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European Marine Protected Areas as tools for Fisheries management and conservation

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1. EVALUATING THE AVAILABLE INSTITUTIONAL INFORMATION NEEDED TO ASSESS THE EFFECTIVENESS OF MARINE PROTECTED AREAS.

Abstract

Marine protected areas (MPAs) have been studied all around the world and their benefits are widely acknowledged. Management in MPAs is very important as it effectiveness ensures the conservation of biodiversity and protection of fish stocks. But management usually has the necessity of tools, and the selection of indicators to assess the protection effects of MPAs, can be one of them. Indicators to be useful need for data and thus gathering this data is one of the main problems to apply them. A total of 149 parameters were selected as possible indicators classified as Driving forces, Pressures, States, Impacts and Responses, related with fisheries and tourism activities of MPAs. The aim of this work was to evaluate the availability and quality of the data available for the parameters defined to assess MPAs effectiveness in the conservations of marine resources. Data availability and their specific gaps and needs were analysed and discussed. Also, an evaluation of institutional involvement in the accessibility and availability of these parameters is determined. The required indicators for marine management were available with a questionable cost-effectiveness in relation with the difficulties on collection data and the quality of this information. Some recommendations are made that should be consider to apply the requirement backgrounds proposed by current European Directives related with marine biodiversity and conservation.

Introduction

Marine protected areas (MPAs) have been widely studied and their effectiveness for conserving habitats, fostering the recovery of overexploited species and maintaining marine communities has been broadly documented. MPAs as tools for conservation and management of marine resources need to define the ecological status of their population and habitats. To define and measure this status and to assess the protection effects of these areas, tools for management to define this status and assess this protection are needed. Indicators are recommended to be used as they are powerful tools to characterise and quantify the environment and to understand the natural and anthropogenic process developed in MPAs. They provide information that can be understood by the managers and stakeholders, and afford them with a base for decision making. For this reasons indicators can contribute to monitoring the state and the effectiveness of MPAs revealing reveal conditions and trends that help in development planning and decision making (Unluata, 1999).

Current European Directives such as the Water Framework Directive (WFD) (EC, 2000) and the future Marine Strategy Directive (MSD) (EC, 2005) constrain to define the state of the ecosystem to protect and conserve. The WFD requests for the optimization of water quality and the conservation of the habitats and biodiversity to reach a good ecological status (GES). The MSD establishes an integrated policy framework to protect Europe's marine environment based in the participation of science, stakeholder and the international commitments (EC, 2006b). Difficulties and challenges of MSD in the sense of the scientific elements are presented in diverse studies (Borja, 2006; Salomon, 2006) and critiques on the provisions related to stakeholder involvement in the MSD have been done (Fletcher, 2007). Both directives present relationships with the Habitats Directive (HD) (EC, 1999). The HD establishes the necessity to define the conservation state of habitats and key species. In the HD framework also have been proposed to protect numerous areas establishing Special areas of conservation (SACs) and specially protected areas for birds (ZEPA) some of them exclusively or partially marines, e.g.: 100 SACs have been proposed (EC 2006 a). This directive requires the member states to turn these areas in special conservation areas. To apply this it is required the development of management plans that incorporate measures of protection and action approaches at different institutional levels. This task compels a strong knowledge of the ecological, socio-economic and policy status of the area subject of protection. Current marine environment legislation and European Directives lead to the necessity of the development of new methodological and conceptual criterion to integrate the available information (Jonge, 2007). There is no need to over-emphasize the necessity for new data as generally the information required for management and planning already exists and only needs to be brought together. As well as biological indicators, it is fundamental to define socioeconomic indicators to assess the evolution of parameters like population density, demographic increase, tourism frequency and maritime traffic, between others (Casazza *et al*., 2002).

Indicators represent a quantitative or descriptive categorization of environmental data and they are designed to inform easily and quickly about the conditions over time and space of our ecosystem. Their characteristics have been widely listed and described

(Unesco, 2003). To be a good indicator a parameters between other characteristics must be accessible. To comply with this characteristic a parameter must; i) exist, otherwise it can be used; ii) be easy to gather or obtain, meaning that the procedure to have it must be fast, being fastest to have data in a computer support that to extract it from technical reports or from aggregated data; iii) be provided easily by the different administrations; iv) have the proper quality, good metrics and long temporal and spatial series and v) not have information lacks.

One of the first steps to establish the guidelines on management of coastal areas is the necessity to define parameters to be used as indicators. It must be verified the quantity, quality and distribution of the available data and their possibility to be used for the evaluation and management of MPAs. Although a parameters can be good at assessing the protection effects in MPAs to be considered as a parameter to be used as an indicator must fulfil the characteristics defined.

The objectives of this study were to: a) determine the availability of the information related to a set of parameters proposed; b) assess the quality of the data gathered and c) weigh up the level of involvement of institutional administrations.

Material and methods.

Preliminary selection of potential indicators

Through a participation process which involved and expert panel of specialists on different areas (www.um.es/empafish/) a set of parameters were identified and defined (Deliverable 19). This preliminary selection of parameters as potential indicators was selected through the application of the DPSIR methodology (OCDE, 1994), that its structure is being applied for the selection of indicators in the implementation of the WFD (e.g. Jeunesse *et al.*, 2003; Mysiak *et al.,* 2005; Borja *et al.,* 2007), coastal zone studies (e.g. Silva and Rodrigues 2002; Nunneri and Hoffman 2003; Picollo *et al.,* 2003) and in fisheries management (Mangi *et al.,* 2007).

A total of 149 parameters were defined, 69 for the fishing sector and 90 for tourism sector, and classified within the framework components; Driving forces (25, 16.77%), Pressures (27, 18.12%), States (19, 12.75%), Impacts (40, 26.84%) and Responses (38, 25.50%).

Data collection and analysis

An extensive request (research) was performed to collect data on parameters on socioeconomic, environmental and managing issues related with MPAs and from the surrounding cities (40 km around an MPA were considered). A preliminary inquiry was done through official request of data (letter or fax) to the different national, regional and local, institutions implied. Also fisheries, tourism, environmental sector and management of MPAs agencies were consulted (Table 1.1).

Table 1.1. List of institutions implied in the national, regional, provincial and local Administration related with fisheries, tourism and environmental sectors and MPAs management.

Sector	Category	Institution name
Fisheries (professional and recreational)	National	*Secretaria General de Pesca Marítima (Ministerio de Agricultura, Pesca y Alimentación).* Fishing institution implied in Tabarca Marine Reserve management.
	Regional	*Direcció General d'Agricultura, Pesca i Alimentació (Conselleria d'Agricultura, Pesca i Alimentació.* Fishing institution implied in Tabarca Marine Reserve management.
	Regional	*Serveis Territorials de Pesca Marítima d'Alacant (Conselleria d'Agricultura, Pesca i Alimentació.,* Fishing institution implied in Tabarca Marine Reserve management.
	Provincial	*Federación de Cofradías de Pescadores de la Provincia de Alicante,* professional fishers brotherhoods of Alicante province.
	Local	*Cofradías de Pescadores,* professional fishing association of different ports
Tourism (e.g.: visitants, tourist provision, diving activities,	National	*INE (Instituto Nacional de Estadística).* National statistic institution.
	Regional	*Federación Valenciana de Actividades Subacuáticas.* Water sports federation.
	Regional	*Conselleria de Turismo (Agencia Valenciana de Turisme.* Institution implied in the tourism administration.

beaches and ports.)	Provincial	*Cámara de Comercio de la Provincia de Alicante*. Chamber of commerce.
	Local	Town halls of different cities near Tabarca MPA.
	Local	Tourist information office of different cities near Tabarca MPA.
	Local	Nautical Club or Marina near Tabarca
Environmental (e.g.: water quality and wastes.)	Regional	*Conselleria de Habitatge*. Environmental and territorial planning institution.
	Local	Town halls of different cities near Tabarca MPA.
	Local	*Institut d'Ecologia Litoral*. Research and environmental education institution depending on local and regional administration.
MPAs Management (e.g.: Budgets, projects and surveillance)	National	*Secretaria General de Pesca Marítima (Ministerio de Agricultura, Pesca y Alimentación).* Fishing institution implied in Tabarca Marine Reserve management.
	Regional	*Direcció General d'Agricultura, Pesca i Alimentació, Conselleria d'Agricultura, Pesca i Alimentació.* Fishing institution implied in Tabarca Marine Reserve management.
	Regional	*Serveis Territorials de Pesca Marítima d'Alacant (Conselleria d'Agricultura, Pesca i Alimentació.* Fishing institution implied in Tabarca Marine Reserve management.

The administrations were classified by their level (local, provincial, regional or national) or their working sector (Management resources or fisheries). A qualitative evaluation of the institutional involvement was done in relation to the responses of the institutions consulted based on the following criteria:

i) Response time (days): number of days lasted since the letter or fax was sent to the day that the answer with or without data is received.

ii) Availability of data (%): percentage number of parameter obtained related to parameters requested.

iii) Quality of data that were scored as, excellent, appropriate or no appropriate, depending if the data fulfilled three, two or only one respectively of the following characteristics: a) Data presented in an appropriate way to facilitate the work (e.g.: electronic format), b) Level of detail of the data (e.g.: monthly data, by species or by fishing gears) and c) Quantity of data (long temporal or spatial series an without gaps).

iv) Facility to access that were scored as, very easy, easy or difficult depending if the data fulfilled three, two or one respectively of the following issues: a) Not necessary bureaucratic applications, b) Immediate or straight accessibility (e.g.: if only one person coordinate the information or if is possible consulting directly database, reports, etc) and c) Free of taxes.

v) Quantity of temporary data: date or year since which exists reference data.

Indicator type	Sector	Indicator	Information source
Driving forces	Fishing	Evolution of fishing boats number	Technical reports of Conselleria de Agricultura, Pesca y Alimentación
		Evolution of fishers number	Database of local professional fishers brotherhood (*Cofradias)*
		Biomass extracted by port/year	Instituto Español de Oceanografía (IEO) *(2003-2005)*
	Tourism	Evolution of recreational fishing	Database of *Servicios Territoriales de Conselleria de Agricultura, Pesca Alimentación*
		Evolution in the influx of visitants	Reports of *Conselleria Turismo* Satistical data of *INE* Mazón (2005)
Pressures	Fishing	Number of boats fishing/year in the MPAs	Technical reports of surveillance services in the MPA (*Secretaria de Pesca Marítima*)
		Biomass extracted in MPAs/year	Instituto Español de Oceanografía (IEO) *(2003-2005)* Annual reports of *Conselleria de Agricultura, Pesca y Alimentación* (1993)
	Tourism	Number of recreational divers/day in the MPA	Technical reports of surveillance services in the MPA (*Secretaria de Pesca Marítima*)
		Number of recreational boats in the MPA	
		Number of visitants/day	Data estimations of commercial ships regular lines
Stat es	Fishing	Abundance	Technical and scientific reports

	& Tourism	Biomass	Scientific publications
		Richness	Different institutions biological database (Universidad de Alacante, Institut d'Ecologia Litoral, etc.)
		Habitat cover	
Impacts	**Fishing & Tourism**	Changes in abundance	Technical and scientific reports Scientific publications Biological databases
		Changes in biomass	
		Changes in richness	
		Appearance of opportunistic species	
		Changes in sensitive species	
Responses	**Fishing & Tourism**	Surface of the MPA	Technical reports of *Secretaria de Pesca Marítima* and *Servicios Territoriales de Conselleria Agricultura, Pesca y Alimentación*
		Surface of integral reserve	
		Zoning surface for each use	
		Number of anchoring points	
		Number of surveillance hours	Technical reports of surveillance services in the MPA (*Secretaria de Pesca Marítima*)
		Number of denounces for illegal fishing / divers / anchoring, etc.	
		Number of people contracted for surveillance	
		Budget for management-conservation, surveillance, divulgation and investigation	Technical reports of *Secretaria de Pesca Marítima* and *Servicios Territoriales de Conselleria Agricultura, Pesca y Alimentación*

Table 1.2. List of gathered indicators for Driving Forces, Pressures, States, Impacts and Responses related with the fishery and tourism sectors in the MPAs: Tabarca Marine Reserve, San Antonio Cape Marine Reserve and Sierra Helada-Benidorm islets.

Results

Availability of information

The final list of data gathered (Table 1.2) includes 62 parameters defined in the preliminary selection (41.6%). By DPSIR levels the availability of parameters was: 10 for Driving Forces (40,0%), 8 for Pressures (29.6%), 7 for States (36.8%), 10 for Impacts (25%) and 27 for Responses (71.6%). From the 32 parameters requested to tourism institutions were available (50 % of the preliminary selection) while the number of parameters gathered for the fisheries institution was only 30 (65 % of the preliminary selection).

The national administrations were the administrations answering for the entire data asked (Fig. 1.1). Meanwhile other administration didn't answer to all the data we asked for being the regional and local those with higher proportions of answers while the answer by the provincial administration, which included the fishers brotherhood aren't likely to answer, was only a 50 %. Also the national administrations were those having the majority of the data available. And even their response was high regional administrations had the less quantity of data available meanwhile the availability of data was high for the provincial and local institutions. But although the national institutions had more available data and all of them answer they were not the quicker (Fig. 1.2), provincial administrations answer was the quicker, while the local administrations, even being more closer to the area, lasted more days in answering. Data was mainly available since 1999 for the local and provincial administrations (Fig. 1.3). The national administration had the longest series available, while the regional data was current with an excellent quality based in monthly technical reports. The quality of data gathered was higher for the national administrations the other administration even not having and excellent quality was good for all of them. However the accessibility to the data was very easy for all but not for the provincial institutions (Fig. 1.4).

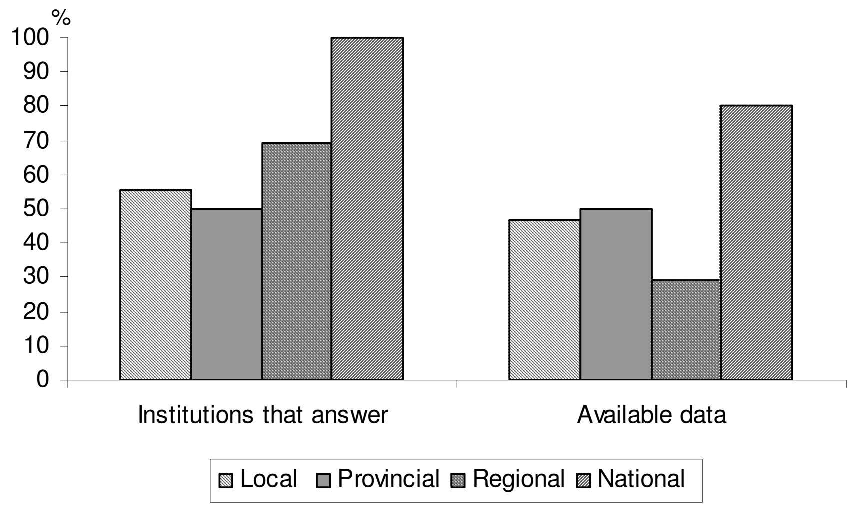

Figure 1.1 Percentage (%) of the institution that answered and % of the data available. Administration were classified depending on the institution level that they belonged.

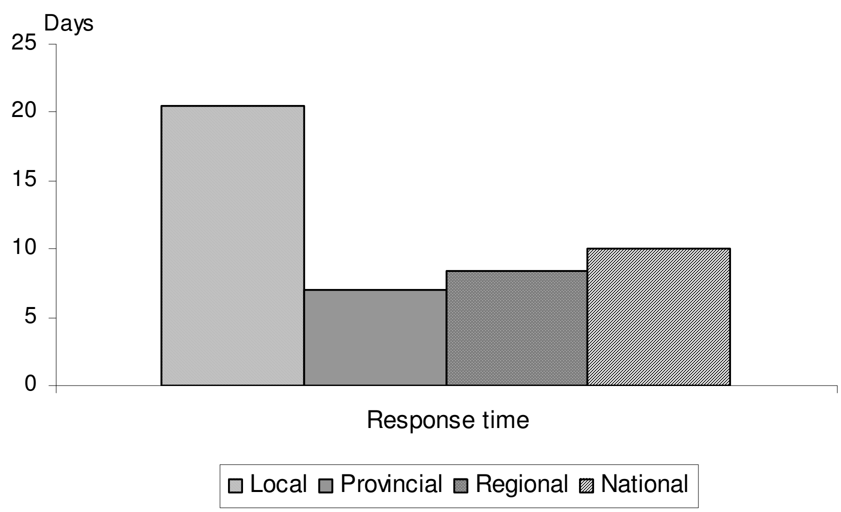

Figure 1.2. Number of days the institutions, classified depending on the institution level that they belonged, lasted to send an answer.

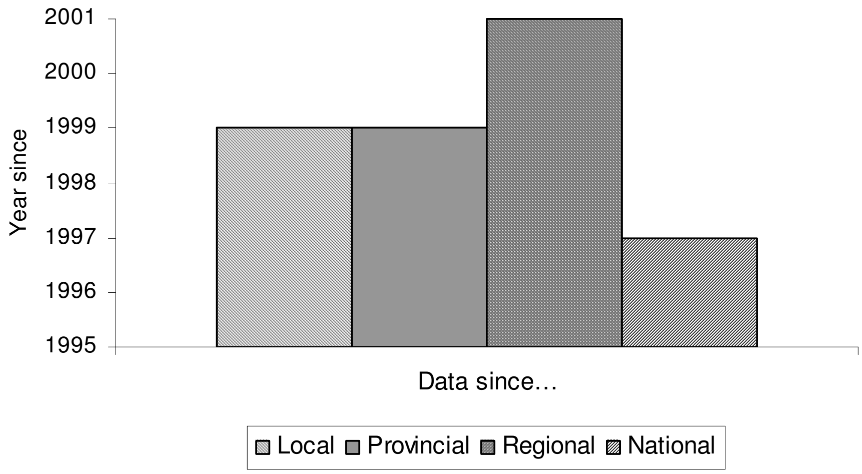

Figure 1.3. Years since data availability. Institutions were classified depending on the institution level that they belonged.

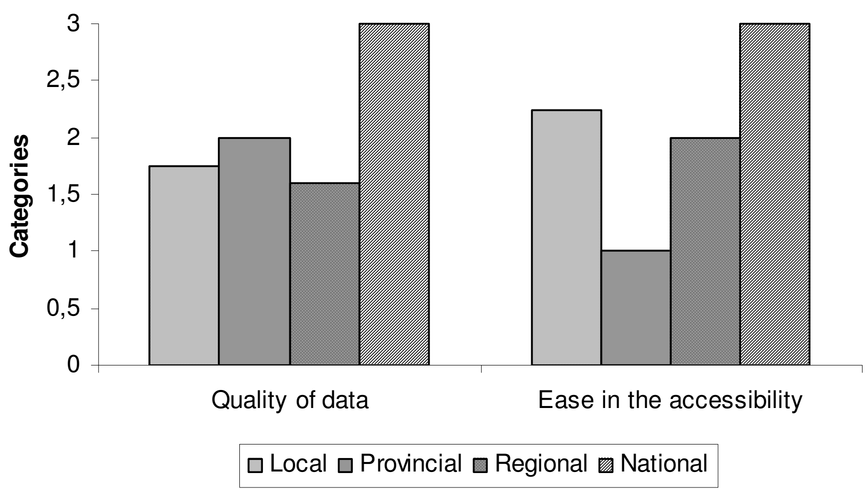

Figure 1.4. Quality of data categorized as (0-1 regular, 1-2 good, 2-3 excellent) and easy in the accessibility categorized as (0-1 difficult, 1-2 easy, 2-3 very easy) depending on the institution level that they belonged.

Analysing the same variables but classifying the institutions according to their working sector responses they are slightly different. More resource management institutions answer to the data enquired. However tourism administrations had more available data (Fig.1.5), this data was related with tourist provision and hotel occupancy rate. These institutions had also interesting studies on the tourism and nautical sector at a regional and/or national level. One of these institutions enquired had a study on the environmental quality tourist perception. Tourism administrations took more time to answer enquires (Fig. 1.6) but when they did their data had longer temporal series as they have data since 1999 (Fig. 1.7). The quality of data gathered was higher for the tourism institutions being from an excellent quality although the resources management data is of a good quality. Nevertheless the ease of accessibility was easy for both of them being easier for the resources management administration data mainly because the data was available in an electronic format (Fig. 1.8). Accessibility to some kind of data from resources management institutions was easy as was available in technical reports.

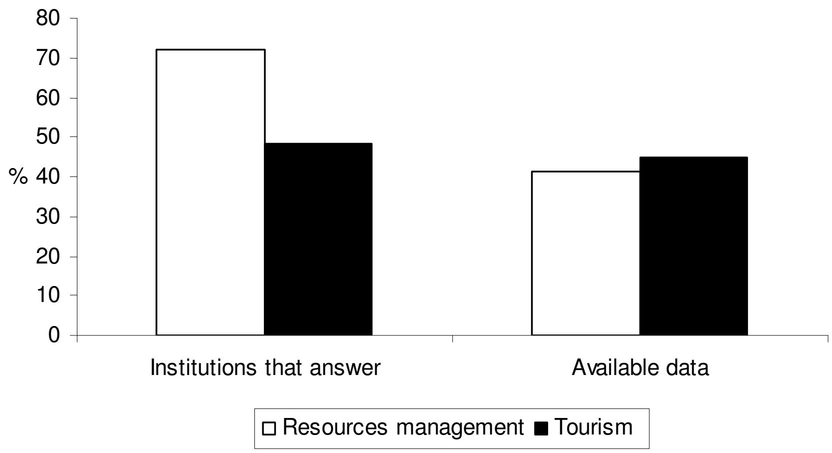

Figure 1.5. Percentage (%) of the institution that answered and % of the data available. Administrations were classified depending on their working sector.

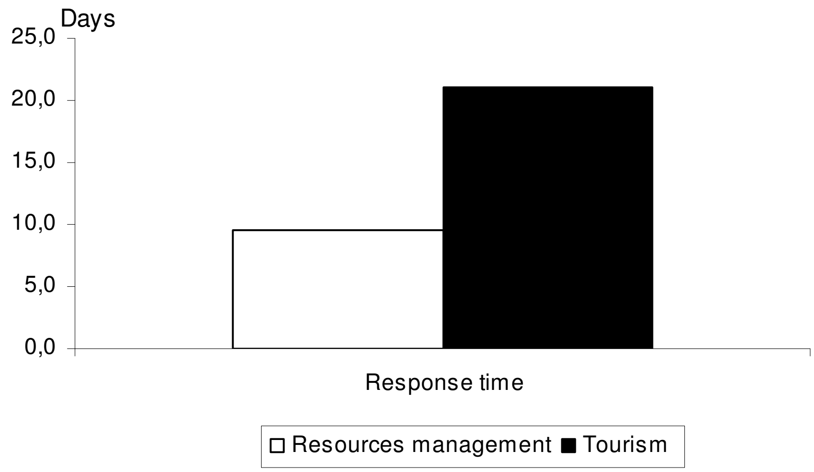

Figure 1.6. Number of days the institutions that were classified depending on their working sector lasted to send an answer.

Figure 1.7. Years since data availability. Institutions were classified depending on their working sector.

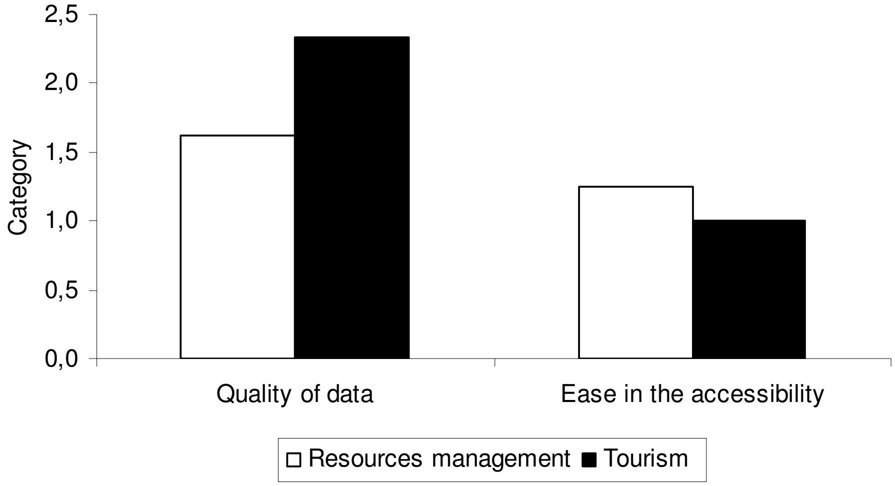

Figure 1.8. Quality of data categorized as (0-1 regular, 1-2 good, 2-3 excellent) and easy in the accessibility categorized as (0-1 difficult, 1-2 easy, 2-3 very easy) classified depending on their working sector.

Discussion

This study is one of the first's studies that evaluate the availability and quality of data to be used as indicators in relation with the assessment of MPAs protection effect. Our results show that in general the data that could be gathered was of a regular-medium quality. Depending on the criteria used the response of the administrations was different varying between many causes. In general data didn't present good qualities, there were not long term series and the majority of the data is available only since the year 2000, gathering data before this year needs of an intricate research. Although the MPAs were mainly established with a fisheries aim (Jones, 1994) this administration showed the worst results to some criteria comparing with the tourism administration that shows better trends in the quality of data.

In general the availability of the data was medium-low, few data from the 169 parameters defined from the conceptual model were finally gathered. Also the quality form those available was regular-low as a general trend. The data presented a very high aggregation level, in a temporal term aggregated by years and in a spatial term aggregated by high areas. This general aggregation makes difficult the evaluation of a small surface as can be the MPAs, isolating the effects due to protection. With this scenery is difficult to assess direct evidences on fisheries stocks, on habitats or even on key species due to protection.

Administrations and public or private institutions traditionally have the labour to gather important data series as indicators of the economic and/or population growth of the state. These indicators measure the economical quality and evaluate the economic country growth rate. This can also explain the data aggregation as for this indicators mainly annual data is required and the specificity because only some of them answer to the economic questions proposed. Apart from this type of descriptors there is no gathering culture to collect other type of parameters. Mainly to this reason the majority of the parameters gathered in this research were classified as Driving Forces and Responses of the DPSIR framework. But almost nothing was found for the States and Impacts parameters which were mainly available for very precise and punctual studies. These studies are not continued in time and even more they are difficult to collect as they are spread in different administration and institutions. Normally this information can be found in doctoral studies and technical reports. To extract information from a technical report, normally, it isn't an easy duty as it is aggregated, difficult to find and is not in an electronic support database. This information does not arrive to scientists, managers and stakeholders, highlighting an historical problem in the flux of information between them (Fletcher, 2007).

The relationship between marine science and marine policy has historically been characterised by communication difficulties (including differing vocabularies and meanings) and clashing values (including differing notions of significance, timescale, and political impact) (Duda and Sherman, 2002). Science seems to have a working philosophy fundamentally different to the one done by policy-making (Fletcher, 2007). Stakeholder opinions towards socio-economic as well as environmental objectives need to be considered and can empirically measured and used as indicators for management (Ramos *et al.,* 2007). The challenge here is then to anticipate in a cost-effective way in terms of data collection and availability of information increasing both marine research and scientist–implementer collaboration (Borja, 2006) and even more administrations participation. This common work should end with gaps in data and short temporal series. Long-term contracts to universities and institutions, guarantees the necessary continuation concerning the physical, chemical and biological monitoring (e.g.: data interpretation, data handling, cause-effect studies) to determine the most available indicators (Fletcher, 2007) and gather more quality data. The increase in co-operation between academic world and governmental services is required for management tools as monitoring, modelling and evaluating the quality of marine ecosystem. The government has the final decision, but the academic community can design the appropriate monitoring programs and data interpretation (Jonge, 2007). This collaboration should make strategies on data collection to accomplish the requirements of EU Directives.

The existence of high quantities of information about tourism demonstrated that in the administration there is a lack of culture of gathering parameters to manage the marine environment. For this reasons there is a lack of long temporal series evaluating the States and Impacts. If data is available is in a punctual way, or with sort temporal series and with a high aggregation level. There is a lack of investment to establish following up programs and sampling protocols to manage. There exists a need to implement this type of programs as European Directives like the actual WFD or the future MDS require the member countries to establish a control plan for which as much as possible data series are needed. Nowadays there exist complications in the implementation of MSD (Marine Strategy Directive) as significant information gaps have been found (Borja, 2006; Salomon, 2006). Our research evidences here a great gap, resulted in a lack of information and data proving, more work is needed to solve this lacks of information and data.

This arises from historical perceptions of marine environment understood as inexhaustible and hardly to explorer. Traditionally marine environments have been forgotten as they are less accessible and difficult to study. For this long temporal and spatial series of data about marine habitats and species are difficult to find. The tourism is the actuality the most important socioeconomic areas in the studied region (Hall, 2001) and this fact of economical importance was reflected in the local and regional policies and administration. Environmental administrations presented a slower response or even didn't answer to our enquiry showing at a local or regional level lack of mobility of data and lower efficiency in the response. Comparing them with tourism institutions that present a good and efficiency response to the enquiry of data it is tangible that there is a high importance on the tourism meanwhile the importance on the fisheries and environmental resources has declined. This economical importance may be one of the causes why the number of human resources destined in the environmental and fisheries administration is fewer than for tourism administrations. Moreover, although more specific data about fisheries must exist this is gathered by private institutions, mainly brotherhoods, that historically do not declare specifically all their captures. Is difficult to know the cause of the lack of involvement of these institutions, but indicators are needed to evaluate how well a fishery is managed, in relation to specified objectives (Hilborn and Walters, 1992). This is the reason why to find data not aggregated is almost impossible, being this aggregation so high that joins fishing areas making the assessment of the protection effect difficult when speaking of smallest areas. Generally by society the increase of captures it is frowned upon, meanwhile the increase of tourism and tourism facilities is related with an economical growth in spite of the environmental impacts.

Even being the tourism administration well organized and quicker in their responses the tourism institutions have a scarce on determinate tourism information, being more controlled in land than in the sea. The number of recreational boats sailing around the coast, the increase of maritime sailing in summer, increase in acoustical pollution, the evolution on the number of mooring points in the recreational ports and the number of anglers and their captures, are some of the data that are unknown. Important factors that impact over several populations (fishes, turtles, sea mammals, etc.) producing also significant impacts in the benthic communities. Also the anglers' data must be regarded as this is an interesting pressure over the supra-littoral and medio-littoral communities. These are uncontrolled activities that have a potential impacts must be regulated.

The conditions of the information and/or data in the administrations have repercussions on the assessment of the protection on MPAs. The inexistence of suitable information makes difficult or even impossible the assessment of the effects of certain pressures of the fishing sector and tourism sector. This gap of information and data makes impossible the management and planning of aspects affecting the MPAs and even makes unachievable the establishment of solutions. This contravenes all the recommendations that have been done by many forums (Pomeroy *et al.,* 2005) and by the regulations proposed by many European Directives. Besides this lack of data is in disagreement with all of the statements done about the effectively and necessity to use indicators as tools for management to evaluate MPAs effectiveness. The assessment of potentially used as indicators however as much correlated with the protection effect that they can be if they are not available and their quality is good they can't be used as indicators.

With the results of this research we propose the following recommendations:

- Data must be at least at a locality sampling level to analyze without confusions the protection effect. For example for the fishing sector, captures should be gathered by boat, by day and with position (GPS) information and for the tourism sector should exist the number of visitants by MPA.
- It must be accorded a consensus between managers and stakeholders to define which the parameters that should be measured are. This must be done by participation processes taking in account every stakeholder and by the use of conceptual frameworks to help in their development (e.g.: DPSIR framework).
- Data available in official databases should provide a spatial and temporal uniform distribution as it will be used to develop indicators.
- It is needed of a disaggregating of biological and socioeconomic information, in time and space to assess the environmental pressures. Monthly local data is the most appropriated scale.
- The definition and use of indicators should guarantee a continuous and updated collection of data.
- State and Impact data available in an academic and scientific context must arrive to a management, policy and stakeholders context. It must be solved the conflict between managers and scientists to increase the effectiveness on the assessment of MPAs protection.

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2. STATISTICAL ASSESSMENT OF PARAMETERS AS POTENTIAL INDICATORS.

Abstract

Marine Protected Areas (MPAs) have become popular tools worldwide for ecosystem conservation and fisheries management. Indicators are being developed as tools to assess MPAs effectiveness. In spite of the great number of indicators found in the bibliography, they don't accomplish the necessary characteristics to be good indicators and fewer are the cases were their validity has been proved. With underwater visual census (UVC) for fish for 34 case studies which belonged to 13 MPAs generating a final database included 3098 samples of abundance data and 2729 samples of biomass With fisheries biomass data we of samples from 11 different fishing gears from 11 MPAs, we generated a final database that included 40978 samples. All the MPAs were located from the North-Western Mediterranean to central-Eastern Atlantic. Data ranged from 1 year before the establishment of the MPA to 34 years after. Species were categorized within taxonomic, trophic and commercial categories. The aim of this study was to: i) assess which parameters were the best indicators of the protection effect for data estimated by UVC census and fisheries samples; ii) determine between them which were those that respond effectively to different structural characteristics of the MPAs and iii) validate with independent data the indicators proposed. This was one of the first's studies that use an independent set of data for validation. Our aim was to find a global set of parameter to assess the protection effect related with structural characteristics of any MPA. Most of the variables were related but with low correlation values. For UVC the taxonomic distinctness diversity index, the total abundance and total biomass, were those best related. For fisheries the results differ among the fishing gears analyzed, however more parameters validate the model. There is a high temporal and spatial variability presenting a high dispersion due to ecological and structural variables of the different MPAs analyzed.

Introduction

Indicators nowadays are being widely used with different ecological purposes. This use has turned them into a complementarily and essential tool for management to address environmental issues (OECD, 1991; OECD, 1994; EEA, 1999). They have been applied to assess the implementation of the European Water Framework Directive (e.g.: Jeunesse et al., 2003; Salas et al., 2004; Mysiak et al., 2005; Borja et al., 2006), coastal zone studies (e.g.: Cooley et al., 1996; Casazza et al., 2002 a; Elliott, 2002; Jorge et al., 2002; Silva and Rodrigues, 2002; Nunneri and Hoffman, 2003; Picollo et al., 2003) and fisheries management (Mangi et al., 2006; Rochet et al., 2007).

An indicator is defined as a measure (quantitative or qualitative) that is indicative of the condition of some aspect of the system as a whole (ANZECC, 1998). Waltz and Meadows (Unesco, 2003) listed the characteristics of a good indicator: 1) to have an agreed scientifically sound meaning, 2) to be representative of an important environmental aspect for the society, 3) to provide valuable information with a readily understandable meaning, 4) to be meaningful to external audiences, 5) to help in focusing information necessary for answering important questions, and 6) to assist decision-making by being efficient and cost-effective to use.

At least in theory, all ecological indicators accounting for the composition and abundance of biological communities might be useful in detecting the environmental situation of an ecosystem. Costello et al., (2004) surveyed the frequency of using diversity indices in the scientific literature and found that the most widely used and popular measure of diversity is species richness (e.g.: number of species, Margalef index). Other reviews assess that the number of species or the Shannon index, are those more used (Salas, 2002). However the parameters used to assess the protection effect in MPAs are mainly those related to the effects on populations and assemblages, being mainly the abundance, biomass and species size (Chapter 2). Though indicators have been widely used in many ecosystems approaches in a marine protected areas (MPAs) ecosystem approach are being now developed.

Over the past decades, marine resources have been overexploited (Castilla, 2000), affecting to marine biodiversity and decreasing the fisheries stocks. In addition, fish habitats have also been strongly altered by, resulting in a reduction of habitat complexity (Sumaila et al., 2000). To decrease this pressures different actions have been established worldwide to protect marine biodiversity and ensure fisheries stocks. One of these tools was the establishment of MPAs that are increasingly considered in coastal areas as an instrument to preserve fauna and habitat from detrimental effects of different pressures (Francour et al., 2001; Halpern, 2003; Sainsbury and Sumaila, 2003). Many studies assess the effectiveness of MAPs (Roberts and Polunin, 1991; Dugan and Davis, 1993; Rowley, 1994; Bohnsack, 1998; Halpern, 2003). But MPAs effects may be diverse in direction and magnitude (Halpern and Warner, 2002). But many of the studies assessing this effectiveness claim to structural characteristics of the MPA, e.g.: effects depending on species and years of protection with respect to reserve establishment (Mosqueira et al., 2000) and effects depending on the size (Forcada, 2007). Yet almost none of these studies had assessed the protection effect relating with the enforcement, the number of surveillance hours or even the budget and it is known that this characteristics mainly structural may affect the protection effect over the species, communities and habitats sheltered.

Marine protected areas (MPAs) are increasingly envisaged as a tools to manage coastal ecosystems and fisheries. Assessment of their performance with respect to management objectives is therefore important. Tools to assess this effects and useful for management are needed and indicators seem to be one of them. When they are used effectively, indicators are expected to reveal conditions and trends that help in development planning and decision making (Unluata, 1999). Therefore, the selection of a set of indicators must ultimately provide information that can be understood by the managers and stakeholders, and provide them with a base for decision making. In this sense indicators can contribute to monitoring the effectiveness of MPAs.

The increase number of indicators and indexes proposed and the dispersion and heterogeneity of MPAs and the high number of situations for which they had been applied raise to question if all of them are applicable in any different structural characteristics and for any type of community or species and even more if all of them are easily understood not only by scientists but for managers. In spite of the great number of indicators found in the bibliography, they don’t accomplish the necessary characteristics to be good indicators and fewer are the cases were their validity has been proved. For this reasons the objectives of this study were to: a) assess which parameters were the best indicators of the protection effect for data estimated by UVC census and fisheries samples, b) determine between them which were those that respond effectively to different structural characteristics of the MPAs and c) validate with independent data the parameters proposed.

Data Collection For Fish Uvc From Wp1

The analyses were done using the database from WP1. This dataset, which included 61 case studies from 19 MPAs, had several important errors:

- There was more than one register for the same species in a sample. This is because there was a lack of information in the space (*"location"*, *"site"*, *"replicate"*) and/or time (*"time"*, *"dummy (t)"*) replication variables, making impossible to know the real number of samples included in each study. This occurred in 14 studies.
- There were several denominations for the same species due to wrong spelling, synonyms and sex differentiation. This carry to an erroneous number of species (total and/or per sample).
- In several studies, the total abundance and the sum of the abundance of the different size groups were not the same. This indicated an error filling the table, but it is impossible to know which the wrong value was.
- Studies of one MPA done in the same year had different values in the *"years since enforcement"* field. This gave to an erroneous evaluation of the effect of time of protection.

All these mistakes came from the original database of WP1 because:

- A field for the sample code was not included, hindering the sample data identification.
- The names of the species entered were not checked looking for possible wrong spelling or synonyms.
- Any check of the data was done looking for obvious mistakes.

Only the studies that included fish recorded by underwater visual census were selected, and after correcting part of the errors possible to solve, the dataset incorporated 34 case studies from 13 MPAs distributed over 2500 km from north-western Mediterranean to central-eastern Atlantic (Figure 2.1). The final database included 3098 samples of abundance data and 2729 of biomass data, which ranged from 5 years before the establishment of MPA to 30 years after. For each MPA, the final number of studies and samples used in the analyses were summarized in Table 2.1.

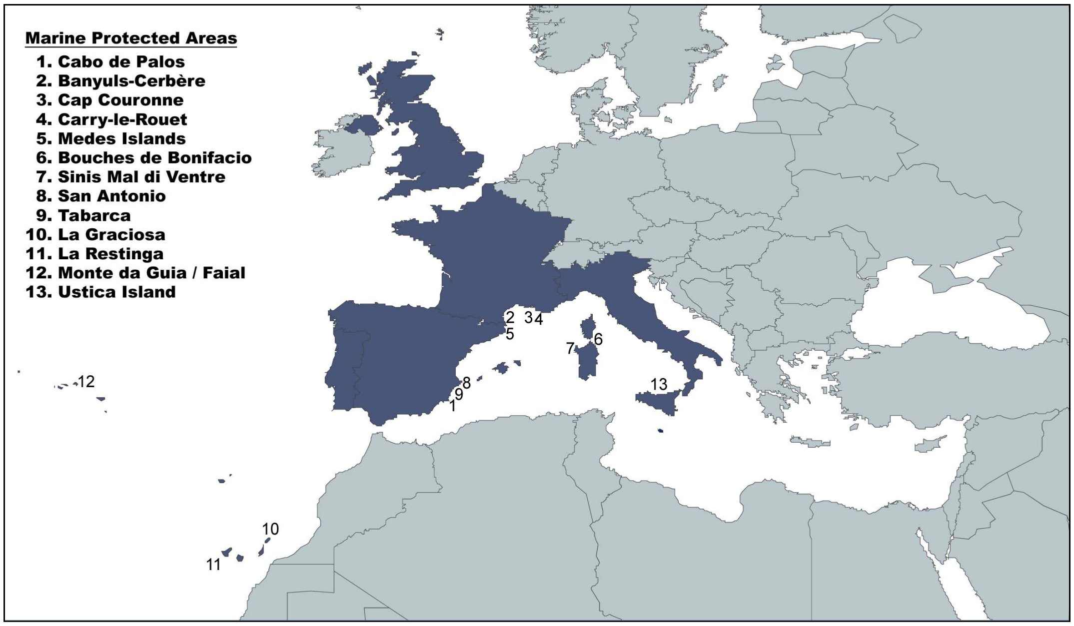

Figure 2.1. Location of the 13 marine protected areas analyzed.

Table 2.1. Number of case studies and samples analyzed per each marine protected area.

Participants	MPA	Abundance data		Biomass data	
		Case studies	Samples	Case studies	Samples
UMU	Cabo de Palos	3	279	1	54
CNRS	Banyuls- Cerbère	3	242	1	161
	Cap Couronne	1	48	1	12
	Carry-le-Rouet	2	410	1	162
ICM	Medes Islands*	1	126	1	126
IMC	Bouches de Bonifacio*	1	600	1	840
	Sinis Mal di Ventre*	2	36	1	33
UA	San Antonio	4	202	3	186
	Tabarca	4	399	4	399
ULL	La Graciosa	6	252	6	252
	La Restinga	4	296	4	296
IMAR	Monte da Guia / Faial*	1	80	1	80
UPA	Ustica Island*	1	128	1	128
TOTAL		33	3098	26	2729

*Indicates the MPAs removed for some analyses because their descriptors characteristics were incomplete (see Table 3).

Fish assemblage structure was specified for each census by species abundance and biomass. Several diversity indexes were estimated for each sample: total species (S), Margalef (d), Pielou's evenness (J'), Shannon-Wiener (H'(loge)), Simpson (1-λ'), taxonomic distinctness (Δ*), average taxonomic distinctness (Δ+), variation in taxonomic distinctness (Λ+), average phylogenetic diversity (Φ+) and total phylogenetic diversity (sΦ+) (Clarke & Gorley, 2006). The recorded species were grouped into 9 taxonomic categories (big labridae, small labridae, big serranidae, small serranidae, big sparidae, *Diplodus* spp., medium pelagics, small pelagics and other species) and 5 trophic categories (detritivorous, herbivorous, microphagous, mesophagous, macrophagous) constructed according taxonomy and feeding habits (Table 2.2).

Table 2.2 Taxonomic categories and trophic categories of the species observed in the case studies analyzed.

Species	Taxonomic category	Trophic category
Abudefduf luridus	Small pelagics	Mesophagous
Acantholabrus palloni	Big labridae	Mesophagous
Alosa fallax	Small pelagics	Microphagous
Aluterus scriptus	Other species	Herbivorous
Anthias anthias	Other species	Mesophagous
Apogon imberbis	Other species	Mesophagous
Argentina sphyraena	Other species	Mesophagous
Argyropelecus hemigymnus	Small pelagics	Mesophagous
Arnoglossus spp.	Other species	Mesophagous
Aspitrigla cuculus	Other species	Mesophagous
Aspitrigla obscura	Other species	Mesophagous
Atherina spp.	Small pelagics	Microphagous
Aulopus filamentosus	Other species	Macrophagous
Aulostomus strigosus	Other species	macrophagous
Auxis rochei	Small pelagics	Macrophagous
Balistes carolinensis	Other species	Mesophagous
Belone belone	Small pelagics	Macrophagous
Bodianus scrofa	Big labridae	Mesophagous
Boops boops	Small pelagics	Microphagous
Bothus podas	Other species	Mesophagous
Callionymus pusillus	Other species	Mesophagous
Canthidermis sufflamen	Other species	Mesophagous
Canthigaster capistratus	Other species	Mesophagous
Caranx crysos	Medium pelagics	Macrophagous
Caranx latus	Medium pelagics	Macrophagous
Caranx lugubris	Medium pelagics	Macrophagous
Centrolabrus trutta	Big labridae	Mesophagous
Chelidonichthys lastoviza	Other species	Mesophagous
Chelon labrosus	Medium pelagics	Detritivorous
Chilomycterus atringa	Other species	Mesophagous
Chromis chromis	Small pelagics	Microphagous
Chromis limbata	Small pelagics	Microphagous
Conger conger	Other species	Macrophagous
Coris julis	Small labridae	Mesophagous
Coryphaena hippurus	Medium pelagics	Macrophagous
Ctenolabrus rupestris	Small labridae	Mesophagous
Dasyatis centroura	Other species	Macrophagous
Dasyatis pastinaca	Other species	Macrophagous
Dentex dentex	Big sparidae	Macrophagous
Dentex gibbosus	Big sparidae	Macrophagous
Dicentrarchus labrax	Small serranidae	Macrophagous
Diplodus annularis	*Diplodus* spp.	Mesophagous
Diplodus cervinus	*Diplodus* spp.	Mesophagous
Diplodus puntazzo	*Diplodus* spp.	Mesophagous
Diplodus sargus	*Diplodus* spp.	Mesophagous
Diplodus vulgaris	*Diplodus* spp.	Mesophagous
Enchelycore anatina	Other species	Macrophagous
Engraulis encrasicolus	Small pelagics	Microphagous
Epinephelus aeneus	Big serranidae	Macrophagous
Epinephelus caninus	Big serranidae	Macrophagous
Epinephelus costae	Big serranidae	Macrophagous
Epinephelus marginatus	Big serranidae	Macrophagous
Gaidropsarus biscayensis	Other species	Macrophagous
Gnatholepis thompsoni	Other species	Mesophagous

Species	Taxonomic category	Trophic category
Gobius auratus	Other species	Mesophagous
Gobius bucchichi	Other species	Mesophagous
Gobius cruentatus	Other species	Mesophagous
Gobius geniporus	Other species	Mesophagous
Gobius niger	Other species	Mesophagous
Gobius paganellus	Other species	Mesophagous
Gobius xanthocephalus	Other species	Mesophagous
Gymnothorax miliaris	Other species	Macrophagous
Gymnothorax unicolor	Other species	Macrophagous
Heteroconger longissimus	Other species	Detritivorous
Heteropriacanthus cruentatus	Other species	Microphagous
Kyphosus sectator	Other species	Mesophagous
Kyphosus spp.	Other species	Mesophagous
Labrisomus nuchipinnis	Other species	Mesophagous
Labrus bergylta	Big labridae	Mesophagous
Labrus bimaculatus	Big labridae	Mesophagous
Labrus merula	Big labridae	Mesophagous
Labrus viridis	Big labridae	Mesophagous
Lepadogaster candollei	Other species	Mesophagous
Lepadogaster zebrina	Other species	Microphagous
Lichia amia	Medium pelagics	Macrophagous
Lipophrys nigriceps	Other species	Mesophagous
Lithognathus mormyrus	Other species	Mesophagous
Liza aurata	Medium pelagics	Detritivorous
Lophius piscatorius	Other species	Macrophagous
Mugilidae	Medium pelagics	Detritivorous
Mulloides martinicus	Other species	Mesophagous
Mullus barbatus	Other species	Mesophagous
Mullus surmuletus	Other species	Mesophagous
Muraena augusti	Other species	Macrophagous
Muraena helena	Other species	Macrophagous
Mustelus mustelus	Other species	Macrophagous
Mycteroperca fusca	Big serranidae	Macrophagous
Mycteroperca rubra	Big serranidae	Macrophagous
Myliobatis aquila	Other species	Macrophagous
Myrichthys pardalis	Other species	macrophagous
Oblada melanura	Small pelagics	Microphagous
Ophioblennius atlanticus	Other species	Mesophagous
Pagellus acarne	Big sparidae	Mesophagous
Pagellus bogaraveo	Big sparidae	Mesophagous
Pagellus erythrinus	Big sparidae	Mesophagous
Pagrus auriga	Big sparidae	Mesophagous
Pagrus pagrus	Big sparidae	Mesophagous
Parablennius gattorugine	Other species	Mesophagous
Parablennius incognitus	Other species	Mesophagous
Parablennius parvicornis	Other species	Mesophagous
Parablennius pilicornis	Other species	Mesophagous
Parablennius rouxi	Other species	Mesophagous
Parablennius ruber	Other species	Mesophagous
Parablennius tentacularis	Other species	Mesophagous
Paralipophrys trigloides	Other species	Mesophagous
Parapristipoma octolineatum	Other species	Mesophagous
Phycis phycis	Other species	Macrophagous
Pomadasys incisus	Other species	Mesophagous
Pomatomus saltator	Medium pelagics	Macrophagous
Pomatoschistus pictus	Other species	Mesophagous
Pseudocaranx dentex	Medium pelagics	Macrophagous
Pteromylaeus bovinus	Other species	Macrophagous
Sarda sarda	Medium pelagics	Macrophagous
Sardina pilchardus	Small pelagics	Microphagous
Sardinella aurita	Small pelagics	Microphagous
Sardinella maderensis	Small pelagics	Microphagous
Sarpa salpa	Other species	Herbivorous
Scartella cristata	Other species	Mesophagous
Sciaena umbra	Other species	Macrophagous
Scomber japonicus	Small pelagics	Macrophagous
Scorpaena canariensis	Other species	Macrophagous
Scorpaena maderensis	Other species	Macrophagous
Scorpaena notata	Other species	Macrophagous
Scorpaena porcus	Other species	Macrophagous
Scorpaena scrofa	Other species	Macrophagous
Seriola dumerili	Medium pelagics	Macrophagous

Species	Taxonomic category	Trophic category
Seriola fasciata	Medium pelagics	Macrophagous
Seriola rivoliana	Medium pelagics	Macrophagous
Serranus atricauda	Small serranidae	Macrophagous
Serranus cabrilla	Small serranidae	Macrophagous
Serranus hepatus	Small serranidae	Macrophagous
Serranus scriba	Small serranidae	Macrophagous
Solea vulgaris	Other species	Mesophagous
Sparisoma cretense	Other species	Mesophagous
Sparus aurata	Big sparidae	Mesophagous
Sphoeroides marmoratus	Other species	Mesophagous
Sphyraena spp.	Medium pelagics	Macrophagous
Sphyrna spp.	Other species	Macrophagous
Spicara flexuosa	Small pelagics	Microphagous
Spicara maena	Small pelagics	Microphagous
Spicara smaris	Small pelagics	Microphagous
Spondyliosoma cantharus	Big sparidae	Mesophagous
Squatina squatina	Other species	Mesophagous
Stephanolepis hispidus	Other species	Microphagous
Symphodus bailloni	Small labridae	Mesophagous
Symphodus cinereus	Small labridae	Mesophagous
Symphodus doderleini	Small labridae	Mesophagous
Symphodus mediterraneus	Small labridae	Mesophagous
Symphodus melanocercus	Small labridae	Mesophagous
Symphodus melops	Small labridae	Mesophagous
Symphodus ocellatus	Small labridae	Mesophagous
Symphodus roissali	Small labridae	Mesophagous
Symphodus rostratus	Small labridae	Mesophagous
Symphodus spp.	Small labridae	Mesophagous
Symphodus tinca	Small labridae	Mesophagous
Syngnathus typhle	Other species	Microphagous
Synodus saurus	Other species	Macrophagous
Synodus synodus	Other species	Macrophagous
Taeniura grabata	Other species	Macrophagous
Thalassoma pavo	Small labridae	Mesophagous
Thorogobius ephippiatus	Other species	Mesophagous
Torpedo marmorata	Other species	Mesophagous
Torpedo torpedo	Other species	Macrophagous
Trachinus draco	Other species	Macrophagous
Trachurus mediterraneus	Small pelagics	Macrophagous
Trachurus picturatus	Small pelagics	macrophagous
Trachurus spp.	Small pelagics	Macrophagous
Trachurus trachurus	Small pelagics	Macrophagous
Trachynotus ovatus	Small pelagics	Macrophagous
Tripterygion delaisi	Other species	Mesophagous
Tripterygion tripteronotus	Other species	Mesophagous
Trisopterus minutus	Other species	Mesophagous
Umbrina canariensis	Other species	Mesophagous
Umbrina cirrosa	Other species	Mesophagous
Umbrina ronchus	Other species	Mesophagous
Uranoscopus scaber	Other species	Macrophagous
Vanneaugobius canariensis	Other species	Mesophagous
Xyrichtys novacula	Other species	Mesophagous
Zeus faber	Other species	Macrophagous

The protection status of each sample was measured by means of 17 variables related with: protection level (no protection: 1; regulated: 2; partial 3; integral: 4), temporal measures of protection (years since MPA creation, years since enforcement), structural characteristics of the MPA (total size, integral reserve size, buffer area size, restricted use area size, proportion of the integral reserve, perimeter, ratio perimeter/size, number of zones), siting place (distance to another MPA, distance to main town, isolation) and management carried out (compliance, total hours of enforcement, total annual budget). For the estimation of these variables where used the data showed in table 2.3.

Table 2.3. Characteristics descriptors of the 13 MPAs included in the analyses.

Participants	MPA	Year of establishment	Year of enforcement	Total size (ha)	Integral reserve size (ha)	Buffer area size (ha)	Resticted use area size (ha)	Proportion of the integral reserve (%)	Perimeter (m)	Ratio perimetar/size	Number of zones	Distance to another MPA (km)	Distance to main town (km)	Isolation*[1]	Compliance*[2]	Total hours of enforcement	Total annual budget (€)
UMU	Cabo de Palos	1995	1995	1898	270	1628	0	14.26	19891	0.00105	2	55	0	2	3	4872	246026
CNRS	Banyuls-Cerbère	1974	1974	650	65	585	0	10.00	8500	0.00131	2	40	0	1	3	1000	400000
	Cap Couronne	1996	1996	210	210	0	0	100.00	6000	0.00286	1	20	0.15	2	3	286	175398
	Carry-le-Rouet	1982	1982	85	85	0	0	100.00	3000	0.00353	1	20	0	1	3	1752	175398
ICM	Medes Islands	1983	1983	511	93	418	0	18.20	9000	0.00176	2	15	1	2	3	2120	NA
IMC	Bouches de Bonifacio	1999	1999	80000	1200	12000	66800	1.50	120000	0.00015	3	3	0.5	2	3	NA	1800000
	Sinis Mal di Ventre	1997	2001	25673	529	1031	24113	2.06	70000	0.00027	3	62	8	2	2	NA	700000
UA	San Antonio	1993	1998	110	110	0	0	100.00	4200	0.00382	1	60	0	1	2	1600	200000
	Tabarca	1986	1987	1400	100	630	670	7.14	17000	0.00121	3	40	4	2	3	15880	555128
ULL	La Graciosa	1995	1997	70000	1225	8479	60296	1.75	175000	0.00025	3	450	27	2	2	1214	585388
	La Restinga	1996	1996	993	180	123	690	18.13	26500	0.00267	3	100	18	1	3	3009	350346
IMAR	Monte da Guia / Faial	1980	1985	443	10	433	0	2.26	2400	0.00054	2	200	3	1	2	NA	NA
UPA	Ustica Island	1991	1996	16000	60	7940	8000	0.38	44000	0.00028	3	65	0	3	2	NA	NA

NA: Not available data. *[1]. 1: in coast; 2: close to the coast; 3: far to the coast. *[2]. 1: null; 2: deficient; 3: good.

Data Analysis

The case studies included had different sampling design, sampling intensity and spatial or temporal scales addressed. As the main objective is to identify indicators of the protection effect, samples were aggregated performing the analyses at level of protection status of the area, years since protection and season.

Two complementary methodological modelling approaches were applied: using empirical models to reveal the causal factors determining the effectiveness of MPAs such as data mining and one of the regression forms to simulate the effects of protection in MPAs for several parameters and investigate the interrelationship between the MPAs effectiveness and the different considered structural issues related with protection. Mechanistic models tend to be more general and widely applicable than empirical models because of their strong theoretical bases. Empirical models, on the other hand, have the advantage of high predictive accuracy over mechanistic models for the areas the models are developed, and can also provide insight into the ecosystem processes if the input variables are properly chosen and ecologically meaningful. An empirical model is therfore a better choice for a predictive purpose, such as the effects of protection in MPAs, due to its reality and accuracy.

Evidencing Important Protection Issues By Data Mining

The development of computer technology allow to be popular the data mining methods as a new empirical model. It exhibits a strong ability to predict new cases based on previously known information. Data mining is a process of querying and extracting useful information, patterns and trends often previously unknown from large quantities of existing data. Decision tree is one of the data mining methods and has been widely used in several scientific areas, including environmental modelling applications with considerable accuracy and ease of interpretation.

Decision tree is a non-parametric modelling approach which recursively splits the multidimensional space defined by the independent variables into zones that are as homogeneous as possible in terms of the rtesponse of the dependent variable. The result of the analysis is a binary hierarchy structure called a decision tree with bhanches and leaves that contains the rules to predict the new cases. Decision tree has many advantages over other model approaches such as regression. Namely, a) it has no strict assumptions for the distribution of the target variable (dependent variable) about which regression assumes normal distribution. Also, there is no multicillinearity problem when input variables (independent variables) are highly correlated, which is a limitation of multiple regression; b) decision tree deals with non-linear models easily without any variable transformation; c) decision tree can clearly indicate the relative importance of input variables with respect to their influences on the model target, and can also indicate the interactions among input variables; d) it can easily incorporate ordinal (such as those measured as low, medium and high), nominal (such as those for MPA objectives) and interval (such as those for abundance) variables in the same model. As limitations, a decision tree requires a relatively large amount of training data. It cannot express linear relationships in a simple and concise way like regressions does; it cannot produce a continuous output due to its binary nature, and it has no unique and best solution.

In this study, we focused on the effects on protection on fish biodiversity developing the decision tree model to evaluate the importance of the different structural issues of MPAs on the structure of fish assemblage.

Data Mining Results

We run the data mning analysis on abundance data of fishes from underwater visual census. We split the data in individual occurrencies reaching 1.640.000 cases for the analysis, organized in 1.640.000 rows and 34 columns. We aggregated the data at functional leves and trophic categories, relating them with the mentioned above descriptors of MPAs. The exploration begun including all the structural descriptors, repeating subsequently the analysis removing those that produce non-explanatory options.

Including all the structural descriptors of MPAs, the tree exhibited an overadjustment for some descriptors such as depth range of type of bottom (Fig. 2.1). Removing these descriptors, the model overadjusted for Distance to main town (Fig. 2.2). These results evidenced some specificity in each set of data coming from the different MPAs related with those descriptors. For this reason, they can be considered as inappropiates to assess the effectiveness of protection.

After several analyses, we obtain an explanatory tree that classified firstly the data according to the size of the buffer area and the perimeter for the functional categories (Fig. 2.3 for all cases and 4 considering only cases from protected areas), evidencing the role of the MPA size in the effectiveness of protection.

Considering only protected cases on trophic categories, the model split firstly on the years from creation and, secondly, on descriptors related to the size of the MPAs (Fig.2.5), suggesting that the effects of size diminish after a certain years from creation and increase the role of management descriptors. These results can suggest the existence of limits in the carrying capacity of the MPAs for the increase of the abundance, that is replaced for the increase of diversity of functional categories.

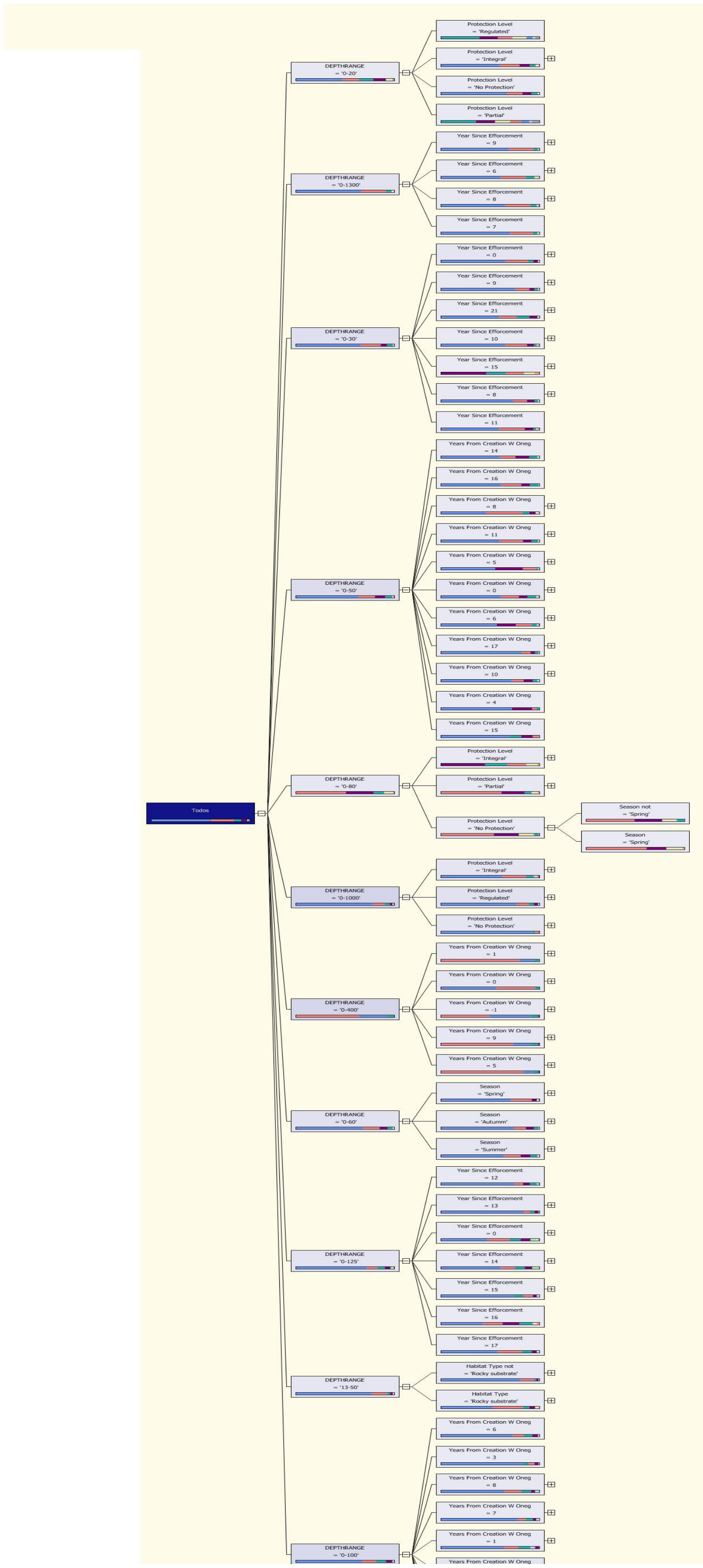
Todos
DEPTHRANGE = '0-20'
Protection Level = 'Regulated'
Protection Level = 'Integral'
Protection Level = 'No Protection'
Protection Level = 'Partial'
DEPTHRANGE = '0-1300'
Year Since Efforcement = 9
Year Since Efforcement = 6
Year Since Efforcement = 8
Year Since Efforcement = 7
DEPTHRANGE = '0-30'
Year Since Efforcement = 0
Year Since Efforcement = 9
Year Since Efforcement = 21
Year Since Efforcement = 10
Year Since Efforcement = 15
Year Since Efforcement = 8
Year Since Efforcement = 11
DEPTHRANGE = '0-50'
Years From Creation W Oneg = 14
Years From Creation W Oneg = 16
Years From Creation W Oneg = 8
Years From Creation W Oneg = 11
Years From Creation W Oneg = 5
Years From Creation W Oneg = 0
Years From Creation W Oneg = 6
Years From Creation W Oneg = 17
Years From Creation W Oneg = 10
Years From Creation W Oneg = 4
Years From Creation W Oneg = 15
DEPTHRANGE = '0-80'
Protection Level = 'Integral'
Protection Level = 'Partial'
Protection Level = 'No Protection'
Season not = 'Spring'
Season = 'Spring'
DEPTHRANGE = '0-1000'
Protection Level = 'Integral'
Protection Level = 'Regulated'
Protection Level = 'No Protection'
DEPTHRANGE = '0-400'
Years From Creation W Oneg = 1
Years From Creation W Oneg = 0
Years From Creation W Oneg = -1
Years From Creation W Oneg = 9
Years From Creation W Oneg = 5
DEPTHRANGE = '0-60'
Season = 'Spring'
Season = 'Autumn'
Season = 'Summer'
DEPTHRANGE = '0-125'
Year Since Efforcement = 12
Year Since Efforcement = 13
Year Since Efforcement = 0
Year Since Efforcement = 14
Year Since Efforcement = 15
Year Since Efforcement = 16
Year Since Efforcement = 17
DEPTHRANGE = '13-50'
Habitat Type not = 'Rocky substrate'
Habitat Type = 'Rocky substrate'
DEPTHRANGE = '0-100'
Years From Creation W Oneg = 6
Years From Creation W Oneg = 3
Years From Creation W Oneg = 8
Years From Creation W Oneg = 7
Years From Creation W Oneg = 1
Years From Creation W Oneg

Figure 2.1.

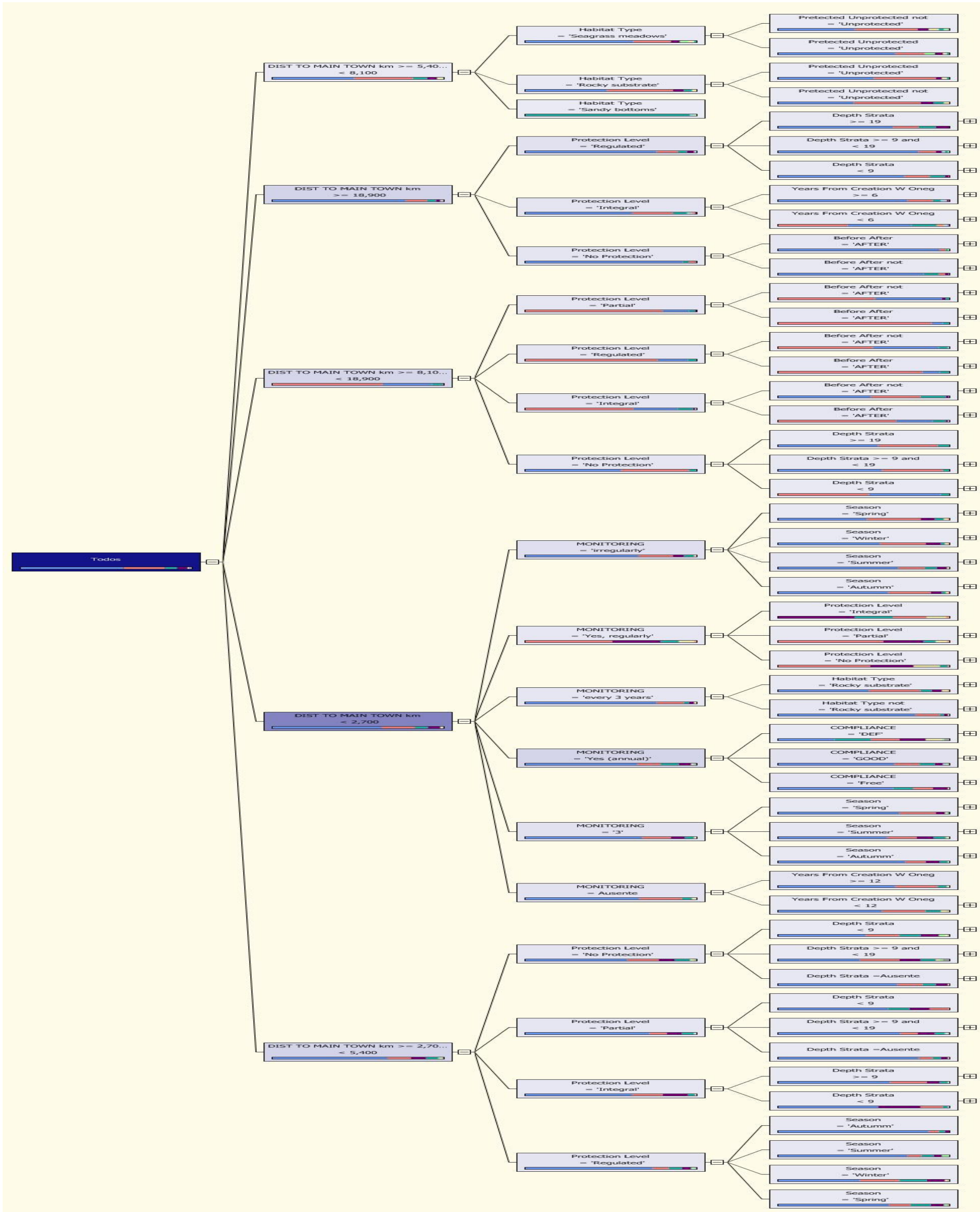
Todos
DIST TO MAIN TOWN km >= 5,40... < 8,100
DIST TO MAIN TOWN km >= 18,900
DIST TO MAIN TOWN km >= 8,10... < 18,900
DIST TO MAIN TOWN km < 2,700
DIST TO MAIN TOWN km >= 2,70... < 5,400
Habitat Type = 'Seagrass meadows'
Habitat Type = 'Rocky substrate'
Habitat Type = 'Sandy bottoms'
Protection Level = 'Regulated'
Protection Level = 'Integral'
Protection Level = 'No Protection'
Protection Level = 'Partial'
Protection Level = 'Regulated'
Protection Level = 'Integral'
Protection Level = 'No Protection'
MONITORING = 'irregularly'
MONITORING = 'Yes, regularly'
MONITORING = 'every 3 years'
MONITORING = 'Yes (annual)'
MONITORING = '3'
MONITORING = Ausente
Protection Level = 'No Protection'
Protection Level = 'Partial'
Protection Level = 'Integral'
Protection Level = 'Regulated'
Protected Unprotected not = 'Unprotected'
Protected Unprotected = 'Unprotected'
Protected Unprotected = 'Unprotected'
Protected Unprotected not = 'Unprotected'
Depth Strata >= 19
Depth Strata >= 9 and < 19
Depth Strata < 9
Years From Creation W Oneg >= 6
Years From Creation W Oneg < 6
Before After = 'AFTER'
Before After not = 'AFTER'
Before After not = 'AFTER'
Before After = 'AFTER'
Before After not = 'AFTER'
Before After = 'AFTER'
Before After not = 'AFTER'
Before After = 'AFTER'
Depth Strata >= 19
Depth Strata >= 9 and < 19
Depth Strata < 9
Season = 'Spring'
Season = 'Winter'
Season = 'Summer'
Season = 'Autumm'
Protection Level = 'Integral'
Protection Level = 'Partial'
Protection Level = 'No Protection'
Habitat Type = 'Rocky substrate'
Habitat Type not = 'Rocky substrate'
COMPLIANCE = 'DEF'
COMPLIANCE = 'GOOD'
COMPLIANCE = 'Free'
Season = 'Spring'
Season = 'Summer'
Season = 'Autumm'
Years From Creation W Oneg >= 12
Years From Creation W Oneg < 12
Depth Strata < 9
Depth Strata >= 9 and < 19
Depth Strata =Ausente
Depth Strata < 9
Depth Strata >= 9 and < 19
Depth Strata =Ausente
Depth Strata >= 9
Depth Strata < 9
Season = 'Autumm'
Season = 'Summer'
Season = 'Winter'
Season = 'Spring'

Figure 2.2

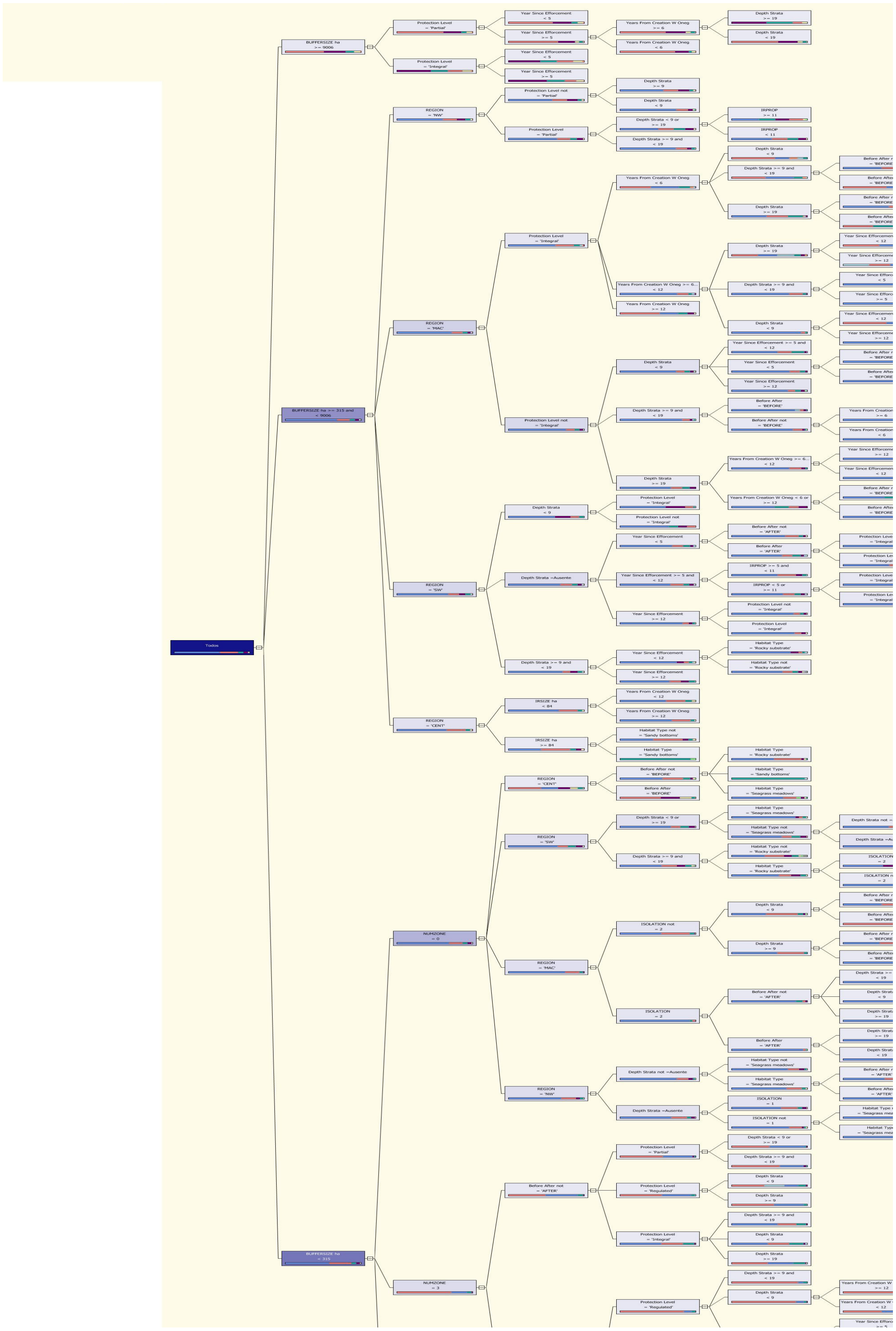

Figure 3.2

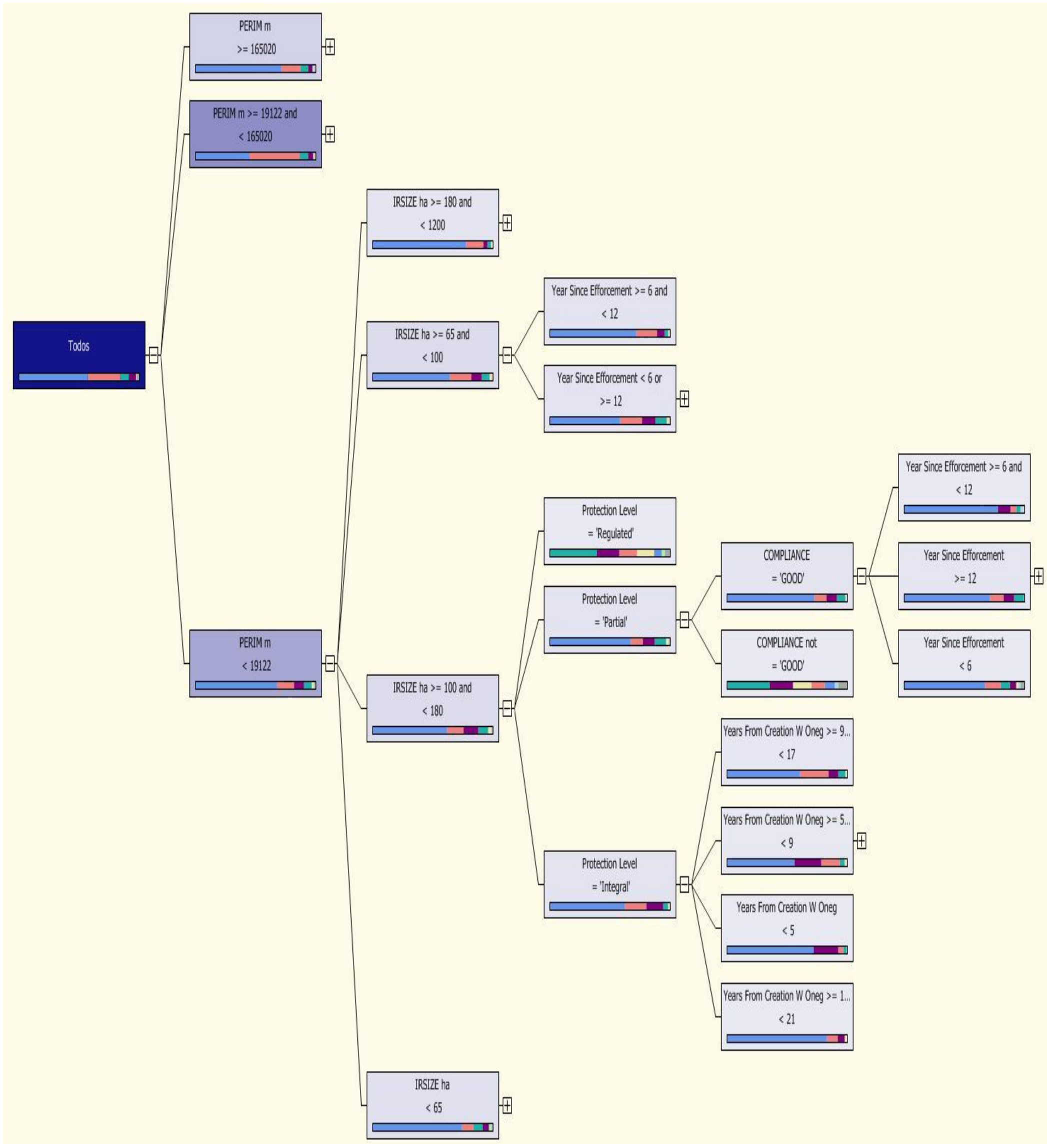
Todos
PERIM m >= 165020
PERIM m >= 19122 and < 165020
PERIM m < 19122
IRSIZE ha >= 180 and < 1200
IRSIZE ha >= 65 and < 100
Year Since Efforcement >= 6 and < 12
Year Since Efforcement < 6 or >= 12
IRSIZE ha >= 100 and < 180
Protection Level = 'Regulated'
Protection Level = 'Partial'
COMPLIANCE = 'GOOD'
COMPLIANCE not = 'GOOD'
Year Since Efforcement >= 6 and < 12
Year Since Efforcement >= 12
Year Since Efforcement < 6
Protection Level = 'Integral'
Years From Creation W Oneg >= 9... < 17
Years From Creation W Oneg >= 5... < 9
Years From Creation W Oneg < 5
Years From Creation W Oneg >= 1... < 21
IRSIZE ha < 65

Figure 4.2

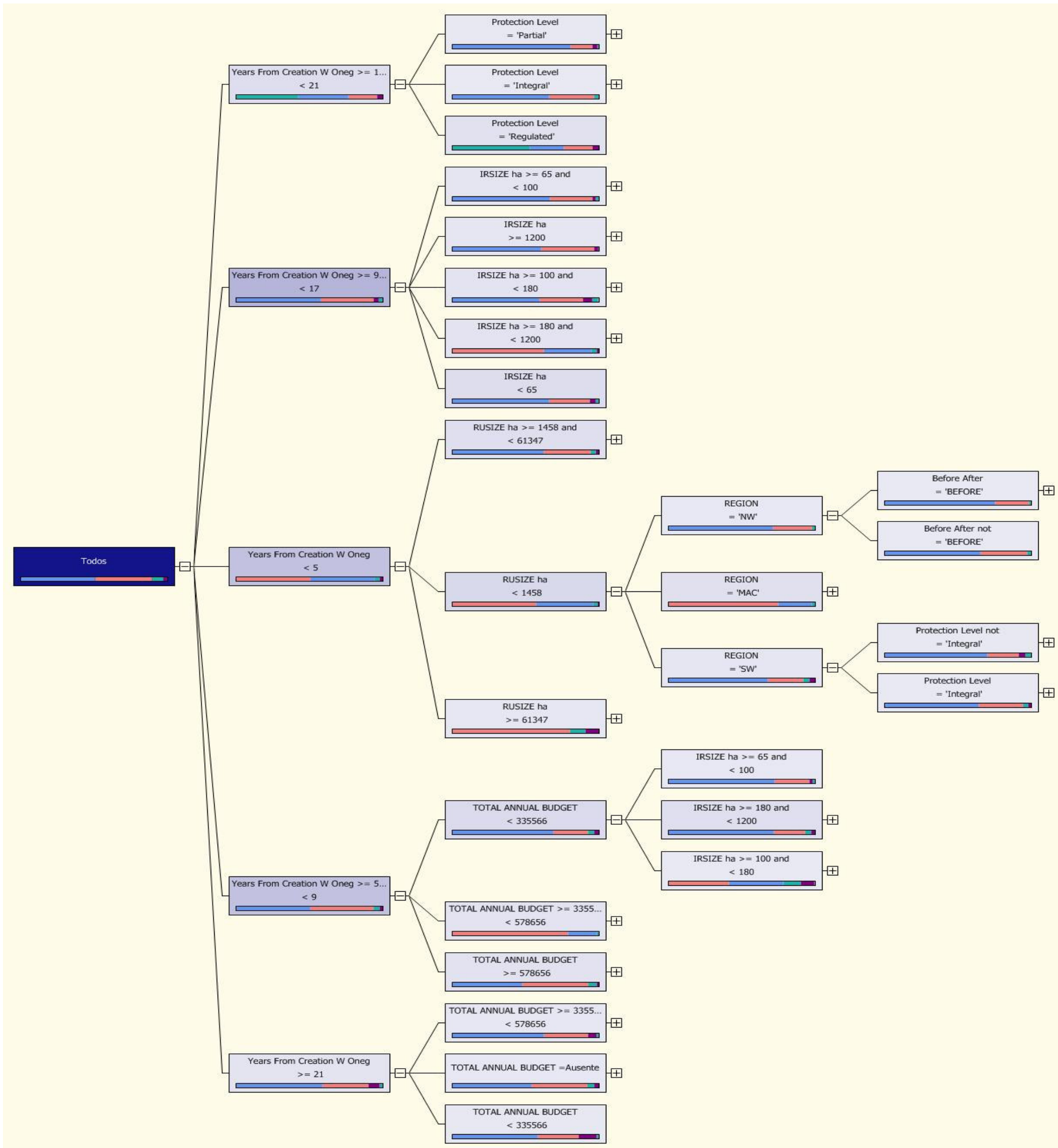
Todos
Years From Creation W Oneg >= 1... < 21
Protection Level = 'Partial'
Protection Level = 'Integral'
Protection Level = 'Regulated'
Years From Creation W Oneg >= 9... < 17
IRSIZE ha >= 65 and < 100
IRSIZE ha >= 1200
IRSIZE ha >= 100 and < 180
IRSIZE ha >= 180 and < 1200
IRSIZE ha < 65
Years From Creation W Oneg < 5
RUSIZE ha >= 1458 and < 61347
RUSIZE ha < 1458
REGION = 'NW'
Before After = 'BEFORE'
Before After not = 'BEFORE'
REGION = 'MAC'
REGION = 'SW'
Protection Level not = 'Integral'
Protection Level = 'Integral'
RUSIZE ha >= 61347
Years From Creation W Oneg >= 5... < 9
TOTAL ANNUAL BUDGET < 335566
IRSIZE ha >= 65 and < 100
IRSIZE ha >= 180 and < 1200
IRSIZE ha >= 100 and < 180
TOTAL ANNUAL BUDGET >= 3355... < 578656
TOTAL ANNUAL BUDGET >= 578656
Years From Creation W Oneg >= 21
TOTAL ANNUAL BUDGET >= 3355... < 578656
TOTAL ANNUAL BUDGET =Ausente
TOTAL ANNUAL BUDGET < 335566

Figure 5.2

Regression Models

To explore the possible relationship among each diversity indexes, or among each taxonomic and trophic categories (in abundance and biomass data) Pearson's correlation coefficient was calculated. The associated Spearman correlation coefficient of pairs of protection variables was examined to identify variables strongly correlated.

The seasonality is an important environmental variable on the fish assemblage in temperate systems (Ansari et al., 1995; Valle et al., 2007). The warm season is the most suitable period for visual counts in temperate systems, as fish communities are more diverse and stable during this period (Harmelin, 1987). For this reason, to reduce the natural variance between replicates and to better evidence patterns of protection, all the samples from winter season were excluded from the subsequent analyses.

To identify indicators of the protection effect several analyses were performed. Firstly, simple Spearman correlation coefficient were estimated between diversity indexes, taxonomic categories, trophic categories and total fish assemblage (in abundance and biomass data) with the 17 variables of protection.

Then, BEST routine (included in PRIMER v6 software; Clarke & Gorley, 2006) was used to select the subset of protection variables which best explains the pattern of the diversity indexes, taxonomic categories, trophic categories and total fish assemblage (in abundance and biomass data). In order to carry out a full search of all possible combinations of protection variables, BIO-ENV procedure was run using Spearman coefficient as rank correlation method. Moreover, global BEST match permutation test (using 99 permutations) was applied to testing agreement between dependent variables and the subset of protection variables selected. The associated Spearman correlation coefficient of pairs of protection variables was examined to identify variables strongly correlated. Were reduced all subsets of variables strongly collinear (total size and years since creation) to a single representative in the BEST run (Clarke & Warwick, 2001).

Moreover, to model the relationship between fish assemblage variables—diversity indexes, taxonomic categories, trophic categories and total fish assemblage (in abundance and biomass data)—and protection variables (and their quadratic and cubic terms to explore the possible nonlinear relationship), multiple regression analyses were performed in the framework of generalized linear models (GLM) (McCullagh and Nelder 1989; Chapman and Kramer 1999; García-Charton et al. 2004). Fish variables were examined using weighted multiple linear regression, a particular case of GLM for which the process of maximizing deviance reduction is equivalent to minimizing the residual sum-of-squares (McCullagh & Nelder, 1989). Weight estimation procedure computed the coefficients of a linear regression model using weighted least squares (WLS), such that the more precise observations (those studies with greater replication) were given greater weight in determining the regression coefficients (SPSS, 2004). In each case, stepwise forward selection of variables was run, with the aim of maximizing the deviance reduction, followed by a stepwise backward elimination to prevent the loss of statistical significance of some variables due to the latter incorporation of new variables into the model (García-Charton & Pérez-Ruzafa 1998). Before accepting any model, an analysis of residuals was performed to detect outliers with high influence on the models (García-Charton & Pérez-Ruzafa 1998). We measured the leverage and the Cook statistic of each sampling unit (McCullagh & Nelder, 1989), so that any one with high values of leverage and influence was removed and the model refitted to insure consistency.

Cross-validations of all the models were performed splitting the dataset into two groups via random selection procedures (Osborne, 2000). Prediction equations were created in the first group, which contained 90% of the samples of the dataset previously exposed. Those equations were then used to create predicted scores for the samples of the second group, which contained 10% of the samples of the dataset and new data from several MPAs (San Antonio, Tabarca, Sierra Helada, Columbretes, La Graciosa, La Restinga) supplied by UA and ULL participants (Table 2.4). The predicted scores were then correlated with the observed scores on the dependent variable obtaining the cross-validity coefficient ($r_{yy'}$), which was used to estimate the shrinkage (Osborne, 2000).

Table 2.4. Number of new case studies and samples included, per each marine protected area, in the cross-validation analyses.

Participants	MPA	Abundance data		Biomass data	
		Case studies	Samples	Case studies	Samples
UA	San Antonio	1	48	1	48
	Tabarca	2	312	2	312
	Sierra Helada	1	100	1	100
	Columbretes	1	91	1	91
ULL	La Graciosa	6	906	6	906
	La Restinga	4	875	4	875
TOTAL		15	2332	15	2332

References

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García-Charton, J.A. y Pérez-Ruzafa, A. 1998. Correlation between habitat structure and a rocky reef fish assemblage in the south-western Mediterranean. *P.S.Z.N.I.: Marine Ecology*, 19(2): 111-128.

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SPSS Inc. 2004. SPSS Regression Models 13.0. USA. 60 pp.

3. DATA COLLECTION FOR FISHERIES DATA FROM WP2

The analyses were done using the database from WP2. This dataset, which included case studies from 14 MPAs encompassing 31 fishing gears, had several important errors:

- There were more than one register for the same species in a sample. This is because in some studies were entered one register per each individual observed instead of one register per each species, making impossible to know the real number of samples included in each study.
- There were several denominations for the same species due to wrong spelling, synonyms and sex differentiation. Moreover, in some cases more than one species appeared in the field *"Species Name"*, or a family name was used, making impossible separate the catch obtained for each species. This carry to an erroneous number of species (total and/or per sample) and to know the real catch obtained per species.
- There were studies which had several species with cero or missing value in all catch fields. This carry to an erroneous number of species (total and/or per sample) and to know the real catch obtained per species.
- In some studies the field *"Harvest Region"* (which indicated the protection level of the location where the fishing was carried out) was empty, making impossible test the effect of protection.
- There were several denominations for the same month or specific date, resulting in erroneous results if data was aggregated by these temporal variables.
- Some studies had incorrect units in some fields of fishing effort (e.g. pieces in stead of meters in the field *"length of net"*), resulting in erroneous results when CPUE data was calculated.

All these mistakes came from the original database of WP2 because:

- A field for the sample code was not included, hindering the sample data identification.
- The names of the species entered were not checked looking for possible wrong spelling, synonyms or invalids entries.
- Any check of the data was done looking for obvious mistakes.

After correcting part of the errors possible to solve, only the studies that included biomass data were selected and analyzed because low number of samples with abundance data were available in the dataset. Were analyzed only the data of those fishing gears that appeared in at least three MPAs. Those samples with insufficient fishing effort resolution were excluded to obtain a high-quality estimation of catch per unit effort (CPUE). Finally, the dataset incorporated samples of 11 fishing gears from 11 MPAs distributed over 2500 km from north-western Mediterranean to central-eastern Atlantic (Figure 1). The final database included 40978 samples, which ranged from 1 year before the establishment of MPA to 34 years after. For each MPA and fishing gear, the final numbers of samples used in the analyses were summarized in Table 3.1.

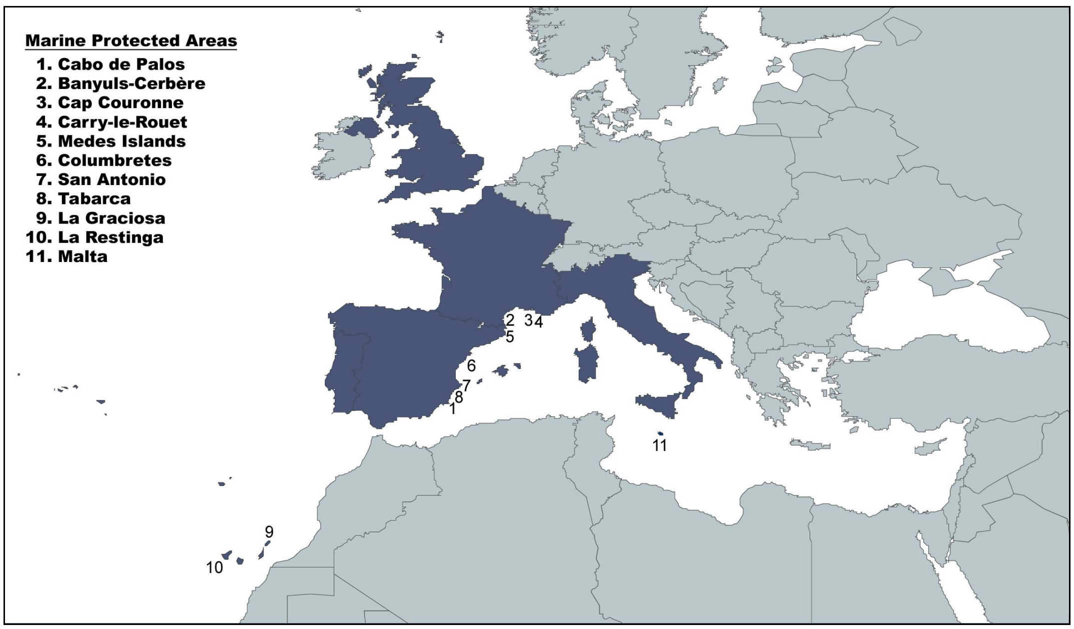

Figure 3.1. Location of the 11 marine protected areas analyzed.

Table 3.1. Number of samples analyzed per each marine protected area and fishing gear.

Participants	MPA	Fishing gear	Samples
UMU	Cabo de Palos	Bottom Longline hooksize <5	12
		Bottom Longline hooksize >=5	1
		Gill net >=100 mm	5
		Trammel net <40 mm	14
		Trammel net >=40 and <60	43
		Trammel net >=60 mm	14
CNRS	Banyuls-Cerbère	Gill net >=50 mm and <100 mm	101
		Trammel net <40 mm	16
		Trammel net >=40 and <60	8
		Trammel net >=60 mm	30
	Cap Couronne	Trammel net <40 mm	76
	Carry-le-Rouet	Bottom Longline hooksize >=5	9
		Hook and line	17

Participants	MPA	Fishing gear	Samples
		Trammel net <40 mm	343
		Trammel net >=40 and <60	5
ICM	Medes Islands*	Bottom Longline hooksize <5	47
		Gill net >=50 mm and <100 mm	61
		Trammel net <40 mm	23
		Trammel net >=40 and <60	27
IEO	Columbretes	Trammel net >=60 mm	298
UA	San Antonio	Trammel net <40 mm	54
	Tabarca	Bottom Longline hooksize <5	21
		Gill net >=50 mm and <100 mm	57
		Trammel net <40 mm	21
		Trammel net >=40 and <60	27
		Trammel net >=60 mm	4
ULL-IEO	La Graciosa	Bottom Longline hooksize <5	926
		Bottom Longline hooksize >=5	180
		Hook and line	13142
		Hook and line with live bait	1251
		Pole-and-line	5543
	La Restinga	Hook and line	5792
		Hook and line with live bait	2293
		Snorkeling handline	9303
UMT	Malta	Bottom Longline hooksize >=5	570
		Trammel net >=40 and <60	644
TOTAL			40978

*Indicates the MPAs removed for some analyses because their descriptors characteristics were incomplete (see Table 3).

For each sample, the capture was specified by species biomass and the effort used in the fishing operation was denoted. The recorded species were grouped into 13 taxonomic categories (big pelagics, medium pelagics, small pelagics, big serranidae, small serranidae, labridae, scorpenids, sparidae, chondrictios, cephalopoda, mollusca, crustacea and other species), 5 trophic categories (detritivorous, herbivorous, microphagous, mesophagous, macrophagous) and 4 commercial categories (by-catch, discards, target and total catch) constructed according taxonomy, feeding habits and commercial value (Table 3.2). The commercial category of each species could vary depending on the MPA and the fishing gear.

Table 3.2. Taxonomic categories and trophic categories of the species observed in the case studies analyzed.

Species	Taxonomic category	Trophic category
Ammodytes spp.	Small pelagics	Microphagous
Anguilla anguilla	Other species	Mesophagous
Anthias anthias	Other species	Mesophagous
Aphia minuta	Other species	Microphagous
Aplysia fasciata	Mollusca	Herbivorous
Apogon imberbis	Other species	Mesophagous
Argyrosomus regius	Other species	Macrophagous
Arnoglossus sp.	Other species	Mesophagous
Aspitrigla cuculus	Other species	Mesophagous
Atherina spp.	Small pelagics	Microphagous
Aulopus filamentosus	Other species	Macrophagous
Auxis rochei	Medium pelagics	Macrophagous
Balistes capriscus	Other species	Mesophagous
Balistes carolinensis	Other species	Mesophagous
Belone belone	Small pelagics	Macrophagous
Berix spp.	Other species	Mesophagous

Species	Taxonomic category	Trophic category
Bodianus scrofa	Labridae	Mesophagous
Bolinus brandaris	Mollusca	Herbivorous
Boops boops	Small pelagics	Microphagous
Bothus podas	Other species	Mesophagous
Calappa granulata	Crustacea	Mesophagous
Callionymus maculatus	Other species	Mesophagous
Cancer bellianus	Crustacea	Mesophagous
Canthidermis sufflamen	Other species	Mesophagous
Carcharhinus spp.	Chondrictios	Macrophagous
Centrolabrus trutta	Labridae	Mesophagous
Centrophorus granulosus	Chondrictios	Macrophagous
Charonia lampas	Mollusca	Herbivorous
Chelidonichthys lastoviza	Other species	Mesophagous
Chelidonichthys lucernus	Other species	Mesophagous
Chelon labrosus	Medium pelagics	Detritivorous
Chondrichthyes	Chondrictios	Macrophagous
Chromis chromis	Small pelagics	Microphagous
Chromis limbata	Small pelagics	Microphagous
Citharus linguatula	Other species	Mesophagous
Conger conger	Other species	Macrophagous
Coris julis	Labridae	Mesophagous
Coryphaena hippurus	Medium pelagics	Macrophagous
Ctenolabrus rupestris	Labridae	Mesophagous
Dactylopterus volitans	Other species	Mesophagous
Dardanus arrosor	Crustacea	Mesophagous
Dardanus calidus	Crustacea	Mesophagous
Dasyatis pastinaca	Other species	Macrophagous
Dentex dentex	Sparidae	Macrophagous
Dentex gibbosus	Sparidae	Macrophagous
Dentex macrophthalmus	Sparidae	Macrophagous
Dentex maroccanus	Sparidae	Macrophagous
Dicentrarchus labrax	Small serranidae	Macrophagous
Diplodus annularis	Sparidae	Mesophagous
Diplodus cervinus	Sparidae	Mesophagous
Diplodus puntazzo	Sparidae	Mesophagous
Diplodus sargus	Sparidae	Mesophagous
Diplodus vulgaris	Sparidae	Mesophagous
Dipturus batis	Chondrictios	Macrophagous
Echinaster sepositus	Echinoderma	Mesophagous
Echinus melo	Echinoderma	Mesophagous
Eledone cirrhosa	Cephalopoda	Macrophagous
Enchelycore anatina	Other species	Macrophagous
Engraulis encrasicolus	Small pelagics	Microphagous
Epinephelus aeneus	Big serranidae	Macrophagous
Epinephelus costae	Big serranidae	Macrophagous
Epinephelus marginatus	Big serranidae	Macrophagous
Euthynnus alletteratus	Medium pelagics	Macrophagous
Eutrigla gurnardus	Other species	Mesophagous
Gaidropsarus mediterraneus	Other species	Mesophagous
Galathea strigosa	Crustacea	Mesophagous
Galeorhinus galeus	Chondrictios	Macrophagous
Galeus melastomus	Chondrictios	Macrophagous
Gephyroberyx darwini	Other species	Macrophagous
Gobius bucchichi	Other species	Mesophagous
Gobius cruentatus	Other species	Mesophagous
Gymnothorax polygonius	Other species	Macrophagous
Helicolenus dactylopterus	Scorpenids	Macrophagous
Heteropriacanthus cruentatus	Other species	Microphagous
Hexanchidae spp.	Chondrictios	Macrophagous
Holothuria spp.	Echinoderma	Detritivorous
Homarus gammarus	Crustacea	Mesophagous
Illex coindetii	Cephalopoda	Macrophagous
Isurus oxyrinchus	Chondrictios	Macrophagous
Kyphosus sectator	Other species	Mesophagous
Labrus bergylta	Labridae	Mesophagous
Labrus bimaculatus	Labridae	Mesophagous
Labrus merula	Labridae	Mesophagous
Labrus viridis	Labridae	Mesophagous
Lepidopus caudatus	Medium pelagics	Macrophagous
Lepidorhombus boscii	Other species	Mesophagous
Lepidotrigla cavillone	Other species	Mesophagous
Lichia amia	Medium pelagics	Macrophagous

Species	Taxonomic category	Trophic category
Lithognathus mormyrus	Sparidae	Mesophagous
Loligo vulgaris	Cephalopoda	Macrophagous
Lophius budegassa	Other species	Macrophagous
Lophius piscatorius	Other species	Macrophagous
Maja squinado	Crustacea	Mesophagous
Makaira nigricans	Big pelagics	Macrophagous
Merluccius merluccius	Other species	Macrophagous
Microchirus ocellatus	Other species	Mesophagous
Microchirus variegatus	Other species	Mesophagous
Micromesistius poutassou	Other species	Mesophagous
Mola mola	Big pelagics	Mesophagous
Monochirus hispidus	Other species	Mesophagous
Mora moro	Other species	Mesophagous
Mugilidae	Medium pelagics	Detritivorous
Mullus spp.	Other species	Mesophagous
Muraena augusti	Other species	Macrophagous
Muraena helena	Other species	Macrophagous
Murex brandaris	Other species	Herbivorous
Mustelus mustelus	Chondrictios	Macrophagous
Mycteroperca fusca	Big serranidae	Macrophagous
Myliobatis aquila	Other species	Macrophagous
Natantia spp.	Crustacea	Mesophagous
Oblada melanura	Small pelagics	Microphagous
Octopus vulgaris	Cephalopoda	Macrophagous
Ophisurus serpens	Other species	Macrophagous
Pagellus acarne	Sparidae	Mesophagous
Pagellus bogaraveo	Sparidae	Mesophagous
Pagellus erythrinus	Sparidae	Mesophagous
Pagellus spp.	Sparidae	Mesophagous
Pagrus auriga	Sparidae	Mesophagous
Pagrus pagrus	Sparidae	Mesophagous
Pagurus arrosor	Crustacea	Mesophagous
Pagurus prideauxi	Crustacea	Mesophagous
Palinurus elephas	Crustacea	Mesophagous
Palinurus mauritanicus	Crustacea	Mesophagous
Palinurus vulgaris	Crustacea	Mesophagous
Parablennius gattorugine	Other species	Mesophagous
Paracentrotus lividus	Echinoderma	Herbivorous
Parapristipoma octolineatum	Other species	Mesophagous
Paromola cuvieri	Crustacea	Mesophagous
Parthenope macrochelus	Crustacea	Mesophagous
Pegusa lascaris	Other species	Mesophagous
Penaeus kerathurus	Crustacea	Mesophagous
Peristedion cataphractum	Other species	Mesophagous
Phycis blennoides	Other species	Macrophagous
Phycis phycis	Other species	Macrophagous
Platichthys flesus	Other species	Mesophagous
Plectorhinchus mediterraneus	Other species	Mesophagous
Pleuronectes platessa	Other species	Mesophagous
Polymixia nobilis	Other species	Mesophagous
Polyprion americanus	Big serranidae	Macrophagous
Pomadasys incisus	Other species	Mesophagous
Pomatomus saltatrix	Medium pelagics	Macrophagous
Pomatoschistus spp.	Other species	Mesophagous
Pontinus kuhlii	Other species	Mesophagous
Portunus spp.	Crustacea	Mesophagous
Prionace glauca	Chondrictios	Macrophagous
Promethichthys prometheus	Other species	Macrophagous
Psetta maxima	Other species	Mesophagous
Pseudocaranx dentex	Medium pelagics	Macrophagous
Raja asterias	Other species	Mesophagous
Raja brachyura	Other species	Mesophagous
Raja clavata	Other species	Mesophagous
Raja microcellata	Other species	Mesophagous
Raja montagui	Other species	Mesophagous
Raja oxyrhincus	Other species	Mesophagous
Raja polystigma	Other species	Mesophagous
Raja spp.	Other species	Mesophagous
Raja undulata	Other species	Mesophagous
Rhizostoma pulmo	Other species	Microphagous
Ruvettus pretiosus	Other species	Macrophagous
Sarda sarda	Medium pelagics	Macrophagous

Species	Taxonomic category	Trophic category
Sardina pilchardus	Small pelagics	Microphagous
Sardinella aurita	Other species	Microphagous
Sardinella maderensis	Small pelagics	Microphagous
Sarpa salpa	Sparidae	Herbivorous
Schedophilus ovalis	Other species	Mesophagous
Sciaena umbra	Other species	Macrophagous
Scomber colias	Small pelagics	Macrophagous
Scomber japonicus	Small pelagics	Macrophagous
Scomber scombrus	Small pelagics	Macrophagous
Scophthalmus rhombus	Other species	Mesophagous
Scorpaena maderensis	Other species	Macrophagous
Scorpaena notata	Other species	Macrophagous
Scorpaena porcus	Other species	Macrophagous
Scorpaena scrofa	Other species	Macrophagous
Scorpenidae	Other species	Macrophagous
Scyliorhinus canicula	Chondrictios	Macrophagous
Scyliorhinus stellaris	Chondrictios	Macrophagous
Scyllarides latus	Crustacea	Mesophagous
Scyllarus arctus	Crustacea	Mesophagous
Sepia officinalis	Cephalopoda	Macrophagous
Seriola carpenteri	Medium pelagics	Macrophagous
Seriola dumerili	Medium pelagics	Macrophagous
Seriola fasciata	Medium pelagics	Macrophagous
Seriola rivoliana	Medium pelagics	Macrophagous
Serranus atricauda	Small serranidae	Macrophagous
Serranus cabrilla	Small serranidae	Macrophagous
Serranus scriba	Small serranidae	Macrophagous
Solea solea	Other species	Mesophagous
Solea vulgaris	Other species	Mesophagous
Sparisoma cretense	Other species	Mesophagous
Sparus aurata	Sparidae	Mesophagous
Sphoeroides pachygaster	Other species	Mesophagous
Sphyraena spp.	Medium pelagics	Macrophagous
Sphyrna spp.	Chondrictios	Macrophagous
Spicara maena	Small pelagics	Microphagous
Spicara smaris	Small pelagics	Microphagous
Spicara spp.	Small pelagics	Microphagous
Spondyliosoma cantharus	Sparidae	Mesophagous
Squalus acanthias	Chondrictios	Macrophagous
Squatina squatina	Chondrictios	Mesophagous
Squilla mantis	Crustacea	Mesophagous
Stephanolepis hispidus	Other species	Microphagous
Symphodus cinereus	Labridae	Mesophagous
Symphodus doderleini	Labridae	Mesophagous
Symphodus mediterraneus	Labridae	Mesophagous
Symphodus melops	Labridae	Mesophagous
Symphodus ocellatus	Labridae	Mesophagous
Symphodus roissali	Labridae	Mesophagous
Symphodus rostratus	Labridae	Mesophagous
Symphodus tinca	Labridae	Mesophagous
Syngnathus acus	Other species	Mesophagous
Synodus saurus	Other species	Macrophagous
Thalassoma pavo	Labridae	Mesophagous
Thunnus thynnus	Big pelagics	Macrophagous
Torpedo marmorata	Chondrictios	Mesophagous
Torpedo torpedo	Chondrictios	Mesophagous
Trachinotus ovatus	Small pelagics	Macrophagous
Trachinus araneus	Other species	Macrophagous
Trachinus draco	Other species	Macrophagous
Trachinus radiatus	Other species	Macrophagous
Trachinus spp.	Other species	Macrophagous
Trachinus vipera	Other species	Macrophagous
Trachurus mediterraneus	Small pelagics	Macrophagous
Trachurus picturatus	Small pelagics	Macrophagous
Trachurus spp.	Small pelagics	Macrophagous
Trachurus trachurus	Small pelagics	Macrophagous
Trigla lyra	Other species	Mesophagous
Trigla spp.	Other species	Mesophagous
Trisopterus luscus	Other species	Mesophagous
Trisopterus minutus	Other species	Mesophagous
Tylosurus acus	Medium pelagics	Macrophagous
Umbrina canariensis	Other species	Mesophagous

Species	Taxonomic category	Trophic category
Umbrina cirrosa	Other species	Mesophagous
Umbrina ronchus	Other species	Mesophagous
Uranoscopus scaber	Other species	Macrophagous
Xiphias gladius	Big pelagics	Macrophagous
Xyrichthys novacula	Other species	Mesophagous
Zenopsis conchifer	Other species	Macrophagous
Zeugopterus regius	Other species	Mesophagous
Zeus faber	Other species	Macrophagous

The protection status of each sample was measured by means of 17 variables related with: protection level (no protected far from the MPA: 1; no protected close from the MPA : 2; partially protected 3; integral: 4), temporal measures of protection (years since MPA creation, years since enforcement), structural characteristics of the MPA (total size, integral reserve size, buffer area size, restricted use area size, proportion of the integral reserve, perimeter, ratio perimeter/size, number of zones), siting place (distance to another MPA, distance to main town, isolation) and management carried out (compliance, total hours of enforcement, total annual budget). For the estimation of these variables where used the data showed in table 3.3.

Table 3.3. Characteristics descriptors of the 11 MPAs included in the analyses.

Participants	MPA	Year of establishment	Year of enforcement	Total size (ha)	Integral reserve size (ha)	Buffer area size (ha)	Resticted use area size (ha)	Proportion of the integral reserve (%)	Perimeter (m)	Ratio perimetar/size	Number of zones	Distance to another MPA (km)	Distance to main town (km)	Isolation*[1]	Compliance*[2]	Total hours of enforcement	Total annual budget (€)
UMU	Cabo de Palos	1995	1995	1898	270	1628	0	14.26	19891	0.00105	2	55	0	2	3	4872	246026
CNRS	Banyuls-Cerbère	1974	1974	650	65	585	0	10.00	8500	0.00131	2	40	0	1	3	1000	400000
	Cap Couronne	1996	1996	210	210	0	0	100.00	6000	0.00286	1	20	0.15	2	3	286	175398
	Carry-le-Rouet	1982	1982	85	85	0	0	100.00	3000	0.00353	1	20	0	1	3	1752	175398
ICM	Medes Islands	1983	1983	511	93	418	0	18.20	9000	0.00176	2	15	1	2	3	2120	NA
IEO	Columbretes	1990	1990	4400	1800	2600	0	40.91	28500	0.00065	2	180	56	3	3	5840	741080
UA	San Antonio	1993	1998	110	110	0	0	100.00	4200	0.00382	1	60	0	1	2	1600	200000
	Tabarca	1986	1987	1400	100	630	670	7.14	17000	0.00121	3	40	4	2	3	15880	555128
ULL-IEO	La Graciosa	1995	1997	70000	1225	8479	60296	1.75	175000	0.00025	3	450	27	2	2	1214	585388
	La Restinga	1996	1996	993	180	123	690	18.13	26500	0.00267	3	100	18	1	3	3009	350346
UTM	Malta	1971	2004	1198000	0	0	1198000	0	376940	0.00003	1	120	0	1	3	8544	200000

NA: Not available data. *[1]. 1: in coast; 2: close to the coast; 3: far to the coast. *[2]. 1: null; 2: deficient; 3: good.

4. DATA ANALYSIS

As the effectiveness of the protection effect on the captures could vary depending on the fishing gear studied (due to they target on different species), to identify indicators analyses where carried out separately in each fishing gear. Some of the 11 fishing gears previously selected were aggregated because they were technically similar and target over the same species. Finally data groups of 7 fishing gears (gill net >50 mm, trammel net <40 mm, trammel net 40-60 mm, trammel net >60 mm, longline hook size <5 longline, hook size ≥5, hook and line) were analyzed. Samples were aggregated performing the analyses at level of protection status of the area, years since protection and season.

To explore the possible relationship among the CPUE of each taxonomic, trophic and commercial categories presented in each fishing gear, Pearson's correlation coefficient was calculated. The associated Spearman correlation coefficient of pairs of protection variables was examined to identify variables strongly correlated.

To identify indicators of the protection effect several analyses were performed. Firs, simple Spearman correlation coefficient were estimated between the CPUE of each taxonomic, trophic and commercial categories presented in each fishing gear with the 17 variables of protection.

Then, BEST routine (included in PRIMER v6 software; Clarke & Gorley, 2006) was used to select the subset of protection variables which best explains the pattern of the CPUE of each taxonomic, trophic and commercial categories presented in each fishing gear. In order to carry out a full search of all possible combinations of protection variables, BIO-ENV procedure was run using Spearman coefficient as rank correlation method. Moreover, global BEST match permutation test (using 99 permutations) was applied to testing agreement between dependent variables and the subset of protection variables selected. The associated Spearman correlation coefficient of pairs of protection variables was examined to identify variables strongly correlated in the data of each fishing gear. Were reduced all subsets of variables strongly collinear to a single representative in the BEST run (Clarke & Warwick, 2001).

Moreover, to model the relationship between CPUE variables—of each taxonomic, trophic and commercial categories presented in each fishing gear—and protection variables (and their quadratic and cubic terms to explore the possible nonlinear relationship), multiple regression analyses were performed in the framework of generalized linear models (GLM) (McCullagh and Nelder 1989; Chapman and Kramer 1999; García-Charton et al. 2004). CPUE variables were examined using weighted multiple linear regression, a particular case of GLM for which the process of maximizing deviance reduction is equivalent to minimizing the residual sum-of-squares (McCullagh & Nelder, 1989). Weight estimation procedure computed the coefficients of a linear regression model using weighted least squares (WLS), such that the more precise observations (those studies with greater replication) were given greater weight in determining the regression coefficients (SPSS, 2004). In each case, stepwise forward selection of variables was run, with the aim of maximizing the deviance reduction, followed by a stepwise backward elimination to prevent the loss of statistical significance of some variables due to the latter incorporation of new variables into the model (García-Charton & Pérez-Ruzafa 1998). Before accepting any model, an analysis of residuals was performed to detect outliers with high influence on the models (García-Charton & Pérez-Ruzafa 1998). We measured the leverage and the Cook statistic of each sampling unit (McCullagh & Nelder, 1989), so that any one with high values of leverage and influence was removed and the model refitted to insure consistency.

Cross-validations of all the models were performed splitting the dataset into two groups via random selection procedures (Osborne, 2000). Prediction equations were created in the first group, which contained 90% of the samples of the dataset previously exposed. Those equations were then used to create predicted scores for the samples of the second group, which contained 10% of the samples of the dataset. The predicted scores were then correlated with the observed scores on the dependent variable obtaining the cross-validity coefficient ($r_{yy'}$), which was used to estimate the shrinkage (Osborne, 2000).

Results For Fish Uvc

Relation Among Variables Of Protection Status

Most variables of protection status were significantly related, but in general they had low values of correlation coefficients (Table 4.1). Only few variables of protection status were highly correlated. Total size was positively correlated with other structural variables of the MPAs (buffer size, perimeter and number of zones), and also with total annual budget. Additionally, the proportion of the integral reserve was highly correlated with ratio perimeter/size. On the contrary, the variables distance to another MPA and compliance were the least correlated with the other variables of protection status.

Relation Among Variables Of Fish Assemblage

In spite of most diversity indexes correlated significantly, they had low values of correlation coefficients (Table 4.2). Exceptionally, total number of species correlated highly with Margalef and total phylogenetic diversity indexes. Moreover, Simpson index correlated with high values with Pielou's evenness and Shannon-Wiener indexes. Finally, average taxonomic distinctness and average phylogenetic diversity indexes were related positively with a high coefficient.

Regarding the taxonomic classification, any pair of taxonomic categories was highly correlated (Tables 4.3 and 4.4). The greater correlations were observed between the abundance of *Diplodus* spp. and the abundance of small Serranidae and small pelagics, however the coefficients lightly exceeded 0.5. In terms of biomass, similar values were observed between big Sparidae and big Serranidae.

Concerning the trophic categories, although some of them were related significantly, the correlation coefficients were very low (any of them reached 0.5) (Tables 4.5 and 4.6). The highest value was observed between the biomases of microphagous and mesophagous.

Table 4.1. Spearman correlation coefficients between the variables of the protection status.

	Protection level	Years since creation	Years since enforcement	Total size	IR size	Buffer size	RU size	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Isolation	Compliance	Hours enforcement
Years since creation	-0.173*															
Years since enforc.	0.497***	0.520***														
Total size	0.587***	-0.325***	0.269***													
IR size	0.631***	-0.540***	0.178*	0.811***												
Buffer size	0.447***	-0.245***	0.228**	0.961***	0.675***											
RU size	0.367***	-0.328***	-0.039	0.741***	0.507***	0.687***										
IR proportion	0.658***	-0.140*	0.552***	0.256***	0.596***	0.056	-0.094									
Perimeter	0.628***	-0.394***	0.215**	0.960***	0.850***	0.868***	0.793***	0.347***								
Ratio P/S	0.678***	-0.023	0.620***	0.216**	0.476***	0.021	-0.046	0.962***	0.311***							
Number of zones	0.600***	-0.233***	0.362***	0.900***	0.687***	0.835***	0.831***	0.291***	0.898***	0.335***						
Distance MPA	-0.117	0.077	0.078	0.220**	0.054	0.234***	0.175*	-0.043	0.214**	-0.034	0.288***					
Distance town	-0.030	-0.213**	-0.100	0.178*	0.200**	0.148*	0.466***	-0.087	0.205**	-0.079	0.396***	0.398***				
Isolation	0.248***	-0.311***	-0.106	0.600***	0.327***	0.643***	0.492***	-0.199**	0.534***	-0.207**	0.451***	0.036	0.065			
Compliance	0.098	-0.242***	-0.099	-0.177*	0.083	-0.187**	-0.216**	0.200**	-0.130	0.153*	-0.180**	-0.735***	-0.204**	-0.081		
Hours enforcement[1]	0.705***	-0.281***	0.586***	0.802***	0.731***	0.694***	0.413***	0.596***	0.756***	0.583***	0.825***	0.117	0.096	0.348***	0.259**	
Annual budget[2]	0.631***	-0.367***	0.425***	0.914***	0.824***	0.855***	0.807***	0.327***	0.915***	0.394***	0.969***	0.133	0.435***	0.393***	-0.068	0.760***

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=205; [1]n=157; [2]n=170.

Table 4.2. Pearson's correlation coefficients between the biodiversity indexes: total species (S), Margalef (d), Pielou's evenness (J'), Shannon-Wiener (H'(loge)), Simpson (1- Lambda), taxonomic distinctness (Delta*), average taxonomic distinctness (Delta+), variation in taxonomic distinctness (Lambda +), average phylogenetic diversity (Phi+) and total phylogenetic diversity (sPhi+).

	S	d	J	H'(loge)	1-Lambda	Delta*	Delta+	Lambda+	Phi+
d	0.911***								
J	-0.272***	-0.001							
H'(loge)	0.388***	0.604***	0.745***						
1-Lambda	0.117	0.363***	0.899***	0.934***					
Delta*	0.283***	0.070	-0.606***	-0.348***	-0.470***				
Delta+	-0.028	-0.183**	-0.393***	-0.337***	-0.374***	0.575***			
Lambda+	0.286***	0.354***	0.215**	0.338***	0.274***	-0.376***	-0.585***		
Phi+	-0.554***	-0.641***	-0.151*	-0.488***	-0.352***	0.319***	0.811***	-0.702***	
sPhi+	0.917***	0.793***	-0.349***	0.279***	0.025	0.460***	0.337***	0.006	-0.195**

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=205

Table 4.3. Pearson's correlation coefficients between the abundance of the taxonomic categories.

	Big Labridae	Small Labridae	Big Serranidae	Small Serranidae	Big Sparidae	*Diplodus* spp.	Medium pelagics	Small pelagics
Small Labridae	0.208**							
Big Serranidae	0.002	0.139*						
Small Serranidae	0.242***	0.176*	-0.104					
Big Sparidae	-0.048	-0.050	0.148*	-0.048				
Diplodus spp.	0.094	0.102	0.331***	0.525***	-0.001			
Medium pelagics	0.219**	0.084	0.298***	-0.074	0.047	0.018		
Small pelagics	0.191**	0.254***	0.114	0.416***	0.151*	0.510***	0.367***	
Other species	0.376***	0.282***	0.257***	0.007	0.129	0.066	0.352***	0.323***

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=205

Table 4.4. Pearson's correlation coefficients between the biomass of the taxonomic categories.

	Big Labridae	Small Labridae	Big Serranidae	Small Serranidae	Big Sparidae	*Diplodus* spp.	Medium pelagics	Small pelagics
Small Labridae	0.157							
Big Serranidae	-0.043	0.164						
Small Serranidae	0.493***	-0.143	-0.043					
Big Sparidae	-0.009	-0.153	0.500***	0.153				
Diplodus spp.	0.242**	0.278**	0.317***	0.097	0.300***			
Medium pelagics	0.338***	0.041	0.101	0.278**	0.149	0.342***		
Small pelagics	0.029	-0.035	-0.070	0.034	0.005	0.117	0.153	
Other species	0.269**	0.149	-0.012	-0.019	0.015	0.165	0.179*	0.248**

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=131

Table 4.5. Pearson's correlation coefficients between the abundance of the trophic categories.

	Detritivorous	Herbivorous	Microphagous	Mesophagous
Herbivorous	0.130			
Microphagous	0.028	0.096		
Mesophagous	0.041	-0.048	0.342***	
Macrophagous	0.241***	0.061	0.125	0.113

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=205

Table4. 6. Pearson's correlation coefficients between the biomass of the trophic categories.

	Detritivorous	Herbivorous	Microphagous	Mesophagous
Herbivorous	0.121			
Microphagous	0.038	-0.049		
Mesophagous	0.079	0.201*	0.432***	
Macrophagous	0.019	0.201*	0.093	0.156

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=131

Table 4.7. Spearman correlation coefficients between the diversity indexes and the variables of the protection status in the warm season. Total species (S), Margalef (d), Pielou's evenness (J'), Shannon-Wiener (H'(loge)), Simpson (1- Lambda), taxonomic distinctness (Delta*), average taxonomic distinctness (Delta+), variation in taxonomic distinctness (Lambda +), average phylogenetic diversity (Phi+) and total phylogenetic diversity (sPhi+).

	S	d	J	H'(loge)	1-Lambda	Delta*	Delta+	Lambda+	Phi+	sPhi+
Protection level	-0.045	-0.111	-0.052	-0.129	-0.122	-0.096	-0.087	0.042	0.025	-0.073
Years since creation	0.243***	0.246***	0.108	0.220**	0.179*	-0.045	-0.026	-0.074	-0.080	0.223**
Years since enforc.	0.212**	0.160*	-0.027	0.092	0.020	0.018	0.045	-0.085	-0.017	0.222**
Total size	-0.059	-0.070	-0.138	-0.153*	-0.149*	-0.009	0.056	-0.072	0.072	-0.048
IR size	-0.149*	-0.200**	-0.133	-0.217**	-0.182*	-0.013	0.088	-0.023	0.131	-0.134
Buffer size	-0.018	-0.015	-0.116	-0.108	-0.105	0.004	0.043	-0.073	0.040	-0.014
RU size	-0.321***	-0.326***	-0.055	-0.197**	-0.133	-0.073	0.038	-0.116	0.171*	-0.263***
IR proportion	0.035	-0.057	-0.145*	-0.144*	-0.181*	0.113	0.125	-0.044	0.121	0.071
Perimeter	-0.121	-0.160*	-0.218**	-0.250***	-0.245***	0.025	0.098	-0.075	0.123	-0.084
Ratio P/S	0.028	-0.063	-0.117	-0.130	-0.166*	0.113	0.098	-0.080	0.123	0.062
Number of zones	-0.189**	-0.233**	-0.152*	-0.230**	-0.201**	0.091	0.186*	-0.252***	0.261***	-0.097
Distance MPA	0.047	-0.037	-0.414***	-0.318***	-0.345***	0.502***	0.791***	-0.711***	0.591***	0.331***
Distance town	-0.549***	-0.585***	-0.034	-0.295***	-0.154*	0.145*	0.453***	-0.559***	0.654***	-0.317***
Isolation	0.076	0.161*	-0.064	-0.023	-0.058	-0.030	-0.132	0.025	-0.142	-0.027
Compliance	-0.025	-0.060	0.029	0.006	0.015	-0.070	-0.354***	0.445***	-0.306***	-0.163*
Hours enforcement[1]	0.049	-0.027	-0.172*	-0.177*	-0.195*	0.242**	0.218**	-0.196*	0.162	0.102
Annual budget[2]	-0.277***	-0.333***	-0.017	-0.178*	-0.094	-0.069	0.087	-0.169*	0.215**	-0.235**

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=188; [1]n=143; [2]n=156.

Relation Among Variables of Fish Assemblage and Variables of Protection Status

-Diversity indexes

All diversity indexes were related significantly with at least one variable of protection status (Table 7). However correlation coefficients were usually low. Values that exceeded 0.7 were observed only in the average taxonomic distinctness and variation in taxonomic distinctness indexes, which increased and declined respectively with distance to another MPA. The index that correlated significantly with more variables of protection was Shannon-Wiener, while taxonomic distinctness was significantly related only with 3 variables of protection. There were 2 variables of protection status (protection level and buffer size) that did not correlated with any diversity index. On the contrary, distance to town was related with 9 diversity indexes, while number of zones and distance to another MPA correlated with 8 indexes.

Table 4.8. Spearman correlation index (ρ_w), obtained using BEST, among the diversity indexes and the combination of the variables of the protection status on the warm season. Only are showed the best correlation for each case. × indicates the variables that resulted in each correlation analysis. The level of significance is denoted between brackets, and was obtained using 99 permutations. N=141. Total species (S), Margalef (d), Pielou's evenness (J'), Shannon-Wiener (H'(loge)), Simpson (1- Lambda), taxonomic distinctness (Delta*), average taxonomic distinctness (Delta+), variation in taxonomic distinctness (Lambda +), average phylogenetic diversity (Phi+) and total phylogenetic diversity (sPhi+).

Diversity Indexes	ρ_w	Protection level	Years since enforcement	IR size	Buffer size	RU size	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Isolation	Compliance	Hours enforcement	Annual budget
S	0.196 (0.01)											×				
D	0.437 (0.01)											×				
J	0.166 (0.01)			×	×			×				×				
H'(loge)	0.337 (0.01)											×				
1-Lambda	0.272 (0.01)			×	×			×				×				
Delta*	0.150 (0.05)					×					×					
Delta+	0.619 (0.01)										×					
Lambda+	0.418										×	×				

	(0.01)															
Phi+	0.614 (0.01)										×	×				
sPhi+	0.123 (0.05)	×													×	

Table 4.9. Results of multiple linear regression analysis for diversity indexes (*superscripts* refer to quadratic, cubic and logarithmic terms of the variables of the protection status used as independent terms). Total species (S), Margalef (d), Pielou's evenness (J'), Shannon-Wiener (H'(loge)), Simpson (1- Lambda), taxonomic distinctness (Delta*), average taxonomic distinctness (Delta+), variation in taxonomic distinctness (Lambda +), average phylogenetic diversity (Phi+) and total phylogenetic diversity (sPhi+). Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001.

Diversity Indexes	n	Adj.R^2	F	Const	Years since enforcement	Distance to MPA	Distance to town	Compliance	Years since enforcement^2	Number of zones^2	Distance to MPA^2	Isolation^2	Compliance^2	Hours enforcement^2	Protection level^3	Years since enforcement^3	IR size^3	RU size^3	Distance to MPA^3	Distance to town^3	Isolation^3	Compliance^3	Annual budget^3	Years since enforcement^{log}	IR proportion^{log}	Distance to MPA^{log}	Distance to town^{log}	Compliance^{log}	Isolation^{log}
S	127	0.456	22.147***	-19.271	-	-	-	-	0.025	-	-	-	-	-	-	-0.001	-	-	-	-	-	-	-	-	-	7.458	-6.795	39.625	-
D	126	0.553	31.981***	0.170	-	-	-0.086	0.349	-	-	-	0.146	-	-1.E-13	-	-	-	-	-	-	-	-	-	-	-	0.893	-	-	-
J	123	0.602	47.153***	1.116	-	-	-	-	-	-0.013	-	-	-0.017	-	-	-	-	-	-	-	-	-	1E-18	-	-	-0.244	-	-	-
H'(loge)	127	0.546	38.891***	1.460	-	-	-0.027	-	-	-	-	-	-	-	-	-	-1E-8	1E-13	-	-	0.026	-	-	-	-	-	-	-	-
1-Lambda	127	0.560	33.085***	1.010	-	-	-0.003	-0.112	1E-4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-0.161	-	-	0.485
Delta*	123	0.388	26.755***	39.588	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-7.8E-8	-	-	-	-	-	-	5.313	1.446	-	-
Delta+	127	0.935	257.99***	35.709	-	0.093	-	-	-	-	-	-	-	-	-	-9.1E-5	-	-8E-15	-5.6E-7	0.001	-	-	-	1.243	-	-	-	8.978	-
Lambda+	127	0.769	71.100***	222.42	-	-	-	-	-	-	-	-	-	-	-0.197	-	-	-	8.8E-7	-	-	1.367	-	-	-	-54.481	-24.605	-	-71.261
Phi+	120	0.843	160.85***	36.938	-	-	0.815	-	-	-	1E-4	-	-	-	-	-	-	-3E-13	-	-	-	-	-	-	1.174	-	-	-	-
sPhi+	127	0.443	21.032***	-430.85	5.812	-	-	187.56	-	-	-	-	-	-	-	-0.013	-	-	-	-	-	-	-	-	-	305.87	-160.96	-	-

Table 4.8 shows the Spearman correlation coefficients among diversity indexes and the most correlated combination of the variables of protection status. All the indexes showed significant correlations and, although the correlation coefficients were low, in general, it was obtained with the combination of more than one variable of protection. The highest correlations were observed for average taxonomic distinctness index (which was related only with distance to another MPA), and for average phylogenetic diversity index (that correlated with the combination of distance to another MPA and distance to town), but reached only 0.6. Once again, distance to another MPA and distance to town were the protection status variables that correlated with more diversity index.

For all diversity indexes was obtained a significant regression model (Table 9). The fitted models accounted for 38.8-93.5% of the observed variation. The diversity index that responded better to the protection status variables was the average taxonomic distinctness, which depended on years since enfforcement, resticted use area size, distance to another MPA, distance to town and compliance. However the shrinkage obtained in the cross-validation process was really high making not valid the model obtained (Table 4.10). Only the model fitted for taxonomic distinctness had been validated, in which distance to another MPA and distance to town explained 38.8% of the variation of this index.

-Taxonomic categories and total fish assemblage

Both, abundance and biomass of all taxonomic categories and total fish assemblage were related significantly with at least one variable of protection status (Tables 4.11 and 4.12). However correlation coefficients were usually low, especially in abundance data. The highest correlation coefficients observed in abundance data (0.559) was obtained for big serranids, which increased with hours of enforcement. Values that exceeded 0.7 were observed only in the biomasses of medium pelagics and small pelagics, which increased with distance to another MPA. Big serranids was the taxonomic category that correlated significantly with more variables of protection, in both abundance and biomass data. All variables of protection status correlated with at least one taxonomic category. Distance to another MPA and distance to town were the ones that correlated significantly with the abundances and biomasses of more taxonomic categories. Moreover, ratio perimeter/size was also import in terms of biomass.

Table 4.11. Spearman correlation coefficients between the abundance of the taxonomic categories and total fish assemblage with the variables of the protection status in the warm season.

	Big Labridae	Small Labridae	Big Serranidae	Small Serranidae	Big Sparidae	*Diplodus* spp.	Medium pelagics	Small pelagics	Other species	Total
Protection level	0.079	0.157*	0.340***	0.133	-0.024	0.151*	0.017	0.043	-0.010	0.082
Years since creation	0.152*	-0.130	-0.347***	0.108	0.262***	0.057	-0.035	0.019	-0.053	-0.094
Years since enforc.	0.129	0.040	0.100	0.067	0.258***	0.231**	0.120	0.092	0.088	0.097
Total size	-0.033	0.118	0.403***	-0.049	-0.096	-0.063	0.176*	-0.026	0.042	0.013
IR size	0.013	0.195**	0.480***	-0.042	-0.091	0.142	0.226**	0.025	0.176*	0.136
Buffer size	-0.084	0.052	0.348***	-0.082	-0.063	-0.064	0.184*	0.011	0.037	-0.004
RU size	0.152*	0.190**	0.336***	-0.022	-0.282***	-0.116	-0.032	-0.154*	-0.037	-0.002
IR proportion	0.036	0.166*	0.287***	0.006	0.111	0.215**	0.183*	0.095	0.173*	0.217**
Perimeter	0.038	0.237**	0.447***	-0.044	-0.158*	-0.107	0.186*	-0.030	0.084	0.088
Ratio P/S	0.037	0.136	0.274***	0.016	0.110	0.203**	0.106	0.079	0.106	0.197**
Number of zones	-0.021	0.188**	0.456***	-0.174*	-0.131	-0.039	0.144*	-0.037	0.063	0.111
Distance MPA	-0.059	0.237**	0.258***	-0.436***	0.132	-0.286***	0.555***	0.238***	0.401***	0.327***
Distance town	0.100	0.189**	0.282***	-0.361***	-0.167*	0.036	0.170*	0.006	0.185*	0.218**
Isolation	-0.294***	-0.197**	0.260***	-0.002	-0.012	-0.193**	0.036	-0.022	-0.150*	-0.169*
Compliance	-0.229**	0.036	0.070	-0.008	-0.170*	0.272***	-0.181*	0.034	-0.009	0.100
Hours enforcement[1]	-0.353***	0.052	0.559***	-0.334***	0.135	0.232**	0.259**	0.142	0.147	0.206*
Annual budget[2]	0.046	0.153	0.458***	-0.081	-0.167*	0.222**	0.113	-0.043	0.087	0.100

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=188; [1]n=143; [2]n=156.

Table 4.12. Spearman correlation coefficients between the biomass of the taxonomic categories and total fish assemblage with the variables of the protection status in the warm season.

	Big Labridae	Small Labridae	Big Serranidae	Small Serranidae	Big Sparidae	*Diplodus* spp.	Medium pelagics	Small pelagics	Other species	Total
Protection level	0.193*	0.184*	0.273**	0.105	-0.091	0.319***	-0.084	-0.181*	-0.004	0.097
Years since creation	-0.046	-0.423***	-0.374***	0.158	0.411***	-0.164	0.167	0.216*	0.139	0.016
Years since enforc.	0.163	-0.230*	0.030	0.202*	0.318***	0.146	0.153	0.165	0.220*	0.205*
Total size	0.321***	0.276**	0.275**	0.228*	-0.150	0.262**	-0.075	-0.150	-0.007	0.058
IR size	0.359***	0.372***	0.461***	0.097	-0.088	0.501***	0.060	-0.044	0.256**	0.317***
Buffer size	0.310***	0.166	0.186*	0.274**	-0.113	0.235**	-0.079	-0.143	-0.024	0.035
RU size	0.340***	0.421***	0.242**	0.197*	-0.301***	0.161	-0.110	-0.161	-0.039	-0.017
IR proportion	0.164	0.070	0.403***	-0.068	0.192*	0.471***	0.205*	0.170	0.368***	0.461***
Perimeter	0.403***	0.366***	0.321***	0.237**	-0.127	0.263**	0.035	-0.060	0.085	0.129
Ratio P/S	0.110	0.023	0.347***	-0.053	0.227*	0.270**	0.196*	0.183*	0.228*	0.331***
Number of zones	0.291**	0.397***	0.384***	0.132	-0.156	0.274**	0.007	0.013	0.015	0.140
Distance MPA	0.292**	0.036	0.090	0.197*	0.239**	0.080	0.717***	0.781***	0.477***	0.551***

	Big Labridae	Small Labridae	Big Serranidae	Small Serranidae	Big Sparidae	*Diplodus* spp.	Medium pelagics	Small pelagics	Other species	Total
Distance town	0.148	0.444***	0.335***	-0.111	-0.082	0.470***	0.388***	0.561***	0.429***	0.596***
Isolation	-0.108	0.080	0.006	0.105	-0.016	-0.212*	-0.289**	-0.304***	-0.543***	-0.436***
Compliance	-0.162	0.286**	0.228*	-0.409***	-0.301***	0.180*	-0.328***	-0.385***	-0.044	-0.059
Hours enforcement[1]	-0.021	0.224	0.575***	-0.156	0.085	0.488***	0.032	0.061	0.066	0.260*
Annual budget[2]	0.358***	0.239*	0.277**	0.260*	-0.186	0.543***	-0.123	-0.158	0.148	0.207*

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=123; [1]n=76; [2]n=91.

Tables 4.13 and 4.14 showed the Spearman correlation coefficients among the abundances and biomasses of the taxonomic categories and total fish assemblage with the most correlated combination of the variables of protection status. Only the biomass of big Sparidae did not show a significant relation with the variables of protection status. In general the correlation coefficients were very low (always less than 0.5), but with greater values in biomass than in abundance data. The highest correlation coefficient was observed for the biomass of *Diploduss* spp., which was related with protection level, perimeter, number of zones, and annual budget. The biomass of total fish assemblage showed a similar value, but was correlated with number of zones and distance to town. The protection status variables that correlated with more taxonomic categories were, for abundance data the proportion of the integral reserve, and for biomass data protection status and distance to town.

Table 4.13. Spearman correlation index (ρ_w), obtained using BEST, among the abundance of the taxonomic categories and total fish assemble with the combination of the variables of the protection status on the warm season. Only are showed the best correlation for each case. × indicates the variables that resulted in each correlation analysis. The level of significance is denoted between brackets, and was obtained using 99 permutations. N=141.

Taxonomic categories	ρ_w	Protection level	Years since enforcement	IR size	Buffer size	RU size	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Isolation	Compliance	Hours enforcement	Annual budget
Big Labridae	0.318 (0.01)				×			×					×		×	
Small Labridae	0.390 (0.01)											×	×			
Big Serranidae	0.230 (0.01)	×	×				×			×			×			
Small Serranidae	0.328 (0.01)						×		×						×	
Big Sparidae	0.231 (0.01)										×					
Diplodus spp.	0.194 (0.01)			×								×				×
Medium pelagics	0.199 (0.01)	×					×						×		×	
Small pelagics	0.213 (0.01)						×				×			×		
Other species	0.133 (0.04)	×		×		×	×	×			×			×		
Total	0.245 (0.01)										×					

Table 4.14. Spearman correlation index (ρ_w), obtained using BEST, among the biomass of the taxonomic categories and total fish assemble with the combination of the variables of the protection status on the warm season. Only are showed the best correlation for each case. × indicates the variables that resulted in each correlation analysis. The level of significance is denoted between brackets, and was obtained using 99 permutations. N=141.

Taxonomic categories	ρ_w	Protection level	Years since enforcement	IR size	Buffer size	RU size	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Isolation	Compliance	Hours enforcement	Annual budget
Big Labridae	0.424 (0.01)	×													×	
Small Labridae	0.243 (0.01)									×		×				
Big Serranidae	0.315 (0.01)	×	×				×			×		×				×
Small Serranidae	0.237 (0.01)													×		×
Big Sparidae	0.185 (0.07)					×					×					
Diplodus spp.	0.469 (0.01)	×						×		×						×
Medium pelagics	0.232 (0.03)	×					×					×			×	
Small pelagics	0.379 (0.01)										×					
Other species	0.203 (0.03)	×										×			×	
Total	0.441 (0.01)									×		×				

Table 4.15. Results of multiple linear regression analysis for mean abundance (ind./100 m^2) of the taxonomic categories and total fish assemblage (*superscripts* refer to quadratic, cubic and logarithmic terms of the variables of the protection status used as independent terms). Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001.

Taxonomic categories	n	Adj.R^2	F	Const	Years since enforcement	Buffer size	Distance to MPA	Compliance	Number of zones^2	Distance to MPA^2	Distance to town^2	Compliance^2	Annual budget^2	Protection level^3	RU size^3	IR proportion^3	Perimeter^3	Isolation^3	Hours enforcement^3	Annual budget^3	Years since enforcement^{log}	Buffer size^{log}	RU size^{log}	IR proportion^{log}	Distance to MPA^{log}	Distance to town^{log}	Isolation^{log}
Big Labridae	127	0.491	31.337***	0.233	0.175	-	-	-	-	-	-	-	-	0.066	4E-14	-	-	-	-	-	-4.636	-	-	-	-	-	-
Small Labridae	126	0.713	52.846***	-18.211	-	-	-	58.210	-	-	-	-	1.8E-9	-	-	-	-	-	-	-5E-15	-	-	94.366	-	-	72.831	-341.85
Big Serranidae	127	0.311	57.955***	0.108	-	-	-	-	0.106	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Small Serranidae	127	0.267	16.280***	5.641	-	-	0.007	-	-	-	-	-	-	-	-	2.9E-6	-	-	-	-	-	-	-	-	-2.731	-	-
Big Sparidae	124	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diplodus spp.	119	0.477	54.779***	9.164	0.519	-	-	-	-	-	-	-	-	-	-	-	-	-	1E-11	-	-	-	-	-	-	-	-
Medium pelagics	125	0.304	14.524***	0.174	-0.184	-	-	-	-	-	-	-	-	-	-	-	0.040	-	-7E-13	-	-	1.279	-	-	-	-	-
Small pelagics	126	0.412	44.844***	115.21	-	0.024	-	-	-	0.001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other species	126	0.461	27.764***	-5.222	-	-	-	-	-	-	0.031	-	-	0.216	-	-	-	-	-	-	-	-	-	-5.341	11.141	-	-
Total	125	0.602	47.924***	-235.90	-	-	-	-	-	-	0.891	33.225	-	-	-	-	-	-11.500	-	-	-	-	-	-	130.15	-	-

Table 4.16. Results of multiple linear regression analysis for mean biomass (g/100 m^2) of the taxonomic categories and total fish assemblage (*superscripts* refer to quadratic, cubic and logarithmic terms of the variables of the protection status used as independent terms). Probability levels: ∗=P<0.05; ∗∗=P<0.01; ∗∗∗=P<0.001.

Taxonomic categories	n	Adj.R^2	F	Const	IR size	Buffer size	Perimeter	Distance to town	Hours enforcement	Annual budget	Years since enforcement^2	Hours enforcement^2	Annual budget^2	Protection level^3	RU size^3	Distance to MPA^3	Distance to town^3	Protection level^{log}	Buffer size^{log}	Distance to MPA^{log}	Distance to town^{log}	Annual budget^{log}	Isolation^{log}
Big Labridae	63	0.686	34.886***	58.215	-	-0.231	0.014	-	-	-	0.208	-	-3E-10	-	-	-	-	-	-	-	-	-	-
Small Labridae	67	0.427	17.364***	387.57	-	-	-	-	-	-	-	-	-	-	-	-3.2E-5	0.137	-	-	-	474.56	-	-
Big Serranidae	67	0.213	18.830***	-1289.9	-	-	-	-	-	-	-	-	-	-	-	-	-	5026.4	-	-	-	-	-
Small Serranidae	67	0.202	9.366***	216.44	-	-	-	-	-	-	-	-	-	-	1E-12	-	-	-	-	-64.963	-	-	-
Big Sparidae	64	0.427	12.749***	17.651	3.372	-	-0.024	-	-	-	-	-	-	-4.291	-	-	-	-	135.01	-	-	-	-
Diplodus spp.	67	0.558	42.644***	732.06	-	-	0.030	-	-	0.003	-	-	-	-	-	-	-	-	-	-	-	-	-
Medium pelagics	67	0.373	13.902***	-239.18	-	-	-	-	-	-	-	-	-	122.20	-	-	0.449	-	-	-	-	-769.07	-
Small pelagics	66	0.240	11.284***	9210.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6940.5	-	-24319.5
Other species	67	0.346	12.648***	401.53	-	-	-	267.50	-	-	-	-3.0E-5	-	191.64	-	-	-	-	-	-	-	-	-
Total	66	0.604	34.021***	2023.1	-	-	-	1023.4	-0.756	-	-	-	-	355.43	-	-3.2E-5	0.137	-	-	-	474.56	-	-

When modelling the relationship between the taxonomic categories and total fish assemblage with the protection status variables, we found that, except abundance of big serranids, all categories showed significant models (Tables 4.15 and 4.16). The fitted models accounted for 26.7-71.3% of the observed variation in the abundance data, and for 20.2-68.6% in the biomass data. In abundance data, the category that responded better to the protection status variables was small Labridae, which depended on compliance, annual budget, restricted use area size, distance to town and isolation. On the other hand, in terms of biomass was the model of big Labridae which explained more variance, incorporating buffer area size, perimeter, years since enforcement and annual budget. Nevertheless, the shrinkages obtained in the cross-validation process of these two models were really high, making them not valid (Tables 4.17 and 4.18). Only the models fitted for the abundance and biomass of small Serranidae, the abundance of small pelagics and the biomass of *Diplodus* spp. had been validated, explaining 26.7%, 20.02%, 41.2% and 55.8% of the variation respectively.

-Trophic categories

The abundances and biomasses of all trophic categories were related significantly with at least one variable of protection status (Tables 4.19 and 4.20). However correlation coefficients were usually low, especially in abundance data where correlation coefficients were always lower than 0.35. The highest correlation coefficients were obtained for the biomasses of mesophagous and microphagous, which respectively increased with distance to town and distance to MPA. Mesophagous and macrophagous were the trophic categories that correlated significantly with more variables of protection, in both abundance and biomass data. All variables of protection status correlated with the biomass of at least one trophic category, while in abundance data total area size, buffer area size, perimeter and compliance did not correlated with any category. On the contrary, distance to another MPA correlated significantly with the biomasses of all the trophic categories.

Table 4.19. Spearman correlation coefficients between the abundance of the trophic categories and the variables of the protection status in the warm season.

	Detritivorous	Herbivorous	Microphagous	Mesophagous	Macrophagous
Protection level	-0.017	-0.024	0.074	0.154*	0.170*
Years since creation	0.073	0.219**	-0.010	-0.164*	-0.133
Years since enforc.	0.062	0.194**	0.054	0.073	0.172*
Total size	-0.037	-0.017	-0.018	0.035	0.143
IR size	0.012	-0.018	0.041	0.215**	0.281***
Buffer size	-0.048	0.022	0.011	-0.028	0.120
RU size	-0.088	-0.154*	-0.152*	0.136	-0.012
IR proportion	0.089	0.021	0.093	0.233**	0.292***
Perimeter	-0.023	-0.078	-0.015	0.135	0.150*
Ratio P/S	0.083	0.003	0.082	0.207**	0.203**
Number of zones	-0.025	-0.085	-0.057	0.172*	0.114
Distance MPA	0.174*	0.061	0.142	0.235**	0.246***
Distance town	0.052	-0.147*	-0.078	0.350***	0.158*
Isolation	-0.005	0.017	0.056	-0.308***	-0.185*
Compliance	-0.050	-0.062	0.102	0.111	-0.049
Hours enforcement[1]	0.042	0.063	0.147	0.164	0.217**
Annual budget[2]	-0.006	-0.051	-0.060	0.237**	0.213**

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=188; [1]n=143; [2]n=156.

Table 4.20. Spearman correlation coefficients between the biomass of the trophic categories and the variables of the protection status in the warm season.

	Detritivorous	Herbivorous	Microphagous	Mesophagous	Macrophagous
Protection level	-0.056	-0.096	-0.118	0.203*	0.214*
Years since creation	0.215*	0.530***	0.172	-0.237**	-0.196*
Years since enforc.	0.135	0.355***	0.137	0.053	0.129
Total size	-0.139	-0.137	-0.113	0.188*	0.256**
IR size	-0.057	-0.122	-0.009	0.475***	0.433***
Buffer size	-0.135	-0.054	-0.128	0.132	0.220*
RU size	-0.173	-0.246**	-0.114	0.167	0.190*
IR proportion	0.108	0.051	0.161	0.467***	0.411***
Perimeter	-0.093	-0.166	-0.015	0.258**	0.301***
Ratio P/S	0.103	-0.006	0.190*	0.293**	0.309***
Number of zones	-0.111	-0.224*	0.051	0.287**	0.320***
Distance MPA	0.233**	0.193*	0.671***	0.380***	0.409***
Distance town	0.137	0.017	0.498***	0.692***	0.452***
Isolation	-0.121	-0.230*	-0.191*	-0.384***	-0.243**
Compliance	-0.096	-0.190*	-0.311***	0.118	0.008
Hours enforcement[1]	-0.040	-0.162	0.086	0.401***	0.385***
Annual budget[2]	-0.135	-0.013	-0.154	0.414***	0.309**

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=123; [1]n=76; [2]n=91.

Table 4.21. Spearman correlation index (ρ_w), obtained using BEST, among the abundance of the trophic categories and the combination of the variables of the protection status on the warm season. Only are showed the best correlation for each case. × indicates the variables that resulted in each correlation analysis. The level of significance is denoted between brackets, and was obtained using 99 permutations. N=141.

Trophic categories	ρ_w	Protection level	Years since enforcement	IR size	Buffer size	RU size	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Isolation	Compliance	Hours enforcement	Annual budget
Detritivorous	0.064 (0.48)	×					×						×		×	
Herbivorous	0.130 (0.06)		×			×		×	×			×				
Microphagous	0.232 (0.01)										×			×		
Mesophagous	0.423 (0.01)											×				
Macrophagous	0.209 (0.01)			×	×	×					×			×		

Tables 4.21 and 4.22 showed the Spearman correlation coefficients among the abundances and biomasses of the trophic categories with the most correlated combination of the variables of protection status. Only microphagous, mesophagous and macrophagous correlated significantly with a combination of the variables of protection status, but with correlation values lower than 0.6. The highest correlation coefficient was observed for the biomass of mesophagous, which was related with number of zones and distance to town.

Table 4.22. Spearman correlation index (ρ_w), obtained using BEST, among the biomass of the trophic categories and the combination of the variables of the protection status on the warm season. Only are showed the best correlation for each case. × indicates the variables that resulted in each correlation analysis. The level of significance is denoted between brackets, and was obtained using 99 permutations. N=141.

Trophic categories	ρ_w	Protection level	Years since enforcement	IR size	Buffer size	RU size	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Isolation	Compliance	Hours enforcement	Annual budget
Detritivorous	0.027 (0.85)														×	
Herbivorous	0.185 (0.06)		×			×			×							
Microphagous	0.347 (0.01)										×					
Mesophagous	0.538 (0.01)									×		×				
Macrophagous	0.353 (0.01)									×		×				

For the abundances and biomasses of all trophic categories were obtained significant regression models (Tables 4.23 and 4.24). The fitted models accounted for 4.4-74.7% of the observed variation in the abundance data, and for 6.8-71.8% in the biomass data. The abundance and biomass of mesophagous responded to the protection status variables better than other categories. Meanwhile 74.7 % of the variation of the mesophagous abundance was explained by 7 variables of protection statues, only protection level and distance to town accounted for 71.8% of the observed variation in its biomass. However the shrinkages obtained in the cross-validation process were high, making not valid these models (Tables 4.25 and 4.26). Exclusively, the model fitted for the biomass of detritivorous had been validated, but it only explained 6.8% of the variation.

Table 4.23. Results of multiple linear regression analysis for mean abundance (ind./100 m^2) of the trophic categories (*superscripts* refer to quadratic, cubic and logarithmic terms of the variables of the protection status used as independent terms). Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001.

Trophic categories	n	Adj.R^2	F	Const	Years since enforcement	IR size	Buffer size	IR proportion	Compliance	Hours enforcement	Number of $zones^2$	Annual $budget^2$	Years since $enforcement^3$	Years since $enforcement^{log}$	Ratio P/S^{log}	Distance to $town^{log}$	$Isolation^{log}$
Detritivorous	125	0.044	6.693*	0.048	-	-	-	-	-	-	0.047	-	-	-	-	-	-
Herbivorous	126	0.146	6.339***	6.844	0.865	-	-	0.082	-	-	-	-	-0.001	-	-8278.4	-	-
Microphagous	125	0.338	64.394***	107.11	-	-	0.047	-	-	-	-	-	-	-	-	-	-
Mesophagous	127	0.747	47.541***	-12.273	-10.596	-	-	-	80.024	-0.015	30.890	-3E-10	-	157.29	-	137.05	-515.03
Macrophagous	125	0.354	68.805***	3.143	-	0.024	-	-	-	-	-	-	-	-	-	-	-

Table 4.24. Results of multiple linear regression analysis for mean biomass (g/100 m^2) of the trophic categories (*superscripts* refer to quadratic, cubic and logarithmic terms of the variables of the protection status used as independent terms). Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001.

Trophic categories	n	Adj.R^2	F	Const	Distance to town	Years since $enforcement^2$	Protection $level^3$	IR $size^3$	Number of $zones^3$	$Isolation^3$	Distance to $town^{log}$
Detritivorous	67	0.068	5.812*	30.390	14.376	-	-	-	-	-	-
Herbivorous	67	0.164	7.479**	875.89	-	12.539	-	3E-11	-	-	-
Microphagous	66	0.174	7.848**	2145.8	-	-	-	-	-	-484.66	5549.5
Mesophagous	65	0.714	81.030***	396.40	493.40	-	58.864	-	-	-	-
Macrophagous	66	0.389	14.784***	-393.44	423.01	-	131.19	-	-176.75	-	-

5. RESULTS FOR FISHERIES DATA

GILL NET >50 mm

Relation Among Variables of Protection Status

Most variables of protection status were significantly related, but in general they had low values of correlation coefficients (Table 5.1). However, several variables of protection status were highly correlated (values greater than 0.9). Years since creation and years since enforcement showed high correlation values between them and among other structural variables of the MPAs (integral reserve size, proportion of the integral reserve and perimeter). In addition, some structural variables also correlated with isolation (is the case of integral reserve size and perimeter) and with annual budget (only proportion of the integral reserve). Moreover, some structural variables were highly related among them: total size with buffer area size and ratio perimeter/size; integral reserve size with perimeter; buffer size with ratio perimeter/size; and restricted use area size and number of zones.

Relation Among Variables of Fish Assemblage

Of the 13 taxonomic categories analyzed in this fishing gear, only 4 pairs were significantly related (Table 5.2). Nevertheless, only 2 showed a correlation coefficient greater than 0.6 (Cephalopoda with Labridae, and chondrictios with other species). Regarding the trophic classification, any pair of taxonomic categories was highly correlated (Table 5.3). Only macrophagous where significantly correlated with herbivorous, however the coefficient was very low (less than 0.3). Concerning the commercial categories, only the total catch was significantly correlated with target species and with by-catch species, obtaining in the last case a large correlation coefficient (Table 5.4).

Relation Among Variables of Fish Assemblage and Variables of Protection Status

-Taxonomic categories

Small pelagics, Sparidae, chondrictios and other species were the taxonomic categories that related significantly with at least one variable of protection status.

Table 5.1. Spearman correlation coefficients between the variables of the protection status of the samples of gear gill net >50 mm.

	Protection level	Years since creation	Years since enforcement	Total size	IR size	Buffer size	RU size	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Isolation	Compliance	Hours enforcement
Years since creation	0.292*															
Years since enforc.	0.292*	1.000														
Total size	-0.239	-0.265	-0.265													
IR size	-0.348*	-0.943***	-0.943***	0.281*												
Buffer size	-0.239	-0.265	-0.265	1.000	0.281*											
RU size	-0.347*	-0.640***	-0.640***	0.679***	0.679***	0.679***										
IR proportion	0.208	0.094	0.094	-0.885***	-0.096	-0.885***	-0.748***									
Perimeter	-0.348*	-0.943***	-0.943***	0.281*	1.000	0.281*	0.679***	-0.096								
Ratio P/S	0.207	0.255	0.255	-0.980***	-0.275*	-0.980***	-0.665***	0.861***	-0.275*							
Number of zones	-0.347*	-0.640***	-0.640***	0.679***	0.679***	0.679***	1.000	-0.748***	0.679***	-0.665***						
Distance MPA	-0.084	0.121	0.121	0.896***	-0.128	0.896***	0.299*	-0.768***	-0.128	-0.877***	0.299*					
Distance town	-0.306*	-0.800***	-0.800***	0.083	0.848***	0.083	0.761***	-0.154	0.848***	-0.081	0.761***	-0.368**				
Isolation	-0.264	-0.865***	-0.865***	-0.122	0.917***	-0.122	0.448***	0.244	0.917***	0.120	0.448***	-0.512***	0.867***			
Compliance	0.845***	0.307*	0.307*	-0.253	-0.344*	-0.253	-0.337*	0.210	-0.344*	0.214	-0.337*	-0.106	-0.285*	-0.253		
Hours enforcement	-0.353**	-0.931***	-0.931***	0.268	0.987***	0.268	0.750***	-0.155	0.987***	-0.262	0.750***	-0.169	0.920***	0.917***	-0.344*	
Annual budget[1]	-0.344*	-0.476**	-0.476**	0.557***	0.557***	0.557***	0.947***	-1.000***	0.557***	-0.538***	0.947***	-0.471**	0.947***	0.683***	-0.319	0.792***

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=53; [1]n=36

Table 5.2 Pearson correlation coefficients between the biomass (kg/500 m of net) of the taxonomic categories captured in the gear gill net >50 mm.

	Big pelagics	Medium pelagics	Small pelagics	Big serranidae	Small serranidae	Labridae	Scorpenids	Sparidae	Chondrictios	Cephalopoda	Mollusca	Crustacea
Medium pelagics	0.135											
Small pelagics	-0.030	0.132										
Big serranidae	-0.026	0.137	-0.032									
Small serranidae	-0.006	0.028	-0.090	-0.037								
Labridae	-0.034	-0.021	-0.094	-0.008	-0.051							
Scorpenids	-0.019	-0.089	-0.064	-0.026	-0.042	-0.034						
Sparidae	0.010	-0.035	0.491***	-0.041	-0.041	-0.104	-0.009					
Chondrictios	0.047	0.059	-0.121	-0.062	-0.091	-0.015	-0.046	-0.094				
Cephalopoda	-0.049	-0.107	-0.069	0.021	-0.075	0.746***	-0.049	-0.083	0.034			
Mollusca	-0.025	-0.095	-0.058	-0.033	-0.036	-0.044	-0.025	-0.056	0.352**	-0.062		
Crustacea	0.040	-0.073	-0.097	-0.005	-0.070	-0.060	-0.034	-0.087	-0.022	-0.082	-0.043	
Other species	0.011	-0.152	0.112	-0.082	-0.151	0.018	0.151	0.200	0.623***	0.060	0.043	0.121

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=53

Table 5.3. Pearson correlation coefficients between the biomass (kg/500 m of net) of the trophic categories captured in the gear gill net >50 mm.

	Detritivorous	Herbivorous	Microphagous	Mesophagous
Herbivorous	0.153			
Microphagous	-0.022	-0.034		
Mesophagous	0.008	-0.032	-0.033	
Macrophagous	-0.068	0.293*	-0.097	0.038

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=53

Table 5.4. Pearson correlation coefficients between the biomass (kg/500 m of net) of the commercial categories captured in the gear gill net >50 mm.

	By-catch	Discards	Target
Discards	-0.042		
Target	0.157	0.211	
Total catch	0.932***	0.136	0.490***

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=53

Table 5.5. Spearman correlation coefficients between the biomass (kg/500 m of net) of the taxonomic categories captured in the gear gill net >50 mm and the variables of the protection status.

	Medium pelagics	Small pelagics	Small serranidae	Labridae	Sparidae	Chondrictios	Other species
Protection level	0.138	0.227	0.182	0.182	0.406**	-0.266	-0.307*
Years since creation	0.099	-0.117	-0.085	-0.085	-0.080	-0.141	-0.449***
Years since enforc.	0.099	-0.117	-0.085	-0.085	-0.080	-0.141	-0.449***
Total size	0.171	-0.229	0.041	0.041	0.257	-0.278*	0.102
IR size	-0.032	0.074	0.013	0.013	-0.024	0.232	0.520***
Buffer size	0.171	-0.229	0.041	0.041	0.257	-0.278*	0.102
RU size	0.219	0.019	0.103	0.103	0.058	-0.106	0.251
IR proportion	-0.265	0.144	-0.079	-0.079	-0.176	0.374**	0.059
Perimeter	-0.032	0.074	0.013	0.013	-0.024	0.232	0.520***
Ratio P/S	-0.210	0.201	-0.058	-0.058	-0.272*	0.278*	-0.115
Number of zones	0.219	0.019	0.103	0.103	0.058	-0.106	0.251
Distance MPA	0.130	-0.300*	0.008	0.008	0.294*	-0.346*	-0.081
Distance town	0.081	0.201	0.075	0.075	-0.127	0.177	0.374**
Isolation	-0.089	0.180	0.003	0.003	-0.137	0.347*	0.487***
Compliance	0.067	0.130	0.213	0.213	0.218	-0.114	-0.129
Hours enforcement	0.011	0.106	0.035	0.035	-0.046	0.208	0.490***
Annual budget[1]	0.242	0.204	0.144	0.144	-0.100	-0.018	0.222

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=53; [1]n=36

Table 5.6. Spearman correlation index (ρ_w), obtained using BEST, among the mean biomass (kg/500 m of net) of the taxonomic categories captured in the gear gill net >50 mm and the combination of the variables of the protection status. Only are showed the best correlation for each case. × indicates the variables that resulted in each correlation analysis. * indicates de variables excluded from the analysis due to the high correlation with others. The level of significance is denoted between brackets, and was obtained using 99 permutations. N=36.

Taxonomic categories	ρ_w	Protection level	Years since enforcement	IR size	Buffer size	RU size*	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town*	Isolation	Compliance	Hours enforcement	Annual budget
Big pelagics																
Medium pelagics	0.245 (0.16)										×					
Small pelagics	0.192 (0.30)										×					
Big serranidae																
Small serranidae	0.101 (0.73)										×					
Labridae	0.224 (0.15)	×														

Taxonomic categories	ρ_w	Protection level	Years since enforcement	IR size	Buffer size	RU size*	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town*	Isolation	Compliance	Hours enforcement	Annual budget
Scorpenids																
Sparidae	0.080 (0.53)	×														
Chondrictios	0.056 (0.89)	×														
Cephalopoda																
Mollusca																
Crustacea																
Other species	0.164 (0.16)		×					×					×		×	×

However correlation coefficients were low and never reached values greater than 0.6. Besides other species was the taxonomic category that correlated significantly with more variables of protection, it showed the highest correlation coefficient, increasing its capture with integral reserve size and perimeter. There were 4 variables of protection status (restricted use area size, number of zones, compliance and total annual budget) that did not correlate with any taxonomic category. On the contrary, distance to another MPA was the variable that correlated significantly with more taxonomic categories.

Any taxonomic category showed significant results on the BEST analyses (Table .6), nevertheless for 3 of them significant linear models were found (Table 5.7). The fitted models accounted for 18.2-53.7% of the variation. The taxonomic category that responded better to the protection status variables was, once again, other species, which depended on protection level and perimeter. However the shrinkages obtained in the cross-validation process were high, making not valid any of the models (Table 5.8).

Table 5.7. Results of multiple linear regression analysis for mean biomass (kg/500 m of net) of the taxonomic categories captured in the gear gill net >50 mm (*superscripts* refer to quadratic, cubic and logarithmic terms of the variables of the protection status used as independent terms). Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001.

Taxonomic categories	n	Adj.R^2	F	Const	Protection level	Hours enforcement^2	Perimeter^3	Protection level^{log}
Big pelagics								
Medium pelagics	31		n.s.					
Small pelagics	32	0.182	7.893**	-0.141	0.202	-	-	-
Big serranidae								
Small serranidae	32		n.s.					
Labridae	32	0.199	8.688**	0.006	-	4.31E-10	-	-
Scorpenids								
Sparidae	32		n.s.					
Chondrictios	31		n.s.					
Cephalopoda								
Mollusca								
Crustacea								
Other species	29	0.537	17.245***	1.999	-	-	3.15E-13	-2.954

Table 5.9. Spearman correlation coefficients between the biomass (kg/500 m of net) of the trophic categories captured in the gear gill net >50 mm and the variables of the protection status.

	Detritivorous	Mesophagous	Macrophagous
Protection level	0.052	0.270	-0.172
Years since creation	0.033	0.044	-0.190
Years since enforc.	0.033	0.044	-0.190
Total size	0.085	0.063	0.383**
IR size	-0.131	-0.130	0.351**
Buffer size	0.085	0.063	0.383**
RU size	0.040	-0.131	0.432**
IR proportion	-0.158	0.011	-0.317*
Perimeter	-0.131	-0.130	0.351**
Ratio P/S	-0.130	-0.086	-0.405**
Number of zones	0.040	-0.131	0.432**
Distance MPA	0.115	0.153	0.226
Distance town	-0.070	-0.218	0.291*
Isolation	-0.164	-0.169	0.209
Compliance	-0.017	0.234	-0.137
Hours enforcement	-0.111	-0.158	0.357**
Annual budget[1]	0.024	-0.235	0.351*

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=53; [1]n=36

-Trophic categories

Only macrophagous correlated significantly with the protection status variables (Table 5.9). This category was related with several structural variables of the MPAs, distance to town, hours of enforcement and annual budget. However, the highest correlation coefficients observed, lightly exceed 0.4, indicating that capture of macrophagous increased as the ratio perimeter size declined.

Table 5.10. Spearman correlation index (ρ_w), obtained using BEST, among the mean biomass (kg/500 m of net) of the trophic categories captured in the gear gill net >50 mm and the combination of the variables of the protection status. Only are showed the best correlation for each case. × indicates the variables that resulted in each correlation analysis. * indicates de variables excluded from the analysis due to the high correlation with others. The level of significance is denoted between brackets, and was obtained using 99 permutations. N=36.

Trophic categories	ρ_w	Protection level	Years since enforcement	IR size	Buffer size	RU size*	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town*	Isolation	Compliance	Hours enforcement	Annual budget
Detritivorous	0.128 (0.55)										×					
Herbivorous																
Microphagous																
Mesophagous	0.060 (0.66)	×								×				×	×	
Macrophagous	0.111 (0.42)												×	×		

Table 5.11. Results of multiple linear regression analysis for mean biomass (kg/500 m of net) of the trophic categories captured in the gear gill net >50 mm (*superscripts* refer to quadratic, cubic and logarithmic terms of the variables of the protection status used as independent terms). Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001.

Trophic categories	n	Adj.R^2	F	Const	Compliance	$Compliance^3$
Detritivorous	32	0.298	14.171**	-0.351	0.547	-
Herbivorous						
Microphagous						
Mesophagous	32		n.s.			
Macrophagous	31	0.208	8.870**	5.619	-	-0.136

Any trophic category showed significant results on the BEST analyses (Table .10), nevertheless for detritivorous and macrophagous significant linear models were found (Table .5.11). The fitted models accounted for only 20.8-29.8% of the variation observed and furthermore, were not valid due to the high shrinkages obtained in the cross-validation process (Table .5.8).

-Commercial categories

All commercial categories were related significantly with at least one variable of protection status (Table 5.12). However correlation coefficients were usually low. Values that exceeded 0.8 were observed only in discards, which increased with integral reserve size, perimeter and isolation. Discards was also the category that correlated significantly with more variables of protection. All variables of protection status correlated with the capture of at least one commercial category, but there were 4 of them (restricted use area size, number of zones, distance to another MPA and isolation) that correlated with three of the four commercial categories.Table 5.13 showed the Spearman correlation coefficients among the commercial categories and the most correlated combination of the variables of protection status. Only the capture of discards correlated significantly, but only with isolation and not with a combination of the variables of protection status. Similar results were obtained in the multiple linear regression models, in which 62.7% of the variation observed in discards was explained exclusively by the isolation (Table 5.14). Additionally a significant model was obtained for the target species, but explaining only 34.3% of the variance depending on the hours of enforcement. Both models were validated due to their small shrinkages obtained in the cross-validation process (Table 5.8).

Table 5.12. Spearman correlation coefficients between the biomass (kg/500 m of net) of the commercial categories captured in the gear gill net >50 mm and the variables of the protection status.

	By-catch	Discards	Target	Total catch
Protection level	0.216	-0.382**	-0.131	0.085
Years since creation	0.212	-0.754***	-0.506***	-0.058
Years since enforc.	0.212	-0.754***	-0.506***	-0.058
Total size	0.313*	-0.055	0.241	0.407**
IR size	-0.142	0.802***	0.527***	0.126
Buffer size	0.313*	-0.055	0.241	0.407**
RU size	0.030	0.360**	0.536***	0.289*
IR proportion	-0.246	0.220	-0.230	-0.345*
Perimeter	-0.142	0.802***	0.527***	0.126
Ratio P/S	-0.352**	0.056	-0.255	-0.440***
Number of zones	0.030	0.360**	0.536***	0.289*
Distance MPA	0.398**	-0.372**	-0.023	0.358**
Distance town	-0.237	0.693***	0.554***	0.050
Isolation	-0.281*	0.847***	0.457***	-0.037
Compliance	0.236	-0.338*	-0.149	0.062
Hours enforcement	-0.162	0.783***	0.559***	0.122
Annual budget[1]	-0.156	0.542***	0.565***	0.143

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=53; [1]n=36

Table 5.13. Spearman correlation index (ρ_w), obtained using BEST, among the mean biomass (kg/500 m of net) of the commercial categories captured in the gear gill net >50 mm and the combination of the variables of the protection status. Only are showed the best correlation for each case. × indicates the variables that resulted in each correlation analysis. * indicates de variables excluded from the analysis due to the high correlation with others. The level of significance is denoted between brackets, and was obtained using 99 permutations. N=36.

Commercial categories	ρ_w	Protection level	Years since enforcement	IR size	Buffer size	RU size*	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town*	Isolation	Compliance	Hours enforcement	Annual budget
By-catch	0.086 (0.48)									×						
Discards	0.894 (0.01)												×			
Target	0.099 (0.53)													×		
Total catch	-0.047 (0.99)	×											×			

Table 5.14. Results of multiple linear regression analysis for mean biomass (kg/500 m of net) of the commercial categories captured in the gear gill net >50 mm (*superscripts* refer to quadratic, cubic and logarithmic terms of the variables of the protection status used as independent terms). Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001.

Commercial categories	n	Adj.R^2	F	Const	Hours of enforcement^2	Isolation^{log}
By-catch	32		n.s			
Discards	29	0.627	47.999***	-1.186	-	3.940
Target	30	0.343	16.126***	2.037	1.4E-8	-
Total catch	32		n.s.			

TRAMMEL NET <40 mm

Relation Among Variables of Protection Status

Most variables of protection status were significantly related (Table 5.15), but only some of them were highly correlated (values greater than 0.9). Years since creation and years since enforcement showed high correlation values between them and among integral reserve size. In addition, several structural variables (total size, buffer area size, perimeter, ratio perimeter/size) were also correlated among them. Furthermore were obtained high correlation coefficients among the proportion of the integral reserve, the number of zones and annual budget.

Table 5.15. Spearman correlation coefficients between the variables of the protection status of the samples of gear trammel net <40 mm.

	Protection level	Years since creation	Years since enforcement	Total size	IR size	Buffer size	RU size	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Isolation	Compliance	Hours enforcement
Years since creation	-0.179															
Years since enforc.	-0.160	0.998***														
Total size	-0.099	-0.137	-0.131													
IR size	0.114	-0.924***	-0.920***	0.354*												
Buffer size	-0.199	0.012	0.016	0.972***	0.217											
RU size	-0.125	-0.205	-0.205	0.491***	0.206	0.505***										
IR proportion	0.171	-0.172	-0.174	-0.890***	0.013	-0.916***	-0.668***									
Perimeter	-0.164	-0.235	-0.228	0.947***	0.480***	0.917***	0.491***	-0.802***								
Ratio P/S	0.066	0.082	0.068	-0.976***	-0.297*	-0.963***	-0.487***	0.880***	-0.923***							
Number of zones	-0.238	0.108	0.111	0.870***	0.078	0.895***	0.695***	-0.961***	0.870***	-0.862***						
Distance MPA	-0.060	-0.214	-0.234	0.556***	0.247	0.558***	0.327*	-0.475***	0.351*	-0.480***	0.300*					
Distance town	-0.036	-0.296*	-0.285*	0.351*	0.342*	0.277	0.693***	-0.427**	0.520***	-0.348*	0.599***	-0.283*				
Isolation	0.072	-0.614***	-0.593***	0.530***	0.763***	0.406**	0.367**	-0.299*	0.718***	-0.525***	0.467***	-0.140	0.762***			
Compliance	0.671***	-0.121	-0.108	-0.067	0.084	-0.181	-0.180	0.138	-0.113	0.087	-0.179	-0.112	0.018	0.102		
Hours enforcement	-0.424**	-0.063	-0.068	0.561***	0.248	0.668***	0.650***	-0.590***	0.700***	-0.570***	0.725***	0.165	0.503***	0.447**	-0.439**	
Annual budget[1]	-0.244	0.194	0.182	0.785***	-0.101	0.820***	0.733***	-0.979***	0.785***	-0.731***	0.970***	0.722***	0.409**	0.291	-0.173	0.547***

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=49; [1]n=40

Table 5.16. Pearson correlation coefficients between the biomass (kg/500 m of net) of the taxonomic categories captured in the gear trammel net <40 mm.

	Medium pelagics	Small pelagics	Small serranidae	Labridae	Scorpenids	Sparidae	Chondrictios	Cephalopoda	Crustacea
Small pelagics	-0.040								
Small serranidae	-0.124	-0.037							
Labridae	-0.050	-0.023	-0.135						
Scorpenids	-0.030	-0.027	-0.090	-0.035					
Sparidae	0.716***	0.309*	-0.172	0.112	-0.050				
Chondrictios	-0.046	0.256	-0.129	0.328*	-0.032	-0.015			
Cephalopoda	0.334*	0.596***	-0.185	0.310*	-0.058	0.693***	0.405**		
Crustacea	-0.035	-0.031	0.446**	-0.041	-0.024	-0.060	-0.037	-0.070	
Other species	0.054	-0.042	0.358*	0.036	0.090	0.021	-0.019	0.015	0.936***

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001 n=49

Table 4.17. Pearson correlation coefficients between the biomass (kg/500 m of net) of the trophic categories captured in the gear trammel net <40 mm.

	Detritivorous	Herbivorous	Microphagous	Mesophagous
Herbivorous	0.983***			
Microphagous	-0.040	-0.040		
Mesophagous	0.012	0.012	0.043	
Macrophagous	0.142	0.146	0.084	0.806***

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001 n=49

Table 5.18. Pearson correlation coefficients between the biomass (kg/500 m of net) of the commercial categories captured in the gear trammel net <40 mm.

	By-catch	Discards	Target
Discards	0.336*		
Target	0.434**	-0.002	
Total catch	0.598***	0.087	0.981***

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001 n=49

Relation Among Variables of Fish Assemblage

Few pairs of taxonomic categories were significantly related, and not all of them showed high correlation coefficients (Table 5.16). A high correlation coefficient (0.936) was observed between Crustacean and other species. Moreover, Sparidae correlated with medium pelagics and with Cephalopoda with values around 0.7. Concerning the trophic categories, only two pairs (detritivorous with herbivorous and mesophagous with macrophagous) correlated significantly showing high correlation coefficients (Table 5.17). With regard to the commercial classification, although by-catch species was significantly related with the other categories, the correlation values obtained never reached 0.6 (Table 5.18). On the contrary, the target species correlated highly with total catch.

Relation Among Variables of Fish Assemblage and Variables of Protection Status

-Taxonomic categories

When analyzing the correlation coefficients between the taxonomic categories and the protection status variables, we found that, except small pelagics, all categories showed significant results with at least one variable of protection status (Table .19). However correlation coefficients were usually low, only exceeded 0.7 in the case of other species, which decreased as the annual budget rose. Moreover, other species was the taxonomic category that correlated significantly with more variables of protection. Isolation did not correlate with any taxonomic category. On the contrary, annual budget was the variable that correlated significantly with more taxonomic categories.

Table .20 showed the Spearman correlation coefficients among the taxonomic categories and the most correlated combination of the variables of protection status. Only the captures of medium pelagics, small pelagics and Sparidae did not show a significant relation with the variables of protection status. In general the correlation coefficients were very low (always less than 0.6). The highest correlation coefficient was observed for other species, which was related with protection level, proportion of integral reserve, number of zones, distance to another MPA and annual budget. The variable of protection status that correlated with more taxonomic categories was the annual budget.

Table 5.19. Spearman correlation coefficients between the biomass (kg/500 m of net) of the taxonomic categories captured in the gear trammel net <40 mm and the variables of the protection status.

	Medium pelagics	Small pelagics	Small serranidae	Labridae	Sparidae	Chondrictios	Cephalopoda	Crustacea	Other species
Protection level	-0.296*	0.043	-0.205	0.114	0.001	-0.094	0.044	0.145	0.361*
Years since creation	-0.193	-0.176	-0.362*	-0.392**	-0.110	0.027	-0.179	-0.347*	-0.406**
Years since enforc.	-0.196	-0.168	-0.372**	-0.398**	-0.103	0.040	-0.163	-0.325*	-0.393**
Total size	0.137	-0.030	0.001	-0.508***	-0.099	-0.216	-0.381**	-0.349*	-0.481***
IR size	0.227	0.165	0.370**	0.232	0.168	0.052	0.156	0.260	0.287*
Buffer size	0.087	-0.048	0.003	-0.499***	-0.125	-0.170	-0.382**	-0.434**	-0.542***
RU size	0.114	-0.030	0.201	-0.048	-0.281	-0.301*	-0.075	-0.338*	-0.308*
IR proportion	-0.083	0.119	0.085	0.581***	0.254	0.317*	0.434**	0.517***	0.657***
Perimeter	0.174	-0.053	0.091	-0.508***	-0.050	-0.086	-0.237	-0.264	-0.450**
Ratio P/S	-0.118	0.064	0.053	0.498***	0.089	0.158	0.308*	0.330*	0.433**
Number of zones	0.121	-0.147	-0.015	-0.609***	-0.220	-0.222	-0.324*	-0.466***	-0.656***
Distance MPA	0.080	0.106	0.122	0.120	-0.120	-0.349*	-0.476***	-0.389**	-0.165
Distance town	0.193	-0.113	0.131	-0.307*	-0.130	-0.100	0.141	-0.018	-0.239
Isolation	0.209	0.018	0.186	-0.242	0.091	0.073	0.187	0.197	-0.018
Compliance	-0.110	0.154	-0.035	-0.095	0.078	-0.098	-0.062	0.289*	0.268
Hours enforcement	0.076	-0.076	0.279	-0.184	-0.113	0.094	0.005	-0.345*	-0.399**
Annual budget[1]	0.167	-0.155	-0.044	-0.624***	-0.313*	-0.423**	-0.473**	-0.639***	-0.732***

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=49; [1]n=40

Were obtained significant regression models for 6 of the 9 taxonomic categories analyzed (Table 5.21). The fitted models accounted for 19.9-45.5% of the observed variation. The taxonomic category that responded better to the protection status variables was Cephalopoda, which depended on years since enforcement and annual budget. However the shrinkage obtained in the cross-validation process was high, making not valid the model (Table 5.22). Only were positively validated the models for small serranids, small peagics and Sparidae, even thought they explained a small part of the variation observed.

Table 5.20. Spearman correlation index (ρ_w), obtained using BEST, among the mean biomass (kg/500 m of net) of the taxonomic categories captured in the gear trammel net <40 mm and the combination of the variables of the protection status. Only are showed the best correlation for each case. × indicates the variables that resulted in each correlation analysis. The level of significance is denoted between brackets, and was obtained using 99 permutations. N=40.

Taxonomic categories	ρ_w	Protection level	Years since enforcement	IR size	Buffer size	RU size	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Isolation	Compliance	Hours enforcement	Annual budget
Big pelagics																
Medium pelagics	0.164 (0.27)	×												×		
Small pelagics	0.049 (0.97)													×		
Big serranidae																
Small serranidae	0.319 (0.05)		×											×		
Labridae	0.360 (0.03)		×				×								×	×
Scorpenids																
Sparidae	0.072 (0.69)						×									×
Chondrictios	0.298 (0.05)		×							×						×
Cephalopoda	0.271 (0.05)		×													
Mollusca																
Crustacea	0.502 (0.01)															×
Other species	0.537 (0.01)	×					×			×	×					×

Table 5.21. Results of multiple linear regression analysis for mean biomass (kg/500 m of net) of the taxonomic categories captured in the gear trammel net <40 mm (*superscripts* refer to quadratic, cubic and logarithmic terms of the variables of the protection status used as independent terms). Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001.

Taxonomic categories	n	Adj.R^2	F	Const	Years since enforcement^2	Protection level^3	Protection level^{log}	Years since enforcement^3	Annual budget^{log}	Distance to MPA^{log}
Big pelagics										
Medium pelagics	36		n.s.							
Small pelagics	36	0.266	6.287**	738.812	-	-	-481.071	-	-	-335.798
Big serranidae										

Taxonomic categories	n	Adj.R^2	F	Const	Years since enforcement^2	Protection level^3	Protection level^{log}	Years since enforcement^3	Annual budget^{log}	Distance to MPA^{log}
Small serranidae	36	0.296	15.732***	0.369	-	-	-	-2.9E-5	-	-
Labridae	36		n.s.							
Scorpenids										
Sparidae	36	0.199	9.671**	1.500	0.425	-	-	-	-	-
Chondrictios	36		n.s.							
Cephalopoda	36	0.475	16.848***	5842.43	1.254	-	-	-	-1104.99	-
Mollusca										
Crustacea	36	0.332	18.412***	-25.222	-	8.894	-	-	-	-
Other species	34	0.365	20.003***	-660.552	-	-	3004.196	-	-	-

Table 5.23. Spearman correlation coefficients between the biomass (kg/500 m of net) of the trophic categories captured in the gear trammel net <40 mm and the variables of the protection status.

	Herbivorous	Microphagous	Mesophagous	Macrophagous
Protection level	-0.183	-0.027	0.171	0.342*
Years since creation	-0.321*	-0.354*	-0.223	-0.323*
Years since enforc.	-0.326*	-0.341*	-0.213	-0.307*
Total size	-0.216	-0.105	-0.421**	-0.516***
IR size	0.233	0.305*	0.177	0.214
Buffer size	-0.259	-0.122	-0.441**	-0.573***
RU size	-0.075	0.038	-0.277	-0.340*
IR proportion	0.297*	0.225	0.549***	0.666***
Perimeter	-0.125	-0.082	-0.383**	-0.502***
Ratio P/S	0.224	0.120	0.393**	0.475***
Number of zones	-0.224	-0.222	-0.536***	-0.682***
Distance MPA	-0.149	0.040	-0.144	-0.179
Distance town	0.084	-0.045	-0.242	-0.280
Isolation	0.125	0.119	-0.076	-0.082
Compliance	-0.199	0.108	0.210	0.285*
Hours enforcement	-0.065	0.001	-0.264	-0.452**
Annual budget[1]	-0.275	-0.294	-0.591***	-0.759***

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=49; [1]n=40

-Trophic categories

All trophic categories were related significantly with at least one variable of protection status (Table 5.23). However correlation coefficients were usually low. A value that exceeded 0.7 was observed only in macrophagous, which increased as decline the annual budget. Macrophagous was also the category that correlated significantly with more variables of protection. Distance to another MPA, distance to town and isolation did not correlate with any taxonomic category. On the contrary, years since creation, years since enforcement and proportion of integral reserve, correlated with three of the four trophic categories.

Table 5.24 showed the Spearman correlation coefficients among the trophic categories and the most correlated combination of the variables of protection status. Only the captures of mesophagous and macrophagous showed a significant relation with the combination of several variables of protection status, but coefficients were very low (always less than 0.5). The highest correlation coefficient was observed for macrophagous, which was related with protection level, proportion of integral reserve, number of zones, distance to another MPA and annual budget. The variables of protection status that correlated with more trophic categories were the proportion of integral reserve and the annual budget.

Table 5.24. Spearman correlation index (ρ_w), obtained using BEST, among the mean biomass (kg/500 m of net) of the trophic categories captured in the gear trammel net <40 mm and the combination of the variables of the protection status. Only are showed the best correlation for each case. × indicates the variables that resulted in each correlation analysis. The level of significance is denoted between brackets, and was obtained using 99 permutations. N=40.

Trophic categories	ρ_w	Protection level	Years since enforcement	IR size	Buffer size	RU size	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Isolation	Compliance	Hours enforcement	Annual budget
Detritivorous																
Herbivorous	0.147 (0.32)	×	×				×							×		×
Microphagous	0.125 (0.38)		×													
Mesophagous	0.290 (0.01)						×				×	×				×
Macrophagous	0.588 (0.01)	×					×			×	×					×

Significant regression models were obtained for microphagous, mesophagous and macrophagous, explaining 26.6-62.5% of the observed variation (Table 5.25). The trophic category that responded better to the protection status variables was the macrophagous, which depended on protection level and distance to another MPA. However the shrinkage obtained in the cross-validation process was high, making not valid the model (Table 5.22). Only were positively validated the models for small serranids, small peagics and Sparidae, even thought they explained a small part of the variation observed.

Table 5.25. Results of multiple linear regression analysis for mean biomass (kg/500 m of net) of the trophic categories captured in the gear trammel net <40 mm (*superscripts* refer to quadratic. cubic and logarithmic terms of the variables of the protection status used as independent terms). Probability levels: $*$=P<0.05; $**$=P<0.01; $***$=P<0.001.

Trophic categories	n	Adj.R^2	F	Const	Years since enforcement	Protection level^{log}	Distance to MPA^{log}	Annual bubget^{log}
Detritivorous								
Herbivorous	36		n.s.					
Microphagous	36	0.266	7.347**	738.841	-	-480.936	-335.883	-
Mesophagous	35	0.327	9.245**	4965.466	21.152	-	-	-941.308
Macrophagous	32	0.625	26.805***	3342.117	-	2805.689	-2429.59	-

-Commercial categories

All commercial categories were related significantly with at least one variable of protection status (Table 5.26). However correlation coefficients were usually low. Values that exceeded 0.7 were observed only in target species and total catch, which increased as annual budget declined. Target species was also the category that correlated significantly with more variables of protection. Integral reserve size and isolation did not correlate with any commercial category. On the contrary, only hours of enforcement correlated significantly with all commercial categories.

Table 5.27 showed the results obtained in BEST analyses, where all the commercial categories correlated significantly with a combination of the protection status variables. In general the correlation coefficients were low (always less than 0.6). The highest correlation coefficient was observed for total catch, which was related with proportion of integral reserve, number of zones, distance to another MPA and annual budget. The variables of protection status which correlated with more taxonomic categories were proportion of integral reserve and annual budget.

Significant regression models were obtained for by-catch species, target species and total catch (Table 5.28). The fitted models explained 42.4-82.3% of the observed variation. Total catch was the category that responded better to the protection status variables, which depended on protection level and distance to another MPA. However any model was valid due to the high shrinkages obtained in the cross-validation process (Table 5.22).

Table 5.26. Spearman correlation coefficients between the biomass (kg/500 m of net) of the commercial categories captured in the gear trammel net <40 mm and the variables of the protection status.

	By-catch	Discards	Target	Total catch
Protection level	0.224	-0.349*	0.409**	0.336*
Years since creation	-0.176	-0.196	-0.338*	-0.296*
Years since enforc.	-0.165	-0.211	-0.317*	-0.280
Total size	-0.261	-0.122	-0.481***	-0.540***
IR size	0.148	0.235	0.255	0.207
Buffer size	-0.306*	-0.082	-0.541***	-0.595***
RU size	-0.383**	0.079	-0.277	-0.379**
IR proportion	0.421**	0.169	0.633***	0.694***
Perimeter	-0.271	0.049	-0.426**	-0.494***
Ratio P/S	0.253	0.139	0.412**	0.495***
Number of zones	-0.450**	-0.027	-0.609***	-0.680***
Distance MPA	-0.047	-0.129	-0.299*	-0.274
Distance town	-0.315*	0.168	-0.133	-0.240
Isolation	-0.076	0.163	0.059	-0.044
Compliance	0.169	-0.237	0.367**	0.322*
Hours enforcement	-0.359*	0.362*	-0.364*	-0.429**
Annual budget[1]	-0.493**	-0.118	-0.708***	-0.757***

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=49; [1]n=40

Table 5.27. Spearman correlation index (ρ_w), obtained using BEST, among the mean biomass (kg/500 m of net) of the commercial categories captured in the gear trammel net <40 mm and the combination of the variables of the protection status. Only are showed the best correlation for each case. × indicates the variables that resulted in each correlation analysis. The level of significance is denoted between brackets, and was obtained using 99 permutations. N=40.

Commercial categories	ρ_w	Protection level	Years since enforcement	IR size	Buffer size	RU size	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Isolation	Compliance	Hours enforcement	Annual budget
By-catch	0.266 (0.01)						×				×				×	×
Discards	0.335 (0.04)		×											×		
Target	0.396 (0.01)						×									×
Total catch	0.580 (0.01)						×			×	×					×

Table 5.28. Results of multiple linear regression analysis for mean biomass (kg/500 m of net) of the commercial categories captured in the gear trammel net <40 mm (*superscripts* refer to quadratic. cubic and logarithmic terms of the variables of the protection status used as independent terms). Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001.

Commercial categories	n	Adj.R^2	F	Const	Years since enforcement	Distance to MPA	$Compliance^3$	$Protection\ level^{log}$	$Distance\ to\ MPA^{log}$	$Annual\ bubget^{log}$
By-catch	36	0.424	13.859***	10044.47	40.814	-	-	-	-	-1899.86
Discards	36		n.s.							
Target	33	0.602	17.144***	555.596	-	-	-42.703	5144.320	-1225.16	-
Total catch	32	0.823	48.993***	19315.03	-	153.159	-	3571.848	-16563.1	-

TRAMMEL NET 40-60 mm

Relation Among Variables of Protection Status

Most variables of protection status were significantly related (Table 5.29), but only some of them were highly correlated (values greater than 0.9). Years since creation was negatively related with the integral reserve size. The same occurred for years since enforcement and perimeter. In addition, several structural variables (total size, perimeter, ratio perimeter/size) were also correlated among them. Furthermore were obtained high correlation coefficients between distance to another MPA with total size and ratio perimeter/size. Finally, annual budget was highly correlated with number of zones.

Table 5.29. Spearman correlation coefficients between the variables of the protection status of the samples of gear trammel net 40-60 mm.

	Protection level	Years since creation	Years since enforcement	Total size	IR size	Buffer size	RU size	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Isolation	Compliance	Hours enforcement
Years since creation	0.328*															
Years since enforc.	-0.333*	0.185														
Total size	0.462**	-0.020	-0.847***													
IR size	-0.324*	-0.969***	-0.142	0.037												
Buffer size	-0.168	-0.828***	-0.065	0.222	0.864***											
RU size	0.271	0.319*	-0.645***	0.654***	-0.324*	-0.278										
IR proportion	-0.391**	-0.233	0.592***	-0.837***	0.218	-0.060	-0.855***									
Perimeter	0.384*	-0.123	-0.950***	0.914***	0.152	0.135	0.654***	-0.675***								
Ratio P/S	-0.458**	0.027	0.847***	-0.991***	-0.037	-0.220	-0.649***	0.826***	-0.906***							
Number of zones	-0.365*	-0.628***	0.216	-0.133	0.679***	0.726***	-0.082	-0.044	-0.133	0.132						
Distance MPA	0.453**	0.058	-0.777***	0.944***	-0.076	0.138	0.597***	-0.779***	0.789***	-0.936***	-0.307*					
Distance town	-0.402**	-0.299*	0.207	-0.355*	0.343*	0.158	0.139	0.066	-0.170	0.352*	0.764***	-0.562***				
Isolation	-0.349*	-0.774***	-0.002	-0.195	0.840***	0.591***	-0.313*	0.348*	0.056	0.193	0.707***	-0.427**	0.654***			
Compliance	0.755***	0.212	-0.293	0.306*	-0.234	-0.180	0.193	-0.215	0.293	-0.312*	-0.317*	0.300*	-0.286	-0.230		
Hours enforcement	0.074	-0.300*	-0.769***	0.673***	0.320*	0.238	0.786***	-0.680***	0.788***	-0.667***	0.321*	0.522***	0.372*	0.272	0.061	
Annual budget[1]	-0.306	-0.366*	0.451*	-0.337	0.371*	0.520**	-0.056	-0.125	-0.337	0.333	0.960***	-0.403*	0.778***	0.592***	-0.301	0.382*

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=44; [1]n=31

Table 5.30. Pearson correlation coefficients between the biomass (kg/500 m of net) of the taxonomic categories captured in the gear trammel net 40-60 mm.

	Big pelagics	Medium pelagics	Small pelagics	Big serranidae	Small serranidae	Labridae	Scorpenids	Sparidae	Chondrictios	Cephalopoda	Crustacea
Medium pelagics	-0.040										
Small pelagics	-0.026	-0.074									
Big serranidae	0.058	-0.083	0.210								
Small serranidae	-0.059	0.022	-0.041	0.016							
Labridae	0.040	-0.003	-0.093	-0.098	-0.124						
Scorpenids	0.131	-0.041	-0.056	-0.046	-0.080	-0.047					
Sparidae	0.031	0.000	0.370*	-0.037	-0.096	0.135	-0.117				
Chondrictios	0.063	-0.120	0.133	0.035	-0.103	0.266	-0.093	0.507***			
Cephalopoda	-0.096	-0.132	0.030	-0.026	0.348*	0.125	-0.131	0.153	0.333*		
Crustacea	-0.069	-0.047	-0.122	-0.127	-0.135	-0.165	-0.092	0.149	-0.039	-0.018	
Other species	0.043	-0.184	-0.021	0.095	-0.206	0.410**	-0.144	0.418**	0.528***	0.039	0.331*

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=44

Table 5.31. Pearson correlation coefficients between the biomass (kg/500 m of net) of the trophic categories captured in the gear trammel net 40-60 mm.

	Detritivorous	Herbivorous	Microphagous	Mesophagous
Herbivorous	0.268			
Microphagous	-0.073	0.027		
Mesophagous	-0.129	0.035	0.101	
Macrophagous	-0.198	-0.090	0.170	0.600***

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=44

Table 5.32. Pearson correlation coefficients between the biomass (kg/500 m of net) of the commercial categories captured in the gear trammel net 40-60 mm.

	By-catch	Discards	Target
Discards	0.104		
Target	-0.025	0.086	
Total catch	0.727***	0.399**	0.613***

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=44

Relation Among Variables of Fish Assemblage

Only 8 pairs of taxonomic categories were significantly related, but all of them with low correlation coefficients (Table .30). Only the capture of chondrictios with Sparidae and other species showed correlation values that reached 0.5. Regarding the trophic classification, any pair of taxonomic categories was highly correlated (Table .31). Only macrophagous where significantly correlated with mesophagous, however the coefficient was low (0.6). Concerning the commercial categories, only the total catch was significantly correlated with the other categories (Table .32). The highest correlation coefficient was obtained with by-catch species, which exceeded 0.7.

Table 5.33. Spearman correlation coefficients between the biomass (kg/500 m of net) of the taxonomic categories captured in the gear trammel net 40-60 mm and the variables of the protection status.

	Medium pelagics	Small pelagics	Big serranidae	Small serranidae	Labridae	Sparidae	Chondrictios	Cephalopoda	Cephalopoda	Other species
Protection level	0.042	0.093	0.370*	-0.008	-0.054	0.171	0.058	0.092	0.058	-0.011
Years since creation	-0.178	-0.003	0.395**	-0.067	-0.528***	-0.353*	-0.159	-0.102	0.087	-0.341*
Years since enforc.	-0.350*	-0.691***	-0.617***	-0.104	-0.325*	-0.556***	-0.521***	-0.371*	0.084	-0.413**
Total size	0.301*	0.651***	0.603***	0.025	0.369*	0.564***	0.444**	0.293	-0.117	0.346*
IR size	0.133	-0.021	-0.424**	0.081	0.518***	0.344*	0.186	0.156	-0.113	0.384*
Buffer size	0.138	-0.007	-0.382*	-0.005	0.582***	0.390**	0.099	0.044	-0.132	0.273
RU size	0.114	0.642***	0.645***	0.237	0.032	0.241	0.241	0.238	-0.101	0.128
IR proportion	-0.154	-0.600***	-0.549***	-0.122	-0.186	-0.374*	-0.220	-0.168	0.128	-0.102
Perimeter	0.304*	0.677***	0.603***	0.111	0.322*	0.569***	0.539***	0.419**	-0.121	0.422**
Ratio P/S	-0.328*	-0.664***	-0.607***	-0.042	-0.370*	-0.561***	-0.451**	-0.304*	0.144	-0.326*
Number of zones	-0.059	-0.085	-0.470**	0.207	0.312*	0.127	-0.120	-0.001	-0.154	0.016
Distance MPA	0.298*	0.592***	0.599***	-0.055	0.344*	0.486***	0.391**	0.199	-0.067	0.344*
Distance town	-0.159	-0.050	-0.305*	0.341*	-0.030	-0.092	-0.137	0.071	-0.111	-0.093
Isolation	0.014	-0.098	-0.432**	0.181	0.260	0.183	0.111	0.196	-0.111	0.193
Compliance	0.108	0.140	0.356*	0.012	-0.062	0.229	0.110	0.246	0.179	-0.080
Hours enforcement	0.202	0.637***	0.393**	0.299*	0.341*	0.466**	0.390**	0.373*	-0.171	0.383*
Annual budget[1]	-0.086	-0.108	-0.411*	0.230	0.277	0.050	-0.218	-0.046	-0.180	-0.120

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=44; [1]n=31

Relation Among Variables of Fish Assemblage and Variables of Protection Status

-Taxonomic categories

When analyzing the correlation coefficients between the taxonomic categories and the protection status variables, we found that, except cephalopods, all categories showed significant results with at least one variable of protection status (Table 5.33). However correlation coefficients were usually low, only exceeded 0.6 in the case of small pelagics and big serranids correlating with several protection status variables. Moreover, big serranids was significantly related with all the variables of protection. All variables of protection status correlated with at least one taxonomic category. Furthermore, perimeter, ratio perimeter/size and hours of enforcement correlated significantly with eight of the ten taxonomic categories.

Table 5.34 showed the Spearman correlation coefficients among the trophic categories and the most correlated combination of the variables of protection status. Only the captures of small pelagics, big Serranidae, Sparidae and chondrictios showed a significant relation with the combination of several variables of protection status, but coefficients were very low (always less than 0.5). The highest correlation coefficient was observed for small pelagics, which was related with years since enforcement, integral reserve size, proportion of integral reserve, and hours of enforcement. The variable of protection status that correlated with more taxonomic categories was hours of enforcement.

Significant models were obtained for 4 of the 10 taxonomic categories analyzed (Table 5.35). The fitted models accounted for 25.7-35.7% of the observed variation and all of them only incorporated one variable of protection status. Only the models for Labridae was positively validated, even thought they explained a small part of the variation observed (Table 5.36).

Table 5.34. Spearman correlation index (ρ_w), obtained using BEST, among the mean biomass (kg/500 m of net) of the taxonomic categories captured in the gear trammel net 40-60 mm and the combination of the variables of the protection status. Only are showed the best correlation for each case. × indicates the variables that resulted in each correlation analysis. The level of significance is denoted between brackets, and was obtained using 99 permutations. N=31.

Taxonomic categories	ρ_w	Protection level	Years since enforcement	IR size	Buffer size	RU size	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Isolation	Compliance	Hours enforcement	Annual budget
Big pelagics																
Medium pelagics	0.273 (0.11)		×				×								×	
Small pelagics	0.468 (0.01)		×	×			×								×	
Big serranidae	0.430 (0.02)		×				×								×	
Small serranidae	0.134 (0.50)			×		×		×					×	×		
Labridae	0.330 (0.33)						×	×	×		×		×		×	
Scorpenids																
Sparidae	0.379 (0.01)		×	×			×								×	
Chondrictios	0.405 (0.03)		×				×								×	
Cephalopoda	0.311 (0.09)		×										×		×	
Mollusca																
Crustacea	0.083 (0.70)											×				
Other species	0.330 (0.09)		×	×											×	

Table 5.35. Results of multiple linear regression analysis for mean biomass (kg/500 m of net) of the taxonomic categories captured in the gear trammel net 40-60 mm (*superscripts* refer to quadratic, cubic and logarithmic terms of the variables of the protection status used as independent terms). Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001.

Taxonomic categories	n	Adj.R^2	F	Const	Protection level^3	IR size^3	Isolation^3
Big pelagics							
Medium pelagics	28		n.s.				
Small pelagics	27	0.353	15.174**	-0.144	0.044	-	-
Big serranidae	28	0.257	10.322**	0.016	0.011	-	-

Taxonomic categories	n	Adj.R^2	F	Const	Protection level[3]	IR size[3]	Isolation[3]
Small serranidae	28		n.s.				
Labridae	27	0.357	15.448**	-0.112	-	-	0.113
Scorpenids							
Sparidae	28		n.s.				
Chondrictios	28		n.s.				
Cephalopoda	28		n.s				
Mollusca							
Crustacea	27		n.s.				
Other species	28	0.362	16.311***	2.973	-	2.29E-7	-

-Trophic categories

When analyzing the correlation coefficients between the trophic categories and the protection status variables, we found that, except detritivorous, all categories showed significant results with at least one variable of protection status (Table 5.37). However, correlation coefficients were usually low (always less than 0.7). Besides microphagous was the trophic category that correlated significantly with more variables of protection, it showed the highest correlation coefficient, increasing its capture with the restricted use area size. There were 6 variables of protection status (protection level, years since creation, number of zones, distance to town, isolation and total annual budget) that did not correlate with any trophic category.

BEST results showed significant correlations for 3 trophic categories, but all coefficient were lower than 0.5 (Table 5.38). The highest correlation coefficient was observed again for the capture of microphagous, which was related with years since enforcement, integral reserve size, proportion of integral reserve, and hours of enforcement. The variables of protection status that correlated with more trophic categories were years since enforcement and hours of enforcement.

Significant regression models were obtained for all trophic categories except detritivorous (Table 5.39). The fitted models accounted for 24.6-47.8% of the observed variation and all of them only incorporated one variable of protection status. The model of microphagous explained more variance, depending on the size of the restricted use area. Nevertheless, the shrinkages obtained in the cross-validation process made not valid any of the models (Table 5.36).

Table 5.37. Spearman correlation coefficients between the biomass (kg/500 m of net) of the trophic categories captured in the gear trammel net 40-60 mm and the variables of the protection status.

	Detritivorous	Herbivorous	Microphagous	Mesophagous	Macrophagous
Protection level	0.048	0.200	0.215	-0.124	0.080
Years since creation	0.175	-0.236	0.150	-0.273	-0.261
Years since enforc.	-0.175	-0.496***	-0.581***	-0.220	-0.589***
Total size	0.148	0.344*	0.548***	0.264	0.538***
IR size	-0.217	0.152	-0.157	0.303*	0.314*
Buffer size	-0.184	0.104	-0.154	0.323*	0.222

	Detritivorous	Herbivorous	Microphagous	Mesophagous	Macrophagous
RU size	0.236	0.249	0.695***	0.056	0.245
IR proportion	-0.204	-0.218	-0.603***	-0.135	-0.245
Perimeter	0.152	0.415**	0.584***	0.249	0.622***
Ratio P/S	-0.184	-0.359*	-0.554***	-0.254	-0.532***
Number of zones	-0.106	0.023	-0.092	0.133	-0.107
Distance MPA	0.107	0.268	0.482***	0.257	0.513***
Distance town	0.001	0.021	0.050	-0.056	-0.208
Isolation	-0.127	0.136	-0.149	0.134	0.130
Compliance	0.184	0.301*	0.286	-0.055	0.093
Hours enforcement	0.108	0.367*	0.604***	0.240	0.468**
Annual budget[1]	-0.056	-0.009	-0.069	0.087	-0.231

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=44; [1]n=31

Table 5.38. Spearman correlation index (ρ_w), obtained using BEST, among the mean biomass (kg/500 m of net) of the trophic categories captured in the gear trammel net 40-60 mm and the combination of the variables of the protection status. Only are showed the best correlation for each case. × indicates the variables that resulted in each correlation analysis. The level of significance is denoted between brackets, and was obtained using 99 permutations. N=31.

Trophic categories	ρ_w	Protection level	Years since enforcement	IR size	Buffer size	RU size	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Isolation	Compliance	Hours enforcement	Annual budget
Detritivorous	0.161 (0.32)		×	×	×		×		×						×	
Herbivorous	0.351 (0.05)		×				×								×	
Microphagous	0.469 (0.02)		×	×			×								×	
Mesophagous	0.153 (0.46)				×											
Macrophagous	0.365 (0.01)		×												×	

Table 5.39. Results of multiple linear regression analysis for mean biomass (kg/500 m of net) of the trophic categories captured in the gear trammel net 40-60 mm (*superscripts* refer to quadratic, cubic and logarithmic terms of the variables of the protection status used as independent terms). Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001.

Trophic categories	n	Adj.R^2	F	Const	RU size	Buffer size^2	Protection level^3	IR size^3
Detritivorous	28		n.s.					
Herbivorous	28	0.347	15.346**	0.066	-	-	0.006	-
Microphagous	28	0.478	25.227***	0.026	2.68E-6	-	-	-
Mesophagous	28	0.246	9.789**	2.481	-	1.25E-6	-	-
Macrophagous	28	0.228	8.996**	5.281	-	-	-	1.82E-7

-Commercial categories

All commercial categories were related significantly with at least one variable of protection status (Table 5.40). However correlation coefficients were usually low. Values that exceeded 0.7 were observed only in discard species, which increased as years since enforcement declined and integral reserve size rose. Discard species was also the category that correlated significantly with more variables of protection. All variables of protection status correlated with at least one commercial category. Furthermore, the variable that correlated significantly with more commercial categories was hours of enforcement.

Only by-catch and discard species showed significant correlation in the BEST analyses (Table 5.41). Although discards species only correlated with isolation in stead of with a combination of protection variables, the correlation coefficient exceeded 0.8. The variable of protection status that correlated with more trophic categories was years since enforcement.

Significant regression models were obtained for all commercial categories except total catch (Table 5.42). The fitted models accounted for 37.9-66.2% of the observed variation and all of them only incorporated one variable of protection status. The commercial category that responded better to the protection status variables was by-catch, which depended on buffer area size. However the shrinkage obtained in the cross-validation process was high, making not valid the model (Table 5.36). Only were positively validated the models for discards and target species, even thought they explained a small part of the variation observed.

Table 5.40. Spearman correlation coefficients between the biomass (kg/500 m of net) of the commercial categories captured in the gear trammel net 40-60 mm and the variables of the protection status.

	By-catch	Discards	Target	Total catch
Protection level	0.006	-0.427**	0.069	0.014
Years since creation	-0.431**	-0.719***	0.062	-0.184
Years since enforc.	-0.122	-0.149	-0.492***	-0.431**
Total size	0.230	0.014	0.421**	0.476**
IR size	0.482***	0.729***	-0.038	0.220
Buffer size	0.553***	0.588***	-0.125	0.246
RU size	-0.241	-0.084	0.418**	0.173
IR proportion	0.008	0.087	-0.310*	-0.265
Perimeter	0.194	0.141	0.490***	0.474**
Ratio P/S	-0.212	-0.035	-0.417**	-0.464**
Number of zones	0.220	0.611***	-0.249	-0.049
Distance MPA	0.189	-0.112	0.429**	0.455**
Distance town	-0.140	0.466**	-0.151	-0.222
Isolation	0.300*	0.687***	-0.121	0.047
Compliance	-0.007	-0.335*	0.115	0.016
Hours enforcement	0.063	0.389**	0.411**	0.319*
Annual budget[1]	0.210	0.555**	-0.358*	-0.117

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=44; [1]n=31

Table 5.41. Spearman correlation index (ρ_w), obtained using BEST, among the mean biomass (kg/500 m of net) of the commercial categories captured in the gear trammel net 40-60 mm and the combination of the variables of the protection status. Only are showed the best correlation for each case. × indicates the variables that resulted in each correlation analysis. The level of significance is denoted between brackets, and was obtained using 99 permutations. N=31.

Commercial categories	ρ_w	Protection level	Years since enforcement	IR size	Buffer size	RU size	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Isolation	Compliance	Hours enforcement	Annual budget
By-catch	0.475 (0.01)		×	×	×		×		×						×	
Discards	0.811 (0.01)												×			
Target	0.258 (0.24)		×										×			
Total catch	0.233 (0.11)		×	×			×								×	

Table 5.42. Results of multiple linear regression analysis for mean biomass (kg/500 m of net) of the commercial categories captured in the gear trammel net 40-60 mm (*superscripts* refer to quadratic, cubic and logarithmic terms of the variables of the protection status used as independent terms). Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001.

Commercial categories	n	Adj.R^2	F	Const	Isolation	Buffer size^2	Distance to MPA^3
By-catch	28	0.662	53.962***	1.148	-	3.08E-6	-
Discards	28	0.497	27.673***	-1.665	1.666	-	-
Target	28	0.379	17.468***	3.324	-	-	4.09E-06
Total catch	28		n.s.				

TRAMMEL NET >60 mm

Relation Among Variables of Protection Status

Most variables of protection status were significantly related (Table 5.43), and lot of them were highly correlated (values greater than 0.9). Years since creation and years since enforcement showed again high correlation values between them. In addition, several structural variables (total size, integral reserve size, buffer area size, perimeter and ratio perimeter/size), variables of siting place (distance to another MPA, distance to main town, isolation) and annual budget were highly correlated. Furthermore were obtained high correlation coefficients among the restricted use area size and the number of zones.

Relation Among Variables of Fish Assemblage

Only few pairs of taxonomic categories were significantly related, but in general correlation coefficients were low (Table 5.44). Only the capture of crustacea and other species were highly related, showing correlation values that exceeded 0.8. With regard to the trophic classification, only macrophagous where significantly related with mesophagous showing a high correlation coefficient (Table 5.45). Concerning the commercial categories, total catch, by-catch species and target species were highly correlated among them, obtaining coefficients that exceeded 0.8 (Table 5.46).

Table 5.43. Spearman correlation coefficients between the variables of the protection status of the samples of gear trammel net >60 mm.

	Protection level	Years since creation	Years since enforcement	Total size	IR size	Buffer size	RU size	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Isolation	Compliance	Hours enforcement
Years since creation	-0.113															
Years since enforc.	-0.113	1.000														
Total size	0.110	-0.357*	-0.357*													
IR size	0.110	-0.357*	-0.357*	1.000												
Buffer size	0.110	-0.357*	-0.357*	1.000	1.000											
RU size	-0.277	0.244	0.244	-0.287	-0.287	-0.287										
IR proportion	0.148	-0.264	-0.264	0.864***	0.864***	0.864***	-0.363*									
Perimeter	0.110	-0.357*	-0.357*	1.000	1.000	1.000	-0.287	0.864***								
Ratio P/S	-0.204	0.360*	0.360*	-0.906***	-0.906***	-0.906***	0.260	-0.906***	-0.906***							
Number of zones	-0.277	0.244	0.244	-0.287	-0.287	-0.287	1.000	-0.363*	-0.287	0.260						
Distance MPA	0.127	-0.354*	-0.354*	0.997***	0.997***	0.997***	-0.352*	0.870***	0.997***	-0.904***	-0.352*					
Distance town	0.066	-0.178	-0.178	0.967***	0.967***	0.967***	-0.159	0.828***	0.967***	-0.876***	-0.159	0.960***				
Isolation	0.092	-0.328*	-0.328*	0.997***	0.997***	0.997***	-0.222	0.854***	0.997***	-0.904***	-0.222	0.991***	0.979***			
Compliance	0.860***	-0.032	-0.032	-0.051	-0.051	-0.051	-0.151	0.027	-0.051	-0.086	-0.151	-0.039	-0.076	-0.063		
Hours enforcement	-0.088	-0.146	-0.146	0.751***	0.751***	0.751***	0.416**	0.571***	0.751***	-0.681***	0.416**	0.704***	0.816***	0.794***	-0.154	
Annual budget	0.057	-0.054	-0.054	0.918***	0.918***	0.918***	-0.157	0.792***	0.918***	-0.831***	-0.157	0.915***	0.986***	0.933***	-0.075	0.776***

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=47

Table 5.44. Pearson correlation coefficients between the biomass (kg/500 m of net) of the taxonomic categories captured in the gear trammel net >60 mm.

	Big pelagics	Medium pelagics	Small pelagics	Big serranidae	Small serranidae	Labridae	Scorpenids	Sparidae	Chondrictios	Cephalopoda	Mollusca	Crustacea
Medium pelagics	-0.032											
Small pelagics	-0.018	-0.041										
Big serranidae	-0.020	-0.024	-0.005									
Small serranidae	0.000	-0.049	-0.050	-0.038								
Labridae	-0.032	-0.022	-0.042	-0.024	-0.049							
Scorpenids	-0.032	-0.022	-0.042	-0.024	-0.049	-0.022						
Sparidae	-0.055	-0.077	0.059	0.267	-0.119	-0.077	-0.054					
Chondrictios	-0.004	-0.074	-0.043	0.117	-0.047	-0.074	0.480***	0.200				
Cephalopoda	-0.052	-0.043	-0.083	0.120	0.511***	-0.043	-0.043	0.129	0.015			
Mollusca	-0.032	-0.022	-0.042	-0.024	-0.049	-0.022	-0.022	-0.077	-0.074	-0.043		
Crustacea	-0.090	-0.071	0.029	0.257	0.112	-0.071	-0.070	0.556***	0.608***	0.388**	-0.071	
Other species	-0.074	-0.085	-0.056	0.087	0.249	-0.085	-0.012	0.653***	0.528***	0.400**	-0.085	0.865***

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=47

Table 5.45. Pearson correlation coefficients between the biomass (kg/500 m of net) of the trophic categories captured in the gear trammel net >60 mm.

	Herbivorous	Microphagous	Mesophagous
Microphagous	-0.024		
Mesophagous	-0.078	-0.072	
Macrophagous	-0.102	-0.093	0.854***

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=47

Table 5.46. Pearson correlation coefficients between the biomass (kg/500 m of net) of the commercial categories captured in the gear trammel net >60 mm.

	By-catch	Discards	Target
Discards	-0.167		
Target	0.886***	-0.128	
Total catch	0.937***	-0.142	0.992***

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=47

Relation Among Variables of Fish Assemblage and Variables of Protection Status

-Taxonomic categories

When analyzing the correlation coefficients between the taxonomic categories and the protection status variables, we found that, except big serranids, all categories analyzed showed significant results with at least one variable of protection status (Table 5.47). In general, correlation coefficients were not very low, ranging values of 0.5-0.7. Other species correlated, showing values greater than 0.8, with ratio perimeter/size, distance to town, isolation and annual budget. Similar result was obtained for Crustacea, which correlated highly with distance to town. Any of the temporal measures of protection variables correlated significantly. On the contrary, hours of enforcement was the variable that correlated significantly with more taxonomic categories.

Table 5.48 showed the Spearman correlation coefficients among the taxonomic categories and the most correlated combination of the variables of protection status. Only the captures of big Serranidae did not correlated significantly with a combination of several variables of protection status. However only two categories were highly correlated (with values that exceeded 0.8), Crustacea and other species. The first was related with the combination of integral reserve size, number of zones and annual budget, meanwhile the second only correlated with distance to town. The variable of protection status that correlated with more taxonomic categories was isolation.

Big Serranidae was the unique taxonomic category without a significant regression model (Table 5.49). For the other categories, models accounted for 9.3-88.3% of the observed variation. Despite Crustacea was the category that better responded to the variables of protection status, depending on protection level and years since enforcement, the model was not validated due to the high shrinkage obtained in the cross-validation process (Table 5.50). However the models fitted for Sparidae, Chondrictios and other species had been validated.

Table 5.47. Spearman correlation coefficients between the biomass (kg/500 m of net) of the taxonomic categories captured in the gear trammel net >60 mm and the variables of the protection status.

	Big serranidae	Sparidae	Chondrictios	Cephalopoda	Crustacea	Other species
Protection level	0.110	0.042	0.303*	0.006	0.481***	0.251
Years since creation	0.131	-0.027	-0.131	-0.106	-0.147	-0.084
Years since enforc.	0.131	-0.027	-0.131	-0.106	-0.147	-0.084
Total size	-0.021	0.611***	0.625***	0.263	0.789***	0.794***
IR size	-0.021	0.611***	0.625***	0.263	0.789***	0.794***
Buffer size	-0.021	0.611***	0.625***	0.263	0.789***	0.794***
RU size	-0.055	-0.102	-0.040	0.071	-0.326*	-0.140
IR proportion	-0.004	0.436**	0.446**	0.227	0.690***	0.722***
Perimeter	-0.021	0.611***	0.625***	0.263	0.789***	0.794***
Ratio P/S	0.087	-0.532***	-0.558***	-0.230	-0.757***	-0.815***
Number of zones	-0.055	-0.102	-0.040	0.071	-0.326*	-0.140
Distance MPA	-0.014	0.606***	0.614***	0.252	0.799***	0.790***
Distance town	0.004	0.625***	0.629***	0.273	0.801***	0.828***
Isolation	-0.021	0.617***	0.634***	0.273	0.787***	0.804***
Compliance	0.004	-0.043	0.231	0.017	0.321*	0.238
Hours enforcement	-0.053	0.513***	0.567***	0.299*	0.533***	0.665***
Annual budget	0.030	0.611***	0.601***	0.258	0.799***	0.822***

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=47

Table 5.48. Spearman correlation index (ρ_w), obtained using BEST, among the mean biomass (kg/500 m of net) of the taxonomic categories captured in the gear trammel net >60 mm and the combination of the variables of the protection status. Only are showed the best correlation for each case. × indicates the variables that resulted in each correlation analysis. * indicates de variables excluded from the analysis due to the high correlation with others. The level of significance is denoted between brackets, and was obtained using 99 permutations. N=47.

Taxonomic categories	ρ_w	Protection level	Years since enforcement	IR size	Buffer size	RU size	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Isolation	Compliance	Hours enforcement	Annual budget
Big pelagics																
Medium pelagics																
Small pelagics																
Big serranidae	0.033 (0.96)									×						
Small serranidae																
Labridae																
Scorpenids																

Taxonomic categories	ρ_w	Protection level	Years since enfforcement	IR size	Buffer size	RU size	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Isolation	Compliance	Hours enforcement	Annual budget
Sparidae	0.461 (0.01)							×					×	×		×
Chondrictios	0.547 (0.01)												×			
Cephalopoda	0.165 (0.07)											×	×			
Mollusca																
Crustacea	0.808 (0.01)			×						×						×
Other species	0.828 (0.01)											×				

Table 5.49. Results of multiple linear regression analysis for mean biomass (kg/500 m of net and day) of the taxonomic categories captured in the gear trammel net >60 mm (*superscripts* refer to quadratic, cubic and logarithmic terms of the variables of the protection status used as independent terms). Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001.

Taxonomic categories	n	Adj.R^2	F	Const	Protection level^2	IR proportion^2	Distance to town^2	Protection level^3	Years since enforcement^{log}
Big pelagics									
Medium pelagics									
Small pelagics									
Big serranidae	42	n.s.							
Small serranidae									
Labridae									
Scorpenids									
Sparidae	37	0.126	6.194*	0.165	-	-	0.034	-	-
Chondrictios	42	0.381	13.595***	289.79	-143.94	-	-	41.881	-
Cephalopoda	42	0.093	5.188*	-1.601	-	-	-	1.623	-
Mollusca									
Crustacea	42	0.883	103.96***	-50714.0	-26288.8	-	-	5294.5	239783.1
Other species	41	0.674	28.615***	875.09	-1187.1	1.172	-	365.41	-

-Trophic categories

Only two trophic categories were captured with trammel net >60 mm, and both were significantly related with most of the protection status variables (Table 5.51). In general the correlation coefficients were high, mainly reaching 0.7. The highest correlation coefficients were observed among distance to town and the capture of mesophagous and macrophagous. Any of the temporal measures of protection variables, restricted use area size and number of zones correlated significantly.

Also both categories showed significant results in BEST analyses, obtaining the same high correlation value (Table 5.52). Whereas mesophagous was related with the combination of protection level, integral reserve size, distance to town and annual budget, macrophagous only was related with distance to town.

Significant regression models were obtained for both, mesophagous and macrophagous, explaining large part of the observed variation (Table 5.52). Capture of mesophagous responded to changes in protection level, while the capture of macrophagous depended on the protection level and the proportion of the integral reserve. Moreover both models had been validated in the cross-validation process (Table 5.50).

Table 5.51. Spearman correlation coefficients between the biomass (kg/500 m of net) of the trophic categories captured in the gear trammel net >60 mm and the variables of the protection status.

	Mesophagous	Macrophagous
Protection level	0.428**	0.235
Years since creation	-0.118	-0.075
Years since enforc.	-0.118	-0.075
Total size	0.789***	0.797***
IR size	0.789***	0.797***
Buffer size	0.789***	0.797***
RU size	-0.163	-0.148
IR proportion	0.660***	0.719***
Perimeter	0.789***	0.797***
Ratio P/S	-0.763***	-0.805***
Number of zones	-0.163	-0.148
Distance MPA	0.787***	0.793***
Distance town	0.824***	0.827***
Isolation	0.798***	0.806***
Compliance	0.288*	0.222
Hours enforcement	0.645***	0.662***
Annual budget	0.823***	0.818***

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=47

Table 5.52. Spearman correlation index (ρ_w), obtained using BEST, among the mean biomass (kg/500 m of net) of the trophic categories captured in the gear trammel net >60 mm and the combination of the variables of the protection status. Only are showed the best correlation for each case. × indicates the variables that resulted in each correlation analysis. * indicates de variables excluded from the analysis due to the high correlation with others. The level of significance is denoted between brackets, and was obtained using 99 permutations. N=47.

Trophic categories	ρ_w	Protection level	Years since enfforcement	IR size	Buffer size	RU size	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Isolation	Compliance	Hours enforcement	Annual budget
Detritivorous																
Herbivorous																
Microphagous																
Mesophagous	0.828 (0.01)	×		×								×				×
Macrophagous	0.828 (0.01)											×				

Table 5.53. Results of multiple linear regression analysis for mean biomass (kg/500 m of net and day) of the trophic categories captured in the gear trammel net >60 mm (*superscripts* refer to quadratic, cubic and logarithmic terms of the variables of the protection status used as independent terms). Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001.

Trophic categories	n	Adj.R^2	F	Const	Protection $level^2$	IR $proportion^2$	Protection $level^3$	Protection $level^{log}$
Detritivorous								
Herbivorous								
Microphagous								
Mesophagous	42	0.875	96.579***	-55623.4	-28778.3	-	5781.09	263329.8
Macrophagous	41	0.637	24.436***	904.41	-1079.8	1.148	324.66	-

-Commercial categories

The three commercial categories analyzed were related significantly with several variables of protection status (Table 5.54). In general the correlation coefficients were high, mainly exceeding 0.7. The highest correlation coefficients were observed among by-catch with distance to town and annual budget. Similar value was obtained between total catch and distance to town. Temporal measures of protection variables, restricted use area size and number of zones did not correlate significantly with any of the commercial categories.

All the commercial categories analyzed showed significant results in BEST analyses, obtaining two of them (by-catch and total catch) values of correlation coefficients that exceeded 0.8 (Table 5.55). Whereas total catch was related with the combination of protection level, integral reserve size, distance to town and annual budget, by-catch only was related with distance to town.

Significant regression models were obtained for the three commercial categories analyzed, explaining large part of the observed variation (Table 5.56). Capture of target species and total catch responded to changes in protection level, while the capture of by-catch depended on the protection level and the proportion of the integral reserve. Moreover all the models had been validated in the cross-validation process (Table 5.50).

Table 5.54. Spearman correlation coefficients between the biomass (kg/500 m of net) of the commercial categories captured in the gear trammel net >60 mm and the variables of the protection status.

	By-catch	Target	Total catch
Protection level	0.257	0.526***	0.297*
Years since creation	-0.045	-0.136	-0.095
Years since enforc.	-0.045	-0.136	-0.095
Total size	0.787***	0.695***	0.797***
IR size	0.787***	0.695***	0.797***
Buffer size	0.787***	0.695***	0.797***
RU size	-0.148	-0.140	-0.163
IR proportion	0.711***	0.549***	0.705***
Perimeter	0.787***	0.695***	0.797***
Ratio P/S	-0.802***	-0.650***	-0.809***
Number of zones	-0.148	-0.140	-0.163
Distance MPA	0.784***	0.692***	0.794***
Distance town	0.827***	0.722***	0.824***
Isolation	0.798***	0.702***	0.805***
Compliance	0.235	0.351*	0.265
Hours enforcement	0.655***	0.570***	0.652***
Annual budget	0.826***	0.717***	0.816***

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=47

Table 5.55. Spearman correlation index (ρ_w), obtained using BEST, among the mean biomass (kg/500 m of net) of the commercial categories captured in the gear trammel net >60 mm and the combination of the variables of the protection status. Only are showed the best correlation for each case. × indicates the variables that resulted in each correlation analysis. * indicates de variables excluded from the analysis due to the high correlation with others. The level of significance is denoted between brackets, and was obtained using 99 permutations. N=47.

Commercial categories	ρ_w	Protection level	Years since enfforcement	IR size	Buffer size	RU size	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Isolation	Compliance	Hours enforcement	Annual budget
By-catch	0.863 (0.01)											×				
Discards																
Target	0.670 (0.01)	×		×								×				×
Total catch	0.862 (0.01)	×		×								×				×

Table 5.56. Results of multiple linear regression analysis for mean biomass (kg/500 m of net and day) of the commercial categories captured in the gear trammel net >60 mm (*superscripts* refer to quadratic, cubic and logarithmic terms of the variables of the protection status used as independent terms). Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001.

Commercial categories	n	Adj.R^2	F	Const	Protection level^2	Protection level^3	IR proportion^3	Protection level^{log}
By-catch	41	0.743	39.629***	937.71	-1345.5	424.88	0.035	-
Discards								
Target	42	0.882	103.199***	-50252.7	-26005.5	5237.5	-	237337.9
Total catch	42	0.856	82.302***	-65216.6	-35279.8	7077.5	-	318315.5

BOTTOM LONGLINE HOOK SIZE <5

Relation Among Variables of Protection Status

The level of isolation of all the samples obtained for bottom longline hook size <5 were the same. For this reason the variable isolation was removed from all the analyses carried out in this fishing gear. Most variables of protection status were significantly related (Table 5.57), but only some of them were highly correlated (values greater than 0.9). Years since creation and years since enforcement showed a high correlation value between them. Moreover, several structural variables (total size, integral reserve size, buffer area size, perimeter and ratio perimeter/size) were also

Table 5.57. Spearman correlation coefficients between the variables of the protection status of the samples of gear bottom longline hook size <5.

	Protection level	Years since creation	Years since enforcement	Total size	IR size	Buffer size	RU size	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Compliance	Hours enforcement
Years since creation	-0.758***														
Years since enforc.	-0.815***	0.960***													
Total size	0.758***	-0.889***	-0.906***												
IR size	0.758***	-0.889***	-0.906***	1.000											
Buffer size	0.758***	-0.889***	-0.906***	1.000	1.000										
RU size	0.796***	-0.837***	-0.884***	0.851***	0.851***	0.851***									
IR proportion	-0.804***	0.853***	0.899***	-0.876***	-0.876***	-0.876***	-0.996***								
Perimeter	0.758***	-0.889***	-0.906***	1.000	1.000	1.000	0.851***	-0.876***							
Ratio P/S	-0.726***	0.824***	0.857***	-0.963***	-0.963***	-0.963***	-0.820***	0.844***	-0.963***						
Number of zones	0.553**	-0.489**	-0.551**	0.397*	0.397*	0.397*	0.775***	-0.772***	0.397*	-0.383*					
Distance MPA	0.758***	-0.889***	-0.906***	1.000	1.000	1.000	0.851***	-0.876***	1.000	-0.963***	0.397*				
Distance town	0.782***	-0.814***	-0.863***	0.820***	0.820***	0.820***	0.996***	-0.985***	0.820***	-0.790***	0.772***	0.820***			
Compliance	0.915***	-0.537**	-0.596***	0.557**	0.557**	0.557**	0.546**	-0.557**	0.557**	-0.530**	0.358	0.557**	0.530**		
Hours enforcement	-0.672***	0.789***	0.802***	-0.892***	-0.892***	-0.892***	-0.779***	0.768***	-0.892***	0.859***	-0.210	-0.892***	-0.784***	-0.475*	
Annual budget[1]	0.763***	-0.813***	-0.869***	0.838***	0.838***	0.838***	1.000	-1.000***	0.838***	-0.799***	0.694***	0.838***	1.000	0.463*	-0.838***

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=28; [1]n=26

Table 5.58. Pearson correlation coefficients between the biomass (kg/100 hooks) of the taxonomic categories captured in the gear bottom longline hook size <5.

	Big pelagics	Medium pelagics	Small pelagics	Big serranidae	Small serranidae	Labridae	Sparidae	Chondrictios	Cephalopoda	Crustacea
Medium pelagics	0.931***									
Small pelagics	-0.053	-0.098								
Big serranidae	-0.057	-0.069	-0.074							
Small serranidae	-0.048	-0.076	0.019	-0.094						
Labridae	-0.052	-0.094	0.894***	-0.070	-0.036					
Sparidae	-0.123	-0.137	0.153	-0.140	-0.066	0.177				
Chondrictios	-0.046	-0.023	-0.066	-0.059	-0.038	-0.037	-0.008			
Cephalopoda	-0.053	-0.120	-0.076	-0.081	-0.092	0.007	-0.158	-0.065		
Crustacea	-0.043	-0.036	-0.061	-0.015	-0.060	0.080	-0.051	0.110	-0.038	
Other species	0.029	-0.048	0.077	0.045	-0.134	0.099	-0.172	-0.080	-0.050	-0.084

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=28

Table 5.59. Pearson correlation coefficients between the biomass (kg/100 hooks) of the trophic categories captured in the gear bottom longline hook size <5.

	Detritivorous	Microphagous	Mesophagous
Microphagous	0.159		
Mesophagous	-0.078	0.199	
Macrophagous	-0.104	0.079	-0.235

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=28

Table 5.60. Pearson correlation coefficients between the biomass (kg/100 hooks) of the commercial categories captured in the gear bottom longline hook size <5.

	By-catch	Discards	Target
Discards	-0.184		
Target	-0.119	-0.088	
Total catch	0.120	0.801***	0.418*

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=28

correlated among them and with years since enforcement and distance to another MPA. Furthermore were obtained high correlation coefficients among restricted use area size, proportion of integral reserve, distance to town and annual budget.

Relation Among Variables of Fish Assemblage

Only two pairs of taxonomic categories were significantly related, medium pelagics with big pelagics and Labridae with small pelagics, showing correlation coefficients that exceeded 0.8 (Table 5.58). With regard to the trophic classification, any pair of categories was significantly related (Table 5.59). Concerning the commercial categories, total catch was significantly correlated with target species and with discards, obtaining only in the last case a large correlation coefficient (Table 5.60).

Relation Among Variables of Fish Assemblage and Variables Of Protection Status

-Taxonomic categories

When analyzing the correlation coefficients between the taxonomic categories and the protection status variables, we found that, except other species, all the categories analyzed showed significant results with at least one variable of protection status (Table .61). However correlation coefficients were usually low, only exceeded 0.6 in the case of small Serranidae, which increased with the annual budget. On the other hand, medium pelagics was the taxonomic category that correlated significantly with more variables of protection. Compliance did not correlate with any taxonomic category. On the contrary, distance to town was the variable that correlated significantly with more taxonomic categories.

All the taxonomic categories analyzed showed significant results in BEST analyses (Table 5.62). Small Serranidae obtained again the highest coefficient of correlation, correlating with the combination of proportion of the integral reserve, number of zones and compliance. The variables of protection status that correlated with more taxonomic categories were compliance and hours of enforcement.

For any of the taxonomic categories captured in bottom longline hook size <5 was obtained a significant regression model (Table 5.63).

Table 5.61. Spearman correlation coefficients between the biomass (kg/100 hooks) of the taxonomic categories captured in the gear bottom longline hook size <5 and the variables of the protection status.

	Medium pelagics	Big serranidae	Small serranidae	Labridae	Sparidae	Other species
Protection level	0.335	0.367	0.241	0.267	0.392*	-0.235
Years since creation	-0.435*	-0.379*	-0.128	-0.360	-0.279	0.118
Years since enforc.	-0.544**	-0.433*	-0.197	-0.368	-0.376*	0.095
Total size	0.556**	0.454*	0.145	0.352	0.297	0.087
IR size	0.556**	0.454*	0.145	0.352	0.297	0.087
Buffer size	0.556**	0.454*	0.145	0.352	0.297	0.087
RU size	0.541**	0.231	0.347	0.454*	0.380*	-0.103
IR proportion	-0.539**	-0.255	-0.291	-0.452*	-0.382*	0.058
Perimeter	0.556**	0.454*	0.145	0.352	0.297	0.087
Ratio P/S	-0.519**	-0.345	-0.125	-0.226	-0.268	-0.113
Number of zones	0.273	-0.075	0.195	0.403*	0.356	-0.097
Distance MPA	0.556**	0.454*	0.145	0.352	0.297	0.087
Distance town	0.539**	0.205	0.399*	0.452*	0.375*	-0.147
Compliance	0.201	0.353	0.217	0.106	0.363	-0.241
Hours enforcement	-0.565**	-0.405*	-0.396*	-0.303	-0.233	0.108
Annual budget[1]	0.531**	0.175	0.638***	0.399*	0.287	-0.323

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=28; [1]n=26

Table .62. Spearman correlation index (ρ_w), obtained using BEST, among the mean biomass (kg/100 hooks) of the taxonomic categories captured in the gear bottom longline hook size <5 and the combination of the variables of the protection status. Only are showed the best correlation for each case. × indicates the variables that resulted in each correlation analysis. * indicates de variables excluded from the analysis due to the high correlation with others. The level of significance is denoted between brackets, and was obtained using 99 permutations. N=26.

Taxonomic categories	ρ_w	Protection level	Years since enforcement	IR size	Buffer size	RU size	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Isolation*	Compliance	Hours enforcement	Annual budget
Big pelagics																
Medium pelagics	0.571 (0.01)		×												×	
Small pelagics																
Big serranidae	0.438 (0.02)		×												×	
Small serranidae	0.710 (0.01)						×			×				×		
Labridae	0.408 (0.01)	×	×							×				×		×

Taxonomic categories	ρ_w	Protection level	Years since enforcement	IR size	Buffer size	RU size	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Isolation*	Compliance	Hours enforcement	Annual budget
Scorpenids																
Sparidae	0.482 (0.01)	×												×	×	
Chondrictios																
Cephalopoda																
Mollusca																
Crustacea																
Other species	0.419 (0.02)													×	×	

Table 5.63. Results of multiple linear regression analysis for mean biomass (kg/100 hooks) of the taxonomic categories captured in the gear bottom longline hook size <5 (*superscripts* refer to quadratic, cubic and logarithmic terms of the variables of the protection status used as independent terms). Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001.

Taxonomic categories	n	Adj.R^2	F	Const
Big pelagics				
Medium pelagics	23		n.s.	
Small pelagics				
Big serranidae	21		n.s.	
Small serranidae	22		n.s.	
Labridae	23		n.s.	
Scorpenids				
Sparidae	23		n.s.	
Chondrictios				
Cephalopoda				
Mollusca				
Crustacea				
Other species	23		n.s.	

Table 5.64. Spearman correlation coefficients between the biomass (kg/100 hooks) of the trophic categories captured in the gear bottom longline hook size <5 and the variables of the protection status.

	Mesophagous	Macrophagous
Protection level	0.474*	-0.170
Years since creation	-0.382*	0.193
Years since enforc.	-0.484**	0.133
Total size	0.321	0.005
IR size	0.321	0.005
Buffer size	0.321	0.005
RU size	0.557**	-0.109
IR proportion	-0.542**	0.069
Perimeter	0.321	0.005
Ratio P/S	-0.304	-0.045
Number of zones	0.593***	-0.011
Distance MPA	0.321	0.005
Distance town	0.568**	-0.148
Compliance	0.398*	-0.121
Hours enforcement	-0.289	0.197
Annual budget[1]	0.491*	-0.337

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=28; [1]n=26

Table 5.65. Spearman correlation index (ρ_w), obtained using BEST, among the mean biomass (kg/100 hooks) of the trophic categories captured in the gear bottom longline hook size <5 and the combination of the variables of the protection status. Only are showed the best correlation for each case. × indicates the variables that resulted in each correlation analysis. * indicates de variables excluded from the analysis due to the high correlation with others. The level of significance is denoted between brackets, and was obtained using 99 permutations. N=26.

Trophic categories	ρ_w	Protection level	Years since enforcement	IR size	Buffer size	RU size	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Isolation*	Compliance	Hours enforcement	Annual budget
Detritivorous																
Herbivorous																
Microphagous																
Mesophagous	0.672 (0.01)	×														×
Macrophagous	0.326 (0.05)													×	×	

Table 5.66. Results of multiple linear regression analysis for mean biomass (kg/100 hooks) of the trophic categories captured in the gear bottom longline hook size <5 (*superscripts* refer to quadratic, cubic and logarithmic terms of the variables of the protection status used as independent terms). Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001.

Trophic categories	N	Adj.R^2	F	Const	Protection level^3
Detritivorous					
Herbivorous					
Microphagous					
Mesophagous	23		n.s.		
Macrophagous	21	0.264	8.158*	27.082	-0.879

-Trophic categories

Two trophic categories were observed in this fishing gear, and only mesophagous was significantly related with several of the protection status variables (Table 5.64). However correlation coefficients were low (less than 0.6). The highest correlation coefficient was observed with number of zones.

Both categories showed significant results in BEST analyses (Table 5.65), but with low correlation coefficients. Only mesophagous obtained a correlation coefficient that exceeded 0.6 with the combination of protection level and annual budget.

However, only for macrophagous was obtained a significant regression model (Table 5.66). The fitted model accounted only for 26.47% of the observed variation and it was not validated in the cross-validation process (Table 5.67).

Table 5.68. Spearman correlation coefficients between the biomass (kg/100 hooks) of the commercial categories captured in the gear bottom longline hook size <5 and the variables of the protection status.

	By-catch	Target	Total catch
Protection level	0.341	0.209	0.016
Years since creation	-0.184	-0.172	0.100
Years since enforc.	-0.279	-0.250	0.010
Total size	0.473*	0.150	-0.105
IR size	0.473*	0.150	-0.105
Buffer size	0.473*	0.150	-0.105

	By-catch	Target	Total catch
RU size	0.175	0.254	-0.016
IR proportion	-0.219	-0.260	-0.011
Perimeter	0.473*	0.150	-0.105
Ratio P/S	-0.489**	-0.134	0.066
Number of zones	-0.108	0.334	0.280
Distance MPA	0.473*	0.150	-0.105
Distance town	0.129	0.246	-0.043
Compliance	0.435*	0.227	0.053
Hours enforcement	-0.330	-0.056	0.327
Annual budget[1]	0.031	0.136	-0.240

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=28; [1]n=26

-Commercial categories

By-catch was the only commercial category that was related significantly with the protection status variables (Table 5.68). Moreover correlation coefficients were low, never reaching 0.5. The highest correlation coefficients were observed with ratio perimeter/size.

All the commercial categories analyzed showed significant results in BEST analyses (Table 5.69). However, correlation coefficients were low, never reaching 0.5. Total catch showed the highest correlation coefficient, and was related with the combination of protection level, compliance and hours of enforcement. The variable of protection status that correlated with more commercial categories was hours of enforcement.

For any of the commercial categories captured in bottom longline hook size <5 was obtained a significant regression model (Table 5.70).

Table 5.69. Spearman correlation index (ρ_w), obtained using BEST, among the mean biomass (kg/100 hooks) of the commercial categories captured in the gear bottom longline hook size <5 and the combination of the variables of the protection status. Only are showed the best correlation for each case. × indicates the variables that resulted in each correlation analysis. * indicates de variables excluded from the analysis due to the high correlation with others. The level of significance is denoted between brackets, and was obtained using 99 permutations. N=26.

Commercial categories	ρ_w	Protection level	Years since enforcement	IR size	Buffer size	RU size	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Isolation*	Compliance	Hours enforcement	Annual budget
By-catch	0.355 (0.02)		×												×	
Discards																
Target	0.494 (0.01)	×												×	×	
Total catch	0.377 (0.02)	×												×	×	

Table 5.70. Results of multiple linear regression analysis for mean biomass (kg/100 hooks) of the commercial categories captured in the gear bottom longline hook size <5 (*superscripts* refer to quadratic, cubic and logarithmic terms of the variables of the protection status used as independent terms). Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001.

Commercial categories	n	Adj.R^2	F	Const
By-catch	23		n.s.	
Discards				
Target	23		n.s.	
Total catch	23		n.s.	

BOTTOM LONGLINE HOOK SIZE ≥5

Relation Among Variables of Protection Status

Most variables of protection status were significantly related (Table 5.71), but only some of them were highly correlated (values greater than 0.9). Years since creation was correlated with integral reserve size and hours of enforcement. Moreover, several

Table 5.71. Spearman correlation coefficients between the variables of the protection status of the samples of gear bottom longline hook size ≥5.

	Protection level	Years since creation	Years since enforcement	Total size	IR size	Buffer size	RU size	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Isolation	Compliance	Hours enforcement
Years since creation	0.292															
Years since enforc.	-0.161	0.768***														
Total size	0.751***	0.527**	-0.039													
IR size	-0.312	-0.921***	-0.724***	-0.572**												
Buffer size	-0.164	-0.895***	-0.822***	-0.376	0.972***											
RU size	0.758***	0.530**	-0.036	0.999***	-0.575**	-0.384										
IR proportion	-0.751***	-0.527**	0.039	-1.000***	0.572**	0.376	-0.999***									
Perimeter	0.751***	0.527**	-0.039	1.000	-0.572**	-0.376	0.999***	-1.000***								
Ratio P/S	-0.717***	-0.562**	-0.023	-0.914***	0.523**	0.343	-0.913***	0.914***	-0.914***							
Number of zones	-0.164	-0.895***	-0.822***	-0.376	0.972***	1.000	-0.384	0.376	-0.376	0.343						
Distance MPA	0.124	-0.772***	-0.909***	-0.034	0.839***	0.930***	-0.037	0.034	-0.034	0.031	0.930***					
Distance town	-0.093	-0.882***	-0.850***	-0.319	0.958***	0.985***	-0.320	0.319	-0.319	0.292	0.985***	0.958***				
Isolation	-0.247	-0.874***	-0.751***	-0.431*	0.949***	0.976***	-0.449*	0.431*	-0.431*	0.394*	0.976***	0.857***	0.925***			
Compliance	0.804***	0.522**	0.247	0.567**	-0.567**	-0.486*	0.568**	-0.567**	0.567**	-0.547**	-0.486*	-0.315	-0.461*	-0.498**		
Hours enforcement	0.301	0.916***	0.719***	0.577**	-0.995***	-0.956***	0.575**	-0.577**	0.577**	-0.527**	-0.956***	-0.834***	-0.958***	-0.914***	0.567**	
Annual budget	-0.006	-0.819***	-0.873***	-0.159	0.889***	0.972***	-0.172	0.159	-0.159	0.145	0.972***	0.970***	0.958***	0.949***	-0.378	-0.864***

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=26

Table 5.72. Pearson correlation coefficients between the biomass (kg/100 hooks) of the taxonomic categories captured in the gear bottom longline hook size ≥5.

	Medium pelagics	Small pelagics	Big serranidae	Small serranidae	Scorpenids	Sparidae	Chondrictios	Cephalopoda	Crustacea
Small pelagics	-0.081								
Big serranidae	0.032	0.198							
Small serranidae	-0.097	-0.081	-0.132						
Scorpenids	-0.059	-0.131	-0.098	-0.131					
Sparidae	0.741***	-0.078	0.173	0.383	-0.125				
Chondrictios	0.065	0.039	0.531**	-0.143	-0.080	0.322			
Cephalopoda	-0.085	0.545**	-0.082	-0.019	-0.116	-0.100	-0.098		
Crustacea	-0.052	-0.086	0.186	-0.123	-0.088	-0.125	-0.094	-0.021	
Other species	0.223	0.044	0.915***	-0.129	-0.105	0.386	0.674***	-0.085	0.096

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=26

Table 5.73. Pearson correlation coefficients between the biomass (kg/100 hooks) of the trophic categories captured in the gear bottom longline hook size ≥5.

	Detritivorous	Herbivorous	Microphagous	Mesophagous
Herbivorous	-0.049			
Microphagous	0.085	0.065		
Mesophagous	-0.050	-0.065	-0.041	
Macrophagous	-0.081	-0.085	0.064	0.883***

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=26

Table 5.74. Pearson correlation coefficients between the biomass (kg/100 hooks) of the commercial categories captured in the gear bottom longline hook size ≥5.

	By-catch	Discards	Target
Discards	0.271		
Target	0.348	-0.019	
Total catch	0.692***	0.108	0.918***

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=26

structural variables (total size, restricted use area size, proportion of integral reserve, perimeter and ratio perimeter/size) were correlated among them. Furthermore, other structural variables (integral reserve size, buffer area size, number of zones) were obtained high correlation coefficients among distance to another MPA, distance to town, isolation, hours of enforcement and annual budget.

Relation Among Variables of Fish Assemblage

Only few pairs of taxonomic categories were significantly related, but in general correlation coefficients were low (Table 5.72). Only the capture of big Serranidae and other species were highly related, showing correlation values that exceeded 0.9. With regard to the trophic classification, only macrophagous where significantly related with mesophagous showing a high correlation coefficient (Table 5.73). Concerning the commercial categories, total catch was significantly correlated with by-catch and target species, obtaining only in the last case a large correlation coefficient (Table 5.74).

Table 5.75. Spearman correlation coefficients between the biomass (kg/100 hooks) of the taxonomic categories captured in the gear bottom longline hook size ≥5 and the variables of the protection status.

	Big serranidae	Sparidae	Chondrictios	Other species
Protection level	0.531**	-0.133	0.030	-0.151
Years since creation	0.403*	0.383	-0.369	0.140
Years since enforc.	-0.009	0.564**	-0.452*	0.212
Total size	0.759***	-0.117	0.022	0.069
IR size	-0.532**	-0.514**	0.416*	-0.346
Buffer size	-0.398*	-0.598**	0.513**	-0.351
RU size	0.760***	-0.121	-0.003	0.059
IR proportion	-0.759***	0.117	-0.022	-0.069
Perimeter	0.759***	-0.117	0.022	0.069
Ratio P/S	-0.654***	0.045	-0.102	0.138
Number of zones	-0.398*	-0.598**	0.513**	-0.351
Distance MPA	-0.144	-0.709***	0.501**	-0.385
Distance town	-0.353	-0.642***	0.453*	-0.392*
Isolation	-0.437*	-0.517**	0.566**	-0.286
Compliance	0.429*	0.257	-0.128	-0.014
Hours enforcement	0.532**	0.520**	-0.366	0.365
Annual budget	-0.241	-0.648***	0.580**	-0.337

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=26

Table 5.76. Spearman correlation index (ρ_w), obtained using BEST, among the mean biomass (kg/100 hooks) of the taxonomic categories captured in the gear bottom longline hook size ≥5 and the combination of the variables of the protection status. Only are showed the best correlation for each case. × indicates the variables that resulted in each correlation analysis. The level of significance is denoted between brackets, and was obtained using 99 permutations. N=26.

Taxonomic categories	ρ_w	Protection level	Years since enforcement	IR size	Buffer size	RU size	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Isolation	Compliance	Hours enforcement	Annual budget
Big pelagics																
Medium pelagics																
Small pelagics																
Big serranidae	0.345 (0.05)						×									
Small serranidae																
Labridae																
Scorpenids																
Sparidae	0.120 (0.47)										×					
Chondrictios	0.648 (0.01)		×													
Cephalopoda																
Mollusca																
Crustacea																
Other species	-0.008 (0.98)											×				

Table 5.77. Results of multiple linear regression analysis for mean biomass (kg/100 hooks) of the taxonomic categories captured in the gear bottom longline hook size ≥5 (*superscripts* refer to quadratic, cubic and logarithmic terms of the variables of the protection status used as independent terms). Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001.

Taxonomic categories	n	Adj.R^2	F	Const
Big pelagics				
Medium pelagics				
Small pelagics				
Big serranidae	23		n.s.	
Small serranidae				
Labridae				
Scorpenids				
Sparidae	23		n.s.	
Chondrictios	23		n.s.	
Cephalopoda				

Taxonomic categories	n	Adj.R^2	F	Const
Mollusca				
Crustacea				
Other species	23		n.s.	

Relation Among Variables of Fish Assemblage and Variables Of Protection Status

-Taxonomic categories

All taxonomic categories were related significantly with at least one variable of protection status (Table 5.75). However correlation coefficients were usually low. Values that exceeded 0.7 were observed only in big serranids, which correlate with total size, restricted use area size, proportion of the integral reserve, and perimeter. Similar value of correlation coefficient was obtained between Sparidae and distance to another MPA. Big Serranidae was also the category that correlated significantly with more variables of protection. All variables of protection status correlated with the capture of at least one commercial category, but there were 4 of them (integral reserve size, buffer area size, number of zones and isolation) that correlated with three of the four taxonomic categories analyzed.

BEST results showed significant correlations for 2 taxonomic categories, but all coefficient were lower than 0.7 (Table 5.76). The highest correlation coefficient was observed for the capture of Chondrictios, which was related only with years since enforcement.

For any of the taxonomic categories captured in bottom longline hook size ≥5 was obtained a significant regression model (Table 5.77).

-Trophic categories

Two trophic categories were observed in this fishing gear, and only mesophagous was significantly related with several of the protection status variables (Table .78). However correlation coefficients were in general low. The highest correlation coefficient, which exceeded 0.7, was observed with distance to another MPA.

For any of the trophic categories captured in bottom longline hook size ≥5 was obtained significant correlation coefficinets in BEST analysis (Table 5.79) and significant regression models (Table 5.80).

Table 5.78. Spearman correlation coefficients between the biomass (kg/100 hooks) of the trophic categories captured in the gear bottom longline hook size ≥5 and the variables of the protection status.

	Mesophagous	Macrophagous
Protection level	-0.115	0.063
Years since creation	0.449*	0.050
Years since enforc.	0.558**	-0.051
Total size	0.005	0.292
IR size	-0.588**	-0.122
Buffer size	-0.652***	-0.025
RU size	0.005	0.271
IR proportion	-0.005	-0.292
Perimeter	0.005	0.292
Ratio P/S	-0.056	-0.207
Number of zones	-0.652***	-0.025
Distance MPA	-0.715***	0.027
Distance town	-0.681***	-0.072
Isolation	-0.588**	0.036
Compliance	0.214	0.014
Hours enforcement	0.589**	0.164
Annual budget	-0.680***	0.074

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=26

Table 5.79. Spearman correlation index (ρ_w), obtained using BEST, among the mean biomass (kg/100 hooks) of the trophic categories captured in the gear bottom longline hook size ≥5 and the combination of the variables of the protection status. Only are showed the best correlation for each case. × indicates the variables that resulted in each correlation analysis. The level of significance is denoted between brackets, and was obtained using 99 permutations. N=26.

Trophic categories	ρ_w	Protection level	Years since enforcement	IR size	Buffer size	RU size	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Isolation	Compliance	Hours enforcement	Annual budget
Detritivorous																
Herbivorous																
Microphagous																
Mesophagous	0.111 (0.53)											×				
Macrophagous	0.166 (0.23)							×							×	

Table 5.80. Results of multiple linear regression analysis for mean biomass (kg/100 hooks) of the trophic categories captured in the gear bottom longline hook size ≥5 (*superscripts* refer to quadratic, cubic and logarithmic terms of the variables of the protection status used as independent terms). Probability levels: ∗=P<0.05; ∗∗=P<0.01; ∗∗∗=P<0.001.

Trophic categories	n	Adj.R^2	F	Const
Detritivorous				
Herbivorous				
Microphagous				
Mesophagous	23		n.s.	
Macrophagous	23		n.s.	

Table 5.81. Spearman correlation coefficients between the biomass (kg/100 hooks) of the commercial categories captured in the gear bottom longline hook size ≥5 and the variables of the protection status.

	By-catch	Target	Total catch
Protection level	-0.011	-0.119	-0.131
Years since creation	-0.137	0.282	0.200
Years since enforc.	-0.293	0.339	0.306
Total size	0.191	0.136	0.081
IR size	0.172	-0.495*	-0.294
Buffer size	0.285	-0.508**	-0.288
RU size	0.165	0.131	0.070
IR proportion	-0.191	-0.136	-0.081

	By-catch	Target	Total catch
Perimeter	0.191	0.136	0.081
Ratio P/S	-0.275	0.007	-0.019
Number of zones	0.285	-0.508**	-0.288
Distance MPA	0.314	-0.519**	-0.315
Distance town	0.226	-0.535**	-0.329
Isolation	0.348	-0.452*	-0.223
Compliance	-0.185	0.057	-0.014
Hours enforcement	-0.119	0.506**	0.316
Annual budget	0.383	-0.492*	-0.266

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=26

-Commercial categories

When analyzing the correlation coefficients between the commercial categories and the protection status variables, we found that only target species showed significant results (Table 5.81). However correlation coefficients were usually low, never reaching 0.6.

Table .82 showed the Spearman correlation coefficients among the commercial categories and the most correlated combination of the variables of protection status. Only the captures of by-catch species correlated significantly with a combination of several variables of protection status (years since enforcement, proportion of integral reserve, perimeter, ratio perimeter/size, distance to another MPA and annual budget), but the coefficient was low.

For any commercial category of bottom longline hook size ≥5 was obtained a significant regression model (Table 5.83).

Table 5.82. Spearman correlation index (ρ_w), obtained using BEST, among the mean biomass (kg/100 hooks) of the commercial categories captured in the gear bottom longline hook size ≥5 and the combination of the variables of the protection status. Only are showed the best correlation for each case. × indicates the variables that resulted in each correlation analysis. The level of significance is denoted between brackets, and was obtained using 99 permutations. N=26.

Commercial categories	ρ_w	Protection level	Years since enforcement	IR size	Buffer size	RU size	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Isolation	Compliance	Hours enforcement	Annual budget
By-catch	0.424 (0.01)		×				×	×	×		×					×
Discards																
Target	0.024 (0.82)											×				
Total catch	0.178 (0.26)														×	

Table 5.83. Results of multiple linear regression analysis for mean biomass (kg/100 hooks) of the commercial categories captured in the gear bottom longline hook size ≥5 (*superscripts* refer to quadratic, cubic and logarithmic terms of the variables of the protection status used as independent terms). Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001.

Commercial categories	n	Adj.R^2	F	Const
By-catch	23		n.s.	
Discards				
Target	23		n.s.	
Total catch	23		n.s.	

HOOK AND LINE

Relation Among Variables of Protection Status

Most variables of protection status were significantly related, but in general they had low values of correlation coefficients (Table 5.84). However, several variables of protection status were highly correlated (values greater than 0.9). Years since creation and years since enforcement showed high correlation values between them. In addition, several structural variables (total size, integral reserve size, buffer area size, restricted use area size and perimeter), variables of siting place (distance to another MPA, distance to main town, isolation) and annual budget were highly correlated. Furthermore were obtained high correlation coefficients between proportion of integral reserve with ratio perimeter/size, and isolation with hours of enforcement.

Relation Among Variables of Fish Assemblage

Several pairs of taxonomic categories were significantly related, but not all of them showed high correlation coefficients (Table 5.85). A relatively high correlation coefficient (0.755) was observed between Labridae and small Serranidae. Concerning the trophic categories, only two pairs (mesophagous with herbivorous and microphagous with macrophagous) correlated significantly, but any of them with high correlation coefficients (Table 5.86). With regard to the commercial classification, only the target species with total catch were related significantly, showing a high correlation coefficient (Table 5.87).

Table 5.84. Spearman correlation coefficients between the variables of the protection status of the samples of gear hook and line.

	Protection level	Years since creation	Years since enforcement	Total size	IR size	Buffer size	RU size	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Isolation	Compliance	Hours enforcement
Years since creation	0.111															
Years since enforc.	0.065	0.954***														
Total size	0.068	-0.068	-0.296***													
IR size	0.068	-0.068	-0.296***	1.000												
Buffer size	0.068	-0.068	-0.296***	1.000	1.000											
RU size	0.068	-0.068	-0.296***	1.000	1.000	1.000										
IR proportion	-0.072	0.116	0.317***	-0.891***	-0.891***	-0.891***	-0.891***									
Perimeter	0.068	-0.068	-0.296***	1.000	1.000	1.000	1.000	-0.891***								
Ratio P/S	-0.108	0.034	0.234**	-0.886***	-0.886***	-0.886***	-0.886***	0.912***	-0.886***							
Number of zones	-0.351***	-0.326***	-0.328***	0.376***	0.376***	0.376***	0.376***	-0.335***	0.376***	-0.333***						
Distance MPA	0.068	-0.068	-0.296***	1.000	1.000	1.000	1.000	-0.891***	1.000	-0.886***	0.376***					
Distance town	0.068	-0.068	-0.296***	1.000	1.000	1.000	1.000	-0.891***	1.000	-0.886***	0.376***	1.000				
Isolation	0.160	0.008	-0.234**	0.973***	0.973***	0.973***	0.973***	-0.867***	0.973***	-0.862***	0.152	0.973***	0.973***			
Compliance	0.787***	0.162	0.034	0.342***	0.342***	0.342***	0.342***	-0.304***	0.342***	-0.314***	-0.446***	0.342***	0.342***	0.475***		
Hours enforcement	-0.244**	-0.085	0.160	-0.894***	-0.894***	-0.894***	-0.894***	0.796***	-0.894***	0.792***	0.080	-0.894***	-0.894***	-0.973***	-0.584***	
Annual budget	0.068	-0.068	-0.296***	1.000	1.000	1.000	1.000	-0.891***	1.000	-0.886***	0.376***	1.000	1.000	0.973***	0.342***	-0.894***

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=137

Table 5.85. Pearson correlation coefficients between the biomass (kg/1 hook per 10 hours) of the taxonomic categories captured in the gear hook and line.

	Big pelagics	Medium pelagics	Small pelagics	Big serranidae	Small serranidae	Labridae	Scorpenids	Sparidae	Chondrictios	Cephalopoda	Crustacea
Medium pelagics	-0.009										
Small pelagics	0.007	-0.014									
Big serranidae	-0.035	0.615***	-0.042								
Small serranidae	-0.027	-0.065	0.371***	-0.094							
Labridae	0.001	0.024	0.378***	-0.065	0.755***						
Scorpenids	0.059	0.261**	-0.042	0.469***	-0.035	-0.078					
Sparidae	0.432***	0.297***	-0.006	0.203*	-0.060	0.109	-0.131				
Chondrictios	-0.051	0.491***	-0.031	0.441***	-0.041	-0.015	0.185*	0.067			
Cephalopoda	-0.050	0.186*	-0.006	0.190*	-0.031	0.020	-0.056	0.295***	0.037		
Crustacea	-0.021	0.090	0.004	0.059	-0.014	0.053	-0.024	0.066	-0.007	0.225**	
Other species	-0.088	0.385***	-0.007	0.492***	-0.063	0.039	-0.103	0.375***	0.263**	0.356***	0.285***

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=137

Table .86. Pearson correlation coefficients between the biomass (kg/1 hook per 10 hours) of the trophic categories captured in the gear hook and line.

	Detritivorous	Herbivorous	Microphagous	Mesophagous
Herbivorous	-0.025			
Microphagous	-0.020	-0.053		
Mesophagous	-0.047	0.483***	-0.034	
Macrophagous	-0.014	-0.028	0.356***	-0.037

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=137

Table 5.87. Pearson correlation coefficients between the biomass (kg/1 hook per 10 hours) of the commercial categories captured in the gear hook and line.

	By-catch	Target
Target	-0.009	
Total catch	-0.002	1.000***

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=137

Relation Among Variables of Fish Assemblage and Variables Of Protection Status

-Taxonomic categories

All taxonomic categories were related significantly with at least one variable of protection status (Table 5.88). However correlation coefficients were usually low. A value that exceeded 0.8 was observed only in medium pelagics when correlated with several structural variables and the variables of siting place. Big Serranidae and small Serranidae correlated significantly with all the variables of protection status. All variables of protection status correlated with the capture of at least one taxonomic category, but there were 3 of them (isolation, compliance and annual budget) that correlated with all the categories analyzed.

Table 5.89 showed the Spearman correlation coefficients among the taxonomic categories and the most correlated combination of the variables of protection status. Only the captures of small pelagics did not show a significant relation with the variables of protection status. In general the correlation coefficients were very low (always less than 0.6) except for other species and medium pelagics, which reached 0.8. The first was related with the combination of number of zones and compliance, meanwhile the second only correlated with proportion of the integral reserve. The variable of protection status that correlated with more taxonomic categories was hours of enforcement.

Were obtained significant regression models for all the taxonomic categories analyzed (Table 5.90). The fitted models accounted for 38.6-86.9% of the observed variation. The taxonomic category that responded better to the protection status variables was other species, which depended on proportion of the integral reserve and compliance. Moreover were positively validated the models for small pelagics, big Serranidae, small Serranidae, Labridae and other species (Table 5.91).

Table 5.88. Spearman correlation coefficients between the biomass (kg/1 hook per 10 hours) of the taxonomic categories captured in the gear hook and line and the variables of the protection status.

	Medium pelagics	Small pelagics	Big serranidae	Small serranidae	Labridae	Sparidae	Cephalopoda
Protection level	0.003	0.282***	0.230**	0.501***	0.430***	0.253**	0.370***
Years since creation	-0.209*	-0.010	-0.230**	0.482***	0.266**	0.337***	0.031
Years since enforc.	-0.398***	-0.074	-0.358***	0.372***	0.173*	0.244**	-0.069
Total size	0.834***	0.165	0.594***	0.276**	0.178*	0.344***	0.572***
IR size	0.834***	0.165	0.594***	0.276**	0.178*	0.344***	0.572***
Buffer size	0.834***	0.165	0.594***	0.276**	0.178*	0.344***	0.572***
RU size	0.834***	0.165	0.594***	0.276**	0.178*	0.344***	0.572***
IR proportion	-0.797***	-0.034	-0.495***	-0.190*	-0.145	-0.264**	-0.461***
Perimeter	0.834***	0.165	0.594***	0.276**	0.178*	0.344***	0.572***
Ratio P/S	-0.736***	-0.064	-0.504***	-0.242**	-0.161	-0.279***	-0.497***
Number of zones	0.322***	-0.243**	0.320***	-0.261**	-0.324***	-0.061	0.325***
Distance MPA	0.834***	0.165	0.594***	0.276**	0.178*	0.344***	0.572***
Distance town	0.834***	0.165	0.594***	0.276**	0.178*	0.344***	0.572***
Isolation	0.809***	0.236**	0.554***	0.360***	0.271**	0.382***	0.529***
Compliance	0.311***	0.430***	0.292***	0.598***	0.595***	0.483***	0.438***
Hours enforcement	-0.741***	-0.294***	-0.484***	-0.424***	-0.349***	-0.400***	-0.458***
Annual budget	0.834***	0.165	0.594***	0.276**	0.178*	0.344***	0.572***

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=137

Table 5.89. Spearman correlation index (ρ_w), obtained using BEST, among the mean biomass (kg/1 hook per 10 hours) of the taxonomic categories captured in the gear hook and line and the combination of the variables of the protection status. Only are showed the best correlation for each case. × indicates the variables that resulted in each correlation analysis. * indicates de variables excluded from the analysis due to the high correlation with others. The level of significance is denoted between brackets, and was obtained using 99 permutations. N=137.

Taxonomic categories	ρ_w	Protection level	Years since enforcement	IR size	Buffer size	RU size*	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Isolation	Compliance	Hours enforcement	Annual budget
Big pelagics																
Medium pelagics	0.850 (0.01)						×									
Small pelagics	0.037 (0.45)														×	
Big serranidae	0.519 (0.01)						×							×		
Small serranidae	0.465 (0.01)														×	
Labridae	0.587 (0.01)									×					×	

Taxonomic categories	ρ_w	Protection level	Years since enforcement	IR size	Buffer size	RU size*	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Isolation	Compliance	Hours enforcement	Annual budget
Scorpenids																
Sparidae	0.503 (0.01)			×											×	
Chondrictios																
Cephalopoda																
Mollusca																
Crustacea																
Other species	0.820 (0.01)									×				×		

Table 5.90. Results of multiple linear regression analysis for mean biomass (kg/1 hook per 10 hours) of the taxonomic categories captured in the gear hook and line (*superscripts* refer to quadratic, cubic and logarithmic terms of the variables of the protection status used as independent terms). Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001.

Taxonomic categories	n	Adj.R^2	F	Const	IR proportion	Perimeter^2	IR proportion^3	Compliance^3	Hours enforcement^3	Years since enforcement^{log}	Number of zones^{log}	Distance to town^{log}	Compliance^{log}	Isolation^{log}
Big pelagics														
Medium pelagics	123	0.386	39.408***	-1.470	-0.035	-	-	-	-	-	-	-	7.096	-
Small pelagics	121	0.392	26.767***	0.054	-	-	-	0.005	-	-0.003	-	-	-0.189	-
Big serranidae	122	0.597	90.662***	-0.458	-	-	-	-	-	-	-	0.192	0.766	-
Small serranidae	123	0.743	130.347***	465.052	-	-	-	-	-	-	-772.031	-	-	-
Labridae	123	0.563	53.424***	0.540	-	-1.4E-11	-	-	-1.9E-11	-0.013	-	-	-	-
Scorpenids														
Sparidae	122	0.753	123.917***	-2.860	-	-	-	-	-	0.347	-	-	-4.229	12.940
Chondrictios														
Cephalopoda														
Mollusca														
Crustacea														
Other species	121	0.869	399.112***	-13.425	-	-	-1.4E-5	-	-	-	-	-	45.354	-

-Trophic categories

Only two trophic categories were captured with the gear hook and line, and both were significantly related with most of the protection status variables (Table 5.92). In general the correlation coefficients were low, except for macrophagous and hours of enforcement, where exceed 0.8.

Also both categories showed significant results in BEST analyses, obtaining high correlation values (Table 5.93). Whereas mesophagous was related with the combination of integral reserve size, buffer area size, perimeter, isolation, compliance, and hours of enforcement, macrophagous only was related with integral reserve size.

Significant regression models were obtained for both, mesophagous and macrophagous, explaining large part of the observed variation (Table 5.94). Capture of macrophagous responded to changes in isolation and compliance, while the capture of mesophagous depended on the proportion of the integral reserve and compliance.. However, only the last model had been validated in the cross-validation process (Table 5.91).

Table 5.92. Spearman correlation coefficients between the biomass (kg/1 hook per 10 hours) of the trophic categories captured in the gear hook and line and the variables of the protection status.

	Mesophagous	Macrophagous
Protection level	0.568***	0.307***
Years since creation	0.339***	0.073
Years since enforc.	0.227**	-0.140
Total size	0.339***	0.684***
IR size	0.339***	0.684***
Buffer size	0.339***	0.684***
RU size	0.339***	0.684***
IR proportion	-0.254**	-0.632***
Perimeter	0.339***	0.684***
Ratio P/S	-0.289***	-0.604***
Number of zones	-0.108	-0.207*
Distance MPA	0.339***	0.684***
Distance town	0.339***	0.684***
Isolation	0.389***	0.781***
Compliance	0.666***	0.614***
Hours enforcement	-0.417***	-0.836***
Annual budget	0.339***	0.684***

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=137

Table 5.93. Spearman correlation index (ρ_w), obtained using BEST, among the mean biomass (kg/1 hook per 10 hours) of the trophic categories captured in the gear hook and line and the combination of the variables of the protection status. Only are showed the best correlation for each case. × indicates the variables that resulted in each correlation analysis. * indicates de variables excluded from the analysis due to the high correlation with others. The level of significance is denoted between brackets, and was obtained using 99 permutations. N=137.

Trophic categories	ρ_w	Protection level	Years since enforcement	IR size	Buffer size	RU size*	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Isolation	Compliance	Hours enforcement	Annual budget
Detritivorous																
Herbivorous																
Microphagous																
Mesophagous	0.743 (0.01)			×	×			×					×	×	×	
Macrophagous	0.822 (0.01)			×												

Table 5.94. Results of multiple linear regression analysis for mean biomass (kg/1 hook per 10 hours) of the trophic categories captured in the gear hook and line (*superscripts* refer to quadratic, cubic and logarithmic terms of the variables of the protection status used as independent terms). Probability levels: ∗=P<0.05; ∗∗=P<0.01; ∗∗∗=P<0.001.

Trophic categories	n	Adj.R^2	F	Const	IR proportion	Isolation^2	Compliance^{log}
Detritivorous							
Herbivorous							
Microphagous							
Mesophagous	123	0.870	409.040	-9.078	-0.139	-	39.038
Macrophagous	120	0.578	82.543∗∗∗	-2.613	-	0.517	7.144

-Commercial categories

The three commercial categories analyzed were related significantly with several variables of protection status (Table 5.95). In general the correlation coefficients were high, mainly exceeding 0.6. The highest correlation coefficients were observed among hours of enforcement with the three categories. Similar value was obtained between by-catch and isolation.

All the commercial categories analyzed showed significant results in BEST analyses, obtaining values of correlation coefficients that exceeded 0.8 (Table 5.96).

The highest coefficient was observed among total catch and the combination of integral reserve size, buffer area size, perimeter, compliance and hours of enforcement.

Significant regression models were obtained for the three commercial categories analyzed, explaining large part of the observed variation (Table 5.97). Capture of target species and total catch responded to changes in proportion of the integral reserve and compliance, while the capture of by-catch depended on years since enforcement, isolation and compliance. Nevertheless, any models had been validated in the cross-validation process (Table 5.91).

Table 5.95. Spearman correlation coefficients between the biomass (kg/1 hook per 10 hours) of the commercial categories captured in the gear hook and line and the variables of the protection status.

	By-catch	Target	Total catch
Protection level	0.256**	0.430***	0.440***
Years since creation	-0.113	0.184*	0.137
Years since enforc.	-0.318***	-0.032	-0.081
Total size	0.742***	0.690***	0.681***
IR size	0.742***	0.690***	0.681***
Buffer size	0.742***	0.690***	0.681***
RU size	0.742***	0.690***	0.681***
IR proportion	-0.706***	-0.578***	-0.600***
Perimeter	0.742***	0.690***	0.681***
Ratio P/S	-0.659***	-0.604***	-0.603***
Number of zones	-0.065	-0.179*	-0.221**
Distance MPA	0.742***	0.690***	0.681***
Distance town	0.742***	0.690***	0.681***
Isolation	0.808***	0.780***	0.781***
Compliance	0.527***	0.671***	0.692***
Hours enforcement	-0.830***	-0.829***	-0.840***
Annual budget	0.742***	0.690***	0.681***

Probability levels: *=P<0.05; **=P<0.01; ***=P<0.001
n=137

Table 5.96. Spearman correlation index (ρ_w), obtained using BEST, among the mean biomass (kg/1 hook per 10 hours) of the commercial categories captured in the gear hook and line and the combination of the variables of the protection status. Only are showed the best correlation for each case. × indicates the variables that resulted in each correlation analysis. * indicates de variables excluded from the analysis due to the high correlation with others. The level of significance is denoted between brackets, and was obtained using 99 permutations. N=137.

Commercial categories	ρ_w	Protection level	Years since enforcement	IR size	Buffer size	RU size*	IR proportion	Perimeter	Ratio P/S	Number of zones	Distance to MPA	Distance to town	Isolation	Compliance	Hours enforcement	Annual budget
By-catch	0.841 (0.01)			×											×	
Discards																
Target	0.886 (0.01)			×	×			×						×	×	
Total catch	0.903 (0.01)			×	×			×						×	×	

Table 5.97. Results of multiple linear regression analysis for mean biomass (kg/1 hook per 10 hours) of the commercial categories captured in the gear hook and line (*superscripts* refer to quadratic, cubic and logarithmic terms of the variables of the protection status used as independent terms). Probability levels: ∗=P<0.05; ∗∗=P<0.01; ∗∗∗=P<0.001.

Commercial categories	n	Adj.R^2	F	Const	IR proportion	Years since enforcement^{log}	Isolation^{log}	Compliance^{log}
By-catch	120	0.779	141.015***	-1.120	-	-0.266	3.168	1.234
Discards								
Target	120	0.898	526.222***	-9.452	-0.200	-	-	44.101
Total catch	120	0.899	531.072***	-9.494	-0.233	-	-	46.274

Discussion

From our results we observed a total lack of univariant correlation among dependent variables for the under water visual census (UVC) and for the fisheries results. Most variables of protection status were significantly related, but in general they had low correlation coefficients values. This trend was found among fish assemblages and among the relation of fish assemblages with protection variables. This drift was the same for UVC and for the different fishing gears analyzed. Although most of the variables were related but with low values of correlation, depending on the analysis some variables stand out having greater correlation values than the others. These variables values never exceeded 0.9. Some variables were correlated but the majority of these correlations were not significant. There was not any common variable for protection or for fish assemblage that correlated in all the analysis. Although some of the variables resulted validated, the shrinkages cross-validation process was invalid for the majority of variables.

Although many potential variables correlated significantly with one or more of the habitat variables most of the correlations did not explain the model. The shrinkage obtained in the cross-validation process was really high. Other authors assume les R values to assess the correlation and validate the model (Paul et al., 2001) but they can explain the model with higher calibration and validation percentages than us. Although they are working in a wider area, they do not assume different structural and biological characteristics Our difficulties to assume different variables to select as indicators lie in the high dispersion of the data belonged to the case studies analyzed.

The high diversity among the results showing a low number of variables relating was related with the different data origins. There exist different specific circumstances due to the high origin diversity making the search of variables as indicators difficult. Data comes from different MPAs and within each MPA data belongs to different studies. These studies usually have been done in a different variety of methods. The sampling methodology undertaken in each study affects when we combine all of them. But what affects and even more than the methodology is the high variability of data in a temporal and spatial scale. Long time series were difficult to find for every MPA analysed. The high abundance of punctual temporal data or short time series (three or four years of sampling) hides continuous trends due to protection effect. The pattern was to find different short time series studies for each case of study. This lack increases the variability in the data resulting in not significant studies, that if we joined them we could obtain positive results due to protection (Ojeda-Martínez et al., 2007). Explicit objectives and monitoring must be defined to determine if objectives met were essential to MPA success (Allison et al., 1998; Claudet and Pelletier, 2004). Monitoring programs provide data for management decisions through the computations of indicators to evaluate progress in conservation programs (Olsen, 2003). The necessity to develop studies continuous over time and sampling protocols to develop similar sampling methodologies in wider geographic regions are needed. This will eliminate the variability due to the data gathering and help in the selection of indicators to address the range of management objectives.

Also comparing different MPAs and even from different oceanic regions (Atlantic and Mediterranean) increases the heterogeneity in the data due to ecological differences. Most of the mechanisms supposed to work in a MPA have not yet been empirically demonstrated. One of the main difficulties to face when approaching this problem is the inherent spatial and temporal heterogeneity of ecosystems. The influence of physical environment or habitat structure on ecological processes occurring at the individual, population, and community / ecosystem levels of organization generated high variability on the data. This could sometimes confound the “reserve effect" with some aspect of the “habitat effect" (García-Charton and Pérez-Ruzafa, 1999). Each MPA is very specific and has its own dynamic as spatial and temporal variations. The community structure can be influenced by both physical (e.g.: habitat structure, light and nutrient availability, currents and wave exposure) and biological (recruitment, predation, competition, mutualism, and disturbance) characteristics. These makes the variables subjected to be confounded with other causal processes not directly related to protection. Ecological heterogeneity (Wiens, 1976; Levin, 1992), habitat structure (Bell et al., 1991), ecological processes (Levin, 1991; McClanahan, 1994) and temporal dynamics (Francour, 1994; Duffour et al., 1995) are factors have a potential role modifying the consequences of ecological processes (García-Charton and Pérez-Ruzafa, 1999). This variability is also due to species and families temporal variations, and it is regular in the fish community. This has been widely studied in works including any type of temporal replication (Harmelin et al., 1995; Edgar and Barrett, 1997; Chiappone et al., 2000; Magill and Sayer, 2002; Valle et al., 2007). Thus, the problem rests on determining the relative importance of such processes in influencing community structure (Menge and Farrel, 1989) and not confounding with the protection effect. Many factors influence that the protection effect can merely be one of them.

Although data analysis took on account structural characteristics the disparity of results demonstrates the influence of these characteristics over the populations and habitats. Therefore the assessment of the protection effect is influenced by them. The size of the MPA, to have a single large or several small, has generated a considerable controversy debate (Zhou and Wang, 2006).Others also like the number of zones and management (Forcada, 2007) or years since establishment have also been studied. But others like (e.g.: hours of enforcement, number of people contracted and total budget) are unlikely to be assessed. These factors increase even more the specificity of the data, making an arduous task to work with different case studies.

This high biological and structural specificity makes difficult to find a similar indicator to be use widely as this characteristics cited may affect each case study. Some practical consideration to improve this aiming to evaluate the effect of protection in the face of this heterogeneity should be the definition of sampling protocols to assess the protection effects. These protocols should be established worldwide making comparison between MPAs and definition of trend of a wider geographical range.

Many indices are widely used to test for differences between community assemblages. Some of these indices incorporate one biotic factor, such as species richness, while others incorporate two factors, e.g., Shannon diversity uses species abundance and richness, although Shannon does not distinguish unique species. Many indices were tested all of them measured in different ways the diversity. Diversity is based on the fact that the relationship between diversity and environmental disturbances can be seen as an inverse one (Salas et al., 2006). Although these types of indices were tested among the same MPAs and variables they never followed a pattern. The correlation value of the different indexes varied among the different analysis. This variation was shown for the UVC data. Nevertheless the taxonomic diversity and distinctness usually presented higher values than the other indexes. This index was proposed by some researchers (Warwick and Clarke, 1995, 1998; Clarke and Warwick, 1999) to evaluate biodiversity in the marine environment, taking into account taxonomical, numerical, ecological, genetical and filogenetical aspects of diversity. For these characteristics it is obvious that it would present high values in protected areas as are MPAs. But in our analysis, although presenting the higher correlation values they significantly related only with 3 variables of protection and they were mainly structural variables (distance to other MPA, distance to main town and compliance). This proves the high variability of the data and its influence of other characteristics more than the protection effect.

MPAs have been widely studied but their assessment of protection has been through a merely hypothetical deductive approach. Accepting as the null hypothesis affirmations widely recognized and confirming them through short term studies. While there is a lack of inductive approach where data should be gathered and the pattern studied along long temporal and spatial series. This approach observes the trends dealing with their natural variations. In this approach trends are important variable instead of the quantity a variable increases or decreases.

There are numerous bio-indicators and ecological indicators that can be found in the literature (Salas et al., 2006) but usually they are more or less specific for a given kind of stress, or applicable to a particular type of community and /or scale of observation, and rarely its validity has in fact been proved. We validated our models with out clear results, even having many data series. Due to the high specificity it was impossible to search a similar variable to be used as an indicator to detect changes in all the case studies. It could not be found the universal indicator to assess MPAs effectiveness.

So, the search of this universal indicator should be subjected to the ecological and structural characteristics of the study area. Even to compare between areas to detect the protection effects at higher scales, it is necessary to combine efforts and develop sampling protocols. This effort will help in the analysis avoiding higher diversity in the data. Also this protocols and samplings must be applied in a continuous way to gather long temporal series. This will allow the comparison between wide geographical areas. More investment is needed to develop and apply these protocols to manage MPAs and to assess the protection effects.

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6. EXPERT-KNOWLEDGE-BASED EVALUATION OF PARAMETERS FOR THE ASSESSMENT OF MPAs EFFECTS

Abstract

Tools to manage Marine Protected Areas (MPAs) are needed. On of these tools to assess the protection effects in MPAs can be the use of indicators. From a driving force-pressure-state-impact-response (DPSIR) framework a set of parameters to assess the protection effect were defined to support an ecosystem approach in MPAs management. To evaluate which were the preferred indicators by managers a survey of their opinions was undertaken through questionnaires. The evaluation was based on mangers knowledge in order to select the best indicators form the whole list of the parameters defined. Managers were classified in two groups: administration level and type of administration resources management. The opinions of managers were measured using summated rating scores. Finally 24 questionnaires answered were obtained. The results reflected the most valuated parameters and the possibility to use them as indicators. From 169 parameters defined best evaluated were those categorized as Driving Forces and Responses meanwhile the States or Impacts did not obtain high scores. Managers showed a high dispersion of opinions. The study proved the steps in selecting indicators to be prone to value judgement. Differences in scores among managers were the main factor contributing to variability in the results. The process enhanced transparency in the indicators proposal by explicitly stating each issue to be addressed in the selection process, and by giving managers the opportunity to present their opinion openly.

Introduction

Marine protected areas (MPAs) have been established throughout the world as a management tool for compensating the effects of human impacts on the coastal marine environment (Agardy, 1994; Ward *et al.,* 1999). They are implemented to reduce the effects of over fishing and preserve marine biodiversity (Francour *et al.,* 2001; Halpern, 2003). They also provide a sustainable socioeconomic development for human communities in coastal areas (Sainsbury and Sumaila, 2003).

The conservation of Marine Protected Areas (MPAs) and coastal marine environments must be based on reliable information on the quality of the marine environment that can be obtained in a reasonable time frame. For this reason more than the assessment of the utility or effectiveness of the MPAs, there exists the necessity to develop tools to measure and monitor that effectiveness. In recent years, governments have placed growing emphasis on outcome-based (rather than activity-based) performance reporting, which includes measures of performance in achieving objectives. There exist different means to assess the aims assigned to MPAs, but selecting suitable indicators can be the best tool for this.

Indicators are defined as quantitative or qualitative measures that are indicative of the conditions of some aspect of the system as a whole (ANZECC Task Force, 1998). They must be capable to indicate the live conditions that correspond to a given situation, to a natural variation or an environmental disturbance (Lebrun, 1981). Indicators are increasingly being developed and used as management tools to address environmental issues because their communicability and transparency (OECD 1994; EEA 1999 a, b). When they are used effectively, indicators are expected to reveal conditions and trends helping in development planning and decision making (Unluata, 1999). Although they are not going to tell us what is wrong or neither what management action should be implemented they will reveal if something is wrong, allowing the evaluation of MPAs management specific objectives.

The characteristics that a good indicator were listed by Waltz and Meadows (Unesco, 2003)and they should be: 1) to have an agreed scientifically sound meaning, 2) to be representative of an important environmental aspect for the society, 3) to provide valuable information with a readily understandable meaning, 4) to be meaningful to external audiences, 5) to help in focusing information necessary for answering important questions, and 6) to assist decision-making by being efficient and cost-effective. Although to consider a given indicator as a good or less good is, and will always be, a matter of perspective (Salas *et al.,* 2006).

The main attribute of an ecological indicator is to combine numerous environmental factors in a single value, which might be useful in terms of management and for making ecological concepts, compliant with the general public understanding. But more than with the general public indicators must be easy to understand for managers. Management evaluation is often viewed as an ‘optional extra’; good in theory but difficult in practice. Monitoring and evaluation programs, although supported in principle, often get displaced by more ‘urgent’ (though often less important) day-to-day management activities. However, without evaluation against objectives, managers are 'flying blind' and lacking the necessary evidence-based feedback to learn from, and improve upon, past management approaches (Jones, 2000). It is important to develop participation processes were managers and even stakeholders could participate in the definition, selection and evaluation of MPAs indicators.

This study therefore aims to: a) evaluate the global importance of a set of parameters according to suitable criteria, b) analyze the importance given to the parameter within each criterion, c) detect differences according to the administration level and d) assess differences regarding management sectors.

Material and methods

Data gathering

Trough a participation process applying the DPSIR methodology (OECD, 1994) a conceptual framework was defined (Deliverable 19). This framework links atrophic activities and processes that cause pressures in the marine environment to the actions that are implemented to solve these environmental problems. From this framework a list of parameters and criteria were defined. They were divided between the tourism and fishing sector and each parameter was classified within the components of the DPSIR methodology. The five criteria defined within the participation process were: 1) consistency (maintenance of low variability of response over time and space), 2) ease of understanding (how easy is the indicator understood by stakeholders), 3) relevance (importance for that to be assessed), 4) feasibility (how difficult is it to obtain and/or measure records for a given indicator considering cost-effective criteria) and 5) sensitivity (susceptibility to detect changes that can be adverted by management actions). For consistency and sensitivity a binary system was used (0: no, 1: yes). The others, ease of understanding, relevance and feasibility could be marked in an increasing scale from 0 to 10. For each parameters all data was standardized, so we obtained a global value between 0 and 5.

Finally the set consisted in 164 relevant parameters that were included in a questionnaire of respondents' manager-knowledge. Managers taking part in the survey were pre-selected choosing those that worked directly in an MPA. The survey was addressed to manager's representatives of: national, regional and local administrations; and environmental and fisheries administrations. Prior contact was established both by post or e-mail. This was accompanied by an introductory letter explaining the objectives of the proposed work. The questionnaires were sent directly to each representative by hand or via post mail, and were addressed to the head representative of each institution, or to the person used to work with fisheries or environmental issues. The survey was carried out approximately during one year (from the middle of February to the end of December 2007). Those managers polled had to value the parameters in relation with five criteria. They should answer for each parameter the question “How good or bad do you think is this parameter to assess the protection effect?”

Data analysis

After collecting all questionnaires, we treated the data in three different ways. For each parameter a final value was obtained, through a mean of the values assigned in each criteria ($P = (\Sigma\ (c_1+c_2+c_3+c_4+c_5))/n$, were P is each parameter, c are the different criteria and n is the maximum global value that could be obtained by a parameter (5)). With this we had an overview of the type of parameters that managers most value to assess the effects of protection of MPAs. By other hand, and within each criterion differences of importance given to each parameter, were analyzed to reflect differences in the operative circumstances of their acquisition. Managers were categorized depending if they belonged to; a) environmental or fisheries administration and b) state, regional or local administration. Non-parametric multivariate techniques were used to compare the global value assessed by managers among their classification. All multivariate analyses were performed using the PRIMER statistical package. Triangular similarity matrices were calculated using the Bray-Curtis similarity coefficient (Clarke and Warwick, 1994). Non-metric multidimensional scaling (nMDS) was used as the ordination method. Variables that had more influence on similarities within groups and dissimilarities among groups, determined by ANOSIM (analysis of similarity), were calculated (Warwick *et al.,* 1990; Clarke, 1993). The ANOSIM permutation test was used to assess the significance of differences between managers classification. ANOSIM produces a global *R* value (= test statistic) based on average similarities between different samples. *R* lies in the range of (-1,1), indicating some degree of discrimination.

Results

The total number of contacted managers representing different entities was 24. They belonged to different administrations most of them (12) worked on a local agency, 10 in a regional agency and only two from a state agency collaborated at the end. Most of the people that answer the questionnaires worked in a fisheries administration (16) whereas the others laboured in an environmental administration (8).

In a global assessment taking on account the sum of all the parameters classified within the DPSIR components (Fig.6.1) Responses and Driving forces were the best classified followed by the States for the fishing sector. However for the tourism sector only the States presented lower values meanwhile the Responses reach the highest values. The fishing sector presented higher values than the tourism sector.

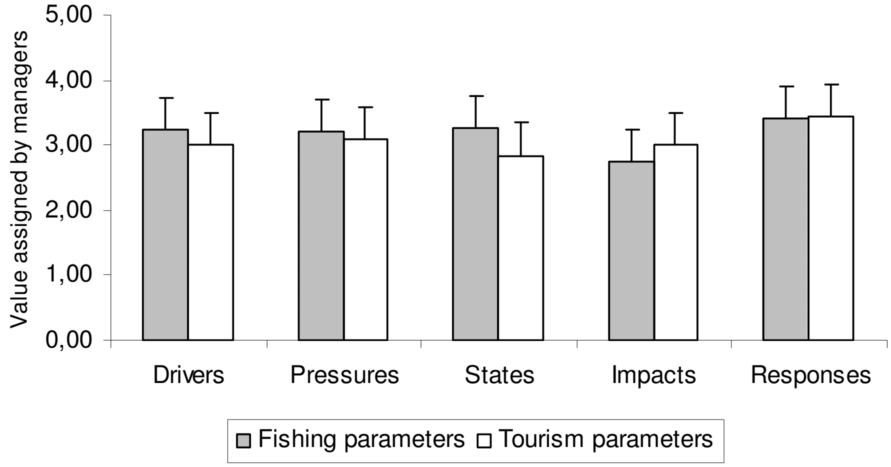

Figure 6.1. Value assigned by managers to the different parameters classified within the DPSIR components for both sectors. Data are mean values and vertical bars represent the SE.

Each manager evaluation for each parameter was summed, distinguishing between fisheries and tourism parameters. None of the parameters evaluated reached the highest punctuation, being the highest for the evolution of nº of fishing boats in the fishing sector (Table 6.1) and the integral reserve surface in the tourism sector (Table 6.2). Parameters classified as the best for the fishing sector were mostly Driving Forces (e.g.: evolution of the number of fishing boats, evolution of the number of fishers) and Responses (e.g.: number of surveillance hours, zoning surface set for each use) and surprisingly some States, mainly abundance. This contrasts with the parameters best valuated for the tourist sector that were mainly Responses (e.g.: integral reserve surface, MPA surface, % of surface limited for sport fishing, budget for surveillance). Within this sector we did not find States but Pressures (e.g.: number of divers/day in the MPA). Also Driving Forces are found as happens in fisheries (e.g.: evolution of diving clubs, evolution in the number of divers, evolution in the number of fishing boats). However, in the fishing sector the less valuated parameters were mainly those classified as Impacts (e.g.: key species; rough, lose of verticality and changes in recruitment rates). In the tourism sector does not happen the same, as those parameters less classified were mainly Driving Forces (e.g.: evolution of sky jets, evolution of the number of recreational boats, evolution of the number of spear fishing tackle sold).

Table 6.1. Punctuation obtained by each parameter by the managers' evaluation for fishing sector. Parameters are classified with the DPSIR framework

DPSIR Type	FISHING SECTOR INDICATORS	Mean	S	Error
Drivers	Evolution of nº of fishing boats	4.35	0.53	0.11
Drivers	Evolution of nº of fishers	4.30	0.43	0.09
Responses	Nº of surveillance hours	4.16	0.72	0.15
Responses	Zoning surface for each use	4.10	0.53	0.11
Drivers	Nº of boats fishing with a kind of gear	3.91	0.82	0.17
Responses	Total budget	3.85	0.77	0.16
States	Abundance	3.83	0.75	0.15
Pressures	Number of boats fishing / day	3.82	0.85	0.17
Responses	Nº of people contracted	3.77	1.00	0.21
Pressures	Biomass extracted by specie	3.75	0.86	0.18
Pressures	Fishing ground area	3.71	1.00	0.20
Responses	Research budget	3.68	0.95	0.19
States	Biomass	3.65	1.06	0.22
Impacts	Species size variation	3.64	0.64	0.13
Pressures	CPUE / day	3.61	0.99	0.20
States	Size structure	3.55	0.83	0.17
Pressures	Total Biomass extracted	3.53	1.17	0.24
Pressures	Nº of gears lost	3.53	0.35	0.07
States	Density	3.52	1.02	0.21
Pressures	Organic matter quantity dumped by fishing boats	3.50	0.00	0.00
Responses	Education budget	3.49	1.18	0.24
Responses	Nº of projects / year	3.46	1.02	0.21
Impacts	Changes in sensitive species	3.45	0.83	0.17
Pressures	Number of species caught	3.40	0.95	0.19
Pressures	Fishing time	3.40	1.00	0.20
States	Richness	3.40	0.94	0.19
States	Diversity	3.39	1.22	0.25
Responses	Budget for improvement actions / year	3.38	1.21	0.25
Responses	Changes in laws and regulations	3.35	0.70	0.14
Impacts	Changes in the composition and/or quality of the sediment	3.35	0.10	0.02
Responses	Nº of improvement actions / year	3.29	1.14	0.23
Drivers	Spatial effort distribution	3.28	1.01	0.21
Impacts	Density	3.24	0.98	0.20
States	Community structure	3.20	0.98	0.20
Responses	Educational programs	3.19	1.11	0.23
Impacts	Habitat surface affected	3.18	1.03	0.21
States	Cover	3.15	1.14	0.23
Drivers	Variation of the fishing boats power	3.13	1.23	0.25

DPSIR Type	FISHING SECTOR INDICATORS	Mean	S	Error
Responses	Budget invested in participation	3.08	1.24	0.25
Responses	Nº of people working in the projects	3.07	1.21	0.25
Responses	Nº of publications	3.05	1.28	0.26
Pressures	Length of the net over a type of habitat	3.05	1.12	0.23
Impacts	Appearance of opportunistic species	3.04	1.07	0.22
States	Relative abundance	3.02	1.13	0.23
Drivers	Fishing sector profit	2.97	1.10	0.23
Impacts	Total surface affected by the gear	2.96	1.14	0.23
States	Dominance	2.95	1.12	0.23
Impacts	Cover	2.94	1.01	0.21
Responses	Budget for participant organisms	2.93	0.86	0.18
Impacts	Structure of key species	2.89	1.00	0.20
Impacts	Species substitution	2.88	1.17	0.24
Pressures	Nº of hooks over a type of habitat	2.84	1.15	0.23
Pressures	Nº of individuals fished / total capture	2.83	1.20	0.25
Impacts	Relative abundance	2.79	0.97	0.20
Drivers	Gross domestic product (GDP) produced by the fishing sector	2.77	1.12	0.23
Responses	Nº of stakeholders meetings	2.72	1.55	0.32
Drivers	RPC in the influenced area	2.70	1.51	0.31
Impacts	Heterogeneity	2.63	1.08	0.22
Impacts	Dominance	2.61	1.16	0.24
Impacts	Families substitution	2.61	1.17	0.24
Drivers	Nº of investments done in the fishing sector	2.56	1.26	0.26
Impacts	Changes in the community structure	2.54	0.92	0.19
Impacts	Changes in trophic levels	2.53	1.08	0.22
Drivers	RPC of the fishing sector	2.43	1.41	0.29
States	Nº of trophic categories affected	2.29	1.26	0.26
Impacts	Changes in recruitment rates	2.00	0.00	0.00
Impacts	Lose of verticability	1.94	1.09	0.22
Impacts	Breaking index	1.78	0.98	0.20
Impacts	Rugosity	1.75	1.06	0.22
Pressures	Hydrocarbon consumed in the close ports by fishing boats	0.80	0.00	0.00

Table 6.2. Punctuation obtained by each parameter by the managers' evaluation for tourism sector. Parameters are classified with the DPSIR framework

DPSIR Type	TOURISM SECTOR INDICATORS	Mean	S	Error
Responses	Surface of integral reserve	4.27	0.84	0.17
Responses	Surface of the MPA	4.25	0.83	0.17
Responses	% of the total surface (MPA) limited for sport fishing	4.24	0.63	0.13
Pressures	Nº of divers / day in the MPA	4.16	0.75	0.15
Responses	Budget for surveillance	4.00	0.80	0.16
Drivers	Evolution on the nº of diving clubs	3.91	0.80	0.16
Drivers	Evolution in the nº of divers	3.85	0.97	0.20
Drivers	Evolution of the nº of recreational fishing boats in the influence ports	3.81	0.78	0.16
Responses	Evolution of diver's quotas (per area. season. etc…)	3.80	1.16	0.24
Responses	Nº of mooring points established for divers	3.76	1.04	0.21
Responses	Nº of illegal / divers / boats fishing denounces	3.72	1.08	0.22
Drivers	Evolution of the tourist influx	3.65	0.93	0.19
Impacts	Evolution of the surface erodes by flapping and influx of divers.	3.62	1.04	0.21
Responses	Budget for investigation for each pressure (waste. divers...)	3.62	1.24	0.25
States	Abundance	3.61	0.66	0.13
Impacts	Variation of size and weight of target species	3.58	0.85	0.17
Responses	Budget for education programs	3.58	0.91	0.19
Responses	Nº of anchoring points	3.53	1.28	0.26
Responses	Nº of licences for sport fishing	3.50	1.13	0.23
Responses	Waste programs budget	3.48	1.10	0.22
Pressures	Nº of recreational boats / day	3.46	1.24	0.25
Impacts	Temporal capture changes	3.45	1.00	0.20
Pressures	Nº of recreational boats (fishing & tourism boats. whale-watching...)	3.42	1.13	0.23
Responses	Nª of licences for the different kinds of sport fishing	3.41	1.08	0.22
Responses	Surface of diving areas	3.41	1.11	0.23
States	Biomass	3.40	0.94	0.19
States	Density	3.40	0.78	0.16
Pressures	Recreational fishing surface	3.37	1.13	0.23
Impacts	Changes in the composition and/or quality of the sediment	3.35	0.10	0.02
Drivers	Evolution of the number of spear fishing / coast	3.35	1.07	0.22
Pressures	Nº of tourists / day	3.35	1.27	0.26
Drivers	Diving licences nº evolution	3.34	1.10	0.22
Responses	Nº of education programs	3.33	1.08	0.22
Drivers	Companies evolution that offer nautical activities	3.33	0.15	0.03
Impacts	Evolution of biomass extracted / specie	3.31	1.04	0.21
Responses	Budget for improvement actions in access areas and littoral paths	3.29	1.34	0.27
Impacts	Changes in key elements cover	3.28	0.05	0.01
States	Size structure	3.27	0.90	0.18
Pressures	Nº of anglers by boat	3.26	0.97	0.20
Responses	Nº of waste awareness actions for stakeholders	3.25	1.13	0.23

DPSIR Type	TOURISM SECTOR INDICATORS	Mean	S	Error
Drivers	Evolution of the nº of littoral guided activities	3.22	1.03	0.21
Pressures	Nº of anglers / coast (km)	3.22	1.15	0.23
States	Richness	3.21	0.87	0.18
Responses	Budget for anchoring points	3.20	1.27	0.26
Impacts	Abundance	3.20	0.84	0.17
Impacts	Eroded surface evolution due to visitants influx	3.18	0.81	0.16
Responses	Divers research programs budget	3.18	1.20	0.25
Responses	Divers management actions budget	3.17	1.25	0.26
States	Diversity	3.17	1.06	0.22
Impacts	Extracted biomass evolution	3.16	1.12	0.23
Drivers	Evolution of the number of anglers / coast (km)	3.15	0.96	0.20
Drivers	Diving incomes evolution	3.15	0.87	0.18
Impacts	Anchoring surface damaged evolution	3.15	0.86	0.17
States	Habitat cover	3.15	0.97	0.20
Pressures	Nº of spear fishers / day	3.10	0.98	0.20
Responses	Surface forbidden for visitants	3.08	1.12	0.23
Responses	Anchoring surveillance	3.07	1.35	0.27
Responses	Evolution in the nº of littoral paths	3.02	1.09	0.22
Impacts	Disappear rate of protected species	3.02	0.90	0.18
Impacts	Richness	3.01	0.87	0.18
States	Community composition evolution	2.95	0.86	0.18
Pressures	Density of recreational fishers / time	2.92	1.03	0.21
Responses	Management duties budget for anchoring points	2.89	1.22	0.25
Drivers	Evolution on specialised shops	2.85	1.32	0.27
Pressures	Nº of tourist by littoral path	2.85	1.31	0.27
States	Occupied surface evolution	2.83	1.13	0.23
Pressures	Nº of jet sky within the AMP and influence area	2.80	0.60	0.12
Impacts	Diversity	2.80	1.12	0.23
Responses	Nº of educational programs	2.78	0.94	0.19
States	Nº of key species (sea mammals. turtle...) endangered by debris	2.72	0.96	0.20
Impacts	Whale-watching decrease	2.70	1.11	0.23
Impacts	Opportunistic species evolution	2.70	0.94	0.19
Impacts	Water quality changes	2.68	0.35	0.07
Impacts	Filter species evolution	2.59	1.08	0.22
States	Recruitment rate	2.58	1.07	0.22
States	Hydrocarbon water column concentration	2.57	1.11	0.23
States	Nº of species broken by angling	2.56	1.12	0.23
States	Chemical products water column concentration	2.54	1.13	0.23
Impacts	Recruitment rate evolution	2.48	1.31	0.27
States	Nº of debris / habitat surface	2.46	1.05	0.22
States	Density of bird nests	2.42	1.04	0.21
Impacts	Mortality rate	2.41	1.19	0.24

DPSIR Type	TOURISM SECTOR INDICATORS	Mean	S	Error
Responses	Changes in laws and regulations	2.38	1.35	0.28
Pressures	Hydrocarbon consumed in the close ports by recreational boats	2.37	1.20	0.25
Impacts	Nº of impacts with sea mammals	2.33	1.21	0.25
Drivers	Evolution on the tourist provision	2.30	0.40	0.08
Drivers	Evolution of the nº of fishing rods sold / habitant	2.13	1.33	0.27
Drivers	Evolution on the nº of spear gun sold / habitant	2.08	1.30	0.27
Pressures	Organic matter quantity dumped by recreational boats	1.95	1.06	0.22
States	Changes in covertures	1.91	1.50	0.31
Drivers	Evolution in the nº of recreational boats sold	1.90	0.80	0.16
Drivers	Evolution in the nº of jet sky sold	1.90	0.80	0.16

Parameters valuated with the consistency criteria for both fishing and tourism showed a great dispersion, except for the Responses of fishing parameters were although the mean is the lowest there is not dispersion in the parameter evaluation (Fig. 6.2). In this criterion the parameters best evaluated reach the highest values for both fishing and tourism. The criterion Easy of Understanding shows also big dispersion, except again for the parameters belonging to Responses (Fig. 6.3). Highest mean values were obtained in general for fishing parameters, except for Responses in tourism parameters. Parameter evaluated with the criteria relevance and feasibility reached the highest values. Although they show some data far from the means, their dispersions are low, and parameters valuated among this criterion present similar trends. Again fisheries Responses show the lowest mean values and the highest variability (Fig.6.4 and 6.5). Appling the sensitivity criteria to the parameters evaluation they presented the lowest values (Fig. 6.6) and a high dispersion. Fisheries Responses parameters have a similar trend as in the other criteria. Among all the criteria the consistency reaches higher values in the parameters. The parameters best valuated applying the criteria were those categorized as Driving Forces and Responses, for fisheries (e.g. evolution of the number of fishing boats, evolution of the number of fishers, fishing ground area), and for tourism (e.g. surface limited for sport fishing, integral reserve surface, evolution of the number of recreational boats, surveillance budget, evolution of the spear and angling fishing, budget for educational programs, evolution in the number of divers, evolution of the number of diving clubs). Also parameters belonging to these categories could be found as those with less value (e.g. changes in laws and normative, number of sky jets, evolution in the tourist provision). But parameters mostly worse valuated for both, fishing and tourism sectors, were those that belonged to the Pressures, States and Impacts, as, e.g.: hydrocarbons consumed by the professional fishing boats and the recreational boats, changes in the community structure, changes in the composition and quality of the sediment and water, evolution of opportunistic species, changes in recruitment rates and number of gears lost. Nevertheless only for the criterion relevant, parameters were valuated totally different. Abundance, biomass, biomass by extracted species, size structure, total biomass and density, were the most valuated parameters.

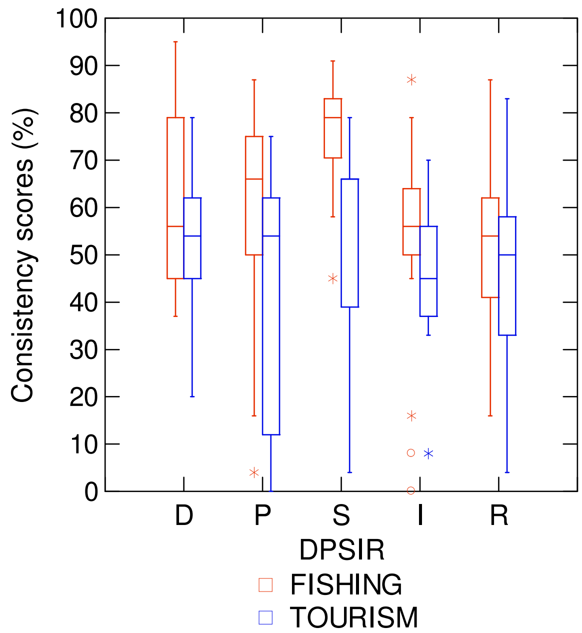

Figure 6.2. Boxplot of percentage distributions of scores of the parameters on the consistency criteria, across managers' evaluation for both sectors. The box itself represents 50% of all cases, and extends from 25th to the 75th quartiles. The line inside the box shows the median. Points beyond the whiskers were drawn individually.

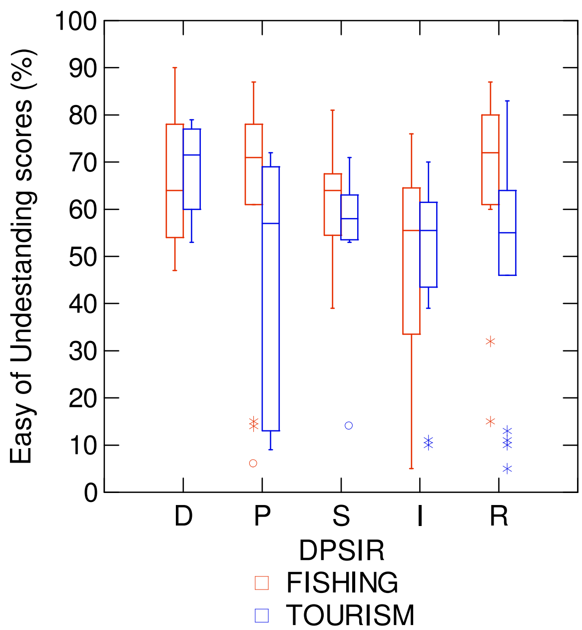

Figure 6.3. Boxplot of percentage distributions of scores of the parameters on the easy understanding criteria, across managers' evaluation for both sectors. The box itself represents 50% of all cases, and extends from 25th to the 75th quartiles. The line inside the box shows the median. Points beyond the whiskers were drawn individually.

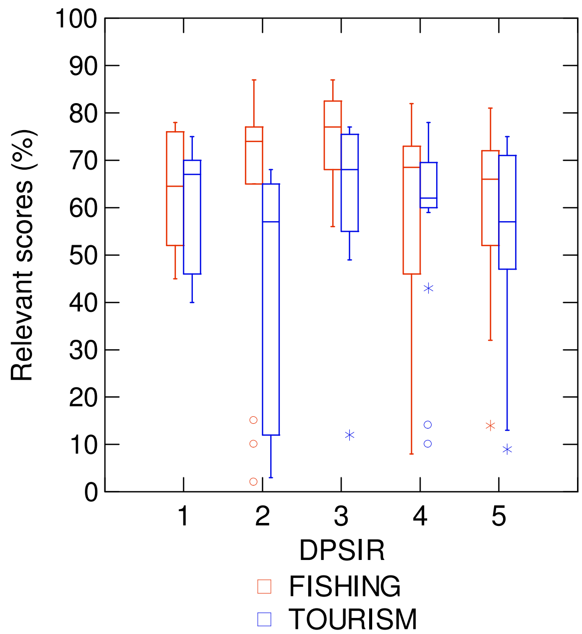

Figure 6.4. Boxplot of percentage distributions of scores of the parameters on the relevant criteria, across managers' evaluation for both sectors. The box itself represents 50% of all cases, and extends from 25th to the 75th quartiles. The line inside the box shows the median. Points beyond the whiskers were drawn individually.

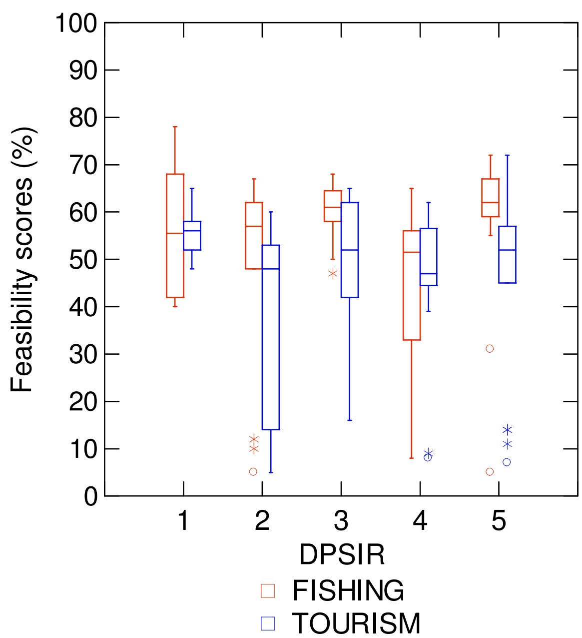

Figure 6.5. Boxplot of percentage distributions of scores of the parameters on the feasibility criteria, across managers' evaluation for both sectors. The box itself represents 50% of all cases, and extends from 25th to the 75th quartiles. The line inside the box shows the median. Points beyond the whiskers were drawn individually.

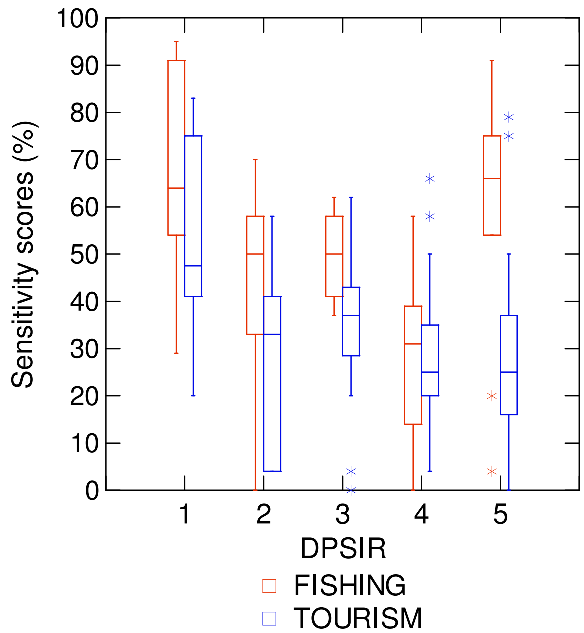

Figure 6.6. Boxplot of percentage distributions of scores of the parameters on the sensitivity criteria, across managers' evaluation for both sectors. The box itself represents 50% of all cases, and extends from 25th to the 75th quartiles. The line inside the box shows the median. Points beyond the whiskers were drawn individually.

A non-metric multi dimensional (nMDS) plot based on managers global scores for the fishing sector classifying them by the different administration levels (local, regional and national) (Fig. 6.7), and by management sectors (natural resources and fishing administrations) (Fig. 6.8) did not revealed any clear separation and the stress was relatively high (0.17). However, ANOSIM tests for management sectors showed differences among groups ($R = 0.451$, $p<0.01$). Between the administration levels the differences were not significant ($R = 0.242$, $p<0.1$) Moreover if a pairwise test is applied we can find greater differences but not significant (p = n.s.) among the administration levels. The same non-metric multi dimensional analyses were applied for the tourism sector (Fig. 6.9 and 7.10) coming across similar results. Any clear separation could be done between classifications. Results showed big dispersions among parameters values. Management sectors ANOSIM showed less dissimilar results but no significant ($R = 0.167$, $p<0.1$). Analysing the data through the classification of the management sectors the results are dispersed. ANOSIM test did not presented dissimilarity ($R = -0.089$, p = ns) presenting the pairwise test the same dissimilarity but less significant. With this R values more differences within each classification group could be found than differences between groups.

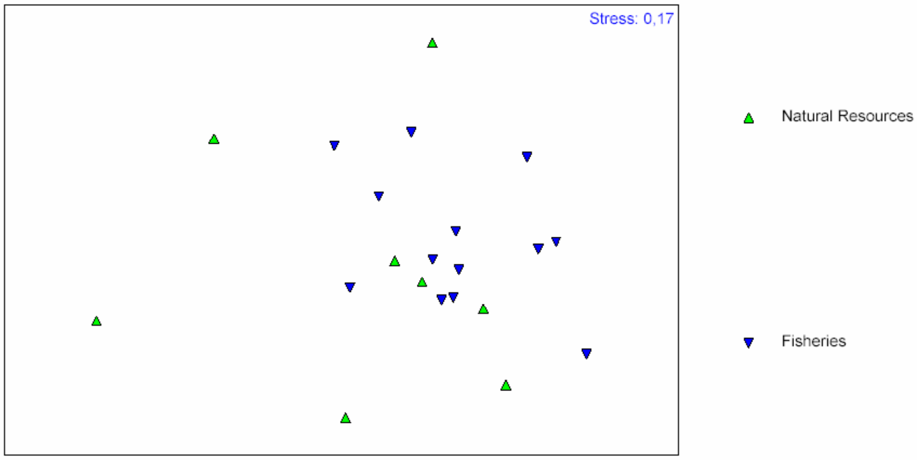

Figure 6.7. Non-parametric multi-dimensional scaling plot of total scores by manager classified in natural resources and fisheries administration for the fishing sector.

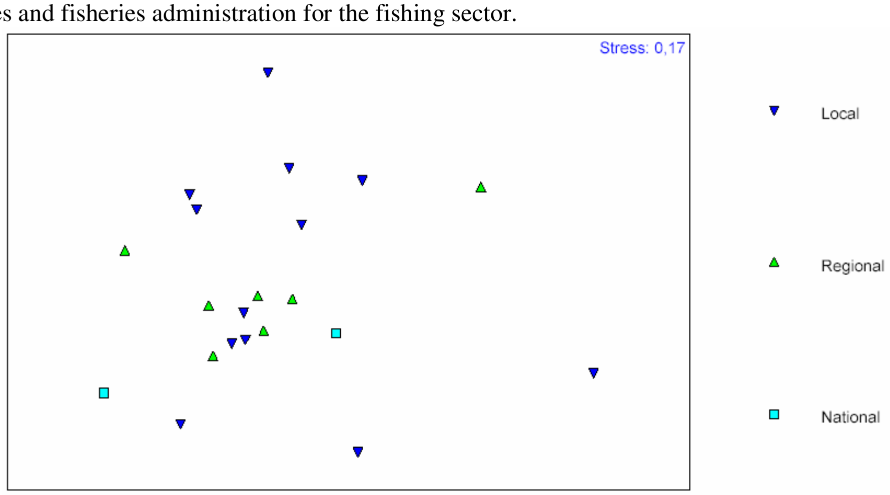

Figure 6.8. Non-parametric multi-dimensional scaling plot of total scores by manager classified in local, regional and national administration for the fishing sector.

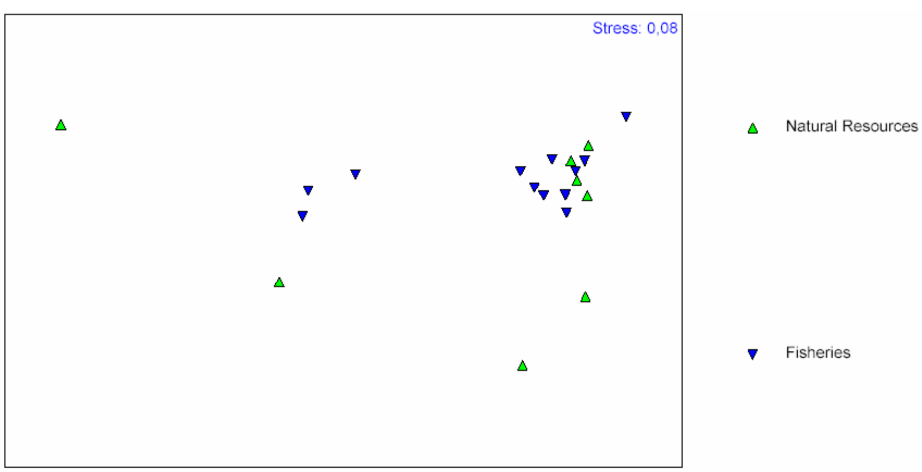

Figure 6.9. Non-parametric multi-dimensional scaling plot of total scores by manager classified in natural resources and fisheries administration for the tourism sector.

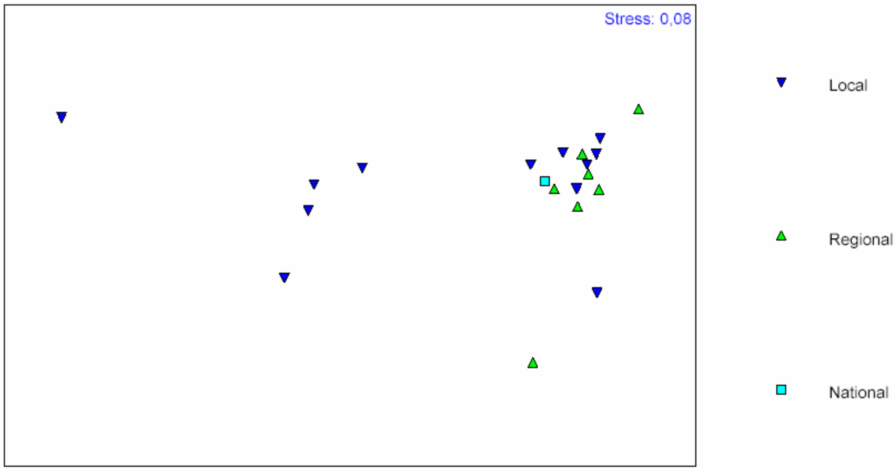

Figure 6.10. Non-parametric multi-dimensional scaling plot of total scores by manager classified in local, regional and national administration for the tourism sector.

An nMDS analysis of the parameters classified within the DPSIR framework for the fishing sector had a lower stress (0.16) than those pertaining to the tourism sector but some dissimilarity was shown by parameters related to Driving Forces (Fig. 6.11). ANOSIM showed significant dissimilarities between and within groups ($R = 0.274$, $p<0.01$). In a pairwise test between groups same dissimilarities but not significant were found. On the other hand the same analysis were done for the tourism sector that presented higher stress (0.2) being able to group the Driving Forces (Fig 6.12). ANOSIM for tourism sector showed significant dissimilarities between and within groups ($R = 0.253$, $p<0.01$). In a pairwise test between groups same dissimilarities but not significant were found.

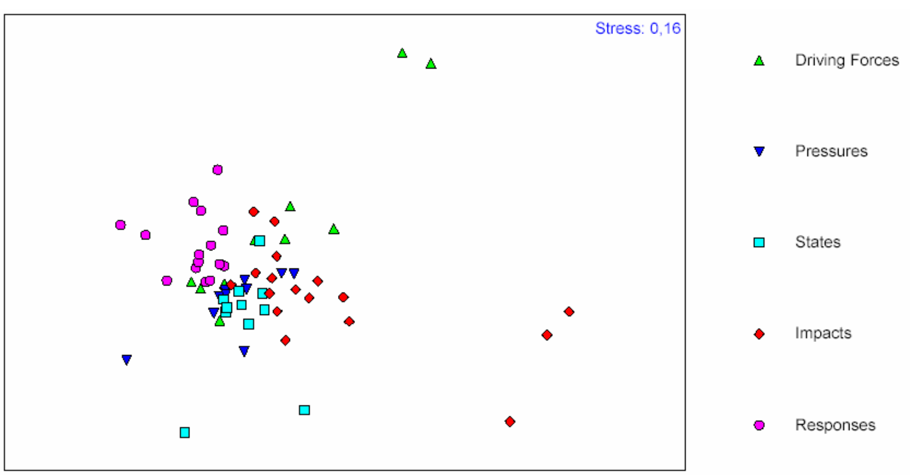

Figure 6.11. Non-parametric multi-dimensional scaling plot of total scores obtained by each parameter for the fishing sector. Parameters were classified within the DPSIR framework components.

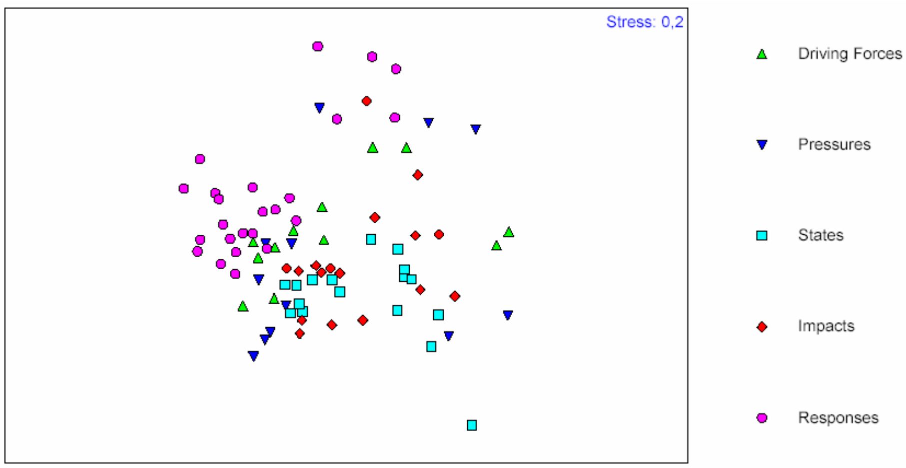

Figure 6.12. Non-parametric multi-dimensional scaling plot of total scores obtained by each parameter for the tourism sector. Parameters were classified within the DPSIR framework components.

Discussion

Our results showed that the parameters best evaluated were those understood as the factors that cause changes in the system and those that reflect the efforts made by society as a result of the changes manifested, categorized respectively as Driving Forces and Responses. Within each criterion parameters show a similar trend. However for the criteria relevance, the results are completely different being parameters describing the States the best considered. We stress that there existed a very high dispersion among the values given by the managers, and that there were no homogeneous pattern within the administration level and management sectors. Surprisingly, parameters best evaluated by managers had not been those that are commonly used in the literature to assess the protection effects in MPA. These results contrasted with those obtained by some authors from merely bibliographical reviews (Pelletier et al., 2005) whom asserted the best candidate indicators to assess the protection effect in MPAs would be total biomass, biomass per family, density, CPUE, size, mean size, movement patterns, species richness or benthic cover, parameters that usually measure States and Pressures. Our results evidenced clearly the different opinion between managers and scientists.

Parameters were not evaluated in the same way even belonging to the same socioeconomic sector. Managers seemed to be influenced by scientist's practices that normally used to assess the state of the environmental issues targeted for protection. This can explain the results obtained within the criteria relevance which contrasted with the homogeneity of the evaluation within the other four criteria. Basically the main issue to assign a high score was the easy to measure or to obtain the parameter data. Abundance, biomass or CPUE data were less valuated because managers need higher investments and effort to obtain them, meanwhile others are easy to obtain as they must be gathered by the administration for statistical purposes. This evidence the difficulties that managers have to measure some parameters despite they use to think that these parameters are the most relevant. Therefore our results confirmed that the best candidate indicators for managers, at least in a way, would be those that their data is already gathered or is based on less demanding in terms of observation skills.

By other hand parameters related with tourism were lower scored. Only in some cases where there exists a high tourism pressure, managers had higher consideration to this type of parameters. This was mainly because the general aims of MPAs are related with fisheries issues (Jones, 1994), not considering really the effect of the tourism in the management plan. This means that specific circumstances of the MPA affected the parameters valuation by managers. Moreover the professional skills of managers are mainly environmental which introduces certain skewnees in the valuation of tourism parameters.

The high dissimilarity exhibited among manager's answers evidenced a lack of coordination in terms of the agreement about the important issues to assess the effects of protection in MPAs even belonging to the same administration and/or management sector, even though some kind of association would be expected. This can occur because the competent administrations would not implement enough actions to transmit the common ideas about policies on and management of MPAs. And if actions are, maybe they could not be well implemented. Managers' dispersed opinions on the importance of parameters, difficult directly the selection of a common set of indicators to assess the efficiency of MPAs. As a consequence, it prevents the spatial and/or temporal comparison among MPAs and the efficient management of MPAs (Pomeroy *et al.,* 2005).

The survey was deliberately oriented toward the evaluation of parameters to select the best indicators to assess the protection effect in MPA. In this work we found that there was not a real consensus among managers, and their opinion differs from that expressed by scientists. Managers globally assess as more important those parameters at which they can access easily over those considered more relevant. They are conditioned by a lack of necessary means to collect information in those parameters. Despite this exists the necessity to select common indicators for a suitable management of MPAs.

For future developments managers and moreover stakeholders must be enquired and must take part of the selection of indicators for the assessment of MPAs as the best way to improve the management practices (Ramos *et al.,* 2007). A future common work must be done between scientists and managers and even stakeholders that will answer to everyone interests. Is the time that science must let used and became understandable for management.

The managers polled highlighted that in the future they would like to be consulted in similar surveys. This is a sign of positive interdisciplinary interest and participation in solving MPAs management problems. It can be added that these sorts of survey can give some advice to MPA managers, which can be used to improve their management practices. In the future research should focus towards each user type getting more people involved with the MPAs use, awareness and management.

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7. GLOBAL INDICATOR EVALUATION AND GENERAL DISCUSSION

Global evaluation

Indicators are seen as one of the possible tools to be used in management of MPAs. This characteristic comes from their facility to measure changes in the ecosystem. Indicators could assess the effects of protection in MPAs therefore they can be suitable tools for management. In this research three evaluations have been developed in the search of the best set of indicators.

Within all the characteristics widely cited in the bibliography a parameter must have to be a good indicator (see Contents above) in this work it has been considered that a good indicators as well as fulfil most of them must be at least accomplish three evaluations. A parameter must achieve three characteristics:

1. Data availability: data gathered by institutions must be easily available, without costs, with long temporal series, quickly gathered and not to much aggregated.
2. Statistical power: the data must pass statistical analysis that ensure their significance and their correlation to protection variables.
3. Managers' agreement: that the stakeholders, in this case managers that are going to use and interpret the data, evaluate the parameters from a management point of view.

This research achieved this tree evaluations over a list of parameters selected and defined with the application of the DPSIR framework. From each evaluation a final data was obtained for each parameter. This data was standardized in a way to obtain a final value of 3 for each evaluation by each parameter. Finally each evaluation was summed and a final classification was developed A classification of three range of values was developed. Values reached 0 to3 were classified as bad indicators (✖), 3 to 6 were medium indicators (~) and those with values between 6 and 9 were good indicators (✓). The aim of this final assessment was to end with a set of indicators to assess the protection effects of MPAs.

The final number of parameter to evaluate was 268 as some parameters had to be divided in different indexes. Finally only 16 parameters could be classified as good indicators. All of these parameters accomplished this status as they were assessed by the three evaluations. They are classified as States by the DPSIR framework. With a medium class we found 157 parameters. Only 91 could be assessed through the statistical power analysis, though they were not available. Classified as bad indicators we found 83 (Table 7.1).

Table 7-1. Final evaluation of parameters. Final value obtained by the standardization of three evaluations, data availability, managers' evaluation and statistical power. Classification: 0-3: bad indicators (✖); 3-6: medium indicators (~); 6-9: good indicators (✔).

SECTOR	TYPE	PARAMETERS	Data availability	Managers' evaluation	Statistical power	Final Value	Classification
FISHING	DRIVING FORCES	Evolution of number of fishing boats	**2.50**	**2.61**	**-**	**5.11**	~
		Evolution of number of fishers	**2.50**	**2.58**	**-**	**5.08**	~
		Fishing sector profit	**0.00**	**1.78**	**-**	**1.78**	✖
		Gross domestic product (GDP) produced by the fishing sector	**0.00**	**1.66**	**-**	**1.66**	✖
		Number of Investments done in the fishing sector	**0.00**	**1.54**	**-**	**1.54**	✖
		Variation of the fishing boats power	**2.50**	**1.88**	**-**	**4.38**	~
		RPC in the influenced area	**-**	**1.62**	**-**	**1.62**	✖
		RPC of the fishing sector	**0.00**	**1.46**	**-**	**1.46**	✖
		Spatial effort distribution	**0.00**	**1.97**	**-**	**1.97**	✖
		Number of boats fishing with a kind of gear	**2.50**	**2.35**	**-**	**4.85**	~
TOURISM		Evolution of the number of recreational fishing boats	**0.00**	**2.29**	**-**	**2.29**	✖
		Evolution of the number of spear fishing / coast km	**0.00**	**2.01**	**-**	**2.01**	✖
		Evolution of the number of angling / coast km	**0.00**	**1.89**	**-**	**1.89**	✖
		Evolution of the number of fishing rods sold per habitant	**0.00**	**1.28**	**-**	**1.28**	✖

SECTOR	TYPE	PARAMETERS	Data availability	Managers' evaluation	Statistical power	Final Value	Classification
		Evolution on specialised shops	**1.00**	**1.71**	**-**	**2.71**	✘
		Evolution on the number of spear gun sold per habitant	**-**	**1.25**	**-**	**1.25**	✘
		Evolution in the number of divers	**1.00**	**2.31**	**-**	**3.31**	~
		Evolution on the number of diving clubs	**1.00**	**2.35**	**-**	**3.35**	~
		Evolution on the incomes from diving	**-**	**1.89**	**-**	**1.89**	✘
		Evolution on the number of diving licences	**0.00**	**2.00**	**-**	**2.00**	✘
		Evolution in the influx of visitants	**2.00**	**2.19**	**-**	**4.19**	~
		Evolution in the number of activities and guided tours	**-**	**1.93**	**-**	**1.93**	✘
		Evolution in the number of recreative boats sold	**-**	**1.14**	**-**	**1.14**	✘
		Evolution in the number of the motorboating shold	**-**	**1.14**	**-**	**1.14**	✘
		Evolution on the companies offering nautical activities	**1.00**	**2.00**	**-**	**3.00**	✘
		Evolution on the hotel industry offer	**3.00**	**1.38**	**-**	**4.38**	~
FISHING	**PRESSURES**	Fishing ground area	**-**	**2.23**	**-**	**2.23**	✘
		Number of boats fishing / day	**2.50**	**2.29**	**-**	**4.79**	~
		CPUE	**-**	**-**	**-**	**-**	

SECTOR	TYPE	PARAMETERS	Data availability	Managers' evaluation	Statistical power	Final Value	Classification
	PRESSURES	CPUE_Tramel net <40 mm	-	-	-	-	
		Small pelagics	1.00	2.17	0.77	3.94	~
		Small serranidae	1.00	2.17	1.83	5.00	~
		Sparidae	1.00	2.17	0.44	3.60	~
		Cephalopoda	1.00	2.17	1.34	4.51	~
		Crustacea	1.00	2.17	1.46	4.62	~
		Other species	1.00	2.17	1.09	4.25	~
		Microphagous	1.00	2.17	0.77	3.94	~
		Mesophagous	1.00	2.17	0.82	3.99	~
		Macrophagous	1.00	2.17	1.76	4.93	~
		By-catch	1.00	2.17	1.22	4.39	~
		Target	1.00	2.17	1.81	4.97	~
		Total catch	1.00	2.17	2.39	5.55	~
		CPUE_Tramel net 40-60 mm	-	-	-	-	
		Small pelagics	1.00	2.17	0.61	3.77	~

SECTOR	TYPE	PARAMETERS	Data availability	Managers' evaluation	Statistical power	Final Value	Classification
		Big serranidae	1.00	2.17	0.56	3.73	~
		Labridae	1.00	2.17	1.25	4.42	~
		Chondrictios	1.00	2.17	0.46	3.63	~
		Crustacea	1.00	2.17	0.39	3.56	~
	PRESSURES	Other species	1.00	2.17	0.83	4.00	~
		Herbivorous	1.00	2.17	0.90	4.07	~
		Microphagous	1.00	2.17	1.30	4.47	~
		Mesophagous	1.00	2.17	0.62	3.79	~
		Macrophagous	1.00	2.17	0.45	3.62	~
		By-catch	1.00	2.17	1.87	5.03	~
		Discards	1.00	2.17	1.65	4.82	~
		Target	1.00	2.17	1.07	4.24	~
		CPUE_Tramel net >60 mm	-	-	-	-	
		Big serranidae	1.00	2.17	0.00	3.17	~
		Sparidae	1.00	2.17	0.38	3.55	~

SECTOR	TYPE	PARAMETERS	Data availability	Managers' evaluation	Statistical power	Final Value	Classification
		Chondrictios	1.00	2.17	1.14	4.31	~
		Cephalopoda	1.00	2.17	0.28	3.45	~
		Crustacea	1.00	2.17	2.65	5.82	~
		Other species	1.00	2.17	2.02	5.19	~
		Mesophagous	1.00	2.17	2.63	5.79	~
		Macrophagous	1.00	2.17	1.91	5.08	~
	PRESSURES	By-catch	1.00	2.17	2.23	5.40	~
		Target	1.00	2.17	2.65	5.81	~
		Total catch	1.00	2.17	2.57	5.74	~
		CPUE_Hook and line	-	-	-	-	
		Medium pelagics	1.00	2.17	1.16	4.33	~
		Small pelagics	1.00	2.17	1.18	4.34	~
		Big serranidae	1.00	2.17	1.79	4.96	~
		Small serranidae	1.00	2.17	2.23	5.40	~
		Labridae	1.00	2.17	1.69	4.86	~

SECTOR	TYPE	PARAMETERS	Data availability	Managers' evaluation	Statistical power	Final Value	Classification
	PRESSURES	Sparidae	**1.00**	**2.17**	**2.26**	**5.43**	~
		Other species	**1.00**	**2.17**	**2.61**	**5.78**	~
		Mesophagous	**1.00**	**2.17**	**2.61**	**5.78**	~
		Macrophagous	**1.00**	**2.17**	**1.73**	**4.90**	~
		By-catch	**1.00**	**2.17**	**2.34**	**5.51**	~
		Target	**1.00**	**2.17**	**2.69**	**5.86**	~
		Total catch	**1.00**	**2.17**	**2.70**	**5.87**	~
		CPUE_Gillnet	-	-	-	-	
		Labridae	**1.00**	**2.17**	**1.74**	**4.91**	~
		Chondrictios	**1.00**	**2.17**	**0.43**	**3.59**	~
		Cephalopoda	**1.00**	**2.17**	**1.75**	**4.92**	~
		Other species	**1.00**	**2.17**	**1.06**	**4.23**	~
		Detritivorous	**1.00**	**2.17**	**0.32**	**3.49**	~
		Discards	**1.00**	**2.17**	**2.03**	**5.20**	~
		Target	**1.00**	**2.17**	**0.92**	**4.08**	~

SECTOR	TYPE	PARAMETERS	Data availability	Managers' evaluation	Statistical power	Final Value	Classification
		CPUE_Longline hook size <5	-	-	-	-	
		Medium pelagics	1.00	2.17	0.00	3.17	~
		Big serranidae	1.00	2.17	0.00	3.17	~
		Small serranidae	1.00	2.17	0.00	3.17	~
		Labridae	1.00	2.17	0.00	3.17	~
		Sparidae	1.00	2.17	0.00	3.17	~
		Other species	1.00	2.17	0.00	3.17	~
		Mesophagous	1.00	2.17	0.00	3.17	~
		Macrophagous	1.00	2.17	0.00	3.17	~
		By-catch	1.00	2.17	0.00	3.17	~
	PRESSURES	Target	1.00	2.17	0.00	3.17	~
		Total catch	1.00	2.17	0.00	3.17	~
		CPUE_Longline hook size ≥5	-	-	-	-	
		Big serranidae	1.00	2.17	0.00	3.17	~
		Sparidae	1.00	2.17	0.00	3.17	~

SECTOR	TYPE	PARAMETERS	Data availability	Managers' evaluation	Statistical power	Final Value	Classification
		Chondrictios	**1.00**	**2.17**	**0.00**	**3.17**	~
		Other species	**1.00**	**2.17**	**0.00**	**3.17**	~
		Mesophagous	**1.00**	**2.17**	**0.00**	**3.17**	~
		Macrophagous	**1.00**	**2.17**	**0.00**	**3.17**	~
		By-catch	**1.00**	**2.17**	**0.00**	**3.17**	~
		Target	**1.00**	**2.17**	**0.00**	**3.17**	~
		Total catch	**1.00**	**2.17**	**0.00**	**3.17**	~
		Length of the net over a type of habitat	**-**	**1.83**	**-**	**1.83**	✘
		Number of hooks over a type of habitat	**-**	**1.71**	**-**	**1.71**	✘
		Fishing time	**2.50**	**2.04**	**-**	**4.54**	~
		Total Biomass extracted	**2.50**	**2.12**	**-**	**4.62**	~
		Biomass extracted by specie	**2.50**	**2.25**	**-**	**4.75**	~
	PRESSURES	Number of individuals fished / total capture	**-**	**1.70**	**-**	**1.70**	✘
		Number of species catched	**2.50**	**2.04**	**-**	**4.54**	~
		Hydrocarbon consumed by professional fishing boats	**0.00**	**0.48**	**-**	**0.48**	✘

SECTOR	TYPE	PARAMETERS	Data availability	Managers' evaluation	Statistical power	Final Value	Classification
		Quantity of organic matter thrown overboard	-	2.10	-	2.10	✘
		Number of fishing gears lost	-	2.12	-	2.12	✘
TOURISM		Number of angling fishermen / km of coast per day	1.50	1.93	-	3.43	~
TOURISM		Number of angling fishermen in boat	1.50	1.96	-	3.46	~
TOURISM		Number of spear fishers / day	1.00	1.86	-	2.86	~
TOURISM		Density of recreational fishers / time	-	1.75	-	1.75	~
TOURISM		Recreational fishing surface	0.00	2.02	-	2.02	~
TOURISM		Number of recreational boats / day	2.50	2.08	-	4.58	~
TOURISM		Number of recreational boats	2.50	2.05	-	4.55	~
TOURISM		Number of divers in the MPA	3.00	2.50	-	5.50	~
TOURISM		Number of visitants	-	1.71	-	1.71	✘
TOURISM		Number of motor boating in the MP	-	1.68	-	1.68	✘
FISHING & TOURISM	STATES	Abundance	-	-	-	-	
FISHING & TOURISM	STATES	Big Labridae	2.50	2.30	1.47	6.27	✓
FISHING & TOURISM	STATES	Small Labridae	2.50	2.30	2.14	6.94	✓
FISHING & TOURISM	STATES	Big Serranidae	2.50	2.30	0.93	5.73	~

SECTOR	TYPE	PARAMETERS	Data availability	Managers' evaluation	Statistical power	Final Value	Classification
	STATES	Small Serranidae	**2.50**	**2.30**	**0.80**	**5.60**	~
		Big Sparidae	**2.50**	**2.30**	**0.00**	**4.80**	~
		Diplodus spp.	**2.50**	**2.30**	**1.43**	**6.23**	✓
		Medium pelagics	**2.50**	**2.30**	**0.91**	**5.71**	~
		Small pelagics	**2.50**	**2.30**	**1.24**	**6.04**	✓
		Other species	**2.50**	**2.30**	**1.38**	**6.18**	✓
		Total Abundance of taxonomic categories	**2.50**	**2.30**	**1.81**	**6.61**	✓
		Biomass	-	-	-	-	
		Big Labridae	**2.50**	**2.19**	**2.06**	**6.75**	✓
		Small Labridae	**2.50**	**2.19**	**1.28**	**5.97**	~
		Big Serranidae	**2.50**	**2.19**	**0.64**	**5.33**	~
		Small Serranidae	**2.50**	**2.19**	**0.61**	**5.29**	~
		Big Sparidae	**2.50**	**2.19**	**1.28**	**5.97**	~
		Diplodus spp.	**2.50**	**2.19**	**1.67**	**6.36**	✓
		Medium pelagics	**2.50**	**2.19**	**1.12**	**5.81**	~
		Small pelagics	**2.50**	**2.19**	**0.72**	**5.41**	~

SECTOR	TYPE	PARAMETERS	Data availability	Managers' evaluation	Statistical power	Final Value	Classification
	STATES	Other species	2.50	2.19	1.04	5.73	~
		Total Biomass of taxonomic categories	2.50	2.19	1.81	6.50	✓
		Density	2.50	2.11	-	4.61	~
		Size structure	2.50	2.13	-	4.63	~
		Diversity	-	-	-	-	
		S_total species index	2.50	2.04	1.37	5.90	~
		Margalef index (d)_species richness	2.50	2.04	1.66	6.19	✓
		Pielou's evenness (J')	2.50	2.04	1.81	6.34	✓
		Shannon (H'(loge))	2.50	2.04	1.64	6.17	✓
		Simpson (1-Lambda)	2.50	2.04	1.68	6.22	✓
		Average Taxonomic Distinctness (Delta*)	2.50	2.04	1.16	5.70	~
		Average Taxonomic Distinctness (Delta+)	2.50	2.04	2.81	7.34	✓
		Variation in Taxonomic Distinctness (Lambda+)	2.50	2.04	2.31	6.84	✓
		Phylogenetic (Phi+)	2.50	2.04	2.53	7.06	✓
		Phylogenetic (sPhi+)	2.50	2.04	1.33	5.86	~
		Relative Abundance	2.50	1.81	-	4.31	~

SECTOR	TYPE	PARAMETERS	Data availability	Managers' evaluation	Statistical power	Final Value	Classification
	STATES	Richness	**2.50**	**2.04**	**-**	**4.54**	~
		Dominance	**0.00**	**1.77**	**-**	**1.77**	✘
		Community structure	**2.50**	**1.92**	**-**	**4.42**	~
		Cover	**2.50**	**1.89**	**-**	**4.39**	~
		Trophic categories	**-**	**-**	**-**	**-**	
		Detritivorous (Abundance)	**-**	**1.38**	**0.13**	**1.51**	✘
		Herbivorous (Abundance)	**-**	**1.38**	**0.44**	**1.81**	✘
		Microphagous (Abundance)	**-**	**1.38**	**1.01**	**2.39**	✘
		Mesophagous (Abundance)	**-**	**1.38**	**2.24**	**3.62**	~
		Macrophagous (Abundance)	**-**	**1.38**	**1.06**	**2.44**	✘
		Detritivorous (Biomass)	**-**	**1.38**	**0.20**	**1.58**	✘
		Herbivorous (Biomass)	**-**	**1.38**	**0.49**	**1.87**	✘
		Microphagous (Biomass)	**-**	**1.38**	**0.52**	**1.90**	✘
		Mesophagous (Biomass)	**-**	**1.38**	**2.14**	**3.52**	~
		Macrophagous (Biomass)	**-**	**1.38**	**1.17**	**2.54**	✘
		Evolution in the community composition	**-**	**1.77**	**-**	**1.77**	✘

SECTOR	TYPE	PARAMETERS	Data availability	Managers' evaluation	Statistical power	Final Value	Classification
		Recruitment rate	2.50	1.55	-	4.05	~
		Evolution of the occupied surface	-	1.70	-	1.70	✘
		Habitat cover	2.50	1.89	-	4.39	~
		Number of key species endangered by solid objects	-	1.63	-	1.63	✘
		Concentration of Hydrocarbons in the water column	0.00	1.54	-	1.54	✘
		Concentration of chemical products in the water column	0.00	1.52	-	1.52	✘
		Number of solid waste / habitat	0.00	1.48	-	1.48	✘
		Number of species broken by angling	-	1.54	-	1.54	✘
		Density of nests (birds)	-	1.45	-	1.45	✘
FISHING	IMPACTS	Total surface affected by the gear	-	1.78	-	1.78	✘
		Habitat surface affected	-	1.91	-	1.91	✘
		Density	2.50	1.95	-	4.45	~
		Cover	2.50	1.77	-	4.27	~
		Structure	2.50	1.73	-	4.23	~
		Species size variation	2.50	2.18	-	4.68	~
		Relative abundance	2.50	1.67	-	4.17	~

SECTOR	TYPE	PARAMETERS	Data availability	Managers' evaluation	Statistical power	Final Value	Classification
TOURISM	IMPACTS	Dominance	**2.50**	**1.57**	**-**	**4.07**	~
		Changes in the community structure	**2.50**	**1.52**	**-**	**4.02**	~
		Species substitution	**-**	**1.73**	**-**	**1.73**	✘
		Families substitution	**-**	**1.57**	**-**	**1.57**	✘
		Breaking index	**-**	**1.07**	**-**	**1.07**	✘
		Rugosity	**-**	**1.05**	**-**	**1.05**	✘
		Lose of verticability	**-**	**1.16**	**-**	**1.16**	✘
		Heterogeneity	**-**	**1.58**	**-**	**1.58**	✘
		Changes in trophic levels	**-**	**1.52**	**-**	**1.52**	✘
		Appearance of opportunistic species	**2.50**	**1.83**	**-**	**4.33**	~
		Changes in sensitive species	**2.50**	**2.07**	**-**	**4.57**	~
		Recruitment rates changes	**-**	**1.20**	**-**	**1.20**	✘
		Changes in the composition and quality of the sediment	**-**	**2.01**	**-**	**2.01**	✘
		Variation of size and weight of target species	**-**	**2.15**	**-**	**2.15**	✘
		Mortality rate	**-**	**1.45**	**-**	**1.45**	✘

SECTOR	TYPE	PARAMETERS	Data availability	Managers' evaluation	Statistical power	Final Value	Classification
		Captures changes along time	**-**	**2.07**	**-**	**2.07**	✘
		Evolution in the recruitment rate	**-**	**1.49**	**-**	**1.49**	✘
		Evolution of the extracted biomass	**-**	**1.90**	**-**	**1.90**	✘
		Evolution of the extracted biomass by specie	**-**	**1.99**	**-**	**1.99**	✘
		Disappear rate of protected species	**-**	**1.81**	**-**	**1.81**	✘
		Abundance	**2.50**	**1.92**	**-**	**4.42**	~
		Richness	**2.50**	**1.81**	**-**	**4.31**	~
		Diversity	**2.50**	**1.68**	**-**	**4.18**	~
		Evolution of filter species	**-**	**1.55**	**-**	**1.55**	✘
		Evolution of the surface damaged by anchoring	**-**	**1.89**	**-**	**1.89**	✘
		Decrease in whale watching	**-**	**1.62**	**-**	**1.62**	✘
		Number of impacts with sea mammals	**-**	**1.40**	**-**	**1.40**	✘
		Evolution in the surface erosion by divers	**2.50**	**2.17**	**-**	**4.67**	~
		Evolution in the surface erosion by the visitants influx	**-**	**1.91**	**-**	**1.91**	✘
		Changes in the coverture of the key elements	**-**	**1.97**	**-**	**1.97**	✘

SECTOR	TYPE	PARAMETERS	Data availability	Managers' evaluation	Statistical power	Final Value	Classification
		Changes in the water quality	**0.00**	**1.61**	-	**1.61**	✘
FISHING & TOURISM	**RESPONSES**	Total budget	**3.00**	**2.31**	-	**5.31**	~
		Surface of the MPA	**3.00**	**2.55**	-	**5.55**	~
		Zonning surface for each use	**3.00**	**2.46**	-	**5.46**	~
		Surface of integral reserve	**3.00**	**2.56**	-	**5.56**	~
		Number of improvement actions / year	**3.00**	**1.98**	-	**4.98**	~
		Budget for improvement actions / year	**3.00**	**2.03**	-	**5.03**	~
		Budget for participant organisms	**2.00**	**1.76**	-	**3.76**	~
		Budget invested in participation	**0.00**	**1.85**	-	**1.85**	✘
		Budget for investigation for each pressure	**3.00**	**2.17**	-	**5.17**	~
		Budget for anchoring points	**0.00**	**1.92**	-	**1.92**	✘
		Budget for research programs for divers	**3.00**	**1.91**	-	**4.91**	~
		Budget for management actions for divers	**3.00**	**1.90**	-	**4.90**	~
		Number of surveillance hours	**3.00**	**2.50**	-	**5.50**	~
		Number of people contracted	**3.00**	**2.26**	-	**5.26**	~

SECTOR	TYPE	PARAMETERS	Data availability	Managers' evaluation	Statistical power	Final Value	Classification
		Research budget	**3.00**	**2.21**	**-**	**5.21**	~
		Education budget	**3.00**	**2.09**	**-**	**5.09**	~
		Surveillance budget	**3.00**	**2.40**	**-**	**5.40**	~
		Educational programs	**3.00**	**1.91**	**-**	**4.91**	~
		Number of publications	**0.00**	**1.83**	**-**	**1.83**	✘
		Number of projects / year	**0.00**	**2.07**	**-**	**2.07**	✘
		Number of meetings between the actors	**2.00**	**1.63**	**-**	**3.63**	~
		Number of people working in the projects	**3.00**	**1.84**	**-**	**4.84**	~
		% of the total surface (MPA) limited for sport fishing	**3.00**	**2.54**	**-**	**5.54**	~
		Number of licences for sport fishing	**1.50**	**2.10**	**-**	**3.60**	~
		Number of licences for the different kinds of sport fishing	**1.50**	**2.05**	**-**	**3.55**	~
		Number of denounces for illegal fishing / divers / boats	**3.00**	**2.23**	**-**	**5.23**	~
		Number of actions done to became aware	**0.00**	**1.95**	**-**	**1.95**	✘
		Budget for waste programs	**0.00**	**2.09**	**-**	**2.09**	✘
		Number of anchoring points	**3.00**	**2.12**	**-**	**5.12**	~

SECTOR	TYPE	PARAMETERS	Data availability	Managers' evaluation	Statistical power	Final Value	Classification
		Budget for duties of management of anchoring points	**0.00**	**1.73**	**-**	**1.73**	✘
		Anchoring surveillance	**0.00**	**1.84**	**-**	**1.84**	✘
		Surface of diving areas proposed	**3.00**	**2.05**	**-**	**5.05**	~
		Number of anchoring points for diving	**3.00**	**2.26**	**-**	**5.26**	~
		Evolution of the diving quota	**3.00**	**2.28**	**-**	**5.28**	~
		Surface with restricted access for the visitant	**-**	**1.85**	**-**	**1.85**	✘
		Evolution on the number of coastal paths	**1.00**	**1.81**	**-**	**2.81**	✘
		Budget for improvement actions for coastal paths	**-**	**1.97**	**-**	**1.97**	✘
		Changes in laws and regulations	**3.00**	**2.01**	**-**	**5.01**	~

General Discussion

It is widespread the importance and effectiveness of marine protected areas (MPAs) and it is well demonstrated that they reduce the effects of over fishing of coastal marine stocks, preserve marine biodiversity, protect key habitats, increase the abundance of juveniles, and act as nurseries (Bell, 1983; Russ and Alcalá, 1998; Francour *et al.,* 2001; Halpern, 2003; García-Charton *et al.,* 2004) and ensure sustainable socioeconomic development for human communities (Sainsbury and Sumaila, 2003).. But though MPAs are functioning and accomplishing their objectives, they must be managed. MPAs nowadays are facing their most dangerous threat, how to be managed effectively.

Managing an MPA is an arduous task that must be done each day, and its decisions, guidelines and actions affect many stakeholders. Managers manage MPAs although they have to take on account stakeholders opinions. Along with increasing calls for more MPAs there are growing expectations for more effective management. Management in the MPA context usually includes attempts to "deal with issues of almost wholly human origin" (Walton and Bridgewater, 1996) and trying to ensure that human activities do not overwhelm the resilience of natural systems (Day *et al.,* 2002).

Worldwide there are increasing requirements for the evaluation of all management programs, and MPAs are no exception. Such evaluations need to demonstrate the effectiveness of management through evidence of results, rather than on the basis of educated guesses, "gut feelings", or assurances like "*trust us we are the experts*" (Jones, 2000). In recent years, governments have placed growing emphasis on outcome-based (rather than activity-based) performance reporting, which includes measure of performance in achieving objectives or targets (Day *et al.,* 2002). However these calls for accountability and evaluation need to recognise:

- The wide variety of MPAs set up to achieve differing purposes and objectives; and
- The issue that "one size certainly does not fit all" (e.g.: the approaches of managing and evaluating a multi-use MPA at the ecosystem level clearly differ markedly from those needed for small single purpose MPA) (Agardy *et al.,* 2003)- and even within a multi-use park there may need to be different strategies.

Evaluation is often viewed as an "optional extra"; good in theory but difficult in practice. Monitoring and evaluation programs, although supported in principle, often get displaced by more "urgent" (though often less important) day-to-day management activities. However, without evaluation against objectives, managers are "flying blind" and lacking the necessary evidence-based feedback to learn from, and improve upon, past management approaches (Jones, 2000).

There exists the need to develop tools to manage MPAs. One of the tools that are widely being developed are indicators. Indicators are increasingly being developed and used as management tools to address environmental issues (OECD 1991, OECD 1994, EEA 1999a,b). When they are used effectively, indicators are expected to reveal conditions and trends that help in development planning and decision making (Unluata, 1999). In this sense indicators can contribute to monitoring of the effectiveness of MPAs. But this search goes beyond the selection of a set of indicators to manage an MPA it search a set to globally manage MPAs.

The study of MPAs started since their creation. The evaluation of their effectiveness and the assessment of the protection effect has been developed using a short range of study subjects (see Bibliographic review). Variables like abundance, biomass, catch per unit effort (CPUE), species size or number of species have been widely studied. Also some species have been more considered than others. The number of objectives assessed is scarce (Jones 1994) being those studied mainly related with economical issues lacking those related with indirect effects or social effects. This research effort mainly focused in certain aspects demonstrates that the MPAs assessment lacks of research of certain parameters. This lack influences in management actions as they are not focusing in certain aspects. There exists some difficulties to study certain aspects in the marine environment but other issues can be covered easily. The lack of enough budget and the lack of definition of management objectives (Fig. 1) generate this type of gaps in research and management. It is important to assess the protection effect over different issues as well as is important how to measure this effect. The parameters researched must fulfil the necessities of an MPA. This issues must measure how has influenced in the habitats, species and the economical sectors the definition of the area as a protected area. Moreover this has to be measured over society especially the one that is directly affected by the establishment of an MPA. Define the desired key outcomes from a management plan is wished.

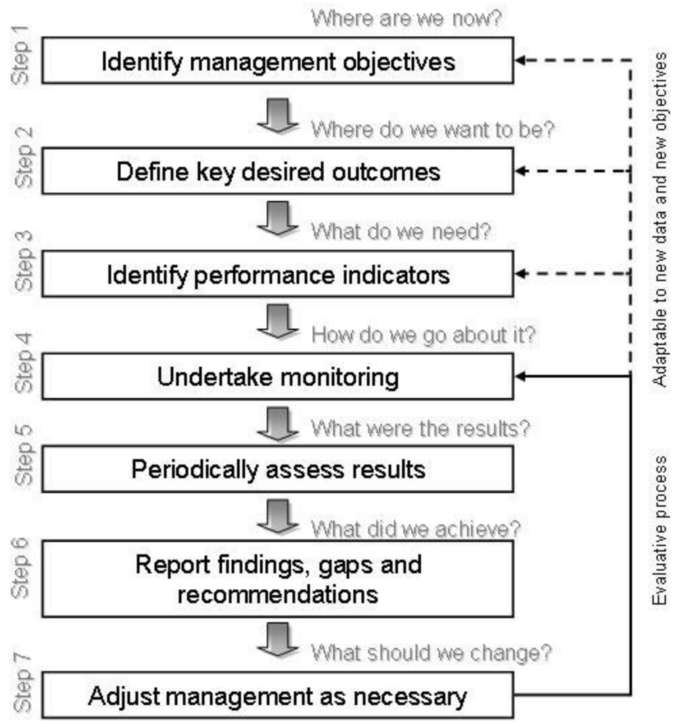

Figure 7.1. Framework to assess management in MPAs. The first and most fundamental, required for measuring performance is to set clear objectives. Form those a indicators selection must be done. Effectiveness is then measured through the process of monitoring and evaluation against those objectives, with the help of indicators. The evaluation needs to be an ongoing process and must be adaptable to incorporate new data as it becomes available, management cannot be static. Temporal series must be gathered as the process allows reorganization. Each of the seven management elements is clarified by simple key question. (Adapted from, Hockings *et al.,* 2000; Jones, 2000)

Environmental protection, especially in those subjects were biological conservation has to deal with society; protected areas, natural parks or national parks, and in our case MPAs, stakeholders must be consulted. In a perfect world, every MPA would have a management plan should be created by a diverse group of stakeholders that represent a variety of interests and preferences of how the MPA should be managed and how could be more successful. In this world not only it would be the management of the MPA but also the establishment and zonation of it. In addition, this ideal management plan would provide specific measurements of performance that could be used in analyzing a MPAs overall effectiveness and success and also between all of them would develop measures to assess the protection effect. The problem managers are facing is that usually have a pre-established handicap to manage, unfortunately, as in many cases around the world, MPAs usually have been created and settled under determinate political conditions. This makes that normally their establishment, their zoning or even their activities allowed and/or forbidden are due to political decisions far from being due to fishing, ecological or conservationist interests. So MPAs are functioning as isolated islands, not only because their ecological conditions but also because their political decisions, we are far from a MPA network if we continue like this. Due to this "hurry" to establish an MPA, usually there isn't enough time to do any stakeholder opinions' analysis this makes hard its management now. Reaching this point, were management of MPAs has to deal with politics and stakeholders, the aims are to combine efforts to develop methodologies and tools which will make easier the management. To develop successful MPA institutions, implementation, and achieve results, management objectives must be defined, targets set and evaluations done to monitor the overall achievement of those targets. Frequently, MPA governing bodies have taken on these responsibilities in their attempts at management. More often than not, however, managers fail to recognize and encompass stakeholder opinions in their attempt at realizing a successful MPA. Individual stakeholders in MPA management often exhibit conflicting needs and interests. Consequently, conflicting management objectives and points of view usually develop on how natural resources should be managed. These differences can allow stakeholders to work together to develop a unique definition of 'success' that may consider the economic, social, biological, or management components of performance, or perhaps a mixture therefore, and help managers improve MPA management. Much has been said about the importance to take on account the stockholder's opinions, and much has been done with them, many authors have discussed the importance of the role that stakeholders play in. Therefore, in order to achieve a well-rounded and well-performing MPA, managers must begin to recognize and incorporate these differences into management plans and interventions (Himes 2007). Therefore the identification of performance indicators should be selected through a participation process (Deliverable 19). From this participation processes must be defined and selected sets of parameters that covered all the aspects related with the protected area. This set must be evaluated to identify which should be the best indicators to assess the protection effects. There exist many studies (Salas *et al.,* 2006; Jørgensen *et al.,* 2005) that define indicators and the characteristic a good indicator must have but those defining indicators for management are scarce.

Future and current European directives like the Marine Strategy Directive (MSD) and the Water Framework Directive (WFD) respectively, constrain to define the ecosystem to protect and conserve through the definition and application of indicators. Gathering data to apply indicators does not mean always to sample new data it is even more effective and with a less cost-effect to gather data that was already collected. The utility of these tools remains latent as is the society the administration and the scientific community prepared to use these tools. In many countries (e.g.: United Kingdom and Australia) technical reports are developed to assess the status of their ecological areas, also MPAs. Society receives reports with indicators adapted to their knowledge to know the state of their natural resources.

Between many of the characteristics an indicator must have, one of them is their availability. If there is no data gathered or gathering data implies many difficulties it is not worthwhile to use this parameter as an indicator. The administration is not prepared to assume this responsibility. The administration should have different types of data but the process to gather these data is difficult (see contents on assessment on availability institutional data). When data are available, after being waiting for an answer, they usually do not have the quality desired. Data series are not temporal, and if they are they usually present series with a lack of continuity with periods of time without data. Data usually are highly aggregated, due to this to apply this data to the assessment of protection of local MPAs is difficult due to their magnitude. The administration does not offer any type of facilities to obtain any type of data. Find computerized data is really difficult and to find it requires going deeply into long technical reports, where also data is highly aggregated. Tourism administrations are more efficient and the availability of data is easy and quicker. Natural resources and fisheries administration are really slow and there exist many difficulties to accede to data. By other hand the association of fisheries in brotherhoods, private entities, generates great difficulties to obtain data form this source. Although the administration gathers some type of data, there are numerous lacks of information of data ease to gather that are not colleted (e.g.: mooring points). There is a lack of investment to establish following up programs and sampling protocols to manage. There exists a need to implement this type of programs as European Directives like the actual WFD or the future MDS require the member countries to establish a control plan for which as much as possible data series are needed. Nowadays there exist complications in the implementation of MSD (Marine Strategy Directive) as significant information gaps have been found (Borja, 2006;

Salomon, 2006). The administration is not prepared to apply the European directives therefore to apply indicators.

But not only is the administration not qualified to apply indicators. The scientific community that normally uses indicators and indexes has also data deficiencies. Their studies are mainly focused in certain issues that can be classified as States or Impacts and certain habitats or species. Studies are mainly short term or punctual, mainly due to the lack of budget and resources. But also due to a hypothetical-deductive opinion that lacks of temporal monitoring to be able to research trends. Few parameters are studied and there exist numerous gaps that do not facilitate temporal and/or spatial comparisons at bigger scales. The incorporation of temporal replications in the experimental design are important due protection differences caused by other variability issues. But it is difficult to establish a suitable temporal design (especially at local and regional scales, due to the effort required) (Forcada, 2007). Assuming that annual samplings can be representative (Harmelin 1987; Harmelin *et al.*, 1995), long temporal series are desiderated to assess the effects of protection in MPAs (Ojeda-Martinez *et al.*, 2007). Few authors validate their indicators and models (for review see Appendix I) generating very specific indicators. Nevertheless the search of a set of indicators to assess the protection effects on MPAs does not result effective due to the structural characteristics of habitats, populations and species. Even the structural characteristics of each MPAs generate a big dispersion among the data resulting in diffuse conclusions (see statistical assessment).

However managers seem to demand indicators as tools to help them to manage. Although there are being developed it is necessary to evaluate if managers are prepared to support their use and application. Managers search for Driving Force and Response indicators as they understand them easily (see knowledge based evaluation by managers). However due to their consistency some parameters like abundance, biomass and CPUE, are well evaluated by managers. This contradiction is due to the necessity of tools easy to apply and understand. However managers demand the search and gathering of this type of indicators although they have available the possibility to gather them by their own (e.g.: number of visitants to the MPA). But managers keep on measuring to assess the protection with the parameters widely used by the scientific community that they apply on the assumption that they are the best as they are widely used by the scientists. Due to the costs and lack of means to develop monitoring there is a lack long series of temporal data. The increase in co-operation between academic world, managers and governmental services is required to develop management tools to monitoring, modelling and evaluating the quality of MPAs. The government has the final decision, but the academic community can design the appropriate monitoring programs and data interpretation (Jonge, 2007). This collaboration should make strategies and develop protocols on data collection to accomplish the requirements of EU Directives.

Different methodological approaches exist on indicators selection. One of them is merely statistical were sampled data is applied through biodiversity indicators and indexes and selection of new ones. The other is based on conceptual frameworks that help to identify parameters to apply them to management. Through this work an attempt to work with both methodological approaches has been done. Indicators selection it should not be based in the application of one or the other methodology it should be a combination of both. When natural resources, in this case MPAs, are managed, the definition of objectives must be the first task. To assess the effectiveness of the area and therefore the objectives proposed it is significant the selection of a set of parameters to help in the results assessment. The pressures over the resources the cause-effects relation in the area must be considered to define this set of parameters to help in the definition of solutions. Once defined through conceptual frameworks based in active participation processes, sampling protocols must be defined to develop appropriate monitoring to gather temporal data. The validation of both models is needed to keep an ongoing process active. This will make the management model more efficient as gaps and trends will be detected. This has been applied through this dissertation. The lack of long temporal series and the specificity of the data had difficult the process. To achieve this aim a more active communication between administrations, scientist and managers is needed.

Through this work some parameters from those previously defined have been selected as indicators. The combination of several evaluations seemed to be useful to identify the best indicator as they had to be assessed by three methodologies. We can conclude that the selection of indicators as tools to assess the effects of protection is necessary. Although there does not exist a universal indicator to assess the protection effects of MPAs, because this areas have different ecological and structural characteristics, which generates high data heterogeneity. To resolve this, protocols to gather, sample and analysis data must be developed, to homogenize data, and allow the comparison among different areas. Samplings to obtain long temporal series must be established. Even though marine protected areas had been studied since they first were established there is too much work to be done to assess effectively the protection effects with management tools.

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