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GUIDELINES AND RECOMMENDATIONS FOR THE DEVELOPMENT OF THE MANAGEMENT AND MONITORING PLANS OF THE POTENTIAL SPECIAL AREA OF CONSERVATION OF BANCO DE LA CONCEPCIÓN

José María Fernández-Palacios

Pablo Martín-Sosa

Sebastián Jiménez

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No data can be taken out of this work without prior approval of the thesis promoter / supervisor
I hereby confirm that I have independently composed this Master thesis and that no other than the indicated aid and sources have been used. This work has not been presented to any other examination board

Jose María Fernández-Palacios Rodríguez
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ACRONYMS INDEX

AHP: Analytic Hierarchy Process
CI: Consistency Index
CR: Consistency Ratio
DPSIR: Driver-Pressure-State-Impact-Response
FCS: Favourable Conservation Status
GES: Good Environmental Status
GPV: Global Priority Vector
HD: Habitats Directive
MCDA: Multicriteria Decision Analysis
MPA: Marine Protected Area
MSFD: Marine Strategy Framework Directive
PV: Priority Vector
SAC: Special Area of Conservation
SCI: Site of Community Interest
SPA: Special Protection Area

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FOREWORD

This master thesis was carried out in the Canary Islands Centre of the Spanish Oceanographic Institute (*Instituto Español de Ocenaografía* (IEO) in Spanish), which is the Spanish institution responsible for the extension of the Marine Natura 2000 network. In this context, the thesis presented here responds to a real necessity, which is the management plan drawing-up for the conservation of a marine protected area. For that reason, this thesis is located in the interface between the environmental, socio-economic and governance ambits.

EXECUTIVE SUMMARY

The monitoring plan of a Marine Protected Area (MPA) is a fundamental element within its management plan, being designed for meeting the requirements of the site, as well as controlling and informing about the processes affecting the system analysed. Despite its importance, several deficiencies have been found in the monitoring and management plans of the Special Areas of Conservation (SACs) of the Macaronesian Region within Natura 2000 network. One of these shortfalls deals with the indicators selected.

Taking advantage of the need of producing a management plan for upgrading the Banco de La Concepción to a SAC, a methodology able to deal with this issue and to generate the necessary guidelines and recommendations on which the management plan can be based, has been set up.

Banco de La Concepción is an offshore seamount located in the Macaronesian biogeographical region, characterized by being a spot of high productivity and biodiversity within a more oligotrophic environment. Among the communities and species existing there we can highlight the presence of reef communities considered a priority habitat and included in the Annex I of the European Habitats Directive as sensitive habitat, as well as the presence of the loggerhead sea turtle (*Caretta caretta*) and the bottlenose dolphin (*Tursiops truncatus)*, both sensitive species included in the Annex II of the same directive.

The methods used have been various including: i) the development of a driver-pressure-state-impacts-response (DPSIR) conceptual model, with the aim of determining the elements affecting the MPA for selecting a suitable list of indicators, ii) the Delphi method for incorporating the experts' opinion, and iii) the implementation of a Multicriteria-Decision-Analysis (MCDA) approach, specifically the Analytical-Hierarchy-Process (AHP) for determining the suitability of the indicators for the evaluated system, thus generating a novel methodological combination used for the first time in a Spain for MPA evaluation.

The results obtained highlight the suitability of 18 indicators from 144 initially detected, divided within four groups considered (driving forces, pressures, state/impact and responses). Among them "Fishing effort", "Catch per unit effort", "Extent of Habitats/Communities" and "Existence and adoption of a monitoring plan" stand out as the more appropriate for each group regarding the Banco de La Concepción monitoring.

Finally, the advices given by the project INDEMARES have been followed and an alternative methodology able to perform in a transparent way the selection of indicators for the Spanish marine SACs management plans, which they currently lack, has been developed.

ABSTRACT

Banco de La Concepción, included in the Natura 2000 network in 2014 is pending on the drawing up and approval of a management plan for being upgraded to a Special Conservation Area. For facilitating this, appropriate guidelines on which the management plan can be based will be advanced here.

Efforts will be put on defining objectives of this site's future management plan and selecting indicators able to monitor them. However, selecting indicators that adequately fit with ecological attributes of complex ecosystems and to the objectives of their management plan is a daunting challenge. For this case a driver-state-impacts-response (DPSIR) framework was used to determine elements affecting the marine protected area (MPA) and to select a suitable indicators' list. Moreover a Multicriteria-Decision-Analysis (MCDA) was used to determine the most appropriate ones. Concretely, a Delphi method together with an analytical-hierarchy-process (AHP) were used to select and prioritize 18 indicators from 144 candidates.

The methods and results of this study intend to streamline the MPA management plan's design and its subsequent put-into-practice process so that Banco de La Concepción SAC, more than a paper-MPA, turns into a real protected area where biodiversity protection and local artisanal economic activities can meet and reconcile.

KEYWORDS: AHP, Banco de La Concepción, DPSIR framework, indicators suitability Marine protected areas, management, Natura 2000 network.

CHAPTER 1. INTRODUCTION & AIM

1.1 Legislative and historical project frame

1.1.1 Habitats Directive and Natura 2000 Network

The increase of concern of the European Union as a consequence of the progressive biodiversity loss led in 1992 to the creation of a common legislative framework (Directive 92/43/CEE) which pretended to protect and conserve the endangered EU habitats and species. Over the years this framework evolved and was consolidated in 2009 as the current Habitats Directive (Directive 2009/147/CE). Together with the Birds Directive, developed in 1979 (Directive 79/409/CEE), both constitute the main instrument to battle against European biodiversity loss. The main consequence of their application has been the creation of the Natura 2000 network through the European territories.

Based on the fact that the conservation of natural habitats is fundamental for the maintenance of species and populations (Meffe and Carroll, 1997, Duarte *et al*, 2016), this network conformed by Special Protection Areas (SPAs), Sites of Community Importance (SCIs) and Special Areas of Conservation (SACs) aims to assure the long-term survival of most valuable and threatened habitats and species by guaranteeing the maintenance and/or reestablishment of their favourable conservation status (FCS) (Box 1.1). The achievement of this goal will come from the hand of the proper protection and management of a sufficiently representative surface of the sites hosting them (CEU, 2007).

BOX 1.1- Favourable Conservation Status in the HD (CEU, 2007, Article 1 of HD).

The main objective of the Habitats Directive is to ensure that the habitats and species covered by it, reach what is called as "favourable conservation status" (FCS) in order to guarantee their long-term survival across their entire natural range within Europe.

In case of habitats, FCS is achieved when:

- *The natural range and the areas it covers within that range are stable or increasing.*
- *The specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue existing for the foreseeable future.*
- *The conservation status of its typical species is favourable (as defined for species).*

In case of species, FCS is achieved when:

- *Population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitat.*
- *The natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future.*
- *There is and will probably continue to be a sufficient large habitat to maintain its population on a long term basis.*

All in all, the Habitats Directive includes over 230 habitat types and around 1.000 animal and plant species. Both protected habitats and species are listed in four annexes, applying a different degree of protection for each one (Box 1.2)

BOX 1.2- HD regime protection depending by Annex (EC, 2007)

Annex I (over 230 habitats): *Natural habitat types of community interest whose conservation requires the designation of SACs and inclusion in the Natura 2000 network.*

Annex II (about 900 species): *Core areas of the natural habitat of these plant and animal species are designated as SACs and included in the Natura 2000 network. These sites must be managed in accordance with the ecological needs of the species.*

Annex IV (over 400 species, including many of Annex II): *A strict protection regime must be applied across their entire natural range within the EU, both within and outside the Natura 2000 sites.*

Annex V *Species of community interest whose taking in the wild and exploitation may be subject to management measures.*

Annex VI (over 90 species): *Member states must ensure that their exploitation and taking in the wild is compatible with maintaining them in a favourable conservation status.*

Currently, according to the European Environmental Agency (EEA) Natura 2000 Network database (2015), around 1.1 Million km^2 of European territory are included in 27,000 protected areas, covering 0.8 M km^2 terrestrial territory and around 0.3 M km^2 of marine surface. The difference between terrestrial and marine realms highlights significant deficiencies in the marine environment protection.

This dearth is accentuated in countries with a wide maritime extension, as is the case of Spain. In spite of being the member state with more terrestrial surface declared as Natura 2000 network (27% of the national territory) (EEA Database, 2015),until year 2013, just 1% of Spanish marine waters were represented in this network (WWF, 2012). These values give an idea of how unbalanced the Natura 2000 network was in this country, specially taking into account that it is the European country that harbors the largest biodiversity in its waters and seabeds (WWF, 2012).

1.1.2 Project Life + INDEMARES

The evident delay in the designation of marine protected sites, plus a negative assessment by the European Commission for the three biogeographic regions surrounding Spain (Mediterranean, Atlantic and Macaronesian), confirmed that the Natura 2000 Network is a pending subject at a national level, largely due to lack of scientific knowledge of these areas, highlighting the urgent need of solutions (WWF/Adena, 2014).

With the aim of seriously responding to these knowledge lacks and to ensure the future survival of habitats and species of European interest, the project Life + INDEMARES ("Inventory and Designation of Natura 2000 Network in Spanish Marine Waters"), was launched by the Spanish Government in 2009, having as ultimate goal to investigate and publicize the natural and socioeconomics values of the Spanish waters in order to complete the Natura 2000 Network in the marine environment (MAGRAMA, 2013)

The project, which lasted 6 years (2009-2014), was a major breakthrough in the marine biodiversity protection, suggesting the inclusion of 10 SCIs and 39 SPA previously studied and characterized in the Natura 2000 web (MAGRAMA, 2013). Furthermore, within the project frame, management guidelines for the selected areas based in the scientific results and socio-economical studies, regarding their future inclusion in the network, were developed.

These sites were finally included in the network by the European Commission that has meant a contribution of more than 7 million ha to the Spanish Natura 2000 network, increasing it up to 8% of protected marine areas, including offshore marine areas for the first time (Fig. 1.1) (WWF/Adena, 2014).

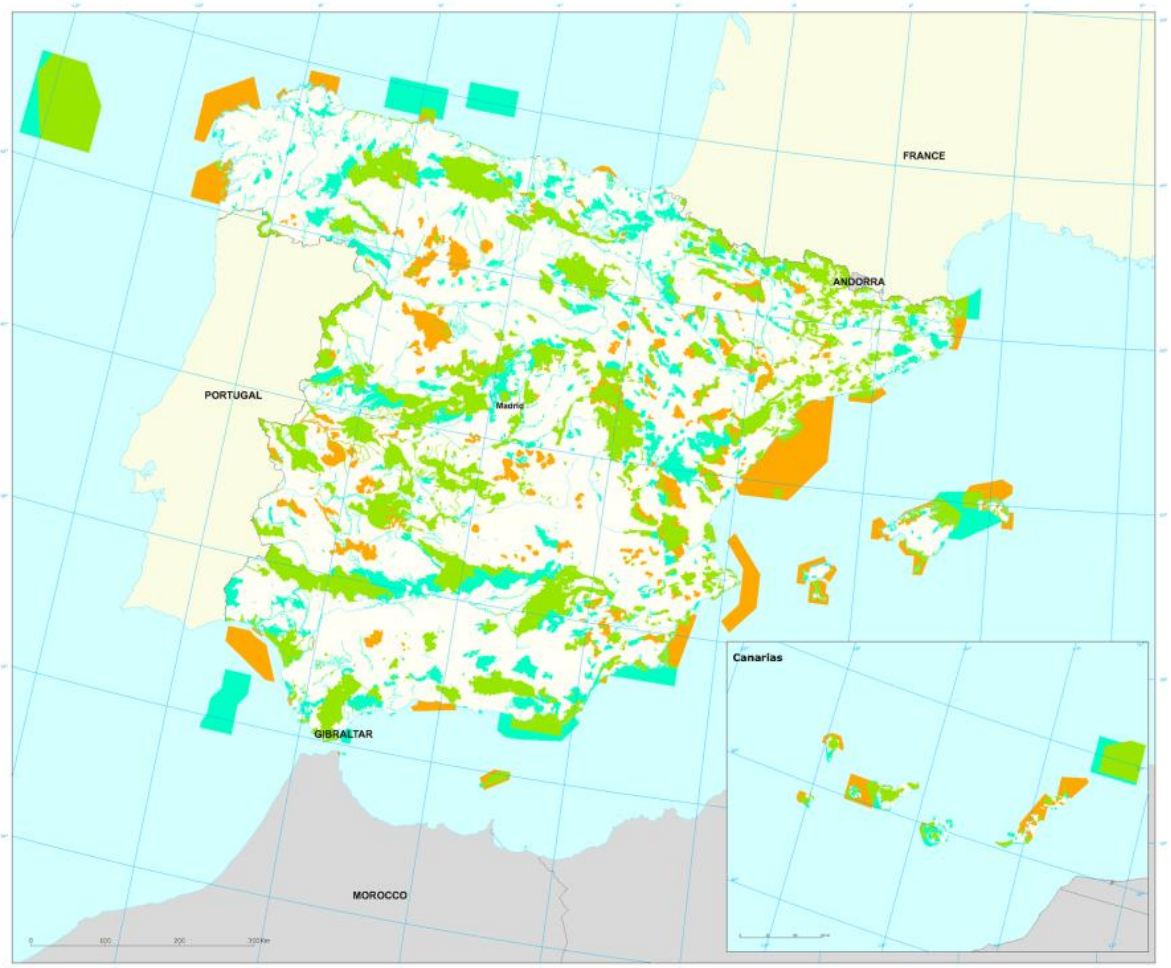

Figure 1.1: Natura 2000 Network in Spain with Birds Directive sites SPAs (Orange), Habitats Directive sites pSCIs, SCIs, SACs (Blue) and sites proposed and designated under both directives (Green). **Source**: EEA, Natura 2000 Network database, 2015.

1.2 Marine Natura 2000 network designation under the Habitats Directive

1.2.1- Site of Community Importance preselection and designation

As was already said, the results of the project, although tremendously remarkable, were only the first step of a much more long and complex designation process. The incorporation of areas to the Natura 2000 network is ruled by a selection process common to all the EU members, according to what was established in the HD, in which three different administrative steps can be clearly distinguished (Fig. 1.2).

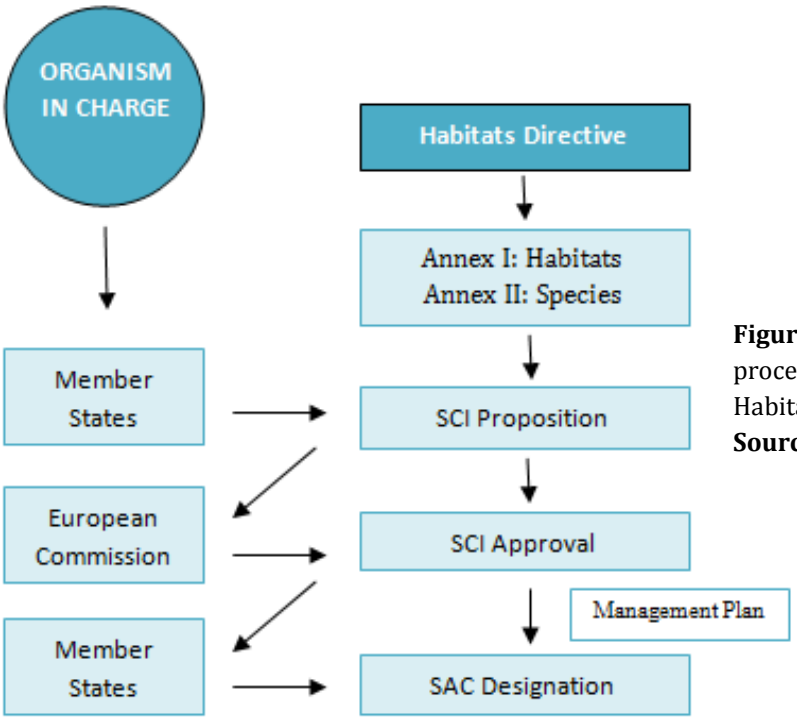

Figure 1.2: Designation process of SACs under Habitats Directive. **Source**: WWF, 2012.

The first of those steps demands that each member state suggests a SCI candidate list, based in a previous elaboration of habitats and species inventories. The selection should be done considering the evaluation criteria stipulated by the HD, such as areas warranting protection for priority habitats and species, those included in HD Annexes I and II (Table 1.1). Life + INDEMARES was a keystone step in the development and consecution of such endeavor, producing a national list of 10 SCI candidates.

Marine and Coastal Habitats (Annex I)		Marine Species (Annex II)	
Code	**Description**	**Code**	**Description**
1110	Sandbanks slightly covered by sea water all the time	1124	*Caretta caretta*
1120	Posidonia beds (*Posidonion oceanicae*)	1227	*Chelonia mydas*
1130	Estuaries	1349	*Tursiops truncatus*
1140	Mudflats and sandflats not covered by seawater at low tide	1351	*Phocoena phocoena*
1150	Coastal lagoons	1366	*Monachus monachus*
1160	Large shallow inlets and bays	1095	*Petromyzon marinus*
1170	Reefs	1101	*Acipenser sturio*
1180	Submarine structures made by leaking gases	1102	*Alosa alosa*
8330	Submerged or partially submerged sea caves	1103	*Alosa fallax*

Table 1.1 Natural marine habitat types of HD Annex I and marine species included in HD Annex II occurring in Spain. **Source**: WWF/Adena, 2014.

The second step is the evaluation and approval by the European Commission of the list submitted by the member states. Once accepted, the selected sites become part of the Natura 2000 network as SIC. This step entails the adoption of protection measures and the obligation of the member states to declare their SCIs as SACs as soon as possible.

1.2.2 From Site of Community Importance to Special Area of Conservarion

The third and last step to complete the incorporation of a protected area to the Natura 2000 web is the declaration as SAC of the SCI designated. This declaration should occur in a maximum time lapse of six years after the SCI designation, otherwise the European Commission will penalize the member state due to the delay. During this period the member state has to establish priorities responding to the ecological exigencies of each concrete site, in order to achieve the proper conservation objectives considering the threats and degree of deterioration of the area being protected.

INDEMARES SCIs		
Name	**Surface (ha)**	**Biogeographical Region**
Banco de Galicia	1.0230.512	Atlantic
Submarine canyons system of Avilés	339.026	Atlantic
Mud volcanoes of Cádiz Gulf	317.724	Atlantic
Banco de La Concepción	610.067	Macaronesian
Eastern and south maritime space of Lanzarote-Fuerteventura	1296.532	Macaronesian
Western submarine canyons system of León Gulf	98.768	Mediterranean
Maritime space of Illes Columbretes	1.277	Mediterranean
Menorca Channel	335.354	Mediterranean
South Almería – Seco de los Olivos	282.922	Mediterranean
Maritime space of Alborán	10.888	Mediterranean
Total	4.318.174	

Table 1.2: SCI designed after INDEMARES project, **Source**: Modified from WWF/Adena, 2014.

This will be achieved through the drawing-up and approval of proper management plans, focused to the maintenance or recovery of the FCS. Each management plan should count with specific measurements for each of the natural values present and has as well to be able to integrate all the socio-economic parts implicated in the use of the area to be protected.

Once the management plan is drafted, it has to be approved by the member state central administration and then, if this is the case, the space will be officially incorporated as a SAC to the Natura 2000 network. This transition from SCI to SAC coincides with the current situation of the candidate areas proposed by the INDEMARES project (Table 1.2). After their designation as SCI by the European Commission, a time lapse of six years (by the end of 2020) was given to Spain for developing a specific management plan for each area.

1.3 Managing a Special Area of Conservation

1.3.1- Need of guidelines

As seen previously, HD states clearly the need of an appropriate and specifically designed management plan for upgrading SCI to SAC. The development and implantation of a proper management plan will be determinant for the SAC's future (WWF, 2012).

These plans will constitute the main tool for achieving the conservation objectives and their application has to be done resting in a strong scientific and technical base. Nevertheless, despite the remarkable importance of this tool, the European Commission will be not involved in this step, as for instance it was with the SCIs selection, so that now each member state will be the unique responsible of their approval.

A consequence of this particularity is the creation of very different management plans, not only among the different EU state members, but also within the same state, because this will depend basically on the administration (i.e. central, regional, insular, local) responsible for developing it. However, very likely due to this fact, the European Commission does actually participate with the development of guidelines, mainly focusing the plan content and structure (Box 1.3), the objectives formulation, the participation procedures and monitoring and finally, the evaluation of the sites. Although those recommendations are not compulsory, they pretend to facilitate the plan's elaboration to the different competent administrations.

BOX 1.3- Content of Natura 2000 Management Plan (Kruk *et al*, 2010)

1. Description of the site, including reasons for selection.
2. Map, location, boundaries and administrative distribution (GIS).
3. Socioeconomic situation, history and uses.
4. Description of the natural values.
5. Description of cultural history and archaeology.
6. Designation of administrative responsibilities and obligations.
7. Current status Natura 2000 habitats and species present at the site and identification of pressures and threats.
8. Conservation objectives.
9. Management measures to meet objectives.
10. Allowed/forbidden activities, good practices.
11. Monitoring plan and review data collection.
12. Stakeholder engagement plan, list and members of managing board.
13. Surveillance Plan
14. Funding and work plan
15. Update, outcomes, reports and briefing.

Turning back to the Spanish situation, despite the publication of the guidelines for the few SACs designated prior to the INDEMARES project, there are remarkable deficiencies in their marine management plans (inventory insufficiencies, indicators of conservation status and target species insufficiencies, socio-economic characterization of the SACs, and some management measures among others) (WWF, 2012) so that the need of their replacement has been currently recognized.

With the aim of avoiding the same error again, within the INDEMARES project several workshops have been organized calling for a coordinated and coherent management of the Spanish SACs, advocating for an innovative, realistic and integrative approach. For achieving this, it will be indispensable the application of appropriate and specific management instruments to the designated areas able to integrate all the stakeholders involved (WWF/ Adena, 2014.).

The guidelines that emerged from these workshops especially stress the transcendence of the objectives' role within a management plan as well as the utilization of proper tools able to quantify the degree of those objectives' accomplishment (WWF, 2012).

As these guidelines point clearly, the key element of a management plan is its objectives. Actually, it can be clearly observed how the elements of a SAC management plan, beyond the descriptive issues, swing clearly directly (points 6, 8, 9, 11 and 14 of Box 1.3) or indirectly (12 and 13 of Box 1.3) around the formulated objectives.

Thus, their definition has to be a conscientious task that will mark the rest of the plan. In general such objectives have to be realistic, coherent among each other, and explicit in the sense that they give no room for interpretation (Kruk *et al*, 2010). Furthermore, they have to be integrative, both in the sense of integrating all the stakeholders' interests involved as well as of integrating all the existing different legislation (Kruk *et al*, 2012).

In relation to the tools to be used for quantifying the objectives' accomplishment, the indicators emerged as the proper elements for doing this task, and they should be framed within a monitoring plan inside the management plan (Pomeroy *et al*, 2004).

1.3.2 The importance of the indicators

Considering that an effective management requires the continuous feedback of information to achieve its objectives (Pomeroy, 2004), the indicators emerge as the proper quantitative or qualitative parameters able to proportionate the kind of information needed about the conditions of and the processes occurring in the territory, community or ecosystems involved (Fernández-Palacios, 2016). The importance of counting with the proper indicators is due to the necessity of providing the managers a tool that presents concisely and representatively specific information about a matter of concern that can easily be understood and used (Fernández-Palacios, 2016).

Following Gallopin (1997) a good indicator has to be able to:

- evaluate conditions and trends
- compare different sites and situations
- know the degree of objectives accomplishment
- provide early warning information
- anticipate conditions and future trends

That way the indicators panels or systems, where a selection of indicators able to monitor ecosystem components changes is collected, have the function of i) reducing the enormous volume of scientific and technical information available to manageable sizes, and ii) allowing the technicians and policy makers to take decisions based in accurate scientific knowledge (Jennings, 2005).

However, conforming an indicators' panel adequately representing the system to be evaluated is a challenging task, where it is necessary to apply a transparent process of decision-making that justifies the obtained results. Throughout this thesis we will deal with such a process.

1.4 Integrated management: Linkage between the Habitats and the Marine Strategy Framework Directive

1.4.1 The Marine Strategy Framework Directive

Adopted in 2008, the Marine Strategy Framework Directive (MSDF 2008/56/EC) aims to achieve or maintain Good Environmental Status (GES) (Box 1.4) of the EU's marine waters by 2020. The purpose of the Directive is "to protect, preserve, prevent deterioration or, where practical, restore Europe's oceans and seas where they have been adversely affected and to prevent and reduce inputs in the marine environment" (Art 1.2(a) & (b)). This should be achieved applying an ecosystem-based approach able to manage human activities while ensuring a sustainable use of marine goods and services (EC, 2008).

In order to achieve GES by 2020, each member state is required to develop a strategy for its marine waters. Steps by each member state to follow are (EC, 2008):

- Initial assessment of the current environmental status of national marine waters and the environmental impact and socio-economic analysis of human activities in these waters.
- Determination of what GES means for each national marine waters.
- Establishment of environmental targets and their associated indicators to achieve GES.
- Establishment of a monitoring programme for the ongoing assessment and the regular update of targets
- Development of a programme of measures designed to achieve or maintain GES.
- Review, reporting and preparation of a second cycle.

BOX 1.4- Definition of Good Environmental Status (EC, 2008):

"'Good environmental status' means the environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive within their intrinsic conditions, and the use of the marine environment is at a level that is sustainable, thus safeguarding the potential for uses and activities by current and future generation."

The GES shall be determined on the basis of the descriptors developed in MSDF Annex I (Box 1.5).

BOX 1.5- Qualitative descriptors for determining the Good Environmental Status (EC, 2008)

(1) *Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions.*
(2) *Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems.*
(3) *Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.*
(4) *All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.*
(5) *Human-induced eutrophication is minimized, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters.*
(6) *Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular are not adversely affected.*
(7) *Permanent alternation of hydrographical conditions does not adversely affect marine ecosystems.*
(8) *Concentrations of contaminants are at levels not giving rise to pollution effects.*
(9) *Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards.*
(10)*Properties and quantities of marine litter do not cause harm to the coastal and marine environment.*
(11)*Introduction of energy, including under water noise, is at levels that do not adversely affect the marine environment.*

1.4.2 Connecting links between Habitats Directive and Marine Strategy Framework Directive

As was explained in section 1.1.1, the aim of the HD is the achievement of a FCS.

Once the general objectives of both directives have been described and the most important issues were brought to light, now we will proceed to highlight their connections. From a general point of view we can start comparing both directives' ultimate goals. MSDF argues for the consecution of a GES, whereas HD for the consecution of a FCS for habitats and species.

Both at an application as well as at a conceptual level, certain similarities can be found in both directives. Focusing on the way both directives should be implemented the similarities are reasonably clear. The principal aim of both directives is to achieve an appropriate conservation level of the different ecosystem attributes, which are defined previously by means of descriptors. Both directives are not only focused on the protection, maintenance and management of their target areas, but they recommend recovery or restoration actions when needed, and in case of lack of relevant information both directives consider the precautionary approach (EC, 2012).

From a conceptual perspective GES and FCS, which are defined in a different way, are not necessarily equivalent, but can be mutually supportive. Thus the implementation of the HD and a step towards the FCS of habitats and species of community interest should make an important contribution for the achievement or maintenance of the GES in European marine waters and vice versa (EC, 2012).

Actually one of the specific elements of the MFSD measurements programme is "achieving a complete protected marine areas network, ecologically representative and

well managed", concretely mentioning the importance of the Natura 2000 web (Article 13(4) MSFD). Thus the consecution of a regional or sub-regional GES will be favoured not only by the benefits that protected marine areas granted to their surrounding waters (Chaigneau *et al* 2016), but also due to the fact that some measurements taken under the HD are implemented outside Natura 2000 sites for avoiding the degradation of the features within SACs.

Moreover, reciprocally the implementation of MSFD measures can help to ensure that Natura 2000 network is not compromised by degradation taking place outsides of protected areas (EC, 2012).

Other encompassed linkages come from the hand of application regions and reporting periods. The nine biogeographical areas identified by both directives, with the aim of facilitating the evaluation and reporting, coincide (with the exception of the Macaronesian region which is considered as a subregion within the Atlantic Region in the MSFD and as a full region in the HD). This will enable a comparison within the objectives achievement among both directives, facilitating a cross-evaluation (EC, 2012). Besides, the reporting time scale has been streamlined between both of them, being scheduled every six years, what will facilitate the evaluations as well (EC, 2012).

An element to highlight that could be seen a priori as antagonist is the approaches in which both directives are based. The MSFD is based in an ecosystem approach; it focuses on the ecosystem as a whole, having thus a much broader material scope (EC, 2012). However HD "just" focus on the conservation of particular habitats and species compared with the MSFD, utilizing the classic single species approach.

Nevertheless, this difference is more important in theory because in practice both habitats and species protected by the HD act as umbrella species, that way warranting not just their direct conservation but indirectly the conservation of other habitats and species no mentioned in the HD (EC, 2012). This issue will be especially stressed with migrant species, which will interact with a great range of habitats. This characteristic bridges the gap among both directives.

In conclusion, we can notice that between both directives more than a linkage exists. Concretely, their ultimate goals are mutually supportive, as well as the relation existing between reporting time scale and regions, and finally, under a different approach, both directives cover the ecosystem attributes.

1.4.3 The support of Habitats Directive' conservation objectives to Marine Stategy Framework D irective targets.

Once we have clarified the more general linkages between both directives, the relation among specific objectives, targets and measurements developed for the fulfillment of each directive ultimate goal will be studied.

Apart from the differences on application areas (Natura 2000 sites and surroundings vs. whole demarcation regions) some of the targets defined by GES descriptors will be similar or will try to obtain the same results of the specific aims developed by HD (EC, 2012). Logically, as the GES consecution is a much broader objective than a FCS, there will be no overlap for all the descriptors, and for those that this may be the case, it can be just partial.

This overlap will occur both to targets focused on the ecosystem state and impacts, as well as to targets focused on pressures. For instance, a clear overlap will take place between the specific objectives of achieving the FCS and the descriptor nº 1 "Biological Diversity" of GES. As can be observed in the next Box 1.6, the criteria used to define both of them, although different, are directly comparable among them:

BOX 1.6-Example of overlapping criteria for the consecution of FCS for species and habitats, as well as criteria for the achievement of descriptor Nº 1 "Biological diversity" (EC, 2008, Article 17 of HD & Annex I MSFD)

Favourable Conservation Status	Biological Diversity
a) Species: • Population dynamics • Range • Habitat suitability	a) Species: • Range & patterns • Population size • Population conditions (size-age structure, sex ratio, genetic structure, etc)
b) Habitats: • Range & area • Specific structure & function • Typical species at favourable conservation status (feedback)	b) Habitats: • Range & pattern • Area & volume • Typical species condition c) Ecosystem: • Composition and relative proportions (habitats & species)

Furthermore, other possible elements where overlapping exists are the descriptors focused on foodweb (D. 4) and seafloor integrity (D.6).

Meanwhile, in relation to pressure descriptors, a certain overlap can be distinguished as well. Basically all pressures that are able to affect habitats and species of community interest are regulated by HD and obviously by the MSFD. This overlap affects descriptors 5 (Human induced eutrophication), 7 (Alteration of hydrographical conditions), 8 (Pollutants), 10 (Marine litter) and 11 (Introduction of energy).

In summary, achieving FCS will cover at least a proportion of the MSFD targets. Nevertheless, achieving GES will likely require additional substantive measures outside and inside the Natura 2000 network, but is the existence of these overlaps between objectives of both directives what should facilitate and encourage the creation of combined or integrated monitoring programs that could help to support the implementation of both directives.

1.4.4 Good Environmental Status situation at Canary Islands demarcation and integration opportunity

Once at this point, the arguments aforementioned open the possibility of creating an integrated management plan within both directives as long as the situation requires and the funding permits.

Focusing on the case of the Canary Island demarcation (Macaronesian biogeographical region), the current situation is highlighted by the failure at establishing baseline levels, assessing the current environmental status or defining GES for the developed descriptors (MS, 2012). This has been mainly due to limitations of historical data series' existence that prevent following the evolution of the ecosystem attributes state (MAGRAMA, 2012d).

This lack of information about the meaning of GES for Canary Islands marine waters prevents considering clear status objectives, appealing to pressure objectives based most of them on the precautionary approach and operative objectives related with knowledge improvement and data availability (MAGRAMA, 2012d). This urgent need of information gives us one more reason to create integrated management programs for SACs. These programs should contain not only the conservation objectives for achieving FCS, which will already take into account GES overlapped targets, but also secondary objectives involved in defining GES.

A practical and economical way to achieve the goals proposed in the plan will be through a common monitoring program, which will incorporate indicators not only able to assess the FCS of habitats and species, but also to provide useful information and data series to move towards the GES of the Canary Islands demarcation.

To finalize this section, it is important to highlight the fact that by acting this way, the future SACs will play a role in obtaining useful information about the attributes of the ecosystem that will help to implant a GES in a region that is far away of meeting the deadlines established by the EU Commission and currently has not even determined a GES for its marine waters (MAGRAMA, 2012d).

1.5 Thesis aims

One of the SCIs designated according to the INDEMARES project research has been Banco de La Concepción (Concepción Seamount), located northeast of the Canaries in the Macaronesian biogeographical region within Spanish territorial waters. This SCI is nowadays within the 6-year period conceived by the European Commission for being upgraded into a SAC.

Its management plan is currently in an early state of accomplishment (Table 1.3), in which the descriptive issues have already been compiled thanks to the INDEMARES surveys, but where still other parts have not yet been developed.

Part of the Management Plan	State
1. Description of the site, including reasons for selection.	
2. Map, location, boundaries and administrative distribution (GIS)	
3. Socioeconomic situation, history and uses	
4. Description of the natural values	
5. Description of cultural history and archaeology	
6. Designation of administrative responsibilities and obligations	
7. Knowledge of the current status of Natura 2000 habitats and species present at the site and identification of pressures and threats	
8. Conservation objectives	
9. Management measures to meet objectives	
10. Allowed/ forbidden activities	
11. Monitoring plan and review data collection	
12. Stakeholder engagement plan, list and members of managing board	
13. Surveillance Plan	
14. Funding and work plan	
15. Update, outcomes, reports and briefing	

Table 1.3: Current state of each part of Banco de La Concepción management plan: developed (green), not developed (red), not necessary (yellow), issue addressed in this work (violet), **Source**: Own elaboration.

The main aim of this thesis is to produce specific and appropriate guidelines on which the management plan of Banco de La Concepción can be based.

This general objective can be disaggregated in the following specific ones:

- To define and analyse the objectives of this specific zone's future management plan, not only considering the HD, but integrating, as much as possible, the other current directives (MSFD).
- To create a list of indicators that can be selected for a monitoring plan, considering the natural attributes and the socio-economical pressures on the ecosystem analysed.
- To evaluate and consequently suggest the most suitable indicators for conforming a monitoring plan which will permit the quantification of the accomplishment degree of the defined objectives.
- To follow the advices given by INDEMARES workshops setting up a better approach to indicators' selection by means of proper and novel methodology combination than those mostly used until now for the Natura 2000 MPAs, which fail to achieve the goals proper of each specific study area (WWF, 2012).

CHAPTER 2. MATERIAL & METHODS

Part 1: Introduction to the study area

2.1 Study area

2.1.1- Location

Located in the Macaronesian biogeographical region, i.e. between 29° 29.00‘ and 30° 23.50‘ N latitude and 12° 18.50‘ and 13° 13.50‘ W longitude, Concepción is a table seamount (guyot) 75 km to the North of Lanzarote (Canary Islands) (Fig. 2.1 A). The seamount emerges from a low-productivity extensive abyssal plain, acting as a submarine oasis (Almón *et al*., 2014). This seamount is part of a series of structures of volcanic origin known as the Canary Island Seamount Province (CISP), embracing the seamounts around the Canaries, together with the current emerged islands being part of the Canarian Volcanic Province (CVP) (Fig. 2.1 B) (Almón *et al*, 2014). As several other volcanic buildings in this seamount province, Banco de La Concepción was emerged in the past, as the rolling stones of its summit testify as product of the wave erosion (Almón *et al*, 2014).

Emerging from a depth of 2678 m, today Conception is a 54 km diameter table seamount with a summit at 158 m below the sea level. Surrounding this platform a slope crisscrossed by a large number of canyons falls to the abyssal plain (Fig. 2.2).

Banco de La Concepción is a large block of volcanic rock partially covered by sediments of organic origin and different width. However, volcanic rock occupies the central part of the platform, its borders and the slopes (Almón *et al*., 2014)

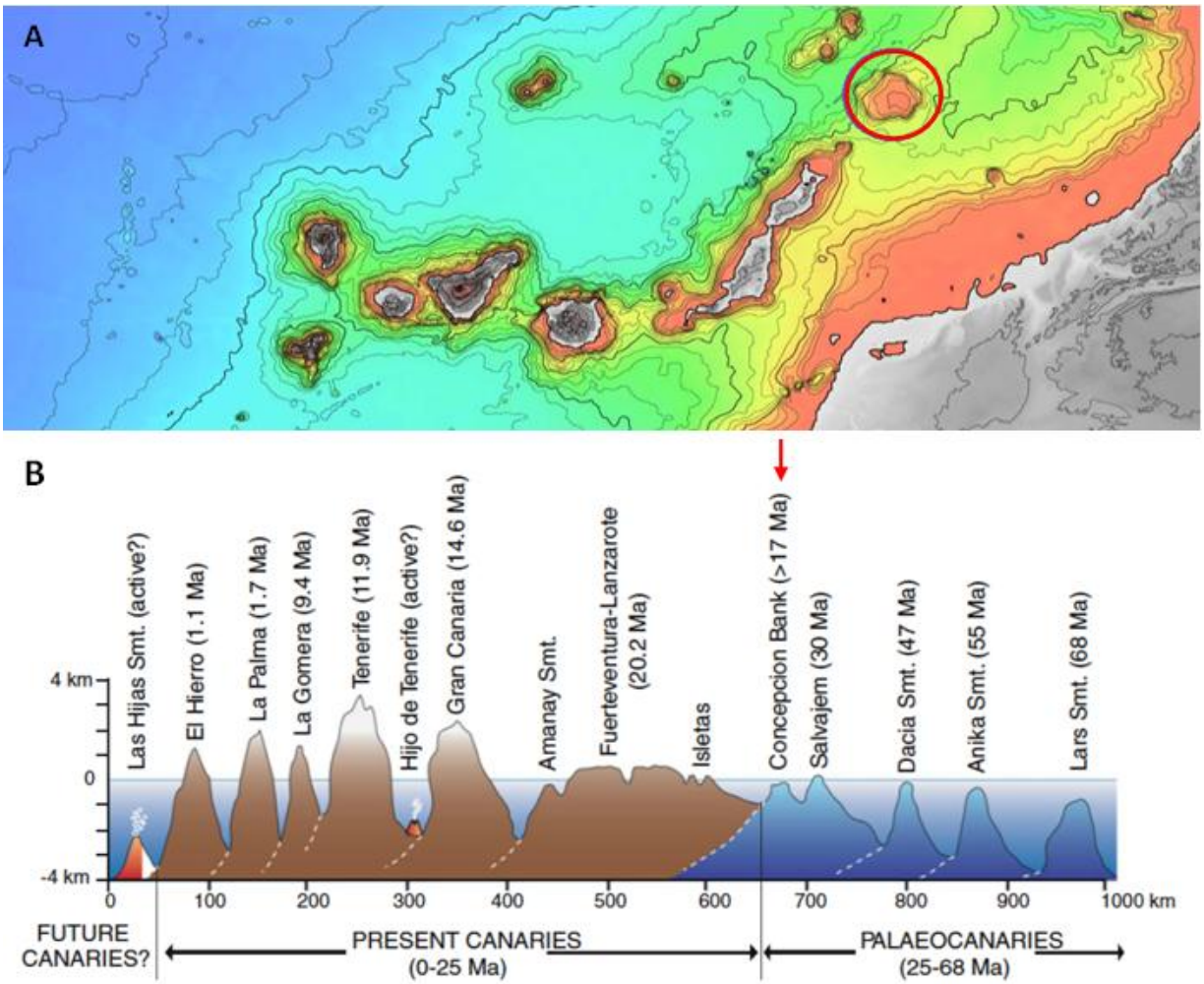

Figure 2.1: A) Bathymetric map of the Canary Islands and surrounding seamounts included in the Canarian Volcanic Province. Banco de La Concepción is inserted in a red circle. Isobaths depicted each 250 m depth. **Source**: earthref.org **B)** Height and age of the volcanic buildings (brown emerged and blue submerged) constituting the Canarian Volcanic Province. Red arrow points Banco de La Concepción**. Source**: Carracedo & Pérez Torrado, 2013

The presence of a hard bottom enables the formation of complex communities and the topographic variety, together with the influence of the Canarian marine current and the upwelling phenomenon taking place in the nearby NW platform of the African continent, generate a biodiversity hotspot in open waters (Almón *et al*., 2014). This fact, besides the active contribution of Banco de La Concepción to organisms' dispersal, a characteristic property of these seamounts (Mullineaux and Mills, 1997), were the key elements for its inclusion in the INDEMARES project as an area of study interest. Later, the surveys carried out within this project contribute with sufficient relevant information about its natural and socio-economic values to be designed as Site of Community Importance (SCI) by the

European Union (EU). Note that these surveys were restricted to a depth range between 0 and 1500 m due to technical viability reasons.

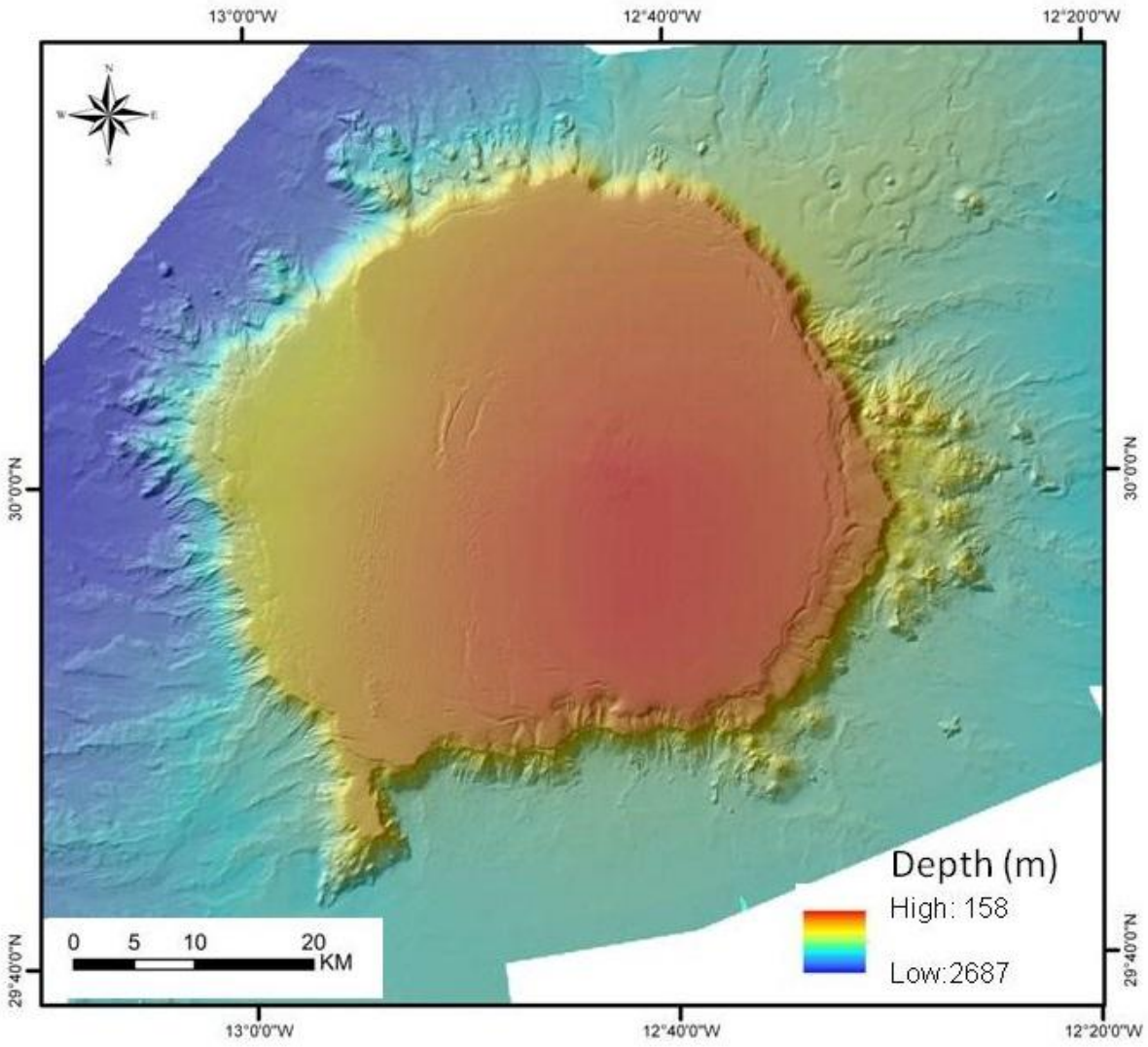

Figure 2.2: Bathymetry of Banco de La Concepción. **Source**: IEO-Database, 2016.

2.1.2 Natural values

- **Habitats**

Considering the range of depths encompassed by the bank, the majority of the communities existing are distributed within the bathyal zone, implying the absence of photosynthetic organisms. The neritic communities found were classified according to the substrate type (hard or soft bottoms) and the more characteristic species constituting them (Table 2.1). As already mentioned, the presence of hard bottoms permits the formation of communities of high complexity that occupy large areas and acquire huge dimensions, whereas the soft bottoms, mainly constituted by muddy and sandy zones, are inhabited by sedimentivorous or suspensivorous organisms, which play an important role in the bioturbation and biostabilization of the sea floor (Almón *et al*., 2014)

Seafloor type	Communities
Rocky bottoms	Bathyal rock with antipatharia
	Bathyal rock with *Callogorgia verticillata*
	Bathyal rock with *Dendrophyllia cornigera* and *Phakellia ventilabrum*
	Bathyal rock with isididae
	Bathyal rock with hexactinellid sponges (*Asconema*)
	Bathyal rock with lithistid sponges
	Bathyal rock with *Pheronema carpenteri* and *Paramuricea biscaya*
	Deep coral reefs *Corallium niobe* and *Corallium tricolor*
	Deep coral reefs of Lophelia pertusa and/or Madrepora oculata
	Dead coral framework
Soft bottoms	Bathyal mud with *Flabellum spp.*
	Bathyal mud
	Soft sandy sediments with sea urchins
	Coral rubble

Table 2.1: Observed communities in Banco de La Concepción. **Source**: Martín-Sosa *et al*., 2013.

Following the description given by the Habitats Directive (HD) for the priority habitats, all the communities classified as rocky bottoms by INDEMARES were encompassed in the habitat category 1170 Reefs (Box 1.2), summing up a total of 62,337 hectares, i.e. 23% of the studied area (Fig 2.3). The existence of these communities and its high degree of conservation (Almón *et al*., 2014) was the principal reason for its recognition as SCI. Furthermore, the community of bathyal mud with *Flabellum* was suggested to the EU as sensitive community to be included in the relevant HD annex.

BOX 2.1-Description of habitat 1170: Reefs (EC, 2007, Appendix I)

"Reefs can be either biogenic concretions or of geogenic origin. They are hard compact substrata on solid and soft bottoms, which arise from the sea floor in the sublittoral and littoral zone. Reefs may support a zonation of benthic communities of algae and animal species as well as concretions and corallogenic concretions".

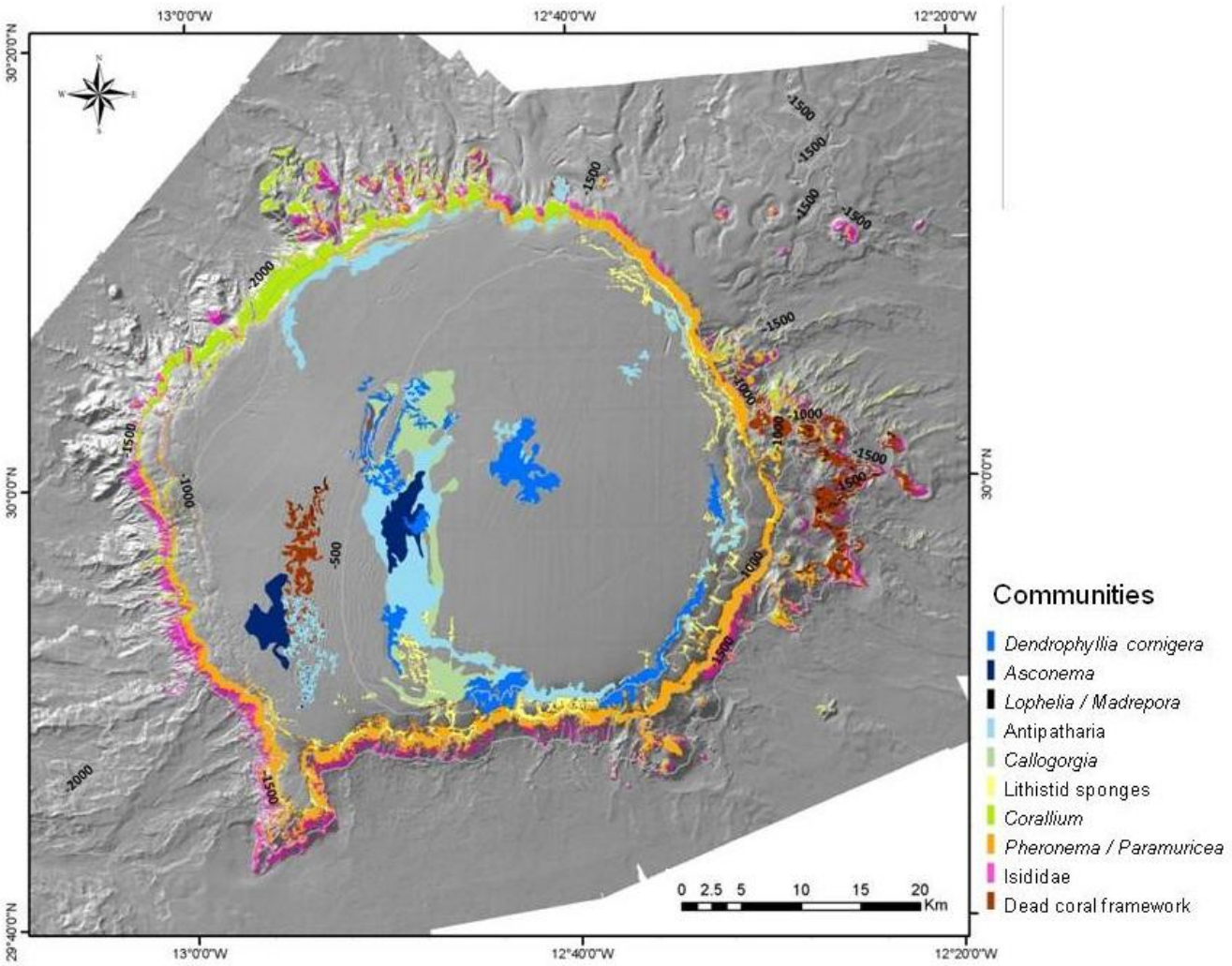

Figure 2.3: Location and distribution of habitat 1170 (Reefs) communities in Banco de La Concepción. **Source**: IEO-Database, 2016.

- **Species**

The fauna responsible for this biodiversity hotspot is composed by species with different geographical origins that reached Banco de La Concepción from the European Atlantic platform, the Macaronesian islands, the African Atlantic coast or the North-East Atlantic banks (Almón *et al*., 2014).

Without focusing on the specific composition of the communities of this seamount, a list of potential focal species (Box 2.2) with high economic/human value with management interest has been prepared (Table 2.2).

BOX 2.2-Types of "focal" species (Adapted from Pomeroy et al, 2004)

- **Vulnerable:** Less resilient species of the community to environmental changes or species requiring a careful management to sustain. (Threatened, endangered or rare species)
- **Endemics:** Species that only occur naturally in a defined region, being in this case waters near the MPA.
- **Invasive:** Non-native species of concern due to its negative effects on the local ecology.
- **Flagship:** Charismatic species of social and/or cultural importance used by managers as symbol of the protected site in order to encourage public interest and support.
- **Keystone:** Species upon which other in the community direct depend.
- **Target:** Species of interest due to their socioeconomic importance en la region managed
- **Sentinel:** Species able to act as suitable indicators. They signal how disturbances are impacting on the ecosystem.

Focal group			Nº Species
Vulnerable species	HD species	Annex II	2
		Annex IV	8
	Other		13
Endemic species*			5
Keystone species			8
Target species			11
Sentinel species	Regime Shift		3
	Ocean Acidification		1

Table 2.2: Species number present at Banco de La Concepción belonging to each focal group. See Annex A for species information, *Macaronesian endemics. **Source:** Own elaboration.

Following Pomeroy *et al.* (2004) definitions for the different focal groups, the species matching those criteria presented in the study area were properly classified. Within the focal group of vulnerable species, those include in the HD have been differentiated from and those include in other lists. Regarding those of the HD, there are 2 species considered

with priority due to their presence in the Annex II: the bottlenose dolphin (*Turpsius truncatus* (Linnaeus, 1758) and the loggerhead sea turtle (*Caretta caretta,* (Linnaeus, 1758). Moreover, species in the Annex IV, those needing a strict protection, include seven cetacean species that were observed during INDEMARES surveys (See Annex A), as well as the sea urchin *Centrostephanus longispinus* (Philippi, 1845).

Beyond the directive but present in other catalogues such as the *Canarian Catalog of Protected Species* and the *International Union for the Conservation of Nature* (IUCN) list, we found 12 species more, which have been classified here within the vulnerable species group. Regarding the endemic species focal group, a total of five species were listed, all of them Macaronesian endemics with the exception of *Isozoanthus sp.* only identified in Banco de La Concepción, what may point to a local endemism. The seven species included as keystone species are the main biobuilding and structuring species of the study zone. The group catalogued as objective species will only comprise those species with commercial (fisheries) interest (11), being the main stocks fished in the zone. Finally, the focal group constituted by the sentinel species can be divided in two different categories, depending on the disturbance they can indicate: several sea urchin species can indicate possible regime shifts due to anthropic pressures in Concepción (Almón *et al*., 2014) whereas the coral (*Lophelia pertusa,* Linneus 1758) can be considered as a good indicator of oceanic acidification (Brito and Falcón, 2013).

Turning back to the more vulnerable species included in the Annex II, it is necessary to clarify that even without relevant data about their populations' abundance in the study zone, their mere presence (although it is still unclear if the bottlenose dolphin is resident on the area) together with the use given to those habitats, have been sufficient reasons for its designation as SCI.

2.1.3 Socio-economical values

The remoteness of Concepción seamount from the closest coasts and the usually adverse climatic conditions prevailing there, have minimized the anthropic uses and related pressures, so that this has made an adequate conservation state of its oceanic floors possible (Almón *et al*., 2014). However, as we are going to see below, although the human impact is reduced in the study area, there are some activities that - even taking place off the study area - may impact the system. The impact with highest social and economical relevance is by far the professional, artisanal fishing. Among the different fisheries types we will analyze later, the tuna fishing is by far the most important, both due to the size of the fishing fleet implied as well as to the number of local families affected, which depend either on the direct fishing or on the activities generated by its commercialization (Almón *et al*., 2014). Due to the remoteness of the site the recreational fishing activity is nowadays considered as irrelevant (WWF, 2013).

2.1.4 Conditions of the collective action

With the aim of finishing the study zone description, the conditions affecting the collective action of Banco de La Concepción have been analysed. The management strategy's development needs to consider the factors affecting the collective action (Martín-Sosa *et al.* 2013). These factors are the reason why in certain human communities

it is easier to designate, implement and enforce the management strategies (Martín-Sosa *et al*., 2013). Depending on these factors, the perception and implication of the community with the area being protected will result in a more straightforward or more complex task, driving in some cases to the success, or in others to the failure, with the same effort level. The site and specific users' characteristics, as well as the relation among them, will determine in a large extent the implication degree of the users with the area being protected (Martín-Sosa *et al*. 2013). In the case of Banco de La Concepción, some factors such as it remoteness as well as the scarce dependence of the users with the site or the difficulty of defining them will hardly limit the collective action that they may develop, as well as their implication with the marine protected area.

- Area remoteness and sporadic use:
  If we add to the difficulties of the protected area surveillance and of the activities control of the competent administration due to their offshore location, its remoteness to the fishery communities and the zone's sporadic use, the result is an exceeding limitation of the implication of these populations in its surveillance.

- Protection of nature:
  Its designation as marine protected area rests in the conservation of certain habitats and in the protection of species without commercial interest. It is, thus, not evident that the fisheries resources need to be improved, so that the perception of this necessity may be diffuse.

- Independence and property sense:
  The big majority of the users come to the zone from different geographical locations and usually there are alternative spaces where to carry out their activities, so that they do not depend on the zone. This will result in a further limitation for their implication in the zone management.

- Users interaction
  One of the consequences of diverse geographic origin of the users groups is the scarce interaction existing among them and thus the inexistence of mutual confidence and reciprocity relationships, what will again difficult their implication in the zone management.

- Conservation experience
  The experience in conservation initiatives among the involved users is very limited, so that reluctances in their attitude are expected.

Part 2: Defining the objectives

2.2 Definition process of the Special Area of Conservation adequate objectives

As commented in the last chapter the objectives play a transcendental role within any management plan, being considered a key element. Furthermore, many of the plan sections will orbit around them, so that they are one of the first items to be fixed. In this section we will tackle the first of the specific objectives of this work: the definition of the specific objectives for Banco de La Concepción SAC, clearly detailing how and under which criteria this has been done.

2.2.1 Objective types and selection criteria

Within a management plan we can usually appreciate different levels of hierarchy among the objectives. Depending on the level they will have different purpose.

Whereas a goal is a broad statement of what the marine protected area (MPA) is ultimately trying to achieve, an objective is a more measurable statement of what must be accomplished to attain a related goal. Generally the main goals are already defined in the legislation or agreement used in setting up of the MPA, so that its definition is not usually part of the managers' tasks (Thomas and Middleton 2003).

Attaining a goal is typically associated with the achievement of the corresponding objectives (Pomery, 2004). Simultaneously, the objectives can be hierarchically divided in generic, specific and operative (called operative tasks in this work).

BOX 2.3-Characteristics of good/well written objectives (Pomeroy et al, 2004, Thomas and Middleton, 2003):

- Precise and specific.
- Achievable, realistic, practical and appropriate within the local context.
- Achievable within a reasonable time period.
- Easily understood by all stakeholders.
- Written in terms of what will be accomplished, not how to go about it.
- Measurable and able to be validated.

Following this procedure, a series of general objectives have been defined. These general objectives have been complemented with a set of more concrete specific objectives to which, for facilitating the designation of actions and monitoring measures, different operative tasks have been assigned.

Usually management plans do not make clear which criteria were followed in the objectives definition, but ample literature can be found on this matter. In this work, the

objectives definition has followed the criteria assembled by Pomeroy (2004) and Thomas and Middleton (2003) (Box 2.1), which are commented below.

- Precise and specific:
  An effective management is not only based on achieving objectives in general, but also on each one of the individual objectives formulated. Without precise and specific objectives it would be very difficult to determine what and how has to de done.

- Achievable, realistic, practical and appropriate within the local context:
  Objectives should be realistic and achievable, in the way that the difficulties the managers will find should be recognized. It is in no case a list of desires. The knowledge of the study area and of its natural and social characteristics (as we have seen above in part 1) is essential for the success. Furthermore, it should be kept quite clear when the objective has been reached.

- Achievable within a reasonable time period:
  As far as possible, the objectives should be time-related, depending on the time frame needed for their achievement on the MPA characteristics. Usually a horizon of 5-10 years is considered.

- Easily understood by all stakeholders:
  The objectives should be defined in a way that they are comprehensible to all the parts involved, not only focused to the scientific community.

- Written in terms of what will be accomplished, not how to go about it:
  This is a common problem, probably because identifying a desired 'end' is more difficult than stating how it will be achieved. The more specific an objective is, the more difficult it is to discern among both approaches. Objectives shouldn't describe programs or performance measures because those are tasks that should be addressed later in the process.

- Measurable and able to be validated:
  Managers should be able to know if the objectives are being accomplished because this will imply knowing if the chosen strategy is successful or failing. This is only possible if the objectives make reference to an outcome or situation measureable in some way. If this is the case, the operative objectives will be easy to verify. Sometimes it may happen that the proper knowledge for doing this is not available, however this can be used for identifying research and information requirements.

2.2.2- Objective components following legislation and guidelines

As commented above a management plan's goals are usually determined by the legislation or agreements used for setting up the protected area. In our study case, as was seen in chapter 1, HD states clearly that a SAC goal is "to warrant the maintenance or

reestablishment of favourable conservation status of habitats and species of community interest".

Nevertheless, the items that the objectives should embrace come not in the legislation, but have been developed in many of the Natura 2000 management guidelines published during the last years. After an exhaustive review of these guidelines, we have selected the following components as necessary to incorporate in our objectives.

- to accomplish with all the ecological requirements (Environment)
- to fulfil knowledge gaps (Research)
- to reinforce collaboration among competent administrations (Engagement)
- to integrate the general public and the affected stakeholders (Engagement)
- to promote a sustainable use of the environment and to increment the social benefits (Socio-economics)
- to integrate coherently other strategies

2.2.3 Integrating the Marine Strategy Framework Directive

As remarked on the first chapter, the objectives related to MSFD would be integrated into the MPA management in order to help moving towards the Good Environmental Status (GES) in the Canary Islands demarcation. Evidently this integration will happen as long as the HD objectives do not lose coherence.

Recommendations and objectives for the consecution of a GES on the Canary Island demarcation were already published by the institution in charge (MAGRAMA) in 2012, so the task basically consisted in a thorough revision of those objectives in order to see how many already overlapped with the HD and how many could be added to the MPA management.

As expected due to the existence of umbrella species in the study area, the HD somehow already covered most of the objectives developed for the GES. Nevertheless as will be shown in the results' chapter, some of them met the criteria and were incorporated.

Part 3: DPSIR framework development and indicators selection

2.3 The DPSIR framework as first step in the indicator system creation process

In this third part the methodology used for achieving the second specific objective of creating an indicators' list for the SAC monitoring plan will be considered. The first necessary step towards the identification of the potential indicators of the monitoring plan will be the clear definition of the cause-effects relationships occurring in the system and the production of a framework from which indicators can be easily chosen (Ojeda-Martínez *et al*. 2008).

2.3.1 The DPSIR framework

One of the techniques frequently used by national and international institutions for such a task is the application of the DPSIR (Driving forces-Pressures-State-Impact-Response) (Skondras *et al*., 2015) model. This conceptual frame developed by the European Environmental Agency (EEA) and supported by the European Commission is basically an extended version of the pressure-state-response model developed by the Organization for Economic Cooperation and Development (OECD) (Skondras *et al*., 2015).

This model, characterized by being transparent and simple, may provide an holistic perspective integrating social and environmental system knowledge and will permit structuring and interpreting this information (Ojeda-Martínez *et al*., 2008). It will be particularly useful when describing the relationships between the origins and consequences of environmental problems, information that will be essential for the indicator system development (OMARCOST, 2013)

The DPSIR framework is an indicator selector that has been widely used in different fields, from the Water Framework Directive and coastal zone studies to the fisheries management (OMARCOST, 2013). For the management of MPAS it has specifically shown to work properly by simplifying the complexity of environmental management (Kelble *et al*, 2013.), facilitating the decision making, and providing a significant fraction of the necessary environmental information (Tschering *et al.*, 2012). All in all, those frameworks allow a better understanding of the results of a developed action or process and the result produced in the system components (Ojeda-Martínez *et al*., 2008).

2.3.2. Model functioning

As its name indicates, five levels compose this framework: *Driving Forces, Pressures, State, Impacts* and *Responses* (Fig 2.5) that will constitute a cause-effect chain. The functioning of the model is based in the description of a feedback dynamic system. The role played by the indicators within this framework will be one of tools that enable to take a snapshot picture of a constantly changing system. The assessment of this picture will provide us with real-time system information.

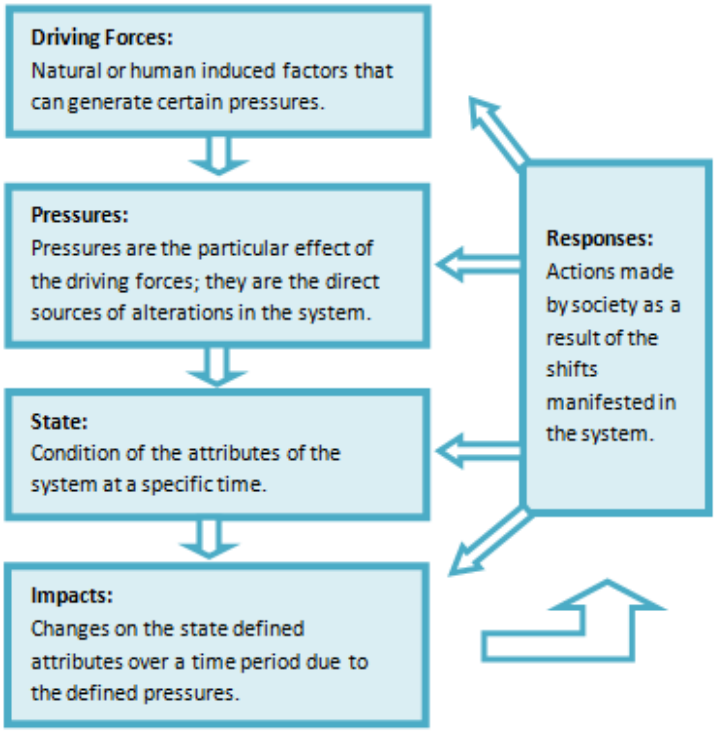

Figure 2.4: DPSIR model functioning and definition of each level added. **Source:** Own elaboration.

According to the functioning of this model, the first level would be the *driving forces* which would make reference to the natural or human induced factors producing specific environmental *pressures*. These pressures will be the second level and will exert an effect on the ecosystems. As a consequence of the pressures, the *state* (third level) of the attributes conforming the ecosystem will suffer changes, which will be defined as *impacts* (fourth level). Finally, these impacts may induce a societal *response*, which will constitute the fifth and last level. Depending on the *response* type, this will feed back any of the previous levels, altering again the system (Tschering *et al.*, 2012).

2.3.3 Model implementation to Banco de La Concepción

With the aim of developing a detailed and specific DPSIR to our study area, each model level was studied in detail. The study was based in a deep search of all the available information about Banco de La Concepción. The bulk of the consulted literature is related to the results obtained by the INDEMARES project's surveys. The method of incorporating this information into the model was characterized by the inclusion of all the elements, independently of its occurrence probability or overall importance.

All the existent *driving forces* and associated *pressures* were also included in the model. Regarding the *driving forces* level, these were classified as "near field forces", in case they

happen within the study area, or "far field forces", if they occur outside the study area, but could have any effect on it.

For the *state* level, instead of identifying only the key elements for which managers are usually more interested, as has been the case in the development of this framework (Ojeda-Martínez *et al*., 2008), all the attributes characterizing the ecosystem in hierarchical order (including the socioeconomic and the ecosystem itself) have been included (the hierarchical perception between community and habitat depending on the author scope). This way impacts occurring within each of the attributes can be more intuitive defined, favouring later the indicator selection process. Besides, also the ecosystem based approach, which is widely recommended particularly when implementing this framework (Kelble *et al*., 2013), or in general for MPA managing (Halpern *et al.,* 2010.).

The *impact* level was likely the most complex field to integrate. With the aim of completing this level as much as possible, an exercise was carried out in which all the possible characteristics of each attribute that could be somehow affected by any of the pressures were identified. Finally, within the *response* level all the management actions usually implemented in MPA were included.

The proper nature of the model will provide the cause-effect linkages, which will be appropriate only when the constituting elements of each level have been correctly integrated.

2.3.4- Indicators selection based on the DPSIR

Once the elements of each framework level were identified, the search of indicators associated with these elements was the next step. As commented above, the aim of this method is to carry out a first selection of viable indicators for the evaluation of the processes occurring in the study zone, indicators which will later be subject to a more complex selection process. Thus, our task here is to identify at least one indicator for any of the elements integrated in each model level. Again, through an exhaustive bibliographic revision variables matching with indicators able to measure: i) the defined driving forces, ii) the existing pressures, iii) the different characteristics of each attribute and iv) each type of response, were searched. It should be considered that the same indicators will be used for measuring the elements included in the "state" and "impacts" level, because the impact indicators actually measure a state at a temporal gradient.

Specific selection criteria were not used for this first indicator list. It was only considered if the indicators were scientifically relevant and supported. The obtained indicators were ordered in the list depending on DPSIR level so the final list included 5 categories corresponding to each of the levels.

Once the indicators' list is completed, we will move towards the following specific objective.

Part 4: Indicators evaluation through a Multi-criteria Decision Analysis approach

2.4 Evaluation process of the identified indicators

The process carried out in the last section allowed us to obtain a list of 144 valid and potentially eligible indicators for the indicator system to be established in Banco de La Concepción SAC management plan. In this section we will developed the methodology used for achieving the last of the specific objectives of this work: to evaluate and suggest the most suitable indicators to constitute a monitoring system. The process carried out to accomplish this objective can be divided in three different phases that will be fulfilled using different methods:

1. Specifying the indicators.
2. Defining and weighting a set of criteria.
3. Eliciting indicators values from an expert panel.

From now on and regarding the methods that are going to be explained the concepts of "alternatives" and "criteria" will be introduced. *Alternatives* can be defined as options, choices or actions that can give solutions to the decision problems. In this case, the indicators will be the alternatives. *Criteria* are defined as characteristics or attributes relevant to alternatives. These alternatives, as we are going to see next, will be evaluated according to different criteria.

2.4.1 Delphi method

2.4.1.1 Definition and characteristics

One of the methodological elements commonly used in the development of indicator systems is the incorporation of the experts' opinion for the selection of the elements to be integrated (Fernández-Palacios, 2015). For this study the experts' opinion will be integrated using a Delphi method approach. This method, developed in the 50s by Olaf Helmet and Theodore Gordon, permits the setting up of a group communication process in an effective way, permitting the specialists to set up their positions against a complex problem (OMARCOST, 2013).

In the Delphi process two groups with different functions participate. One monitoring group will be in charge of designing all the exercise phases, whereas the expert group will answer the inquiries prepared by the first group (OMARCOST, 2013). The monitoring group will select the expert panel, obtain their collaboration commitment and explain what the study in general, and the applied method in particular, are about. The results obtained will be thus the responsibility of the monitoring group (OMARCOST, 2013). Due to the reasons explained in Annex B, both monitoring members were also included on the expert group.

The design and application of a Delphi method should count with the following steps (Fernández-Palacios, 2015):

1. Identification and invitation of the specialist integrating the expert group (the experts should be conscientiously chosen, and should represent a wide opinion spectrum about the study object).
2. Inquiry document elaboration.
3. Experts receive and fulfil the document returning it to the monitoring team.
4. The monitoring team uses the experts' opinions for creating a new document.
5. The experts have the opportunity to analyse their answers for understanding the monitoring group considerations regarding the raised issue.
6. If an evident disagreement takes place, its cause(s) should be analysed in an extra phase.

2.4.1.2 Working protocol

Experts' selection:

The monitoring group, made up in this case by this work's author and supervisor (Martín-Sosa) selected and invited a group of individuals, offering them the opportunity to participate as experts in this study. In the selection process the capacity and MPA management knowledge of the experts were considered, as well as their knowledge about the study area, from different perspectives depending on the field of their expertise. A total of 31 experts were invited, with the idea of fulfilling the guidelines developed by Dalkey *et al*. (1970) for the Delphi method, where a number of experts between 7 and 30 is recommended. According to these authors with at least 7 experts the dispersion error of the answers diminishes significantly, whereas with more than 30 participants the increase in the dispersion decrement is not significant for the effort and costs assumed. The invitation was finally accepted by 15 experts, whose data are reflected in the Annex C.

Inquiry elaboration and responses' analysis

With the aim of obtaining the experts' answers to the problem raised, three different inquiries were designed, each of them in relation to the results offered by the previous one. In all of them the fulfilling instructions were attached, as well as at least one example of how this should be done. Now the function of the first inquiry will be explained, while the characteristics of inquiries 2 and 3 will be explained in the next section, because they are integrated within the Multi-Criteria Decision Analysis approach (MCDA).

- Inquiry Nº1

The goal of this inquiry was to carry out a selection of the 144 indicators identified through the DPSIR method. We should keep in mind that on the DPSIR framework all type of existing elements, independently of the probability of occurrence or total importance, were included. So this panel, as experts on that site, should evaluate all indicators identified, so that afterwards the monitoring group can decide where to establish a threshold. This threshold will include or exclude more indicators depending on the

workload accepted by the experts. Assumptions regarding the workload assigned to the expert group and the nature of the threshold established, can be consulted in Annex B.

Considering their experience and knowledge, the experts were asked to evaluate from 0 (useless) to 9 (ideal) each indicator included in the list. Despite their expertise, they were asked to qualify only those indicators they consider to have sufficient knowledge, not qualifying those far from their expertise. The qualities of a good indicator, also called criteria, were attached to the inquiry instructions. I will later go into more detail regarding these criteria. On the attached indicators' list references of each indicator were removed so that this information does not cause bias on the scoring exercise.

Once the results generated by the expert panel were obtained, the data were subject to a selection process based on those evaluations. The procedure followed was the calculation of each indicator mean value according to their experts scoring. In order to increase mean precision, the maximum and the minimum scores obtained were not included on the average sum.

Moreover, a threshold of 18 indicators was set up (the criteria used for this threshold level and the reasons for selection are compiled in Annex B), (Inquiry 1 attached in Annex D).

2.4.2 Multi-Criteria Decision Analysis

2.4.2.1 Definition and characteristics

The Multi-Criteria Decision Analysis (MCDA) is a group of approaches on decision evaluation methods, which help to take complex decisions considering several criteria (Belton and Steward, 2002). In situations where multiple criteria are involved, confusion can arise if a logical well-structured decision-making process is not followed. For these cases MCDA will help the decision maker to understand and structure the problem, recognize trade-offs and select the preferred option (Belton and Steward, 2002). The use of this method enables a multidisciplinary team to reach a consensus without having to agree on the relative importance of every factor. Each member just inputs his/her own judgements, which will contribute to the consensus conclusion.
MCDA has been applied in an ample spectrum of fields, from economy to engineering or from enterprise management to environmental sciences. The environmental decisions are usually complex and imply to appeal to multidisciplinary knowledge incorporating biological, physical, socio-political or ethical variables. It is exactly in these multidisciplinary frames where MCDA vindicates itself as a useful instrument (OMARCOST, 2013). Concretely, for addressing challenges involved in indicators' assessment MCDA provides a more than appropriate tool (Mendoza *et al*., 1999) (Box 2.4)

BOX 2.4-Specific useful attributes of MCDA methods for indicator assessment (Center of International Forests Research (Mendoza *et al*., 1999)

- Capability to accommodate multiple criteria in the analysis
- Capability to deal with mixed data, allowing the incorporation of both qualitative and quantitative information
- Allow direct involvement of multiple expert, group of interest and stakeholders
- Analysis is transparent to participants
- Includes mechanisms for feedback concerning the consistency of the judgements made

Furthermore, the goals for which MCDA can be applied to indicator assessment are (Mendoza *et al*., 1999)

- As a way to facilitate the decisions of each participant regarding the importance of each Indicator
- As a way to assess the relative importance of each indicator in order to select a set deemed most significant
- As a way to aggregate all the evaluations made by participants/experts to arrive at a consensus or group based evaluation of all indicators.

2.4.2.2 The Analytic Hierarchy Process

The Analytic Hierarch Process (AHP) is one of the methods encompassed within MCDA. The AHP, developed by Saaty (1980), has been used in a variety of application areas to evaluate user preference based on the concept of paired comparisons (Saaty and Vargas, 2001) but it was applied by Himes (2005) for the first time in context of MPA management (Pendret *et al*., 2016). AHP has resulted in the more convenient method for our aim, according to the characteristics of our decision problem (See Annex E).

The AHP is based on arranging the important components of the problem into a hierarchical structure. This method that compares and evaluates both criteria and alternatives simply requires the decision maker to express the level of preference among criteria and alternatives. Thus, the method reduces complex decisions into series of Pairwise Comparisons. Pairwise comparisons refer to a process of comparing entities in pairs in order to judge which of each pair is preferred (Himes, 2007) This method is also able to check the consistency of the decision maker's responses through a consistency index.

2.4.2.3 Working protocol

For the implementation of this method the steps proposed by Sen Yang (1998) and Saaty (1980) have been followed. Those are:

- Identify the hierarchical structure and the elements of MCDA problem
- Formulate the Pairwise Comparisons Matrix and score criteria and alternatives
- Generate a Priority Vector also called Relative Weight Vector

- Check the consistency Index
- Rank the elements based on their Global Priority Vector values

The hierarchical structure:

The AHP permits the organization of the problem's elements in a hierarchical structure for facilitating and identifying the concern of decision makers (Belton y Stewards, 2002). Figure 2.6 represents the hierarchical structure according to our work. The first level of the structure corresponds to the overall goal of the decision problem (which are the more appropriate indicators for monitoring Banco de La Concepción SAC). The second level encompassed the decision makers, in our case, all the experts consulted. The third level embraces the relevant criteria for our goal. The alternatives will be evaluated according to those criteria. Following Dogson *et al*. (2000), it is important to keep a low number of criteria, but this number should be large enough to contribute to a well-grounded decision. The fourth and last level of our hierarchical structure will be the alternatives, i.e. the indicators to be evaluated.

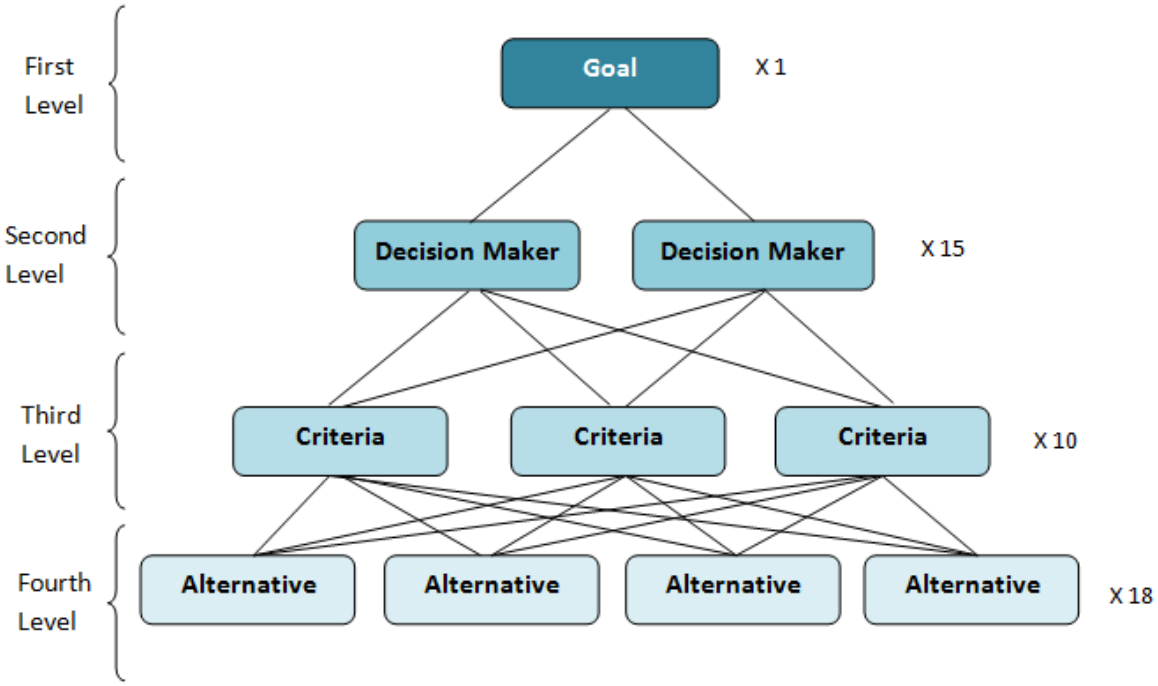

Figure 2.5: Hierarchical structure of AHP method. Right side numbers represent the quantity of elements per level in this work. **Source**: Own elaboration.

Selecting and describing the criteria:

As seen above, the capacity of an indicator for being sufficiently good or valid will be defined by a series of attributes or criteria. For carrying out this work a set of criteria for evaluating the effectiveness and suitability of the DPSIR generated indicators has been developed. The criteria chosen by the monitoring group (Table 2.3) are basically based in those exposed by ICES (2013) and Ojeda-Martínez *et al.*, (2008). Depending of the characteristics of each criterion they have been divided in "data quality", "management" and "others".

Code	Criteria	Description	Reference
Data quality			
C1	Existing and ongoing data	Indicators supported by already existing monitoring programs with time series fully available.	ICES, 2013
C2	Consistency	Indicator is able to keep a low variability respond	Ojeda-Martínez *et al.*, 2008
C3	Tangibility	Indicators should be easily and accurately determined using feasible techniques	Ojeda-Martínez *et al.*, 2008
C4	Quantitative vs. qualitative	Preference of quantitative data rather than qualitative.	ICES, 2013
C5	Sensitivity	Susceptibility for detecting changes on pressures or state/impacts.	Ojeda-Martínez *et al.*, 2008
C6	Representative or repeatability friendly	Indicator should be representative of the area/attribute under study (whole SAC, concrete community, etc), when needed, repeatability shouldn't be a major issue.	ICES, 2013
C7	Early warning / Preventive	Indicator is able to highlight potential changes before harm is done.	ICES, 2013
C8	Scientific credibility	Scientific per-reviewed findings guarantee the validity of the indicator.	ICES, 2013
Management			
C9	Relevant to defined objectives	Indicator should be in accordance to established operative tasks and specific goals.	ICES, 2013d
C10	Comprehensible	Indicator and variation consequences should be easily interpretable by policy makers and engaged stakeholders.	Ojeda-Martínez *et al.*, 2008, ICES, 2013
C11	Cost-effectiveness	Sampling, measuring, processing, analysing and reporting outcomes should be in accordance with financial resources.	Ojeda-Martínez *et al.*, 2008, ICES, 2013
Others			
C12	Cross-applicability	Indicator fit in more than one aspect being evaluated.	ICES, 2013
C13	Independence	Not redundant with other indicators	ICES, 2013
C14	Established	Indicator is already used in other monitoring programs with same o similar objectives. (Even greater relevance if used in other local places (Canarian demarcation).	Ojeda-Martínez *et al.*, 2008

Table 2.3: List of criteria selected for experts panel evaluation. **Source:** Own elaboration

The pairwise comparisons

With this step, alternatives performance on criteria (scoring) and criteria among themselves (weighting) are going to be evaluated. This will be done generating a comparison matrix both for criteria as well as for alternatives. At this point the help of our experts will be needed, to which the second and third inquiries have been sent.

- Inquiry Nº2:

The aim of this second questionnaire is the weighting of the 14 criteria chosen. For minimizing the workload of the, the four least weighted criteria were discarded in this step. Thus, in this case the expert group was asked to fulfil a criteria comparison matrix according to their preference on a scale 1 to 9, with 1 indicating equal preference and 9 absolute preference (Saaty 1980, 2001) (Table 2.4), (Inquiry 2 attached in Annex D).

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
2	Weak	Experience and judgment slightly favour one activity over another
3	Moderate importance	-
4	Moderate plus	Experience and judgment strongly favour one activity over another
5	Strong importance	-
6	Strong plus	An activity is favoured very strong over another, its dominance demonstrated in practice
7	Very strong or demonstrated importance	-
8	Very, very strong	The evidence favouring one activity over another is of the highest possible order of affirmation
9	Extreme importance	.

Table 2.4: The fundamental scale of AHP. **Source:** Saaty and Vargas, 2001

- Inquiry Nº3:

In the last of the inquiries the expert team was asked to make comparative judgement on the relative importance of the selected alternatives (18 indicators) in terms of the different criteria. This was again carried out generating a comparison matrix among alternatives for each of the criteria. This confrontation should be done as many times as criteria exist (10 criteria = 10 matrixes), because the importance of one alternative over another will depend on the criterion evaluated. We used the same values scale used by Saaty (1980, 2001). Similarly to the first questionnaire and for facilitating the expert task, instructions and a clarifying example of the second and third inquiries were attached. The list of defined objectives for the SAC developed in this work was attached in this inquiry.

Experts should be aware of the objective so they can score the alternative considering that criteria (C9), (Inquiry 3 attached in Annex D).

The Priority Vector

The way to address the results obtained from the experts is by reducing the Pairwise Comparison matrix to a set of scores representing the relative importance of each weight. Those scores are denominated *priority vectors* (PV).

Those PV will be calculated both for the criteria comparison as well as for the alternatives matrixes. The steps of this procedure are the following (Roche and Viejo, 2005) (An example of this process can be found in Annex F):

- Step 1, development of a normalised matrix. Normalise the elements of the matrix by dividing each value by the sum of all values in its column.
- Step 2, calculation of the PV, using each row mean of the normalised matrix.
- Step 3, accounting all the opinions.

Until now the Priority Vector has been calculated using the knowledge of a single expert. For establishing a common PV with the input of all the experts an average value of the results obtained by all of them has to be calculated.

We should keep in mind that the calculation of the PV was done both for the matrix comparing criteria (inquiry 2) as well as for the matrix comparing alternatives (inquiry 3).

At this point, all we have to do is to combine the PV worked out both for each criterion alternatives as well as for the criteria themselves. This will be achieved calculating a Global Priority Vector (GPV).

- Step 4: calculation of the GPV. Generate a new matrix listing the alternatives by row and criteria by column. Fulfil this matrix with the alternative PV values based in each criterion. Develop the GPV of each alternative multiplying the criteria PV by the matrix previously generated.

Ranking the alternatives

At this point, the alternatives will be ranked according to their Global Priority Vector. The most suitable alternatives for our goal will be those with higher GPVs, and they will be ranked from highest to lowest values. Decision-making problem is solved this way.

Calculating the consistency

In decision-making problems it is important to know how good the consistency of judgments is, in order to avoid decisions based on random judgements or judgements with low consistency (Saaty, 1995). Furthermore, it is probable to find inconsistencies when judging the importance of more than two elements. For instance, it may happen that element A is considered preferable than B, B preferable than C, but C preferable than A. Due to this reason it is recommendable to establish levels of (in)consistency. This calculation is possible due to the Consistency Index (CI), developed by Sen and Yang (1998) and Saaty (1980):

$$CI = \frac{\lambda max - n}{n - 1}$$

Where *n* is the matrix order, and λmax the mean value obtained from the division of the weighted sum of the values assigned to each element in the initial matrix multiplied by their respective PV and divided by the its PV.

After obtaining this index, the Consistency Ratio (CR) should be calculated in order to know how appropriate the judgment was. For this ratio we use the already calculated CI and the Random Index (RI) developed by Saaty (1980), obtained from the following table:

Matrix Order	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

Table 2.5: Random Index **Source**: Saaty, 1980

A CR value < 0.1 means that the matrix is consistent, whereas any value > 0.1 indicates inconsistency. However, while a value of 0.9 indicates that the pairwise judgements are random and completely untrustworthy, a value slightly greater than 0.1 indicates that the matrix is slightly inconsistent (Saaty, 1980). With matrixes with an order larger than 9, higher consistency ratios are tolerated (Saaty, 1980). Nevertheless in practice, independently of the matrix order, CRs of more than 0.1 sometimes have to be accepted (Coyle, 2004). An example of calculating this ratio is given in Annex F

CHAPTER 3. RESULTS

Part 1: Objectives of Banco de La Concepción Special Area of Conservation

3.1 Goals and objectives

As commented in the introduction chapter the aim of a Special Area of Conservation (SAC) is to assure the long-term survival of the most valuable and threatened habitats and species by guaranteeing the maintenance and/or reestablishment of a Favourable Conservation Status (FCS). This statement, extracted from the first article of Habitats Directive (HD) explains clearly which the main goal of these marine protected areas (MPAs) should be. Furthermore, as explained along this work, a second supplementary goal of Banco de Concepción SAC is to progress towards its Good Environmental Status (GES) by reducing pressures and improving knowledge. Consequently, all the objectives, which were defined following the criteria and structure described in chapter 2, are oriented towards the consecution of these two goals (Table 3.1).

3.1.1 Environmental objectives

These objectives whose aim is to protect any characteristic of the ecosystem, with the exception of the ecosystem services, have been defined. Two different types of environmental objectives have been considered, one strictly related with the HD goal, and a second one aimed for advancing towards the GES, but without overlapping with the first one.

General Objective	Specific Objective	Operative Task 1	Operative Task 2	Operative Task 3	Operative Task 4
1. Protect and preserve species and habitats of community interest					
1170 Reefs (Annex I)	Natural range and area it covers is stable or increasing	Establish location and spatial structure of 1170 communities + Monitoring trends in spatial structure.	Assess incidence of pressures on communities spatial structure	Human activities should occur at levels not affecting the community spatial structure	If there is insufficient knowledge, minimize activities that may suppose a risk to the spatial structure of the community
	Specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future	Deepen knowledge about complexity and functioning of 1170 communities + Monitoring trends in these attributes	Assess incidence of pressures on communities functioning and complexity	Human activities should occur at levels not affecting the community functioning or complexity	If there is insufficient knowledge, minimize activities that may suppose a risk to the community functioning and complexity
	Conservation status of its typical species is favorable	Identify typical species of 1170 communities and deepen into their conservation status + Monitoring trends in population dynamics of these species	Assess incidence of pressures on typical species of these communities	Human activities should occur at levels not affecting the favorable conservation of these species	If there is insufficient knowledge, minimize activities that may suppose a risk to the favorable conservation of these species
1349 *Tursiops truncatus* & 1224 *Caretta caretta (Annex II)*	Population dynamics data on the species concerned indicate that it is maintaining itself on a long term basis	Deepen knowledge about population dynamics of *T. truncatus* and *C.caretta* + Monitoring population dynamics trends	Assess incidence of pressures on populations of these species	Human activities should occur at levels not affecting the population dynamics of these species	If there is insufficient knowledge, minimize activities that may suppose a risk to populations of these species
	Natural range is neither being reduced nor is likely to be reduced for the foreseeable future	Deepen knowledge of distribution area of these species + Monitoring distribution area	Assess incidence of pressures on distribution area	Distribution area should not be reduced or restricted by artificial barriers	If there is insufficient knowledge, minimize activities that may suppose a reduction of these areas
	There is and will be a sufficiently large habitat to maintain its population on a long term basis	Identify "habitats use" of these species + Monitoring conservation status of habitats being use by these species	Assess incidence of pressures on habitats identified	Human activities should occur at levels not affecting the habitat favorable conservation	If there is insufficient knowledge, minimize activities that may affect the favorable conservation of these habitats

General Objective	Specific Objective	Operative Task 1	Operative Task 2	Operative Task 3	Operative Task 4
Cetacea and *C. longispinus (Annex IV)*	Population as well as certain habitats used by these species should be included in a protection regime	Deepen knowledge about population dynamics of these species + Monitoring population dynamics trends	Assess incidence of pressures on populations of these species	Avoid impacts resulting in captures or killing and avoid disturbance of these species particularly during the period of breeding, rearing, hibernation and migration if they exist. Sites where this happens should be protected as well	If there is insufficient knowledge, minimize activities that may result in captures, killing or disturbance
2.Progress towards a Good Environmental Status	Assure conservation and recovering of marine biodiversity through effective measures and tools	Minimize introduction possibilities or secondary expansion of exotic species	Reduce main mortality causes of non commercial apical predators	Maintain commercially exploited species stocks between safe biological limits	-
	Prevent and reduce spills into the marine environment in order to remove progressively marine pollution	Prevent and reduce incidence and frequency of accidental spills	Prevent and reduce quantity of marine litter throw	Do not overcome pollution established limits for human consumed species	-
3.Aware and involve the public in general and the stakeholders in particular	Build consensus among parts affected fomenting confidence and trust between them	Identification of key stakeholders and representatives	Identification and application of suitable engagement tools and targets	Evaluation and report of the engagement process	-
	Spread values of the SAC and share available information in a comprehensible and accessible way	Development of specific informative and sensitizing programs about the conservation objectives	Creation of suitable pedagogical contents as dissemination tools on different media	-	-
	Release the management plan of the SAC, protection figures and established normative	Redact and approve the management plan and the associated normative	Comprehensible and accessible spreading of the plan	-	-
4.Favor coordination and cooperation between public administrations	Foment institutional collaboration between the different parts with competence over the SAC in order to facilitate the consecution of the developed objectives	Identify institutions with competence over the SAC and their representatives	Keep them informed about updates and changes	-	-

General Objective	Specific Objective	Operative Task 1	Operative Task 2	Operative Task 3	Operative Task 4
4.Favor coordination and cooperation between public administrations	Guarantee regulation, surveillance and sanctioning of activities being developed on the SAC	Development of a surveillance and control plan	Training of the agents in charge	Periodic evaluation of the plan and obtained results	-
	Guarantee effective cooperation between administrations in case of accidental events	Redaction and approval of a action protocol for urgent and risky situations	-	-	-
5.Foment a sustainable use and exploitation of the environment	Promote implantation of professional good practices on implicated sectors	Identification of applicable good practices for each sector	Spread actions defined as good practices	Evaluate the impact of the application of these practices	-
	Promote artisanal fishing arts	Favor the sale of products fished in a sustainable way inside the SAC	-	-	-
	Implant technological improvements able to favor sustainability	Identification of technological improvements appropriated for each implicated sector	Evaluate the utility of the implanted improvements	-	-
6.Favor investigation lines able to deepen into the SAC knowledge	Promote relations with scientific community in order to developed applied investigation to the SAC	Establish agreements with research institutions at a national and international level	-	-	-
	Promote research projects	Detect necessary research lines in order to improve the knowledge about the SAC and impacts of the activities being developed	Enable the creation of a finance instrument for investigation	-	-

Table 3.1: Identified appropriate objectives for the potential SAC of Banco de La Concepción. **Source**: Own elaboration.

To achieve FCS, as stated in the first HD article, both for habitats and for species in annexes II and IV, the first general objective ("Protect and preserve species and habitats of community interest") will be carried out by means of several specific objectives. In this case the specific objectives are based on the requirements defined on HD article 1.

The operative tasks to carry out each of these specific objectives were developed under a common criterion, i.e. to cover all the knowledge gaps existing, both related with the state as well as with the pressures, monitoring trends and controlling activities based either in the best knowledge available or the precautionary principle.

Meanwhile, the second general objective tries to move the system towards the GES and is divided in two specific branches. The first one, which is focused on biodiversity conservation, breaks down in operative tasks aiming for the protection of species with renowned importance not covered by the HD and for the control of invasive species. The second branch is centered on the prevention and reduction of a series of pressures that may escape from the HD coverage, or that at least may have a significant impact on ecosystem attributes not protected by the HD.

3.1.2 Engagement objectives:

The engagement objectives are those directed to promote the participation and consciousness of the parts affected. These objectives have been divided in those focused to the stakeholders and public in general and those designed for the administrations. Despite administrations actually constitute a stakeholder as well, we preferred to reserve them an own section due to their importance in managing MPAs.

Stakeholders and public

Public participation is becoming increasingly embedded in national and international environmental policy, as decision makers recognize the need to understand who is affected by the decisions and actions they take, and who has the power to influence their outcome (Reed *et al*. 2009). Aware of this fact, Natura 2000 guidelines highlight the importance of the engagement of affected parts as vital for the consecution of conservation goals.

The starting conditions of Banco de La Concepción conservation issue are not the ideal for obtaining the cooperation of the users affected, as we explained in the second chapter. Thus, an extra effort has to be done for achieving this goal.

The third general objective, which is to "*Make aware and involve the public in general and the stakeholders in particular"*, is divided as well in three specific objectives:

- "*Build consensus among parts affected fomenting confidence and trust between them*": MPA managers have realized that the active participation of stakeholders in the planning and management of a MPA can improve the success of the MPA (Pomeroy *et al*., 2004). If stakeholders are involved in the MPA, they will feel that their views and concerns are being heard and considered, what will probably lead to a feeling of ownership. This perception makes them more likely to support the MPA. Oppositely, a wrong engagement would mean a poor satisfaction what will without doubt lead to a

more reticent attitude when supporting the MPA. This dissatisfaction may be transformed in a boycott, resulting in environmental and economic losses.

The operative tasks within this point are directed towards the achieving of a consensus among the parts, for which a correct identification of the parts involved and of their representatives, as well as choosing the proper engagement tools for each stakeholder, are fundamental.

Evaluation and report should not be neglected during the process. The actions developed for achieving these tasks should be included in the engagement plan.

- "*Spread values of the SAC and share available information in a comprehensible and accessible way*": The engagement process, although principally focused on the main stakeholders, should not stop there. The general public represents an important puzzle piece because its awareness, instead of its indifference, is of our interest. A conscious public is a very valuable lobbying tool.

  Operative tasks are centered on making the information about the SAC values comprehensible and accessible to the public.

- "*Release the management plan of the SAC, protection figures and established normative*": MPA rules and regulations define specifically what activities are required, permitted and forbidden within the MPA. When stakeholders are aware of and have an understanding of the rules and regulations for management of the MPA, there is a greater chance for the MPA success. Stakeholders may violate rules and regulations if those are not well understood or if they do not make sense to the stakeholders (Pomeroy *et al*., 2004). Again, operative tasks will be related to the production of this information and its broad dissemination.

Administrations

To coordinate adequately the institutions and security forces implied in the management and surveillance is necessary in order to avoid the MPA turning into an obstacle or a *paper-park*. The good management and the demonstrable efficiency of the surveillance is an indispensable factor to the credibility of the protected area (Martín-Sosa *et al.* 2013.).

The specific objectives developed for favouring this coordination are centered on three issues:

- A correct identification of the administrations with responsibilities on the SAC and the role they play.
- To warrant regulation, surveillance and sanctioning. This point is considered crucial for succeeding with the management strategy. A strong and exemplary performance for sanctioning clearly deviated behaviours is convenient, and surveillance formulas should be found for minimizing its costs without diminishing its efficacy. The higher the level of implication and consciousness of the users, the more they will contribute to the surveillance and control tasks. Sharing surveillance, monitoring and enforcement activities with local stakeholders can be effective in controlling non-

compliance behaviour through social and peer pressure (Pomeroy *et al*., 2004, Martín-Sosa *et al*. 2013).

- Clear development of action plans for warranting a fast response in case of emergency situations.

3.3.3 Socio-economic objectives

The management of marine spaces is not only pursuing the preservation of the biodiversity through the protection of habitats and species, but is furthermore trying to assure the sustainability of the marine resources involved and the economy that is depending on them.

The fifth general defined objective is centered on this issue and is divided in three specific objectives trying to:

- Promote the implantation of good practices for improving the sustainability of the professional activities occurring in the zone.
- Create economic opportunities that enhance the profit of the artisanal sustainable fisheries.
- Improve the available technology so that the pressures on the environment can be reduced.

3.3.4 Research objectives

If there are already important knowledge gaps about the Canary Islands' marine ecosystems in general (Martín-Sosa *et al*. 2013.), this situation is even more severe in relation to the deep marine systems. Concretely, the Banco de La Concepción was not studied in detail until the launching of the INDEMARES project, which has been so far the only approach to its knowledge. If this MPA is pretended to be managed with a certain guarantee, taking the proper decisions regarding its conservation, a higher level of knowledge about the ecosystem should be achieved. This is exactly the aim of the last of the general objectives, which can be broken down in two different specific objectives.

First, the promotion of relations with the local, national and international scientific community in order to develop applied investigation into the SAC is considered. The management plan, moreover, considers the need of detecting the knowledge gaps about the SAC, both in its inherent natural characteristics as well as in the quantification of the impact of the activities being carried out there, in order to design the research lines to be considered. In this specific objective we could include the search for public and/or private funding calls from which researchers could benefit.

Part 2: Developed DPSIR framework and identified indicators

3.2 Banco de La Concepción DPSIR conceptual model

This section presents the results obtained from the development of the Driver, Pressure, State, Impact and Response (DPSIR) conceptual model specifically carried out for the Banco de La Concepción ecosystem (Fig. 3.1). As already commented in chapter 2, all the possible existing elements were included in the model independently of the occurrence probability or importance.

3.2.1 Driving Forces and associated pressures

In the second chapter the driving forces were defined as "*natural or human induced factors that can generate certain pressures"* and the pressures as "*particular effect of the driving forces that are the direct sources of alterations in the system*".

As explained in chapter 2, drivers were classified as being far-field and/or near-field depending on being risen outside or inside the study area respectively. Hence near-field drivers and generated pressures can be managed by responses occurring within the protected area, whereas far-field drivers and their corresponding pressures may be managed in broader scales, including areas outside the SAC.

A total of six driving forces were detected generating any type of pressures on the Banco de La Concepción ecosystems. These are the fishing sector, telecommunication sector, transport sector, military sector, energy sector and climate change.

The first driving force identified was the fishing sector, which involves all the fishing taken place within the MPA, so that it is considered a near-field force. This driving force is without doubt the most frequent and important within the MPA, reaching more than 43 vessels specialized vessels in different gears (Almón *et al*., 2014). The most active fleet in the zone is the artisanal fishing dedicated to the handline fishing of tropical tunas, which is composed by 30 vessels based in the Canaries. Associated to this fishery and with the aim of obtaining live bait, purse seine fisheries of small pelagic is also developed (Almón *et al*., 2014). After the tuna fisheries, the fishing with bottom logline is the second with highest intensity, followed by surface and vertical longlines (Almón *et al*., 2014). Target species of these fisheries can be consulted in annex A.

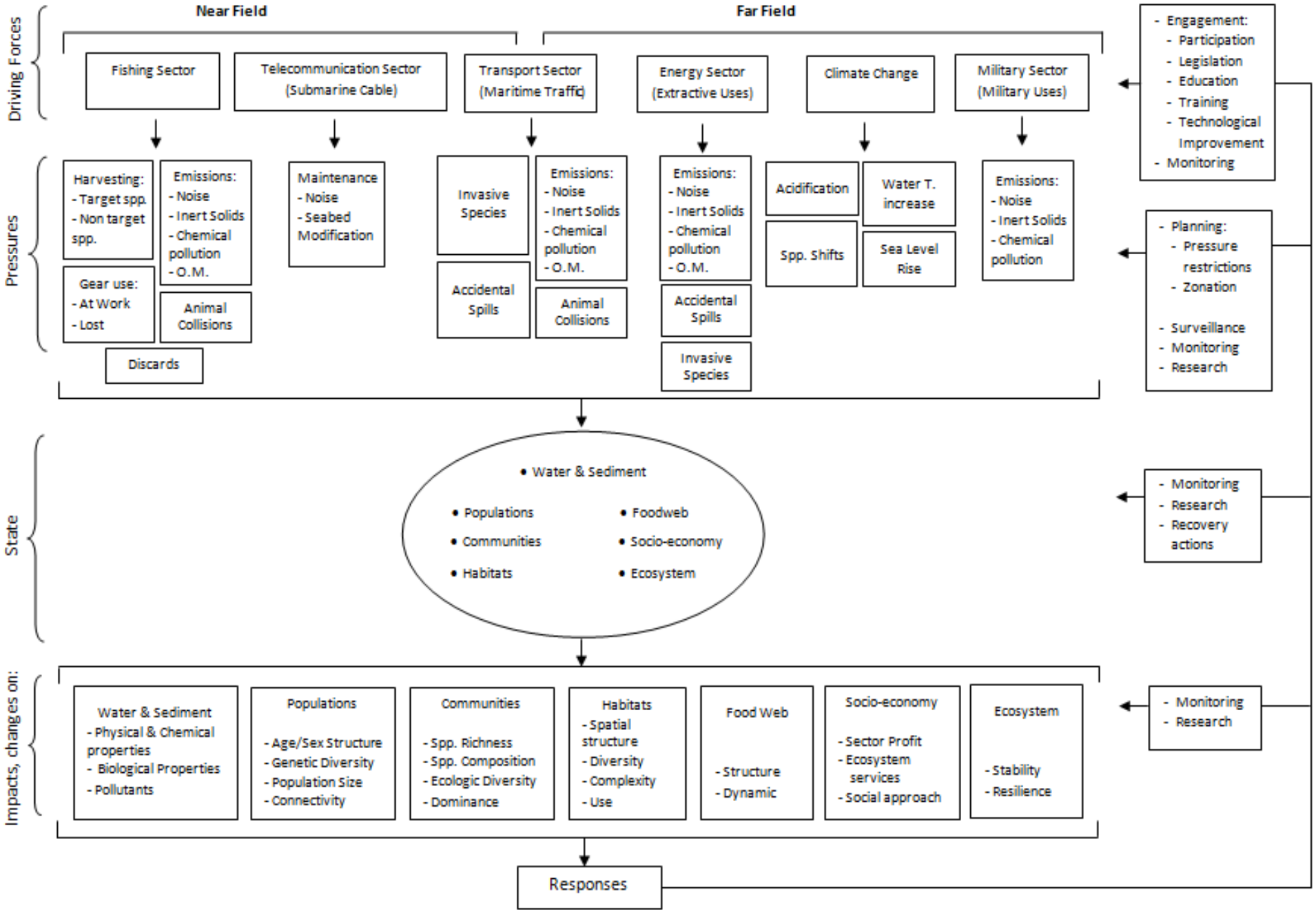

Figure 3.1: DPSIR conceptual framework for Banco de La Concepción SAC. Arrows represent the cause-effect relationships. *OM=Organic matter. **Source**: Own elaboration.

Although in the past Banco de La Concepción was very frequented by trawlers, after 2002 there are no signs of such trawling activity in the area. A likely consequence of this activity is that habitats such as soft sands with sea urchins appear today dominated by one or few species, symptom of an ecosystem equilibrium loss (Almón *et al*., 2014).

Fishing can exert pressures over the marine environment in different ways, from which at least five have been identified in this model: i) the harvesting of the resources itself, affecting both target and not target species at levels that surpass the regeneration capacity of the stocks; ii) the indirect pressure produced by the gear use itself, both when being used or if it is lost during the fishing; iii) the emissions and waste generated from the fishing activity, including noise, litter dropped from the deck, both of solids as well as organic material and chemical pollutants (hydrocarbons); iv) collisions of the boats with pelagic fauna, and finally v) effects of discards on the environment.

The telecommunication sector is included as well in this conceptual framework due to the presence within the limits of the MPA of an underwater communications cable. Pressures associated to this force will be noise and seabed modifications in case of working for maintenance, withdrawal or placement of new installations.

The transport sector, very likely the second force with highest importance within the MPA, makes reference to the maritime traffic in or near the Banco de La Concepción, what justify its classification as near and far field driver. This traffic is intense due to the location of the bank close to a maritime traffic highway, which goes through the channel between Fuerteventura and Gran Canaria. Moreover, the traffic concentration in the eastern part of the MPA is due to the ships that surround Fuerteventura and Lanzarote by their leeward coast. Here, any type of ships can be found, from passengers vessels to tankers, cargo or bulk carriers. Four main pressures derive from this sector: i) likelihood of invasive species introduction due to vessels' hull hitchhiking or due to release of ballast waters; ii) emission of noise, solid and organic litter and chemical pollutants. iii) collisions of boats with pelagic fauna, and iv) possibilities of accidental spills.

The energy sector is included as relevant far-field force due to the frequency of extractive uses in the Canarian waters. Nowadays there are not current exploitation permissions at the study zone and as SCI it is unlikely that there will be in the future. Nevertheless, in the proximities (40 km off Lanzarote) there were mining exploration concessions valid until January 2016 and it is possible that new ones will be permitted. Far-field pressures derived from this activity are emissions both of noise as well as of organic and inorganic waste or chemical pollutants, possibilities of accidental spills and introduction of invasive species through hitchhiking or simply swimming around the oil platforms that act due to their low translation speed and the tropical location of their last destination as mobile coral reefs (Falcón, 2015).

As extractive uses, the military ones do not take place within the MPA, but there are military exercises that occur in waters relatively close to the MPA (WWF, 2013). The pressures derived from this sector are basically emissions again; concretely noise, inert solids and

chemical pollution. Nevertheless noise emissions should not be a major issue any more after the passing in 2004 of the Canary Islands waters Moratorium which bans the deployment of high-intensity sonar until the completion of a global assessment of its effects on marine life (Fernández *et al*., 2013)

The last driver included in this DPSIR model is climate change as an exclusive far-field driver. Four pressures are identified as a consequence of this force: ocean acidification, water temperature increase, sea level rise (Kelbe *et al*. 2013) and species shift. This last pressure refers to the shift in species composition due to the new environmental conditions created by climate change (Falcón, 2015.).

3.2.2 State and Impacts

The next levels of the DPSIR model are states, defined as *"conditions of the attributes of the system at a specific time*" and impacts defined as "*changes on the state defined attributes over a time period due to the defined pressures".* As explained in the second chapter, the model state level was depicted with seven attributes of the system representing a hierarchy with the ecosystem: water column and sediments, populations, communities, habitats, food web, socio-economy and ecosystem itself. At the same time for the impact level the characteristics of each state attribute that could be modified by the defined pressures were identified.

Those are: i) physical and chemical properties, biological properties and pollutants concentration of the water column and sediment, ii) age and sex structure, genetic diversity, connectivity and size of populations, iii) spatial structure, diversity, complexity and habitat use, iv) species richness, species composition, dominance and ecological diversity of communities, v) structure and dynamic of the food web, vi) sector profit, ecosystem services quality and social approach of socio-economical attribute and vii) stability and resilience of the ecosystem.

3.2.3 Responses

The responses were defined as "*actions made by society as result of the shifts manifested on the system*" and they will vary according to the degree of their implementation. Some identified responses include: i) monitoring and research in relation to impacts, ii) monitoring and research plus recovery actions for the state, iii) zonation and restrictions together with monitoring research and surveillance for pressures and iv) monitoring and engagement in the form of participation, legislation, education, training and technological improvement for the driving forces.

3.3 Defined indicators

Through an analysis of all the information synthetized in the model, a total of 144 indicators were defined and classified within the DPSIR framework. Tables 3.2, 3.3, 3.4 and 3.5 gather all the defined variables that can be used as potential indicators specifically for Banco de La Concepción MPA. The tables also provide information about how each of the indicators should be applied and short explanatory observations were considered necessary in cases. Reference about where the indicator has been consulted and a code that will identify the indicator for the rest of the work are added as well.

3.3.1 Driving forces indicators:

Table 3.2 collects a total of 15 indicators applicable to the six forces identified. The indicators selected for this level should be able to embrace all the pressures that these specific sectors exerts over the future SAC.

Code	Indicator	Measures pressures of	Applicability	Observation	Reference
1001	Fleet capacity	Fishing Sector	By gear	Number of fishing boats that fish on the SAC	Piet *et al.*, 2007
1002	Fishing effort	Fishing Sector	By gear, by boat	Hours or days at sea inside the SAC	Piet *et al.*, 2007
1003	Total area fished &/or Proportion over total surface	Fishing Sector	By gear	-	Piet *et al.*, 2012
1004	Km cable inside SAC	Submarine Cable	By cable type	-	▪
1005	Nº reparations, installations or removal actions per year	Submarine Cable	By cable type	-	▪
1006	Nº vessel passing through SAC	Maritime Traffic	By vessel type	Total number of vessels per month or year	▪
1007	Nº vessel passing/operating at same time inside SAC	Maritime Traffic	Total, by sector, by vessel type	-	▪
1008	Vessel average time inside SAC	Maritime Traffic	By vessel type	-	▪
1009	Nº licenses granted	Extractive Uses	By resource nature	-	▪
1010	Nº platform installed and distance to SAC	Extractive Uses	By structure	-	▪
1011	Global CO_2 emission	Climate Change	General	-	US EPA, 2016
1012	Atmospheric concentration greenhouse gases	Climate Change	General	-	US EPA, 2016

Code	Indicator	Measures pressures of	Applicability	Observation	Reference
1013	Ocean heat content	Climate Change	General	Observed change in global heat content (Joules)	US EPA, 2016
1014	Sea ice total coverage	Climate Change	General	-	US EPA, 2016
1015	Nº maneuvers and distance to SAC	Military Uses	By type	Nº maneuvers per month or year	▪

Table 3.2: List of potential driving force indicators developed from the DPSIR conceptual framework. *▪: Not referred to a specific bibliographic source. **Source**: Own elaboration.

3.3.2- Pressures indicators

Table 3.3 offers 30 indicators identified for the pressures level. For this case the indicators are characterized by being able to quantify a specific pressure, without considering if this pressure is produced by one single force or by a combination of some of them. In case that the pressure should be measured outside the SAC, it is stated in the observation column.

Code	Indicator	Measured pressure	Applicability	Observation	Reference
2001	Catch per unit effort (CPUE)	Harvesting	-	-	Ojeda-Martínez *et al.*, 2008
2002	Total biomass extracted	Harvesting	By gear/ boat By species	Kilograms of extracted biomass	Ojeda-Martínez *et al.*, 2008
2003	Annual fishing mortality	Harvesting	Target & Non target	-	Piet *et al.*, 2007
2004	Total area used by gear	Gear use	-	-	Ojeda-Martínez *et al.*, 2008
2005	Time gear is at work	Gear use	Over habitat	-	Piet *et al.*, 2007
2006	Length Net / Nº Hooks	Gear use	Over habitat	Length of the net over a type of habitat. Number of hooks over a type of habitat	Ojeda-Martínez *et al.*, 2008
2007	Areas impacted by mobile bottom gears	Gear use	-	Currently no trawling in the SAC	ICES, 2012
2008	Reported lost gears	Gear use	By gear type	Number of fishing gears lost	Ojeda-Martínez *et al.*, 2008
2009	Reported animal collisions	Animal collisions	By type of vessel, By family /species	Number of reported collisions	▪
2010	Discard rate	Discards	By gear	Ratio of discards to landings	Fulton et al., 2004
2011	Discard rate of commercially exploited species	Discards	By boat	Measurement of "Highgrading". Not anymore after Discard ban implementation	ICES, 2012

Code	Indicator	Measured pressure	Applicability	Observation	Reference
2012	Bycatch per unit effort	Discards	All, Vulnerable spp. By gear,	If possible record age of protected spp.	Meager and Sumpton, 2016
2013	Hydrocarbons consumed	Emissions	By sector	Liters of hydrocarbons consumed inside de SAC	Ojeda-Martínez *et al.*, 2008
2014	Volume Gas/Oil extracted	Emissions	By platform	Outside SAC	▪
2015	Organic matter thrown	Emissions	By sector	Kilograms of organic matter thrown to the sea	Ojeda-Martínez *et al.*, 2008
2016	Inert solids thrown	Emissions	By sector	Kilograms of inert solids thrown to the sea	▪
2017	Proportion of days exceeding anthropogenic sound established levels	Emissions	By sector, by activity (construction, exploration or exploitation)	Impulsive noise indicator	Dekeling *et al.*, 2014
2018	Trends annual average sound pressure	Emissions	-	Continuous noise indicator	Dekeling, *et al.*, 2014
2019	Volume of material removed / relocated	Maintenance of underwater cables	-	Seabed material	▪
2020	Reported leaks	Accidental spills	By sector	Volume/ time unit Inside & Outside SAC	▪
2021	Nº accidental events	Accidental spills	By sector	Per year Inside & Outside SAC	▪
2022	Accumulate Nº of alien species	Invasive species	-	-	Orendt *et al.*, 2009
2023	Occurrence of invasive Alien species	Invasive species	-	-	McGeoch *et al.*, 2015
2024	% Area affected by invasive species	Invasive species	By habitat, by community	Sessile species	McGeoch *et al.*, 2015
2025	Dissolved carbon dioxide	Acidification	-	-	USEPA, 2015
2026	pH	Acidification	-	-	USEPA, 2015
2027	See Surface Temperature	Water T. increase	By season	-	Philipart *et al.*, 2011
2028	Concepción summit Depth	Sea level rise	-	-	▪
2029	Distance summit to photic zone	Sea level rise	-	-	▪
2030	Records tropical species	Species shits	-	-	▪

Table 3.3: List of potential pressure indicators developed from the DPSIR conceptual framework. *▪: Not referred to a specific bibliographic source. **Source**: Own elaboration.

3.3.4 State/Impacts indicators

Table 3.4 shows the 48 indicators identified for state/impact level. Variables compiled in this table measure the state of the system at a specific time point. Continuous measurement of these variables in a time gradient will inform about possible impacts.

Code	Indicator	Measuring Impacts on	Applicability	Observation	Reference
3001	Turbidity	Water quality		-	OMARCOST, 2013
3002	Salinity	Water quality		-	OMARCOST, 2013
3003	Temperature	Water quality		-	OMARCOST, 2013
3004	Dissolved O_2	Water quality		-	OMARCOST, 2013
3005	Nutrients concentration	Water quality		-	OMARCOST, 2013
3006	Chlorophyll a concentration	Water quality/ Food-web dynamic		-	ICES, 2014
3007	O_2 & sulfide concentration	Sediment quality		-	Piet and Hintzen, 2012
3008	Areal extent of O_2 depletion	Sediment quality	By habitat	-	Rice *et al.*, 2012
3009	Pollutants concentration	Sediment quality	Sediment	Heavy metals, PAH's, PCB´s, OCP´s	EMDC, 2012
3010	Vol./Density macroplastics at surface	Water quality		-	Ojeda-Martínez *et al.*, 2008
3011	Density inert solids at seabed	Seafloor quality	By habitat	-	▪
3012	Report Nº individuals affected by inert solids	Water quality	Vulnerable spp.	-	▪
3013	Large Fish Indicator (LFI)	Population size structure/ Food web structure	Target spp.	Proportion of total fish biomass exceeding a specified threshold length	Modica *et al.*, 2014
3014	Age/ Sex structure	Population age/sex structure	Vulnerable spp. Target spp.	-	▪
3015	Density/ Total abundance	Population size	Vulnerable spp. Target spp. Sensitive spp. Endemic spp. Keystone spp.	-	ICES, 2015
3016	Total Biomass	Population size	Keystone spp. Sensitive spp.	-	EMDC,2012

Code	Indicator		Measuring Impacts on	Applicability	Observation	Reference
3017	Calves ratio		Habitat use	Vulnerable spp.	-	▪
3018	Spawning Stock Biomass		Population fitness	Target spp.	-	Piet *et al.*, 2007
3019	Genetic diversity Index		Genetic diversity	Target spp. Vulnerable spp.	-	▪
3020	Phylogeographic structure		Connectivity	Vulnerable spp. Endemic spp. Keystone spp.	Haplotype cross-comparison other seamounts / regions	▪
3021	Extent of Habitats / Communities		Habitat spatial structure	-	Area, Depth	MAGRAMA, 2012b
3022	Habitat & communities diversity		Habitat diversity	-	-	▪
3023	Biomass structuring species		Habitat complexity	By community	-	MAGRAMA, 2012b
3024	Density structuring species		Habitat complexity	By community	-	MAGRAMA, 2012b
3025	Rugosity Index		Habitat complexity	By habitat By community	-	Dustan *et al.*, 2013 ICES, 2015
3026	Bioturbation potential (BPc)		Habitat functioning		-	ICES 2015
3027	Richness		Species richness	By community	-	ICES,2015
3028	Relative abundance		Species composition	By community	Species list with reference to abundance	ICES,2015
3029	Proportion invasive/ natives (PIN)		Species list	By habitat By community	-	MAGRAMA, 2012a
3030	Ratio Opportunistic/Sensitive		Species list	By community	-	Rice *et al.*, 2012
3031	Hill Indices	Richness	Richness	By community	-	▪
3032		Shannon/ Simpson	Ecologic Diversity			ICES 2015
3033		Berguer-Parker	Dominance			Ojeda-Martínez *et al.*, 2008
3034	Beta diversity		Ecologic diversity	By community	-	Rice *et al.*, 2012
3035	Biomass/Productivity key trophic groups*		Foodweb structure		-	ICES,2014
3036	Mean weight Zooplankton key groups		Foodweb dynamic/ functioning		-	ICES,2014

Code	Indicator	Measuring Impacts on	Applicability	Observation	Reference
3037	Mean weight at age of predatory fish*	Foodweb dynamic/ functioning	Only for non migratory apical predator	-	ICES,2014
3038	High Trophic level Indicator (HTI), Apex Predator Indicator (API)*	Foodweb dynamic		Data income unclear: Landings, surveys, modeling?	Bordaud *et al.*, 2016
3039	Income fishing sector	Socio-economy		-	Ojeda-Martínez *et al.*, 2008
3040	Nº young bellow age of 35 working in the sector	Socio-economy		-	▪
3041	Per capita income of the sector	Socio-economy		-	Ojeda-Martínez *et al*, 2008
3042	Nº boats registered	Socio-economy		-	▪
3043	Nº Jobs / Employment	Socio-economy		-	▪
3044	Nº families associated with fishing sector	Socio-economy		-	Rodríguez-Rodríguez and Martínez-Vega, 2016
3045	Pollutants concentration on captured fish	Socio-economy	Target spp.	-	MAGRAMA, 2012c
3046	Perception conservation state	Socio-economy		Stakeholders and public perception of the conservation state	Rodríguez-Rodríguez and Martínez-Vega, 2016
3047	Perception seafood availability	Socio-economy		Stakeholders perception of seafood availability	Pomeroy *et al.*, 2004
3048	Early Warning Signals	Ecosystem stability and resilience		Resilience quantification	Kéfi *et al.*, 2013

Table 3.4: List of potential state/ impact indicators developed from the DPSIR conceptual framework. *▪: Not referred to a specific bibliographic source. **Source**: Own elaboration.

3.3.5 Response indicators

The last of the tables (3.5) includes with their numerical codes the 50 indicators identified for the response level.

Code	Indicator	Measures response of:	Applicability	Observation	Reference
4001	Surface SAC	General management		-	Ojeda-Martínez *et al.*, 2008
4002	Degree fulfillment objectives SAC	General management	By objectives	-	▪

Code	Indicator	Measures response of:	Applicability	Observation	Reference
4003	Frequency of updates and revision of key management elements	General management	Objectives, DPSIR, indicators, plans, etc.	-	▪
4004	Monitoring budget	Monitoring		-	▪
4005	Nº contracts on monitoring program	Monitoring		-	▪
4006	Nº reports produced by monitoring program	Monitoring		-	▪
4007	Nº and frequency of surveys	Monitoring	By pressure, by impact	-	▪
4008	In situ survey effort (hours at sea)	Monitoring		-	▪
4009	Budget research projects	Research	By pressure, by impact		Ojeda-Martínez *et al.*, 2008
4010	Nº research projects per year	Research			Ojeda-Martínez *et al.*, 2008
4011	Outreach project	Research		Nº publications, conferences, media, etc.	▪
4012	Nº collaboration agreements with other scientific institutions	Research			▪
4013	Nº new investigation lines detected / promoted	Research	By line		▪
4014	Budget recovery actions	Recovery actions	By objective		Ojeda-Martínez *et al.*, 2008
4015	Nº actions taking place	Recovery actions	By impact		▪
4016	Budget surveillance	Surveillance	Total, by sector, by pressure		Ojeda-Martínez *et al.*, 2008
4017	Surveillance effort	Surveillance	By pressure		▪
4018	Nº sanctions /year	Surveillance	By sector, by pressure		▪
4019	Nº contracts surveillance project	Surveillance			▪
4020	Zoning surface	Planning	By use		Ojeda-Martínez *et al.*, 2008
4021	% Non take zone over total surface	Planning			▪
4022	Total nº implanted limitations	Planning	By pressure		▪

Code	Indicator	Measures response of:	Applicability	Observation	Reference
4023	Nº legislation changes	Engagement / Planning	By Sector		Ojeda-Martínez *et al.*, 2008
4024	Nº administration playing a role on SAC	Engagement			▪
4025	Perception of coordination between administrations	Engagement			▪
4026	Ratio affected parts/contacted parts	Engagement		"This ratio will let us know if we are ignoring key parts in the engagement process or if on the other hand we are engaging more parts than necessary "	▪
4027	Nº engagement tools used	Engagement	By stakeholder		▪
4028	Nº times applied tool has been repeated / updated	Engagement	By tool	i.e. nº meetings with the part, webpage updates, nº workshops, etc	▪
4029	Nº reports produced during engagement process	Engagement			▪
4030	Budget engagement actions	Engagement	By tool		Ojeda-Martínez *et al.*, 2008
4031	Nº submission received	Engagement	By stakeholder	Nº answers obtained from active stakeholders (i.e. ONG's) after engagement process	▪
4032	Level stakeholder participation and satisfaction with management	Engagement	-		Pomeroy *et al.*, 2004
4033	Level stakeholder involvement in surveillance	Engagement	-		Pomeroy *et al.*, 2004
4034	Level of resource conflict	Engagement			Pomeroy *et al.*, 2004
4035	Local sense of approval	Engagement	-		▪
4036	Local understanding of SAC rules and regulations	Engagement	-		Pomeroy *et al.*, 2004
4037	Nº platforms created for information dissemination	Engagement			▪
4038	Nº of Tech. improvements detected/applied	Engagement	By sector		▪

Code	Indicator	Measures response of:	Applicability	Observation	Reference
4039	Budget invested on technological improvement	Engagement	By sector, by pressure		Ojeda-Martínez *et al.*, 2008
4040	Nº good practices identified/ implanted	Engagement	By sector		▪
4041	Nº educational programs / year	Engagement		Information + awareness	Ojeda-Martínez *et al.*, 2008
4042	Nº actions implemented to broadcast action protocols and codes of good practices	Engagement	By sector, by type	Related to good practices (i.e. training programs)	▪
4043	Budget educational programs	Engagement			Ojeda-Martínez *et al.*, 2008
4044	Budget training programs	Engagement		Related to good practices and sustainable use	▪
4045	Legislation changes	Engagement	By sector		Ojeda-Martínez *et al.*, 2008
4046	Existence of measures to favor artisanal fishing	Engagement			▪
4047	Existence and adoption of an action protocol in case of risk situations	General management			▪
4048	Existence and adoption of a management plan and associated regulations	General management			Pomeroy *et al.*, 2004
4049	Existence and adoption of an engagement plan	General management			▪
4050	Existence and adoption of a monitoring plan	General management	-		▪

Table 3.5: List of potential response indicators developed from the DPSIR conceptual framework. * ▪: Not referred to a specific bibliographic source. **Source**: Own elaboration.

Part 3: Experts' consultancy and AHP method results

3.4 Selected indicators

As result of the analysis of the information generated by the experts in the first inquiry an evaluation of the 114 indicators identified (Annex G) was obtained. Table 3.6 compiles the indicators that surpassed the selection process and have taken part in the next questionnaire phase. From the starting 114 indicators only 18 (15%) were evaluated with the Analytical Hierarchy Process (AHP) method.

Code	Indicator	Level	Measure of	Score
1002	Fishing effort (hours fishing or days at sea)	Driving Forces	Fishing	7.4
1003	Nº platform installed and their distance to SAC	Driving Forces	Extractive uses	6.3
1007	Nº vessel passing/operating at same time inside SAC	Driving Forces	Maritime traffic	6.1
1010	Total area fished and/or proportion over total surface	Driving Forces	Fishing	6.1
2001	Catch per unit effort (CPUE)	Pressures	Harvesting	7.2
2002	Total Biomass extracted	Pressures	Harvesting	7.1
2012	Bycatch per unit effort	Pressures	Bycatch	6.8
2003	Annual fishing mortality	Pressures	Harvesting	6.6
3015	Density / Total abundance	State-Impact	Populations	7.6
3022	Habitat & communities diversity	State-Impact	Habitat / Communities	7.0
3021	Extent of Habitats / Communities	State-Impact	Habitat / Communities	6.9
3114	Age/ Sex structure	State-Impact	Populations	6.9
3016	Total Biomass	State-Impact	Populations	6.8
4033	Level stakeholder involvement in surveillance	Response	Engagement	7.1
4050	Existence and adoption of a monitoring plan	Response	General management	7.1
4036	Local understanding of SAC rules and regulations	Response	Engagement	6.8
4016	Budget surveillance	Response	Surveillance	6.8
4032	Level stakeholder participation and satisfaction with management	Response	Engagement	6.8

Table 3.6: Selected indicators for the AHP method evaluation ordere in each group by decreasing sceres. Blue: driving forces, Red: pressures, green: state/ impacts, orange: responses. Scores values explained in chapter two and Annex D. **Source:** Own elaboration

Within the driving forces level, the four indicators with the highest value are measures of three of the six drivers identified, concretely two are focussed on fisheries, one on other extractive uses and the fourth on maritime traffic. Moreover, three out of four selected pressure indicators are centered on harvesting, and the remaining one on the bycatch. For the impact/state level, from the five best-scored indicators, three focussed on "populations" and two on "habitats and communities". Finally, from the five selected response indicators, three concentrate on engagement responses, one on surveillance and the last on management general questions.

3.5 Selected criteria

The experts' response to the second questionnaire provided the necessary information for carrying out the selection of the 10 criteria to be used for the alternatives evaluation.

Table 3.7 shows the weight obtained by each criterion after applying the pairwise comparison characteristic of the AHP method. Notice that all the weights or priority vectors (PVs) have been multiplied by 100 in the column "Score" in order to make the numbers easy to work with and understandable.

Code	Criteria	PV	Score
Data quality			
C1	Existing and ongoing data	0.067	6.68
C2	Consistency	0.055	5.47
C3	Tangibility	0.068	6.82
C4	Quantitative vs. qualitative	0.063	6.32
C5	Representative or repeatability friendly	0.045	4.45
C6	Sensitivity	0.121	12.12
C7	Early warning / Preventive	0.102	10.19
C8	Scientific credibility	0.06	6.03
Management			
C9	Relevant to defined objectives	0.098	9.82
C10	Comprehensible	0.082	8.22
C11	Cost-effectiveness	0.102	10.17
Others			
C12	Cross-applicability	0.033	3.27
C13	Independence	0.042	4.20
C14	Established	0.062	6.21

Table 3.7: Weight and selection of criteria by AHP method. Red: rejected, green: accepted. Priority Vector values were obtained by application of the AHP method. Score was obtained by multiplying by 100 the priority vector**. Source**: Own

The lowest PV scores were obtained by the criteria C2: “Consistency”, C5: “Representative or repeatability friendly”, C12: “Cross-applicability” and C13: “Independence”, so that they were not considered in the evaluation alternatives. On the other hand, according to our expert panel, C6 “Sensitivity” emerges as the most important criterion when selecting an indicator.

The consistency ratio was calculated for each expert response matrix. However as explained in Annex B, one of this work assumptions is to consider as acceptable an consistency ratio lower than 0.3, due to the high order (14) of the analysed matrix.

From a total of 15 experts, only 9 answered this questionnaire. From the answers obtained only two of them showed a CR > 0.3, so that they were considered as inconsistent and thus rejected.

3.6 Indicator suitability

The last inquiry provided the information needed for weighting the indicator alternatives according to each criterion. The processing of this information together with the weighting obtained in the last step, allows us to calculate the Global Priority Value (GPV) of each alternative, or in other words, the suitability degree of each indicator for the SAC monitoring. Table 3.8, which compiles the GPV obtained, ranked the indicators in decreasing order of importance classifying them by DPSIR levels.

Again, nine experts answered this third questionnaire, although not the same ones as the last occasion. For this analysis a CR < 0.2 was considered valid and all the matrixes with a higher ratio were rejected. Rejecting a matrix does not mean rejecting all the matrix of the concerned expert, but only those that do not meet the Consistency Ratio value required. Due to this decision not all the alternatives comparisons counted with nine different opinions. Actually, in four cases we count with less than seven opinions, what implies a violation of the minimal number of opinions required for the Delphi procedure, driving us to another assumption of this work (see Annex B).

Regarding the driving forces level results, the indicator “Fishing effort”, which quantifies the professional fishing activity in the MPA, stands clearly above the rest of indicators.

The second indicator considered more suitable for this level was again related with the fisheries sector: “Total area fished and/or proportion over total surface”. Then, the maritime traffic indicator. “Number of vessels passing/operating at same time inside SAC “was selected and finally, the list ends with an extractive uses indicator: “Number of platforms installed and their distance to SAC”.

As for the pressures level, again an indicator is clearly standing above the rest, namely “Catch per unit effort (CPUE)”, which is responsible of measuring the harvesting pressure. After this one, “Total Biomass extracted“ is scored as the second in importance, followed by “Bycatch per unit effort” and by the harvesting indicator “Annual fishing mortality.”

Driving Forces					Pressures				
Code	**Indicator**	**Measure of**	**Application**	**GPV***	**Code**	**Indicator**	**Measure of**	**Application**	**GPV***
1002	Fishing effort	Fishing	By gear	0.316	2001	Catch per unit effort (CPUE)	Harvesting	-	0.316
1003	Total area fished &/or Proportion over total surface	Fishing	By gear	0.179	2002	Total Biomass extracted	Harvesting	By gear, by boat	0.194
1006	Nº vessel passing/operating at same time inside SAC	Maritime traffic / Fishing	Total, by sector, by vessel type	0.171	2012	Bycatch per unit effort	Bycatch	Total, vulnerable spp., Target spp.	0.161
1010	Nº platform installed and their distance to SAC	Extractive uses	By structure	0.160	2003	Annual fishing mortality	Harvesting	Target and non target spp.	0.155
State / Impacts					**Responses**				
Code	**Indicator**	**Measure of**	**Application**	**GPV***	**Code**	**Indicator**	**Measure of**	**Application**	**GPV***
3021	Extent of Habitats / Communities	Habitat spatial structure	-	0.189	4050	Existence and adoption of a monitoring plan	General management	-	0.219
3015	Density/ Total abundance	Population size	Vulnerable spp., Target spp., Keystone spp., Endemic spp., Sensitive spp.	0.186	4016	Budget surveillance	Surveillance	Total, by sector, by pressure	0.211
2022	Habitat & communities diversity	Habitat diversity	-	0.177	4032	Level stakeholder participation and satisfaction with management	Engagement	-	0.135
3026	Total Biomass	Population size	Keystone spp., Sensitive spp.	0.149	4033	Level stakeholder involvement in surveillance	Engagement/ Surveillance	-	0.133
3024	Age/ Sex structure	Population structure	Target spp., Vulnerable spp.	0.125	4036	Local understanding of SAC rules and regulations	Engagement	-	0.129

Table 3.8: Suitability of each indicator determined by the AHP method *GPV: Global Priority Vector. **Source:** Own elaboration

GPV for suggested indicators are much more equilibrated for the state/impact level. The list is headed by the indicator evaluating habitat and community attributes "Extent of Habitats/Communities". With a similar score, the indicator "Density/Total abundance", applicable to population attributes and population size characteristics, appeared. In the third position an indicator describing the diversity of the habitats was chosen, and after this first three and separated from them by a significant gap in GPV, two population attributes

indicators such as “Total Biomass” y “Age/Sex structure” emerged.

Finally, experts considered “Existence and adoption of a monitoring plan” and “Budget surveillance” as the most suitable response indicators, both with very similar score. After them and separated by a small gap we can find “Level stakeholder participation and satisfaction with management”, “Level stakeholder involvement in surveillance” and “Local understanding of SAC rules and regulations”.

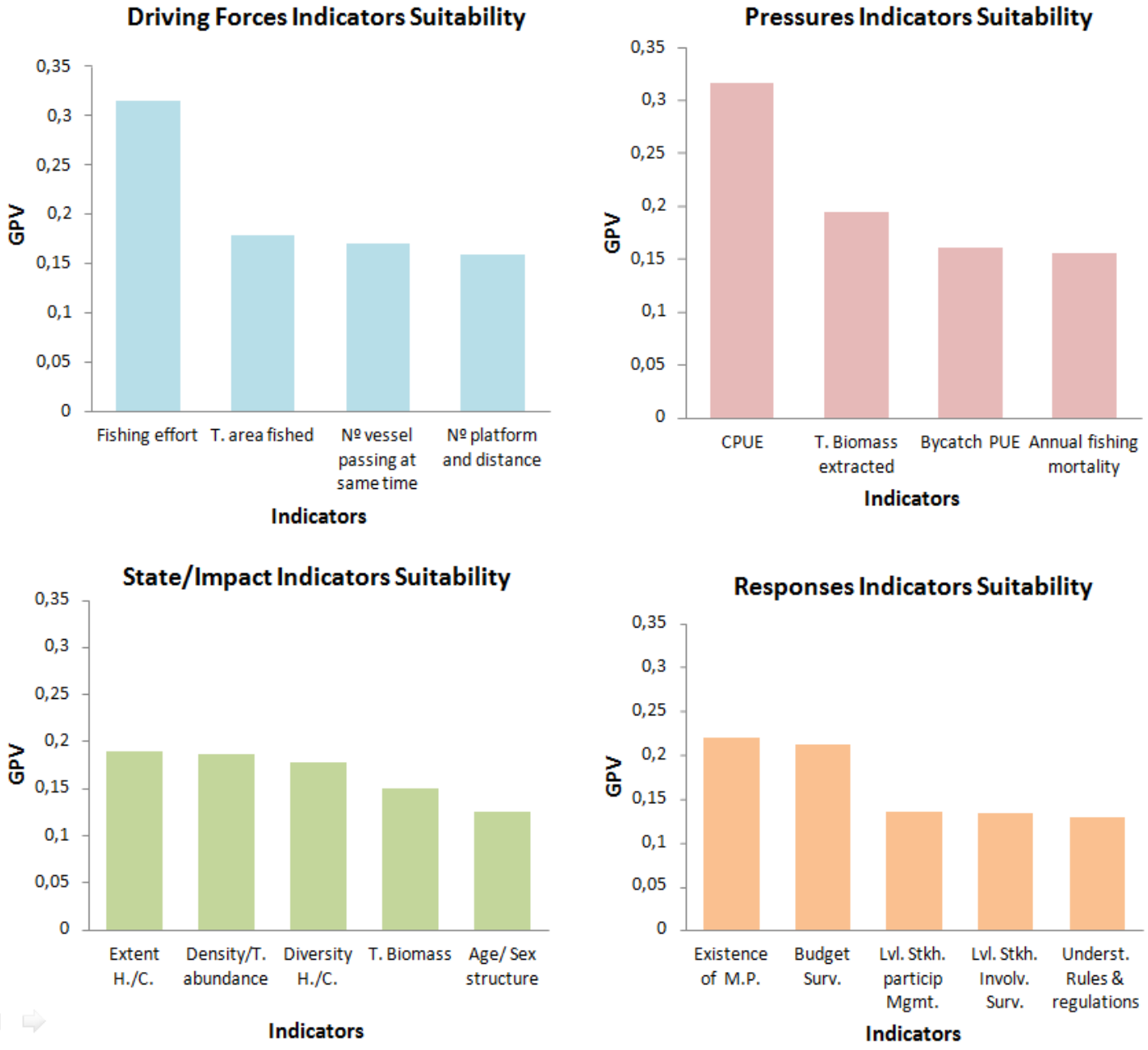

Figure 3.2: Bar-plots representing the Global Priority Vector (GPV) of each indicator per level. T: Total, H./C.: Habitat /Community, M.P.: Monitoring Plan. **Source:** Own elaboration

CHAPTER 4. DISCUSSION

4.1 About the results

At this point we have achieved to address all the specific objectives planned for this work, obtaining a series of results, each of them constituting the basis for generating the following one. At first, the definition of the Special Conservation Area (SAC) objectives was made, moving on to the DPSIR development and the indicators selection stemming from this procedure, to end with the Delphi method application and the multi-criteria analyses for the indicators selection and suitability calculation.

Focusing in the last phase of the results (chapter 3, part 3), the Delphi method application permits to obtain from the experts a selection of the indicators that were considered as most relevant for our purposes (Table 3.6). Analysing each one of the blocks we realized that the results obtained match in a logic way with the protected zone characteristics, reflecting as well some points to be highlighted.

Regarding the driving forces block we can observe how the experts have opted for fishing, maritime traffic and extractive uses indicators. As already mentioned in chapter 3, both fishing and maritime traffic are by far the more important driving forces acting on the zone, what justifies their election, whereas the election of an extractive uses indicator could rest on the high impact risk of such activities. The importance of fishing over any other driving force is clearly reflected in the fact that half of the selected indicators (2 of 4) quantify this activity.

The importance of the fishing sector is exceedingly reflected in the pressures level, where all the indicators are focusing fishing pressures, such as “harvesting” or “bycatch”. A priori, it may be surprising the importance received by the harvesting pressure (3 of 4 of the selected indicators), especially because it is not directly affecting the issues protected by the HD. However, the reason for its election is a clear symptom that the highest pressure affecting the system is the harvesting, and that it is more convenient to address the situation from an

comprehensive protection perspective not based exclusively in the pressures pointing directly to the HD protected elements.

However, pressures such as "gear use", which can affect directly the habitat 1170 favourable conservation status (FCS), do not even appear as considered in the selection block. This can be likely due to the fact that the fishing activities carried out in Banco de La Concepción are not characterized for producing big impacts on the seabed (Martín-Sosa *et al*. 2013.).

To the detriment of this pressure, bycatch does appear, very likely related with the high bycatch ratio produced by the longlines, especially on *Caretta caretta*, a species of community interest (Luchetti and Sala, 2010).

Regarding state/impact indicators, the experts have preferred indicators related with population and habitat characteristics, very likely considering that this level is better framed within the SAC main goal, which is the maintenance and/or reestablishment of the Favourable Conservation Status (FCS).

Finally, regarding the response indicators, the majority are focused towards the stakeholders' engagement, reflecting the experts' awareness with the relevant role that stakeholders have to play in the protection of a SAC such as Banco de La Concepción.

After the multicriteria analysis for the decision making has been carried out, the indicators priority shifts in most cases when compared to the scores obtained in the first inquiry. This fact is going to be analysed later, and by now we will only consider the interpretation of the results obtained.

It is evident that an indicator will be favoured when it is preferred over others for the more weighted criteria, in our case "Sensitivity", "Preventive" y "Cost-effectiveness" (Table 3.7).

Clear examples of these position shifts happen in the block of response indicators where "existence and adoption of a monitoring plan" and "budget surveillance" led the list due to their good cost/effectiveness ratio and preventive capacity, besides their quantitative nature compared with the rest of indicators of the same level. Other indicators such as "age-sex structure" or "annual fishing mortality", although achieving a priori a good score due to their sensitivity and preventive nature, are penalized due to their low cost/effectiveness ratio. Making interpretation for the rest of the indicators is much more complex because their suitability is a less clear reflection of the ten criteria considered.

There is no sense on comparing the results obtained regarding indicators suitability with those that are currently employed in other Spanish SACs given that our working procedure (DPSIR development and experts evaluation) depends directly on the features of the system to be protected, especially if we consider that we are dealing with an offshore zone what makes it even more specific.

Let's imagine two very similar natural areas, both from a biogeographical as well as from a ecological perspectives, that are going to be protected, but that vary significantly in the

pressures which are subject to, for instance from aquiculture activities and wave energy exploitation, respectively. Obviously, the indicators to be selected in such cases should be clearly different. Nevertheless, when carrying out such comparative exercise among the Management Plans of the Canarian SACs approved so far (BOE, 2011), it is clearly noticeable that the indicators used are only related to the established objectives, not considering at all the particular features of each MPA. This is pointing to a mechanical selection of the indicators based in the conservation objectives, without taking into account the area's singularities nor the pressures it is subject to. This way of working can be one of the reasons of the criticism received by INDEMARES in relation to the shortcomings (WWF, 2012) of these management plans.

All this brings us directly to the next section, where the carried out methodology will be analysed.

4.2 About the methods

This thesis begun assuring the necessity of improving the indicators selection procedure needed for a SAC's Management Plan. Trying to answer to this necessity an alternative and innovative method for the selection of adequate indicators for the Spanish SAC has been developed. This method, although susceptible of refining, can clearly serve as guideline for the Banco de La Concepción in particular and for future Spanish SAC in general.

Refining issues are mainly due to the numerous assumptions we needed to take (see Annex B) that can be clearly improved. To begin with, and despite sincerely acknowledging the effort carried out by our expert panel with their participation in this work, it is evident that a larger contribution from some of them was missed. Although this work is not more than a Master Thesis, a real implementation of this method would need a higher number of experts, besides their stronger implication and motivation, perhaps achievable through an attractive professional or economical reason. This fact would certainly diminish the number of assumptions made and would permit, as well, a wider indicators' selection which would result in a larger number of alternatives in the AHP method, significantly enriching the recommendations delivered.

In this case, the threshold used and thus the quantity of indicators selected has been limited by the workload we wished to give to the experts. It is also important to keep in mind that it is not just a matter of increasing the number of possible indicators to work with, but identifying the adequate quantity of them according to the MPA Management Plan budget.

It is also noteworthy that despite including just 18 indicators (4 or 5 per level), some selected indicators, although being not identical, could have been grouped under a common one. This is for instance the case of "total abundance" and "total biomass", both listed within the top 4 state/impact indicators, and both, although different, reflecting the importance of a species within a community. In case of doing a more ample selection this would not be an inconvenient any more.

Another issue to be considered without meaning that it has to be refined is that the most suitable or priority indicators will give us a clue about where to attack first, what don't make them optimal indicators for a continuous management. It is well known the extreme dynamicity of the marine environment making its management a very complex task (Maxwell *et al*. 2015). To be able to control the marine environment dynamicity firmly depends on the dynamic capacity of the tools used. A DPSIR approach, accompanied with periodic actuations can become a fundamental tool for a management that trace all the system cause-effect relations enabling the use of other indicators, acquiring a rapid speed of response if needed by the circumstances.

Independently of the topics to be refined and turning back to what was commented in the results section, something that is absolutely reflected in this work is the priority shift that experienced the majority of the indicators after the implementation of the AHP in respect to the scores given by the experts in the first questionnaire.

This evaluation shift could be caused by the fact that without using a multicriteria approach the experts are basing their recommendations in a predefined knowledge logically derived from their experience. When through the AHP procedure the experts are asked to compare indicators that now depend on criteria weighted by themselves the results can vary, and the answer will be more elaborated. This is far from being a critique to the experts' opinion, as both scores are given by them, but the procedure complemented with the decision making analysis will help them to pass from a more intuitive to a more based or supported evaluation.

If the already operative management plans (at least those included in the Spanish Natura 2000 MPAs web) are analysed, it can be easily observed that there is no reference to the methodology used for the indicators selection, process that is usually based on an experts' consultancy of the administration assistant in charge.

The methodology carried out in this thesis means a significant contribution for the improvement of the indicators selection procedure, because it captures in a transparent way the selection process. The method has proven to be particularly strong for providing quantitative information departing from qualitative one, something that was already advanced by the authors that implement this management tool for the MPAs management (Himes, 2007, Pendred *et al*. 2016). That way it is possible to consult how and under which criteria each of the decisions involving the indicators selection has been taken.

Another issue of this procedure that deserves to be highlighted is the functioning of the DPSIR as a tool for simplifying the system complexity, facilitating the decision-making in several management fields (in this case, the indicators selection), reason for its recommendation by Ojeda-Martínez *et al*. (2008).

Part of the success of this tool is due to its capacity for linking issues stemming from marine science and policy-making, which use to generate a challenge relationship. Furthermore, it can summarize for stakeholders and policy makers the complex functioning of the system (Ojeda-Martínez *et al*., 2008).

This discussion chapter will be concluded commenting the tasks still needed to be carried out for completing the management plan for Banco de La Concepción SAC.

The identification of the proper indicators, even being an important stage, is just only the first step for conforming an adequate monitoring system. The monitoring constitutes a key factor for the long-term success of the MPA (Martín-Sosa *et al*, 2013), so that it should be designed for its long-range functioning based in adequate and solid sampling strategies that consider spatial, temporal and material organization (Martín-Sosa *et al*, 2013).

This monitoring plan should as well foster its own objectives considering the goals expected and the MPA objectives, and should guarantee that the monitoring actions will be carried out regularly and always under the supervision of scientific staff (Martín-Sosa *et al*, 2013).

We would like to end this discussion stressing the fact that this study is the first time that DPSIR, MCDA and AHP have been used together in an Spanish context for MPA evaluation, and in spite of assumptions due to budget limitation to pay an experts' panel, administrations carrying out this methodology for the design of management plans and monitoring programs around MPAs would have a great probability of success.

CHAPTER 5. CONCLUSIONS

5.1 About the results

1. The objectives for the management plan of the future SAC of Banco de La Concepción have been defined, including among them some that will permit an advance towards the GES of the Canary Islands demarcation.

2. A DPSIR model that adjusts to the system to be managed has been developed.

3. 18 out of the 144 indicators identified for the Banco de La Concepción monitoring plan have been selected by the experts as priority.

4. A priority scale based in their suitability has been established for the 18 indicators selected.

5. The more suitable selected indicators for evaluating the driving forces in Banco de La Concepción are “Fishing effort”, “Total area fished &/or Proportion over total surface”, “Nº vessel passing/operating at same time inside SAC” and “Nº platform installed and their distance to SAC” in this order.

6. The more suitable selected indicators for evaluating the pressures affecting Banco de La Concepción are “Catch per unit effort”, “Total Biomass extracted”, “Bycatch per unit effort” and “Annual fishing mortality” in this order.

7. The more suitable selected indicators for evaluating the state and the impacts on Banco de La Concepción are “Extent of Habitats/Communities”, “Density/Total

abundance", "Habitat & communities diversity", "Total Biomass" and "Age/ Sex structure" in this order.

8. The more suitable selected indicators for evaluating the responses of Banco de La Concepción are "Existence and adoption of a monitoring plan", "Budget surveillance", "Level stakeholder participation and satisfaction with management", "Level stakeholder involvement in surveillance" and "Local understanding of SAC rules and regulations" in this order.

9. Recommendations and guidelines on which the future management plan of Banco de La Concepción can be based have been established.

10. The selected indicators are related with the naturalistic as well as with the socio-economic features of the study area.

11. The selected indicators point to the fishing activity as the principal focus of pressure on Banco de La Concepción.

12. The experts have opted for an ecosystem level approach instead of focusing on specific protected species or habitats.

5.2 About the methods

1. The advices given by the project INDEMARES have been followed and an alternative methodology able to perform in a transparent way the selection of indicators for the Spanish marine SACs management plans, until now absent of those plans, has been developed.

2. The use of the AHP procedure has enabled the transformation of more intuitive opinions into more based/supported criteria.

3. To a certain extent, it has been complex to keep the pairwise comparisons answers within the theoretical consistency values established by Saaty (1980), reaffirming that in practice a less strict value of consistency should be accepted.

4. From the 15 experts chosen initially only a 60% have participated during the whole process, very likely due to an excess of workload. Thus, it is recommended that the number of experts to be consulted should be higher in order to guarantee with sufficiency the Delphi method requisites, unless there is a budget to directly hire the experts, thus, expecting from them a higher degree of compromise.

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ANNEXES

Annex A: Possible focal species of Banco de La Concepción

Focal group		Species name	Observations
Vulnerable species	HD species	*Tursiops truncatus*	Annex II
		Caretta caretta	Annex II
		Delphinus delphis	Annex IV
		Stenella frontalis	Annex IV
		Grampus griseus	Annex IV
		Globicephala macrorhynchus	Annex IV
		Physeter macrocephalus	Annex IV
		Ziphius cavirostris	Annex IV
		Balaenoptera edeni	Annex IV
		Centrostephanus longispinus	Annex IV
	Other	*Hippocampus hippocampus*	Canarian Catalog of Protected Species
		Alopias superciliosus	Canarian Catalog of Protected Species
		Ranella olearium	Canarian Catalog of Protected Species
		Neophrysospongia nolitangere	Canarian Catalog of Protected Species
		Epinephelus marginatus	Red List of Threatened Species – Endangered
		Pagrus pagrus	Red List of Threatened Species – Endangered
		Thunnus thynnus	Red List of Threatened Species – Endangered
		Thunnus obesus	Red List of Threatened Species – Vulnerable
		Centrophorus granulosus	Red List of Threatened Species – Vulnerable
		Centrophorus squamosus	Red List of Threatened Species – Vulnerable
		Isurus oxyrinchus	Red List of Threatened Species – Vulnerable
		Eunicella verrucosa	Red List of Threatened Species – Vulnerable
		Sphyrna spp.	Red List of Threatened Species – Endangered

Focal group		Species name	Observations
Keystone species		*Lophelia pertusa*	Bioconstructor
		Solenosmilia variabilis	Bioconstructor
		Madrepora oculata	Bioconstructor
		Antipathella wollastoni	Structuring
		Corallium niobe	Structuring
		Viminella flagellum	Structuring
		Callogorgia verticillata	Structuring
		Asconema setubalense	Structuring
Target species		*Thunnus obesus*	Handline fishery
		Thunnus albacores	Handline fishery
		Thunus alalunga	Handline fishery
		Thunnus thynnus	Handline fishery
		Katsuwomis pelamis	Handline fishery
		Scomber scolias	Purse seine
		Helicolenus dactylopterus	Bottom longline
		Merluccius merluccius	Bottom longline
		Xiphias gladius	Surface longline
		Isurus oxyrinchus	Surface longline
		Polyprion americanus	Vertical longline
Endemic species		*Antipathella wollastoni**	Macaronesian
		Isozoanthus cf. primnoidus	Macaronesian
		Isozoanthus sp.nov.	¿Endemism?
		Corallium tricolor	Macaronesian
		Raja maderensis	Macaronesian
Sentinel species	*Ocean Acidification*	*Lophelia pertusa*	-
	Regime shift	*Coelopleurus floridanus*	-
		Stylocidaris affinis	-
		Centrostephanus longispinus	-

Table A.1: Focal species identified for Banco de La Concepción. Observations column makes reference to protection scope, organism characteristics, fisheries type and region depending on the focal group. **Source**: Own elaboration. Data obtained from Martín-Sosa *et al*., 2013.

Annex B: Assumptions

The big majority of the work carried out in this Master Thesis is based in the disinterested participation of an expert panel. Knowing their busy schedule we have tried to diminish as much as possible their workload. Many of the assumptions assumed in this report are related to this fact.

- Both members of the monitoring panel acting as experts as well was assumed as irrelevant.
  Explanation: Despite that it is recommended to distinguish between two different working groups for developing the Delphi procedure (OMARCOST, 2013), it wasn't followed to assure the minimal of 7 different opinions recommended in Delphi (Dalkey *et al*. 1970).

- A threshold of 18 indicators (12.5% of the total) after analyzing the results generated by inquiry 1 was assumed as sufficient.
  Explanation: To establish a realistic and affordable workload for the expert panel was essential.

- The 15 experts participating in the first questionnaire not repeating in the second one was assumed as irrelevant.
  Explanation: We failed to receive more answers within the agreed deadline.

- Experts answering inquiries 2 and 3 not being the same was assumed as irrelevant.
  Explanation: Although the logic would have been that the same experts evaluating the criteria should have evaluated the alternatives as well, two of the experts answering the third inquiry couldn't participate in the second one. With the aim of counting with a minimal number of 7 experts' opinions, both answers were accepted.

- Assumed as consistent all 14 order matrixes with a CR < 0.3 generated in inquiry 2.
  Explanation: i) the higher the matrix' order the higher probability for occurring answer inconsistencies. For high order matrixes it is acceptable to work with higher CR values (Saaty, 1980). ii) To avoid the repetition of the questionnaire by some experts we decided to work with all of matrixes with a CR < 0.3 (thus being 77.7% of the answers accepted).

- Assumed as consistent all 4 & 5 order matrixes with a CR < 0.2 generated in inquiry
  Explanation: Despite the low order of those matrixes in practice it is usual to work with CR > 0.1 (Coyle, 2004). For this case and with the aim of avoiding a repetition of the inquiry by some experts, CR < 0.2 were considered as acceptable (thus 83% of the answers being accepted)

- A minimum of five experts' responses for analyzing the data obtained in inquiry 3 was assumed as sufficient.
  Explanation: A minimal of 7 opinions is necessary in the Delphi method for diminishing significantly the dispersion error (Dalkey *et al*. 1970) Nonetheless, for the analysis of the data generated by the third questionnaire it was considered more convenient a smaller reduction of the dispersion error than working with data coming from high inconsistent matrixes, because this would be a synonym for less feasible data.

Annex C: Expert panel composition

Expert	Institution	Sector	Knowledge Area	Inquiry
Ricardo Haroun Tabraue	Biodiversity and environmental Management Research Centre, Universidad de Las Palmas de Gran Canaria	Research	Conservation	I1, I2, I3
José Juan Castro Hernández	Fisheries Resources Research Group, Universidad de Las Palmas de Gran Canaria	Research	Fisheries	I1,I2
Alberto Brito Hernández	Biodiversity, Marine Ecology and Conservation Research Group, Universidad de La Laguna	Research	Ecology	I1,I2,I3
Beatriz Ayala Óscar Esparza	Adena WWF Canarias	NGO	Conservation	I1,I3
Celia Ojeda Martínez	Greenpeace	NGO	Conservation	I1,I2,I3
Just Bayle Sempere	Universidad de Alicante	Research	Conservation	I1
Raquel Goñi	Instituto Español de Oceanografía - CO Baleares	Research	Fisheries	I1
Alberto Serrano	Instituto Español de Oceanografía - CO Santander	Research	Conservation	I1,I2
Matías González	Universidad de Las Palmas de Gran Canaria	Research	Economy	I1
Isabel Tamia Brito	TRAGSA, La Palma and La Restinga Marine Reserves Coordinator	Management	Conservation	I1, I2, I3
Rogelio Herrera	Environmental Ministry, Gobierno de Canarias	Management	Conservation	I1
Carlos Hernández	Instituto Español de Oceanografía - CO Canarias	Research	Conservation	I1, I2, I3
Marisa Tejedor	Sociedad para el Estudio de los Cetáceos en Canarias	NGO	Conservation	I1, I3
Pablo Martín-Sosa	Instituto Español de Oceanografía - -CO Canarias	Research	Fisheries and Conservation	I1, I2, I3
José María Fernández-Palacios	Ghent University	Research	Conservation	I1, I2, I3

Table C.1: Composition of the expert panel including affiliation, institution, sector, knowledge area and inquiries responded. **Source**: Own elaboration.

Annex D: Model inquiries sent to the panel of experts

D.1: 1st Inquiry

Invitation and Instruction inquiry 1

Dear colleague

I am sending you this e-mail because I consider you one member of my expert group for evaluating the indicators of the different parts of the system "Site of Community Importance (SCI) **Banco de La Concepción**" once it has been structured in the **DPSIR** (Driving Pressures-State-Impact-Response) format.

This study is part of the Master Thesis from José María Fernández-Palacios, a student of the International Master of Sciences in Marine Biodiversity and Conservation of the Ghent University (Belgium), who is under mine supervision in the *Centro Oceanográfico de Canarias*of the *Instituto Español de Oceanografía*.

After the **INDEMARES** project and thanks to the information gathered about the activities producing impact on the SCI, on the sensitive habitats and species existing there, as well as on the governance conditions resulting of the implementation of this SCI as Marine Protected Area, this Master Thesis would like to provide the administration with some valuable information for the elaboration of the Management Plan which shall drive to the declaration of the SCI as SAC within the Natura 2000 web.

In the frame of this work and after designing the DPISR and the management objectives, an Excel file with a list of indicators has been elaborated (attached to this mail) with the aim that you, as part of the Experts Panel which counts with the representation of different sectors and knowledge areas, can evaluate each of them. Your evaluation will be the first step in a multi-criterion analysis (MCA) which we would like to carry out using the Analytical Hierarchical Process (AHP) methodology. With this evaluation we will select the indicators best scored and on them we will apply the AHP, what will need again of your cooperation in the next future.

According to your expertise and knowledge and considering that the qualities of a good indicator should be:

- Regarding data quality: the existence of historical series, their consistence, better quantitative than qualitative, representativeness, sensible to changes, preventives and with scientific credibility

- Regarding management: relevant for the aims followed, understandable, profitable, wide applicability, contrasted use and non redundant.

We would require from you to fill in the evaluation field a value from 0 to 9, meaning 0 an absolutely useless indicator and 9 an ideal one. It is important that you just fill the fields of **those indicators** for which you consider you are an expert, and not those others beyond your expertise. Keep in mind to check all the excel pages.

Based on the schedule we have consider for the defence of the Master Thesis we would need your answer no later than the 4th of April answering to this same e-mail account. For the first week of April you will receive our second consultation, once the indicators have been selected.

Thanks a lot in advance for your attention and time invested. Warm greetings.

Pablo Martin-Sosa & José María Fernández-Palacios

Code	Indicator	Measures pressures of	Applicability	Observation	Score
1001	Fleet capacity	Fishing Sector	By gear	Number of fishing boats that fish on the SAC	
1002	Fishing effort	Fishing Sector	By gear, by boat	Hours or days at sea inside the SAC	
1003	Total area fished &/or Proportion over total surface	Fishing Sector	By gear	...	
1004	Km. cable inside SAC	Submarine Cable	By cable type	-	
1005	Nº reparations, installations or removal actions per year	Submarine Cable	By cable type	-	
1006	Nº vessel passing through SAC	Maritime Traffic	By vessel type	Total number of vessels per month or year	
1007	Nº vessel passing/operating at same time inside SAC	Maritime Traffic	Total, by sector, by vessel type	-	
1008	Vessel average time inside SAC	Maritime Traffic	By vessel type	-	
1009	Nº licenses granted	Extractive Uses	By resource nature	-	
1010	Nº platform installed and distance to SAC	Extractive Uses	By structure	-	
1011	Global CO_2 emission	Climate Change	General	-	
1012	Atmospheric concentration greenhouse gases	Climate Change	General	-	
1013	Ocean heat content	Climate Change	General	Observed change in global heat content (Joules)	
1014	Sea ice total coverage	Climate Change	General	-	
1015	Nº maneuvers and distance to SAC	Military Uses	By type	Nº maneuvers per month or year	

Code	Indicator	Measured pressure	Applicability	Observation	Score
2001	Catch per unit effort (CPUE)	Harvesting	-	-	
2002	Total biomass extracted	Harvesting	By gear/ boat By species	Kilograms of extracted biomass	
2003	Annual fishing mortality	Harvesting	Target & Non target	-	

Code	Indicator	Measured pressure	Applicability	Observation	Score
2004	Total area used by gear	Gear use	-	-	
2005	Time gear is at work	Gear use	Over habitat	-	
2006	Length Net / Nº Hooks	Gear use	Over habitat	Length of the net over a type of habitat. Number of hooks over a type of habitat	
2007	Areas impacted by mobile bottom gears	Gear use	-	Currently no trawling in the SAC	
2008	Reported lost gears	Gear use	By gear type	Number of fishing gears lost	
2009	Reported animal collisions	Animal collisions	By type of vessel, By family /species	Number of reported collisions	
2010	Discard rate	Discards	By gear	Ratio of discards to landings	
2011	Discard rate of commercially exploited species	Discards	By boat	Measurement of "Highgrading". Not anymore after Discard ban implementation	
2012	Bycatch per unit effort	Discards	All, Vulnerable spp. By gear,	If possible record age of protected spp.	
2013	Hydrocarbons consumed	Emissions	By sector	Liters of hydrocarbons consumed inside de SAC	
2014	Volume Gas/Oil extracted	Emissions	By platform	Outside SAC	
2015	Organic matter thrown	Emissions	By sector	Kilograms of organic matter thrown to the sea	
2016	Inert solids thrown	Emissions	By sector	Kilograms of inert solids thrown to the sea	
2017	Proportion of days exceeding anthropogenic sound established levels	Emissions	By sector, by activity (construction, exploration or exploitation)	Impulsive noise indicator	
2018	Trends annual average sound pressure	Emissions	-	Continuous noise indicator	
2019	Volume of material removed / relocated	Maintenance of underwater cables	-	Seabed Material	
2020	Reported leaks	Accidental spills	By sector	Volume/ time unit Inside & Outside SAC	

Code	Indicator	Measured pressure	Applicability	Observation	Score
2021	Nº accidental events	Accidental spills	By sector	Per year Inside & Outside SAC	
2022	Accumulate Nº of alien species	Invasive species	-	-	
2023	Occurrence of invasive Alien species	Invasive species	-	-	
2024	% Area affected by invasive species	Invasive species	By habitat, by community	Sessile species	
2025	Dissolved carbon dioxide	Acidification	-	-	
2026	pH	Acidification	-	-	
2027	See Surface Temperature	Water T. increase	By season	-	
2028	Concepción summit Depth	Sea level rise	-	-	
2029	Distance summit to photic zone	Sea level rise	-	-	
2030	Records tropical species	Species shits	-	-	

Code	Indicator	Measuring Impacts on	Applicability	Observation	Score
3001	Turbidity	Water quality		-	
3002	Salinity	Water quality		-	
3003	Temperature	Water quality		-	
3004	Dissolved O2	Water quality		-	
3005	Nutrients concentration	Water quality		-	
3006	Chlorophyll a concentration	Water quality/ Food-web dynamic		-	
3007	O2 & sulfide concentration	Sediment quality		-	
3008	Areal extent of O_2 depletion	Sediment quality	By habitat	-	
3009	Pollutants concentration	Sediment quality	Sediment	Heavy metals, PAH's, PCB´s, OCP´s	
3010	Vol./Density macroplastics at surface	Water quality		-	
3011	Density inert solids at seabed	Seafloor quality	By habitat	-	

Code	Indicator	Measuring Impacts on	Applicability	Observation	Score
3012	Report Nº individuals affected by inert solids	Water quality	Vulnerable spp.	-	
3013	Large Fish Indicator (LFI)	Population size structure/ Food web structure	Target spp.	Proportion of total fish biomass exceeding a specified threshold length	
3014	Age/ Sex structure	Population age/sex structure	Vulnerable spp. Target spp.	-	
3015	Density/ Total abundance	Population size	Vulnerable spp. Target spp. Sensitive spp. Endemic spp. Keystone spp.	-	
3016	Total Biomass	Population size	Keystone spp. Sensitive spp.	-	
3017	Calves ratio	Habitat use	Vulnerable spp.	-	
3018	Spawning Stock Biomass	Population fitness	Target spp.	-	
3019	Genetic diversity Index	Genetic diversity	Target spp. Vulnerable spp.	-	
3020	Phylogeographic structure	Connectivity	Vulnerable spp. Endemic spp. Keystone spp.	Haplotype cross-comparison other seamounts / regions	
3021	Extent of Habitats / Communities	Habitat spatial structure	-	Area, Depth	
3022	Habitat & communities diversity	Habitat diversity	-	-	
3023	Biomass structuring species	Habitat complexity	By community	-	
3024	Density structuring species	Habitat complexity	By community	-	
3025	Rugosity Index	Habitat complexity	By habitat By community	-	
3026	Bioturbation potential (BPc)	Habitat functioning		-	
3027	Richness	Species richness	By community	-	
3028	Relative abundance	Species composition	By community	Species list with reference to abundance	
3029	Proportion invasive/ natives (PIN)	Species list	By habitat By community	-	

Code	Indicator		Measuring Impacts on	Applicability	Observation	Score
3030	Ratio Opportunistic/Sensitive		Species list	By community	-	
3031	Hill Indices	Richness	Richness	By community	-	
3032		Shannon / Simpson	Ecologic Diversity			
3033		Berguer-Parker	Dominance			
3034	Beta diversity		Ecologic diversity	By community	-	
3035	Biomass/Productivity key trophic groups*		Foodweb structure		-	
3036	Mean weight Zooplankton key groups		Foodweb dynamic/ functioning		-	
3037	Mean weight at age of predatory fish*		Foodweb dynamic/ functioning	Only for non migratory apical predator	-	
3038	High Trophic level Indicator (HTI), Apex Predator Indicator (API)*		Foodweb dynamic		Data income unclear: Landings, surveys, modeling?	
3039	Income fishing sector		Socio-economy		-	
3040	Nº young bellow age of 35 working in the sector		Socio-economy		-	
3041	Per capita income of the sector		Socio-economy		-	
3042	Nº boats registered		Socio-economy		-	
3043	Nº Jobs / Employment		Socio-economy		-	
3044	Nº families associated with fishing sector		Socio-economy		-	
3045	Pollutants concentration on captured fish		Socio-economy	Target spp.	-	
3046	Perception conservation state		Socio-economy		Stakeholders and public perception of the conservation state	
3047	Perception seafood availability		Socio-economy		Stakeholders perception of seafood availability	
3048	Early Warning Signals		Ecosystem stability and resilience		Resilience quantification	

Code	Indicator	Measures response of:	Applicability	Observation	Score
4001	Surface SAC	General management		-	
4002	Degree fulfillment objectives SAC	General management	By objectives	-	
4003	Frequency of updates and revision of key management elements	General management	Objectives, DPSIR, indicators, plans, etc.	-	
4004	Monitoring budget	Monitoring		-	
4005	Nº contracts on monitoring program	Monitoring		-	
4006	Nº reports produced by monitoring program	Monitoring		-	
4007	Nº and frequency of surveys	Monitoring	By pressure, by impact	-	
4008	In situ survey effort (hours at sea)	Monitoring		-	
4009	Budget research projects	Research	By pressure, by impact		
4010	Nº research projects per year	Research			
4011	Outreach project	Research		Nº publications, conferences, media, etc.	
4012	Nº collaboration agreements with other scientific institutions	Research			
4013	Nº new investigation lines detected / promoted	Research	By line		
4014	Budget recovery actions	Recovery actions	By objective		
4015	Nº actions taking place	Recovery actions	By impact		
4016	Budget surveillance	Surveillance	Total, by sector, by pressure		
4017	Surveillance effort (hours)	Surveillance	By pressure		
4018	Nº sanctions /year	Surveillance	By sector, by pressure		
4019	Nº contracts surveillance project	Surveillance			
4020	Zoning surface	Planning	By use		

Code	Indicator	Measures response of:	Applicability	Observation	Score
4021	% Non take zone over total surface	Planning			
4022	Total nº implanted limitations	Planning	By pressure		
4023	Nº legislation changes	Engagement / Planning	By Sector		
4024	Nº administration playing a role on SAC	Engagement			
4025	Perception of coordination between administrations	Engagement			
4026	Ratio affected parts/contacted parts	Engagement		"This ratio will let us know if we are ignoring key parts in the engagement process or if on the other hand we are engaging more parts than necessary "	
4027	Nº engagement tools used	Engagement	By stakeholder		
4028	Nº times applied tool has been repeated / updated	Engagement	By tool	i.e. nº meetings with the part, webpage updates, nº workshops, etc	
4029	Nº reports produced during engagement process	Engagement			
4030	Budget engagement actions	Engagement	By tool		
4031	Nº submission received	Engagement	By stakeholder	Nº answers obtained from active stakeholders (i.e. ONG's) after engagement process	
4032	Level stakeholder participation and satisfaction with management	Engagement	-		
4033	Level stakeholder involvement in surveillance	Engagement	-		
4034	Level of resource conflict	Engagement			
4035	Local sense of approval	Engagement	-		
4036	Local understanding of SAC rules and regulations	Engagement	-		
4037	Nº platforms created for information	Engagement			

Code	Indicator	Measures response of:	Applicability	Observation	Score
	dissemination				
4038	Nº of Tech. improvements detected/applied	Engagement	By sector		
4039	Budget invested on technological improvement	Engagement	By sector, by pressure		
4040	Nº good practices identified/ implanted	Engagement	By sector		
4041	Nº educational programs / year	Engagement		Information + awareness	
4042	Nº actions implemented to broadcast action protocols and codes of good practices	Engagement	By sector, by type	Related to good practices (i.e. training programs)	
4043	Budget educational programs	Engagement			
4044	Budget training programs	Engagement		Related to good practices and sustainable use	
4045	Legislation changes	Engagement	By sector		
4046	Existence of measures to favor artisanal fishing	Engagement			
4047	Existence and adoption of an action protocol in case of risk situations	General management			
4048	Existence and adoption of a management plan and associated regulations	General management			
4049	Existence and adoption of an engagement plan	General management			
4050	Existence and adoption of a monitoring plan	General management	-		

Table D.1 List of Indicators sent to the experts in inquiry 1, column "scores" was filled by them. **Source:** Own elaboration

X.2: 2nd Inquiry

Instructions for filling the Criteria Pairwise Comparison Matrix

For understanding the associations among the compared pairs (in this specific case criteria) it is necessary to enter through each row. The more important criterion is personal skill (in grey) because it is moderately preferred to the leadership (3) and between equal and moderately preferred to the management skills (2). The leadership criterion (indications in black and continuous line) presents a less relative importance, actually 1/3 of personal skills criterion (moderately preferred) and 1/4 of the management skills one (between moderately and strongly preferred, score of 4). The management skills criterion (indications in black and discontinuous line) represents a lower importance than personal skills criterion, due to the fact that this last one is located between equally and moderately preferred (score of 2). THESE DATA SHOULD BE COMPLETED BY THE EXPERTS. Edited from Roche and Viejo, 2005.

	Liderazgo	Habilidad personal	Habilidad de gestión
Liderazgo	1	1/3	1/4
Habilidad personal	3	1	2
Habilidad de gestión	4	1/2	1

Table D.2: Example of a pairweise comparation matrix of criteria sent to the experts in inquiri 2. **Source:** Roche and Viejo, 2005.

Liderazgo = Leadership
Habilidad Personal = Personal Skills
Habilidad de Gestión= Management Skills

Criteria Pair wise Comparison Matrix :

In order to evaluate the criteria and to understand the associations between them , we should get into the matrix by each row.

As an example, in the matrix located above the most important criteria is "personal ability" (grey line). Hence its moderate important in comparison to leadership (3) and between equal and moderate important in relation to "management ability" (2).

On the other hand the "leadership" criteria (black line) presents less relative importance , achieving 1/3 compared to "personal ability" and 1/4 (between moderate importance and strong importance) compared to "management ability" .

Finally "management ability" criteria is less important than "personal ability", thus the ranking between them is 1/2 (between equal and moderate importance).

Keep in mind the fact that if you score the relationship "personal ability" vs. "leadership" with a mark of 2. Than logically the inverse relation have to be 1/2.

You will find the score legend attached in the "Matrix" excel page.

	Criteria	Description
Data quality		
C1	Existing and ongoing data	Indicators supported by already existing monitoring programs with time series fully available.
C2	Consistency	Indicator is able to keep a low variability respond
C3	Tangibility	Indicators should be easily and accurately determined using feasible techniques
C4	Quantitative vs. qualitative	Preference of quantitative data rather than qualitative.
C5	Representative or repeatability friendly	Indicator should be representative of the area under study (whole SAC, concrete community, etc), when needed, repeatability shouldn't be a major issue.
C6	Sensitivity	Susceptibility for detecting changes on pressures or state/impacts.
C7	Early warning / Preventive	Indicator is able to highlight potential changes before harm is done.
C8	Scientific credibility	Scientific per-reviewed findings guarantee the validity of the indicator.
Management		
C9	Relevant to defined objectives	Indicator should be in accordance to established operative tasks and specific goals.
C10	Comprehensible	Indicator and variation consequences should be easily interpretable by policy makers and engaged stakeholders.
C11	Cost-effectiveness	Sampling, measuring, processing, analyzing and reporting outcomes should be in accordance with financial resources.
Other		
C12	Cross-applicability	Indicator fit in more than one aspect being evaluated.
C13	Independence	Not redundant with other indicators
C14	Established	Indicator is already used in other monitoring programs with same o similar objectives. (Even greater relevance if used in other local places).

Table D.3: List of criteria sent to experts in inquiry 2.
Source: Own elaboration

MCP	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
C1	1													
C2		1												
C3			1											
C4				1										
C5					1									
C6						1								
C7							1							
C8								1						
C9									1					
C10										1				
C11											1			
C12												1		
C13													1	
C14														1

Figure D.1: Criteria pairwise comparison matrix to be filled by experts. **Source**: Own elaboration.

Intensity of importance	Definitions	Explanation
1	Equal Importance	Two activities contribute equally to the objective
2	Weak	Experience and judgment slightly favour one activity over another
3	Moderate importance	"
4	Moderate plus	Experience and judgment strongly favour one activity over another
5	Strong importance	"
6	Strong plus	An activity is favoured very strongly over another; its dominance demonstrated in practice
7	Very strong or demonstrated importance	An activity is favoured very strongly over another; its dominance demonstrated in practice
8	Very, very strong	The evidence favouring one activity over another is of the highest possible order of affirmation
9	Extreme importance	"

Table D.4: The fundamental scale of AHP sent in inquiry 2. **Source:** Saaty and Vargas, 2001

X.3: 3rd Inquiry

Instructions:

Develope the following Alternatives (Indicators) Pairwise Comparison Matrixes (PCM) for each of the criteria referred, establishing the importance between alternatives within each criteria.

Take into account that if a relation is scored with a value of "2", the inverse relation should be "1/2"

Example:

C1	Ind1	Ind2	Ind3	Ind4
Ind1	1	1/8	1/4	2
Ind2	8	1	4	9
Ind3	4	1/4	1	5
Ind4	1/2	1/9	1/5	1

For this example, Ind 2 is of extremely important (9) compared to Ind4. Ind1 is weekly important(2)compared to Ind4.Finally, Ind3 is of moderate importance (4) compared to Ind1.

Criteria description:

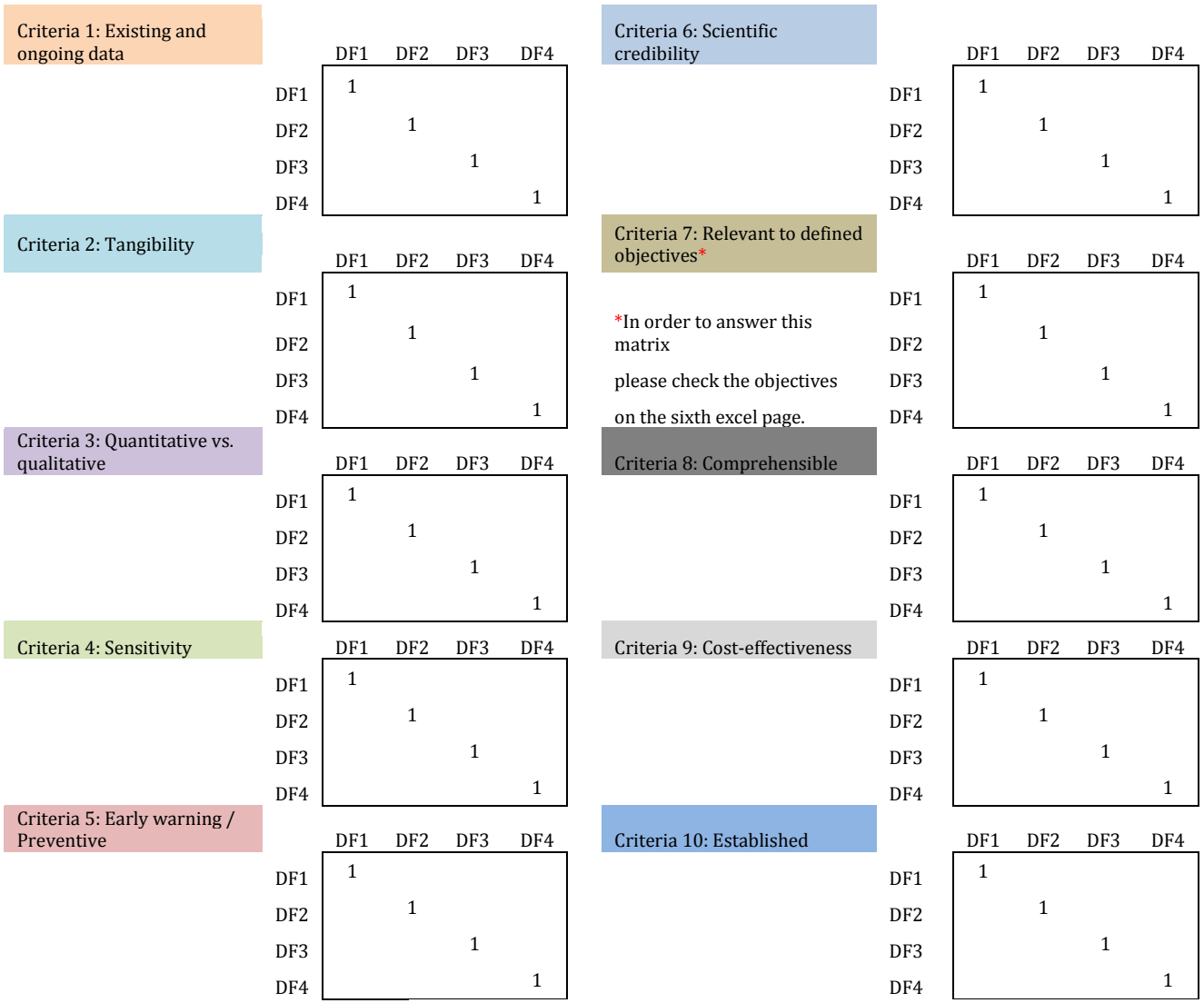
	Criteria	Description
Data quality		
C1	Existing and ongoing data	Indicators supported by already existing monitoring programs with time series fully available.
C2	Tangibility	Indicators should be easily and accurately determined using feasible techniques
C3	Quantitative vs. qualitative	Preference of quantitative data rather than qualitative.
C4	Sensitivity	Susceptibility for detecting changes on pressures or state/impacts.
C5	Early warning / Preventive	Indicator is able to highlight potential changes before harm is done.
C6	Scientific credibility	Scientific per-reviewed findings guarantee the validity of the indicator.
Management		
C7	Relevant to defined objectives	Indicator should be in accordance to established operative tasks and specific goals.
C8	Comprehensible	Indicator and variation consequences should be easily interpretable by policy makers and engaged stakeholders.
C9	Cost-effectiveness	Sampling, measuring, processing, analyzing and reporting outcomes should be in accordance with financial resources.

Other		
C10	Established	Indicator is already used in other monitoring programs with same o similar objectives. (Even greater relevance if used in other local places (Demarcación Canaria)).

Table D.5: List of criteria sent to experts in inquiry 3. **Source:** Own elaboration

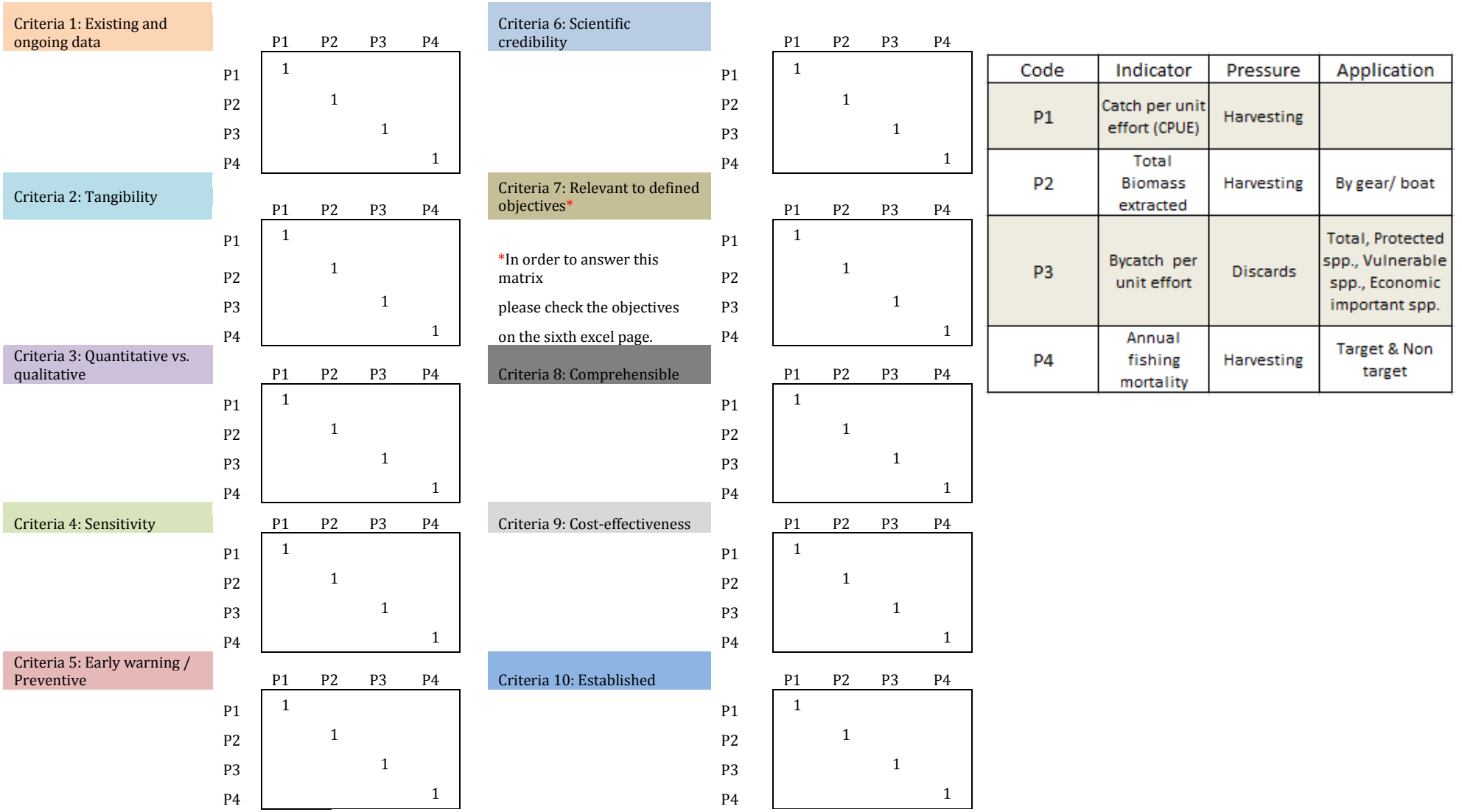
Intensity of importance	Definitions	Explanation
1	Equal Importance	Two activities contribute equally to the objective
2	Weak	Experience and judgment slightly favour one activity over another
3	Moderate importance	"
4	Moderate plus	Experience and judgment strongly favour one activity over another
5	Strong importance	"
6	Strong plus	An activity is favoured very strongly over another; its dominance demonstrated in practice
7	Very strong or demonstrated importance	An activity is favoured very strongly over another; its dominance demonstrated in practice
8	Very, very strong	The evidence favouring one activity over another is of the highest possible order of affirmation
9	Extreme importance	"

Table D.6: The fundamental scale of AHP sent in inquiry 3. **Source:** Saaty and Vargas, 2001



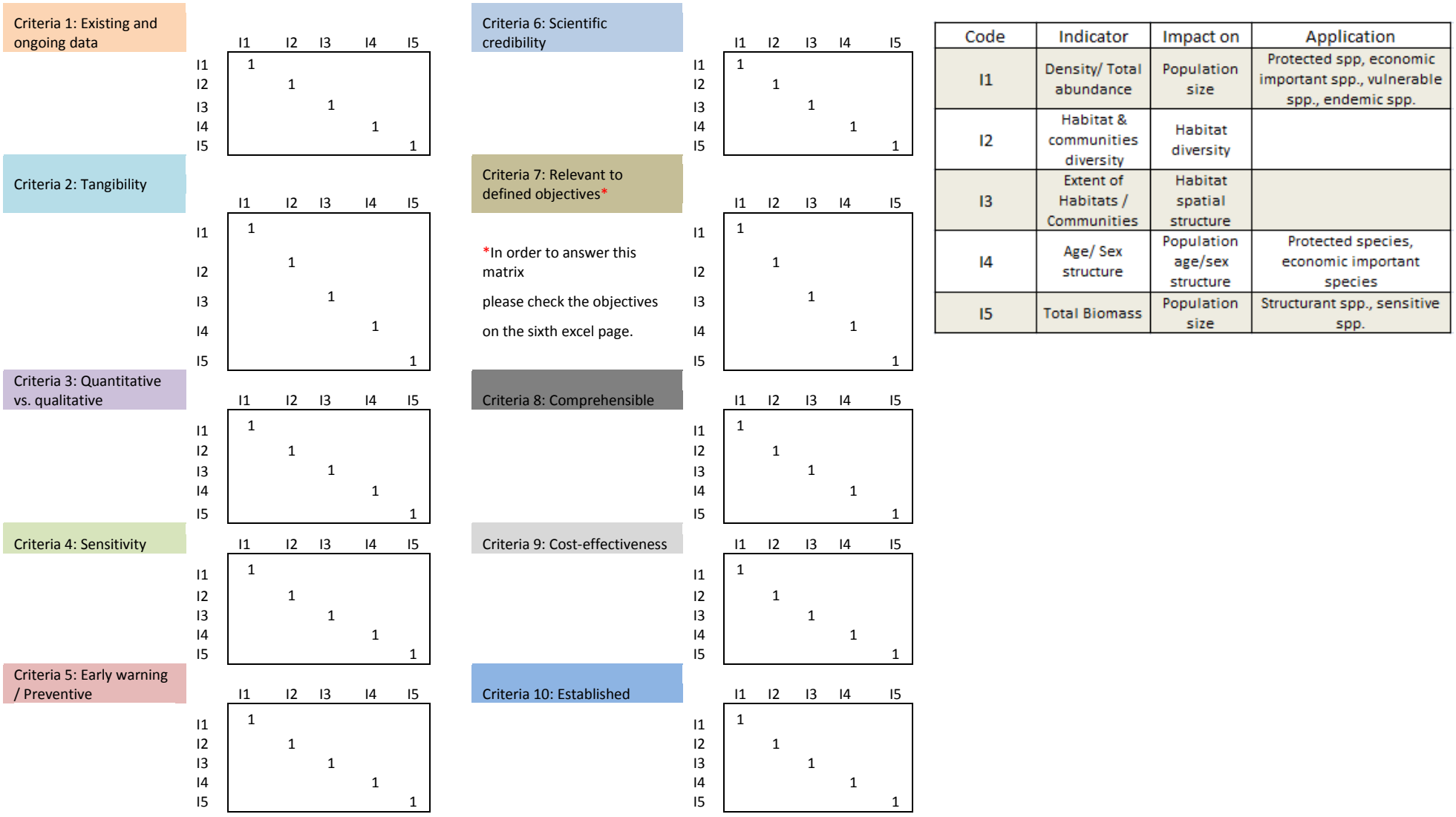
Code	Indicator	Force	Application
DF1	Fishing effort (hours fishing or days at a sea)	Fishing Sector	By gear
DF2	Nº platform installed and their distance to ZEC	Extractive Uses	By structure
DF3	Nº vessel passing/operating at same time inside ZEC	Fishing Sector	Total , by sector, by vessel type
DF4	Total area fished &/or Proportion over total surface	Fishing Sector	By gear

Figure D.2: Alternatives pairwise comparison matrixes for driving forces indicators sent in inquiry 3. **Source:** Own elaboration



Code	Indicator	Pressure	Application
P1	Catch per unit effort (CPUE)	Harvesting	
P2	Total Biomass extracted	Harvesting	By gear/ boat
P3	Bycatch per unit effort	Discards	Total, Protected spp., Vulnerable spp., Economic important spp.
P4	Annual fishing mortality	Harvesting	Target & Non target

Figure D.3: Alternatives pairwise comparison matrixes for pressures indicators sent in inquiry 3. **Source:** Own elaboration



Code	Indicator	Impact on	Application
I1	Density/ Total abundance	Population size	Protected spp, economic important spp., vulnerable spp., endemic spp.
I2	Habitat & communities diversity	Habitat diversity	
I3	Extent of Habitats / Communities	Habitat spatial structure	
I4	Age/ Sex structure	Population age/sex structure	Protected species, economic important species
I5	Total Biomass	Population size	Structurant spp., sensitive spp.

Figure D.4: Alternatives pairwise comparison matrixes for state/impacts indicators sent in inquiry 3. **Source:** Own elaboration

Criteria 1: Existing and ongoing data

	R1	R2	R3	R4	R5
R1	1				
R2		1			
R3			1		
R4				1	
R5					1

Criteria 2: Tangibility

	R1	R2	R3	R4	R5
R1	1				
R2		1			
R3			1		
R4				1	
R5					1

Criteria 3: Quantitative vs. qualitative

	R1	R2	R3	R4	R5
R1	1				
R2		1			
R3			1		
R4				1	
R5					1

Criteria 4: Sensitivity

	R1	R2	R3	R4	R5
R1	1				
R2		1			
R3			1		
R4				1	
R5					1

Criteria 5: Early warning / Preventive

	R1	R2	R3	R4	R5
R1	1				
R2		1			
R3			1		
R4				1	
R5					1

Criteria 6: Scientific credibility

	I1	I2	I3	I4	I5
I1	1				
I2		1			
I3			1		
I4				1	
I5					1

Criteria 7: Relevant to defined objectives*

*In order to answer this matrix please check the objectives on the sixth excel page.

	R1	R2	R3	R4	R5
R1	1				
R2		1			
R3			1		
R4				1	
R5					1

Criteria 8: Comprehensible

	R1	R2	R3	R4	R5
R1	1				
R2		1			
R3			1		
R4				1	
R5					1

Criteria 9: Cost-effectiveness

	R1	R2	R3	R4	R5
R1	1				
R2		1			
R3			1		
R4				1	
R5					1

Criteria 10: Established

	R1	R2	R3	R4	R5
R1	1				
R2		1			
R3			1		
R4				1	
R5					1

Code	Indicator	Response of	Application
R1	Level stakeholder involvement in surveillance	Engagement	
R2	Existence and adoption of a monitoring plan	General management	
R3	Local understanding of ZEC rules and regulations	Engagement	
R4	Budget surveillance	Surveillance	By pressure
R5	Level stakeholder participation and satisfaction with management	Engagement	

Figure D.5: Alternatives pairwise comparison matrixes for response indicators sent in inquiry 3. **Source:** Own elaboration

Annex E: Selection process of AHP method

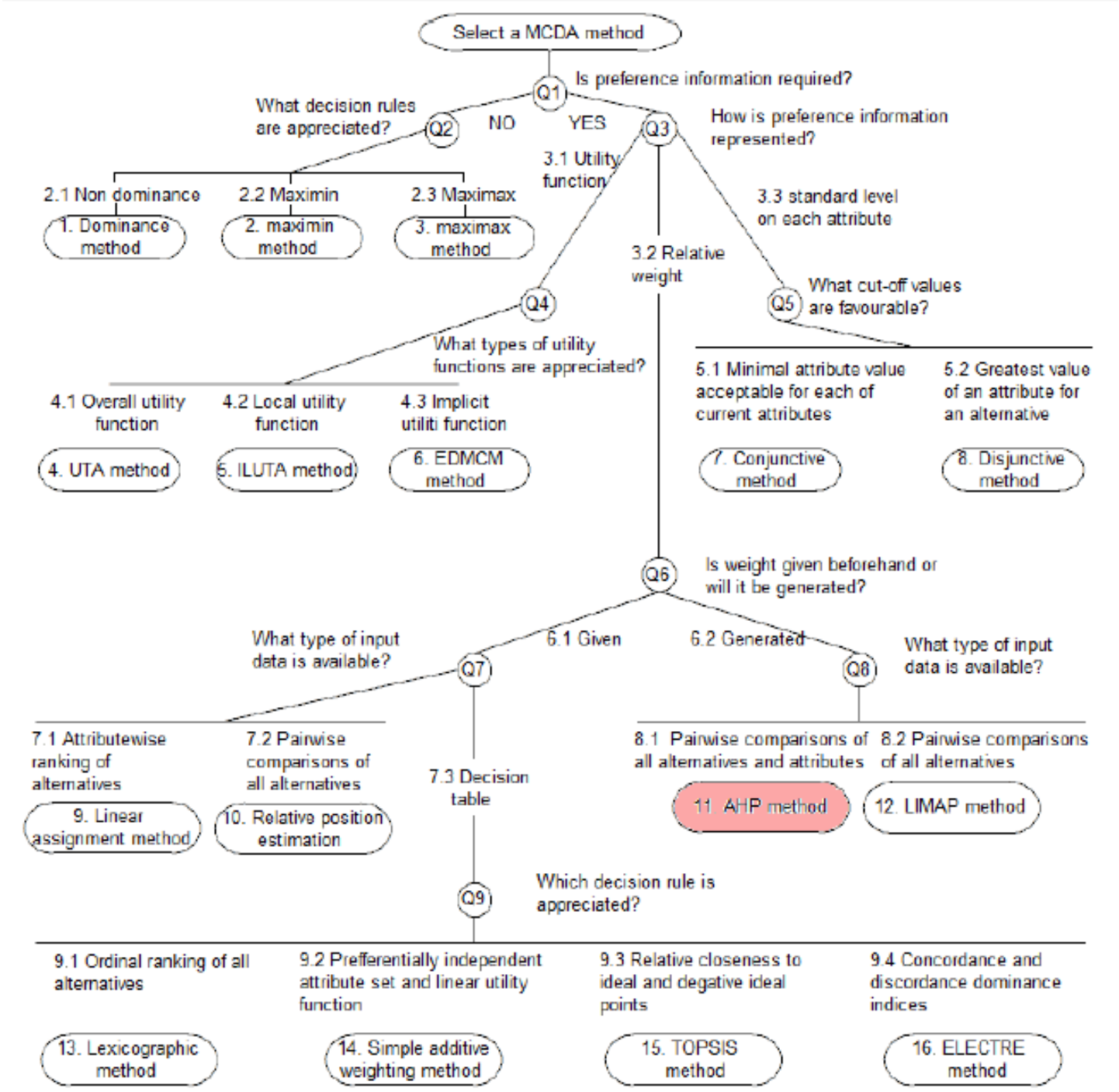


Figure E.1: Decision tree for selecting a MCDA method. **Source**: Edited from Sen and Yang 1998.

In chapter 2 the AHP method was affirmed as the most convenient for our decision problem. Figure D.1 shows the Decision Tree proposed in 1998 by Sen and Yang. The aim of this tree is to help in the selection of the most appropriate MCDA method. Guidance is given accordingly to the information that is available in the decision problem and the information required as output.

For this case the preference information was required and generated. Furthermore, pairwise comparisons of all attributes/criteria and alternatives were needed. These characteristics lead directly to the AHP method.

Annex F: Example of the application of an Analytic Hierarchy Process (AHP) method

Let's imagine that we have decided to use a Multi-Criteria Decision Analysis (MCDA) approach, concretely the AHP, for identifying the more appropriate indicator for the monitoring of species richness in a marine reserve (Goal). The identified criteria are: cost-effectiveness (CE), scientific credibility (SC) and comprehensibility (C). The indicators A1, A2, A3 and A4 are the four possible alternatives. The consulting process of the unique expert has already been carried out and we have obtained his results of relative weights assignations in form of pairwise comparisons matrix (we should keep in mind that in our case we count with more than one expert).

This expert has presented the following alternatives comparison matrix (for understanding the scores given by the expert check the Saaty and Vargas valoration scale in chapter 2, table 2.4)

Cost-effectiveness

	A1	A2	A3	A4
A1	1	1/2	1	2
A2	2	1	2	4
A3	1	1/2	1	2
A4	1/2	1/4	1/2	1

Scientific Credibility

	A1	A2	A3	A4
A1	1	1/8	1/4	2
A2	8	1	4	9
A3	4	1/4	1	5
A4	1/2	1/9	1/5	1

Comprehensibility

	A1	A2	A3	A4
A1	1	1	1	1
A2	1	1	1	1
A3	1	1	1	1
A4	1	1	1	1

According to the expert, regarding cost-effectiveness the alternative 1 (A1) is slightly worse than A2, equal to A3 and slightly better than A4. A2 is logically slightly better than A3 and strongly better than A4. A4 is thus slightly worse than A1 and A3, and strongly worse than A2. Regarding credibility, A2 would be extremely more important than A4. A1 would be slightly more important than A4, and A3 moderately more important than A1. Finally, regarding to comprehensibility, expert decided that all alternatives were of equal importance.

The expert evaluated, as well, the different criteria producing the following matrix:

	CE	SC	C
CE	1	1/2	2
SC	2	1	3
C	1/2	1/3	1

The process for the quantification of the expert opinion is the following:

Step 1: Development of a normalised matrix. Normalise the elements of the matrix by dividing each value by the sum of all values in its column.

- 1.1 Calculate the sum of each column:

CE	A1	A2	A3	A4
A1	1	1/2	1	2
A2	2	1	2	4
A3	1	1/2	1	2
A4	1/2	1/4	1/2	1
	4,50	2,25	4,50	9,00

SC	A1	A2	A3	A4
A1	1	1/8	1/4	2
A2	8	1	4	9
A3	4	1/4	1	5
A4	1/2	1/9	1/5	1
	13,50	1,49	5,45	17,00

C	A1	A2	A3	A4
A1	1	1	1	1
A2	1	1	1	1
A3	1	1	1	1
A4	1	1	1	1
	4	4	4	4

- 1.2 Normalize each element of the matrix dividing by its column sum:

CE	A1	A2	A3	A4
A1	0,222	0,222	0,222	0,222
A2	0,444	0,444	0,444	0,444
A3	0,222	0,222	0,222	0,222
A4	0,111	0,111	0,111	0,111

SC	A1	A2	A3	A4
A1	0,074	0,084	0,046	0,118
A2	0,593	0,673	0,734	0,529
A3	0,296	0.168	0,183	0,294
A4	0,037	0,075	0,037	0,059

C	A1	A2	A3	A4
A1	0.25	0.25	0.25	0.25
A2	0.25	0.25	0.25	0.25
A3	0.25	0.25	0.25	0.25
A4	0.25	0.25	0.25	0.25

Step 2: Calculation of the Priority Vector.

- 2.1 Add the normalized elements of each row and divide it by the number of alternatives compared (4)

CE	PV A1	0,889 ÷ 4	0,222
	PV A2	1,778 ÷ 4	0,444
	PV A3	0,889 ÷ 4	0,222
	PV A4	0,444 ÷ 4	0,111
SC	PV A1	0,322 ÷ 4	0,080
	PV A2	2,529 ÷ 4	0,632
	PV A3	0,942 ÷ 4	0,236
	PV A4	0,207 ÷ 4	0,052
C	PV A1	1÷ 4	0,25
	PV A2	1÷ 4	0,25
	PV A3	1÷ 4	0,25
	PV A4	1÷ 4	0,25

- 2.2 Once the PV has been calculated, we can obtain the Consistency Ratio matrix (observe the last paragraph of Annex E)

Step 3. In case of working with more experts, calculate the mean PV value of all of them.

Step 4. Following the same procedure the criteria matrix has been evaluated obtaining the following PV values: (as before, this will be the moment for calculating the criteria matrix consistence)

CE	0,285
SC	0,515
C	0,199

Step 5: Calculation of the Global Priority Vector (GPV). Generate a new matrix listing the alternatives by row and criteria by column. Fulfil this matrix with the alternative PV values based in each criterion. Calculate the weighted sum for each alternative multiplying by the respective criterion PV.

	CE	SC	C
A1	0,222	0,080	0,25
A2	0,444	0,632	0,25
A3	0,222	0,236	0,25
A4	0,111	0,052	0,25

A1 GPV	0,154
A2 GPV	0,502
A3 GPV	0,235
A4 GPV	0,108

	CE	SC	C
A1	0,222*0.285	0,080*0.515	0,25*0.199
A2	0,444*0.285	0,632*0.515	0,25*0.199
A3	0,222*0.285	0,236*0.515	0,25*0.199
A4	0,111*0.285	0,052*0.515	0,25*0.199

Step 6: Rank the alternatives:

This method points that indicator nº 2 obtained the highest priority, so that it will be the most appropriate for monitoring the species richness according to the expert consulted.

Consistency Ratio (CR)

Calculation of the CR of the following matrix:

	A1	A2	A3	A4
A1	1	1/8	1/4	2
A2	8	1	4	9
A3	4	1/4	1	5
A4	1/2	1/9	1/5	1

- Calculate the PV of the compared alternatives → (0.080, 0.632, 0.236, 0.052)
- In order to calculate λmax, first multiply the matrix of judgements by the PV (ej. First row → 1 * 0.080 + 1/8 * 0.632 + 1/4 * 0.236 + 2 * 0.052 = 0.32) resulting the following vector: (0.32, 2.68, 0.97, 0.21)
- Calculate the lambda vector by dividing each component of the anterior vector by the PV →(4,0, 4,25, 4,13, 4,02)
- λmax is the mean value of the lambda vector → 4,1
  Consistency Index (Saaty, 1980) → $CI = \frac{\lambda max - n}{n-1}$ taking into account that for this case n= 4; CI = 0,033
- The Consistency Ratio will be obtained diving the CI by the Random Index for an order 4 matrix given by Saaty (1980) (See table in chapter 2); CR = 0,036

For this matrix CR < 0,1 what indicates the consistency of the judgements done by the expert.

Annex G: Indicator' scores given by the experts in the first inquiry

1001	Fleet capacity	5.7	2007	Areas impacted by mobile bottom gears	5.9	2028	Concepción summit Depth	4.2
1002	Fishing effort	7.4	2008	Reported lost gears	5.7	2029	Distance summit to photic zone	3.7
1003	Total area fished &/or Proportion over total surface	6.1	2009	Reported animal collisions	5.6	2030	Records tropical species	6.0
1004	Km. cable inside SAC	4.6	2010	Discard rate	5.9	3001	Turbidity	5.0
1005	Nº reparations, installations or removal actions per year	4.7	2011	Discard rate of commercially exploited species	5.3	3002	Salinity	4.4
1006	Nº vessel passing through SAC	5.6	2012	Bycatch per unit effort	6.9	3003	Temperature	5.9
1007	Nº vessel passing/operating at same time inside SAC	6.1	2013	Hydrocarbons consumed	4.5	3004	Dissolved O_2	5.4
1008	Vessel average time inside SAC	5.5	2014	Volume Gas/Oil extracted	3.7	3005	Nutrients concentration	5.9
1009	Nº licenses granted	6.0	2015	Organic matter thrown	4.6	3006	Chlorophyll a concentration	6.3
1010	Nº platform installed and distance to SAC	6.2	2016	Inert solids thrown	5.0	3007	O_2 & sulfide concentration	5.1
1011	Global CO_2 emission	3.0	2017	Proportion of days exceeding anthropogenic sound established levels	5.6	3008	Areal extent of O_2 depletion	4.3
1012	Atmospheric concentration greenhouse gases	2.3	2018	Trends annual average sound pressure	5.4	3009	Pollutants concentration	5.9
1013	Ocean heat content	3.0	2019	Volume of material removed / relocated	4.2	3010	Vol./Density macroplastics at surface	5.7
1014	Sea ice total coverage	1.3	2020	Reported leaks	5.7	3011	Density inert solids at seabed	5.7
1015	Nº maneuvers and distance to SAC	5.9	2021	Nº accidental events	5.8	3012	Report Nº individuals affected by inert solids	5.6
2001	Catch per unit effort (CPUE)	7.2	2022	Accumulate Nº of alien species	6.1	3013	Large Fish Indicator (LFI)	6.7
2002	Total biomass extracted	7.1	2023	Occurrence of invasive Alien species	6.2	3014	Age/ Sex structure	6.9
2003	Annual fishing mortality	6.6	2024	% Area affected by invasive species	6,1	3015	Density/ Total abundance	7.6
2004	Total area used by gear	6.2	2025	Dissolved carbon dioxide	5.2	3016	Total Biomass	6.8
2005	Time gear is at work	6.5	2026	pH	5.3	3017	Calves ratio	6.2
2006	Length Net / Nº Hooks	6.5	2027	See Surface Temperature	5.6	3018	Spawning Stock Biomass	6.3

3019	Genetic diversity Index	5.5	3042	Nº boats registered	5.4	4017	Surveillance effort (hours)	4.7
3020	Philogeographic structure	5.3	3043	Nº Jobs / Employment	6.5	4018	Nº sanctions /year	5.7
3021	Extent of Habitats / Communities	6.9	3044	Nº families associated with fishing sector	5.7	4019	Nº contracts surveillance project	6.7
3022	Habitat & communities diversity	7.0	3045	Pollutants concentration on captured fish	5.8	4020	Zoning surface	6.6
3023	Biomass structuring species	6.7	3046	Perception conservation state	5.6	4021	% Non take zone over total surface	6.7
3024	Density structuring species	6.6	3047	Perception seafood availability	5.5	4022	Total nº implanted limitations	5.0
3025	Rugosity Index	5.5	3048	Early Warning Signals	5.8	4023	Nº legislation changes	4.3
3026	Bioturbation potential (BPc)	4.4	4001	Surface SAC	6.5	4024	Nº administration playing a role on SAC	4.4
3027	Richness	6.6	4002	Degree fulfillment objectives SAC	6.7	4025	Perception of coordination between administrations	4.8
3028	Relative abundance	6.6	4003	Frequency of updates and revision of key management elements	5.4	4026	Ratio affected parts/contacted parts	5.4
3029	Proportion invasive/ natives (PIN)	6.5	4004	Monitoring budget	5.2	4027	Nº engagement tools used	5.4
3030	Ratio Opportunistic/Sensitive	5.9	4005	Nº contracts on monitoring program	5.5	4028	Nº times applied tool has been repeated / updated	5.4
3031	Richness	6.0	4006	Nº reports produced by monitoring program	5.7	4029	Nº reports produced during engagement process	4.4
3032	Shannon / Simpson	5.8	4007	Nº and frequency of surveys	6.4	4030	Budget engagement actions	5.9
3033	Berguer-Parker	5.6	4008	In situ survey effort (hours at sea)	5.8	4031	Nº submission received	5.7
3034	Beta diversity	5.5	4009	Budget research projects	5.6	4032	Level stakeholder participation and satisfaction with management	6.8
3035	Biomass/Productivity key trophic groups*	6.3	4010	Nº research projects per year	4.8	4033	Level stakeholder involvement in surveillance	7.1
3036	Mean weight Zooplankton key groups	5.5	4011	Outreach project	5.4	4034	Level of resource conflict	6.0
3037	Mean weight at age of predatory fish*	5.8	4012	Nº collaboration agreements with other scientific institutions	5.9	4035	Local sense of approval	6.4
3038	High Trophic level Indicator (HTI), Apex Predator Indicator (API)*	6.3	4013	Nº new investigation lines detected / promoted	5.9	4036	Local understanding of SAC rules and regulations	6.9
3039	Income fishing sector	6.1	4014	Budget recovery actions	6.8	4037	Nº platform created for information dissamination	5.7
3040	Nº young bellow age of 35 working in the sector	5.8	4015	Nº actions taking place	6.6	4038	Nº of Tech. improvements detected/applied	5.5
3041	Per capita income of the sector	5.7	4016	Budget surveillance	5.8	4039	Budget invested on technological improvement	5.7

4040	Nº good practices identified/ implanted	6.5	4045	Legislation changes	5.8	4050	Existence and adoption of a monitoring plan	7.1
4041	Nº educational programs / year	6.7	4046	Existence of measures to favor artisanal fishing	6.2			
4042	Nº actions implemented to broadcast action protocols and codes of good practices	6.3	4047	Existence and adoption of an action protocol in case of risk situations	6.1			
4043	Budget educational programs	6.7	4048	Existence and adoption of a management plan and associated regulations	6.7			
4044	Budget training programs	6.6	4049	Existence and adoption of an engagement plan	6.6			

Table G.1: Codes, indicators and scores given by the experts as response of the first inquiry. Blue: Driving forces indicators, Red: Pressures indicators, Green: State/Impacts indicator and Orange: Response indicators. **Source**: Own elaboration