ASSESSMENT AND MONITORING OF THE FISHERY RESOURCES
AND ECOSYSTEMS IN THE STRAITS OF SICILY

MiPAAF

MedSudMed

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Report of the MedSudMed Expert Consultation on Marine Protected Areas and Fisheries Management

Salammbô, Tunisia, 14-16 April 2003

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The conclusions and recommendations given in this and in other documents in the *Assessment and Monitoring of the Fishery Resources and Ecosystems in the Straits of Sicily* Project series are those considered appropriate at the time of preparation. They may be modified in the light of further knowledge gained in subsequent stages of the Project. The designations employed and the presentation of material in this publication do not imply the expression of any opinion on the part of FAO or MiPAAF concerning the legal status of any country, territory, city or area, or concerning the determination of its frontiers or boundaries.

Preface

The Regional Project "Assessment and Monitoring of the Fishery Resources and the Ecosystems in the Straits of Sicily" (MedSudMed) is executed by the Food and Agriculture Organization of the United Nations (FAO) and funded by the Italian Ministry of Food, Agriculture and Forestry Policies (MiPAAF).

MedSudMed promotes scientific cooperation between research institutions in the four participating countries (Italy, Libya, Malta and Tunisia) for the continuous and dynamic assessment and monitoring of the status of the fisheries resources and the ecosystems in this area of the Mediterranean.

Research activities and training are supported to increase and use knowledge on fisheries ecology and ecosystems, and to create a regional network of expertise. Particular attention is given to the technical coordination of the research activities between the countries, which should contribute to the implementation of the Ecosystem Approach to Fisheries. Consideration is also given to the development of an appropriate tool for the management and processing of data related to fisheries and their ecosystems.

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GCP/RER/010/ITA Publications

MedSudMed Project publications are issued as a series of Technical Documents (GCP/RER/010/ITA/MSM-TD-00) related to meetings, missions and research organized by or conducted within the framework of the Project.

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Preparation of this document

This document is the final version of the Report of the MedSudMed Expert Consultation on Marine Protected Areas and Fisheries Management, organised by the FAO-MedSudMed Project (*Assessment and Monitoring of the Fishery Resources and the Ecosystems in the Straits of Sicily)* in Salammbô, Tunisia, from 14 to16 April 2003.

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ABSTRACT

The second Expert consultation organized by the MedSudMed Project was devoted to Marine Protected Areas as tools for fishery management. It took place in Tunis from 14 to 16 April 2003. Twenty-seven experts from research institutions in the MedSudMed participating countries, as well as experts from the FAO CopeMed Project, UNEP RAC/SPA and IUCN attended the meeting. A total of 15 presentations were given according to the terms of reference of the meeting. On the basis of the experts' experience, an overview of several issues related to MPAs in the Mediterranean Sea was given. It highlighted the existence of expertise in the Project area as for monitoring and management of MPAs. The main points raised were: the suitable size for MPAs; impact of fishing closure and artificial reefs on stock and species diversity enhancement; impact of alien species on species diversity and strategies for their monitoring; the suitability of MPAs as fishery management tools. The meeting also allowed taking stock of the existing MPAs in some of the participating countries.

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Report of the Expert Consultation on Marine Protected Areas and Fisheries Management

Salammbô, Tunisia, 14-16 April 2003

1. Summary of the discussions

This EC on Marine Protected Areas and Fisheries Management was the second one organized by the Project. The objective was to discuss aspects of Marine Protected Areas (MPAs) in the Project Area, in an attempt to accomplish a synthesis of existing knowledge and activities dealing with MPAs and an overview of the types of studies conducted to date, giving particular attention to fisheries management. National contributions were requested to describe studies or measures that have been implemented or are under implementation/proposal. The Terms of Reference for the meeting also included topics such as the effects of fishing bans on fish size, biomass and spatial distribution and the possibility of transposing existing experiences to zones where fishery resources are depleted or overexploited (see Annex C). Moreover, the need to provide a synthesis of the previous MedSudMed EC held in Malta was highlighted in order to avoid overlaps with some specific topics. It was also recommended that the discussions take into account the Project's component on Data Base and Information Systems (MedSudMed Information System, MSM-IS hereafter) for which an update of on-going activities was briefly presented.

Twenty-seven experts from research institutions in the MedSudMed participating countries, as well as experts from the FAO CopeMed Project, UNEP RAC/SPA and IUCN attended the meeting. The first half of the EC was dedicated to the experts' contributions and to a discussion of the papers presented. A total of 15 presentations were given according to the terms of reference of the meeting. On the basis of the experts' experience, an overview of several issues related to MPAs in the Mediterranean Sea was given, each one implemented for different purposes. Indications were given on the advised size and localization of the MPAs in order to maximize their efficiency for the protection of the different fractions of fish stocks (eggs, larvae, juveniles, adults). Key studies were also presented; they dealt with fishing closures or limitations as management tools. The context and results of such measures were presented in detail, from a biological and socio-economic point of view. National Action Plans and specific management issues focusing on future MPAs were also presented. Habitats were addressed, in particular mapping issues such as the cartography of *Posidonia* beds, or the inventory and monitoring of habitats in protected areas. Legal aspects of MPAs were also touched on and the available information was given. Furthermore the general structure of the MSM-IS was presented, examples of data visualization using ArcView software and an example of knowledge and spatial management tools for the environmental sciences were shown. This last issue was considered highly important and the meeting agreed on the need for a regional database with a common format for all MedSudMed participating countries.

Discussions during the experts' contributions highlighted several points:

- There is experience and scientific expertise in the Project area for the studies, implementation and monitoring of MPAs and Fisheries Management.
- In some cases MPAs also represent a tool to mitigate conflicts in "multi-use areas"

and in “multi-use fishery areas”.

- It appears necessary to find common ground among the usual considerations on MPAs for biodiversity conservation and fisheries management.
- All papers presented, experiences and study cases highlighted the fact that even though the objectives and the dimensions of MPAs are different in each case, their implementation for Fisheries Management could, *inter alia,* reduce fishing mortality and protect a portion of the stock and of fish feeding grounds.
- No information related to spill-over effects is available and very few elements on the impact on fishery activities in adjacent areas were presented.
- Scientific knowledge on fishery stocks should be improved in order to allow a precise localization of feeding and spawning grounds, as key information for determining size and location of MPAs.
- There is an obvious link between MPAs and spatial issues (mapping of habitats and of areas of particular interest, biocenosis information, etc.). Considering the overlap of some aspects with the MedSudMed EC on spatial distribution of demersal resources, many common issues were identified such as: information on biocenosis, environmental description of the area, mapping tools, GIS technology. In this perspective, the development and use of the MSM-IS was declared of utmost importance.
- Three steps to be followed for the implementation of MPAs as a tool for Fisheries Management were identified: 1) establish the spatio-temporal dynamics and status of the fisheries resources inside and outside the identified area, particular attention must also be given to the issues related to the abiotic environment as well as biodiversity, including knowledge of biocenosis present in the area; 2) description of the fishing effort and pressure exerted inside and outside the area (in space and time); 3) on the basis of the above, identify clear objectives of fisheries management, technical measures to be adopted and the monitoring programme, including biological, environmental and socio-economic aspects.
- Other important issues were indicated as critical points such as: (i) the size of the area to be protected; (ii) legal aspects of the access of the different users to the protected areas; (iii) assessment of the socio-economic benefits of the implementation of MPAs; (iv) monitoring, control and surveillance (MCS) to be implemented with particular attention to fishing exploitation.
- The adoption of common terminology among scientists is relevant and the preparation of specific guidelines on the use of MPAs as a tool for fisheries management could help with this aspect.

2. Conclusions and follow-up

The experts identified the existing gaps in the specific knowledge, and the steps to be followed to fill them, as well as a lack of guidelines on the use of MPAs as a tool for fisheries management specifically for the Mediterranean.

Among the activities proposed was a working group on this topic, as well as the identification of zones to carry out study cases. These would consist in setting objectives of

fisheries management, technical measures and monitoring programs to be adopted on the basis of biological, environmental and socio-economic aspects. Therefore, the experts underlined that study cases should be interdisciplinary and require a valuable amount of information on fisheries ecology, fishing activities, abiotic environment, biodiversity, biocenosis and suggested that a synthesis of information is first carried out in the Project area before implementing any study. This implies that the main gaps in the knowledge on Small pelagic and demersal fisheries resources present in the area are covered and particular attention should be paid to the collection and analysis of the basic scientific information aimed at identifying the Essential Fish Habitat of those species. Furthermore, the topic on MPAs must be investigated more deeply in the context of fisheries management.

The main objective is to identify and study areas subject to different levels of fishing effort, studying their dynamics and making progress in the scientific and methodological knowledge for the resources and for environment management

The approach of utilizing some parts of the work carried out for the component on demersal resources (for instance, the identification of essential or critical fish habitats) in the MPAs component should be contemplated even though it covers only one of several aspects related to MPAs.

However, special care should be taken to clarify methodological aspects, and to be sure of the different national priorities and expectations, according to a clear definition of the different purposes of the MPAs. Eventually, practical guidelines could possibly be produced by the Project focusing on the Project Area.

Moreover, the problem of working with sensitive data has to be considered.

Study cases on the implementation of the MPAs as a tool for Fisheries Management should be supported by MedSudMed in the Project Area.

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Establishing the 25-mile Fisheries Conservation Zone around the Maltese Islands

Matthew Camilleri*

1. Background and scientific criteria

Malta's negotiations with the European Union prior to its accession as a member state included two years of highly technical discussions related to the establishment of a 25 nautical mile Fisheries Conservation Zone around the Maltese Islands – the first of its kind in the Mediterranean. In fact, five technical documents[1] were produced to back these negotiations and a non-discriminatory management regime was finally agreed upon on the basis of the scientific information presented.

Malta has managed an extended fisheries management zone, beyond its territorial waters, since 1971 and has maintained a strict licensing scheme, keeping large-scale industrial fishing such as trawling at a minimum. From the start of the negotiations, Malta stated that as a member of the EU, its fisheries should be safeguarded and resources within the current 25-mile Exclusive Fishing Zone should continue to be kept at sustainable levels. Concern was expressed about the inevitably large increase in fishing intensity that would occur in the Zone if it were to deregulate the band between 12 and 25 nautical miles which would become Community Waters. Malta had proposed that in line with the "Code of Conduct for Responsible Fisheries" of the Food and Agriculture Organisation of the United Nations, a Precautionary Approach had to be adopted and a tight control on the increase in the fishing effort should continue to be kept especially with regard to demersal trawl fisheries. It was demonstrated that there were criteria for defining the area as a distinct Conservation Zone – there was evidence that adult populations of shallow (less than 200m depth) shelf resources within the zone were isolated from adjacent areas and that the Maltese shelf constitutes the main offshore area where spawning could take place for a significant proportion of the zone's demersal resources and other deep-water species. Moreover it was argued that as a consequence of the oceanographic features in the region, larval contribution from outside the Zone was an unlikely source of major recruitment of juvenile fish to demersal fisheries. In addition, satellite imagery offered clear evidence that Malta was surrounded by water masses which are limited in productivity (oligotrophic), making the ecosystem within the Zone more prone to negative effects caused by high exploitation rates.

The opinion of the General Fisheries Commission for the Mediterranean is that effort control should be the main management tool in the Mediterranean through a limitation on the number of boats, their horsepower and fishing capacity. The EU was informed that Malta had taken such effort control measures on a routine basis and from the best available scientific information, the demersal fisheries resources within the 25-mile zone appeared to be close to

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[1] - MAF (2000) Maintaining the Maltese Fisheries Management Zone
- MAF (2001) Malta's fishery management system for demersal resources
- Camilleri M. (2001) The Medits 2000 trawl survey reviewed
- Fiorentino F., Norrito G., Ragonese S., Camilleri M. and Bianchini M.L. (2002) An attempt to compare the status of the groundfish resources within the Maltese Exclusive Fishing Zone and the surrounding bottoms of the Strait of Sicily
- Camilleri M., Cordina G. and Franquesa R. (2002) An analysis of the impact of purse seining and industrial longlining in Malta's 25-mile Conservation Zone

Maximum Sustainable Yield (MSY) conditions and that they would be placed in a seriously overfished condition, if the fishing effort would be increased even by just adding a few large trawlers.

Amongst the sources of evidence to establish the Conservation Zone, recent scientific trawl survey data were used. Trawl surveys estimate abundance (as biomass and density per km^2) of important commercial species in different depth strata. Comparing abundance data obtained for Maltese waters with those of Sicilian waters revealed that, in general, the abundance or catch rate at depths between 50 and 500 meters was double in the former. With this information in hand and considering that in a published document the Sicilian fleet was shown to be operating at bioeconomic equilibrium point (a situation of no net profit), Malta was able to fairly state that its demersal fisheries were operating at Maximum Economic Yield (using the Gordon-Schaefer model - Figure 1) which is close to MSY conditions.

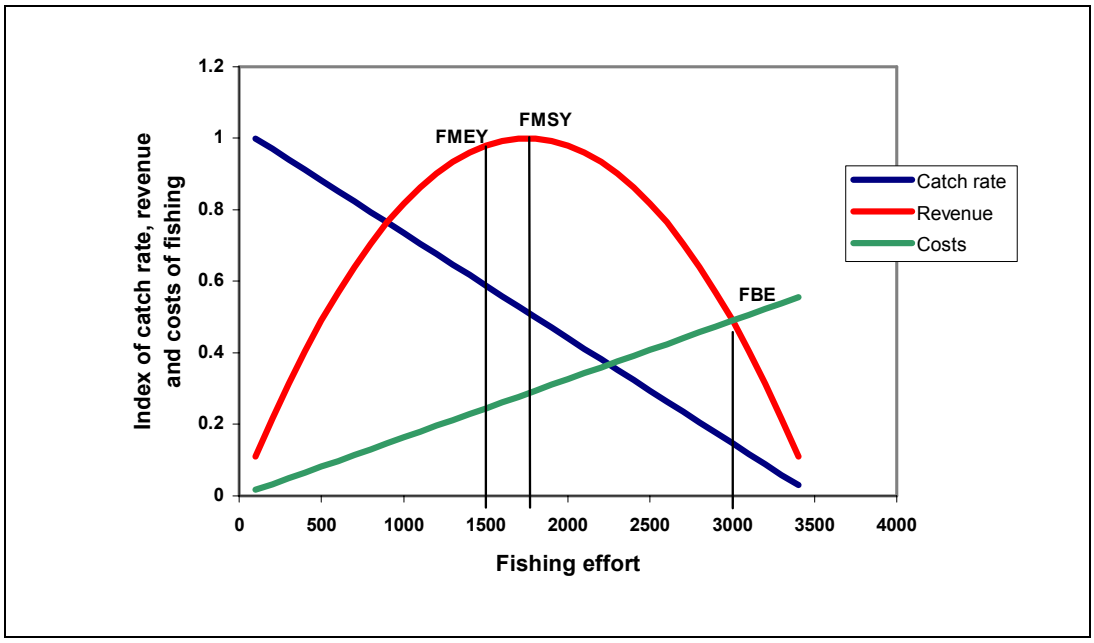

Figure 1. Gordon-Schaefer model of a fishery with MSY normalised to unity (FMEY= fishing effort at Maximum Economic Yield; FMSY = fishing effort at Maximum Sustainable Yield; FBE= fishing effort at Bioeconomic Equilibrium point). Adapted from Seijo et al. 1998[2].

Malta's backing documents also demonstrated that the current fisheries management regime allows escapement of demersal species into non-exploited or slightly exploited areas creating important refugia for spawners and juvenile fish from which the latter eventually recruit themselves into fishing areas both within and outside the Zone. In this respect, it was therefore stressed that areas where trawling is currently absent should continue to remain free from this type of fishing operation, both to maintain these vital sources of recruitment and also to protect fragile benthic ecosystems which are likely to be present in these particular areas.

[2] - Seijo, J.C., Defeo, O. and Salas, S. (1998) Fisheries bioeconomics. *FAO Fisheries Technical Paper,* No. 368: 108 p.

Besides, focusing on demersal resources, negotiations dealt with highly migratory fish species such as *lampuki*, tuna and swordfish, which make up more than 70 percent of the value of Maltese total annual landings. In this context, it was stressed that the sustainability of fisheries for these species in ecological, biological, economical and social terms should be safeguarded. Backing documents highlighted the fact that the Maltese population involved in the fishing industry is economically, geographically and culturally dependent on artisanal fisheries, and that the introduction of large-scale industrial practices would completely disrupt artisanal fishing operations. With particular reference to the vulnerable blue-fin tuna Mediterranean stock, Malta proposed that the Principal of Relative Stability should be applied whereby the fishing effort on this stock in recent years would not change both in intensity and spatial distribution. It was also explained that increasing the fishing effort, especially by using large-scale industrial fishing gear, would not only contribute to a reduction in the abundance of tuna stocks but could also affect other species such as mammals and birds.

2. Drawing up the Management Regime

The measures adopted for the management of resources within the Fisheries Conservation Zone essentially limit fishing effort and capacity by restricting size and engine power (Figure 2). In order to maintain current sustainable conditions of demersal resources, trawling fishing effort will not be increased within the Zone and will be shared by non-industrial vessels (under 24 meters in length) which do not use heavy gear and have short fishing trips. In addition, for the purpose of conserving the distinct fish populations of the Maltese shelf, a restriction on engine power has also been included as a measure for trawlers operating in waters shallower than 200m. Moreover, trawling will be limited to specified areas within the Zone so as to conserve existing "refuges" and fragile benthic ecosystems.

With the exception of particular categories of fishing vessels such as those involved in *lampara* (targets pelagic species using light sources) and *lampuki* fisheries, it was agreed that only small-scale fishing vessels (under 12 meters in length) will be authorised to fish within the Zone and that the current fishing effort of this category of vessels will not increase. This size restriction would have a direct effect on the limitation of fishing capacity and fishing effort, since, generally, the size of a fishing vessel is directly proportional to the size and number of elementary units of the fishing gear and the effective fishing time. On the basis of the best scientific information available, all the measures described so far will ensure that the state of demersal resources with the Zone would be kept between MEY and MSY conditions.

The management regime also addresses the *lampuki* fishery since fishing operations start within 25-miles from the coastline (usually starting at 7 miles). It ensures that the traditional management scheme will continue to be applied, with the number of courses along which fishermen would lay Fish Aggregating Devices (*kannizzati*) being limited to a maximum of 130, and that this fishery would be protected from interference by other types of fishing operations. The management regime also commits itself to ensuring the sustainability of fisheries for other highly migratory species such as tuna and swordfish, which also take place both within and outside the Zone.

Efficient monitoring and control of the activities of vessels within the Zone will be supported by an electronic Vessel Monitoring System. Vessels over 24 meters in length along with those vessels over 12 meters in length which are authorised to carry out fishing operations within

the Zone would be obliged to carry the required tracking electronic equipment on board at all times.

3. Is the Management Regime in conformity with Ecosystem Based Fisheries Management?

The Management Regime for this unique Mediterranean Fisheries Conservation Zone is in some ways a response to the international call to adopt an ecosystem approach to fisheries. In fact, the foundation criteria for defining the Zone include aspects of productivity, oceanography and physical characteristics in the region. It also covers the conservation of various levels of the fisheries resources in the food chain together with fragile benthic ecosystems, and protects species such as mammals and birds by restricting the type of gear used in the Zone. Ultimately, the ecological, biological, economical and social environments which, to a certain extent, make up the fisheries ecosystem have been safeguarded and the sustainability of fisheries within the 25-mile Fisheries Conservation Zone has been guaranteed.

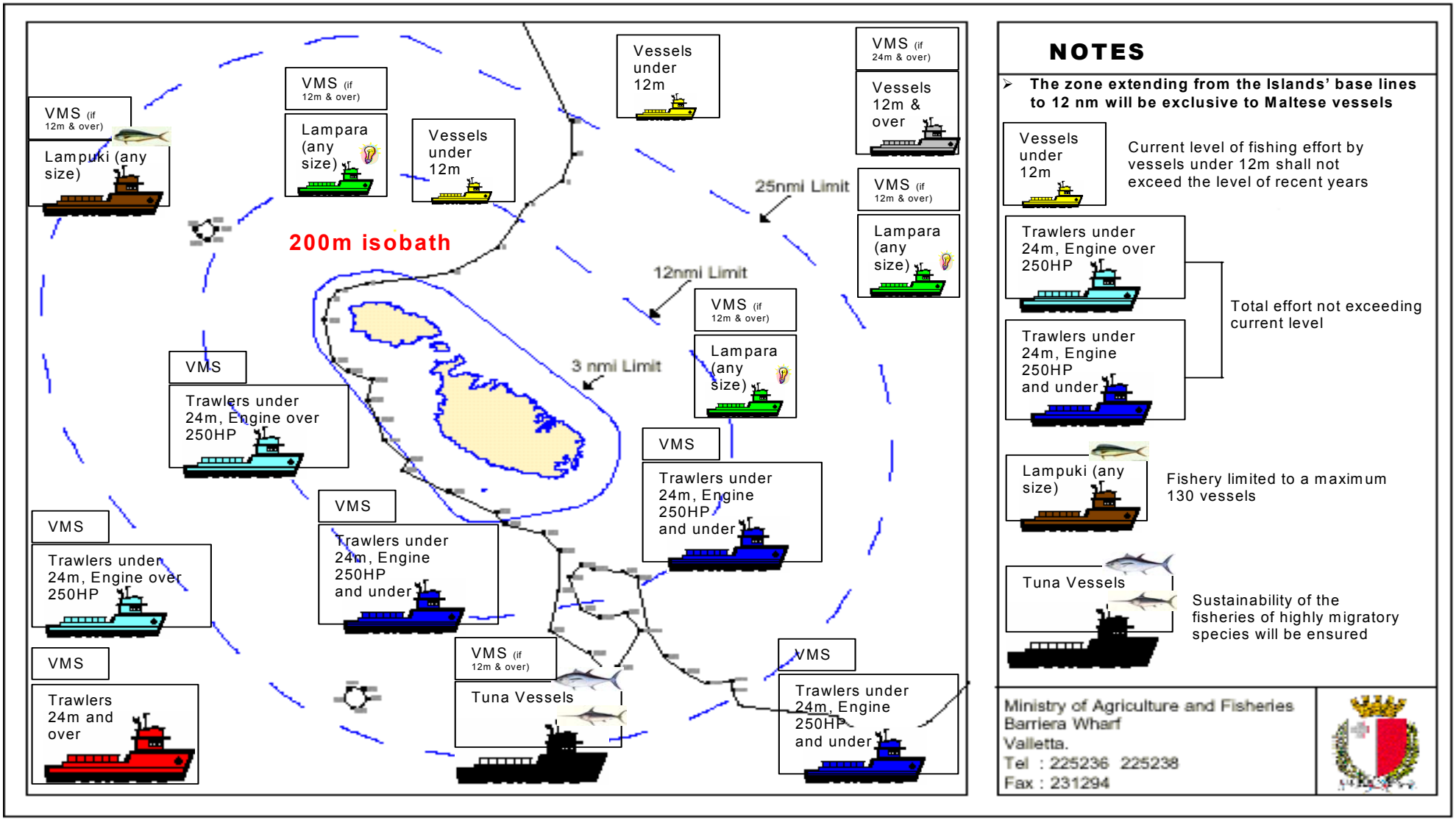

Figure 2. A summary of the Management Regime

Fishery reserves in the Mediterranean Sea: the Gulf of Castellammare case study

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Abstract

The effects of fisheries management based on artificial reefs and on trawl banning are explored in the Gulf of Castellammare fishery reserve by means of biological (from trammel and trawl survey) data collected during several research programs between 1990 and 2001. The artificial reefs have caused an increase of diversity but not of biomass, as suggested by the comparison between the associated fish assemblage and that of nearby sandy bottoms. The associated species however do not have any trophic relation to the boulders, except the two-banded seabream, *Diplodus vulgaris*. An overall increase of experimental trammel net yields in the artificial reef area was observed from 1990 to 1998, due mainly to pelagic species associated with the boulders. The trawl ban caused a dramatic increase of groundfish biomass in the protected area (+711% after four years, total species). Different species had different increase rates, from 2-fold for the musky octopus, *Eledone moschata* to 127-fold for the gurnard, *Lepidotrigla cavillone*. Eight and ten years after the ban started, the yields did not vary significantly in the overall area, but decreased near to (both outside and inside) the protected area, probably due to increased legal and illegal trawling. The mean size did not increase in three studied species, except for the monkfish, *Lophius budegassa*. In conclusion the Gulf of Castellammare fishery reserve is considered a positive example of marine coastal fisheries management, especially considering the effects of the trawl ban on the abundance of groundfish stocks, although the cooperation between scientists and administrative bodies is still far from optimal.

Keywords: coastal fisheries management, marine protected areas, trawl ban, artificial reefs, artisanal fisheries, Sicily.

1. Introduction

The quest for fishery management practices not tied to a traditional approach based on single-species population dynamics models, has pushed scientists and managers towards Marine Protected Areas (MPAs), considered a powerful tool for the management of coastal fisheries. The rationale behind this lies in the concept of protection (full or partial) of habitats and organisms aimed at their sustainable exploitation. Several potential effects are expected from MPAs, among others the increase of mean size and standing crop inside the protected area and the enrichment of surrounding fished grounds through egg/larval dispersal and adult spillover (Bohnsack, 1998). MPAs aimed at fisheries management have been created in

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several areas in the Mediterranean (Figure 1 for some examples of existing fishery reserves; Figure 2): no-take zones in Corsica (*cantonnements de pêche*: Meinesz *et al*., 1983), no-trawl zones in Greece (Vassilopoulou & Papaconstantinou, 1999) and Italy (Pipitone *et al*., 2000a); seasonal trawl ban in Cyprus (Garcia, 1986) and in Italy (Cau *et al*., 1993; Pranovi *et al*., 1996; Relini *et al*., 1996); artificial reefs in most countries (see Jensen *et al*., 2000). The Gulf of Castellammare (Figure 3) has acted in the last two decades as a sort of natural lab where several different management measures have been implemented, aimed at reducing the conflict between the trawl and artisanal fleets and at rebuilding the depleted groundfish stocks (Arculeo *et al*., 1990). Such measures included the deployment of artificial reefs and the creation of a no-trawl zone on about 50% of the Gulf surface (Badalamenti *et al*., 2000). No-trawl zones are particularly useful when the reduction of fishing mortality is deemed necessary for stock enhancement, and at the same time small-scale artisanal fishing is considered advantageous from the economic, social and environmental point of view (e.g., Bailey, 1997). On the other hand, artificial reefs are considered a viable method to prevent inshore trawling and to provide potential shelter and food to fishes (Bombace, 1997).

The present paper is based on already published data collected during studies carried out since 1990 at the Marine Biology Laboratory of CNR-IAMC, concerning the effects of artificial reefs and of the trawl ban on the abundance of resources. It tries at the same time to highlight the complex fishery management issues inherent to the Gulf.

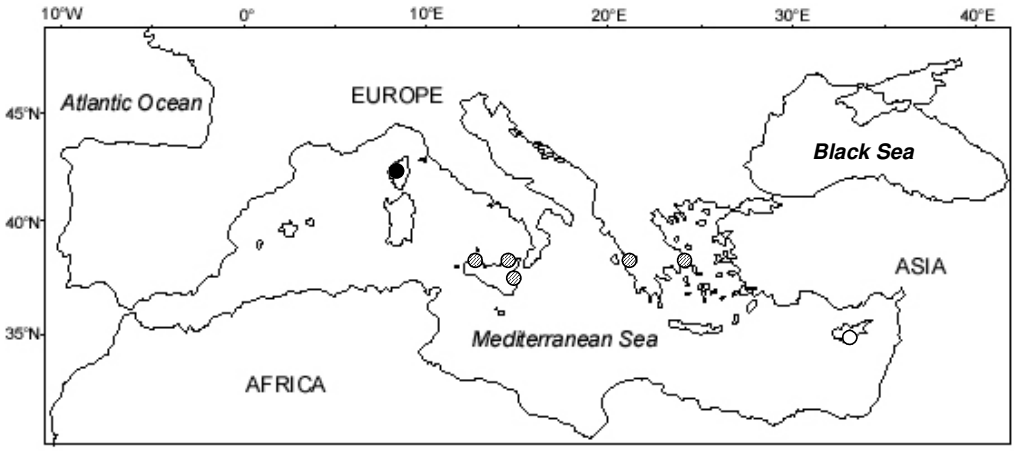

Figure 1. Some of the existing MPAs aimed at fisheries management in the Mediterranean. Black circle: no-take zones; striped circles: trawl ban zones; white circle: seasonal trawl ban.

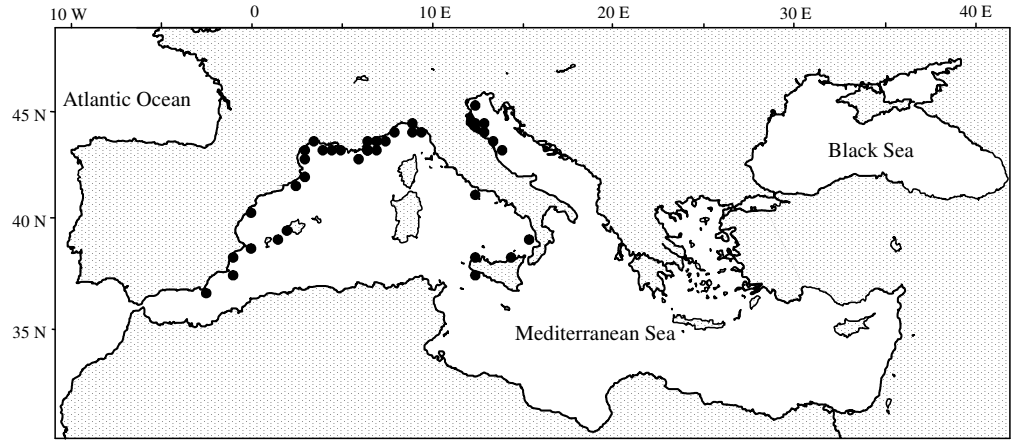

Figure 2. Artificial reef areas along the European coasts of the Mediterranean (from Jensen, 2002).

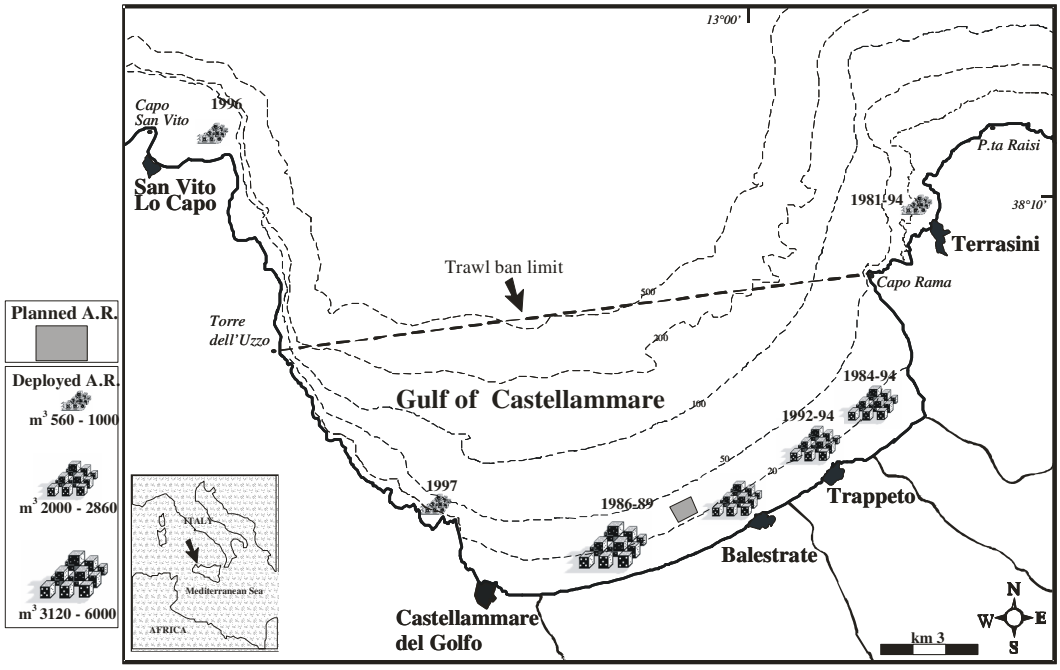

Figure 3. Map of the Gulf of Castellammare, with the trawl ban limit and the artificial reefs (A.R.).

2. Background information on the Gulf of Castellammare

The Gulf of Castellammare lies along the northwestern coast of Sicily (Figure 3). Its surface from Capo San Vito to Punta Raisi is 397 km^2 (=115 nm^2). The coast is rocky along the eastern and western sides, and sandy in the whole central part, where the outlets of a few small streams are located. The seafloor is covered to a great extent with soft bottoms; rocks and scattered small *Posidonia oceanica* meadows occur along both sides of the Gulf. There are four ports in the Gulf (from east to west): Terrasini, Trappeto, Balestrate and Castellammare. A fifth port - San Vito - can be considered out of the study area, due to its location at the farthest western corner of the Gulf and to the patterns of activity of its fishing fleet that are concentrated in areas not directly affected by the local management regime. 138 boats are registered as licensed fishing vessels in the Port Authority (Figure 4), 98 of them (71%) as artisanal vessels, 27 (20%) as purse seiners and 13 (9%) as trawlers. Most artisanal fishermen use a trammel-gillnet as their main fishing gear (Figure 5), switching to other gear on the basis of the target species available at different periods of the year. The most important seasonally active artisanal fisheries are (i) the fish fry fishery, that targets larval clupeoids in late winter-early spring, and (ii) the FAD (Fish Aggregating Device) fishery (Figure 6) that targets dolphinfish as well as other less abundant mid-size pelagic species from late summer to mid-autumn (Pipitone *et al*., 2000b).

The legal framework that regulates fishery management in the Gulf (as well as in the whole Sicily) is summarized in Table 1. The current management regime includes artificial reefs deployed over a wide area between 10 and 50 m depth, and a year-round trawl ban imposed over the continental shelf and part of the upper slope on a surface of 200 km^2 (=58 nm^2). It is noteworthy that, although the law imposed fishing restrictions and allowed the creation of an artificial reef area, there is neither an explicit definition of the Gulf of Castellammare as a "protected area", nor a body institutionally charged with monitoring the effects of management.

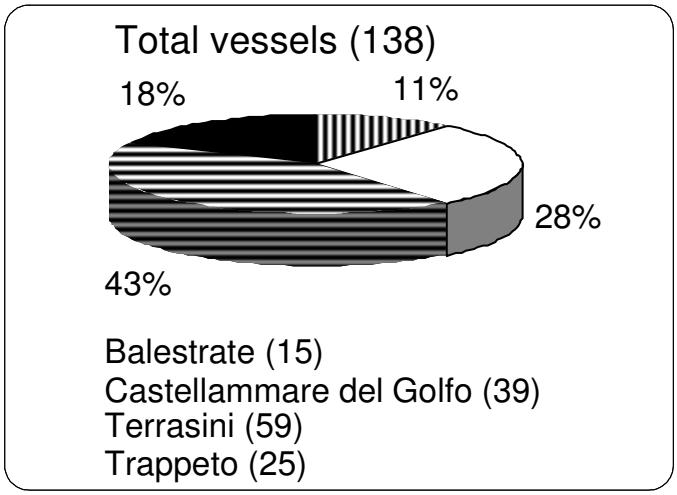

Figure 4. Distribution of total fishing vessels among the four ports in the Gulf of Castellammare.

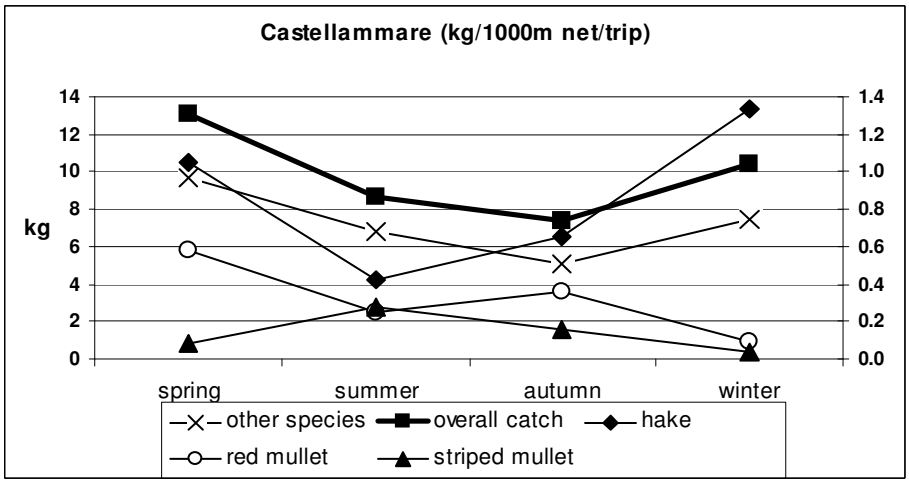

Figure 5. Landings from the Castellammare trammel-gillnet fishery, 1998-99 landings survey. Yields on the left *y* axis refer to the overall catch, while those on the right *y* axis refer to single species.

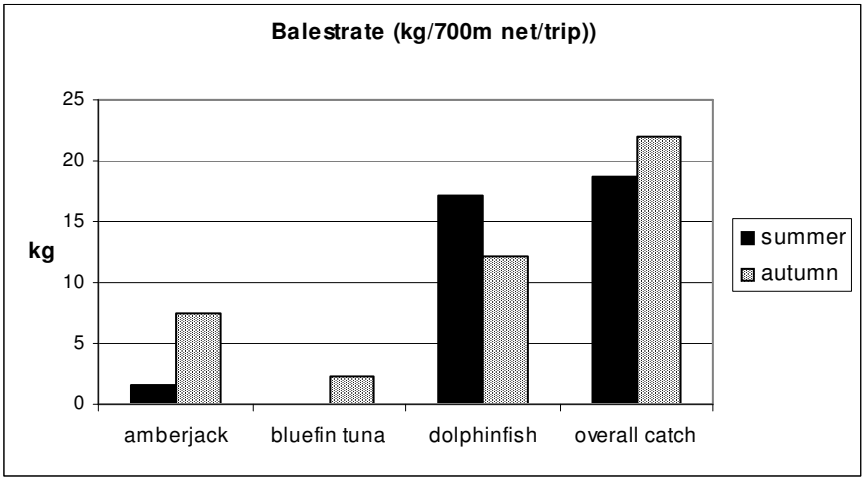

Figure 6. Landings from the Balestrate FAD fishery, 1998-99 landings survey.

Table 1. Laws that regulate fishery management in Sicily.

Act	Content	Goal
L.R. 31/1974	Measures for the enhancement of fish stocks. Institution of three Associations of local authorities (*Consortia*) in Sicily	Fish stock enhancement and protection by means of artificial reefs
L.R. 1/1980 L.R. 26/1987	General laws on fisheries in Sicily	Modernization of the fleet; reduction of trawling effort through change to a different gear; seasonal fishing ban; increase of fish and shellfish open-sea culture; measures for scientific research
L.R. 25/1990	Year-round trawling ban in three Sicilian Gulfs	Enhancement of fish stocks
L.R. 32/2000	Economic and industrial development and planning of Sicily for 2000-2006	Chapter XII concerns the fishing activities, and updates previous regulations

3. Assessment of the effects of fisheries management

- *Artificial reefs*

Cubic concrete boulders, either isolated or assembled in pyramids were deployed on the sandy and muddy bottoms of the Gulf between 10 to 50 m depth from 1981 to 1998 (Figure 3) (Badalamenti *et al*., 2000). Experimental trammel net surveys and visual census surveys were carried out to assess the effectiveness of the artificial reefs as a tool for increasing the fish biomass. Moreover the benthic fauna settled on the boulders and the stomach contents of several fish species were studied to assess the trophic links between artificial reefs and associated fish species.

The artificial reefs host rocky bottom species that were absent from the original soft bottom, causing an increase of biological diversity (D'Anna *et al*., 1994, 1995). The mean value of the associated fish standing crop, as estimated in one year of observations, was 7.9 kg/pyramid (=0.07 kg/m^3). The dominant species were the damselfish, *Chromis chromis*, sparids (*Diplodus annularis*, *D. vulgaris*, *D. sargus* and *Lithognathus mormyrus*) and mullids (*Mullus barbatus* and *M. surmuletus*). Qualitative underwater observations have also revealed that bottom FADs associated with artificial reefs attract the amberjack, *Seriola dumerili* and help to keep its shoals in the area for a longer time than observed before.

The trophic studies have demonstrated that the main fish species occurring on the artificial reefs do not have any direct trophic relation with the boulders, with the exception of the two-banded seabream, *D. vulgaris* (Pepe *et al*., 1996).

The catches per unit effort (cpue) from experimental trammel net surveys conducted in the artificial reef area from 1990 to 1998 ranged between 1.4 and 3.6 kg/500m net (D'Anna *et al*., 2001). Figure 7 shows the temporal trend of cpues for pelagic, sandy bottom and rocky bottom species separately. No increment across time was observed for the two latter categories ($p>0.05$, Spearman correlation), while catches of pelagic species like bogue, *Boops boops* and horse mackerel, *Trachurus trachurus* increased ($p<0.02$).

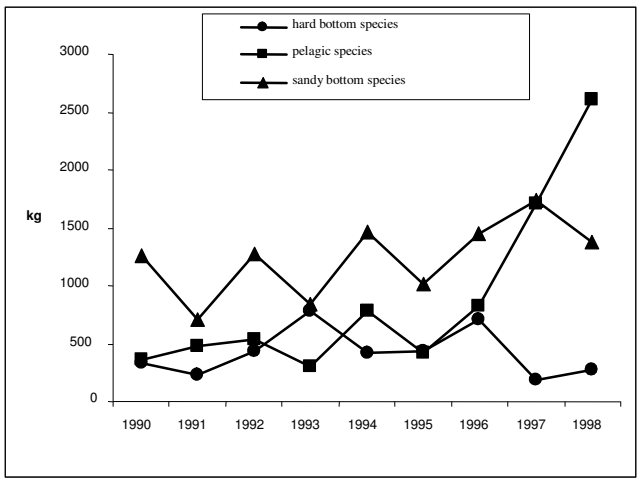

Fig. 7 - Cpue (kg/500 m net/trip, annual mean) from trammel net surveys in the artificial reefs in the Gulf of Castellammare.

- *Trawl ban*

The assessment of the effect of the trawl ban was based on the analysis of cpues from trawl surveys conducted before (1987-89) and during (1993-94, 1998-99 and 2000-01) the ban. Only spring surveys data were used, due to insufficient data from other seasons in the pre-ban period (Pipitone *et al*., 1996). The area was surveyed between -10 m and -200 m depth according to a stratified random sampling design. Figure 8 shows the cpues of the total catch expressed as kg/30min tow (mean values over the total study area). Cpues in 1993-94 increased by 711% (from 3.8 to 31.1 kg) if compared with the pre-ban period ($p<0.001$, Mann-Whitney U-test). In 1998-99 and 2000-01 cpues did not vary significantly if compared to 1993-94 (Pipitone *et al*., 2001). The ANOVA between cpues of each survey showed that (a) yields outside the protected area were always lower than inside, and (b) yields inside the protected area remained constant through time, while those outside decreased from 1998-99 to 2000-01 (Pipitone *et al*., in press).

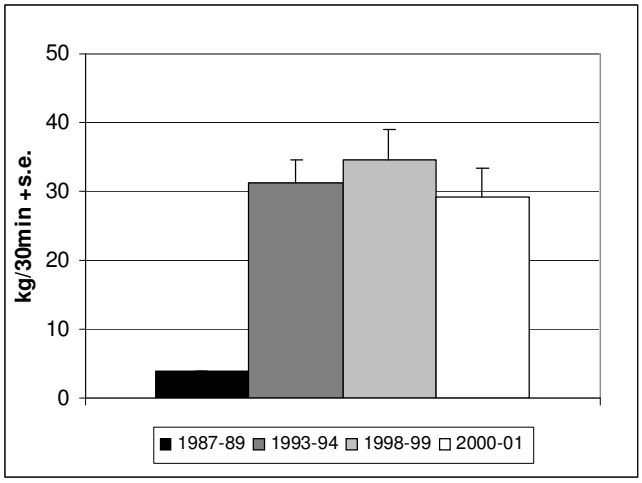

Fig. 8 - Cpue (kg/30min tow, total area, spring surveys) of total catch from trawl surveys in the Gulf of Castellammare. s.e.: standard error.

Figure 9 shows cpues (annual mean) from the trammel net surveys conducted from 1990 to 1999 at less than -30 m depth, in areas with hard and soft bottoms as well as with artificial reefs, traditionally exploited by artisanal fishermen. An increase of fish biomass across time ($p<0.001$, Spearman correlation) was observed, with a peak in 1995 due to the increase of sandy bottom species, whose cpues rose from 1.3 to 3.6 kg.

Finally, the size structure of a few species in the no-trawl area was analyzed (Badalamenti *et al*., 2002). An increase in the mean size was observed in the monkfish, *Lophius budegassa* but not in the hake, *Merluccius merluccius* and the red mullet, *M. barbatus*.

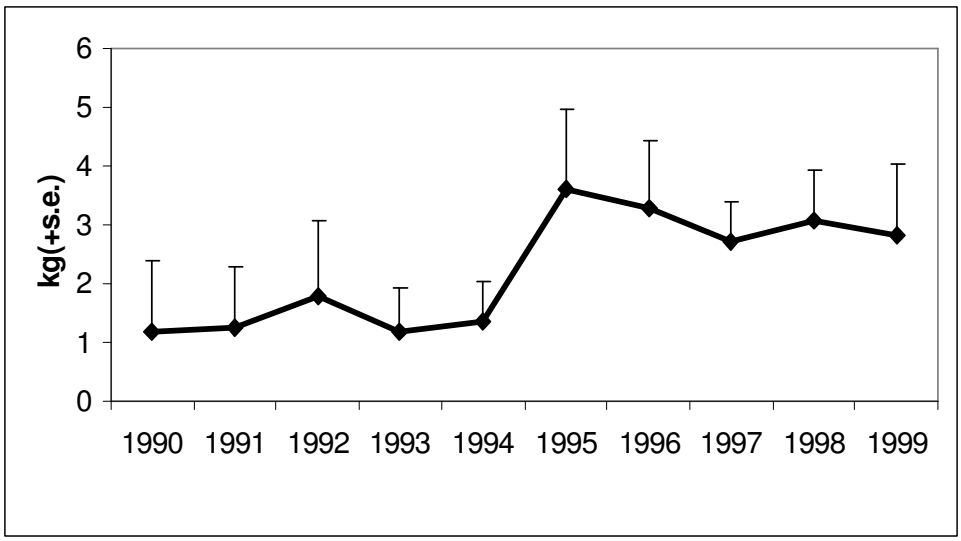

Fig. 9 - Cpue (kg/500 m net/trip, annual mean) from trammel net surveys in the total study area, Gulf of Castellammare.. s.e.: standard error.

4. Discussion

The management of coastal fisheries in the Gulf of Castellammare has developed along two main lines: (a) the deployment of artificial reefs aimed at protecting the coastal zone from trawling and at providing food and shelter to coastal fishes, and (b) the imposition of a trawl ban aimed at rebuilding the shelf groundfish stocks and at solving conflicts between the artisanal and trawl fleets.

Artificial reefs have led to an increase of biological diversity of the fish assemblage, if compared to the original soft bottom assemblage. This increase is due mainly to hard bottom species that probably joined the artificial reefs as adults, rather than recruiting at an early life stage (Badalamenti & D'Anna, 1997). Such hard bottom species as well as resident pelagic species seem tied to the boulders more by tigmotropic attraction and by the shelter provided by the boulders rather than by food resources, since a direct trophic link with the artificial reefs was detected only for *D. vulgaris*. Nonetheless a possible role of artificial reefs in supporting the artisanal fishery could consist in enlarging the distribution of valuable hard bottom species like the seabream, *D. sargus* that shelters among the concrete boulders and feeds in the nearby *Cymodocea nodosa* meadows (Badalamenti & D'Anna, 1997).

Unlike biological diversity, fish biomass in the artificial reef area did not increase after the deployment of the boulders. This is one of the reasons why artisanal fishermen in the Gulf have shown a less than favourable attitude towards artificial reefs, the other being that they have experienced a reduction of the overall fishable area due to the wide portion of seafloor occupied by the boulders (Pipitone *et al*., 2000b). Yet another positive role of artificial reefs - in particular those associated with bottom FADs - is their ability to maintain in place commercially important species with a seasonal occurrence, like the amberjack. This suggests a large potential for wisely planned artificial structures (Badalamenti & D'Anna, 1997). Although artificial reefs in the Gulf of Castellammare have at least partially failed in their purpose of increasing shallow water fish resources, they have successfully acted as a research tool for the study of ecological processes in the coastal zone (Bombace *et al*., 2000; Riggio *et al*., 2000). The results of research carried out to date suggest that detailed preliminary studies are needed before the planning phase, in order to assess the cost/benefit ratio of artificial reefs according to their goals.

The trawl ban in the Gulf of Castellammare has caused a dramatic increase in groundfish stock size, as suggested by the trawl surveys made four years after it started, in spite of artisanal and recreational fishing. The lack of any further significant variation of biomass from 1994 to 2001 could be explained with a steady state reached by the environment and the permitted fisheries. Yet it is not unlikely that a possible further increase of biomass has been masked by the intense trawling activity along the protected area border and by the frequent poaching occurring in the eastern part of it (Whitmarsh *et al*., 2002). The lack of any observed increase of mean size (except for the monkfish) could be due to a density dependent effect on individual growth, as observed in marine protected areas by Sanchez Lizaso *et al*. (2000) and Béné & Tewfik (2003). This could be true in particular for the red mullet, which underwent a dramatic biomass increase in the Gulf after the imposition of the trawl ban.

5. Conclusion

The Gulf of Castellammare is an interesting case of coastal fisheries management achieved through a marine protected area that includes artificial reefs and a trawl ban zone. The use of fishery reserves of this or similar type has spread worldwide in recent years, and is considered a highly promising tool for the sustainable exploitation of living resources (*e.g.*, Hall, 1998; Hastings & Botsford, 1999). Trawl bans have been applied elsewhere in the Mediterranean, as well as artificial reefs. The Castellammare case study is unique in that it includes data sets collected before and during the current management regime as well as socioeconomic data (Pipitone *et al*., 2000b), which have allowed us to assess some effects of management with more detail than in the rest of the Mediterranean (Pipitone *et al*., 2000a; Badalamenti *et al*., 2002; Whitmarsh *et al*., 2002, in press). The overall picture is made even more complex by offshore fish farming in floating cages, developed in recent years. Considering this articulated framework, it should be highlighted that, at least locally, a deep gap exists between fishery scientists and fishery managers, and that two issues stand out dramatically: (1) the management body (i.e., the Regional Council for Fisheries) does *not* manage the resources, i.e., there is no follow-up to policy decisions (e.g., closing an area to trawling); (2) the same body does not put any scientific institution in charge of monitoring the effectiveness of management and studying its effects on the resources (although the laws account for research funding). It is left to single research teams to raise funds to assess such effects. This gap needs to be filled if management has to play its expected role of assuring the sustainable exploitation of resources.

6. Acknowledgments

The authors wish to thank professors Silvano Riggio and Marco Arculeo for giving access to the 1987-89 trawl survey data. Research was funded by the "Consorzio Golfo di Castellammare", the MRAAF (Ministry of Food, Agriculture and Forest Resources) and the European Commission.

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Marine Protected Areas along Libyan coast

D. A. Haddoud* and A. A. Rawag

Abstract

The Libyan coast and its lagoons play an important role in the biodiversity and productivity of Mediterranean marine life; it is fairly, unpolluted, and includes gigantic beds of marine plants, which are used by different fauna species for shelter and nursery grounds during breeding and other stage of their life cycle. This makes the Libyan coast profitable for fish production, and other edible marine organisms.

In 1993, a study was initiated by the Marine Biology Research Centre (MBRC) to designate certain sites as Marine Protected Areas (MPAs) along the Libyan coast. In this paper, the most important established and proposed MPAs (El Kouf National Park, Ain Gazala MPA, Farwa MPA, El Burdi MPA, Ain -Ziyana MPA) are presented and discussed.

1. Introduction

Natural marine habitats and ecosystems are being lost as a result of human activities. Therefore, there is a need for Marine Protected Areas to preserve the natural habitat of marine ecosystems. Some specialists believe that at least 10% of the total marine area should be protected. In the Mediterranean, which is one of the seas with great biodiversity, under 0.01% of its surface area is considered protected. Thus, there is a need for more Protected Areas in the Mediterranean (Kelleher *et al*., 1995).

Marine Protected Areas (MPAs) are necessary as fisheries management tools. Because of an increase in fishery pressure, due to the use of more effective modern instrumentations and variety of different gear types, in addition to powerful vessels, MPAs are needed. MPAs conserve biodiversity and variability of exploited populations. Some of the main objectives of MPAs are to protect spawning stocks and endangered species, and to promote basic and applied research, which is important in fisheries management. However, the main problems facing MPAs effectiveness are their protection and management (Foster and Lemay, 1989).

There are four important lagoons on the Libyan coast: Farwa, Ain Zayana, Ain Gazala and Elburdi. These are well described in Kerambrun (1986), Lemoalle & Saad (1987), Reynolds *et al.* (1995), MBRC (2000), and Gashout and Haddoud (2001). There are also, some coastal studies from an ornithological point of view by Meininger *et al*. (1994a, b). The avifauna of the coastal fringes was studied by Bundy (1976), and Haddoud and Zagozi (1998). Turtle survey data on the El Kouf National Park coast, were also studied (Armsby, 1980; Schleich, 1987 and Laurent et al., 1995).

The fishing sector is still very little developed in Libya. Total catch for the Libyan coast is low, estimated in 1991 as 7,700 tons, whereas it was 90,710 tons in Tunisia and 40,192 tons in Egypt in 1991. In 1994 Libyan production was estimated as 33,469 tons (Lamboeuf and

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Reynolds, 1994; Reynolds *et al*., 1994). The total fleet in Libya during 1995 was 1911 and 1,866 during the year 2000; and trawlers were 105, however, the number of trawlers was only 65 boats during the year 2002.

There are six main types of fishing in Libya: coastal fishing, Lampara fishing, bottom trawling, tuna fishing with seines, longlining, and Tunaras. Coastal fishing is mainly practiced in the east and west of the country, and occasionally in the Gulf of Sirte, using trammel-nets, gill-nets, and bottom and drifting long lines. There are about 3,000 small craft of varying lengths. Lampara fishing catches small pelagics such as sardines and mackerel by using lights, it occurs only on the west coast (Lamboeuf and Reynolds, 1994; Reynolds *et al*., 1994).

In 1993, a study was initiated by the MBRC to select special sites along the Libyan coast as MPAs. Before this initial study, the Libyan authorities issued Law No 14 with Articles 75- 78 concerning MPAs. This Law was outlined in 1991, and came into force in 1992.

2. Methods of study

Libyan MPAs were selected according to generally known universal criteria, based on the biological, physical, and socio-economic features. This information was collected from fixed stations at each chosen location. Previous information on the locations was taken into consideration for MPA evaluations.

The established and proposed Libyan MPAs (Figure 1) were selected according to the initial study indicated above. In addition, the selection of each MPA was based on its biodiversity, occurrence of endangered species such as nesting sea turtles, sea birds and others, and over fishing (e.g., Farwa MPA).

3. Results and discussion

Established Marine Protected Areas:

<u>El Kouf National Park</u>
The El Kouf National Park was projected with the aid of the Arab Centre for the Studies of Arid Zones and Dry Lands (ACSAD). A Secretariat of the State for Marine Resources, established in 1975, gave a high priority to the creation of protected sectors in the sea.

This Park is located in the north-west Flank of the Jabel Al Akhdar, near the town of El Beidha in north-eastern Libya. The park surface area is about 32,000 ha wth about 20 km of coastline. The Park has a large conservation area of 100,000 ha which includes the wider catchments of Wade El Kouf. It covers the northern slopes and plateau of the Jabel Al Akhdar, bordering on the Mediterranean. Jabel Al Akhdar is the only naturally forested mountain range of the entire North African coast between the Gulf of Gabs and Haifa Gulf.

The rectangular watershed of Wade Al Kouf is part of Jabel Al - Akhdar Mountain which is of deep layers of limestone rock with carsick caves and cracks (max. altitude 860 m). Wade Al Kouf, with its tributaries Wade Beit Saleh and Wade Sudan, make up the main Jarjarumah Wade which flows its water into the Mediterranean Sea during the rainy season. Wade had made its paths through many rocky high and narrow valleys. Some valleys are about 200 m

deep. Springs are restricted to the coastal area and ground water can be obtained between 100 and 400 m. Beaches, sand dunes and seasonally inundated lagoons are found on the eastern edge of the coast, a rocky low cliff formation characterizes the western part of the frontage.

The land vegetations in the Park are mainly, *Juniperus, phoenicea, pistacia lentiscus, Arbutus pavarii, Olea europaea, Myrtus communis,* and *Quercus coccifera*. In few protected localities, good groves of *Cupressus sempervirens* can be seen. Its Fauna has been considerably reduced by hunting and includes *Hyaena hyaena, Canis aureas, Vulpes vulpes, Genetta genetta, Felis libyca,* and *Hystrix cristata*. In the sea *Delphinus delphis* and *Tursiops truncatus* have been recorded. Bird species include *Phoenicopterus ruber* and several birds of prey.

Libya, being one of the Mediterranean States and at the same time occupying a large space of the Mediterranean southern shore, deserves to have some studies conducted on its more significant shores as an attempt to estimate the real stock of marine turtles latent in the Mediterranean. The recent available information lacked sufficient and adequate accuracy and details. Part of such information was logging of existence of loggerhead marine turtles on the shores of natural protectorate at Al-Kuf Valley (Herbert, 1979, Armsby, 1980; Schleich, 1987) as well as the information already logged about the locations of marine turtles nesting as well as the information already surveyed about the locations of marine turtles nesting during the field visits the shores of the eastern region (Haddoud *et al*., 1995; and Laurent, et al., 1995). Several archaeological remains, including Greek and Roman ruins linked to the ancient cities of Apollonia and Cyrene located 40 km east of the Park.

Ain Gazala MPA

Ain Gazala MPA is a Lagoon located at latitude 32° 13' N and longitude at 23° 18' E, about 130 km east of Derna in the direction of Tobrok. The lagoon covers a surface area of about 180 ha with an average depth of 2m. Underground springs at the inner side of the Lagoon discharge water of low salinity (8‰) with a flow of about 1m³/sec. The lagoon's water temperature, salinity and pH ranges are: 12.5 – 28 ºC, 37.5 - 40‰ and pH 8.2 - 8.5. The lagoon's Water of the springs having salinity of pH, 7.8 and temperature 18Co. The Lagoon's water has 5.6 mg/L suspended matter, Nitrogen compounds, 2.4 -7.8 mg/L and Phosphorus compounds, 0.9 –1.4 mg/L.(Gashout,S.F. and Haddoud, A.D. 2001)

The lagoon is a long cove 6.5 km long and 1.5 km wide, with on its north–east side a 10-m high cliff and on its southern side a 300 ha salt marsh. The water's physic-chemical properties and the presence of natural springs make it a suitable bed for the growth of marine plants and animals (Gashout and Haddoud, 2001).

The lagoon is used for fisheries by near villagers. Recently, aquaculture (fish cages and mussels) was introduced but the profit was very small. A development plan has been suggested to improve economic achievement by building hatchery and concrete tanks on its southern side.

Posidonia and *Cymodocea* species cover over 95% of the lagoon bed and serve as a protective and breeding site; this has been noticed in the diversification of species recorded from the lagoon (Table 1). Nesting sites of sea birds and turtles have been observed on its beaches and on the small island (El-Elba) nearby (Meininger et al., 1994a, b; Laurent et al., 1995).

Table 1. Check-list of species recorded from the Libyan lagoons (Gashout and Haddoud, 2001).

Sea grass and weeds	**Amphiura chiajei**	**Capitellidae** *sp.*
Posidonia oceanica	*Porania puvillus*	**Nereidae spp**
Cymodocea nodosa	*Thyone fusus*	**Aphroditidae** *sp.*
Caulerpa prolifera	**Phylum Nemertina**	*Nephyts hombergi*
Padina pavonica	**Tubulanidae *sp.***	**Neries pelagica**
Halimeda tuna	**Phylum Sipunculida**	*Neries diversicdor*
Valonia aegagropila	*Sipunclus nudus*	*Sabella pavonina*
Cladophora sericea	**Phylum Annelida**	*Nerocila bivittata*
Lithothamnion fasciculatum	*Eunice harassi*	*Ophelia bicornis*
Chaetomophora sp.	*Euphrosine folisa*	**Phylum Arthropoda**
Diplophus spiraalis	*Sternaspis scutata*	*Carcinus maenus*
Pterocladia pinnata	*Sternaspis scutata*	*Squtha mantis*
Bangia fuscopurapurea	**Lumbrinereinai**	**Gammaridea** sp.
Derbessia sp.	*Arenicola marina*	**Stomatopoda** sp.
Dasyopsis sp.	*Polyophathalmus pictus*	*Gammarus locusta*
Neria sp.	*Alciopa contrainii*	*Palaemon serratus*
Lamourouxi sp.	**Syllidae** *sp.*	*Orchestia gammarella*
Phylum Porifera	*Arnicola ecudata*	*Nerocila bivittata*
Calcarus sponge	**Glyceridae** *sp.*	*Megancyctiphanes*
Corals sp.	**Eunicidae** *sp.*	*nerveica*
Verongia aerophoba	*Ophryotrocha puerilis*	*Hypreria sp.*
Phylum Cnidaria	**Hesionidae *sp.***	*Sphaeroma serratum*
Actinia equina	*Dorvillea rubrovittata*	**Maldanidae** *sp.*
Phylum Echinodermata	*Vermiliopsis infundblum*	**Pasiphaeidae** *sp.*
Asterina gibbosa		**Mysidae** *sp.*
Phylum Mollusca	*Dicentrarchus labrax*	*Umbrina cirrosa*
Diodora italica	*Striarca lactea*	*Sciaena umbra*
Dentalium dentale	*Naticarius millepunctatus*	*Mullus surmuletus*
Dentalium rubescens	*Lima lima*	*Muraena helena*
Gastrana frgilis	*Smaragdia viridis*	*Trachinotus glaucus*
Abra tenuis	*Tillena planata*	*Uronoscopus scober*
Parvicardium Papilosum	*Pyrene sp.*	*Siganus luridus*
Acanthocardia tuberculata	*Trochus erythreus,*	*Solea lascaris*
Venericardia antiquata	*Donax venustus*	*Scorpaena notata*
Modiolus barbatus	*Clathrella clathrata*	*Torpedo torpedo*
Lithophaga Lithophaga	**Phylum Chordata (Fishs)**	*Trygon pastinaca*
Mytilus edulis	*Dentex dentex*	*Balistes capriscus*
Venerupis Pullastra	*Sparus auratus*	*Anguilla anguilla*
Venerupis aurea	*Lithognathus marmyrus*	**Sea turtles**
Venerupis rhomboides	*Diplodus anuaularis*	*Caretta caretta*
Rissoa monodonta	*Diplodus sargus*	*Chelonia mydas*
Pinna hydatis	*Boops salpa*	**Water Birds**
Littorina nerilodes	*Diplodus vulgaris*	*Phalacrocorax aristotelis*
Cerithium vulgatum	*Bolinus brandaris*	*Haematopus ostralegus*
Bittium reticulatum	*Janthina janthina*	*Charadrius alexandrinus*
Conus mediterraneus	*Haminea hydatis*	*Charadrius leschenaultii*
Strombus sp.	*Turritellta tripllcata*	*Pluvialis squataros*
Neverita josephina	*Turritella communis*	*Calidris minuta*
Tricolia speciosa	*Loripes Lacteus*	*Calidris alpina*
Buccinidae sp.	*Hyalina secalina*	*Numenius arquata*
Euthria cornea	*Anadara corduloides*	*Tringa glareola*
Nassariidae sp.	*Puntazzo puntazzo*	*Tringa ochropus*
Cylichna cylindracea	*Epinephelus alexandrinus*	*Tringa nebularia*
Nassarius reticulatus	*Mugil cephalus*	*Actitis hypoleucos*
Hexaplex trunculus	*Mugil auratus*	*Arenaria interpres*
	Mugil sp.	*Larus cachinnans*
	Epinephelus aeneus	*Sterna bengalensis*
		Sterna albiforns

Geziret Elba is an island about 2 km from the coast in the mouth of the Ain Ghazalah lagoon. It is a low island, with a maximum length of 2.5 km and a width of up to 1 km. The northern more rocky part is the highest (1.5 m above sea level), gradually sloping into a salt marsh at sea level on the southern part. Vegetation is dominated by thinly distributed *Salicornia fruticosa* and *Halimione portulacoides*, and most of the shore is covered by dense mats of accumulated sea grass *Posidonia oceanica*, washed ashore.

In July 1993, 40 pairs of lesser crested Tern were found breeding on the island, and small numbers of waders were seen, (Meininger et al., 1994a, b). Geziret Elba holds one of the two known colonies of lesser crested tern in Libya. The population does not seem to be directly threatened by disturbance or otherwise, both the island and the salt marshes along the shore are potentially suitable areas for migrating and wintering water birds. The fishermen use Drena (surrounding nets) in this area to collect the fingerlings of Sea bass and Sea bream. Two endangers species of turtles Chelonia mydas and Caretta caretta were recorded in the area (Laurent et al., 1995).

There is no source of organic pollution in the area but the introduction of aquaculture, over fishing, the catching of migratory sea turtles and sea birds are the main threats in the lagoon and sea birds should be monitored (Meininger et al, 1994 a).

Farwa MPA

This MPA is located at latitude 33° 04' N and longitude at 11° 50' E to 33° 08' N and 11° 32' E (Approx) from Abu- Kamash east to the Tunisian border in the west. It comprises Farwa lagoon which is the largest lagoon on the Libyan coast, covering an area of 32 km2. Farwa MPA, especially Farwa lagoon, has meadows of *Posidonia* and *Cymodocea* sp., due to certain economical important species (Sponges, shrimp, and fishes) in addition to some endangered species which makes it an important area for larva and juvenile protection. In the biodiversity of Farwa MPA we can recognize many economically important species and certain endangered species. Thus, it is of great importance that this area is protected.

The maximum altitude of the land on both sides of the lagoon is about 2-3 m (Sand type). Mean annual temperature varies from one month to another due to the recent closing of the east side of the lagoon. The minimum mean temperature in winter is 10ºC, while the maximum mean temperature in summer is 27ºC. Prevalent wind direction and speed wind direction is mainly NW and NNW, but a hot southern wind sometimes blows from the Sahara.

The Meteorological conditions of the area are those of the western part of Libyan coast: winter season extends from November to April and is generally cold and rainy with unstable winds blowing from different directions. The summer season (June to September) is rather hot and dry. The wind is more stable N and NW. Spring and autumn are very short transitional periods.

The lagoon is separated from the sea by an 11-km long narrow sand bar. The eastern part of the lagoon is very shallow with no aquatic vegetation and is bordered at its 1 km side tip by a semi-desert land (now closed). The southern shore of the lagoon (13 km long) is shallow, and made of sand and clay, its minimum depth is 0.5 m. on the sides while, its maximum depth is 4 m in the centre of the Lagoon. Salinity range in summer is from 38 to 44,5‰, and in winter is from 40 – 41.5 ‰.

On the uninhabited peninsula of Farwa nests of sea turtles (Laurent *et al*, 1999), gulls and migratory Terns were observed. A systematic list of birds observed in Farwa lagoon was given by Haddoud and Zgozi (1998).

In May, current velocities are between 15-60 cm/Sec., in June 7-40 cm/Sec. and in August 28-52 cm/Sec. In general, the current velocities in the inner part of the lagoon are greater than in the outer part. The island's flora is mainly made up of palms and desert trees and grasses, there are no fruit trees on the island or nearby main land, many different wild animals were recorded on the island as it is uninhabited island. The marine fauna of the lagoon is very rich; its marine flora is composed mainly of Posidonia, Zostera and many species of green and brown algae. The type of the soft bottom allows many burrowing organisms to live there (Table 1).

It should be indicted here that the trawlable area of the Libyan coast is from Musrata to Tunisian border. However, in this area, including Farwa lagoon, trawling is prohibited during July and August of each year. Despite the fact that Farwa MPA has been established (meanings all kinds of fishing gear are prohibited) nothing has been achieved in this respect. About 50 fishermen use the lagoon only for fishing and mooring their boats. It might be interesting here to point out that, the population of the nearby village (Abukamash) is about 1,000.

The proposed Marine Protected Areas:

<u>El Burdi MPA</u>
The El Burdi lagoon MPA is located near the Egyptian border at latitude 31° 45' N and longitude 25° 06' E (Approx) (Figure 1). This MPA characterized by its water deepness (4- 25 m.), and low diversity of animal species. The most common are Gastropods, Crustacean and Bivalves species. Also, there are a few plant species, mainly the sea grasses Posidonia and *Cymodocea* and *Chalorophyceae algae* (Table 2).

The low diversity of El Burdi lagoon is mainly due to its sandy substrate. It is well documented that, sandy substrates contain less organic matter, which result in low densities of micro-organisms, and hence low macro-organisms densities (Meadows and Campbell, 1988). The lagoon location suggests less human activities and its natural habitat (deep water and low diversity) makes it an ideal candidate for a MPA on the eastern coast of Libya.

<u>Ain -Ziyana MPA</u>
Ain -Ziyana Lagoon MPA is located at latitude 32° 06' N and longitude at 20° 05' E (approx), is a brackish water lagoon situated about 15 km east of Benghazi city, covering an area of 50 ha with an average depth of 2 m. It is connected to the sea by a canal made by the overflow of the water from underground springs in the lagoon.

The underground springs discharge brackish water of 10‰ into the Lagoon with a capacity of 4.5 m3 /sec. This discharge capacity lowers the Lagoon's water salinity giving it a range of 16-28 ‰. The lagoon water has a temperature range of 14-28C° and a pH of 7.8.

The lagoon is used as a harbour for several small boats. About 10 ha at the North West side of the Lagoon it is used for aquaculture, where a complex was built consisting of tens of metal tanks, rooms, hatcheries, stores, etc. The complex is still under operational trial (Reynolds *et al.*, 1995).

The presence of underground springs, which discharge water of low salinity (10 ‰) and the extensive tamarisk bushes around the lagoon, make it a niche site for migratory water birds: gulls, terns, ducks, swam and others. Kerambrun (1986) and Meininger et al.(1994a), recorded more than 1000 nests of water birds in the area, some species recorded for the first time (e.g. yellow wagtail). The opening of MBRC branch in Benghazi city will help in monitoring and conserving life in this lagoon.

Table 2. Check-list of species, recorded from El-Burdi lagoon (MBRC, 2000)

Gastropoda	**Holothurioidea**
Cerithiidae	Cucumaridae
Conidae	**Crustacea**
Coralliophilidae	Hoplophoridae
Rissoidae	Sphaeromidae
Truncatellidae	Gammaridae
Pyramidellidae	Corophiidae
Triphoridae	Mysidaceae
Retusidae	Pontoniinae
Vermetidae	Paguridae
Turridae	Palaemoniidae
Trochidae	Cnidaria
Phassionellidae	Sphaeromidae
Sascioloriidae	Gammaridae
Buccinidae	Corophiidae
Naticidae	**Scaphopoda**
Nassariidae	Dentaliidae
Cerithiopsidae	**Scaphopoda**
Collumbellidae	Dentaliidae
Epitoniidae	Annelida
Muricidae	Arenicolidae
Bivalvia	Nereidae
Carditidae	Arenicolidae
Cardiidae	**Echinodermata**
Glycymerididae	Echinoidea
Veneridae	**Actinidae**
Semelidae	**Porifera**
Peticolidae	Desmospongia
Pteridae	Polychaeta
Mytilliidae	Nereidae
Ostreidae	**Pheaophyceae**
Lucinidae	
Tellinidae	*Dictyota linea*
Veneridae	*Padina pavonica*
Scaphopoda	**Chalorophyceae**
Dentallidae	*Valonia* sp
Asteroidea	*Cladophora* sp
Asteroidae	*Caulerpa prdifera*
Collumbellidae	*Anadyomene stellata*
Epitoniidae	**Rhodophyceae**
Muricidae	*Pterocladia capilaceae*
Bivalvia	*Jania adherens*
Carditidae	**Sea grasses**
Cardiidae	*Posidonia oceanica*
Glycymerididae	*Cymodoceasp.*

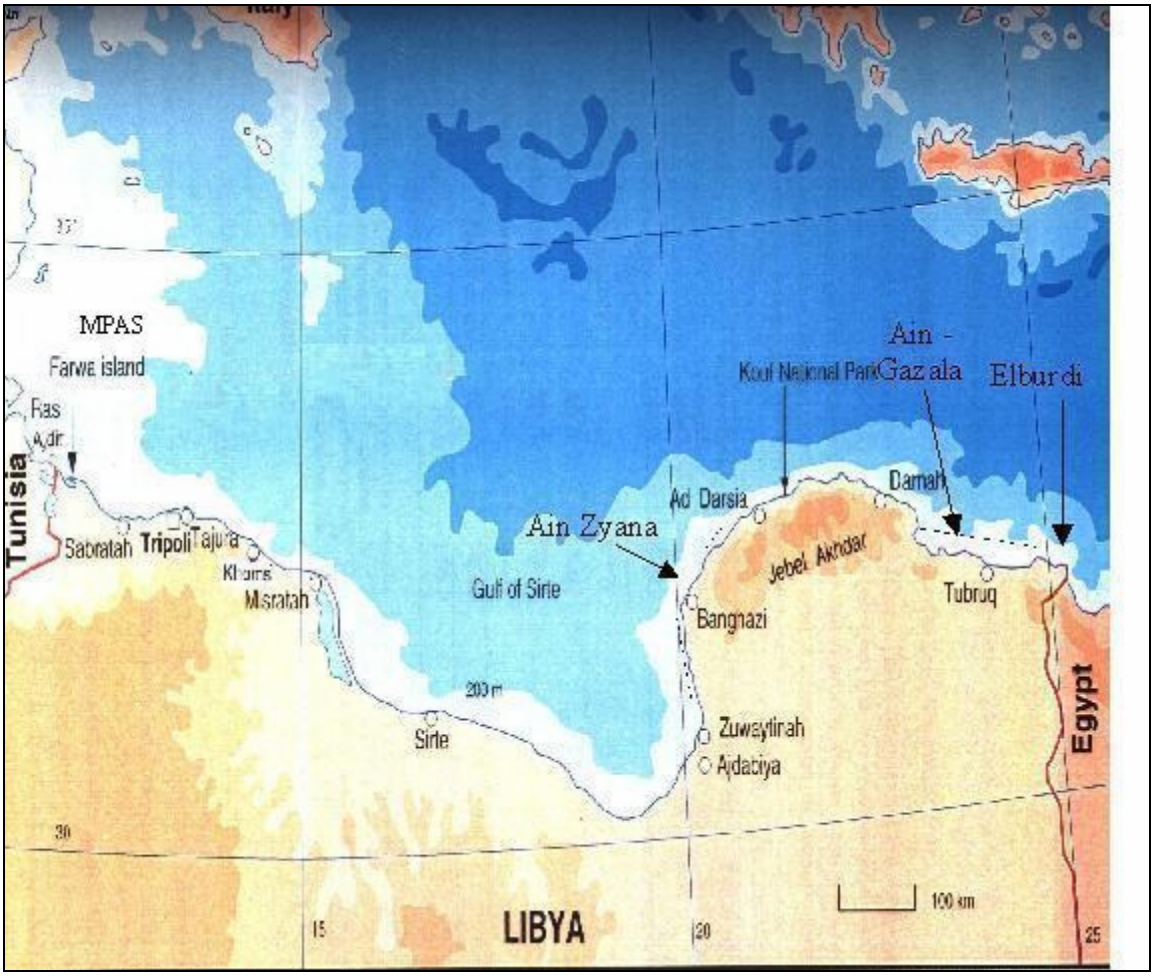

Figure 1. Established and proposed MPAs in the Libyan coast

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Quelques traits de la biodiversité marine de Tunisie

Proposition d'aires de conservation et de gestion

K. Ben Mustapha* and A. Afli

Résumé

Faute d'inventaires actualisés, l'étude de la biodiversité marine en général reste toujours subjective étant donné qu'elle fluctue au cours du temps. En Tunisie, les études effectuées montrent que les côtes nord sont caractérisées par une alternance de fonds rocheux et de fonds meubles et un plateau continental à pente forte. Cette diversité des biotopes leur confère une biodiversité élevée. Certains écosystèmes paraissent alors importants, à l'instar du coralligène et des systèmes insulaires qui abritent une biocénose remarquable et diversifiée. Les côtes est sont moins rocheuses et pourvues d'un plateau continental relativement étendu avec des herbiers de posidonie assez fréquents et en bon état. Elles constituent, entre autre, une zone de ponte pour la tortue marine *Caretta caretta* (îles Kuriat). Quant aux côtes sud, elles sont caractérisées par des fonds sableux et sablo-vaseux, favorables au développement des prairies de végétaux marins. Elles disposent d'un plateau continental très étendu, à pente très douce. Cette région est caractérisée par une marée de forte amplitude et une salinité relativement plus élevée. La biodiversité rencontrée présente certains traits particuliers.

Sur le plan conservation, les écosystèmes remarquables en Tunisie (herbiers de posidonie, coralligène, lagunes, bans marins, etc.) font l'objet d'une attention particulière, que ce soit dans le cadre des conventions internationales visant à protéger le milieu marin ; ou bien à l'échelle nationale comme la création d'aires marines protégées et le renforcement de la réglementation des pêches. Ainsi outre les aires marines et côtières déjà instaurées et celles projetées dans le cadre du 6ème plan de développement, nous proposons dans le présent travail la protection de nouvelles zones dans chacun des trois golfes de Tunisie : golfe de Tunis, golfe de Hammamet et golfe de Gabès. .

1. Introduction

La Tunisie (figure 1), avec 1300 km de côtes, est ouverte sur les deux bassins de la Méditerranée, le bassin occidental par sa façade nord, et le bassin oriental par ses façades est et sud-est. Au nord, une des branches du courant atlantique y est prédominante, alors qu'à l'est et au sud-est, l'hydrodynamisme est plus contrasté avec le même courant atlantique qui baigne la haute mer, et des courants plus chauds et plus salés dans les zones plus littorales, dont l'empreinte levantine est très accentuée (Hopkins, 1985; Brahim *et al*, 1994 ; Brandhorst, 1977 ; Samari et Gana, 1995). La topographie du littoral tunisien est aussi très variée : Côtes rocheuses ou sableuses, baies profondes échancrées, caps parfois saillants, nombreuses îles et îlots et une ceinture de hauts fonds sont les éléments les plus caractéristiques (Le Danois, 1925; Azouz, 1966; Ben Mustapha, 1966; Poizat, 1970; Azouz, 1973; Ben Othman, 1973; Blanpied *et al.*, 1979; Pergent et Kempf, 1993). L'ensemble de ces spécificités permet

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l'existence d'une biodiversité marine et côtière particulièrement intéressante. Toutefois, malgré certains efforts visant à mieux l'étudier, les données restent insuffisantes en raison de l'hétérogénéité des travaux. Même l'inventaire des espèces et leur identification posent de nombreux problèmes, notamment en ce qui concerne les phylums réputés difficiles tels que ceux des cnidaires, des bryozoaires, des annélides, des algues et des éponges). Bien que la Tunisie dispose d'un inventaire global de la biodiversité biologique, établi suite à une étude entreprise en 1997 par le Ministère de l'environnement tunisien, ce travail a mis en exergue notamment la disparité des données ainsi que la nécessité de les mettre à jour (Anonyme, 1977 a et b).

Nous présentons ci-après quelques données relatives à la biodiversité marine en Tunisie, et nous récapitulons l'état de connaissance sur les plans dynamique, biologique, sédimentologique et faunistique dans les trois golfes de Tunisie ; en insistant sur les paramètres prépondérants dans le choix des sites susceptibles d'accueillir des récifs artificiels ou d'être classés aire marine protégée en Tunisie.

2. Biodiversité Marine de Tunisie

2. 1. Biodiversité spécifique de la flore marine en Tunisie

D'après le travail de synthèse de Ben Maïz (1995), 414 taxons sont recensés[1] en Tunisie, dont 71 sont exploités ou ayant été étudiés à cette fin dans des pays autres que la Tunisie, néanmoins on estime le nombre réel à prés de 600 taxons. Cette biodiversité est riche en comparaison à celle d'autres pays du bassin oriental, mais elle est pauvre par rapport à celle des pays du bassin occidental.

Les côtes Nord et le golfe de Tunis ont la biodiversité algale la plus riche par rapport au reste du littoral tunisien. Ceci s'explique du fait que cette région, située dans le bassin occidental bénéficie d'une topographie très variée.

Parmi les 54 macro-algues et magnophyta considérées comme menacées à l'échelle méditerranéenne (Anonyme, 1990), 23 taxons sont signalés en Tunisie (Ben Maiz, 1995).

[1] algues unicellulaires planctoniques et benthiques non retenues

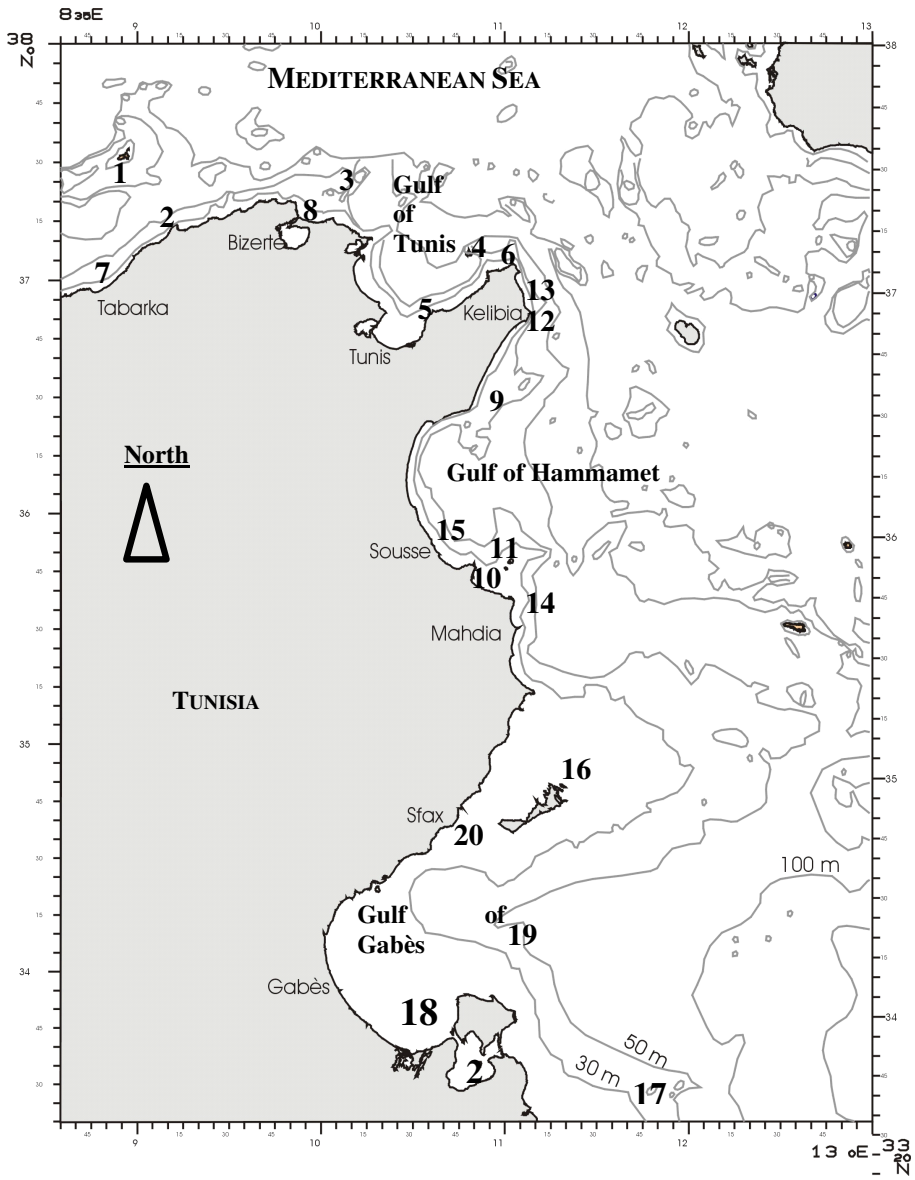
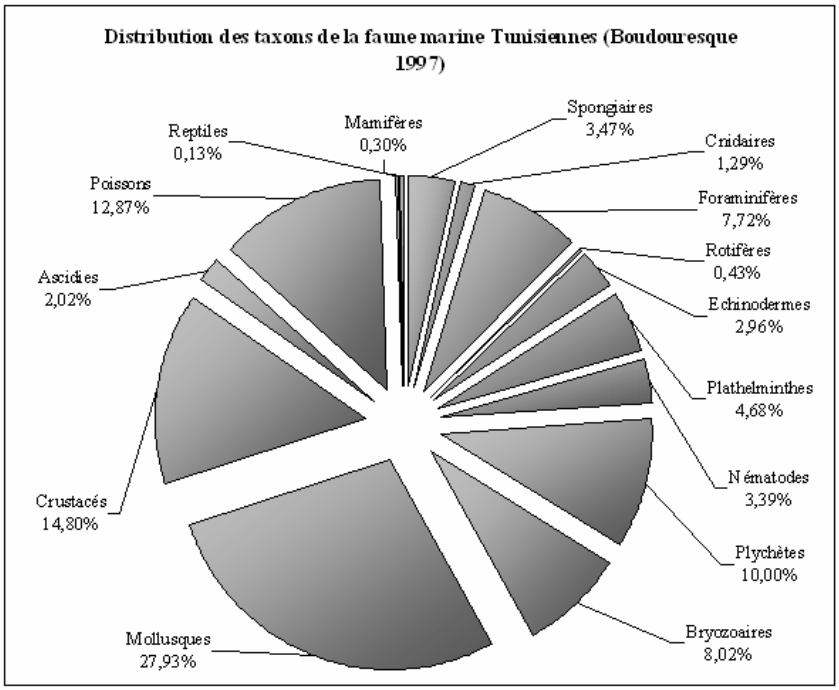


Figure 1. Localisation des principaux sites. 1. Ile de la Galite; 2. Iles Fratelli 3. Ile Cani; 4. Zone Zembra – Zembretta; 5 Cap Fartas; 6. Zone du Cap Bon; 7 Tabarka; 8 Bizerte; 9. Bancs de Maamoura et Korba; 10. Zone de Monastir; 11. Zone des îles Kuriat; 12. Zone de Kelibia; 13. Zone de Kerkouène; 14. Salakta; 15. Sousse; 16. Platier des îles Kerkennah; 17. Les bancs de Zarzis; 18. Ile Djerba; 19. Zone centrale du golfe de Gabès; 20. Sfax, 21 Lagune D'El Bibane.

2.2. Biodiversité spécifique de la faune marine en Tunisie

Les inventaires récents sont peu nombreux, sauf pour quelques groupes tels que ceux des spongiaires et des poissons, mais ils sont plus anciens en ce qui concerne les échinodermes et les gastéropodes. En outre la plus part des inventaires, sont généralement incomplets. Néanmoins, un effort a été entrepris ces dernières années afin d'entamer la révision des inventaires de certains groupes (Bryozoaires et Ascidies notamment) et de compléter ceux existants (Spongiaires, Annelides…). La lecture des différents inventaires permet de

remarquer que 36 espèces sont listées comme espèces en danger ou menacées dans les annexes des Conventions de Barcelone et/ou de Berne)[2].



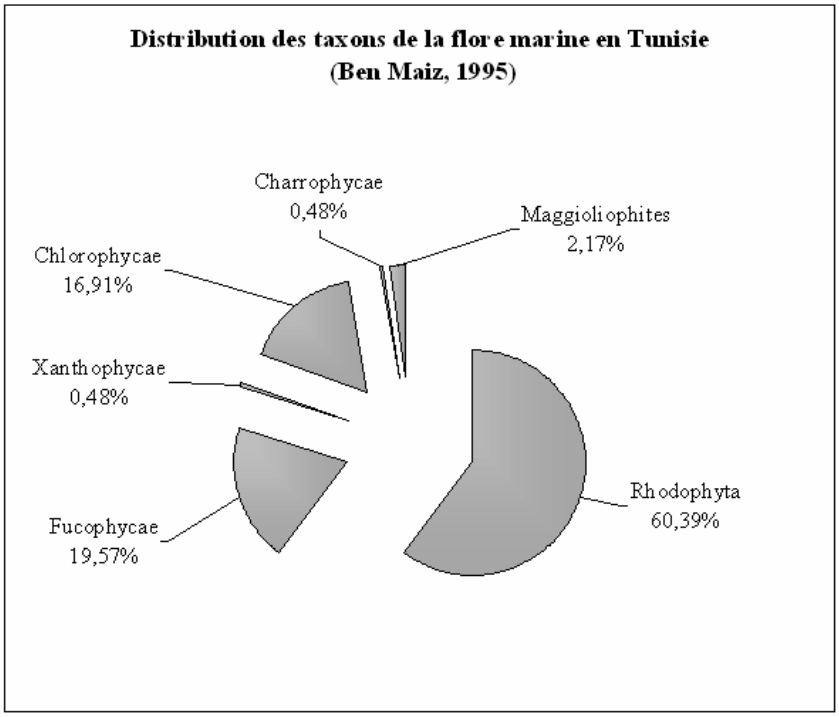


Figure 2. Distribution des principaux phylums marins recensés en Tunisie

[2] Il est á signaler qu'il est urgent d'établir des critères de sélections spécifiques à la biodiversité tunisienne, car plusieurs espèces classées comme menacées en méditerranée, ne sont pas menacées en Tunisie, alors que d'autres le sont.

2.3. Biodiversité des écosystèmes

La diversité des écosystèmes marins littoraux est remarquable en méditerranée (Boudouresque, 1997; Ramos-Espla et Sanchez-Lizaso, 2002; Ballesteros, *sous presse*) Cette diversité ainsi que la richesse de ces écosystèmes permet le foisonnement de la faune et de la flore associées. Ainsi la biocénose à *Posidonia ocenica* abrite près de 1400 espèces animales et végétales (Anonyme, 1991), alors qu'au dernier recensement, la biocénose coralligène abrite près de 1600 taxons du mégabenthos (Ballesteros, *sous presse*).

En Tunisie, des écosystèmes remarquables sont signalés du nord au sud du pays, dans ses milieux insulaires et dans ses bancs:

- Trottoirs à vermetidae (gastéropodes), signalés notamment au Cap Bon ; à Zembra et au Cap Blanc
- Récifs à *Néogoniolithon*[3], long de 30 km au nord de la lagune El Bibane ; foisonnement dû aux conditions particulières du milieu (température et salinité élevées), qui limitent les compétitions interspécifiques
- L'herbier à *Posidonia oceanica* ; dont la distribution, la vitalité et l'état de dégradation diffèrent d'une région à l'autre
- Biocénose coralligène, généralement dans un état excellent (Golfe de Tunis, îles de la Galite, de Zembra, Fratelli, Cani, les hauts fonds ou bancs : Mazarilles, Speiss, Hallouf, Korba, Gréco…), sauf dans ses faciès à fond meuble ou l'action des chalutiers est parfois visible.

3. Données récentes sur la biodiversité marine en Tunisie

Dans le cadre d'un travail de synthèse général des travaux relatifs à la biodiversité marine en Tunisie, un groupe de travail de l'INSTM, dont les auteurs du présent travail, a passé en revue l'ensemble des travaux et études signalant des espèces marines dans les trois principales régions de la Tunisie, à savoir les golfes de Tunis, de Hammamet et de Gabès (Afli, 2001; Afli et Ben Mustapha, 2001 ; Afli et Riveill, 2002 ; Bradai, 2001; 2002 ; Ben Mustapha et El Abed, 2002; Ben Mustapha *et al*., 2002a; Langar, 2002 ; Gharbi et Zarrad, 2002 a et b ; Sellem, 2002).

Nous résumons le résultat de ce travail de recensement dans le tableau suivant :

[3] Cette rhodophycae participe aussi à la formation des trottoirs à vermets

Tableau 1. Distribution du nombre de taxons des principaux phylums animaux marins signalés en Tunisie

	GOLFE DE TUNIS	GOLFE DE HAMMAMET	GOLFE DE GABES
Echinodermes	48	29	46
Cnidaires	23	17	6
Bryozoaires	57	12	57
Annélides	10	8	11
Crustacés	120	27	24
Ascidies	7	25	17
Spongiaires	45	51	108
Mollusques	416	10	171
Poissons	106	113	227
Total	**832**	**292**	**667**

Ce travail a permis de connaître les taxons recensés en Tunisie, ainsi que leurs aires de distribution géographique. Il a aussi déclenché un intérêt de la part des chercheurs en sciences de la mer à combler certaines lacunes importantes dont celles relatives :

- à la taxonomie de phylum réputés difficiles (essentiellement ceux des invertébrés benthiques) : Spongiaires, Bryozoaires, Annélides, Ascidies, …
- à l'étude quantitative de certains peuplements (composition et structure des peuplements, étude des peuplements fonctionnels de substrats meubles, etc.) : Structure du peuplement des spongiaires du banc Messioua (sud Tunisie) du banc Hallouf (est Tunisie) et du cap bon ; Etude des peuplements fonctionnels du golfe de Tunis, etc.
- à la recherche « d'empreintes » biochimiques de certains groupes importants ; Algues, Spongiaires et Echinodermes notamment.

3. 1. Les Herbiers de Posidonies

C'est une biocénose typique de la Mer Méditerranée, représentant un grand pôle de diversité biologique. L'espèce *P. oceanica* est une espèce endémique à cette mer, elle vit dans la frange littorale depuis le rivage jusqu'à la limite inférieure de l'infra littoral. Il a été démontré que 20 à 25 % des espèces méditerranéennes sont abritées par les herbiers de posidonies. En effet près de 400 espèces végétales et 1000 espèces animales y trouvent refuge (Anonyme, 1991), fixées sur les rhizomes et/ou les feuilles de *Posidonia oceanica*.

L'état de cet écosystème en Tunisie et plus particulièrement dans le Sud Est de la Tunisie est fragilisé du fait de la pollution marine et à cause du chalutage illicite dans les profondeurs interdites (Darmoul, 1988; Hattour, 1991 ; Ben Mustapha et Hattour, 1992 ; Ben Mustapha, 1995 ; Ben Mustapha *et al*, 1999 ; Afli et Ben Mustapha, 2001 ; Ben Mustapha et El Abed, 2002 ; Ben Mustapha *et al.,* 2002 a et b).

Bien que les travaux d'exploration des herbiers sont rares, discontinus dans le temps et inégalement répartis dans l'espace, nous connaissons les zones ou ces herbiers existent et nous avons une meilleure information sur leur phénologie (Ben Mustapha et al, 1999, 2002 a, b et c ; Komatsu et al, 2001 et 2004). Les herbiers de Posidonie ont une distribution

importante au large des côtes tunisiennes (figure 3), ainsi 167 km² ont été répertoriés dans le golfe de Hammamet en 1992. Dans le golfe de Gabès, on estime que seuls 5% de l'herbier de 1925 (Le Danois, 1925). Toutefois cet herbier présente dans certaines zones de très grandes étendues tel que le platier de Kerkennah, la zone nord entre Cap Farina, îles Cani et Bizerte, ou bien la zones s'étendant de l'est de Djerba jusqu'à la frontière tunio-libyenne et notamment ses hauts fonds.

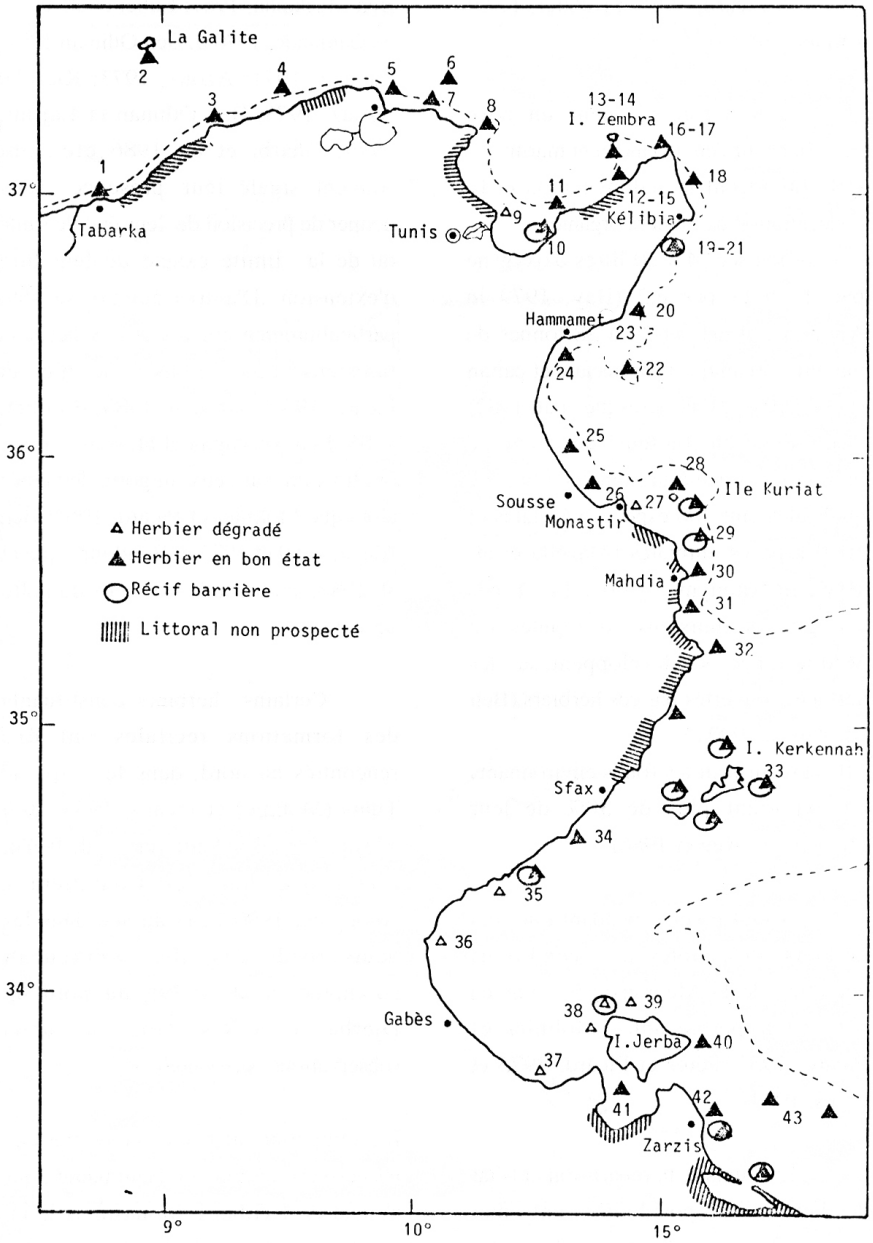


Figure 3. Répartition des herbiers de posidonie le long du littoral tunisien (*d'après Ben Mustapha et Hattour; 1992*).

3. 2 Le coralligène.

Cette biocénose, constituée par un concrétionnement (formant des blocs) d'algues calcaires corallinacées sciaphiles colonisées par un grand nombre d'espèces animales (Eponges, Ascidies, Bryozoaires, Cnidaires…), constitue le pôle principal de la biodiversité marine en Méditerranée, 1600 espèces macro-benthiques y ont été signalées (Ballesteros, sous presse). Ces algues calcaires, à croissance extrêmement lente, ne se développent qu'en milieu sciaphile. Un coralligène appauvri, « le précoralligène », se rencontre en sous-strates sur les rhizomes de *Posidonia oceanica*, quand l'herbier a une densité foliaire élevée. Néanmoins, même en sous strates de peuplement dense d'algues phaeophycae, il peut se présenter alors sous la forme d'un coralligène riche et diversifié comme c'est le cas au banc Hallouf (Ben Mustapha *et al*., 2002b). La plupart des animaux fixés se nourrissent du plancton et des particules en suspension dans l'eau. La compétition pour accéder à la masse d'eau et au flux de nourriture qu'elle représente s'additionne à la compétition déjà sévère pour l'occupation de l'espace.

En Tunisie, cette biocénose peut se rencontrer soit sur la roche littorale (falaises littorales et insulaires : Île de Zembra ; Cap Bon ; entrées de grottes et Tunnels aux îles Cani et à Tabarka etc.), soit en bio-concretionnement dur formant alors le coralligène de plateau (véritable gisement coralligène entouré de fonds meubles), soit sur la roche du large (Les bancs en général). Elle se rencontre aussi sur substrat meuble (fonds à maërl, algues corallinacées calcifiées : *Lithotamnium sp.*) formé par un détritique grossier et concrétionné par les algues corallinacae du genre *Neogoniolithon* et dans lequel les éponges de la famille Clionidae présentent un faciès prédominant entre 35 et 65 m de profondeur (Présent travail). Phénomène nouveaux, l'algue verte *Caulerpa racemosa* côtoie *Fabiola petiola* et lui dispute même l'espace à coloniser (coralligène installé sur détritique côtier au cap bon, Zembra, Banc Hallouf etc.). C'est sous cette dernière forme (fonds à maërl) que le coralligène est soumis à l'action dévastatrice des chaluts.

Au banc Hallouf, situé à 30 Miles nautiques l'est de Monastir, la quantité importante d'algues brunes a attiré l'attention des auteurs (Anonyme, 1923 ; Pruvot, 1923 ; Le Danois, 1925), qui ont alors décrit un nouveau faciès bionomique à algues brunes au large des côtes tunisiennes. Lors des travaux de prospection en plongée en scaphandre autonome de ce banc en 2002 à bord du « NRO Hannibal », nous avons confirmé la présence de ce faciès (Ben Mustapha et al, 2002). En effet le banc Hallouf, constitué par des zones rocheuses formées par des blocs très étendus hauts de 8 à 12 m reposant par 45 m de fond, est entouré par un fonds meuble à éléments grossiers (gros débris coquilliers et mäerls d'un diamètre moyen de 10 à 12 cm). Le substrat meuble est recouvert par un dense « manteau » à pheophycae dont le recouvrement horizontal atteint une moyenne de 93%.

Parmi les espèces et les associations rencontrées, on signale :

Les algues *Pheophycae* représentent un dense couvert algal (du moins en volume) sous lequel se développe un important coralligène. Elles sont essentiellement représentées par *Dictyota membranacea, Sargassum hornschuchii, Sargasum valgarae (*dont les thalles sont long de 15 à 35 cm) et *Zonaria tournefortii*. *Asperococus bullosus* y est rare.

Les algues *Rhodophycae* sont représentées par un nombre d'espèces encore plus important, occupant le plus souvent la sous-strate, étant donné leur taille moins imposante que celle des pheophycae. Nous avons identifié les espèces suivantes *: Fauchea repens, Galaxaura oblongata, Ptilophora mediterranea, Phyllophora nervosa, Vidalia volubilis,*

Chondrymnea lobata, Sebdenia dichotoma, Halarchnion ligatum, Halymenia sp (à thalle cartilagineux à surface « glissante »), Peyssonnelia rosa-marina, Peyssonnelia rubra, Lithophyllum expansum et *Litothamnium sp.*

Les algues *Chlorophycae* sont les moins bien représentées. Deux espèces dominent ce groupe par leur présence massive : *Udotea (Flabellia) petiola* et *Caulerpa racemosa* (formant des tâches de superficie variable comprise entre 0,5 et 2 m²). Enfin une troisième espèce, également d'affinité sciaphile, a été rencontrée dans quelques stations, il s'agit de *Palmophyllum crassum*.

Ainsi, la présence de ces espèces indicatrices, dans leur majorité, de la présence d'un peuplement a affinité fortement sciaphile, la densité de ce peuplement ainsi que la taille des individus, soulignent l'importance de la biocénose coralligène au banc Hallouf. Par ailleurs, la présence de certaines espèces observées pour la première fois en Tunisie est à souligner.
En outre l'absence de la phanérogame marine *Posidonia oceanica* a été remarquée, alors que la profondeur et la luminosité ne lui sont pas défavorables, notamment sur l'étendue importante des aires horizontales des blocs rocheux (vers 35 m de profondeur). Il est à remarqué que la Posidonie est signalée dans le nord de la Tunisie (au sud des îles Cani, à une profondeur de – 42 m). Son absence est d'autant plus remarquable que ce banc se situe juste en amont des grandes régions à Herbiers de Tunisie (Plateau des îles Kuriat, Plateau des îles Kerkennah-Chebba, littoral du Sahel, Golfe de Gabès) etc.

Le peuplement animal est caractérisé par une grande richesse en spongiaires dont les représentants occupent un espace appréciable. Les plus fréquentes parmi ces espèces sont les suivantes : *Hippospongia communis* (avec la présence d'un peuplement dense de « juvéniles »), *Cacospongia mollior, Ircinia dendroides, Ircinia fasciculata, Petrosia dura, Chalinella sp, Cliona sp, Chondrosia reniformis, Crambe crambe, Hamigera hamigera, Anchinoe sp, Acanthella acuta, Agelas oroides, Axinella damicornis, Axinella polypoides.* Certaines Dictyoecratida (éponges « cornées ») atteignent des volumes importants avec un diamètre variant entre 50 et 120 cm (*Cacospongia mollior* et *Hippospongia communis* notamment).

Parmi les autres représentants du macro benthos animal, nous pouvons citer :

- L'oursin *Sphaerichinus granularis*, rencontré dans l'ensemble des stations et atteignant des densités de 4 à 6 individus/m², et dont la taille moyenne est de 7 cm de diamètre et *Centrostephanus longispinus* qui est plutôt rare.
- Les gorgonaires *Eunicella singularis* (représentées par un peuplement de 2 individus/5 m² de densité) et *Lophophorgia sp* (qui est plutôt rare).
- Les annélides *Spirographis spallanzanii* et *Cerianthus sp*, plutôt rares, se développant soit sur substrat meuble soit sur la roche.

Nous avons aussi été surpris par la pauvreté spécifique des Bryozoaires (*Sertella septentrionalis* ; *Pentapora fascialis et Myriapora truncata)* et des Ascidies (*Aplidium sp*) rencontrées dans ce banc.

Dans le cadre de cette revue des principales espèces de la biocénose coralligène rencontrées au banc Hallouf, nous soulignons la présence d'une faune ichtyque particulièrement abondante. Nous citons en particulier la présence de *Seriola dumerili*, *Serranus scriba, Serranus cabrilla, Boops boops, Boops salpa , Spicara maena, Epinephelus guaza, Epinephelus alexandrinus*, *Sciaena umbra* etc.

En conclusion, ce banc présente un potentiel important, non seulement à cause du nombre d'individus de poissons signalés en plongée, mais surtout de par la richesse de son coralligène. Ses peuplements benthiques et leur structure ainsi que son peuplement icthyque doivent être étudiés plus en détail. Le faciès à algues brunes est dense et en bon état, ce qui permet le développement d'une sous strate coralligène riche et bien représentée.

3. 3. Espèces invasives

La mer Méditerranée ; zone de transition entre l'océan atlantique (à travers le détroit de Gibraltar) et l'océan indien (via le canal de Suez et la mer Rouge), a connu dès la fin du XIX ème et au cours du XX ème siècles plusieurs perturbations (ouverture du canal de Suez, domestication des eaux fluviales, sur-pêche, pollution, activités maritimes et aménagement du littoral. Ces perturbations ont entraîné des modifications dans sa composition floristiques et faunistiques.
Les côtes tunisiennes, particulièrement la région du golfe de Gabès, subissent les conséquences de ces perturbations. En effet, plusieurs espèces animales et végétales sont arrivées en Tunisie en provenance soit de l'Atlantique soit de l' Indo-Pacifique. Ces espèces proviennent principalement de la Mer Rouge (espèces lessepstiennes) et secondairement de l'Atlantique. Les espèces lessepstiennes intéressent principalement le bassin oriental. On considère qu'il s'agit, à l'échelle mondiale, de l'évènement biogéographique actuel le plus important.

Nous allons nous intéresser brièvement aux cas des deux Caulerpales suivantes :

- *Caulerpa taxifolia*: Les premières signalisations de cette espèce invasive remonte au mois de février 2000 dans la rade de Sousse (Langar, 2002). Les zones touchées actuellement sont la rade de Sousse, El Kantaoui, la marina de Monastir, Sidi Daoud ; El haouaria et le Cap Bon (Ben Mustapha *et al*., 2002 b).
- *Caulerpa racemosa*: cette algue verte, d'origine tropicale, signalée en Tunisie depuis 1926, a été rencontrée à Mahdia et dans le golfe de Gabès par 15 m de profondeur en 1971, à Salakta sur les blocs rocheux du port (depuis 1971), au large de Monastir dans l'herbier de Posidonie (1992), aux alentours des îles Kuriat (1997), à Bizerte, au cap Bon, au îles Cani et à Zembra depuis 2000. Elle a aussi été signalée dans la région du golfe de Gabès à des profondeurs importantes (72 m) formant des pelouses sur fond sableux avec des débris coquilliers et mélobésiers (1995) et plus récemment (juillet 2000) à la Chebba et dans le port d'El Ataya à Kerkennah (2000). Enfin elle a même été signalée sur les hauts fonds en mer ouverte et loin des côtes dans les bancs Hallouf (2002) et Messioua (2000). (Djallouli, 2000, Hamza *et al*., 1995, Ben Mustapha et El Abed, 2000, Ben Mustapha *et al*., 2002a et b.

4. Le cas du golfe de Gabès.

Le golfe de Gabès, large échancrure située sur le littoral sud de la Tunisie, constitue le golfe le plus important du littoral tunisien. Cette zone dispose de conditions climatiques, topographiques, géomorphologiques et océanographiques favorables au fonctionnement d'un système littoral marin naturel remarquable dont le résultat le plus important a été la mise en place d'un climax constitué par la biocénose à *Posidonia oceanica (L)* Delile. Cette dernière

s'étend jusqu'au au golfe de Syrte en Libye, formant ainsi la biocénose à *Posidonia oceanica* la plus étendue du monde.

Toutefois, depuis quelques dizaines d'années, l'ensemble de ce système naturel marin littoral subit des agressions aussi bien d'origine anthropique que naturelle. La conséquence principale fut le développement de biocénoses caractéristiques d'un état de délabrement de l'écosystème qui s'est traduit principalement par la perte importante d'étendues du couvert végétal et par sa dégradation.

Par ailleurs, des résultats et des conclusions préliminaires relatifs à la dégradation du couvert végétal et aux transformations du système marin dans cette région, ont été publiés depuis 1992 (Ben Mustapha *et al*., 1999). Les conclusions pertinentes relatives aux changements écosystèmiques du golfe de Gabès suite à une étude qui a visé un total de 143 stations prospectées par plongée en scaphandre autonome depuis 1988 sont résumées ci-après.

Le milieu marin du golfe de Gabès est actuellement caractérisé par un ensemble de traits tels que la disparition de surfaces importantes couvertes par la Posidonie, l'envasement de son herbier observé dans de nombreuses stations, la raréfaction des sites d'implantations de *Cymodocea nodosa*, la disparition presque totale de C*aulerpa prolifera* et l'installation de fonds instables. Ce travail a mis en exergue (i) La présence (qualitativement importante) d'espèces indicatrices de milieux instables, (ii) La présence d'espèces sciaphiles à des profondeurs très faibles et (iii) La régression de la limite inférieure de l'étage infralittoral et par conséquent une remontée de la limite supérieure de celle du circalittoral.

Cette transformation de la physionomie du fond du golfe de Gabès a induit un changement de la bionomie benthique, avec une perte du couvert végétal originel de l'ordre de 90% conduisant à l'installation de biocénoses caractérisées par une faune et une flore de milieux envasés et dégradés, et par la multiplication de stations de biocénose du précoralligène dégradé.

5. Propositions d'aires marines de protection et de conservation

Nous présentons ci-après une brève synthèse de l'important travail de recensement mené par un groupe de travail de l'INSTM en vue d'aider à identifier les aires marines de protection et de conservation dans les trois golfes de la Tunisie (Anonyme 2001, 2002 a et b), dans laquelle nous récapitulons l'état de connaissance sur les plans dynamique, biologique, sédimentologique et faunistique, en insistant sur les peuplements benthiques importants. Nous mettons également l'accent sur les paramètres prépondérants dans le choix d'un site susceptible d'accueillir des récifs artificiels ou d'être classé aire marine protégée.

En effet, l'étude assez exhaustive sur l'état des connaissances de l'habitat et de ses caractéristiques (hydrologie, climatologie, sédimentologie, nature des fonds, sels nutritifs, activités anthropiques, pollution, perturbations diverses), et aussi des habitants (les espèces) et leurs caractéristiques (richesse spécifique, abondance, répartition, biologie, écologie, mécanismes trophiques, etc.) met en exergue la nécessité de penser à l'instauration d'aires marine protégées et de zones d'implantation de récifs artificiels. Elle vient concrétiser les efforts déployés par la Tunisie dans le but de sauvegarder le patrimoine biologique et ainsi assurer une gestion optimale des ressources marines.

Les **objectifs** visés par cette étude peuvent être résumés essentiellement en trois points :

1- Etablissement d'un inventaire détaillé des espèces animales et végétales le long des côtes tunisiennes, essentiellement dans le périmètre de l'étude.

2- Caractérisation spatio-temporelle de l'état des ressources et des activités anthropiques. Il s'agit là d'étudier les écosystèmes (espèces et habitats) ainsi que les différents facteurs susceptibles de jouer un rôle dans leur équilibre (surexploitation, pêche de juvéniles, techniques de pêche non appropriées, pollution, nuisances diverses). Les différents thèmes traités sont les suivants : les facteurs hydrologiques, la pêche, les ressources biologiques, les indicateurs socio-économiques, etc. Parallèlement, une base de données est créée, elle permet de suivre l'évolution temporelle des paramètres physiques, chimiques et biologiques de la zone étudiée.

3- Etude de scénarios d'aménagement de ces ressources par réglementation des activités anthropiques et limitation des sources de nuisance, ce qui permettra de prendre des mesures de protection et de conservation dont l'efficacité sera suivie dans le temps à l'aide d'un Système d'Information Géographique (SIG). A la lumière des résultats de cette étude et en tenant compte des espèces à protéger et des zones qui nécessitent des actions de conservation et de protection, des sites préférentiels pour l'implantation des récifs artificiels sont définis. Cet aménagement doit tenir compte des points suivants :

- Le choix d'**emplacement des sites d'implantation des récifs artificiels** se base sur la présence d'espèces à protéger. La sélection des espèces rares ou menacées de disparition est réalisée en se basant sur la « liste de références des types d'habitats pour la sélection des sites à inclure dans les inventaires nationaux de sites naturels d'intérêt pour la conservation », tel que signalé lors de la 4ème réunion des points focaux nationaux pour les Aires Spécialement Protégées (Tunis, 12-14 avril 1999) et validé par la réunion des points focaux nationaux du Plan d'Action pour la Méditerranée (Athènes, 6-9 septembre 1999).
- Les **espèces** à protéger dans chaque zone sont **signalées**. Ces zones, grâce à leur "effet réserve", contribueront au repeuplement en poissons et autres espèces marines des zones voisines ouvertes à la pêche.
- Le choix des sites d'emplacement des récifs artificiels tient compte des **contraintes (hydrologiques, géomorphologiques, sédimentologiques, etc.)** de la zone en question. Ces récifs artificiels sont préconisés pour augmenter la production d'une zone donnée (récifs d'enrichissement) ou pour la soustraire de l'action illicite de chalutage (récifs anti-chalutages). Pour plusieurs raisons, les structures récifales doivent être construites en béton. Leurs formes, dimensions et dispositions doivent être bien étudiées.

5. 1. Golfe de Gabès

Dans le golfe de Gabès, la production de la pêche a nettement régressé ces dernières années, le stock des produits marins à intérêt commercial a été affecté, comme celui des poissons démersaux (rouget, pagre, etc.). Un autre phénomène écologiquement important affecte les eaux tunisiennes, il s'agit de l'entrée des espèces invasives dont certaines déséquilibrent le milieu et peuvent affecter des communautés natives, tels la caulerpe *Caulerpa taxifolia* qui supplante la posidonie *Posidonia oceanica* et la crevette lessepsienne *Trachypenaeus curvirostris* qui remplace la crevette royale *Penaeus kerathurus* (Bradai, 2000).

Il ressort du rapport cité en référence (Anonyme, 2001) que certains stocks et plusieurs espèces sont menacées dans le golfe de Gabès. Si certaines de ces espèces ont un intérêt commercial, comme la crevette royale ou les poissons démersaux, d'autres ont une grande importance écologique dans le maintient de la stabilité de l'écosystème, comme la posidonie. La conservation de tout le patrimoine biologique du golfe de Gabès est donc nécessaire.

Le moyen de protection contre le braconnage des chalutiers, préconisé dans cette étude est l'implantation dans certains sites du golfe de Gabès de récifs artificiels. Il consiste à installer sur le fond marin des éléments en béton. Deux objectifs sont attendus de l'implantation de ces récifs artificiels :

- Réduire la mortalité par pêche des espèces commerciales à protéger et les stades larvaires de certaines autres espèces à intérêt commercial en empêchant les pêcheurs d'opérer dans ces zones à cause des risques de déchirures des filets de pêche par les récifs artificiels.
- Protéger les couverts végétaux et les peuplements benthiques associés contre les actions anthropiques (chalutages) abusives. Ces peuplements ont une grande importance écologique puisqu'ils représentent des maillons indissociables des écosystèmes (chaîne trophique).

En Tunisie, un projet pilote d'installation de récifs artificiels a déjà été réalisé en 1992 (Ben Mustapha, 1995). Douze modules de récifs anti-chalutages ont été immergés le long de la côte ouest de Djerba (Sidi Jamour), très affectée par le chalutage illégal. L'étude de suivi, réalisée cinq ans plus tard, a montré une bonne reconstitution des communautés benthiques dans la zone d'influence des récifs et un meilleur rendement de la pêche, par rapport aux zones chalutées. Du point de vue du rendement de la pêche artisanale, la zone de récifs artificiels était comparable à l'herbier de Posidonie.

Vu la nature des données disponibles dans la bibliographie (absence de données géoréférencées) et le peu de travaux effectués sur le golfe de Gabès, il est très difficile de lister pour chaque site retenu pour l'implantation des récifs artificiels toutes les espèces à protéger. D'autre part, la plupart des espèces signalées dans le golfe de Gabès effectuent de grands déplacements. Ceci nous incite à porter le choix des sites sur les autres critères, notamment le couvert végétal et la nature du sédiment, etc. Le choix est porté sur un site (site I) pour les aires à protéger et deux sites (II et III) pour l'implantation des récifs artificiels :

Site I (10-20m) **– Sud Kerkennah** (figure 4) : Il s'étend du large de la bouée n° 8 (34° 25' N, 10° 58' W) à la bouée n° 4 (34° 52' N, 11° 50' W).
Présence d'herbier de posidonie menacés par les activités de chalutage ainsi que des espèces animales à protéger. Cette zone est large et est normalement interdite au chalutage, mais des traits de chalut ont été constatés. Ce qui fait qu'il est souhaitable de classer cette zone en zone marine protégée.

Site II – Borj Djilidj (ouest Djerba) (figure 5)
Dans cette zone (33 ° 50' N ; 10 ° 40' W) peu profonde (5-12m), il y a des herbiers de posidonie en bon état qu'il faut protéger. Ceci est certainement dû à l'action pilote de 1993 (installation de récifs artificiels). L'élargissement de la zone des récifs vers le nord contribuera au renforcement de la protection de cette zone et des espèces qu'elle héberge. Il s'agit donc d'appuyer et renforcer l'action pilote de 1993.

Site III – Ras Taguerness (est Djerba) (figure 6)
Le choix de cette zone (33 ° 50' N ; 11 ° 10' W) a pour objectif de sauvegarder l'herbier de posidonie et le coralligène du détritique côtier environnant (20-30m), surtout qu'il existe dans cette zone des stades juvéniles des espèces commerciales. Cette zone constitue donc une nurserie qu'il faut absolument protéger.

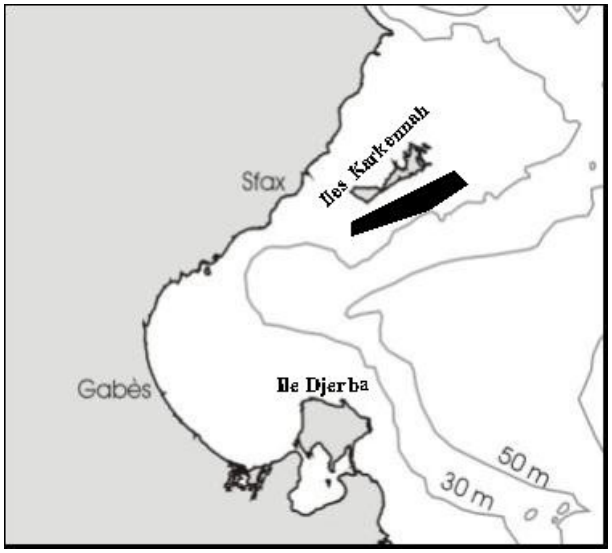


Figure 4. Golfe de Gabès, Site I : Sud Kerkernnah

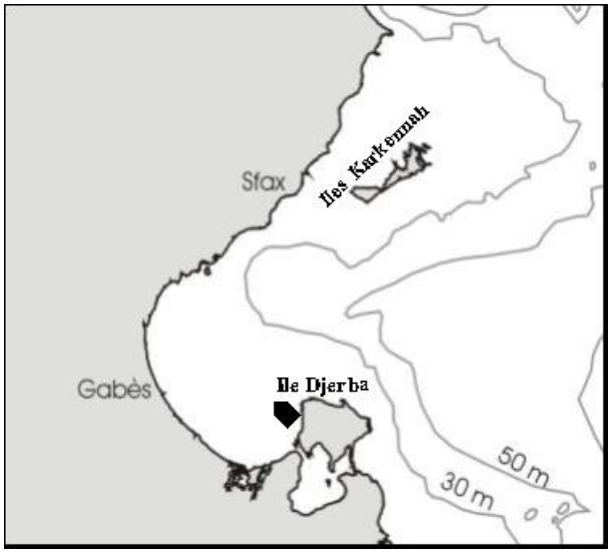


Figure 5. Golfe de Gabès, Site II : Borj Djilidj

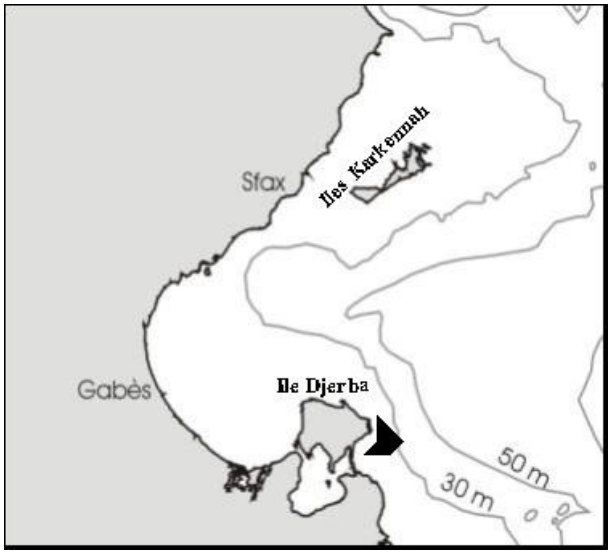


Figure 6. Golfe de Gabès, Site III : Ras Taguerness

5. 2. Golfe de Tunis

Pour le golfe de Tunis, nous récapitulons l'état des connaissances sur les plans dynamique, biologique, sédimentologique et faunistique, en insistant sur les peuplements benthiques importants. Nous mettons également l'accent sur les paramètres prépondérants dans le choix d'un site susceptible d'accueillir des récifs artificiels ou d'être classé aire marine protégée.

Même si la synthèse bibliographique a mis en évidence le manque de données notamment dynamiques et biologiques au niveau du golfe de Tunis, quelques sites nous ont paru répondre à quelques-uns des critères qui les rendraient susceptibles d'être classés en aires marines

protégées ou encore de recevoir des récifs artificiels.**Site I – Axe Cap Carthage - Cap Farina** (figure 7)

Les données dont nous disposons sur cette région mettent en évidence une forte abondance d'œufs. Il y a donc lieu de penser qu'il s'agit d'une aire de ponte. Cependant, ces données concernent plus le poisson pélagique, donc non grégaire, pour lequel la concentration est saisonnière. Il nous semble donc prématuré de proposer cette aire pour y implanter des récifs artificiels, même si des mesures de gestion préventives méritent d'être prises et l'interdiction pendant une période de tout type de pêche paraît comme étant une solution adaptée.

L'installation de récifs artificiels dans cette région est d'autant plus compliquée que la nature des sédiments (à majorité vaseuse car se trouvant à proximité de l'embouchure de l'Oued Medjerda) rend très difficile la conception technique de ces récifs.

Ainsi, une étude spécifique conformément à la méthodologie décrite ci-dessous, est fortement recommandée pour mieux conforter nos propos.

Site II – Polygone Cap Zebib – Cani - Cap Farina (figure 8)
Ce polygone se prête bien à une aire marine protégée. En effet, L'herbier y descend jusqu'à -42 mètres ; ceci le place parmi les plus profonds de la Méditerranée, où des herbiers dépassant l'isobathe -40 mètres sont très rares (cas de Zakynthos en Grèce). C'est un herbier qui est en très bon état (type II à III : nombre de faisceaux/m² compris entre 300 et 700), très dense (type 3 : de 75 à 100% de couverture horizontale). Il s'étend sur une grande superficie (presque sans discontinuité à part la passe 45-65m entre Cani et le continent) qui pourrait être l'une des plus importantes du littoral tunisien. Il est important de noter que la superficie de cet herbier dépasserait celle de l'axe Kélibia – Mâamoura (97km²). En plus, cette zone dispose d'un coralligène excellent qu'il faudrait préserver.

Site III – Site Ras Fartas, Ras Lahmar, Cap Bon (figure 9)
L'herbier entre Ras Fartas et Ras Lahmar est un bel herbier qui s'étend jusqu'à la profondeur de -27 m, sur fonds détritiques et rocheux que nous proposons comme aire marine protégée (sans nécessité de récifs) en y autorisant une activité humaine non destructrice. Par ailleurs, cette aire protégée doit s'étendre jusqu'au Cap Bon, étant donné le riche coralligène qui caractérise cette zone. Un gorgonaire extrêmement rare a été signalé en face de Sidi Daoud. Toute cette aire serait contiguë à l'aire marine protégée de Zembra et Zembretta et contribuerait ainsi à renforcer sa protection puisqu'il s'agirait de créer une aire tampon. Dans cette aire l'activité humaine (pêche) serait tolérée (Thonnaire, Pêche au palangre, pêche aux filets trémails, pêche sportive) mais doit être réglementée et contrôlée. Il serait intéressant de mettre aussi des bouées d'amarrage pour éviter la prolifération de la caulerpe *Caulerpa racemosa*, déjà signalée dans cette zone.

Ainsi, l'aire Zembra – Zembretta continuerait à bénéficier d'une protection qui apparaît aujourd'hui indispensable (Ben Mustapha et *al*., 2002b). Un tel scénario permettrait à la Tunisie de répondre aux critères de l'UNESCO en ce qui concerne le programme MAB (Réserves de la biosphère); Puisque les réserves de la biosphère comprises dans ce programme (comme c'est le cas de Zembra) doivent justifier d'un minimum d'activités humaines.

Site I V– Récif barrière de Sidi Rais (figure 10)
Il s'agit d'un récif barrière, considéré comme un patrimoine naturel et dont la protection s'avère plus que nécessaire de nos jours. Par ailleurs, ce récif constitue un héritage naturel

qui attire beaucoup d'intérêt, et nombreux sont les experts méditerranéens qui ont appelé à sa protection. L'installation de bouées d'amarrage à proximité paraît comme l'une des solutions envisageables dans des délais raisonnables en raison de sa fréquentation croissante par les plaisanciers.

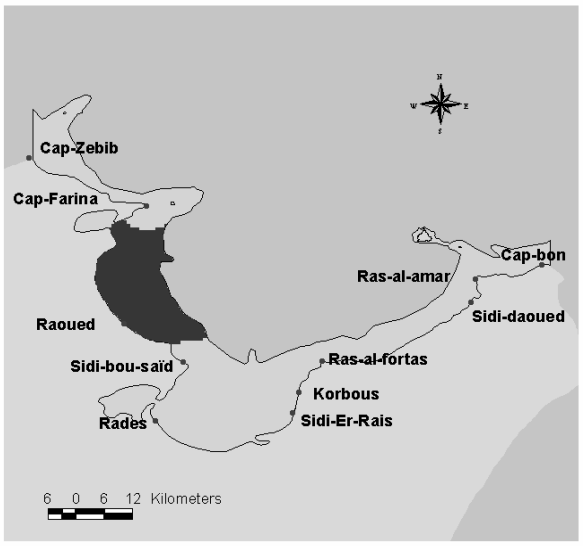


Figure 7. Golfe de Tunis, Site I : Axe Cap Carthage – Cap Farina

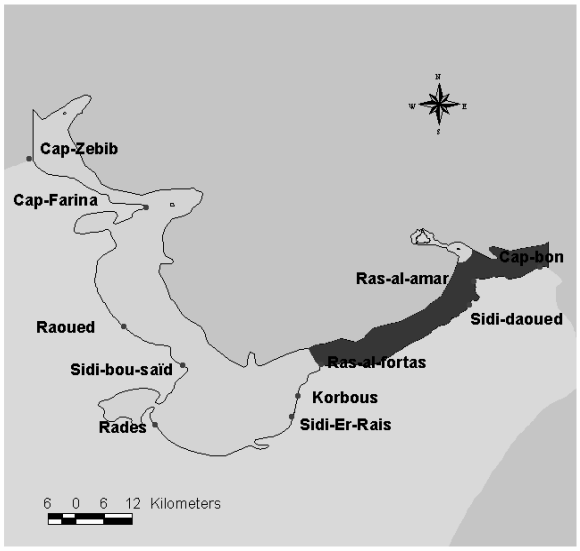


Figure 9. Golfe de Tunis, Site III : Site Ras Fartas, Ras Lahmar, Cap Bon

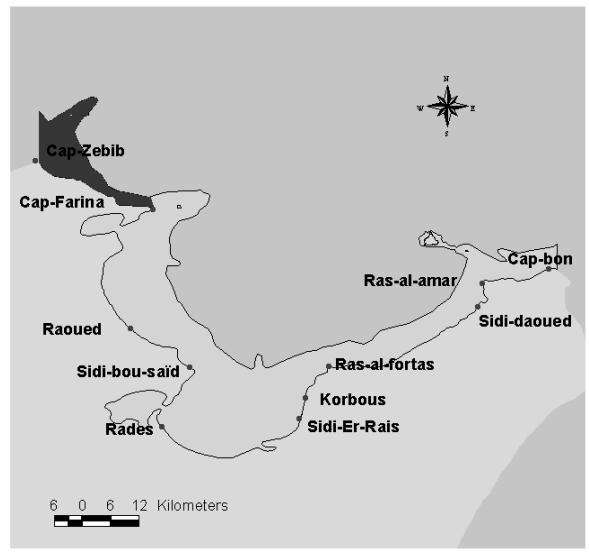


Figure 8. Golfe de Tunis, Site II : Polygone Cap Zebib – Cani - Cap Farina

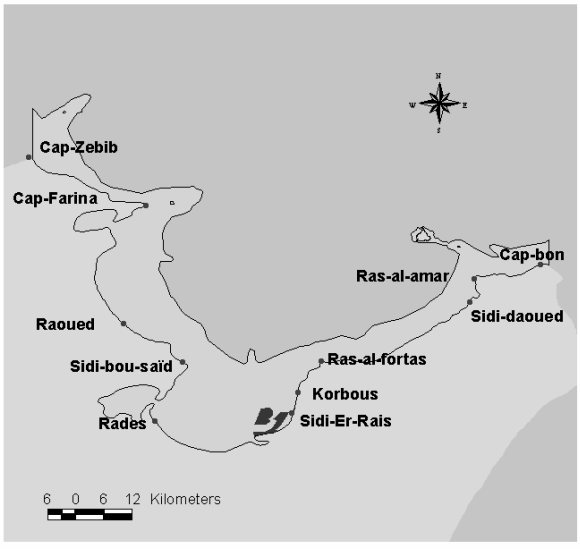


Figure 10. Golfe de Tunis, Site IV : Récif barrière de Sidi Rais

5. 3 . Golfe de Hammamet

Le manque de travaux complets se pose plus pour le golfe de Hammamet. A titre d'exemple, nous pouvons disposer de l'information relative à la distribution générale de l'herbier de Posidonie dans cette zone, sans toutefois avoir des données détaillées sur sa phénologie dans des régions particulières ; comme c'est le cas aux bancs Korba et Mâamoura, de même que

nous savons où se trouve le coralligène dans ce golfe mais nous avons actuellement des problèmes pour quantifier cet habitat et le qualifier de manière satisfaisante.

Pourtant, bien que l'information compilée dans le présent travail ne peut pas être considérée comme étant exhaustive pour permettre un choix rigoureux de sites potentiels, il n'en demeure pas moins qu'elle présente l'avantage d'une part de nous orienter vers la possibilité d'un classement satisfaisant, et d'autre part de nous indiquer les thèmes de recherches futurs sur lesquels l'effort devrait être axé en vue d'obtenir l'information complémentaire.

5.3.1. Proposition de sites potentiels pour une protection future

Le golfe de Hammamet est caractérisé par l'existence d'un courant relativement fort et permanent, auquel s'ajouteraient les courants littoraux ainsi qu'un signal de marée qui est certes assez faible mais conjugué aux courants générés par le vent, peut contribuer à une dynamique relativement intense. En période estivale, les eaux du golfe seraient régénérées par la veine d'origine atlantique, alors qu'en période hivernale, on signale l'existence d'un brassage vertical de ces eaux.

Sa géomorphologie est caractérisée par une prédominance de substrats meubles ; bien que le substrat rocheux soit présent notamment dans la région nord du golfe, entre Korba et le cap Bon ainsi qu'aux prolongements des saillies (Caps).

Dans la zone comprise entre 0 et 50 m, le substrat meuble est surtout marqué par la présence des sables. Néanmoins, ce substrat est aussi souvent composé par :

- des débris coquilliers
- des éléments grossiers (cas de Mâamoura) à assez grossiers (Kélibia ; Mâamoura et Hergla)
- des d'algues calcaires concrétionnées (limite profonde de l'herbier, coralligène au large du littoral Mâamoura – Kélibia – Cap Bon, ainsi qu'au nord de l'île Kuriat)

La présence de ces éléments indique l'existence d'un fort courant de fond, dont les ripple-marks hauts de 30 à 35 cm (Kélibia, Kerkouène, Mâamoura, Kuriat) constituent une preuve visible qui vient conforter les constatations du paragraphe précédent.

L'herbier de posidonie Comparativement aux autres régions géographiques de la Tunisie, la posidonie se développe assez bien dans le golfe de Hammamet, exception faite de la partie centrale du golfe. La posidonie couvre des superficies importantes au nord du golfe (Mâamoura – bancs Korba et Mâamoura - Kélibia – Cap Bon) ainsi qu'au sud (Sousse, Monastir, Kuriat) et s'étend presque sans interruptions importantes, vers le platier des îles Kerkennah.

Dans la région comprise entre Mâamoura et Kélibia, l'estimation de l'aire couverte fait état de 97 km², dont 77,5% des herbiers observés de type 3, c'est à dire une posidonie dont le recouvrement dépasse 90% et qui pousse à partir de rhizomes orthotropes sur des mattes bien formées. Par ailleurs et comme cela a été vérifié par plusieurs observations, cet herbier s'étend sans discontinuité importante jusqu'au port de pêche de Haouaria, c'est à dire sur prés de 20 km de linéaire au nord du Ras Mostpha (nord de la zone d'étude). Sa limite profonde, qui peut varier entre 23 et 35 m de profondeur, cède la place à un beau coralligène installé sur

sédiment meuble. La présence d'un coralligène de plateau riche et diversifié (Bancs de Mammoura et de Korba) n'est pas chose rare.

Plus au sud, l'herbier dont l'étendue peut être considérée comme exceptionnelle (Sousse, Monastir, Kuriat et le platier de Kerkennah) est confronté à plusieurs pressions, dont celle (potentielle) de la présence de *Caulerpa taxifolia* sur des étendues relativement importantes dans le polygone SousseMonastirKuriat.

Le coralligène : Cette biocénose, dont l'étude approfondie devrait figurer parmi les priorités de la recherche traitant de la biodiversité marine en Tunisie, reste quelque peu méconnue. Pourtant sa présence, non seulement au delà de la limite profonde de l'herbier, c'est à dire au-delà de 30 m (herbier de Mâamoura –Kélibia – Cap Bon ; Bancs Mâamoura Korba ; Nord Kuriat) mais aussi sur détritique côtier (Nord Kuriat) ou sur fonds rocheux (Kélibia) constitue autant d'indices de la richesse de la diversité écologique et biologique de ces régions.

L'Activité de pêche : D'après les données relatives à l'activité de pêche nous pouvons constater que la pêche dans cette région est essentiellement caractérisée (notamment en termes de valeur de la production, du nombre d'unités et de population maritime), par la pêche côtière, y compris la pêche au feu, dont les unités concentrent leurs actions soit sur les bancs, sur la zone de l'herbier et ses régions côtières avoisinantes et dans certains cas sur les endroits où le coralligène de plateau est bien dense.

La pêche côtière dans le golfe de Hammamet est pratiquée dans les zones littorales situées en deçà de l'isobathe – 50 m en général, là où la création d'aires marines protégés (notamment dans la région Sousse Monastir où le rendement de cette pêche est relativement faible) assurerait une protection des juvéniles de poissons.

De plus, les données de chalutage expérimental, permettent de conclure que la région considérée dans cette étude constitue une zone de frai pour la majorité des espèces de poissons benthiques et pélagiques, et que sa frange littorale est une nurserie pour les juvéniles de poissons. Par ailleurs Gharbi et Zarrad (2002 b) constatent que *« les résultats d'évaluation des principales espèces benthiques dans la région Est montrent que les chalutiers agissent principalement sur les juvéniles et en partie sur les adultes, alors que le profil d'exploitation des engins de pêches côtiers est orienté vers les individus matures ayant pondu au moins une fois dans leur vie* ». Ceci revient à dire qu'il y a intérêt à conserver les aires de pêches de la flottille de pêche côtière étant donné que son exploitation du milieu marin est mieux orientée que celle de la pêche au chalut dans cette zone ; en outre les auteurs appellent à la non utilisation de chalut crevettiers sur les régions d'herbiers.

Par ailleurs, les juvéniles des petits pélagiques se concentrent essentiellement dans les zones des bancs de Korba et Mâamoura ; étant donné l'importance socio-économique de cette activité dans cette région, il conviendrait de retenir ces zones lors du choix d'aires marines protégées.

5.3.2. Choix des sites

D'après ce qui précède et qui récapitule succinctement l'intérêt de certaines zones de la région du golfe de Hammamet pour une protection appropriée, nous proposons les sites

suivants comme étant susceptibles d'être classés Aires marines protégées et/ou d'accueillir des récifs artificiels:

Site I – Herbier de posidonie de Kélibia - Mâamoura, y compris le récif barrière de Kélibia (Figure 11)

Objectifs:

- Préserver cet excellent herbier qui se continue au nord sur un linéaire de près de 20 km
- Préserver le coralligène qui se développe à sa limite,
- Favoriser la pratique de pêche côtière responsable.
- Protéger le monument naturel qu'est le récif barrière
- Préserver la lagune de Korba

Site II – Les bancs de Mâamoura et de Korba (Figure 12)

Objectifs:

- Préserver la frayère de petits pélagiques,
- Protéger l'herbier et le coralligène bien constitués,
- Favoriser la pêche côtière surtout si l'interdiction d'actions de chalutages y est renforcée, notamment par la pose de récifs de protection.

Site III – Le polygone Sousse –Monastir – Kuriat (Figure 13)

Objectifs:

- Préserver son herbier,
- Suivre et « cantonner » autant que possible l'expansion de *Caulerpa prolifera*,
- Promouvoir la reprise de la pêche côtière dans cette zone
- Tenir compte de la fréquentation du site par la tortue *Caretta caretta* qui pond aux îles Kuriat.

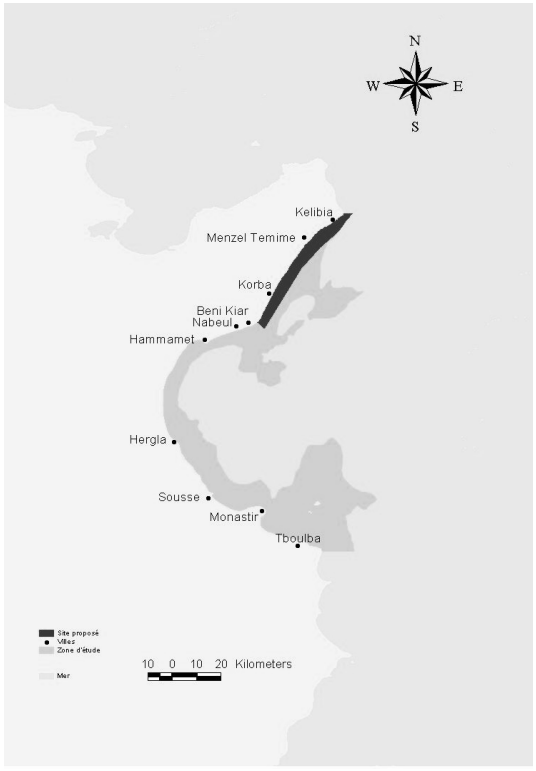


Figure 11. Golfe de Hammamet, Site I : Herbier de Kélibia-Mâamoura

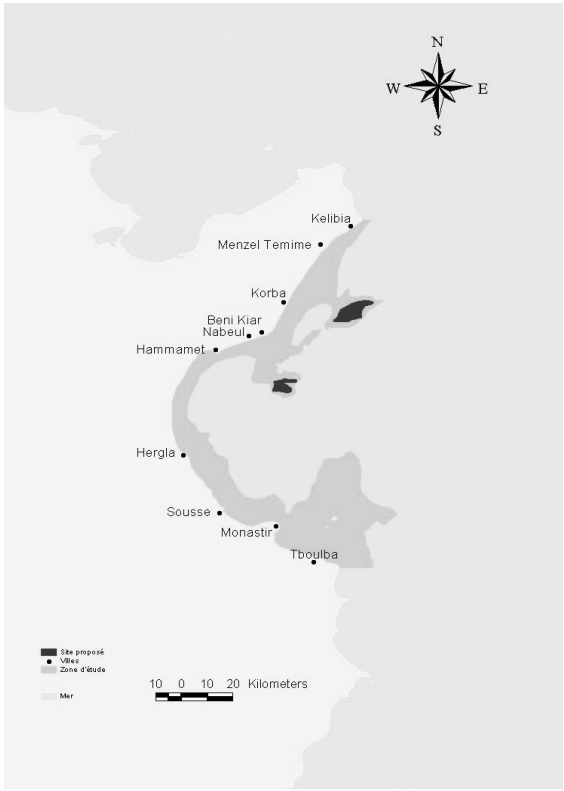


Figure 12. Golfe de Hammamet, Site II : Les bancs de Mâamoura et de Korba

Figure 13. Golfe de Hammamet, Site III : Le polygone Sousse – Monastir - Kuriat

6. Conclusion

Il est certain que l'écosystème marin a été affecté ces dernières décennies par une population mondiale grandissante et ce qu'elle engendre comme épuisement de la richesse naturelle, le plus souvent en employant des techniques destructives. Les changements climatiques et l'industrialisation amplifient, eux aussi, la dégradation de ces écosystèmes. Devant cette problématique, il apparaît que le seul moyen pour espérer préserver les écosystèmes, ou plutôt certains d'entre eux, est l'instauration d'aires protégées qui représentent un espace sauvage où seule la loi de la nature peut contrôler la vie marine. Ces zones préservent les espèces rares ou menacées de disparition et représentent aussi un réservoir qui permettra d'enrichir la mer en espèces animales et végétales.

Bien que le présent travail soit le résultat de la compilation d'une grande masse de données, diverses et complémentaires à la fois, il est certain que beaucoup de critères reconnus à l'échelle mondiale pour classer les aires nécessitant une protection ne peuvent pas être intégralement appliqués dans les zones étudiées. Néanmoins, à la lumière des données disponibles dans la littérature, il a été possible de dégager des zones plus fragilisées que d'autres à cause des activités anthropiques nuisibles, comme le chalutage et l'industrie polluante.

Si cette étude a permis de proposer la classification de certaines zones comme des aires nécessitant une protection, le choix du type de celles-ci (aire marine protégée, réserve, parc national, interdiction du chalutage, etc.) est réservé aux décideurs qui tiennent compte, entre autre, des facteurs socio-économiques. Dans notre étude, le recours aux récifs artificiels permet d'empêcher le braconnage par les chalutiers et aussi de fournir à certaines populations animales et végétales un refuge dans les formes variées et poreuses des récifs. A cet égard, il faut que les récifs soient bien étudiés sur le plan de la forme, des dimensions, des matériaux utilisés, etc. En effet pour que les récifs artificiels permettent de créer un nouvel habitat hétérogène, plus productif donnant naissance à une biomasse riche et diversifiée, leur architecture doit être réfléchie de manière à s'adapter au mieux à la faune et à la flore que l'on espère développer. A titre d'exemple, au Japon, des productivités spécifiques (par unité de volume immergé) d'environ 9 à 20 kg/m3/an ont pu être observées, ce qui constitue des résultats supérieurs aux valeurs observées dans la nature. Ceci peut être expliqué justement par la différence d'architecture. Les récifs artificiels ne peuvent rivaliser en taille avec leurs homologues naturels, mais comportent plus de vides et de caches que ces derniers etaccueillent une plus grande densité d'organismes marins.

7. Bibliographie

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Mapping natural and man-induced untrawlable grounds (no-take zones, NTZs) in view of managing the fisheries of the Strait of Sicily.

S. Ragonese*, G. B. Giusto, M. L. Bianchini and G. Morizzo

Abstract

Fishery reserves or no-take zones (NTZ), defined as limited areas in which fishing is temporarily or permanently restricted, are generally considered a suitable tool for fisheries management. Experimental bottom trawl surveys are a source of information to identify unsuitable bottoms, both natural (cliffs, rocky outcrops, boulders and coralligenous habitats) or man-induced (shipwrecks, "mazzare", etc.), which make fishing dangerous for the gear. This note presents, for the first time, a map of rough, hard-to-trawl or untrawlable patches, based on the occurrence of not-valid hauls (interrupted before scheduled time or with evidence of gear malfunctioning) over almost 20 years of surveying in the Sicilian Strait. This knowledge may be useful in assessing the quantitative importance of such refuges in the resilience of the resources to fishery, and to help establish regulated NTZs.

1. Introduction

Although the concept of "Marine Protected Area" (MPA) encompasses a wide range of definitions and applications, fishery reserves or no-take zones (NTZs) are usually distinguished from MPAs; the latter should be more oriented towards enhancement of the marine environment and conservation of biodiversity (Anon., 1999), whereas the former are generally designed within fishery scenarios (Horwood, 2000).

In fact, NTZs, herein defined as limited areas in which fishing is temporarily or permanently restricted, have been generally considered as a suitable mean of fisheries management, although their success depends on the specific context of application (Horwood, 2000).

The growing specific literature (e.g.: García Charton and Pérez Ruzafa, 1999; Horwood, 2000) has demonstrated the need for a proper spatial and dynamic evaluation before setting up NTZs. Both empirical and model-based assessments are difficult to deal with (Horwood, 2000); however, in data-limited situations, such as most Mediterranean fisheries, Setting up NTZs should be considered a feasible management tool in view of a precautionary approach to fisheries (Lindeboom, 2000).

A NTZ-based trawling ban may be of great relevance not only for the protection of nursery areas, but also because they represent a refuge (Agardy, 1997) for highly vulnerable, low mobility and seriously depleted species (such as rays or rockfishes; Ragonese *et al.*, 2003a, b).

Whatever the principle adopted in setting up NTZs, long-time monitoring is required to assess their effectiveness. Experimental bottom trawl surveys, like those which have been more or less regularly conducted in the Italian seas (Bertrand and Relini, 2000), might represent a good opportunity to monitor NTZs, without further costs. As a matter of fact, experimental

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tows are shorter than commercial ones and can be carried out also on hard-to-trawl bottoms. At the same time, these surveys represent a source of information for identifying “rough” bottoms, both natural (rocky outcrops and coralligenous habitats) or man-induced, such as shipwrecks or “mazzare” (stone blocks) fields (Bianchini and Ragonese, 1999).

Many bottom areas in the Sicilian Strait present “tormented” morphological features, i.e. steep declivities, vertical cliffs, narrow canyons, huge boulders and other geological accidents, which make the grounds difficult or impossible to trawl.

In the Sicilian Strait, the hard bottoms of the bathyal layer are characterized (Arena, 1985) by huge “buildings” produced by madrepores (*Madrepora oculata*, *Lophelia prolifera*) and barnacles (“denti di cane”, *Balanus* sp.), generally forming scattered clumps, that produce the "white coral assemblages" biocenosis (Pérès and Picard, 1964), locally known as “cannelleri”: they present strong, stony corms that form extended surfaces dangerous for the gear, or even absolutely untrawlable between 250 m and 500 m depth. Another yellow coral, *Dendrophyllia cornigera*, less hard but still representing an obstacle for fishing activity, lives at higher depths, colonizing rocky substrates exposed to hydrodynamism, while the former coelenterates prefer finer sediments.

Shipwrecks or other steel debris also prevent trawling and therefore represent another important cause of the bottoms'unvulnerability to trawls. The former, moreover, can be considered as important artificial refuges for many fish species (García Charton and Pérez Ruzafa, 2002; Tunesi and Diviacco, 2002). Work is in progress at IRMA (Ragonese *et al*., in prep) to collect and map all available information on ship sinking in the Sicilian Strait; to date, data on more than 400 wrecks have been retrieved both from published (for an *ad hoc* publication, cfr. Semeraro, 2001) and unpublished (mainly fishermen's logs, also reporting over 1,000 additional fishing obstacles) sources.

A fourth important category of man-induced fishing obstacles is the presence of fields of large stone blocks (called “mazzare”), used as anchors for fish aggregating devices (FADs) and left behind after each fishing season; the fishery that creates the "mazzare" fields is most typical of the eastern Sicilian Strait. Incidentally, even the deepest fishing grounds in the Sicilian Strait are littered with anthropic wastes, as shown by the small percentage of the hauls that are "clean" (11%) or "almost clean" (25%) (Bianchini and Ragonese, 1999).

The aim of the present note is to present, for the first time, a map of the untrawlable bottoms, drawn on the basis of the not-valid hauls recorded over almost 20 years of scientific trawl surveying.

2. Materials

The results of 26 seasonal surveys, carried out in the framework of the Grund (since 1985) and Medits programs (since 1994) by the Institute of Marine Resources (IRMA-CNR) in Mazara del Vallo, were examined.

All hauls of the data set are comparable between them, given that the same sampling unit, *i.e.* the commercial stern trawler “Sant'Anna” (198 GRT, 32.2 m long, 1,012 HP engine) with the same net (the “di fondale” trawl gear) and using standardized fishing procedures, has been consistently used in all the surveys.

Not-valid hauls interrupted before the scheduled time because of “grasping” obstacles (“afferrature”), or presenting once on deck extended net tearing and/or gear damages due to hard invertebrates and rock spikes, or impossible to finish because of too rocky or rough landscapes were selected and mapped, under the above categories.

3. Results and discussion

Summary results are reported in Table 1. Of more than 3,100 hauls made in 26 surveys, 7.4% were not-valid; of these, half were considered as "afferrature", one third as "gear damage" and the rest were due to rough bottom morphology.

Table 1. Not-valid hauls recorded during the Grund and Medits surveys carried out in the Sicilian Strait (1985-2002).

Reason for invalidation	Number of hauls
grasping ("afferratura")	113
net tearing and/or gear damage	77
unsuitable bottoms	36

The geographical localization of the not-valid hauls is presented in Fig. 1. The scarcity of points outside the Italian area may be ascribed to lesser coverage due to a limited sampling effort (only two surveys); matter-of-factly, the Italian bottoms were extensively covered with a random-stratified design, and the representation reflects the real "density" of invalidating occurrences. It is therefore evident that grasping events are concentrated in shallower areas, i.e. on the western banks, on the eastern platform and near the coast; on the contrary, net tearing and gear damages often occurred in deeper grounds, where the “white coral assemblages” are present.

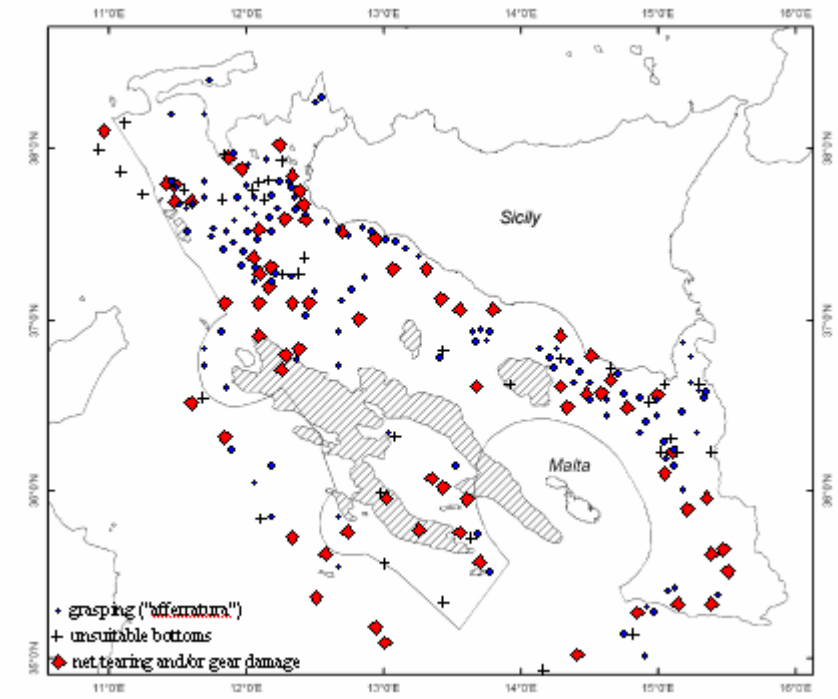

Figure 1. Not-valid hauls occurred during the Grund and Medits surveys carried out in the Sicilian Strait (1985-2002). (dots: grasping; diamonds: gear damage; crosses: rough morphology)

4. Conclusion

"There are undoubtedly many potential benefits that might be derived from the creation of protected areas in the marine environment. Nature conservation calls for them, scientific research desperately needs them and even fisheries might benefit from them" (page 299, in Lindeboom, 2000).

The facts presented in this paper may be useful for assessing the quantitative importance of such refuges in the resilience of the resources to trawl fishery. In fact, even a qualitative analysis of the species (and size) composition in the catch of not-valid hauls may show significant differences *vs*. the catch from neighboring grounds; unfortunately, the catch in not-valid hauls has been irregularly or seldom recorded until recently. In the future, this oversight will be corrected, and detailed information will be recorded to allow some sort of comparison (not-valid hauls are *per se* not strictly comparable with valid hauls) between assemblages.

Finally, the presence of already untrawlable patches should make establishing regulated protected areas around them more acceptable for trawl fishermen, who use the most impacting gear, while a limited and sustainable use may still be allowed to other forms of exploitation (Agardy, 1997).

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Marine Protected Areas as a Mediterranean fisheries management tool[1]

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Let us look to the long-term, and use this present generation of marine reserves to gain the knowledge we will need as we seek to make our fisheries sustainable and manage our coastal environments (Rowley, 1994).

Abstract

As a consequence of the high variety of the bio-ecological and socio-economic factors that are intrinsic to fishery, the traditional management methods of the fisheries (minimum size, effort and catch limitations, closed seasons…) that often do not give the results required for a sustainable fishery and the preservation of marine biodiversity, marine protected areas (MPAs) have been suggested as a complementary management tool in the preservation of the marine living resources and biodiversity. In multi-specific fisheries, as the Mediterranean bottom fisheries, where the existence of numerous species prevents managers from applying single-species stock assessment techniques, MPAs may be only the available tool. By the other hand, MPAs, as an ecosystem management strategy, should aim at contributing to the maintenance of biodiversity, ecological processes, and sustainable resource usage. The adequate (*ad hoc*) planning, design, management and long term perspective represent important items for the MPA success, taking into account the collaboration of the fishery community.

1. Introduction

Although there are signs of overexploitation in most of the world's fisheries (Ludwig *et al*., 1993; Goñi, 1998; Agardy, 2000), we still have to formally address the effects of fishing on entire ecosystems. Dependence on accurate estimates of single-species stocks, as well as on efficient control of effort and catch, raises serious concerns about the efficacy of current fisheries management strategies in ensuring sustainable fisheries (Ludwig *et al*., 1993; Bohnsack & Ault, 1996; Roberts, 1997; Sumaila *et al*., 2000). In addition, reducing the effective fishing effort is almost impossible to achieve in the face of gear efficiency through technological improvements. Focusing on only one stock at a time, we fail to realise the significance of serial depletion of individual stocks and fishing grounds, as illustrated by fisheries in all parts of the world (Dugan & Davis, 1993; Lindholm *et al.,* 2001).

On the other hand, fishing down an ecosystem renders the latter vulnerable to random processes (Lauck *et al*., 1998), and fishing may even eliminate trophic groups or keystone species and result in a complete change to the overall community structure (Botsford *et al*., 1997; Hall, 1999).

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Moreover, as a consequence of the high variety of the bio-ecological and socio-economic factors that are intrinsic to a fishery, traditional methods of managing fisheries (minimum size, effort and catch limitations, closed seasons…) often do not give the results required for a sustainable fishery and the preservation of marine biodiversity (Bohnsack & Ault, 1996; Roberts, 1997). Marine Protected Areas (MPAs) have been suggested as complementary management tools for the preservation of the marine living resources and biodiversity (Plan Development Team, 1990; Ballantine, 1991; Bohnsack, 1996; Agardy, 2000). In multi-specific fisheries, like Mediterranean bottom fisheries, where the existence of numerous species prevents managers from applying single-species stock assessment techniques, MPAs may be the only available tool (Roberts & Polunin, 1993; Badalamenti *et al*., 2000). By the other hand, MPAs, as an ecosystem management strategy, should aim at contributing to the maintenance of biodiversity, ecological processes, and sustainable use of resources (Ballantine, 1991; Bohnsack & Ault, 1996; Sumaila *et al.,* 2000).

Interest in fishery reserves, marine harvest refugia, and MPAs as fishery management tools has grown quickly over the last decade. Most of the early experiments have been characterised by: i) initial resistance by fishers who were excluded from traditional fishing areas; ii) significant, and often dramatic, increases in numbers and size of fish or other harvested resources within refugia; iii) often anecdotal increases in harvests outside refugia; iv) poor documentation of baselines and changes in biological assemblages and fishery catches.

Despite this lack of documentation, results have been perceived as sufficiently positive to result in (Hourigan, 1998): i) local community support for refugia; ii) inclusion of refuges in fishery 'best practices' (e.g. FAO Code of Conduct for Responsible Fisheries), especially for new or still-developing fisheries and artisanal fisheries; and iii) the beginning of a much more ambitious dialogue about the next generation of MPAs. Furthermore, the UNCLOS (United Nations Convention on the Law of the Sea) has proposed the adoption of emerging concepts that would enforce the legal regime of the oceans (Bliss, 2003): the integrated management of oceans, the ecosystem-based approach, and marine protected areas.

2. Marine Protected Areas: Justification and needs

The global biodiversity conservation movement has accelerated interest in marine protected areas and harvest refuges (Norse, 1993). This stems from the view that such areas are the fishery management tool most likely to conserve biological communities and their processes in addition to target fishery species (Hourigan, 1998). The Conference of Parties to the Convention on Biological Diversity specifically identified the need for Parties to establish MPAs, and in May 1998, urged both Parties and the Secretariat of the Convention to facilitate research and monitoring activities related to the value and the effects of marine and coastal protected areas or similarly restricted management areas (as no-take harvest refuges) on the sustainable use of marine and coastal living resources. This issue will form part of the Convention's program of work on marine and coastal biodiversity. It is reflected in several IUCN resolutions and the conclusions of the International Group of Experts on Marine and Coastal Protected Areas (1995). The First Symposium on Marine Conservation Biology issued this call: *'Increase the number and effectiveness of marine protected areas so that 20% of Exclusive Economic Zones and High Seas are protected from threats by the year 2020'* (Hourigan, 1998).

One of these important recommendations is: *'to ensure a sustainable exploitation of the species and the ecosystems'*. In this sense, the FAO Code of Conduct for Responsible Fisheries in Article 6.8 requires that the States provide adequate protection for critical fisheries habitats so as to ensure the health and viability of the fishery resources, through the establishment of MPAs (Hourigan, 1998). In this regard, COPEMED (Co-operation across Mediterranean Fisheries Project of the FAO) aims to foster fisheries co-ordination and information exchange among Mediterranean countries and highlight the importance of local support for the preservation of nature. In accordance with these principles, COPEMED organizes activities related to the conservation and protection of living marine resources (research, training) to maintain the small-scale fisheries, and to promote the fishermen participation in MPA management.

Some problems are generated by the confluence of various uses on the same area. This leads to a variety of conflicts, for example:

- i) Small-scale fisheries *vs.* industrial fishing (trawling, purse seine): loss of the nursery areas caused by non selective methods (juvenile fishing); sea bed degradation; loss of artisanal gear (trammel nets, long-lines)
- ii) Sports fishing *vs.* small-scale fishing: spearfishing (impact on large hermaphrodite individuals); illegal use of professional methods (nets, long-lines) by sports fishermen
- iii) Leisure and tourism *vs.* small-scale fisheries: Loss of nursery areas (e.g. seagrass meadow destruction) by beach replenishment, harbour sediment extraction and dumping, and mooring of boats
- iv) Exploitation vs. conservation: e.g. fishermen and conservationists.

These conflicts are more pronounced in the Mediterranean, where tourism and fisheries are developed almost everywhere. To avoid these conflicts, MPAs represent one of the most important tools for preserving marine biodiversity and ensuring sustainable development of marine resources. In those areas, it is possible to reconcile protection of marine life with rational use of marine resources (selective fishing, ecotourism). The approach combining nature conservation and sustainable exploitation has been supported by several international programs and forums (like Man and Biosphere Program, UNESCO, 1976; World Conservation Union, 1978; Bali Declaration, 1982; Rio Summit 1992; Barcelona Convention, 1995). Some basic recommendations have been proposed: i) to preserve the biodiversity and the most essential ecological processes; ii) to protect environmental quality and to prevent any danger to the biological equilibrium of the marine and coastal communities; iii) to ensure sustainable exploitation of species and ecosystems; and, iv) to keep pristine areas for research, training and educational purposes.

Among the objectives and needs of the MPAs figure, apart from the conservation and social needs, and from the fisheries point of view (modified from Kingsford & Battershill, 1998):

- Reservoir for commercial and non-commercial species
- Refuge for different life history stages (e.g. juveniles, change of sex) and for fishes of highest fecundity (e.g. large individuals)
- Protect a portion of spawning stock
- Conserve genetic diversity of populations (especially with respect to max. size)
- Recover size-class structure of the exploited species

- Increase in abundance, size and age of vulnerable species
- Recovery of depleted stocks (fishes, invertebrates)
- Enhanced fishing in adjacent grounds by restocking (biomass exportation)
- Protect spawning/mating and nursery areas of commercial species
- Increase yield per recruit (when nursery grounds are protected)
- Increase reproductive output (larval supply) and recruitment to external areas
- Protect migration stop over points and bottlenecks
- Reduce conflicts between user groups on areas of coast (artisanal vs. trawl fishing, sports vs. professional fishing…).

3. Fisheries angle

The establishment of an MPA supposes, up to a point, a return to an initial situation of the fishery where the exploitation has only affected some parts of the target population distribution. So, the non-exploited or inaccessible sites should be *de facto* restocking areas (Boudouresque, 1990). On the other hand, the MPAs represent measures focused to the uncertainty of the fisheries management and the variable conditions of the marine ecosystems, and to try to mitigate possible mistakes in the fisheries management or environmental imbalances and marine production (Dayton *et al.*, 2000).

a) Single species

From the single-species point of view, a MPA is expected to help control fishing mortality and, by so doing, restore, at least partially, pre-industrial exploitation patterns, when less efficient fishing techniques and lower boat power prevented the exploitation of portions of the fishing grounds (Boudouresque, 1990). An increase in the mean body size, density and biomass of various species, and especially those targeted by the fishery, has been reported in several reserves (Roberts & Polunin, 1991,1993; Dugan & Davies, 1993; Jones *et al.*1993; Rowley, 1994). As a result, reproduction potential would increase within and perhaps outside the reserve.

Although MPAs have not been shown to swell the fish population in the unprotected parts of the habitat, in some cases they sustain yield by adult migration into the neighbouring fishing grounds (Ramos *et al.*, 1992; Bohnsack, 1996; Russ & Alcala, 1996). Closed areas used as part of fisheries management regimes (for single species or gear) have produced positive results for several species (Davis & Dodrill, 1989; Pipitone *et al.*, 1996).

b) Reduce fishery mortality and by-catch

An important aspect of the MPA's potential benefits is the fishing mortality decrease for a target population part in a certain area (e.g. recover of the demographic structure; increase of the spawning biomass). Moreover, the MPAs present other positive effects, prohibiting the trawling, and/or reducing the conflicts between fishers (Bohnsack & Ault, 1996). For example, the trawls and dredges may modify or destroy the habitat, reduce seabed complexity and remove macrobenthic organisms that provide shelter and food for target species (Hutchings, 1990; Jones, 1992). From a formal point of view, the MPAs are of different kinds, created for biodiversity preservation (nature reserves and parks) or to manage fisheries (closed areas, 'no-take zones', harvesting refuges, fisheries reserves…). However, in spite of the

primary objectives (biodiversity, fisheries), the management of MPAs should be convergent and share, in the same time, the conservation and exploitation objectives, directed to the sustainable use of resources.

MPAs may also be a suitable tool for reducing bycatch, when critical habitats of the species or age group at risk are protected. Such reserves would be more efficient than size limits, as well as easier to regulate and enforce than single-species oriented regulations.

c) Habitat protection

The observed effects of fishing on benthic-community structure underline the importance of creating permanent reserves. By eliminating fishing by trawling gears, bottom complexity as well as benthos and fish species composition is likely to change from disturbed to mature ecosystems (see references in Hutchings, 1990; Jones, 1992; Hall, 1999; Lindholm *et al*., 2001). Evidence that closed areas may result in community structure modification has been found in *Posidonia* meadows (Ramos-Esplá *et al*., 1997) and maërl beds (Bordehore *et al*., 2003). However, because of some epibenthic species (like *Posidonia* and maërl rhodoliths) are slow-growing and long-lived (up to 100 years), rebuilding the habitat structure may be a long process.

4. Types and figures of MPAs

There is no standard model of marine protection; most of the existing models have been taken from regulations based on protected land areas. It is necessary to know what is the main aim at establishing each MPA (species and/or community protection?, to promote fishing development?, educational or cultural purposes?…) and what means and infrastructure are available to attain the objectives of each area. MPAs have been established under different legislation and with diverse objectives/criteria:

- 1) A variety of nomenclature has been used, and established under different national and regional legislation (fisheries, hunting, environment…): fishery preserved zone, prolongation of terrestrial parks, hunting refuges, marine reserves, marine-terrestrial parks.
- 2) Objectives are diverse:
    - Restricting fishery activity (number of boats, methods, periods, species)
    - Marine protection of terrestrial parks (marine buffer zone)
    - Preservation of the flag species (sanctuaries for monk seal, marine turtles, cetaceans)
    - Restocking areas (marine reserves, ‘cantonnements de pêche’, ‘aree di tutela biologica’)
    - Preservation of the marine and/or terrestrial coastal environment (e.g. National Parks, natural marine reserves)

5. Legal aspects

For the conservation and management of the Mediterranean fisheries through MPAs in the COPEMED countries (Algeria, France, Italy, Libya, Malta, Morocco, Spain and Tunisia), the States have promulgated specific legislation (Cacaud, 2000) and there are some regional organizations which coordinate the management and conservation of the living resources in the Mediterranean Sea.

a) State level

All the countries in the COPEMED zone have adopted a legal framework to minimize the impact of fishing activities on the living resources (Cacaud, 2000). These management measures mainly concern the fishing effort (fishing gear and methods, licensing of fishing activities, time and area restrictions, mesh size), prohibition methods and minimum fish size. Besides, with regard to MPAs, all of them contemplate in their environmental legislation extended protection inside the territorial waters. Nevertheless, only some of them (e.g: France, Italy, Malta, Spain) have legislated fisheries MPAs.

b) Regional cooperation

Under the UNCLOS, the Mediterranean Sea falls in the category of enclosed or semi-enclosed seas without economic exclusive zone (EEZ). In this case, the UNCLOS requires that States bordering this sea cooperate directly or through an appropriate regional organisation to: 'coordinate the management, conservation, exploration and exploitation of the living resources of the sea' (article 123).

At present, three regional organisations dealing with the conservation of the living marine resources in the Mediterranean have been established: FAO General Fisheries Commission for the Mediterranean (GFCM), the International Commission for the Conservation of Atlantic Tuna (ICCAT), and the Mediterranean Action Plan of the United Nations Environment Programme, with its Regional Activity Centre for Specially Protected Areas (RAC/SPA). The first two organisations (GFCM and ICCAT) dealing with fisheries issues, and the third one (RAC/SPA) dealing with Special Protected Areas of Mediterranean Interest (SPAMI) and Biological Diversity (Barcelona Convention, 1995).

6. Design

Costs associated with any management strategy can be magnified by poor design and inadequate or inaccurate evaluation. The reserves may contribute to, but may not be sufficient protection for, some marine resources (Allison *et al*., 1998). Because of reserves have argued mainly to strengthen rather than replace other management strategies (Carr & Reed, 1993; Roberts, 1997; Allison *et al.,* 1998), the cost of implementing reserves may detract from the efforts and finances required for other strategies (e.g. enforcement). The main problems are:

- Poorly designed fishery reserves could provide minimal benefits while giving a false sense of security to managers and fishers (Carr & Raimondi, 1998). In this case, the reserves could be used to justify relaxed restrictions in the remaining fishing grounds and exploited populations could be subjected to a combination of concentrated effort and less restrictive regulations

- Like poor design, improper evaluation could jeopardise the future of a reserve program. Well designed reserves may be highly effective at sustaining and enhancing fisheries, but flawed methods of evaluation can fail to demonstrate their positive effects. Again, it may be difficult to justify the future of a reserve program because of a lack of demonstrable benefit

The effectiveness of any MPA depends on its location, size and shape in relation to the life history characteristics and habitat requirements of the species to be protected (Rowley, 1994). The great differences between terrestrial and marine systems require that care should be taken in applying to marine reserves conclusions based on terrestrial systems. However, many useful ideas have been generated which are applicable to marine reserves.

a) Location

Poor results have been shown when the protected area is located in unfavourable habitats, or is not protecting a sufficient portion of critical habitats (Armstrong *et al*., 1993; Tegner & Dayton, 2000). To prevent this situation and to enhance local fishing, a MPA should (Rowley, 1994): i) be within reach of fisheries; ii) include relevant recruitment and nursery habitats, or be close enough to receive recruits from separate nursery grounds (which may require protection as well); iii) have juveniles in many size/age classes which tend to indicate a recent history of consistent recruitment; iv) be subject to long-term regional control to protect the reserve, its nursery areas, and the routes of migration from nursery to reserve; and v) for species reluctant to disperse across 'foreign' habitats, a reserve should be located within a larger patch of similar habitat such that the reserve perimeters have high 'permeability'.

b) Size

Lacking a conservation objective to start with, scientists have tried to devise a minimum proportion of the habitat that should be protected. Based on the minimum spawning biomass that should be preserved in exploited stocks, the Plan Development Team (1990) suggested that 20% of the total habitat should be protected. The appropriate proportion, although unknown, is likely to be larger. Modelling based on species with different life histories suggests that a large proportion of the local habitat (up to 50%) should be included in reserves to efficiently protect both the habitat and the animals contained therein from the negative impacts of exploiting the resources. Based on observed dispersion rates for commercial North Sea fish stocks, Daan (1993) showed that if a contiguous area of 25% was closed, the reduction in mortality would only be in the order of 12%.

Both larval dispersal and adult migration patterns (Table 1) are important for determining the location, size and number of reserves necessary to protect a particular species (Allison *et al*., 1998). A high rate of adult migration out of the reserve is likely to decrease the efficiency of the reserve since a large proportion of individuals would still be vulnerable to exploitation (Sumaila *et al*., 2000). In consequence, the need for knowledge of the home range and migration patterns becomes crucial (Bennett & Attwood, 1991; Zeller, 1997)

Table 1. Relationship between spatial scale of the attached or site-dependent phases of the adult and the embryonic stage with regard to minimum size of MPAs (modified from Kenchington, 1990).

Type	Adult phase	Embryonic phase and/or juvenile	Examples	MPA size (ha)
A	fixed or territorial	direct development	Syngnathidae	<1000
B	fixed or site dependent	planktonic larvae	Serranidae, lobsters	10^3-10^4
C	adult territory ± diffused (demersal or pelagic spp.)	direct development (egg-laying zones)	Cephalopoda	10^3-10^4
D	adult territory ± diffused (gregarious demersal spp.)	planktonic larvae	Merluccidae, Mullidae	10^4-10^5
E	large adult territory (gregarious pelagic spp.)	nursery and/or spawning areas	Thunnidae	10^5-10^6
F	large adult territory (solitary pelagic spp)	planktonic larvae or direct development	Xiphiidae, pelagic sharks	> 10^6

From a pragmatic point of view, Tisdell and Broadus (1989) consider a minimum area of 1000 ha (see paragraph 6. e) Socio-economic factors), mainly for enforcement reasons. Figure 1 shows the percentage of MPAs (Nº= 60 at 2003) in the COPEMED countries with regards to the protected area.

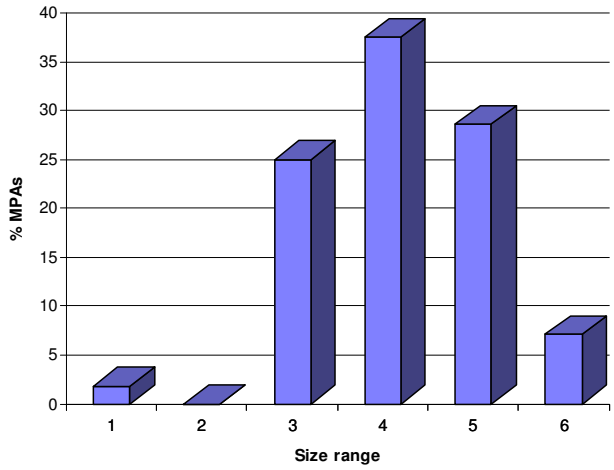

Figure 1. Percentage of the MPAs (Nº = 60) in the COPEMED region (Algeria, France, Italy, Libya, Malta, Morocco, Spain, Tunisia) related to the protected surface area (in ha). Surface ranges: (1) ≥ 10^6 ha; (2) 10^6 - 10^5 ha; (3) 10^5 - 10^4 ha; (4) 10^4 - 10^3 ha; (5) 10^3 - 10^2 ha; (6) < 100 ha.

c) Reserve shape

- Perimeter/area ratio: This could influence the movement of animals across reserve borders. For two reserves of equal area that are equivalent in terms of habitat, productivity and other factors, we can expect more spillover from the reserve with the longer border. In terms of spillover supporting local fishing, however, we must remember that a long perimeter also spreads any potential increase in catch due to the reserve across a larger area and so decreases the likelihood of increases being substantial or easily caught (Rowley, 1994).
- Variety of habitats: Increased habitat diversity within a reserve will both increase the diversity of species protected, and be more likely to protect both adult populations and

the nursery habitats required by some species. Many important fishery species require specific habitats or substrates for larval settlement and/or juvenile 'nursery grounds' e.g.: seagrasses are required as settlement and juvenile habitat for Labridae, Sparidae and Scorpaenidae (Jiménez *et al.,* 1996); maërl bottoms as recruitment grounds for *Pecten* and *Octopus* (BIOMAERL team, 2003); spiny lobsters (*Palunirus argus*) recruit into specific juvenile or nursery habitats, and successful recruitment of stocks may be limited by the availability of such habitats (Davis & Dodrill, 1989).

- 'Corridors': The permeability of a reserve edge may be increased by placing reserves within large patches of similar habitats or within a habitat strip (such as rocky shore lines, hard bottoms, seagrass meadows, maërl beds). These habitats could act as 'corridors' that 'spill' the individuals into local fisheries. Alternatively, spillover may be limited from reserves that protect disjoint patches of habitat separated from similar habitats by expanses of 'foreign' habitat or deep water.

Protection of species with separate juvenile and adult habitats may require that both habitats are included within one reserve, or that there is protection of separate nursery and adult reserves and the dispersal corridors between them (Rowley, 1994).

d) SLOSS debate

'Single large or several small reserves of similar total area' (SLOSS debate). A single reserve could be self-replenishing and therefore potentially self-sustaining only if it is sufficiently large to encompass the range of dispersal of many larvae produced by its local populations.. But it seems unlikely that any single reserve will be of sufficient spatial extent to be largely self-sustaining (because of the long planktonic duration and tremendous dispersal potential of many exploited species: e.g. 1-2 months)

Therefore, a collection or network of reserves seems necessary in order to ensure that reserve populations are both self-replenishing and self-sustaining. The spatial design (distribution and number) of a network should aim for a high likelihood of connectivity (via larval dispersal) among reserves, while replenishing exploited populations outside the reserves (Carr & Raimondi, 1998). Several authors (Ballantine, 1991; Carr & Reed, 1993; Roberts, 1997) have pointed the advantages of a network of reserves, each lying within the 'replenishment area' of the others, so that larvae produced within one reserve are likely to recruit to other reserves. This design allows local extinctions within a reserve to be replenished from distant reserves and buffers the entire system against the effects of local recruitment failure.

Compared with one single large reserve, a network of small ones would provide greater protection against environmental variations and local catastrophes (Ballantine, 1991; Carr & Reed, 1993; Rowley, 1994). Multiple reserves would also allow the replication of study sites needed to provide scientifically conclusive answers to many of the questions about reserve function (Ballantine, 1991).

From a practical point of view, a system or a network of small MPAs is sometimes the only possible choice along an urbanised coastline where the marine environment is exposed to a multitude of uses. In this context, Francour *et al.* (2001) stated that the establishment of several small MPAs rather than a few of larger size in Mediterranean countries is the result of independent local decisions rather than instructions in national management plans. Siting and size of MPAs are generally chosen more for human reasons than for ones of ecology, e.g.: i)

maintenance of traditional small-scale fisheries, or ii) marine leisure activities, potential conflicts, effective surveillance.

e) Socio-economic factors

Apart from resource conservation and food supply, ecosystem management goals include wealth and the maintenance of viable fishing communities. The long-term effects of fishing on the economic and social well-being of fishing communities may be positive if the interaction between the community and the fish is such that the ecological base of the resources remains intact through time. However, economic factors are generally not taken into account in the planning of MPAs (Tisdell & Broadus, 1989), probably because MPAs are usually created either in anticipation of biological and ecological benefits or in response to public pressure, in particular from conservationist groups.

The economic justification for establishing MPAs usually takes two broad forms (Sumaila *et al.,* 2000): i) it is argued that economic benefits may follow the establishment in the form of creating employment through non-consumptive activities such as tourism and recreation; ii) it is expected that MPAs may protect future jobs by increasing the chances of managing stock sustainability.

7. Management and Zoning

Generally, conflicting interests, such as those between conservation and exploitation, represent a major issue in resource-allocation exercises. There are many different approaches to marine protected area planning, management and zoning. The choice of approach should be influenced by the prevailing resources as well as the environmental, social, political and economic parameters (Salm & Dobbin, 1993). Thus, we should consider in MPAs (Figure 2):

- the ecological component: linked environments and component species (scientific support)
- the socio-economic component: pressures on the ecological component from human activities and needs (socioeconomic support)
- the political component: the political, administrative and institutional influences and constraints (legal support).

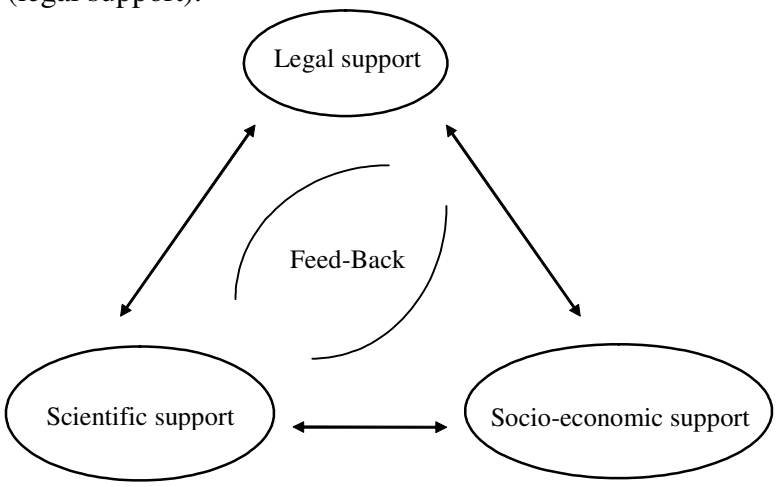

Figure 2. Three main components in the establishment of MPAs.

To avoid as far as possible human impacts, it is necessary to consider the zoning of the MPA planning. Moreover, the zoning may resolve some conflicts between users of the coastal zone (selective/non selective fishing methods, professional/sports fishing, Scuba diving/spear-fishing). The principle objectives of zoning reflect the objectives for the management of the MPA and are usually (Kelleher & Kenchington, 1992; Laffoley, 1995):

- To provide protection for critical or representative habitats, ecosystems and ecological processes
- To preserve some areas of the MPA in their natural state undisturbed by humans except for the purposes of scientific research or education
- To separate conflicting human activities
- To protect the natural and/or cultural qualities of the MPA whilst allowing a spectrum of reasonable human uses
- Traditional users of the managed area should be consulted and involved in the development and implementation of management plans
- To reserve suitable areas for particular human uses, whilst minimising the effects of those uses on the MPA.

An MPA refers to a management area in which use is regulated by zoning for different activities. It includes marine reserves, which are strictly no-take areas. In this sense, the philosophy and zoning (Figure 3) of the Biosphere Reserves (Man and Biosphere Program, UNESCO, 1976) may be useful for integrating the conservation and exploitation in MPAs, according to three basic functions of the Biosphere Reserves:

- ***Conservation function***: preservation of the different levels of biological biodiversity (genetic, taxonomic, habitats, ecosystems)
- ***Logistic function***: focused to research and monitoring from inside and outside the MPAs, as well as supplying services for education and information
- ***Development function***: to allow traditional uses (artisanal fishing) and low impact activities ('soft-tourism') that sustain a rational and continuous exploitation of natural resources and cooperation with local populations.

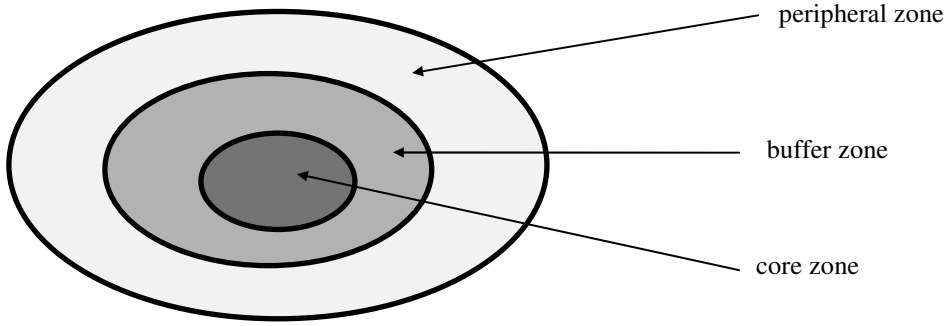

Figure 3: Zoning in the Biosphere Reserves (MaB, UNESCO, 1976): core zone or integral reserve (≥10% of the protected area); buffer zone or protection of the core zone; peripheral or multi-use zone, development area.

The table 2 shows the zoning of the Marine Reserve of the Tabarca Island in these three areas, with integral protection (core area), and fisheries and tourism uses (buffer and peripheral areas).

Table 2. Zoning of the Marine Reserve of Tabarca 1400 ha in Alicante, Spain): (I) core zone (integral reserve: 100 ha); (II) buffer zone (core zone protection: 630 ha); (III) peripheral zone (multi-use zone: 670 ha); (a,b) sub-zones. Spear fishing prohibited (Ramos-Esplá, 1990)

USES	**I**	**IIa**	**IIb**	**IIIa**	**IIIb**
Conservation	♦	♦	♦	♦	♦
Scientific research (monitoring, evaluation)	♦	♦	♦	♦	♦
Trawl-line (professionals)	·	♦	·	·	♦
Hand-line (squids by professionals)	·	♦	·	·	♦
2 Large trap nets (amberjack, April-June) (professionals)	·	·	♦	·	·
10 Small trap nets (Atherinids, October-December) (professionals)	·	·	·	♦	♦
SCUBA diving (30 divers with permission)	·	♦	♦	♦	♦
Education (nature trips)	·	·	·	♦	♦
Snorkelling	·	·	·	♦	♦
Sun-bathing	·	·	·	♦	♦
Hand-line (amateurs)	·	·	·	·	♦
Anchoring (beach and harbour sectors)	·	·	·	·	♦
Glass-bottomed boat	·	·	·	·	♦

8. Involving the fishermen community

It is important that local communities participate in marine conservation and the rational management of marine resources. Socio-economic activities (like fisheries and tourism) must be compatible with the environment preservation, by establishing limits to the development. Trying a balanced tourism development generates benefits to the local population, by creating new professional activities (sea-watching, Scuba-diving, bottom-glass boats, guides, guardians), where the fishermen participate. The general principles to apply to community involvement are(Wells & White, 1995):

- i) the concept of a new protected area should be introduced very carefully to the community
- ii) the benefits of protected areas must be made clear to the people and their needs should be addressed
- iii) in many cases, the appointment of a community worker, trained in both resource management and community skills, may be enormously beneficial and sometimes essential
- iv) the establishment of a committee to oversee the development and management of the protected area; and
- v) where possible, the community should be responsible for enforcement, allowing traditional disincentives and peer pressure to operate
- vi) a protected area needs to be managed in such a way that its future survival is guaranteed beyond the early stages, when community support may mainly reflect the novelty value of the project.

It has been widely recognised that public participation and local community involvement is an essential factor that contributes to the success of a MPA (Fiske, 1992; Wells & White, 1995). In the absence of strong community support, the integrity of MPAs relies more heavily on efficient enforcement, which is costly and not easily achieved.

However, co-management and community involvement require a great deal of commitment and energy from all parties. Fishermen must be involved early in the decision-making process to ensure support and ultimately to reap the expected benefits (Alder *et al*., 1994), because they possess detailed knowledge of their fishing grounds, which is essential for the design of efficient reserves (Neis, 1995).

9. Discussion

Considered the limitations in fully understanding the ecosystem, the precautionary approach could be attempted when creating a network of MPAs. MPAs can be used, in combination with other management measures, as part of an adaptive management scheme. Rather than solely controlling fishing mortality for targeted species, MPAs should be designed to allow permanent and/or temporal closures to cover critical habitats such as nurseries, spawning and feeding grounds or to protect stocks during crucial life-history events such as migrations and spawning aggregations. MPAs should be seen as tools for learning and experimentation with target and non-target species recovery and ecosystem management.

However, the reserves may be contributory, but not sufficient protection for some marine resources (Allison *et al*., 1998; Carr & Raimondi, 1998). Because reserves are designed to effectively augment rather than replace other management strategies (Carr & Reed, 1993); Roberts, 1997; Allison *et al*., 1998), the cost of implementing reserves may then detract from the effort and finances required of other strategies (e.g. enforcement).

Perhaps the most robust purpose of a MPA designed primarily as a fisheries management tool is to provide insurance against fishery management failures. Thus, fishery management protects fish projected to exist, based on uncertain data and models. Well-designed and managed marine reserves would protect real fish and real ecosystems even if fishery management completely fails, or results in fishing mortality that is greater than projected (Fujita, 1998).

Research should be directed towards the evaluation of existing MPAs to determine their success and potential benefits. Well-designed long-term monitoring programmes will be necessary to gather data about the processes of population and ecosystem rebuilding, to assess benefits, to increase knowledge of both fishers and scientists, and to improve the level of protection.

In conclusion, when properly established, MPAs offer a viable additional management tool to help stem the decline of fisheries at risk, rehabilitate those that have collapsed, and contribute to the sustainability of future fisheries. Not only MPAs can help to address the ecological problems of poorly managed fisheries, but they can also assist in improving the long-term socio-economic welfare of coastal communities that often rely on very resource they are depleting.

10. Recommendations

To attain the objectives for an adequate and effective protection, management and monitoring it is necessary to consider some recommendations (Ramos-Esplá & Mas, 1995; Francour *et al*., 2001):

a) Design: the importance of the initial choice

- Ecological parameters: i) apart from the living resources, it is necessary to consider the variety and complexity of habitats (e.g. seabed with heterogeneous topography, seagrass meadows) and availability of corridors; ii) the possibilities for recruitment of the biota (e.g. suitable nursery areas in the MPA or nearby, and a good influx of currents carrying fish larvae) are adequate (shape, perimeter, …)
- Site selection (ecological and socio-economic studies) with some preliminary studies on the living marine resources and habitats mapping of the possible protected area. The size (> 1000 has) and shape of the area could be a compromise between: habitats/species preservation, management objectives (protection, socio-economic and cultural components), and easy delimitation and enforcement
- In the case of the Mediterranean, several MPAs of relative limited size (1000-10000 has) may be preferable to the option of one single large protected area, as much for ecological reasons as socio-economic ones. The distance between these MPAs should be not more than 100 km.

b) Legislation

- The initial choice of legislation regulating the management of the future MPA is of prime importance. However, the creation and management of a protected area, generally depends on the use of various existing pieces of legislation, but to be effective this legislation must be able to be amended by additional arrangements without involving too complex a legislative procedure.
- To bear in mind: The greatest flexibility in the regulatory arrangements and a certain amount of decision-making autonomy for the managers is necessary and appropriate.

c) Management and zoning

- Realistic management planning and zoning, bearing in mind some areas with different protection levels, at least two zones: a core zone of integral protection(about 10-20% of the MPA); and a buffer zone to protect the core area with selective fishing methods (e.g. hand-lines, long-lines, trap-nets). The management plan should be flexible to allow later improvement as result of experience
- Integration and participation in the management committee of representatives from the local communities and socio-economic activities (fisheries, tourism)
- Effective enforcement by land and sea (rangers with a boat) and well-trained personnel
- Public and administrative awareness is very important for the acceptance of the marine protected area
- Suitable funding support is necessary for the scientific monitoring, infrastructure, maintenance, enforcement and educational activities that guarantee the long-term continuity of the MPA. It is important to consider possible self-funding sources (eco-taxes, visits, sea-watching…)

- Logistic parameter: related to the effectiveness of surveillance (the site chosen should be accessible throughout its extent from a terrestrial base).

As Fancour *et al.* (2001) state: '… the results of the past and present experiences indicate that the significance of management conflicts within any future MPA will be inversely proportional to the extent of preliminary consultations with all of the users (both professional and amateur) of the area to be protected'.

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Assessing the potential for using Marine Protected Areas as a tool for the environmental management of fisheries resources in Maltese waters

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Abstract

The intensity of activities in the coastal zone[2] of the Maltese Islands reflects the economic significance of this area. The interdependence between the ecological health of the marine environment and the economic activities that depend on marine resources highlights the need for effective management of marine areas. A management tool that may be used to promote the sustainable use of marine resources is the designation of Marine Protected Areas (MPAs).

The management objectives of MPAs should include the protection of natural resources, and the management of resource conflicts arising from the spatial proximity of activities that require (or affect) the coastal zone and contiguous marine areas. The above objectives are of relevance to the fisheries industry, since protection of fisheries resources requires the effective regulation of activities/developments that may affect fisheries, or the viability of fish stocks.

1. Introduction

The industries making intensive use of the marine environment and the contiguous terrestrial area around the Maltese Islands include the shipping and bunkering industry, ports facilities and the tourism industry. The demand for development in these areas, and the resulting environmental concerns are detailed in the Coastal Strategy Topic Paper (Planning Authority, 2001), and the State of the Environment Report for Malta (Axiak & Sammut, 2002).

Issues associated with the marine environment are complex, given the economic value of the various industrial activities, and the various environmental concerns. The value of maritime areas as economic resources depends upon the environment health of the marine ecosystems, of which fisheries stocks form an integral part.

The integration of fisheries management initiatives with other legitimate uses of the marine environment would facilitate the successful implementation of environment protection measures. Effective environmental protection must include the effective protection of fisheries stocks, consequently the protection of their value as an economic resource.

The Structure Plan for the Maltese Islands (Planning Services Division, 1990) recognised the need for regulation and coordination of activities and development in the coastal and marine areas, through the application of the principles of coastal zone management. The main objectives of this strategy include the management of activities and development in a way that promotes the mitigation of environmental impacts, and the protection of environmental resources.

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[1] The coastal zone includes both the marine environment, and the contiguous terrestrial area.

Given the above scenario, coastal zone management offers the possibility of achieving an equitable balance between the health of the marine environment, the interests of the fisheries sector, and the interests of other legitimate users of the marine environment. The potential of coastal zone management as a tool facilitating the conservation of fisheries resources (and marine areas in general) is recognised by the FAO Code of Conduct for Responsible Fisheries (1994).

Nevertheless, the designation of Marine Protected Areas (MPAs) is still required to allow management of sensitive areas that are of critical environmental and/or economic importance. It should be noted that the effective protection and management of the marine environment requires that the areas protected are of a size that is ecologically significant, and that the protected areas are significant from a biogeographic perspective (Kelleher *et al.*, 1995). Consequently, the effective protection of fisheries resources requires the establishment of a network of protected areas at both local and regional level.

2. MPAs in the Maltese archipelago

The accession of Malta to the European Union has involved the designation of a 25-mile fisheries conservation zone around the Maltese Islands. Such designation promotes the sustainable harvesting of fisheries resources, through the application of various fisheries management techniques that limit the fishing effort within Maltese waters.

No MPAs have been designated in the Maltese Islands as yet. Although the Structure Plan (Planning Services Division, 1990) lists thirteen candidate sites for designation as MPAs, the boundaries of these areas are not defined, and the list of sites is in the process of being reviewed (as is discussed below). The coordination of fisheries management techniques with area management initiatives would render the conservation of the natural environment (including fisheries resources) more effective.

The attempt to integrate fisheries management techniques within conservation areas has been limited to the prohibition of fishing activity within an area of one nautical mile radius around the islet of Filfla (Schembri, 1999). However, opposition to the designation of this area resulted in the resumption of fishing activities after a period of three years.

3. Management Strategies

Various definitions of MPAs have been proposed in the literature; definitions that are widely recognised are the categories of MPA proposed by the IUCN (1994). The objectives of the various categories range from strict conservation to the management of specific resources; a category of MPA that is of particular relevance to fisheries management is the Managed Resource Protected Area (MRPA).

Managed Resource Protection Areas (MRPAs) require the regulation of the exploitation of species present in a specific area, including fish stocks of commercial importance. Effective resource protection would also include protection of spawning areas and nursery areas; feeding grounds; habitats of importance to fish stocks; and species on which fish stocks are dependent. Management would be effected through fisheries management methods directed

towards limiting fishing effort. Another strategy is the No Take Zone (NTZ) as defined by the JNCC (2003), where fishing effort is restricted seasonally or permanently.

Regardless of the definitions that may be applied with respect to the form or function of MPAs, the formulation of a management strategy requires the collection and analysis of data regarding the natural environment; data on the various activities located within the coastal/marine zone is required to assess the human impact on the marine environment. Effective management of the resource also requires the identification of actual and potential threats.

The choice of management strategy should depend on the characteristics of the area requiring protection, and the specific objective of the MPA; the latter should consider the needs of all legitimate users of the area. The review of MPAs in the Maltese archipelago by Schembri (1999) is an indication of the potential for conflict between fisheries interests and conservation interests. Consequently, designation of MPAs must emphasise the fact that both 'interests' have a common goal: safeguarding the viability of fisheries stocks, and of the marine environment in general.

The above implies that MPA designation should apply the concept of multiple-use management in protected areas through the zoning of activities and the regulation of specific activities, e.g. anchoring, to control specific impacts. To achieve this objective, MPAs should involve:

- co-ordination of different activities and the promotion of conflict management;
- application of management measures over large areas;
- provision for a number of levels of access and of fishing in different zones;
- provision for the continued sustainable harvest of fish stocks; and
- minimisation of the possibility of concentrating fishing activities in particular locations, as may occur with NTZ.

To date, the lack of information with respect to coastal waters has hampered the effective formulation and implementation of policies with respect to marine areas and resources. Current priorities include the:

- identification of areas that are particularly sensitive and/or important (ecologically or economically) through benthic mapping etc.
- collection of data regarding marine activities, and activities in the contiguous coastal areas
- identification of actual/potential threats and impacts, and establishment and enforcement of environmental quality standards e.g. pollution control, environmental monitoring of development

The above process is currently underway, with substantial amounts of environmental data having been collected to allow prioritisation for area designation. Although a definitive management strategy has yet to be established, it is envisaged that effective use of MPAs will involve the establishment of a network of protected areas, where key sensitive sites will be strictly protected as NTZ, while wider scale protection will be given through designation of MRPAs. Regular review of the performance of the MPA network would be required, to allow refining of management measures according to the results obtained.

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Monitoring of *Caulerpa taxifolia* (Vahl) C. Agardh and *Caulerpa racemosa* (Forskaal) J. Agardh in Tunisia: Strategy and results

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Abstract

Accidentally introduced into the Mediterranean Sea in 1984, the tropical alga *Caulerpa taxifolia* has spread since then, reaching the Tunisian coast. Another variety of *Caulerpa racemosa* (*Caulerpa racemosa* var *occidentalis*) was discovered in Tunisia and qualified as invasive. The ecological and economic threats related to these invasions led us to adopt a strategy of monitoring our littoral. This paper describes this strategy and summarizes the ensuing results.

1. Introduction

Given the phenomenon of the introduction of exotic species into the Mediterranean, and following the coastal States' concerns about the recent accidental introduction of the green alga *Caulerpa taxifolia* (Vahl) C. Agardh in 1984 (Meinesz and Hess, 1991), the UNEP organized a workshop on the invasive *Caulerpa* species in the Mediterranean (UNEP, 1999). Among the conclusions on which all present agreed were:

- *Caulerpa taxifolia* is a tropical species, observed for the first time in the Mediterranean Sea in Monaco in 1984. Since then it has expanded, covering large areas of the Western Mediterranean and of the Adriatic coastal region. At the same time, another *Caulerpa* species, *C. racemosa* (Forskaal) J. Agardh, expanded in many parts of the Mediterranean.
- *Caulerpa taxifolia* has been studied extensively in the Mediterranean, as its impact on the marine ecosystem is well admitted. It colonizes all types of sea bottoms such as, rock, sand, mud and dead *Posidonia* meadows, and invades indigenous biocenoses, modifying the biodiversity and the ecodiversity.
- *Caulerpa racemosa* has not been studied intensively, like *C. taxifolia*, but it is becoming clear that it may present different morphological characteristics from one region to another, that it colonizes all types of substrata such as, rock, sand, mud and dead *Posidonia* meadows, down to 60 m depth and interferes with marine coastal biocenoses, and that its expansion, according to preliminary research, may alter marine habitats.

Taking into account the Protocol of the Barcelona Convention concerning Specially Protected Areas and Biological Diversity in the Mediterranean (1995), which states that the Parties shall take "all appropriate measures to regulate the intentional or accidental introduction of non-indigenous or genetically modified species ... and prohibit those that may have harmful impacts on the ecosystems or species" and endeavour "to implement all possible measures to eradicate species that have already been introduced when, after scientific assessment, it appears that such species cause or are likely to cause damage to ecosystems, habitats or species in the area to which this Protocol applies", it was recommended that all the

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Mediterranean countries, besides adopting the necessary measures for the application of the Convention on Biological Diversity adopted at Rio de Janeiro in 1992 and of the Protocol of the Barcelona Convention (1995), and prohibiting trade and use of *C. taxifolia* and *C. racemosa* and avoiding the sale and use of the *Caulerpa* genus for aquaria (with the exception of the Mediterranean species *Caulerpa prolifera*):

- Promote national and international coordination and cooperation of all the partners to prevent and slow down the spread of *C. taxifolia* and *C. racemosa* in the Mediterranean
- Support international programs for the exchange of information, training and scientific research
- Support the dissemination of information designed to encourage users of the sea to prevent the spread, and indicate the presence, of *C. taxifolia* and *C. racemosa* and
- Issue official instructions calling upon users of the sea to indicate the presence of *C. taxifolia* and *C. racemosa* to the designated bodies.

Similarly, it was recommended that all the countries in which one or both of the two *Caulerpa* are present

- Issue official instructions for all users of the sea to avoid practices contributing to the spread of these species, particularly through the cleaning of anchors, fishing gear and diving equipment on the spot. The release of fragments of these algae at sea must be avoided. Large colonized areas should be indicated in port offices and nautical instructions
- Establish inventories and carry out cartographic surveys of colonized areas and monitor the evolution of the biocenoses in these zones
- Support scientific research in all aspects relating to these species, the understanding of the phenomenon, the evolution of its consequences and the control of its dynamics
- Control, where possible, the expansion of the two species, particularly by eradicating small colonies in areas that are highly valued for their natural heritage and regions that are distant from strongly colonized areas.

The first step towards the implementation of an international strategy is thus to sensitize and inform scientists and the decision-makers in the various Mediterranean countries. The Heraklion workshop was, as such, decisive.

2. Strategy of monitoring and control of Tunisian coasts

Signatory to all the conventions related to marine biodiversity preservation, Tunisia has since 1997 adopted prevention measures and a strategy to monitor and control its coasts. Since then, this strategy has been revised and at present consists of:

a) Information and sensitization

The general public is often confused and bewildered by some sensational press articles and by certain declarations that have appeared in the various media. To cure this, a leaflet on *Caulerpa taxifolia*, answering in a simple and non-alarmist way to the questions put by the general public, was realized by scientists. In this leaflet, a drawing of the alga is given to facilitate its identification and modes of its dissemination are described. Up-to-date

knowledge on its environmental impact is summarized and action to undertake against a discovered colony described. Anyone recognizing or believing s/he recognizes the alga is invited to contact the organization monitoring the expansion of the alga along the Tunisian littoral (the National Institute of Marine Sciences and Technologies: INSTM), by phone (the phone number appears on the leaflet) or by returning a coupon attached to the leaflet and pre-addressed to the INSTM, after filling it with some basic information related to the observations (substrata, distance from the coast,etc.).

This leaflet was published in Arabic and in French, with 10,000 copies (5,000 for each language) in 1997 (Langar *et al*., 1998) and republished after revision with 5,000 copies in Arabic in 2000. It was widely distributed to all the users of the sea (divers, spear fishers, fishermen, sailors, bathers, harbour offices, etc.) and placed at the disposal of the public in the oceanographic museum and diving and fishing equipment stores.
To attract a wider public, parallel actions were carried out to help spread the information. Several conferences on *Caulerpa taxifolia* and *Caulerpa racemosa* were held in various ports and diving clubs. An Arabic translation of an IFREMER video film on *Caulerpa taxifolia* was made and broadcast to the general public at marine environment demonstration events. Several articles approved by scientists appeared in national newspapers and several interviews in relation to exotic algae were given to the national and regional radios.

b) Verification of information

All information that reaches us, either by telephone or by mail, is taken into account. In each case direct contact is made to verify some points permitting to guarantee that there is no confusion with another alga. If the verification reveals a mistaken identification of the alga, information is not taken into consideration. In the opposite case a diving visit is necessary to verify the information. Once the information validated, and if it is proved that the zone where the alga is present is relatively large, an underwater prospecting campaign is conducted in the area to map or to define the extent of the concerned area.

c) Centralization of the Information and decision-making

All information and data are centralized within the INSTM team in charge of the monitoring program for introduced algae in Tunisia. This team regularly gives an account of its activities and results to an interdepartmental national commission for introduced marine species that was created in 2000 under the presidency of the INSTM. This commission, judging facts presented by scientists, studies all possible proposed solutions, makes recommendations to the competent bodies and acts to justify for decision-makers the funding of research programs dedicated to the introduced species.

d) Publishing of scientific results

All research works leading to original results are published at national or international level, in scientific magazines and proceedings of symposia. The sensitisation and the vulgarization aspects were the subject of two publications in two proceedings of symposium (Langar *et al*., 1998; Djellouli *et al.,* 1999). Identification of sites, biogeography and mapping of *Caulerpa* produced 5 communications at various scientific meetings (Djellouli *et al.,* 1998; 1999; Djellouli, 2000; Langar *et al.,* 2001; Langar *et al.,* 2003) and two scientific publications (Langar *et al.,* 2000; Langar *et al.,* 2002). The growth dynamics of *Caulerpa taxifolia* and its impact on *Posidonia* meadows in the roadstead of Sousse were presented at Mediterranean level (Langar *et al.*, 2003) and the impact of *Caulerpa taxifolia* on fishing outputs and on the socio-economy are the main subject of a recent paper (Ben Salem and Gaamour, in this issue).

3. Results and discussion

Since the first sensitization campaign in 1997 (Langar *et al*., 1998), three sightings were verified in the field, one in the roadstead of Sousse in 2000 (Eastern coast of Tunisia) (Langar *et al*., 2000), and two others in the area of Cap Bon (North-East Tunisia) in 2001 and 2002. Underwater mapping performed in the roadstead of Sousse revealed an area of 350 ha where *Caulerpa taxifolia* was present (Langar *et al*., 2001). In the area of Cap Bon, sightings were made by nearly 40 m depth that did not permit us to achieve direct underwater mapping of the area. This is why a rough delimitation of the concerned zone was made with the help of fishermen interviews. The map produced (Fig. 1) revealed a vast zone where *Caulerpa taxifolia* was present, from Sidi Daoud to Ras Adar by -15 to -45 m, along 15 km of coast.

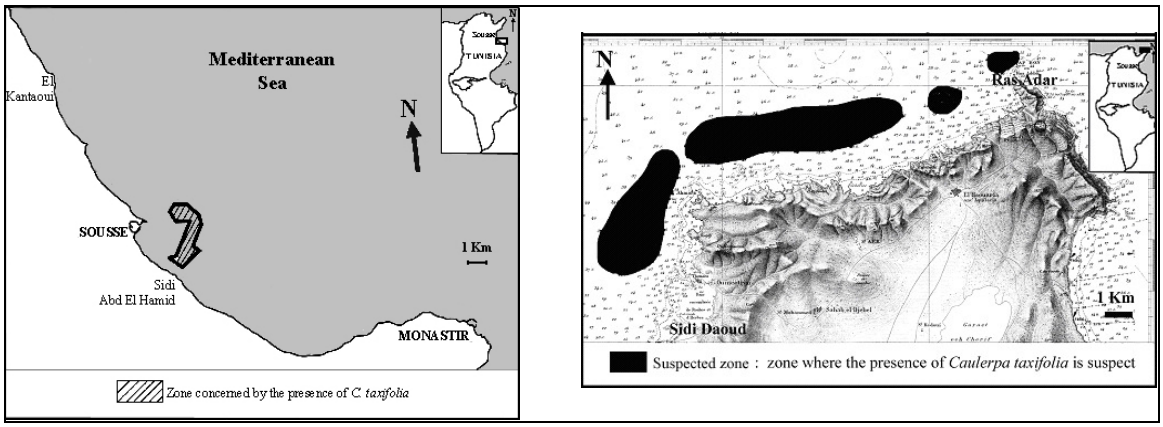

Figure 1: *Caulerpa Taxifolia* situation in the roadstead of Sousse (left) and in the Cap Bon area (right)

Caulerpa racemosa was identified along nearly the entire Tunisian coast, in 15 localities (Figure 2). Two varieties of *Caulerpa racemosa* were identified: the *uvifera* variety and the *occidentalis* one qualified as invasive.

In the light of this, the interdepartmental national commission in charge of the introduced marine species recommended applying the fishing and anchoring closure to the roadstead of Sousse, and worked to free a financing of 100,000 euros to acquire underwater prospecting equipment (ROV and accessories). Similarly, a research program has been financed; its main goals are to localize new sites contaminated by the introduced alga, to map them if possible, to follow the kinetics of *Caulerpa taxifolia* growth in Tunisian environmental conditions and

to study impacts of the introduced *Caulerpa* on biodiversity and more especially on the benthic macro flora, on fishing outputs and on the socio-economy. The more recent results are those concerning the impact of *Caulerpa taxifolia* on fishing outputs and on the socio-economy (Ben Salem and Gaamour, in this issue) and the kinetics of growth and the impact of *Caulerpa taxifolia* on *Posidonia* meadows in the conditions of the roadstead of Sousse. This later work showed that in conditions of the roadstead of Sousse, where the temperature falls rarely below 15 °C, the potentialities of growth of *C. taxifolia* does not seem different from those described in the conditions of the north-west Mediterranean (Meinesz *et al*., 1997): a colony of 700 cm² reaches 7.25 m² in 2 years. *Posidonia* bed seems to resist to *C. taxifolia* the first year of contact and is invaded more easily from the second year of contact. The impact of *C. taxifolia* on the degraded *Posidonia* meadow, in the conditions of this work, is close to that described in the conditions of the north-west Mediterranean (Meinesz *et al*., 1997).

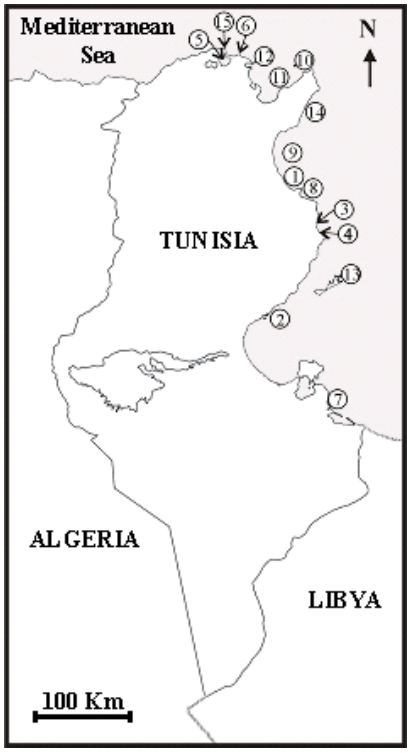

Figure 2 : Distribution of *Caulerpa racemosa* in Tunisia: (1) Sousse harbour; (2) Golf of Gabes; (3) Mahdia harbour; (4) Salakta; (5) Lagoon of Bizerte; (6) Cani Islands; (7) Zarzis; (8) Monastir; (9) Hammamet; (10) Sidi Daoud; (11) Sidi Raïs, Korbous and Ras Fartas; (12) Metline and Rafraf; (13) Kerkennah Islands; (14) Beni Khiar; (15) Bizerte

4. Conclusion

Official communication campaigns and prevention measures are cost-effective means to partly control the spread of exotic algae. The fact that only one organization collects the data avoids loss of information.

The official quality of the scientific team in charge of the monitoring, and the involvement of all the governmental bodies in managing the crisis implies that any decision is well considered and takes into account concern for the conservation of biodiversity and socio-economic consequences. Communication and cartography campaigns remain the basis for research. They must be the main objectives of *Caulerpa* monitoring and control projects.

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Caulerpa taxifolia impact on exploitable marine resources of the Cap Bon area. Preliminary data

S. Ben Salem[1] & A. Gaamour

Abstract

The aim of this work is the evaluation of changes in the fish community caused by the recent colonization by the green alga *Caulerpa taxifolia* in some areas of the Sidi Daoud region (Cap Bon). Experimental trammel net sampling has shown a higher number of species and of individuals in the areas covered by *C. taxifolia*. However, the mean weight of catches was higher in the control areas (not covered by the alga). In terms of frequency of occurrence, 5 species are representative of the *C. taxifolia* area (*Mullus surmuletus, Scorpaena scrofa, Diplodus sargus, Diplodus annularis* and *Scorpaena porcus*) and 2 species are representative of areas not covered by *C. taxifolia* (*Pagellus erythrinus* and *Spicara flexuosa*). Preliminary inquiries revealed that this alga generates a decrease of yields for artisanal fishermen and an increase of some costs (gas oil, maintenance of gears and their immobilization for a long period, etc.).

1. Introduction

Caulerpa taxifolia is an alga of tropical origin. It was observed for the first time in the Mediterranean along the Monaco coast in 1984 (Meinesz & Hesse, 1991; Boudouresque et al., 1992). Its presence in Tunisia was recorded for the first time at the beginning of 2000 in the roadstead of Sousse (Langar & *al*, 2000). Then, it appeared during 2001 (Langar, pers. com.) in the Sidi Daoud region which represents our survey zone (Figure 1).

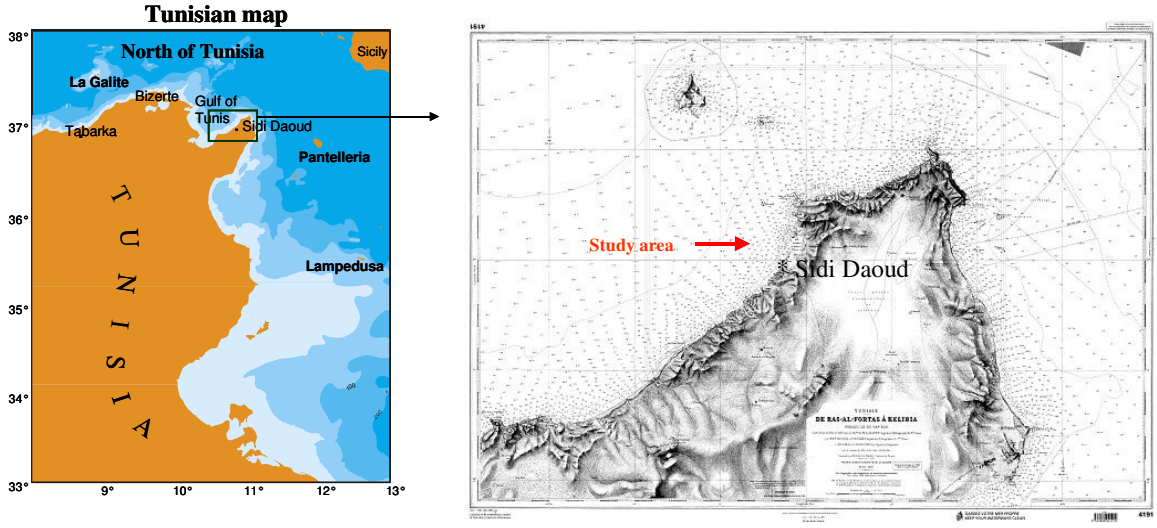

Figure 1 : The study area of Sidi Daoud (Cap Bon)

This zone, situated along the northwestern coast of Cap Bon, belongs to the transition zone between the western and eastern Mediterranean basins. The seafloor at Sidi Daoud is sandy -

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muddy, and sometimes rocky close to El Haouaria (Lubet et Azzouz, 1969). Considering these specificities, Sidi Daoud is endowed with a rich and diversified marine life. The most frequent species in the catches are: striped red mullet, red mullet, common dentex, white sea bream, scorpionfishes, clupeids (sardine, round sardinella) and scombrids (mackerel, tuna and bonito).

2. Materials and methods

The evaluation of the impact of the green alga *C. taxifolia* on species richness and on the productivity of exploitable marine resources has not yet been studied along the Tunisian coast. In order to identify possible changes in species composition and in yields of the artisanal fleet of the Sidi Daoud region due to the presence of *C. taxifolia*, we proceeded as follows:

✓**Experimental surveys**:

- Stations covered (C) and not covered (T) by *C. taxifolia*
- Trammel net (500 m length, 1.5 m depth and 30 mm mesh size)
- Hauls made during the night (about 12hrs soak time)
- Species identification and collection of biological parameters (length, weight, diet, etc.)

✓**Inquiries** aimed at having the opinion of fishermen concerning:

- Variation of productivity and species composition of commercial catches
- Changes of the fishing strategy (gears and fishing zones)
- Changes of exploitation costs (gas oil, maintenance, etc)

✓**Collection of statistical data** aimed at analyzing:

- The annual and seasonal evolution of landings and fishing effort (CPUE)
- The annual and seasonal evolution of catches value

3. Results and discussion

At this stage of the work, three trammel net samplings were made in each station. The average trammel net catch was 1786 g and 15 individuals in stations C, while the corresponding values were respectively 1930 g and 12 individuals in stations T.
In term of species composition, a total of 22 commercial species (19 fishes, 2 cephalopods and one crustacean), were recorded. In stations C, 15 species were caught, 12 of which were exclusive to this area and the others were common to both areas. However, only 7 species were caught in stations T (Table 1).

Table 1: List of fishes, cephalopods and crustaceans caught by trammel net at stations covered (C) and not covered (T) by *C. taxifolia*

	C. taxifolia 12/12/2002		C. Taxifolia 10/01/2003		Témoin 10/01/2003		C. Taxifolia 16/01/2003		Témoin 16/01/2003	
Poissons	Nb.	weight (g)	Nb.	weight (g)	Nb.	weight (g)	Nb.	weight (g)	Nb.	weight (g)
Diplodus annularis	1	40	2	64						
Diplodus sargus	4	225					5	218		
Labrus viridis	1	78								
Merluccius merluccius					1	186				
Mullus barbatus					4	242				
Mullus surmulettus	2	262			1	94	8	792		
Mustellus mustellus					1	313	1	764		
Pagellus erythrinus					2	157	3	131	4	270
Raja clavata					4	994				
Raja miraletus					1	280				
Scorpaena porcus	1	46					1	33		
Scorpaena scrofa	3	466					2	414		
Serranus cabrilla							3	217		
Solea vulgaris									1	14
Spicara flexuosa					1	60			1	55
Spondyliosoma cantharus							1	107		
Synodus saurus							2	378		
Torpedo marmorata					3	1196				
Trigla lucerna	1	55								
Subtotals	13	1172	2	64	18	3522	26	3054	6	339
Céphalopodes										
Octopus vulgaris	1	700								
Sepia officinalis							1	346		
Subtotals	1	700	0	0	0	0	1	346	0	0
Crustacés										
Squilla mantis							1	20		
Subtotals	0	0	0	0	0	0	1	20	0	0
Totals	14	1872	2	64	18	3522	28	3420	6	339

The 3 co-occurring species were *Mullus surmuletus, Pagellus erythrinus* and *Mustelus mustelus*.

In terms of frequency of occurrence, 5 species were more frequent in the *C. taxifolia* area (*Mullus surmuletus, Scorpaena scrofa, Diplodus sargus, Diplodus annularis* and *Scorpaena porcus*) and 2 (*Pagellus erythrinus* and *Spicara flexuosa*) in areas not covered by the alga. Preliminary interviews to fishermen revealed that this alga generates a decrease in yields for artisanal fishermen and an increase in some costs (gas oil, maintenance of gears and their immobilisation for a long period, etc.). The data obtained show clearly that the fish community in the *C. taxifolia* areas is qualitatively richer than the in areas not colonised by this alga, while yields are greater in areas not colonized. These preliminary conclusions must be taken with precaution because the study is at an early stage.

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Annex A: Terms of reference

1. Introduction

As a consequence of the technical guidelines produced by FAO in support of the implementation of the Code of Conduct for responsible fisheries, research activities increasing knowledge on ecosystem approach to fisheries are becoming a priority. This was further underlined and strongly recommended by the Declaration of the Reykjavik Conference (1-4 October 2001), which encourages the incorporation of ecosystem considerations into fisheries management, particularly by *"building expertise for collecting and processing the biological, oceanographic, ecological and fisheries data for designing, implementing and upgrading management strategies"*. This was recalled during the twenty-fifth session of the Committee on Fisheries (Rome, 24-28 February 2003), by several Country Members who underlined the importance of deeper analysis of bioecological issues, and development of ecosystem-related indicators, reference points and decision rules.

In this line, the FAO Trust Funds Regional Project MedSudMed "Assessment and Monitoring of the Fishery Resources and the Ecosystems in the Strait of Sicily" is a regional project aimed at supporting scientific communities and countries in the development of a monitoring system for the studies of the fisheries resources and the ecosystems. The main objectives of the Project are to increase the scientific knowledge on ecosystems in the Project Area, strengthen national and regional expertise, and develop the scientific cooperation of the standardization of the methodologies used in fishery research.

During the 1st Meeting of the MedSudMed Coordination Committee, a general outline of research and the activities to be implemented by the Project have been discussed by the participants. A preliminary plan was presented for research activities aimed at improving information resources for fisheries management, biodiversity protection, and ecosystem preservation in area covered by the Project. It was focused on three main proposals: *(i)* Spatial distribution of demersal resources according to environment and fishery features; *(ii)* stock identification of small pelagic fish and oceanographic processes influencing their abundance and distribution; *(iii)* Marine Protected Areas and Fisheries Management.

The MedSudMed Project, for each one of the three research topics, decided to organize an Expert Consultation (EC) in order to provide an overview of available knowledge on fishery ecology in the region. The ECs consist of regional and extra-regional experts and will provide an overview of available knowledge on the addressed issues. The aims of the ECs are the definition of a work program for the activities to be implemented on the basis of common methodology and the proposition of pilot study cases. Furthermore the ECs should also identify needs in national and regional expertise and are the opportunity to define criteria for the data collection, and identify a task leader who will coordinate this program of work.

The present document refers to the EC on "Marine Protected Areas and Fisheries Management", which is the second one organized by the Project.

2. Background information

The document CC1/02, "General Outline of Research", submitted to the 1st Coordination Committee (19-20 September 2002) was focused on the comparison of areas subject to different fishing efforts and the study of the consequent dynamics of inshore and offshore food webs, by using the fish size. The proposal regarded both closed areas to fishing, and zones under strong fishing pressure. The ultimate objective was to have *(i)* an accurate description of the trophic interactions in exploited and non-exploited ecosystems, *(ii)* strong and comparative elements regarding the effect of fishing closure.

However, the discussions of this research proposal led to the conclusion that priority would rather be given to the exchange of experiences regarding Marine Protected Areas with particular attention to the areas in which fishing activities occur and are managed. This would allow, when the case arises, to foresee a possible methodology prior to the closure of fishing, once qualitative and quantitative effects will have been estimated. More accurate priorities can then be discussed and agreed upon in the framework of this EC.

According to the Project Document, focus will be made on the zone covered by the Project, *e.g.* the Southern part of the Central Mediterranean which includes all the corresponding GFCM Geographical sub-areas and part of Northern Tunisia, in order to include the Strait between Tunisia and Sicily. Moreover, as discussed and agreed upon during the 1st Coordination Committee, the experiences made by IRMA in the Gulf of Castellammare MPA, will be taken in consideration.

3. Objectives of the Expert Consultation

The EC will explore all facets dealing with Marine Protected Areas (MPAs) in the zones mentioned above, in attempting to have a synthesis of existing knowledge and activities dealing with MPAs and an overview of the types of studies. The National contributions should describe studies and/or measures that have been conducted / applied to date, or any project on (possible) future protected areas. The effects of fishing ban on fish size, biomass and spatial distribution will be analyzed, by taking advantage of the existing key-studies. The possibility of transposing the existing results to zones where fisheries resources are deployed (or overexploited) will be explored. Particular attention will be given to the indicators that should be monitored in future areas of interest.

Moreover, comparative studies can possibly be conducted; therefore, the presentation of all available information is a must for future activities (research, training, or management). This would enable listing the gaps in the knowledge and methodologies, and draw-up consequent working and training programs agreed upon by all participating countries.

4. Focus and issues to be addressed

The focus of the Expert Consultation will be on MPAs and Fisheries Management, *e.g.* any marine area that is under any kind of protection. However, the EC will focus on

issues related to fisheries (marine refuges, area closures, fisheries reserves) (see glossary at the end of the document).

When no such zones exist, experience on Marine Reserves / National Parks oriented towards biodiversity conservation can also be presented, provided that the results may be useful from a fisheries point of view, *e.g.* if these zones show particular environmental or ecological characteristics that may regard species exploited by fisheries. Therefore, it seems also important to know what has been done in such zones, for which purpose, and to have an idea of the results obtained. This will let us appraise to which extent fisheries-oriented issues can be studied using these already protected zones.

Moreover, ongoing projects could be presented, as well as biological, ecological and socio-economical issues, and the methodology used to gather such information.

Therefore, types of studies and topics that can be addressed are:

- **Key studies**: studies conducted on a zone closed to fishing, and where ecological effects have been observed and quantified. The particular issue regarding trophic interactions should be considered as a priority, as well as studies on fish dispersion around MPAs. Indirect descriptions, such as economic effects of the closure can also be presented.
- **Feasibility studies**: in highly depleted zones, where the closure has been envisaged as a possible solution for stock enhancement. Observed effects of over-fishing on trophic interactions can also be addressed. Feasibility studies may also regard cases of envisaged fishing closure or restriction as a management tool of areas that are not necessarily over-exploited.
- **Problems affecting fisheries resources** that can possibly be resolved by the creation of an MPA, such as:
    - Over-fishing: qualitative and quantitative description/assessment, and effects on trophic interactions (fishing pressure on preys, predators);
    - Illegal coastal fishing.
- **Artificial reefs** as a tool to prevent illegal fishing in protected areas.
- **Sensitive habitats**: this topic includes the presentation of any sensitive habitat that deserves appropriate protection, because it has been identified as an important element in fisheries ecology (reproduction, spawning, feeding zones, …).
- **Abiotic environment**: physico-chemical parameters will be examined as elements conditioning plankton productivity, and therefore, the trophic chain affecting fisheries resources. This issue will deal with the physico-chemical characteristics of both sediments and water column, as well as the interface between the two (oxygen, ph, salinity, nutrients, …).
- **Socio-economical and cultural issues**: as a part of the feasibility or the key studies, these aspects can be addressed to show the effect of the fishing closure / protection, or effect of over-fishing on socio-economical and cultural features of an area.

- **Legal aspects**: existing laws and control procedures, respect/non respect of national regulations. This topic will be addressed in order to foresee the existing controlling procedure in case of fishing closure.

5. Overlapping with previous expert consultation and other Projects

To date, one MedSudMed EC has been held on "Spatial distribution of demersal resources in the Strait of Sicily and the influence of environmental factors and fishery characteristics" (Malta, 10-12 December 2002). In order to gather and process the available information, four tasks were identified:

1. Spatial distribution of target species
2. Fishing pressure on demersal resources
3. Biocenosis
4. Physical description of the area

For each one of these tasks, the available information was listed, and the gaps were identified. In order to increase the available information at regional level a synthesis of the information gathered will be presented. The present EC could take advantage of these results, in particular regarding the fishing pressure, the biocenosis and the physical description of the area. The first would help situating the zones suffering from over-fishing, the latter can be related to the issue on habitats.

6. Expected outputs

- Synthesis of the knowledge on Marine Protected Areas and related fisheries management aspects in MedSudMed study area, both on already protected zones and zones that can possibly be protected in a next future (identifying criteria and methodology to be applied).

- Identification of gaps: will give an overview of the information that is still missing, in particular regarding the effect of fishing closure, the missing elements necessary to feasibility studies, knowledge gaps regarding target species in "biodiversity reserves".

- Methodology to fill the gaps: this will regard more particularly feasibility studies, and/or research activities to be conducted to improve knowledge on the effect of fishing closure on fish size, and biomass, *e.g.* data collection may be organized according to the on-going studies in the participating countries (agreement on the type of sampling, calendars, comparative studies).

- Pilot study cases that can possibly be conducted. Advantage will be taken of outputs produced by previous studies on similar topics.

- Overview of the regional and national expertise

- Training needs / possibilities: according to the needs that will have been expressed, the training organization will be discussed, in particular regarding

exchanges between countries, possible organization of visiting scientists, collective courses for all countries.

- Creation of a regional network of multidisciplinary experts, to be involved in the MedSudMed activities related to this EC.

Discussions held during this expert consultation should not overlap with previous ones, in particular dealing with conservation. Presentations and discussions should be focused on fisheries and fisheries management. Therefore, it is important that Marine Protected Areas should be considered in a management perspective, and that all outputs be focused on this issue.

The report of the expert consultation will be edited as Technical Document of MedSudMed Project and will be available as an information paper for the SAC and SAC sub-committees on Ecosystems and Marine Environment and Stock Assessment, as well as for other relevant regional meetings and bodies related to the addressed issue. An editorial board will select the abstracts which are the most coherent with the present Terms of Reference, and will ask the authors to produce an extended written version. The remaining summaries will be put in the final report, as contributions to the discussions held during the meeting.

7. Participation

The Expert Consultation will consist of regional experts. The participants will have broad discipline background, it is of outmost importance that persons with different skills be brought to share their knowledge and experience.
Discussions will be conducted by Scientific Director of the Project, Project staff and experts participating to the expert consultation. A team leader will be nominated, to chair the meeting, help to the preparation of the final document, and coordinate the activities that will have been agreed upon.

The Expert Consultation will be conducted in English or French.

8. Organization and activities of the Expert Consultation

The Expert Consultation will be convened by the “Institut National des Sciences et Technologies de la Mer” (INSTM), in cooperation with FAO. It will be held at the research Institute in Salammbô from 14th to 16th April 2003. Participation is by invitation only.

Annex B: Agenda

Monday 14 April 2003

10:00-13:00

1. Opening of the meeting - Greetings from local Authorities
2. Election of the Chairman and of the Reporting group
3. Presentation of the agenda and organization of the Expert Consultation
4. Objectives and expected outputs of the EC, by Fabio Massa, MedSudMed Project Coordinator
5. Introduction by Dino Levi, Scientific Coordinator of MedSudMed Project

10.45 ***Coffee break***

12.30 ***Lunch***

14:00 – 14:45 List and Discussion of terms to be adopted (definitions) (K. Ben Mustapha)

14:45 – 15:15 Short synthesis of the MedSudMed EC on Demersal Resources (Malta, December 2002) (S. Ragonese and T. Bahri)

15:15 – 15:45 Coffee break

15:45 – 16:15 Marine Protected Areas as a Fisheries Management tool
Alfonso Ramos for Copemed Project

16:15 – 16:45 Overview of the national implementation plan for 6 new MPAs
Intervener from APAL (Agence de Protectionet d'Aménagement du Littoral - Tunis, Tunisia)

16:45 – 17:15 Case study: the Maltese 25-mile fisheries conservation zone
Matthew Camilleri (MCFS – Marsaxlokk, Malta)

Tuesday 15 April 2003

09:00 – 09:20 The Western Marine Protected Areas in Libya.
Amer A. Rawag and Daw A. Haddoud (MBRC - Tajura, Libya)

09:20 – 10:20 The Castellammare experience:
1. MPAs: the Gulf of Castellammare case study. Environmental features and fishery structure
D'Anna G., Badalamenti F. & Pipitone C. (IRMA-CNR - Castellammare del Golfo, Italy)

2. MPAs: the Gulf of Castellammare case study. Results after ten years of trawling ban. 1. Biological aspects.
Badalamenti F., D'Anna G. & Pipitone C. (IRMA-CNR - Castellammare del Golfo, Italy)

10:20 – 10:40 Coffee break

10:40 – 11:00 The Tunisian proposals of five National Action Plans for the conservation of the marine and coastal biodiversity
Mohamed Salah Romdhane (INAT, Tunis, Tunisia), Bradai Nejmeddine (INSTM - Sfax, Tunisia), Karim Ben Mustapha (INSTM - Salammbo, Tunisia) and Hechmi Missaoui (INAT - Tunis, Tunisia)*

11:00 – 11:20 Background analysis of the state of the marine biodiversity of the Tunisian coasts and proposal of new area of conservation management: MPAs and ARs (Synthesis of the study of the three Gulfs)
Karim Ben Mustapha (INSTM - Salammbo, Tunisia) and Ahmed Afli (INSTM - Salammbo, Tunisia)

11:20 – 11:40 Monitoring guidelines for the presence of *Caulerpa taxifolia* and *Caulerpa racemosa*:

1. **Monitoring strategy and results** *Habib LANGAR (INSTM, Salammbo, Tunisia), Aslam Jellouli (FST) and Amor EL Abed (INSTM, Salammbo, Tunisia)*
2. **Economical, ecological and fisheries guidelines** *, Adel Gaamour (INSTM, Tunisia) and Skander Ben Salem (INSTM,La Goulette, Tunisia)*

11:40 – 12:00 Small fish discard caused by trawling activities in the Gabes gulf (Tunisia)
Jarboui et al. (INSTM -Sfax, Tunisia)

12:00 – 12:20 Mapping natural and man-induced untrawlable grounds in view of managing the fisheries of the Strait of Sicily.
S. Ragonese, G.B. Giusto, M.L. Bianchini and G. Norrito (IRMA-CNR – Mazara del Vallo, Italy)

12:20 – 12:40 Mapping benthic marine habitats in the Zembra MPA.
Karim Ben Mustapha (INSTM - Salammbo, Tunisia) , Jeres Pablo (University of Alicante), Liman Atef and Rais Chedly (MedMPA-RAC/SPA, Tunis, Tunisia)

12:40 – 13:00 Indicators for monitoring program in new or existing MPAs (Standard data forms)
Rais Chedly (CAR/ASP, Tunis, Tunisia) and Afli Ahmed (INSTM, Salammbo, Tunisia)

13:00 – 14:00 Lunch break

14:00 – 14:20 Overview of the legal status of Fisheries, marine species and MPAs in Tunisia (including area closures, fisheries reserves etc)
Hattour Abdallah (INSTM, Tunis, Tunisia) and Mohamed Salah Romdhane (INAT, Tunis, Tunisia)

14:20 – 14:40 Marine Protected Areas: a tool for the environmental management of natural resources
Michael Sant (MEPA – Floriana, Malta)

14:40 – 15:00 MedSudMed Data Base and Information System
T. Bahri (FAO-MedSudMed)

15:00 – 15:20 Tunisian experience and expertise in GIS and Information System
M. Belhassen (INSTM, Salammbo, Tunisia)

15:20 – 15: 40 Knowledge and Spatial Management Tools for Environmental Sciences
(C. Agius, MEPA – Floriana, Malta)

15:40 – 16:00 *Coffee break*

16:00 – 17:00 Synthesis of existing knowledge and available information on the issue
Identification of gaps by topics

Wednesday 16 April 2003

09:00-13:00

Discussion of the main topics to be addressed from a Fisheries Management perspective (Socio-economical aspects, spill over, …)

Discussions of practical guidelines for the Project area/Mediterranean