Bases para la planificación sostenible de áreas marinas en la Macaronesia

PLASMAR

Development of the Marine Strategy Framework Directive: reference points for commercially exploited species of the small-scale fisheries in Macaronesian archipelagos

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1. Introduction

The small-scale coastal fisheries are important complex systems world-wide, whom management should cover sustainable aspects (Hilborn et al., 2003), in a way that knowledge about the target species, fishermen idiosyncrasy and organisation, as well as external factors that affect them are fully integrated (FAO, 2019). However, the knowledge on these fisheries remains poor, despite its considerable importance (FAO, 2018; Lunn et al., 2006; Nadon and Ault, 2016; Pauly and Zeller, 2016). Much of these artisanal fisheries lack of required data to apply the traditional stock assessments tools (Fenner, 2012; Nadon and Ault, 2016), which force to use less robust and reliable methods to determinate parameters to management them (e.g. reference points) (Free et al., 2019; Pilling et al., 2008). Multispecific poor-data artisanal fisheries which take place in Hawaii waters (Nadon et al, 2015), off the Canary Islands (García-Mederos et al., 2015; Hernández-García et al., 1998), or those that take place along the Mediterranean Sea and other European coastal regions (Guyader et al., 2013; Stobberup et al., 2017) could be good examples of this situation.

European Union (EU) defines small-scale or artisanal fisheries as those whose fishing vessels are less 12 meters of length and not using bottom trawl or similar gears (listed in annex XI, currently) (Regulation (EU) No 508/2014). Fishing fleets with home ports in the Azores, Madeira and Canary Islands can be considered mostly as artisanal, because a high proportion of their boats are less than 12 m of length (http://ec.europa.eu/fisheries/fleet/index.cfm), and trawling is forbidden in most of their waters (Regulation (EU) 2019/1241). The Azores (754 vessels) and Madeira (431 vessels) fishing fleets account for over 15% of the Portuguese fishing fleet (in number of ships), while the Canarian fleet comprises the 8.5% (771 vessel) of the Spanish fishing fleet. These vessels usually operate within waters of their exclusive economic zones, but mostly on the island shelves close to their home port (Martín-Sosa, 2012; Ojamaa, 2015; Shon et al., 2015; Vallerani et al., 2017). Nevertheless, the fleets of the three archipelagos also have a less proportion of long-distance boats, which operate far from the shorelines and/or in large-distance, for example in the neighbouring African fishing grounds. Both sub-fleets (artisanal and long-distance) have co-existed for decades in the Canary Islands (Balguerías-Guerra, 1993), although the last one has experimented an important reduction (Martín-Sosa, 2012; Popescu and Ortega-Grass, 2013). In 2011, Azores and Madeira there were 117 and 51 vessels over 12 m in length respectively, operating in the eastern central Atlantic and international waters (Iborra-Martín, 2011; MAPA, 2020).

On the other hand, the fishing fleet of the Canary Islands (Martín-Sosa, 2012), and also those of Madeira and Azores (Morato et al., 2012), could be subdivided in inshore fleet, tuna live-bait fleet, deep-water fish fleet (i.e. the Madeiran black scabbardfish fishery), and African or large-distance grounds fleet. The inshore one is composed by artisanal polyvalent boats (multi-gears and multi-species) that are addressed to fish mainly neritic bentho-demersal and middle-sized pelagic fish species, but also tuna when these species pass across the archipelagos (Martín-Sosa, 2012; Morato et al.,2012). Nevertheless, pelagic longline targeting swordfish fleet has been also important in the Azores (Morato et al.,2012; Ojamaa, 2015).

The polyvalence of most of these fleets makes difficult their management (Caddy and Mahon, 1996; Morato et al., 2012). However, in this context, the Food and Agriculture Organization of the United Nations (FAO) calls for the use of the Ecosystem Approach to fisheries (EAF) in support of it (Cochrane and Garcia, 2009; FAO, 1995, 2003), because it is aimed at achieving their sustainable development (FAO, 2019). Thus, one EAF plan exposes, among other issues, the importance of transforming the different goals in specific operational objectives which are of direct application. As well as it is necessary to set performance measures and reference points to verify the development of the management, both short and longer-term (FAO, 2003).

The reference points are parameters (qualitative and quantitative) for monitoring this activity, since these indicate whether the chosen characteristics for its assessment proceed in accordance with the established aims (Cochrane and Garcia, 2009). According to Cadima (1997), biological reference points (BRP) are devoted to measure the fishing mortality rate (F) or the biomass or harvested stocks (B, or the spawning stock biomass, SSB). The target reference points (TRP) (e.g. $F_{0.1}$ or F_{MSY}) are BRP established to explain the performance of the decisions based on long-term aims. Whiles the limit reference points (LRP) are those used as thresholds dedicate to safeguard the stocks. Different versions of F_{LIM} y SSB_{LIM} (LRP) can be obtained according to the approach used to estimate (e.g. the precautionary principle) (Cadima, 1997; FAO, 1995). Operational objectives and BRP are important to guide and monitor the fisheries from EAF, and for it, these are key aspects in the Marine Strategy Framework Directive (MSFD) (Directive 2008/56/EC).

MSFD was published in June 2008, and its purpose is to create a framework where the Member States of the European Union must implement measures to achieve or maintain “the Good Environmental Status” (GES) of the marine environment. GES 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 generations.

In order to achieve the MSFD objectives, administrations of member states must design actions to protect and preserve the marine environment, as well as to restore the ecosystems, and to ensure the lowest possible anthropogenic influence on diverse issues: biodiversity, human health, conservation of the ecosystem services, etc., as a result of the ecosystem approach which guides to MSFD. They need to address the inherent challenges, such as the integration of the knowledge from both, the whole natural system (physical-chemical and biological aspects), and human activities that could affect the environmental status, and address subsequent research about the possible impacts (Boyes et al., 2016; Oesterwind et al., 2016).

Thus, environmental Status should be assessed according to 11 qualitative descriptors, following the Commission Decision (EU) 2017/848, which makes possible to verify whether GES has been reached. In the present report, only descriptor 3 (D3) is addressed. Commercially exploited fish and shellfish species are the criteria elements which should be assessment according to the D3 criteria (D3C1, D3C2 y D3C3), and the target of the Common Fisheries Policy is the maximum sustainable yield (MSY) (Regulation (EU) No 1380/2013). The criteria definitions and related methodologies are detailed below, but only D3C1 and D3C2 is the subject of the present work:

D3C1- The Fishing mortality rate (F) of populations of commercially-exploited species is at or below levels which can produce the MSY (F_{MSY}). It is intended to measure of the exploitation rate by fishing activity (Piet et al., 2010).

D3C2- The Spawning Stock Biomass (SSB) of populations of commercially-exploited species are above biomass levels capable of producing the MSY (SSB_{MSY}). It is an indicator of reproductive capacity of stocks (Nadon et al., 2015; Piet et al., 2010).

D3C3- The age and size distribution of individuals in the populations of commercially-exploited species is indicative of a healthy population.

Commission Decision (EU) 2017/848 describes another important issue, the possibility to use alternatives variables when it is not possible to estimate reference points (F_{MSY} and SSB_{MSY}) indicated in those criteria,… and an appropriate method for trend analysis shall be adopted (e.g. the current value can be compared against the long-term historical average). Nevertheless, progress on the data-limited assessment methods (DLMs) are being very useful, because these have been designed to data-poor stock assessment and being used in fishery management (Dowling et al., 2019).

This report describes the assessment process of the most important stocks in the Azores, Madeira and the Canary Islands archipelagos, with the objective to determine the GES, according to the D3C1 (F) and D3C2 (SSB) criteria from D3 (MSFD), in a poor-data fisheries context. The objectives of both criteria are developed through models for reference point estimate in relation to the theoretical reference (according to MSY), F/F_{MSY} y B/B_{MSY}, that can contribute to the design of more accurate measures in the fishery management process. These relations have been calculated for those stocks that were considered according to their relevance for the small-scale coastal fisheries in these archipelagos and their ecological role in the marine biological communities.

1.1 MSFD Background

The evaluation of the D3 during the first cycle of the MSFD, was mainly focused on tuna and middle-sized pelagic fish in the Canary archipelago, since these species represent a higher proportion of landings, and because more detailed information is available. Initially, it was proposed to evaluate some benthic and demersal species such as *Sparisoma cretense*, *Dentex gibbosus*, *Pagrus pagrus*, *Sarpa salpa*, *Muraena augusti* and *Spondyliosoma cantharus* (Jiménez et al., 2012), but this idea was discarded in the absence of data and only *Sparisoma cretense* has been proposed for the second cycle of the MSFD (MITECO, 2019).The assessment in Madeira was mainly composed of tuna and coastal pelagics, with *Pagrus pagrus* being the only demersal specie; unlike the Canary Islands, the mollusc *Patella candei* was also evaluated in Madeira (SRA, 2014). The Azores archipelago has the largest number of assessed stocks, focusing not only on tuna and coastal pelagics but also on neritic and deep-water species. Likewise, various species of molluscs and crustaceans were included in this evaluation (SRMCT, 2014).

However, the results obtained for some stocks are contrary to the results obtained in studies realized in the same areas. For example, Morato (2012) made a detailed description about the knowledge of fish stocks and fisheries in Azores and Madeira, concluding that the status of most of the targeted species was unknown, particularly in Madeira fishing grounds. The black scabbardfish (*Aphanopus carbo*) is the most important resource exploited in Madeira, and the report prepared for the MSFD considers that the stock is in good condition, despite that landings are steadily decreasing since 1998 (Morato, 2012; Serrano-Gordo, 2009). It is assumed that intensive fishing of deep-sea species caused a decrease in their relative abundance in the usual fishing grounds, leading to an extensive geographical expansion of the fishery reaching as far as the Southern Azores Seamount Chain and the EEZ of the Canary Islands (Delgado et al., 2018). On the other hand, large pelagic species (tuna and swordfish), blue jack mackerel and conger are also very important in Azores, and bottom longlines and handlines fisheries are focus on deep-water species such as blackspot seabream (*Pagellus bogaraveo*), wreckfish (*Polyprion americanus*), alfonsinos (*Beryx* spp.) and blackbelly rosefish (*Helicolenus dactylopterus*). Stocks assessment in the 1st period of the MSFD point out that those are within the sustainable limits of exploitation, despite the fact that since the mid-1990s the landings of deep-water species show a decreasing tendency, reflecting a change in the target of the fleet towards blackspot seabream (ICES, 2019). Moreover, other studies also suggested that alfonsinos (da Silva and Pinho, 2007) and blackbelly rosefish (Perrotta and Hernández, 2005) are intensively exploited, and *Pagellus bogaraveo* is overexploited (Novoa-Pabon et al., 2015). Regarding the Canary Islands, the stocks of benthic and demersal species have not been assessed, despite their importance in the fishery and that they have been showing symptoms of depletion in the archipelago for years, so it is considered that many stocks are currently overexploited (Castro et al., 2019; González, 2008).

2. Methodology

2.1 Study area

Fishing data of assessed stocks come from the Exclusive Economic Zones (EEZ) of the Azores, Madeira and Canary archipelagos (Figure 1). These large areas are included in the Northeast Atlantic fishing area or area 27 (Azores archipelago), and the Central-east Atlantic fishing area or area 34 (Canary and Madeira archipelagos). The fishing area 27 is under the scientific supervision of the ICES (International Council for the Exploration of the Sea), while the fishing area 34 is under the management of CECAF (Committee for the Central Eastern Atlantic Fisheries).

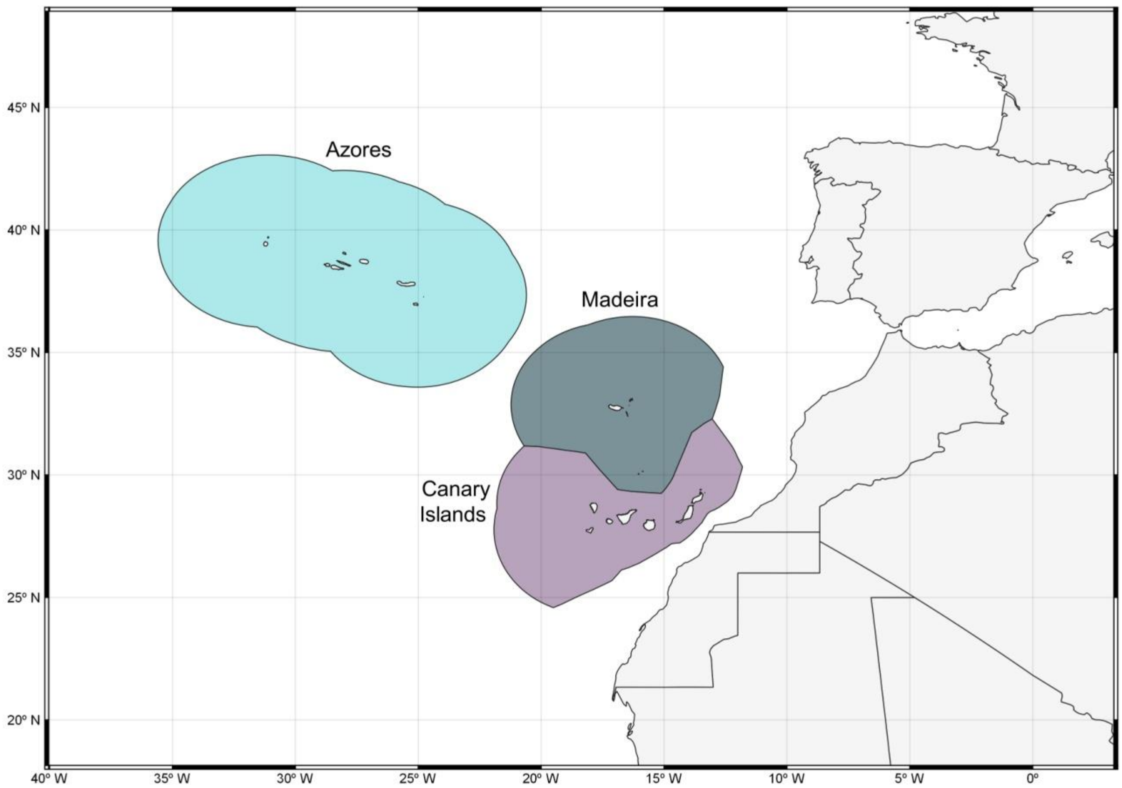

Figure 1. Exclusive Economic Zone of each archipelago. Source: www.marineregions.org

Fisheries in these archipelagos are characterized by high biodiversity and low biomasses conducted by polyvalent fleets mainly focused on demersal fish, middle-sized coastal pelagic fish and tuna. However, fishing strategies differ between archipelagos, and this is also reflected in the target demersal species, since small-scale fishing fleets of Azores and Madeira they are focused mainly on deep-water species (Morato, 2012), while in the Canary Islands the most fished species are demersal neritic ones (Bas et al., 1995). Fishing grounds are concentrated on islands shelves and seamounts (Menezes et al., 2006; Morato et al., 2008), with the exception of large pelagic fish that are fished in open waters. However, deep-sea fisheries usually take place in a relatively larger area, in waters between 200 and 1700 m deep, on the islands slopes (Delgado et al., 2013; Morales-Nin and Sena-Carvalho, 1996).

3. Stocks assessments

Our input data comprise the catches of thirty-one species (Table 1) caught in the EEZs of Azores, Madeira and Canary archipelagos during the period 1950-2014, from reconstructed time series including artisanal, industrial, recreational and subsistence fishing which have been previously validated (Castro et al., 2019; Pham et al., 2013; Shon et al., 2015). These databases were downloaded from *Sea Around Us* web page (Pauly et al., 2020).

Considering the available data, and the absence of a measure of effort that was homogeneous in the three archipelagos and for all fleets, we choose the optimized catch-only method (OCOM), developed by (Zhou et al., 2018) based on the Graham-Schaefer surplus production model:

$$B_{t+1} = B_t + rB_t\left[1 - \frac{B_t}{K}\right] - C_t \qquad (1)$$

where B_y is the biomass at the start of time step t, r is the intrinsic growth rate, K is the carrying capacity, and C_t is the catch during time-step t. Because depletion $d = 1 – S = 1 – B_t/K$, where S is referred to as stock saturation, K can be solved if prior information on r and S is available. The prior distribution for population growth rate r is deduced from natural mortality M. In a previous work, Zhou et al. (2012) linked F_{MSY} with natural mortality, assuming $r = 2F_{MSY}$, which is the case for the Schaefer model, to obtain r from M.

The prior distribution of saturation parameter S is derived from catch trend over the fishery history using a boosted regression tree (BRT) model (Zhou et al., 2017). The two parameters, K and r, are negatively correlated, so the maximum K is constrained by $r = 0$, and maximum r is constrained by the minimum viable K. The aim of this approach is to identify the most likely $r \sim K$ combination on the curve which retain a viable population over time (i.e. where $B_t > C_t$, $B_t \leq K$ and $B_t > 0$ always hold true) excluding unfeasible values.

Time series of stock biomass and harvest rate, the parameters r and K as well as MSY benchmarks (MSY, F_{MSY} and B_{MSY}) will be calculated using the OCOM model, implemented as an R package within the datalimited2 suite (https://github.com/cfree14/datalimited2).

Natural mortality for each stock was estimated using the following empirical equation (Pauly, 1980):

$$LogM = -0.0066 - 0.279 \cdot LogL_\infty + 0.6543 \cdot LogK + 0.4634 \cdot LogT \qquad (2)$$

where L_∞ is the asymptotic length, and K is the curvature parameter obtained from the Von Bertalanffy growth equation. T is the mean sea water temperature of the depth range where each stock usually lives, expressed in ◦C. The values of M of each species were obtained from the bibliography (Table 1).

Table 1. Stocks evaluated during the analysis indicating their fishing ground (A: Azores; M: Madeira; C: Canary Islands); the number in brackets represents the code used to identify each species in subsequent related analysis, and M is the natural mortality

Specie	**EEZ**	**M**	**Reference**
(1) *Aphanopus carbo*	M	0.23	(Delgado et al., 2013)
(2) *Atherina presbyter*	C	1.4	(Lorenzo and Pajuelo, 1999)
(3) *Beryx decadactylus*	A	0.13	(Krug et al., 2011)
(4) *Beryx splendens*	A	0.46	(Rico et al., 2001)
(5) *Boops boops*	A, M, C	0.32	(Massaro and Pajuelo, 2018)
(6) *Brama brama*	M	0.17	(Lobo and Erzini, 2001)
(7) *Conger conger*	A, M, C	0.1	(Correia et al., 2009)
(8) *Dentex gibbosus*	C	0.28	(Pajuelo and Lorenzo, 1995)
(9) *Diplodus sargus*	M	0.30	(Pajuelo and Lorenzo, 2002)
(10) *Engraulis encrasicolus*	C	0.85	(Bellido et al., 2000)
(11) *Epinephelus marginatus*	A	0.14	(Bouchereau et al., 1999)
(12) *Helicolenus dactylopterus*	A	0.13	(Abecasis et al., 2006)
(13) *Lepidopus caudatus*	A	0.32	(Figueiredo et al., 2014)
(14) *Mullus surmuletus*	M, C	0.55	(Pajuelo et al., 1997)
(15) *Muraena helena*	A	0.14	(Jiménez et al., 2007)
(16) *Pagellus acarne*	M	0.30	(Pajuelo and Lorenzo, 2000)
(17) *Pagellus bogaraveo*	A, M	0.25	(Krug, 1989)
(18) *Pagellus erythrinus*	C	0.30	(Pajuelo and Lorenzo, 1998)
(19) *Pagrus pagrus*	A, M, C	0.11-0.31	(Pajuelo and Lorenzo, 1996; Serafim and Krug, 1995)
(20) *Phycis phycis*	A, M	0.23	(Abecasis et al., 2009)
(21) *Polyprion americanus*	M	0.10	(Sedberry et al., 1999)
(22) *Pontinus kuhlii*	A	0.237	(Guénette and Morato, 2001)
(23) *Sardina pilchardus*	A, C	0.55	(Abderrazik et al., 2018)
(24) *Sardinella aurita*	C	0.49	(Navarro, 1932)
(25) *Sardinella maderensis*	C	0.71	(Ba et al., 2016)
(26) *Sarpa salpa*	A, C	0.42	(Villamil et al., 2002)
(27) *Scomber colias*	M, C	0.34	(Vasconcelos et al., 2011)
(28) *Sparisoma cretense*	A, C	0.22	(Lozano and González, 1993)
(29) *Spondyliosoma cantharus*	C	0.52	(Pajuelo and Lorenzo, 1999)
(30) *Trachurus picturatus*	A, M, C	0.33 – 0.49	(Jurado-Ruzafa and Santamaría, 2014; Vasconcelos et al., 2018)
(31) *Zeus faber*	A	0.617	(Guénette and Morato, 2001)

4. Results and discussion

4.1 Evolution and expansion of fisheries

As a previous step to the stock assessment, we made a brief analysis of the catches grouping them according to the type of fishing, and also according to decades (Figure 2) to see global changes in the fishing strategies over time.

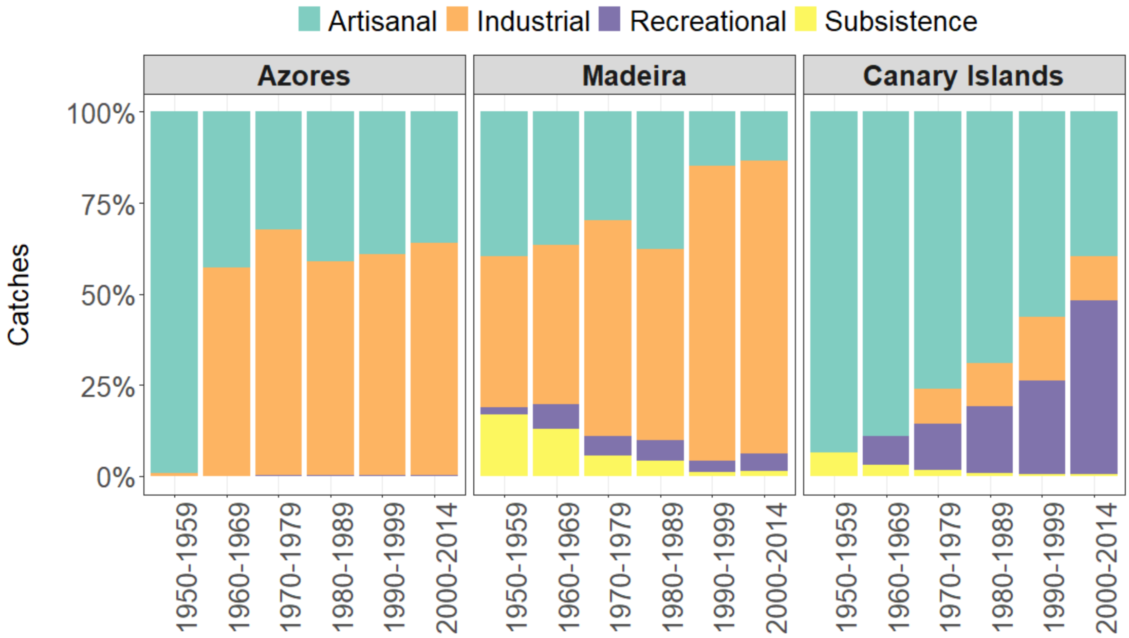

Figure 2. Evolution of the different fisheries during the period 1950-2014 in the three Macaronesian archipelagos.

More than 90% of the catches from the Canary and Azores archipelagos were obtained by the artisanal fisheries in the '50s, while catches in Madeira were distributed in almost identical proportions between the artisanal and industrial fleets. Over the decades the proportions of catches by fishing modality changed, so industrial fishing was gradually replacing artisanal fishing in Azores and Madeira archipelagos, increasing catches up to 64% and 80% at the end of the study period, respectively. Recreational and subsistence fishing represented approximately 20% of all catches in the 50s in Madeira, but at the end of the available time series they were less than 10%. Industrial fishing in the EEZ of the Canary Islands reached its maximum development in the '90s, encompassing almost 20% of the total catch, but the most significant change is the increase of recreational catches from 1990 until today, surpassing the artisanal ones. It is important to highlight that despite that the Canary Islands have an important industrial fleet that fish abroad, mainly in the African fishing grounds next to the islands, the capture series used in this analysis was only referred to catches obtained in waters within the EEZ of the Archipelago.

The impact that each type of fishing has on ecosystems and stocks is difficult to assess since insufficient information is available. Furthermore, the impact on the target species must be considered not only, but also on the associated fisheries. For example, after analysing the databases, it can be observed that industrial fishing in Azores has the greatest impact on large pelagic fish, sharks, pelagic cephalopods and deep-water species, while its artisanal fleet is mainly focused on middle-sized coastal pelagic fish and other benthodemersal species. On the other hand, industrial fishing in Madeira is focused on large deep-water species (i.e. scabbardfishes), as well as sharks and tunas. Regarding Canary Islands, industrial fishing is limited to large bathypelagic species and small to middle-sized sharks, including some tuna catches, while subsistence fishing comes down to invertebrate species (gathering), predominantly on octopus and limpets. However, in this last area, recreational anglers play a significant role and compete for the main target species with the artisanal fleet (MAPYA, 2006).

In this context, it can be verified that several shark populations can be indirectly affected by the capture of other commercial species and discarded. The main problem is that these catches are rarely recorded, so its impact could be underestimated and even put these populations at risk, since their stock assessments are based on the reported catches. In the particular case of recreational fishing in the Canary archipelago, it would be advisable to review the current applicable fishing regulation and propose modifications that limit the effort, and the list of targeting species to this fishing, because in addition to the impact it has on the ecosystem and anglers compete for the same species with the professional fishing sector.

4.2 Stocks assessment

Results obtained from the only-catch model were represented in Kobe plots, that show the evolution of the catches along time for a better interpretation of the results (Figures 3-5). The Kobe plot split the graph into four sections, where the red zone corresponds to not desirable phase (overfishing and overfished), while the green one represents a healthy stock (overfishing is not happening) and yellow areas show intermediate situations.

Sudden increases in the pattern of the catches, either over time or at specific periods, may indicate an expansion of the fishery or a change in fishing techniques. Thus, for example, it can be seen that until the 1980s the catches of species such as *Beryx splendens, Helicolenus dactylopterus, Pontinus kuhlii* or *Pagrus pagrus* were mostly anecdotal in Azores (Figure 3A). This is also notable in the cases of *Aphanopus carbo, Scomber colias* and *Trachurus picturatus* in Madeira (Figure 4A). More striking are the plots for the Canary Islands (Figure 5A), which show an increase in catches for most stocks from the 1970s, probably related to the technological development of vessels and the growth of the fish product demand until the mid-80s, that led the fleet overcapacity and, consequently, the overexploitation of neritic resources (Barrera Luján, 2016).

Of the seventeen Azorean stocks analysed, nine are in the red zone and the remaining eight stocks are overfished (Figure 3B). The species that are in a more vulnerable situation are, in this order: *Lepidopus caudatus, Conger conger, Muraena helena, Sparisoma cretense, Phycis phycis, Epinephelus marginatus, Zeus faber, Pagrus pagrus* and *Pontinus kuhlii*. The only stock found in the critical zone in Madeira is *Phycis phycis,* although the rest of the analysed stocks are overfished and have biomasses below the maximum sustainable yield (Figure 4B). The coastal pelagic stocks are shown as highly vulnerable in the Canary archipelago, being the only one analysed in the red zone. However, the rest of the stocks do not fare much better because they appear as overexploited, except for the stocks of *Pagellus erythrinus* and *Sarpa salpa* which are apparently in good condition (Figure 5B).

In general terms, our results show the inadequacy of the current fishery management strategy on most of the analysed stocks in the Canary Islands (Table 2). Although the most plausible explanation of this failure may be related with the use of single-species stock approximations for assessment instead an ecosystem approach (Couce-Montero et al., 2015), the real situation is that management has been always made by eye, because there were not enough biological and fishery information necessary to reach that these stocks were fished within safe biological limits.

Unfortunately a similar situation has happen in Azores and Madeira archipelago, where managers have ignored the less important commercial species and have focused the assessment only in a few species, as scabbardfishes and tuna-like species (Table 2).

Based on the fisheries reconstruction done in the framework of the *Sea Around Us* programme (Pauly et al., 2020), the present work shows that almost all the stocks analysed are overexploited in the three Macaronesian archipelagos and, in the particular case of Azores, many of the bentho-demersal stocks continue to be exploited above the F_{MSY}. Differences in the results obtained in this work and reports prepared during the first cycle of the MSFD lie in the underestimation of the input data if comparing the two approaches.

Fisheries included in this study are characterized by the complexity and the versatility of their fleets, with the additional problem of geographical dispersion of the extractive units. The first problem we face with this situation is that fishing activities alter the structure and functioning of marine food webs, so fishery management based on single species could be not enough to develop adequate sustainable exploitation strategies to preserve marine ecosystems.

For example, discards usually encompass marine mammals, sea turtles, seabirds, elasmobranches and some bony fishes, including endangered, threatened and protected species. Elasmobranches are a common component of the bycatch and discard from fisheries (Bonanomi et al., 2017; James et al., 2016; Megalofonou et al., 2005; Zhou and Griffiths, 2008) being also vulnerable to overexploitation due to their life strategies. Leafscale gulper shark (*Centrophorus squamosus*), smooth lanternshark (*Etmopterus pusillus*), and Portuguese dogfish (*Centroscymnus coelolepis*), among other elasmobranches, are incidentally captured and discarded in the longline fisheries targeting black scabbardfish (*Aphanopus carbo*) in Azores and Madeira archipelagos (Ramos et al., 2013). Leafscale gulper shark is assessed as critically endangered, and the other two elasmobranch species have been recently assessed as Endangered in the Red List of European marine fish (Nieto et al., 2017). Deep-sea sharks were also observed to be the most important component of the incidental catch of the black scabbardfish longline fishery in the Canary Islands, being *Zameus squamulosus*, *Deania hystricosa*, *Centrophorus squamosus*, *Centroscymnus coelolepis* and *Etmopterus princeps* the most frequently species present in the catches (Pajuelo et al., 2010). Based on (Zeller et al., 2018), the vast majority of discards come from industrial fisheries and, although this type of fishing is barely developed within the EEZ of the Canary Islands, it has greater importance in the Azores and Madeira archipelagos, so it is a factor to consider in fisheries management policies.

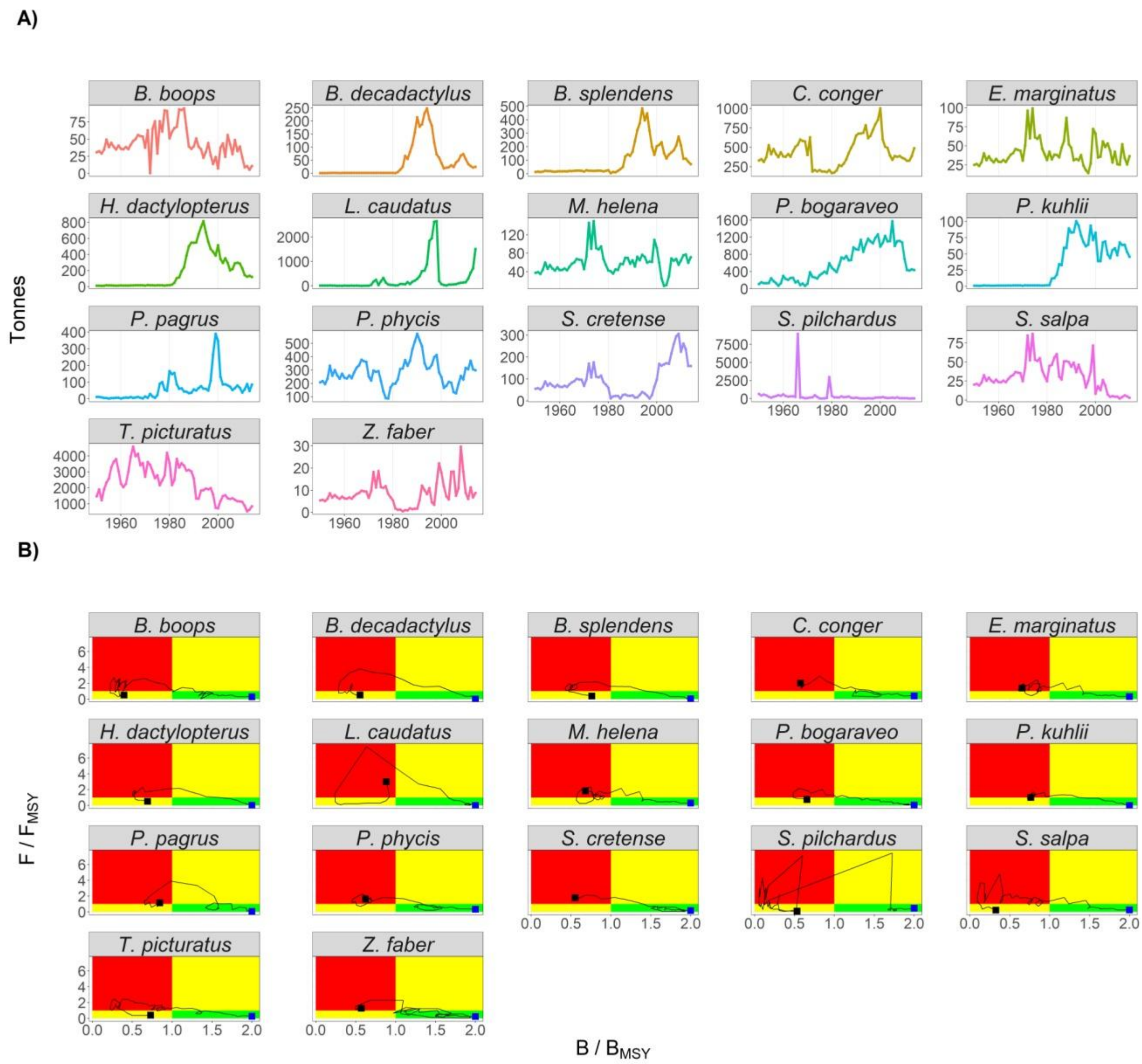

Figure 3. A) Catch time series of the evaluated species .B) Kobe plots to compare the evolution of target species stocks in Azores EEZ. The blue square represents the start year of the time series and the black square the year 2014.

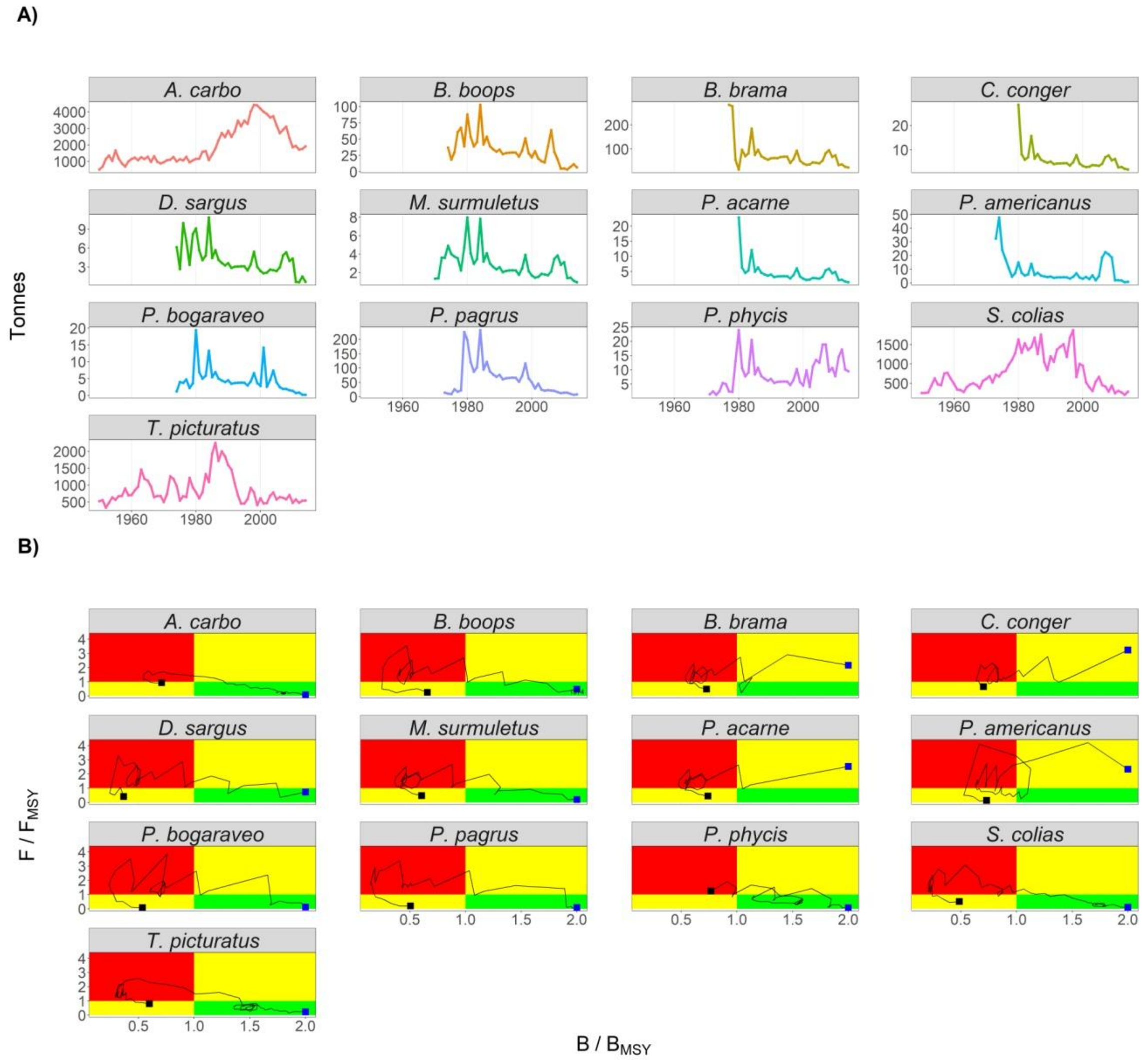

Figure 4. A) Catch time series of the evaluated species. B) Kobe plots to compare the evolution of target species stocks in Madeira EEZ. The blue square represents the start year of the time series and the black square the year 2014.

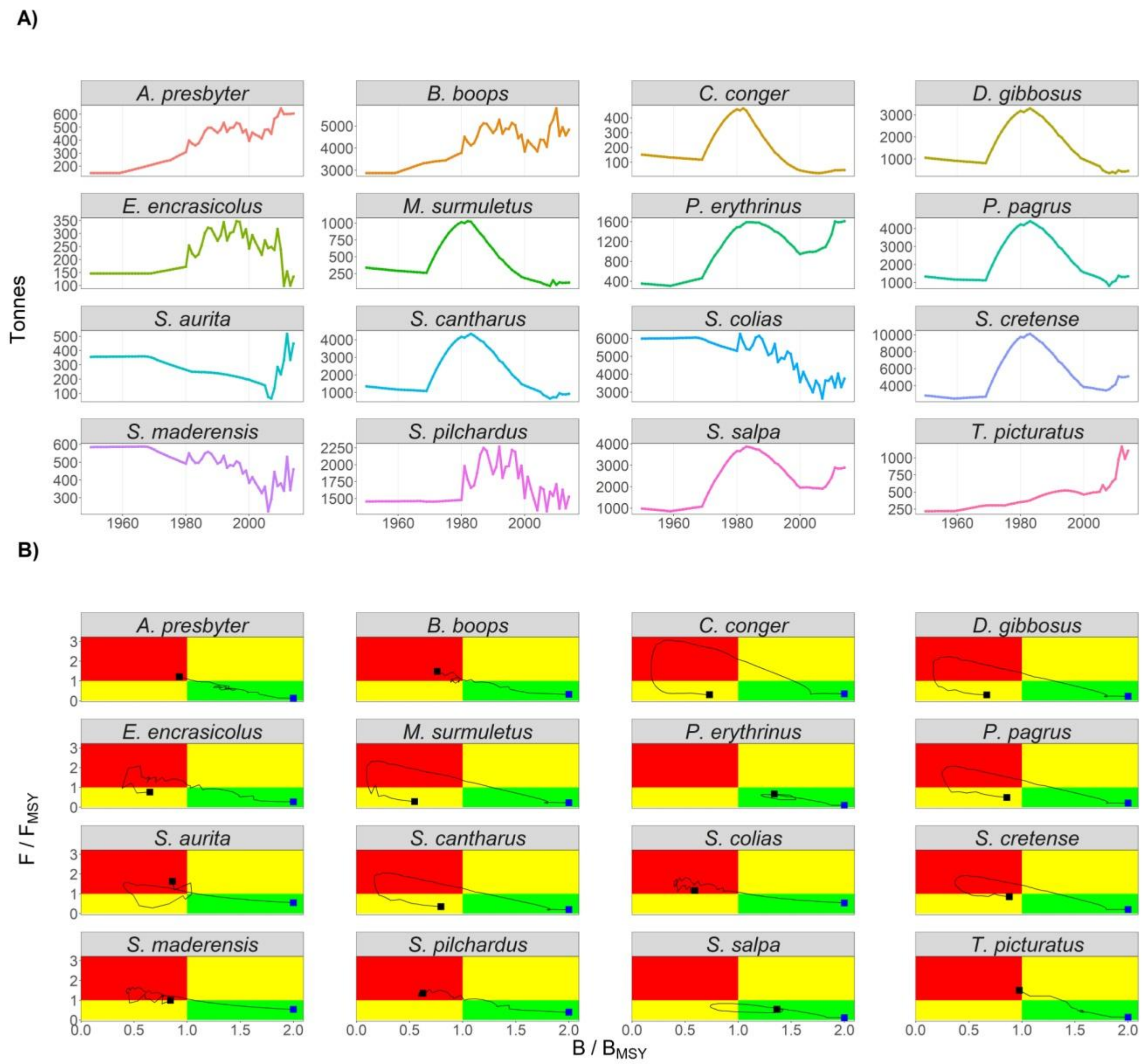

Figure 5. A) Catch time series of the evaluated species. B) Kobe plots to compare the evolution of target species stocks in Canary Islands EEZ. The blue square represents the start year of the time series and the black square the year 2014.

Table 2. The reference points (F/F_{MSY} and B/B_{MSY}) estimated for the main target species of the fishing fleets of Azores, Madeira and Canary archipelagos.

EEZ	Specie	Start year	End year	F/FMSY (2014)	B/BMSY (2014)
Azores Isl. (Portugal)	*Boops boops*	1950	2014	0.50	0.40
	Beryx decadactylus	1950	2014	0.52	0.55
	Beryx splendens	1950	2014	0.38	0.75
	Conger conger	1950	2014	2.01	0.58
	Epinephelus marginatus	1950	2014	1.38	0.65
	Helicolenus dactylopterus	1950	2014	0.53	0.69
	Lepidopus caudatus	1950	2014	3.00	0.88
	Muraena helena	1950	2014	1.83	0.68
	Pagellus bogaraveo	1950	2014	0.75	0.66
	Pontinus kuhlii	1950	2014	1.02	0.76
	Pagrus pagrus	1950	2014	1.15	0.85
	Phycis phycis	1950	2014	1.62	0.62
	Sparisoma cretense	1950	2014	1.79	0.55

EEZ	Specie	Start year	End year	F/FMSY (2014)	B/BMSY (2014)
	Sardina pilchardus	1950	2014	0.09	0.53
	Sarpa salpa	1950	2014	0.22	0.32
	Trachurus picturatus	1950	2014	0.40	0.73
	Zeus faber	1950	2014	1.27	0.57
Madeira Isl. (Portugal)	*Aphanopus carbo*	1950	2014	0.95	0.71
	Boops boops	1974	2014	0.26	0.66
	Brama brama	1977	2014	0.49	0.71
	Conger conger	1980	2014	0.65	0.70
	Diplodus sargus	1974	2014	0.45	0.33
	Mullus surmuletus	1970	2014	0.47	0.59
	Pagellus acarne	1980	2014	0.44	0.75
	Polyprion americanus	1973	2014	0.1	0.73
	Pagellus bogaraveo	1974	2014	0.07	0.55
	Pagrus pagrus	1973	2014	0.20	0.51
	Phycis phycis	1971	2014	1.24	0.77
	Scomber colias	1950	2014	0.51	0.48
	Trachurus picturatus	1950	2014	0.82	0.61
Canary Isl. (Spain)	*Atherina presbyter*	1950	2014	1.23	0.92
	Boops boops	1950	2014	1.47	0.77
	Conger conger	1950	2014	0.31	0.70
	Dentex gibbosus	1950	2014	0.28	0.70
	Engraulis encrasicolus	1950	2014	0.72	0.67
	Mullus surmuletus	1950	2014	0.26	0.59
	Pagellus erythrinus	1950	2014	0.65	1.35
	Pagrus pagrus	1950	2014	0.49	0.88
	Sardinella aurita	1950	2014	1.55	0.91
	Spondyliosoma. cantharus	1950	2014	0.34	0.82
	Scomber colias	1950	2014	1.16	0.60
	Sparisoma cretense	1950	2014	0.84	0.87
	Sardinella maderensis	1950	2014	0.99	0.87
	Sardina pilchardus	1950	2014	1.39	0.61
	Sarpa salpa	1950	2014	0.51	1.37
	Trachurus picturatus	1950	2014	1.43	1.00

5. Conclusion

Single-species models focus on few target species, and generally do not include secondary and/or highly vulnerable species that can jeopardize the ecosystem structure. In conclusion, and although the use of these indicators and single-stock assessment are acceptable to obtain an overview of the ecosystem in a broader context, the results are highly conditioned by the input data and the methodology used.

For this reason, and in view of the discrepancies obtained with the previous evaluations carried out within the framework of the MSFD, we recommend full ecosystem models to evaluate marine ecosystems and their fisheries associated, especially in large areas as EEZs since they can include multiple species and relate changes in their biomass and impacts

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