Rapid assessment of protection and ecological effectiveness of the Spanish Fishing Reserve Network

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Abstract: Fishing Reserves (FRs) are primarily designated for the enhancement of local fisheries and, secondarily, for biodiversity conservation. In Spain, FRs are considered marine protected areas (MPAs) and included in the country's MPA network. MPAs' ecological effectiveness is linked to a number of legal, managerial and bio-physical factors. With the amount of MPA area rapidly rising and conservation funds largely stagnant or decreasing, rapid, cost-effective MPA assessment techniques are becoming increasingly useful to verify fulfillment of global conservation targets and ascertain potential conservation effectiveness. Here, a rapid MPA protection assessment framework and one MPA ecological effectiveness framework were applied to the Spanish Network of 10 FRs (FRN): the MaPAF and NEOLI frameworks. The FRN was moderately legally protected, with over 50.5% of its area having three or more overlapping legal designations, but only 3.8% of the FRN's area being no-take. All FRs had management plans and active surveillance. According to MaPAF, Columbretes FR was the most highly legally protected whereas Cabo de Palos was the FR with the greatest managerial effort. Both rank highest in protection. In contrast, Masía Blanca FR and Alborán FR were the least legally protected whereas Alborán FR and Graciosa FR were the least managerially protected FRs of the FRN and rank the lowest in protection, respectively. According to the NEOLI framework, Columbretes would also be the most effective FR whereas Masía Blanca FR would be the least ecologically effective. These results can help to spur and better allocate conservation efforts across the fastly growing Spanish MPA network.

1. Introduction

FRs are one type of spatial protection measure of the seas aimed at enhancing fishing resources for sustainable fishing activities. As a result of the legal and managerial protection FRs are afforded, they also act as de facto MPAs by helping to conserve valuable biodiversity within their borders. International guidelines recommend not considering FRs as MPAs because their main aim is not biodiversity conservation, but as Other Effective Area-Based Conservation Measures (OEABCMs; Day et al., 2012). Both MPAs and OEABCMs should contribute to globally accepted targets to conserve at least 10% of coastal and marine areas through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures by 2020 (CBD, 2010). Meeting that target on

time seems challenging despite recent substantial rises in MPA coverage (Bhola et al., 2016), as just three years ahead of the deadline, only 6.4% of the global ocean, including 15.9% of waters under national jurisdiction and 0.25% of waters in areas beyond national jurisdiction are covered by MPAs (UNEP-WCMC & IUCN, 2017). Moreover, last year, the International Union for the Protection of Nature (IUCN) approved to call for '30% of each marine habitat' to be included in 'highly protected MPAs and OEABCMs' by 2030, with the ultimate aim of reaching 'a fully sustainable ocean, at least 30% of which has no extractive activities' (Davis, 2016).

Management is considered an essential factor for the ecological effectiveness of any protected area (Hockings et al., 2006; Bhola et al., 2016), more so in highly connected, heavily pressured and little enforced marine environments (Halpern et al., 2008; Mora & Sale, 2011). Nevertheless, proper assessment of the effects of

protection measures on biodiversity is costly, effort-intensive and complex, as it very much depends on adequate semi-experimental designs that must account for natural populations' variability and a high number of confounders (García-Charton et al., 2004; Addison, 2011). Therefore, effectively protecting such huge amount of marine area seems a daunting task given the important costs of MPA designation and essential management activities such as surveillance or monitoring (Balmford et al., 2004; McCrea-Strub et al., 2011) and chronic underfunding of marine conservation activities (de Santo, 2013; Mazor et al., 2013) which currently result in most MPA area being insufficiently managed (Rodríguez-Rodríguez, in press). Moreover, there are little prospects that marine conservation funds are going to increase at all, let alone to keep pace with foreseen rapid MPA coverage growth (de Santo, 2013). Thus, scarce funds will have to render greater efficiency if some management is to be afforded to MPAs. As a result, rapid, cost-effective methods that are able to validly estimate conservation effectiveness are likely to become increasingly useful for the marine conservation community.

(M)PAs effective conservation and management is required by international policy (CBD, 2010) and, though a number of PA assessment techniques and evaluation frameworks have been developed (Leverington et al., 2010), very few have been yet applied to the marine environment, thus remaining a pending research task (Bhola et al., 2016). The most broadly used systems in terrestrial PAs are opinion-based (Ervin, 2003; Stolton et al., 2007) and, although they are of some use to identify major pressures, strengths and weaknesses to PAs, they have not shown accurate or precise enough to assess ecological effects (Carranza et al., 2014; Cook et al., 2014). Thus, there is the need for rapid assessment systems based on official statistics rather than (on in addition to) informed opinions, so at least precision can be ensured. Rodríguez-Rodríguez et al. (2016a) developed a Marine Protected Area Protection Framework (MaPAF) aimed at objectively assessing protection of (M)PAs based on indicators of legal and managerial protection and applied it to the Mediterranean MPA system. MPA protection was used as a surrogate for ecological effectiveness, although proper validation is needed.

In Spain, FRs were pioneering measures to improve the sustainability of the marine environment, with the first FR being designated in 1986 (Spanish Government, 1986). Though designated through the fisheries legislation and aimed at the enhancement of fishing resources and artisanal fisheries (Spanish Government, 2001), Spanish FRs have been historically considered the only MPA network in the country and included in national (García-Charton et al., 2004; Planes et al., 2006) and international MPA publications (Gabrié et al., 2012). Since 2010, they were officially included in the Spanish MPA Network (Spanish Government, 2010). They are generally considered ecologically effective, highly protected and well managed MPAs (García, 2010),

although specific studies to assess their actual protection are scarce and opinion-based. Studies on FRs' ecological effects are more abundant, but they do not cover all FRs, are often site and feature-specific, and sometimes lack adequate controls (Planes et al., 2006).

In this study, the MaPAF (Rodríguez-Rodríguez et al., 2016a) was applied to assess the protection afforded to the Spanish FRN in order to identify legal and managerial strengths and weaknesses. The results on protection were compared with a quick assessment of the FRN's ecological effectiveness based on essential factors for the ecological effectiveness of MPAs (Edgar et al., 2014).

2. Methods

2.1. Study area

The FRN includes ten FRs which are managed by the Spanish Ministry of Agriculture, Fisheries, Food and the Environment alone or jointly with regional governments. They cover approximately 266,900 hectares of chiefly inshore area, distributed in zones of different legal stringency, and are located in three different marine ecoregions (Table 1).

2.2. Protection assessment

The MaPAF (Rodríguez-Rodríguez et al., 2016a) was applied to the Spanish FRN. The MaPAF assesses MPA protection through two sub-indices of equal value: legal protection (level of protection; LoP), valued from 1 point to 6 points, and management effort (sub-level of protection; SloP), valued from 0 points to 6 points. Both indices are divided in four headline indicators: legal designations and regulation stringency (for LoP); and enforcement and management planning (for SloP; Fig. 1). Table 2 shows how each headline indicator was measured and valued.

The FRN central managerial authority, the Fisheries Unit of the Spanish Ministry of Agriculture, Fisheries, Food and the Environment provided management effort data and the GIS layer with boundaries of the FRN. To assess the number of overlapping legal designations (valued from 1 to 3 points), the digital layers of all other MPA designations currently designated or proposed in Spain were downloaded from the Spanish Ministry of Agriculture, Fisheries, Food and the Environment's digital repository (Spanish Government, 2017). MPA designations included: 1) Special Areas of Conservation (SACs); 2) Sites of Community Importance (SCIs); 3) Special Protection Areas (SPAs); 4) Ramsar sites; 5) Biosphere Reserves; 6) Special Protection Areas of Mediterranean Importance (SPAMIs); 7) and Nationally designated MPAs or PAs with some marine area. All MPA layers were unioned and the resulting layer was clipped against the FR layer, counting legal designations on each protected polygon of the FRN. Finally, a weighted mean according to the proportion of each FR's

Fig. 1. Outline of the MaPAF and its application to the Spanish Fishing Reserve Network.

Table 1
Main characteristics of the Spanish Fishing Reserve Network

Fishing Reserve	Designation	Area (ha.)	No-take area (ha.)	Management	Marine ecoregion*
Tabarca	1986	1,754	78	Joint	Western Mediterranean
Columbretes	1990	5,493	3,112	Spanish Ministry	Western Mediterranean
Graciosa	1995	70,439	1,076	Joint	Azores, Canaries and Madeira
Cabo de Palos	1995	1,931	267	Joint	Western Mediterranean
Cabo de Gata	1995	12,468	1,665	Spanish Ministry	Alboran Sea
La Restinga	1996	1,180	237	Joint	Azores, Canaries and Madeira
Alborán	1997	158,594	695	Spanish Ministry	Alboran Sea
Masia Blanca	1999	457	43	Spanish Ministry	Western Mediterranean
La Palma	2001	3,455	837	Spanish Ministry	Azores, Canaries and Madeira
Cala Rajada	2007	11,285	2,000	Joint	Western Mediterranean

*Based on the classification by Spalding et al. (2007)

Table 2
Measurement, valuation and interpretation of MaPAF's headline indicators

Headline indicator	Indicator	Valuation (points)	Interpretation
Legal designations	Mean number of legal designations (x)	$x < 1.5 \rightarrow 1$ point	Low
		$1.5 \leq x \leq 2.5 \rightarrow 2$ points	Medium
		$x > 2.5 \rightarrow 3$ points	High
Regulation stringency	Proportion of no-take area (y)	$y < 10\% \rightarrow 0$ points	Very low
		$10\% \leq y \leq 25\% \rightarrow 1$ point	Low
		$26\% \leq y \leq 50\% \rightarrow 2$ points	Moderate
		$y > 50\% \rightarrow 3$ points	High
Enforcement	Surveillance effort (v)	$v \leq 0.99 \rightarrow 0$ points	Very low
		$1 \leq v \leq 1.98 \rightarrow 1$ point	Low
		$1.99 \leq v \leq 2.97 \rightarrow 2$ points	Moderate
		$v > 2.97 \rightarrow 3$ points	High
Management planning	Existence and update of management plan (w)	No $w \rightarrow 0$ points	Very low
		$w > 10$ ys old $\rightarrow 1$ point	Low
		10 ys $\leq w \leq 5$ ys $\rightarrow 2$ points	Moderate
		$w < 5$ ys old $\rightarrow 3$ points	High

area covered by each number of legal designations was calculated. Regulation stringency was assessed as the proportion of no-take area relative to overall FR's area, and valued from 0 to 3 points.

To measure enforcement (valued from 0-3 points), a standardised surveillance effort index that added the hours of terrestrial and marine surveillance in each FR per year and divided it by each FR's area was produced. Mean surveillance effort (in hours / ha.) for the 2008-2015 period was calculated. Valuation thresholds were established according to data range's quartiles. Surveillance effort data for two FRs (Graciosa and Masía Blanca) was not provided, so its lowest value was conservatively assigned to both, because of existence of active management including surveillance boats. The Spearman rank order correlation test was used to check whether surveillance effort was related to FR's size, for $\alpha=0.05$, after checking the non-normality of variables. Management planning was assessed as the existence of updated management plans for each FR, and valued from 0-3 points. Each headline indicator was valued for integration in each sub-index by simple addition as

shown in Table 2. Then, protection was assessed by summing the results of LoP and SloP.

2.3. Assessment of ecological effectiveness

To estimate the potential ecological effectiveness of the Spanish FRN, a rapid evaluation framework based on the five key factors for MPA effectiveness identified by Edgar et al. (2014) was developed: no-take area; enforcement; age; size; and degree of isolation. Such criteria have been used in recent studies on MPA ecological effectiveness (Giakoumi et al., 2017). Valuation thresholds were adapted from Edgar et al. (2014) when possible or from the MaPAF assessment (Table 3). FRs' effectiveness was calculated summing the scores of each factor.

All calculations were done using Arc-GIS v. 10.3 in the ETRS 1989, UTM Zone 30 coordinate system and Microsoft Excel.

Table 3

Measurement, valuation and interpretation of NEOLI's framework indicators

Factor	Indicator	Valuation (points)	Interpretation
No-Take area	Proportion of no-take area (y)	$y < 10\% \rightarrow 0$ points	Very low
		$10\% \leq y \leq 25\% \rightarrow 1$ point	Low
		$26\% \leq y \leq 50\% \rightarrow 2$ points	Moderate
		$y > 50\% \rightarrow 3$ points	High
Enforcement	Surveillance effort (v)	$v \leq 0.99 \rightarrow 0$ points	Very low
		$1 \leq v \leq 1.98 \rightarrow 1$ point	Low
		$1.99 \leq v \leq 2.97 \rightarrow 2$ points	Moderate
		$v > 2.97 \rightarrow 3$ points	High
Age	Age of the fishing reserve (z)	$z < 5$ ys old $\rightarrow 0$ points	Very low
		$5 \text{ ys} \leq z \leq 9 \text{ ys} \rightarrow 1$ point	Low
		$10 \text{ ys} \leq z \leq 15 \text{ ys} \rightarrow 2$ points	Moderate
		$z < 15$ ys old $\rightarrow 3$ points	High
Size	Size of the fishing reserve (u)	$u < 1 \text{ km}^2 \rightarrow 0$ points	Very low
		$1 \text{ km}^2 \leq u \leq 10 \text{ km}^2 \rightarrow 1$ point	Low
		$10 \text{ km}^2 \leq u \leq 100 \text{ km}^2 \rightarrow 2$ points	Moderate
		$u > 100 \text{ km}^2 \rightarrow 3$ points	High
Degree of isolation	Distance from the coastline (c)	$c = 0 \text{ km} \rightarrow 0$ points	Very low
		$0 \text{ km} \leq c < 10 \text{ km} \rightarrow 1$ point	Low
		$10 \text{ km} \leq c \leq 50 \text{ km} \rightarrow 2$ points	Moderate
		$c > 50 \text{ km} \rightarrow 3$ points	High

3. Results

3.1. Protection assessment of the FRN

3.1.1. Legal protection

Most FRN area is afforded one legal designation. However, the amount of FRN area that is afforded three or more legal designations exceeds 50% (Table 4). Fig. 2 shows the number and geographic distribution of legal designations across the FRN.

The proportion of cumulative legal designations within FRs is shown in Appendix 1.

Of the approximately 267,000 hectares of the FRN, around 10,000 hectares, or 3.75%, are fully no-take (Table 5). The only FR with greater amount of no-take area than multiple-use area was Columbretes FR.

Table 4

Area and proportion of the Fishing Reserve Network covered by cumulative legal designations

Number of legal designations	Area (ha)	Network area (%)
1	95,672	35.85
2	36,318	13.61
3	70,177	26.30
4	43,121	16.16
5	21,582	8.09
Total	266,870	100

Fig. 2. Legal designations across the Spanish Fishing Reserve Network

1: Masía Blanca; 2: Columbretes; 3: Cala Rajada; 4: Tabarca; 5: Cabo de Palos; 6: Cabo de Gata; 7: Alborán; 8: La Palma; 9: La Restinga; 10: Graciosa

3.1.2. Management effort

Surveillance effort ranks from 3.97 h/ha.x year in La Restinga FR to 0.01h/ha.x year in Alboran FR (Table 6). There was a very strong, negative correlation between surveillance effort and FR's size: $r_{s(6)} = -0.83$; $p = 0.01$).

All FRs have management plans. For some FRs different activities are regulated in different norms. The oldest management plan dates 2000 and the newest, 2017 (Table 7).

3.1.3. Overall protection

The Spanish FRN has medium-high protection, averaging very similarly in LoP and SloP. The strongest contributor to protection is legal designations, whereas

the weakest is legal stringency (Table 8). Columbretes FR and Cabo de Palos FR are the most protected FRs. Columbretes FR reaches has the greatest LoP, whereas Cabo de Palos is afforded the greatest managerial effort of the FRN. In contrast, lowly legally protected and managed Alboran FR ranks last in protection.

3.2. Potential ecological effectiveness of the FRN

The Spanish FRN is potentially moderately effective. Age is the factor contributing most positively to ecological effectiveness of the FRN whereas isolation is the factor contributing the least. Columbretes FR and Alboran FR were the most ecologically effective FRs, whereas Masía Blanca was the least ecologically effective (Table 9).

Table 5.

Amount and proportion of no-take area across the Fishing Reserve Network

Fishing reserve	Area (ha)	No-Take area (ha)	No-Take area (%)
Columbretes	5,493	3,112	56.65
La Palma	3,455	837	24.23
La Restinga	1,180	237	20.08
Cala Rajada	11,285	2,000	17.72
Cabo de Palos	1,931	267	13.83
Cabo de Gata	12,438	1,665	13.39
Masía Blanca	457	43	9.41
Tabarca	1,754	78	4.45
Graciosa	70,439	1,076	1.53
Alborán	158,594	695	0.44
<i>NETWORK</i>	<i>267,026</i>	<i>10,010</i>	<i>3.75</i>

Table 6.

Surveillance effort and boats across the Fishing Reserve Network

Fishing reserve	Area (ha.)	Surveillance effort (h/ha.)	Surveillance boats
La Restinga	1,180	3.97	1
Tabarca	1,754	2.92	3
Cabo de Palos	1,931	1.57	3
La Palma	3,455	1.28	2
Columbretes	5,493	0.79	3
Cala Rajada	11,285	0.15	2
Cabo de Gata	12,468	0.15	2
Alborán	158,594	0.01	3
Graciosa	70,439		1
Masía Blanca	457		2

Table 7.

Existence and date of management plans across the Fishing Reserve Network

Fishing reserve	Management plan	Date
La Palma	Yes	2001; 2002; 2010
La Restinga	Yes	1996, 2005
Graciosa	Yes	1995; 1999; 2000; 2001; 2003
Tabarca	Yes	1986; 1988; 2000
Alborán	Yes	1998; 2001
Cabo de Gata	Yes	1995; 1996; 2001; 2011
Cabo de Palos	Yes	1995; 1999; 2000; 2001; 2002; 2017
Columbretes	Yes	1990; 2000; 2002; 2003; 2008; 2009
Cala Rajada	Yes	2007
Masía Blanca	Yes	1999; 2000; 2001; 2004; 2010, 2016

4. Discussion

4.1. Protection of the FRN

The Spanish FRN is moderately protected, both legally and managerially. In general, our findings reflect comparatively high protection of the FRN in the Mediterranean MPA context, to which most Spanish FRs belong, especially regarding managerial effort (Rodríguez-Rodríguez et al., 2016a). Our results are also akin to those by Rodríguez-Rodríguez et al., (2015a) in the English Channel, a similarly pressured marine environment (McClellan et al., 2014). Using an expert-based assessment approach, they ascertained medium protection of most Channel MPAs. However, our results on the Spanish FRN are generally less optimistic than those by García (2010). The finer, non-perceptual assessment done here is likely to explain most differences with her study. There are also some methodological explanations to this divergence. For instance, in this study the total area of Cabo de Gata FR more than doubled and Alboran FR's area almost increased by two orders of magnitude with regard to previous publications (García, 2010; Spanish Government, 2016). This resulted from the inclusion of interspersed marine nature park's area in the case of Cabo de Gata FR. This area was included as FR's area in

Table 8

Valuation of protection across the Fishing Reserve Network using MaPAF. LoP: Level of protection; SloP: Sub-level of protection

Fishing reserve	Legal designations	Regulation stringency	LoP	Management planning	Enforcement	SloP	Protection
Columbretes	3	3	6	2	1	3	9
Cabo de Palos	3	1	4	3	2	5	9
La Palma	3	1	4	2	2	4	8
La Restinga	3	1	4	1	3	4	8
Cabo de Gata	3	1	4	2	1	3	7
Tabarca	3	0	3	1	3	4	7
Cala Rajada	2	1	3	2	1	3	6
Masía Blanca	2	0	2	3	1	4	6
Graciosa	3	0	3	1	1	2	5
Alborán	2	0	2	1	1	2	4
NETWORK MEAN	<i>2.7</i>	<i>0.8</i>	<i>3.5</i>	<i>1.8</i>	<i>1.6</i>	<i>3.4</i>	<i>6.9</i>

Table 9

Valuation of potential ecological effectiveness across the Fishing Reserve Network using the NEOLI framework

Fishing reserve	No-Take	Enforcement	Age	Size	Isolation	Effectiveness
Columbretes	3	1	3	2	2	11
Alborán	0	1	3	3	3	10
Tabarca	0	3	3	2	1	9
Cabo de Gata	1	1	3	3	0	8
Cabo de Palos	1	2	3	2	0	8
La Palma	1	2	3	2	0	8
La Restinga	1	3	3	1	0	8
Cala Rajada	1	1	2	3	0	7
Graciosa	0	1	3	3	0	7
Masía Blanca	0	1	3	1	0	5
NETWORK MEAN	<i>0.8</i>	<i>1.6</i>	<i>2.9</i>	<i>2.2</i>	<i>0.6</i>	<i>8.1</i>

the GIS layer provided by the FRN's managers but not in related publications. In the case of Alboran FR, previous publications did not account for the large, nationally designated peripheral fisheries restricted area (of approx. 157.000ha.) adjacent to the FR and subject to specific fishing regulations (Spanish Government, 1998). Thus, we think that this study shows a more accurate picture of the FRN's design and protection. Those updates affected the two area-related headline MaPAF indicators and resulted in much lower surveillance effort in both FRs and, provided that all this 'new' area is multiple-use, it also resulted in substantially lower regulation stringency for both.

The Spanish FRN has a high degree of legal designation overlap which should theoretically confer greater protection than single designations (Rodríguez-Rodríguez et al., 2016a). However, no-take zones allowing only for scientific research cover a small fraction of the FRN network area, whereas most of it is multiple-use. Positive ecological effects from small no-take zones have been reported (Rife et al., 2013). However, the current no-take proportion in the FRN will probably result most insufficient soon in view of oncoming stricter protection targets at 30% (Davis, 2016). In FRN's multiple-use zones, different human activities of varying degrees of environmental impact are allowed with some restrictions: artisanal fishing, scuba diving and recreational fishing are the most common ones (Spanish Government, 2016). Such fishing activities can exert considerable pressure on some biological resources and are suggested to be responsible for the low effectiveness of multiple-use MPAs or zones compared to marine reserves or no-take zones (Planes et al., 2006; Lester & Halpern, 2008).

Regarding legal MPA coverage, Spain has already exceeded current international targets by 2020 in inshore and offshore waters (Rodríguez-Rodríguez et al., 2016b). As a result, the country's MPA network can be considered close to completeness, with no massive additions expected in the near future. However, foreseeable oncoming MPA coverage and stringency targets are likely to force the country to expand its MPA legal and managerial effort, including a much greater proportion of no-take area and managed area (Davis, 2016), as now most of the Spanish MPA network is multiple-use and unmanaged (Rodríguez-Rodríguez et al., 2016a).

Management effort of the Spanish FRN is generally greater than in Mediterranean MPAs, especially for management planning (Rodríguez-Rodríguez et al., 2016a). Cullis-Suzuki & Pauly (2010) also found relatively good managerial performance of Spanish MPAs (by that time, entirely FRs) in a global context using another indicator of managerial effort: investment in MPAs on running or maintenance costs. García (2010) similarly states favourable perception on existing management means and infrastructures by FRs' managers and 24/7 surveillance all the year through in seven FRs in 2010. However accurate that statement

may be, the official FRN managers' data does not reflect spatial or temporal distribution of surveillance effort.

The commonest stated pressure by FRs' managers was poorly practiced fishing (either industrial, recreational or artisanal fishing; García, 2010), which largely coincide with the views of Mediterranean MPA managers who considered artisanal and recreational fishing the main pressures to their MPAs (Gabrié et al., 2012). Other stated pressures by Spanish FRs' managers included boat anchoring, illegal extractive activities, waste spills from recreational boats, infrastructure and urban development, introduction of non-local species, and public use (García, 2010). Thus, the majority of common pressures in the FRN can be tackled by FRs' managers, although other important pressures to marine environments such as ocean warming or pollution (Halpern et al., 2008) are largely outside their means and scope (Rodríguez-Rodríguez et al., 2015b). In terms of sea surveillance (boat density), Spanish FRs are within the minority of Mediterranean MPAs with some boats for surveillance, but their boat-to-area ratio is low (Rodríguez-Rodríguez et al., 2016a).

4.2. Potential ecological effectiveness of the FRN

Overall, the FRN was moderately to highly effective as assessed here. Only one FR was assessed as little ecologically effective. A bibliographic review found general positive ecological effects of five FRs on fish and benthic fauna abundance, density and/or biomass compared to unprotected sites: Cabo de Palos FR, Tabarca FR, Columbretes FR, Graciosa FR, and Restinga FR (Planes et al., 2006). They also found greater effectiveness in their no-take zones than in the FRs' multiple-use zones. Their study partially validated the results shown here by stating the comparatively low effectiveness of Graciosa FR. In another study comparing ecological effects of four Mediterranean MPAs that included three FRs (Cabo de Gata, Cabo de Palos and Columbretes), García-Charton et al. (2004) similarly found generally higher average values of total abundance and biomass, species richness and abundance, and biomass of different target species inside MPAs than in unprotected sites, although they highlighted the important effect of habitat dissimilarity between cases and controls and thus, the limited validity of their comparisons. Selecting adequate controls is as essential as challenging for valid semi-experimental studies on MPA effectiveness (Addison, 2011).

There was low correspondence between FRs' ranking by protection and by potential ecological effectiveness even though both indices shared a remarkable percentage of indicators. Previous studies have neither been able to link protection intensity to MPAs' ecological outcomes (Rodríguez-Rodríguez et al., 2015a) beyond dual multiple-use versus no-take comparisons (Sciberras et al., 2015). It is worth noting the limited geographic representation of MPAs in the study by Edgar et al. (2014) from which the NEOLI framework was derived, with half of their 87 MPA sample from Australia and New Zealand. This may have

biased their results to regional-specific contexts and effectiveness factors.

4.3. Individual performance of FRs

Columbretes FR ranked the first, both in terms of protection and of potential ecological effectiveness. It meets most legal and bio-physical characteristics for ecological effectiveness (Edgar et al., 2014): it has medium size (5,500 ha.), 57% of which is no-take; it is 27 years old; and it is located more than 45 km from the coastline. It also has a reasonably updated management plan. García (2010) also pointed to comparatively good local stakeholder participation in the management of the FR. Columbretes FR's main weakness comes from low surveillance effort. In their study, García-Charlton et al. (2004) found generally better values on number of species, mean species richness, mean abundance, mean biomass and species diversity for Columbretes FR than for some control sites, although they did not found consistent better performance than two other FRs: Cabo de Gata FR and Cabo de Palos FR.

In turn, Alboran FR was the least protected FR. It scores very lowly in regulation stringency and lowly in both management indicators. It, however, ranked second in potential ecological effectiveness. Alboran FR has a number of characteristics that make it prone to ecological effectiveness (Edgar et al., 2014). Firstly, it is, together with Columbretes FR, the only offshore FR. This may prevent most pressures which originate in or concentrate along the coast (Halpern et al., 2008; Rodríguez-Rodríguez et al., 2015b) and reduce the need for increased protection, although that remains to be studied, as important threats to biodiversity such as bottom trawling or pollution from abundant ship traffic in the area can occur. Secondly, it is an old, well established FR with 20 years of age. Thirdly, it is the biggest FR in the FRN. According to García (2010), the most pressured FRs were Cabo de Gata FR, Tabarca Island FR and Alboran Island FR, respectively. The main pressures in Cabo de Gata FR were public use and industrial fishing. In the case of Tabarca Island FR, the most serious pressures were recreational fishing and pollution from liquid spills, whereas all main pressures in Alboran FR related to fishing, especially industrial fishing (García, 2010).

The relatively poor legal and managerial performance of Alboran FR and Graciosa FR were related to their great size, which affected three of the four MaPAF indicators. Small, coastal, mostly multiple-use and lowly enforced Masía Blanca scored the lowest in potential ecological performance, followed by coastal, huge, but little stringent Graciosa FR. Those results are partially coincident with those of the perceptual study

by García (2010) that stated that Tabarca Island FR and Graciosa FR were the FRs with the poorest managerial outcomes. The little surveillance effort in Graciosa FR was already pointed out more than a decade ago and was suggested responsible for the reduced ecological effects of the FR and its no-take zone due to poaching (Planes et al., 2006).

5. Conclusions

The Spanish FRN is moderately protected, both in legal and managerial terms, and has moderate-to-high potential ecological effectiveness. It is better protected than most Mediterranean MPAs, although greater legal and managerial effort should be done to ensure their ecological effectiveness. More precisely, most effective no-take zones should be considerably expanded throughout the FRN in light of new oncoming international marine protection targets. Nevertheless, this expansion should consider other MPAs making the Spanish MPA network and MPAs-to-be, be gradual and include local stakeholders as much as possible in order to avoid pervasive social or economic effects. Also, greater managerial effort, chiefly in terms of surveillance, should be provided to currently undersurveilled FRs. Among those, important effort should be put in ensuring adequate levels of surveillance in the biggest FRs: Alboran FR and Graciosa FR. Complementary studies on ecological features and pressures should be developed to properly allocate further legal or managerial resources. Nevertheless, the Spanish FRN is comparatively well protected so additional legal or managerial resources, if any, would most likely be more necessary in other newly designated MPAs of the rapidly expanding MPA network of the country (Bhola et al., 2016; Rodríguez-Rodríguez et al., 2016b) which still lacks legal protection and, especially, managerial effort.

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Appendix 1
Cumulative legal designations in Spanish Fishing Reserves

Fishing Reserve	Area (ha)	Number of designations	Area covered by legal designation class (ha)	Proportion of legal designation class in fishing reserve (%)
Cabo de Palos	1,931	2	171.62	8.89
Cabo de Palos	1,931	3	1,758.78	91.07
Alborán	158,594	1	90,783.20	57.24
Alborán	158,594	2	31,394.80	19.80
Alborán	158,594	3	10,978.50	6.92
Alborán	158,594	4	25,436.60	16.04
Tabarca	1,379	2	7.23	0.52
Tabarca	1,379	3	1,372.03	99.48
Graciosa	70,784	1	25.22	0.04
Graciosa	70,784	2	2,679.49	3.79
Graciosa	70,784	3	40,756.90	57.58
Graciosa	70,784	4	5,739.49	8.11
Graciosa	70,784	5	21,582.00	30.49
La Restinga	912	2	60.36	6.62
La Restinga	912	3	850.68	93.32
Columbretes	5,490	3	5,489.80	99.99
Masía Blanca	446	1	1.45	0.33
Masía Blanca	446	2	444.58	99.67
Cabo de Gata	12,468	1	161.13	1.29
Cabo de Gata	12,468	2	234.57	1.88
Cabo de Gata	12,468	3	126.50	1.01
Cabo de Gata	12,468	4	11,945.30	95.81
Cala Rajada	11309.90	1	4,638.79	41.02
Cala Rajada	11309.90	2	904.79	8.00
Cala Rajada	11309.90	3	5,765.56	50.98
La Palma	3560.96	1	61.95	1.74
La Palma	3560.96	2	420.49	11.81
La Palma	3560.96	3	3,078.09	86.44

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