invaded. Equally, protection cannot stop an oil wave deriving from of an oil tanker wreck. Direct threats like these, in fact, do not depend on the local conditions of the MPA, those that can be controlled by management, but do have their origin outside the MPA and, within this framework, they might be called indirect threats. Such threats therefore cannot be avoided by localized protection, as that of MPAs, but need basin-scale management, like that protecting *Posidonia* meadows. Protection can avoid direct and localized threats, such as overfishing, sewage discharges, and untenable tourist pressure.

Promising impossible results, thus, invariably leads to failure.

6. THE GREATEST THREAT TO MEDITERRANEAN BIOTAS

There are three areas in the entire Mediterranean basin that are of paramount importance for the well being of its biota. One is Gibraltar, from where a shallow Atlantic current enters the basin and a deep Mediterranean current flows out. This water exchange is vital for Mediterranean biota. The other two places are the northern portions of the Western and the Eastern basins, namely the Gulf of Lyon (maybe the Ligurian Sea) and the Northern Adriatic, plus some parts of the North Aegean. At these places, the northerly cold winds reduce temperatures in surface waters to a much greater extent than in any other part of the basin. Cold water is heavier than warmer water, and tends to sink. At these places, therefore, a shallow formation of potentially deep water occurs. The cold water, in fact, tends to sink towards the deeper portions of the Mediterranean. The Gulf of Lyon is the point of origin of deep waters in the Western Mediterranean, whereas the Northern Adriatic and the Northern Aegean are the points of origin of deep waters in the Eastern Mediterranean. The new deep water displaces the old water and generates a turn-over that is vital for the mixing of the basin. If vertical mixing stops, for any reason, we can have a situation like that of the Black Sea, where the surface is vital but the deeper parts are anoxic and host much simplified biota. Now the situation becomes clear. If there is a tendency towards global warming, what are the portions of the Mediterranean that will be most affected by it? The answer is simple: the coldest portions. The threat is twofold. There is a direct threat to the northern biotas, since they cannot tolerate too warm waters and run the risk of extinction. In the Northern Adriatic, for instance, there is a boreal biota having the brown alga *Fucus virsoides* as its flagship species. It is the only *Fucus* of the whole eastern basin and, together with it, there are other species that are endemic to that portion of the Mediterranean. These species cannot migrate northwards and they cannot go deeper, since the Northern Adriatic is a shallow *cul-de-sac*. If there are species running a serious risk of extinction due to global warming, then they are certainly in the Northern Adriatic. The other threat is indirect for the whole basin. If deep water is not formed anymore, since the climate is not conducive for its formation, there will be a weaker renewal of deep waters, with a tendency of stagnation. The catastrophic scenarios for this event are happening already. In 2007, along the Apulian coast, from the Gargano Peninsula to the Gulf of Taranto, mucilage events occurred during January and April, impairing coastal fisheries in a dramatic way. This had never happened before. Jellyfish blooms are becoming more and more frequent, with impacts on tourism and on fisheries.

The formation of the Eastern Mediterranean Transient, at the end of the 1990s, stemmed from the stopping of deep water formation in the Northern Adriatic, the deep waters of the Eastern Mediterranean being formed in the Northern Aegean. What might happen if the formation of deep waters near the coast comes to a stop due to global warming?

Localized environmental protection, such as that of Marine Protected Areas, surely cannot stop such disasters. Some people claim that a protected area will show more resistance (the tendency to resist an impact while maintaining own features) and resilience (the tendency to go back to own features after an impact has ceased to occur) in respect to global change. This might be true, in a sense. A healthy body is more resistant to disease, but we cannot say that

being healthy is enough to prevent any kind of threat to our health. One does not practise jogging and stops smoking to prevent being intoxicated by a firm that is spoiling air quality in the area where s/he lives, even though a non smoking person that does some sport might answer better to air pollution than a sedentary smoker!

The presence of MPAs in the colder parts of the Mediterranean, however, might help in keeping the situation under control, tracking the changes and eventually indicating if measures taken at the global level are proving effective in the most sensitive parts of the planet to global warming.

MPAs main objective is to protect the extraordinary features of a certain piece of environment. In a way, each one is an island (and many are on islands!). Their positive impact, thus, is to be expected as being very localized and idiosyncratic. These might be called proximate goals of MPAs. The ultimate goals of MPAs, however, should be essentially two: to enhance public concern about environmental integrity and to act as sensors of environmental integrity. The levels of action of MPAs should therefore range from the proximate and local activities, to the ultimate and basin-scale activities. This second group of actions requires networking, leading to a shared strategy aimed at environmental protection.

7. HOW TO ENHANCE PUBLIC CONCERN ABOUT ENVIRONMENTAL INTEGRITY?

Knowledge is the way. If people know what the sea is giving us, in terms of goods and services, then they understand that their well being depends on environmental well being. Public outreach, thus, is essential. It has to concentrate on the peculiarities of the site, but it should also develop a shared message that is equal throughout the basin, with the production of collectively conceived posters (to donate to all schools) and simple manuals, integrating school textbooks. The proximate message is peculiar to each MPA, but the ultimate message is to be agreed upon by the network, so that people, in all countries, will ask for the same policy. This should be achieved by using all communication tools, especially television. More conscious people will take more conscious decisions, caring also for environmental gain, and not only for economic profit.

8. HOW TO SENSOR ENVIRONMENTAL INTEGRITY?

Marine environments are not as easy to monitor as terrestrial environments. Satellites can be used to obtain information about surface temperatures, or phytoplankton blooms, but we cannot infer from these data the maximal depth of the summer thermo cline, or the presence of jellyfish blooms. Scientists, furthermore, often do collect data aimed at answering very specific questions, posed by the financing of very specific research projects. If something “strange” happens, like a bloom of gelatinous plankton, or a mucilage event, usually they are not ready to record it, and the scientific literature is not very interested in these “simple” observations. Scientists are often

looking for regularities, so to discover rules, and tend to disregard irregularities that cannot be predicted in a research project. If irregularities occur during a project on regularities, then they are not relevant to the project and are simply discarded. Let us explain this with a simple example. In the study of fisheries, the attention is invariably focused on the targeted fish, and the only impact is usually fisheries. A bloom of the by-the-wind sailor (*Velella velella*) might have a heavy impact on fisheries, since these floating hydroids feed on fish eggs and larvae. But the impact will be felt by fisheries only after the occurrence of the bloom, when the larvae that should have become adults will not have developed, since they ended up in the coelenteron of the predator. The effects of predation, thus, might be perceived when the predator is not around anymore. The cause is very far in time from the effect.

Organized amateurs, such as the Cornwall wildlife trust, sometimes record episodic events that pass unnoticed by the scientific community. The scientific literature paid no attention to the presence of *Velella* along the Cornwall coast. On the contrary, the page <http://www.glaucus.org.uk/Velella.htm> reports on the presence of the by-the-wind sailor during an extensive period of time! Such information, if available over a basin scale, might provide precious insight about the state of the environment, supplementing in an effective way the observations of the scientific community.

9. THE OBSERVATORIES OF BIODIVERSITY

MPAs should map their biodiversity at the habitat level with great precision, on a GIS standard, and the area of each habitat should be measured at proper intervals, so to perceive possible change. All-species inventories should be made for all MPAs, involving the scientific community. Such inventories should be repeated at proper intervals, too, to monitor the state of biodiversity at the species level. These monitoring should satisfy the proximate needs of each MPA, but might also play a relevant role as an alert system for phase shift at the basin level. Such phase shifts, in the Mediterranean, might be:

- From fish to jellyfish
- From algal canopies to sea-urchin barrens
- From temperate to tropical biota
- From artisanal to industrial fisheries
- From fisheries to aquaculture
- From predictable to unpredictable seasons

Most of these phase shifts have been detected from isolate observation, and data are not spread enough on a basin scale to show if the trends are real (for instance, this is very true of the fish-jellyfish transition). Such information is only available to people who live permanently on the shore and work there, just as the managers of MPAs. The evaluation of a series of macrodescriptors, easy to evaluate at the basin level, through a network, might provide vital information on the state of the environment. A common monitoring programme, operating across a network of MPAs, might regard such macrodescriptors as:

- gelatinous plankton blooms

- mass mortalities
- harmful algal blooms (planktonic and benthic)
- ammasses of seagrass leaves and mollusc shells
- sea-urchin barrens
- arrival of alien species
- disappearance of native species
- any natural event covered by the press

If put into a common database, these data might provide for an instant evaluation of the state of the whole Mediterranean through the network of biodiversity observatories operating in each MPA.

10. A FURTHER STEP

The aims of MPAs are also scientific research and public education. Whenever possible, MPAs should become equipped with simple laboratories right on the shore, with water tables, a classroom, and the basic equipment for field courses at the university level. In this way, they might attract courses in marine sciences that might contribute to monitoring programmes, involving undergraduate and graduate students, and their professors, becoming the subject and not the object of scientific research, proposing problems to scientists and to their students while providing facilities for their institutional activities. These laboratories should become an instrument for continuous capacity building of the personnel of the MPA through the research centres operating in the area, triggering a fruitful symbiosis between research and conservation institutions.

11. SUMMARY

Marine Protected Areas are becoming the main tool for the protection of marine environments in the Mediterranean. Even if they do not suffice to warrant proper protection, especially of functionally important areas with no emotional appeal, MPAs are the irreplaceable tool for increasing public awareness towards the problem of marine protection and, also, have the potential to favour a much-needed return to field studies, after a too laboratory-concentrated activity of the scientific community, even at marine research stations.

The cooperation among MPA managers, through the formation of an extensive network, and the collaboration with the scientific community to solve both specific and general problems regarding marine protection, are the key to taking proper advantage of this unique occasion to protect the sea. Marine Protected Areas are a reality in almost all Mediterranean countries; they provide an occasion that should not be wasted by mismanagement and lack of proper knowledge.

12. POVZETEK

Zavarovana morska območja postajajo glavno orodje za zaščito morskih okolij v Sredozemlju. Tudi če ne jamčijo ustrezne zaščite posebno funkcionalno pomembnih območij, so zavarovana območja nenadomestljiva za dvigovanje ozaveščenosti javnosti na področju zaščite morskih okolij, hkrati pa imajo tudi potencial, da podprejo že tako zelo potrebno vrnitev k terenskim študijam po vse preveč laboratorijsko osredotočenim dejavnostim znanstvene skupnosti, celo na morskih raziskovalnih postajah samih.

Sodelovanje med različnimi upravljavci zavarovanih morskih območij prek oblikovanja obsežnih omrežij in sodelovanje teh upravljavcev z znanstveno skupnostjo, da bi skupaj poskusili rešiti tako specifične kot splošne probleme glede zaščite morskega okolja, je ključ k temu, da ustrezno izkoristijo prednost te enkratne priložnosti za zaščito morje. Zavarovana morska območja so realnost v skoraj vseh sredozemskih državah, saj jim dajejo priložnost, ki je ne bi smeli zapravljati z zgrešenim upravljanjem morskega okolja in pomanjkljivim znanjem.

13. LITERATURE

The literature on this topic is overwhelmingly vast. I decided not to quote any paper in the text because they are too many and any sub-sample would have omitted relevant contributions. Only some recent references from the Lecce group are reported here, containing extensive bibliographic sections.

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