Evaluating MPA effectiveness through inside and outside uses allowed: Portugal as a case study

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Resumo

As áreas marinhas protegidas (MPAs) são ferramentas de conservação mundial utilizadas para reduzir actividades humanas com impacto no meio marinho. No entanto, desenvolvimentos recentes colocam a sua validade em causa. A necessidade de avaliar a sua eficácia requer novas abordagens. Aqui, eu utilizo comparações dentro:fora de actividades que apresentam impacto potencial sobre a biodiversidade (pesca, aquacultura, exploração do fundo e actividades de recreio). As actividades foram recolhidas recorrendo às regulamentações em vigor em cada zona. Proponho relacionar cada redução de usos observada com o nível de proteção atribuído à MPA; e pela primeira vez, classificar o nível de proteção das zonas imediatamente fora usando um sistema de classificação baseado nos regulamentos para as MPAs. Todas as MPAs portuguesas efectivamente reduziram actividades extractivas e não-extractivas; enquanto, algumas MPAs não providenciaram proteção extra do exterior. Apenas áreas totalmente protegidas e áreas altamente protegidas reduziram/restringiram actividades extractivas. No geral, as MPAs portuguesas mostraram reduções de usos semelhantes com áreas moderamente protegidas; das quais 17 não aumentaram o nível de proteção observado. Novas medidas de gestão e conservação são urgentemente necessárias.

Palavras-chave: Área marinha protegida (MPA); eficácia; actividades; redução; nível de proteção; RBCS

Abstract

Marine protected areas (MPAs) are world conservation tools to reduce human activities impacting the marine environment. However, recent developments place its validity in check. The need to assess their effectiveness calls for new approaches. Here, I use inside:outside comparisons of activities that have a potential impact on biodiversity (fishing, aquaculture, bottom exploitation, and recreational uses). The activities were collected using the regulations in force in each zone. I propose to relate each reduction of uses to the level of protection assigned; and, for the first time to evaluate the level of protection of outside zones, using a recent regulation-based classification system for MPAs. All Portuguese MPAs effectively reduce non-extractive and extractive activities, whereas some MPAs do not provide extra protection from outside. Only fully protected areas and highly protected areas reduce/restrict extractive uses. Overall, Portuguese MPAs show a similar reduction to moderately protected areas; of which 17 did not increase the protection level observed outside. New management and conservation measures are urgently needed.

Keywords: marine protected area (MPA); effectiveness; activities; reduction; level of protection; RBCS;

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1. Introduction

Marine protected areas (MPAs) are increasing worldwide as a large-scale conservation tool to mitigate human threats and meet the international conservation targets proposed (e.g. Aichi Biodiversity Targets, Sustainable Development Goals) (Claudet et al., 2020). Simultaneously, managers and conservationists found different ways to accommodate human activities (uses) in MPAs without creating major impacts on the marine environment (Partnership for Interdisciplinary Studies of Coastal Oceans, 2011). Recent MPA guidelines show how to establish effective MPAs through (1) well-defined science-based objectives; (2) good designs; (3) solid regulations; and (4) active and adapted management with consistent monitoring programs (Grorud-Colvert et al., 2021).

Portugal, like other countries in the Convention on Biological Diversity (CBD), agreed to protect 10% of their coastal or maritime waters by 2020 (Aichi Biodiversity Target 11), through protected area systems (Coates, 2018). The last report (Horta e Costa et al., 2019) shows that Portugal practically achieved the international target just looking to MPAs coverage. However, the increase in established large- or small-, fully- or partially- protected areas does not automatically guarantee higher protection in a certain location (Claudet et al., 2020). Current MPA coverages are insufficient (O'Leary et al., 2016; Spalding et al., 2013), can be misleading, and create a false sense of protection of marine biodiversity (Horta e Costa et al., 2019).

The race to meet international conservation goals led to the creation of MPAs ("paper parks") that do not effectively restrict uses allowed outside (Rife et al., 2013); with most MPAs allowing fishing uses that impact marine biodiversity (Costello & Ballantine, 2015). Hence, distinguishing protection levels makes it possible to assess which MPAs or zones can achieve ecological outcomes or conservation goals (Zupan, Fragkopoulou, et al., 2018). Whilst partially protected areas confer some benefits over open access areas; full protection areas generally have greater benefits, ensure resilience to climate changes and generate significantly higher densities of organisms within MPA boundaries than partially protected areas (Lester & Halpern, 2008; McLeod et al., 2009). MPAs classified with high levels of protection exhibit higher biomass and abundance of commercial species (Zupan, Fragkopoulou, et al., 2018); often preserving the connectivity of fish populations, through spillover of larvae, juveniles, and adults to adjacent unprotected areas (Halpern & Warner, 2003; Pelc et al., 2010). However, only 0.0002% of Portuguese territorial waters (TW) and exclusive economic zone (EEZ) are effectively covered by fully protected areas (Horta e Costa et al., 2019).

The International Union for Conservation (IUCN) classifies MPAs *a priori* according to their management objectives (Kelleher & Kenchington, 1992). However, this classification system does not consider the cumulative impact of allowed uses and objectives may be inconsistent with regulations enforced; resulting in different evaluations of MPAs (Horta e Costa et al., 2016). As a result, a new regulation-based classification system (RBCS; Horta e Costa et al., 2016) for MPAs was developed based on the uses allowed (Horta e Costa et al., 2016); evaluating open access areas, where any use is allowed, to areas of restricted access and total exclusion of extraction uses.

In this report, I propose for the first time to evaluate the immediately outside areas of Portuguese MPAs; whilst evaluating the effectiveness of Portuguese MPAs through inside and outside uses allowed that impact the marine environment. Marine ecosystems are complex connected systems that require a global view of their functioning; e.g. nutrients circulate, habitats are linked, multispecies interact (Doney et al., 2012). The protection of biodiversity should not necessarily be “fixed” on the boundaries of MPAs. Uses inside MPAs can be excluded or reduced, but that does not suggest that conservation goals will be achieved; if the outside uses continue to increase or diminish the health of the ocean (Zeppel, 2012). Nonetheless, MPAs must provide extra protection to outside uses but there is no empirical evidence of how good the by-laws of each country are. Herein I intend to answer the following questions: (1) Do Portuguese MPAs reduce the number of uses allowed outside? And, is this reflected in the use type or level of protection assigned?; (2) How good are Portuguese MPAs in reducing outside uses by ocean zone, region and management approach?

2. Methods and Materials

2.1. Study Area

Portugal is found in southwestern Europe, more specifically in the Iberian Peninsula. According to the Portuguese National Ocean Strategy (NOS), the mainland land area covers around 89,000 km²; the volcanic archipelagos of Azores and Madeira located in the North Atlantic Ocean cover a land area of approximately 3,000 km². Portugal has a coastline of around 2,500 km, with the 20th largest exclusive economic zone (EEZ) in the world that extends over 1,600,000 km². Moreover, Portugal claims an extension of the continental shelf in the United Nations (UN) Commission on the Limits of the Continental Shelf (CLCS), resulting in a maritime territory 40 times larger than on land, of around 4,100,000 km², if the Portuguese proposal is recognized.

Portugal is home of marine habitats on which several species depend for their growth, reproduction, or migration (Cunha, Assis, & Serrão, 2013; Friedlander et al., 2019; Morato et al., 2008). To protect its wide ocean area and high biodiversity and resources, Portugal has designated numerous MPAs (71 MPAs according to the last report; Horta e Costa et al., 2019). The first MPA to be established was the natural reserve of Selvagens islands, in 1971. Internationally, Portugal established the world's first high seas MPA in the extended continental shelf (ECS), in 2010 – the "Rainbow hydrothermal field".

2.2. Data collection

Portuguese MPAs were listed until 2020 from previous studies by Horta e Costa et al., 2019; and reviewed with up-to-date information collected online from national databases of MPAs, such as the Portuguese Maritime Spatial Planning Plan (PSOEM for Mainland, Madeira, and Continental Shelf subdivision, https://www.psoem.pt/; PSOEMA for Azores region, https://oema.dram.azores.gov.pt/) (Table 1). All MPAs were confirmed by national and regional institutes with competence in MPA management (Mainland Portugal – ICNF and DGRM; Azores – DRAM and PNI; and, Madeira – IFCN). Marine areas allocated in the Natura 2000 network were not considered due to the lack of management plans unless they were incorporated in nationally designated MPAs. In total, 74 MPAs throughout the entire Portuguese territory (Mainland Portugal n = 8; Azores n = 60; Madeira n = 6) were legally designated.

Each Portuguese MPA differs in the classified level of protection corresponding to the established regulations (Horta e Costa et al., 2016): unprotected areas (UPAs), weakly protected areas (WPAs), moderately protected areas (ModPAs), highly protected areas (HPAs) and fully protected areas (FPAs). UPAs, WPAs, ModPAs, and HPAs permit and/or regulate all or some extractive and non-extractive uses, and exclude others; FPAs ban all extractive or destructive uses, and allow few non-extractive uses. MPAs design can be formed by one single area or by multiple zones types within the same MPA allowing different uses across the different zones (multiple-use MPAs) (Wood, 2007). All Portuguese MPAs are defined by the IUCN guidelines as small-scale MPAs (< 150.000 km^2) (Lewis et al., 2017). Portuguese MPAs cover different protection areas ranging from 0.0165 km^2 (Table 1; SMG06) to 108.000 km^2 (PMA12 – beyond EEZ).

Uses with a degree of threat to the marine environment (fishing, aquaculture, bottom exploitation, and recreational; Horta e Costa et al., 2016) were quantified/identified both inside and outside MPAs by gathering information on the respective institute's websites (e.g. https://dre.pt/dre/home; http://www.azores.gov.pt). Regulations inside the MPAs were gathered through management plans or equivalent, or designation decree with regulations plus regional regulations; regulations outside were collected by assessing bylaws and the Portuguese Maritime Spatial Plan. The evaluated groups were composed of 31 fishing gears (commercial + recreational; 2 of high impact fishing gear, 16 of medium impact fishing gear, 13 of low impact fishing gear), 3 aquaculture uses, 12 bottom exploitation uses and 3 recreational access uses (Table 2). The recently proposed RBCS (Horta e Costa et al., 2016) was used to compare the level of protection of each MPA inside and outside with the reduction of uses observed. Analysis were done at the zone level, resulting in 89 zones (hereafter referred to as MPAs), grouped by region (Azores n = 60; Madeira n = 7; and Mainland Portugal n = 22) and by ocean zone (TW n = 72; EEZ n = 11; and ECS n = 6); of which 8 were UPAs, 57 were ModPAs, 15 were HPAs, and 9 were FPAs (no-take/no-go or no-take/regulated access areas). The Azores region has MPAs established in all oceanic zones; Mainland Portugal and Madeira have only MPAs established in the TW.

To understand the effectiveness of MPAs in reducing the impacts, a comparison between the allowed uses inside and outside in the marine unprotected area (MUA) was conducted. The MUA immediately adjacent to the maximum limit of the MPA was defined as having a small radius of 3 nautical miles so that there is no over-or undervaluation of possible uses mitigated by the MPAs. All fishing-related uses were further divided into 3 categories given their impact, based on Zupan et al. (2018) threat indices and Horta e Costa et al. (2016) gear scores: low (corresponding to gear score 1 to 5), medium (gear score 6 to 8), and high (gear score 9). Both aquaculture and bottom exploitation (AB) uses were grouped in the same category due to their frequency and impact; see Appendix A on Horta e Costa et al. (2016). Finally, the MPAs were grouped according to their management approaches (1) active management plan with regulations (n = 27); (2) absent management plan without any regulations (n = 30); and, (3) simply designation decree with regulations without an active management plan (n = 32). Not all Portuguese MPAs have an active management plan that monitors and supervises protection or enforces regulations over time; not making it possible to know the current status of protection and effectiveness of conservation measures (Pomeroy et al., 2005).

2.3. Data analysis

Statistical analyses of the collected data were performed using the open-source RStudio software (version 1.2.5001), following the methods of Zupan, et al. (2018). Overall, the effectiveness of MPAs in reducing targeted impacts was compared based on the ratio of uses allowed. The ratio was calculated as the average of the allowed uses in the MPAs (inside), divided by the average of the allowed uses in the MUAs (outside). Inside:outside ratios and their standard deviations and errors were calculated for each region (Azores, Madeira, Mainland Portugal); ocean zone (TW, EEZ, ECS), level of protection (UPAs, ModPAs, HPAs, FPAs), management (present, absent, regulated), and type of use (fishing, aquaculture, bottom exploitation, recreational); to observe how different they influence the effectiveness of established MPAs. For possible comparison within regions and ocean zones two subsets were created; Azores region with all MPAs of ocean zones (TW n = 43; EEZ n = 11; and ECS n = 6) and TW oceanic zone with all MPAs of regions (Azores n = 43; Madeira n = 7; and Mainland Portugal n = 22). Ratio values (R_i) below 1 indicate that uses are being reduced, i.e. fewer uses allowed inside than outside; ratio values above 1 indicate more uses allowed within the MPA; ratios values equal to 1 indicate that there were no differences. The 95% confidence interval (CI) was calculated to test the significance of the inside:outside ratios obtained; if it falls below or above the corresponding CI it is considered significantly different (R Core Team, 2020)

3. Results and Discussion

3.1. Do Portuguese MPAs reduce the number of uses allowed outside?

One of the easiest approaches to assess the effectiveness of MPAs in protecting a particular area is through the reduction of generally allowed outside uses. The results of this study show that Portuguese MPAs effectively reduce the number of all uses types allowed outside (Fig. 1). In:out ratios revealed a lower number of uses inside than outside for all uses types. The smaller the ratio, the larger the reduction of uses by MPAs. Portuguese MPAs showed that on average 46.2% of all uses are reduced ($\overline{R_\iota} = 0.538 \pm 0.058$). However, human activities have different impacts on marine ecosystems (Brander et al., 2010); therefore the assessment of whether high-impacted uses are reduced or not within an MPA should be one of the main procedures in evaluating MPAs.

Portugal has several regulations for various types of activities occurring in national waters. Uses with great impact on the marine environment such as the high-impact fishing gears (Horta e Costa et al., 2016; Zupan, Bulleri, et al., 2018) are not allowed over a large area of the Portuguese ocean or only allowed fitting certain depths or distances to the coastline. Of all Portuguese MPAs reported, only 3 Multi-use MPAs could do this comparison, according to by-laws and regulations in force; in this scenario, bottom trawl gears (gear score 9; Horta e Costa et al., 2016) allowed in the MUA (outside) were excluded inside. For this reason, we cannot assume that Portuguese MPAs reduce high-impact fishing gears.

Nonetheless, MPAs showed on average 59.5% reduction of medium-impact fishing gears ($\overline{R_\iota}$= 0.405 $\pm$ 0.07), followed by 50.1% reduction of low-impact fishing gears ($\overline{R_\iota}$ = 0.499 $\pm$ 0.067) (Fig.1). Hence, Portuguese MPAs reduce more medium- and low-impact fishing gears than other uses; with medium-impact fishing gears showing the greatest reduction of uses inside MPAs. Low- and medium-impact fishing gears were the most frequently allowed outside uses. On the other hand, low-impact fishing uses were still the type of uses most allowed inside MPAs. This trend can be explained as a procedure to avoid conflicts whenever fishing uses are excluded and others not, e.g. ecotourism (Carter, 2003). Public participation and involvement in MPA management create a positive effect on established actions (Ferreira et al., 2015). Thus, populations may comply with conservation measures and regulations imposed; not restricting all uses related to fishing, but excluding all gears (destructive and less selective) with a large impact on the marine environment.

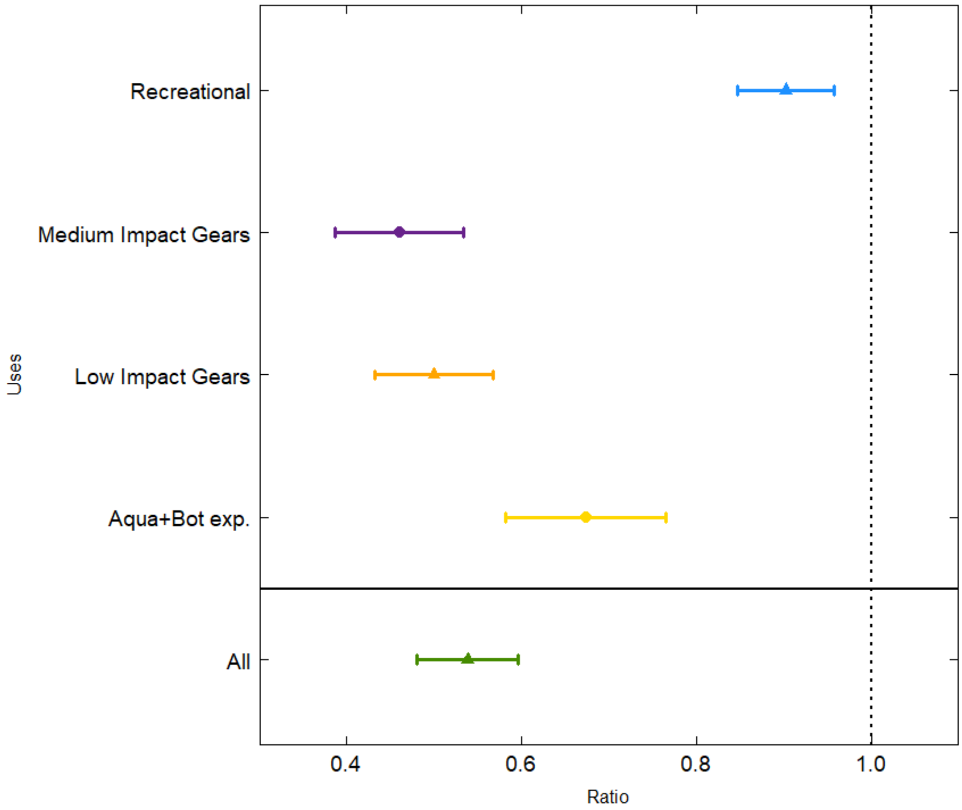

Fig. 1. Effectiveness of Portuguese MPAs in reducing all uses observed outside. The reduction for different types of uses is shown: medium impact fishing gears (n = 16); low impact fishing gears (n = 13); aquaculture plus bottom exploitation uses (n = 12); recreational uses (n = 3). The horizontal dotted line at 1 represents an equal number of uses inside and outside the MPAs; ratio values lower than 1 indicate more uses allowed outside; ratio values greater than 1 indicate more uses allowed inside. The 95% confidence interval bars are plotted.

MPAs showed on average a 32.7% reduction of AB uses ($\overline{R_i}$ = 0.673 $\pm$ 0.092) (Fig.1). However, 5 MPAs showed more AB uses allowed inside than outside. Further, uses such as sand extraction and sewage discharge (use score 3; table 2) with great impact on biodiversity were allowed inside 8 MPAs. The results suggest that AB uses may not be properly managed/regulated and could not ensure the expected levels of protection within MPAs; especially in FPAs that aim to exclude all extractive uses (third step of RBCS; Horta e Costa et al., 2016). Despite the lack of strong scientific evidence, AB uses with low-impact such as underwater cables or coastal defense structures should also be considered when implementing MPAs. These uses were frequently found inside MPAs and have consequences for the environment (Anton, et al., 2019; Taormina et al., 2018).

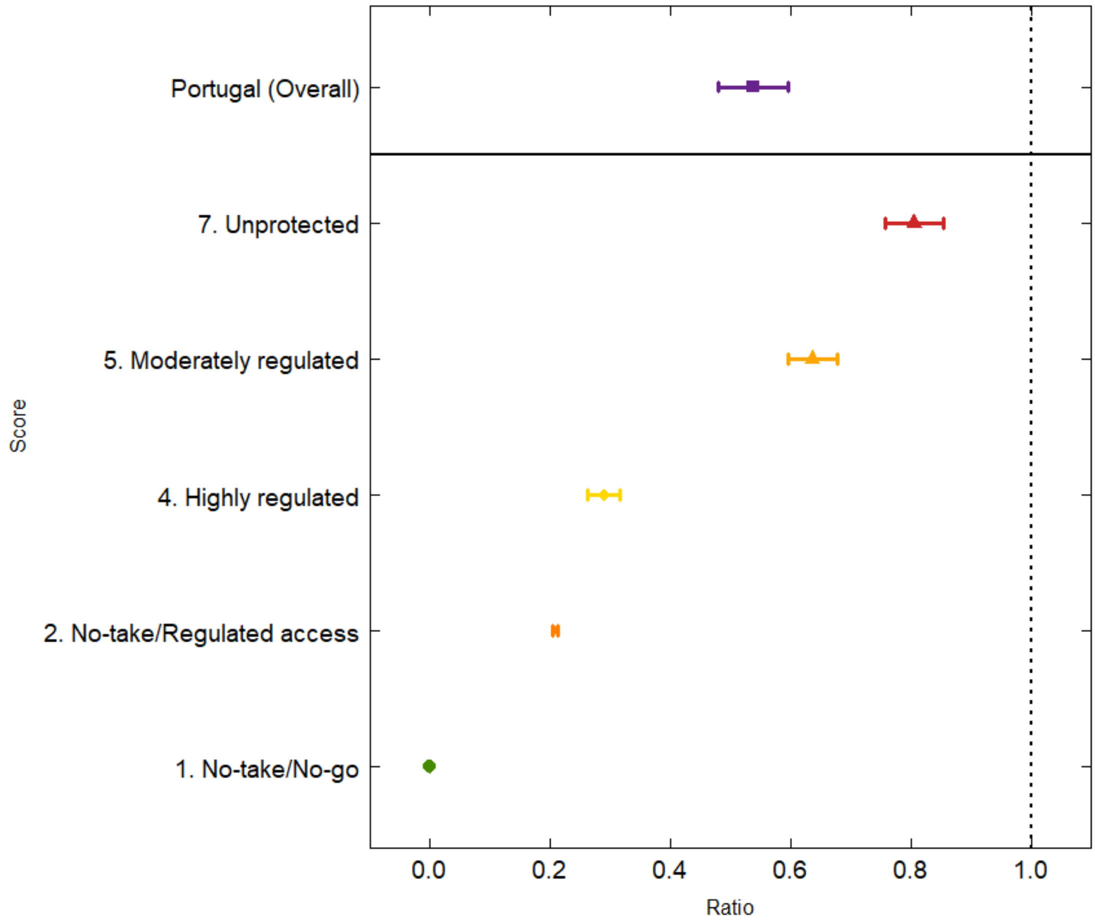

Fig. 2. Reduction of all uses for all Portuguese MPAs classified with the RBCS. Each MPA class and score is classified as followed: FPAs (score 1 – no-take/no-go areas and score 2 – no-take/regulated access areas); HPAs (score 4 – highly regulated); ModPAs (score 5 – moderately regulated areas); and, UPAs (score 7 – unprotected areas). Adapted from Horta e Costa et al., 2016. The horizontal dotted line at 1 represents an equal number of uses inside and outside the MPAs; ratio values lower than 1 indicate more uses allowed outside; ratio values greater than 1 indicate more uses allowed inside. The 95% confidence interval bars are plotted.

Portuguese MPAs showed on average 9.8% reduction of recreational uses ($\overline{R_\iota}$ = 0.902 $\pm$ 0.055). The type of use that is least effectively reduced (Fig.1). Only 6 MPAs (no-go areas) had no recreational uses (e.g. swimming, diving, and boating) allowed inside. However, this use type has the lowest impact potential of all uses (Horta e Costa et al., 2016; Zupan, Bulleri, et al., 2018). Many MPAs around the world aim to attract socioeconomic income from non-consumption activities (e.g. ecotourism) (Thurstan et al., 2012); which could be the case for Portuguese MPAs. In this scenario, MPAs can promote environmental education and help employment whereas excluding/restricting extractive and destructive uses (Hargreaves-Allen, Mourato, & Milner-Gulland, 2011; Pascual et al., 2016).

All ratios showed a reduction of uses (Fig. 2). MPAs classified with higher levels of protection such as FPAs showed greater reductions. Portuguese by-laws were also classified considering the allowed uses in the MUAs; resulting in 25 ModPAs, 39 WPAs, and 25 UPAs (Table 1). The highest level of protection observed outside was ModPA.

The results are consistent with FPAs providing greater protection than outside areas and allowing fewer uses (Costello & Ballantine, 2015; Weeks et al., 2010). All MPAs categorized as FPAs (n = 9) increased the level of protection observed outside; MUAs were classified as 2 ModPAs, 3 WPAs, and 4 UPAs. No take/no-go MPAs showed a 100% reduction of uses as no uses were allowed inside; whereas no-take/regulated access MPAs only allowed recreational uses and showed on average 79.2% ($\overline{R_\iota}$ = 0.208 $\pm$ 0.004) reduction of uses.

HPAs well managed/regulated prove to be a great measure when, and if MPAs objectives fit, FPAs cannot be established. However, not so remarkable; HPAs (n = 15) increased the level of protection of all MUAs (5 ModPAs, 7 WPAs, and 3 UPAs). HPAs showed on average 71% reduction of all uses ($\overline{R_\iota}$ =0.289 $\pm$ 0.026); the maximum number of uses allowed inside HPAs were 4 low-impact fishing gears.

More than half of the MPAs studied were classified as ModPAs (n = 57) and 8 MPAs were classified as UPAs (Table 1). Despite in:out ratios showing on average 36,4% reduction of uses for ModPAs ($\overline{R_\iota}$ = 0.636 $\pm$ 0.041) and 19,5% reduction for UPAs ($\overline{R_\iota}$ = 0.805 $\pm$ 0.049). Only, 40 ModPAs increased the protection level of adjacent MUAs (23 WPAs and 17 UPAs). Not only did 17 ModPAs and 1 UPA show no differences in the level of protection, but also 7 UPAs showed an inferior level of protection than outside. Lack of enforcement and public compliance are some of the reasons why MPAs established fail (Ferreira et al., 2015; Giakoumi et al., 2018); herein, the results show that 24 MPAs allow uses with the same or worse potential impact as outside, despite reducing the allowed outside uses.

As expected, the results supported the hypothesis that regulations are correlated to their potential impacts; the reduction of uses increased with the increase in the level of protection. All MPAs provided extra protection to outside uses. However, it was not enough to provide higher levels of protection to MPAs classified with lower levels; since some MPAs allow uses with even higher potential impact than outside. Also, Portuguese MPAs showed a similar reduction of uses to that presented by ModPAs ($\overline{R_\iota} = 0.538 \pm 0.058$); putting at-risk any ecological target and pointing to failure.

3.2. How good are Portuguese MPAs in reducing outside uses?

3.2.1. Ocean zone

In:out ratios revealed a lower number of uses inside than outside for all MPAs of the Azores (n = 60) established in different oceanic zones (Fig. 3). The results suggest a significant interaction between the distance where the MPAs are located and the reduction of uses. The MPAs of the TW showed on average the highest (44%) reduction of all uses ($\overline{R_i}$ = 0.560 $\pm$ 0.067). Nonetheless, over the different types of uses, the TW showed the highest and lowest number of uses allowed inside and outside the MPAs (Table 1). Also, the MPAs of the TW showed quite variable levels of protection, with the highest and lowest level of protection found (5 FPAs and 4 UPAs, respectively). Realizing that FPAs restrict all extractive uses and UPAs allow different uses of high potential impact.

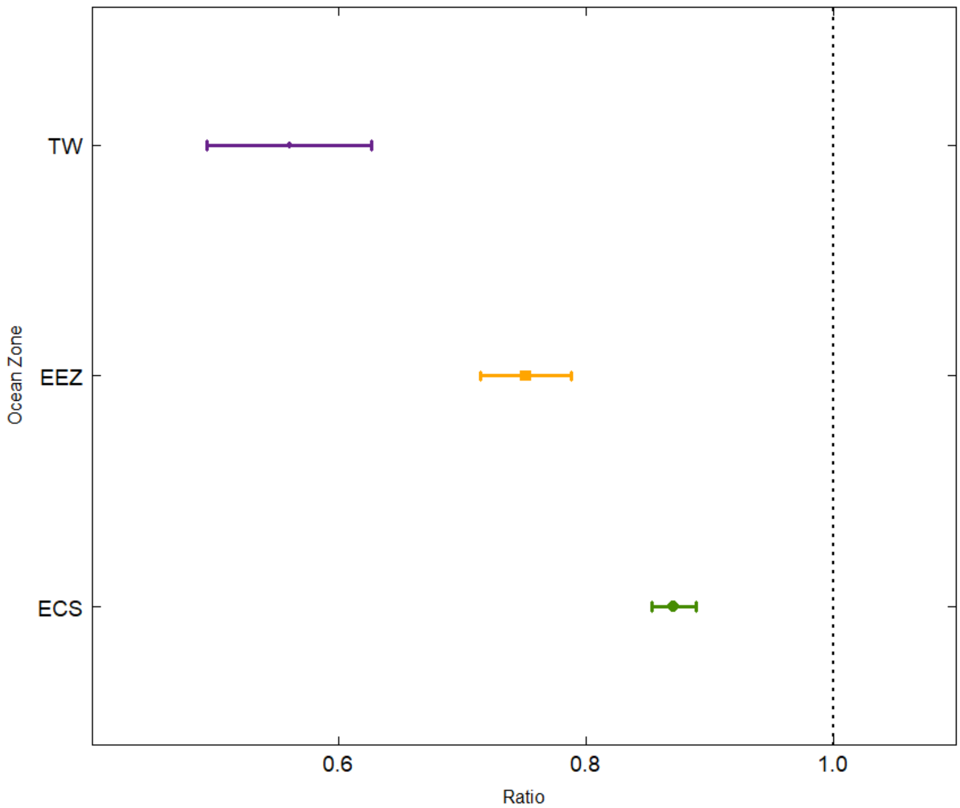

Fig. 3. Effectiveness of Azores MPAs in reducing the number of uses allowed outside in different ocean zones: TW (n = 43), EEZ (n = 11) and, ECS (n = 6). The horizontal dotted line at 1 represents an equal number of uses inside and outside the MPAs; ratio values lower than 1 indicate more uses allowed outside; ratio values greater than 1 indicate more uses allowed inside. The 95% confidence interval bars are plotted.

On the other hand, the MPAs of the EEZ showed on average 24.9% reduction of all uses ($\overline{R_\iota}$ = 0.751 $\pm$ 0.037); whereas the MPAs of the ECS showed the lowest (12.9%) reduction of uses ($\overline{R_\iota}$ = 0.871 $\pm$ 0.018). Although, without great variation in the categorized level of protection and number of uses allowed inside and outside the MPAs. In general, all MPAs and MUAs of the EEZ and ECS were classified as ModPAs (Table 1).

As reported by O'Leary et al., 2018, establishing large-scale MPAs can be challenging since it poses serious questions about their validity. Despite no Portuguese MPA being classified as large-scale by IUCN criteria (Lewis et al., 2017); some of the largest established Portuguese MPAs are found in the farthest offshore governance zones (EEZ and ECS). In addition, except for one MPA, none of the others showed differences in the level of protection observed outside. Assuming that place and distance make enforcement of strict regulations and monitoring difficult; Portuguese MPAs especially on the ECS may be suffering from problems inherent to the poor political management of offshore areas. Remote areas where human pressures and uses are less than coastal systems can become easy targets for implementing MPAs at no cost; while counting towards international conservation goals (Leenhardt et al., 2013; Lubchenco & Grorud-Colvert, 2015).

3.2.2. Region

For all MPAs of the TW, the in:out ratios showed a lower number of uses inside than outside (Fig. 4). The MPAs of Mainland showed a higher (66.3%) reduction of uses ($\overline{R_\iota}$ = 0.337 $\pm$ 0.058); than Madeira (58.6%) ($\overline{R_\iota}$ = 0.414 $\pm$ 0.018); and Azores (44%) ($\overline{R_\iota}$ = 0.560 $\pm$ 0.061), respectively. The results suggest that there is higher protection in Mainland Portugal. Despite, the Azores represent the largest number of FPAs (n = 5) than Mainland (n = 4) and Madeira (n = 0). Mainland represents the largest number of Multi-use MPAs (n = 7). Multipurpose areas are recognized to allow different types of uses (extractive and non-extractive); whilst maintaining the socioeconomic and ecological objectives balanced (Edgar et al., 2014). Normally, the zones of greater protection are surrounded by buffer zones of lesser protection that guarantee benefits and attract more stakeholders (Di Franco et al., 2016).

3.2.3. Management approaches

The main difficulties in implementing effective MPAs are the absence of public involvement (Maestro et al., 2020), the reduced definition of management objectives, and the application of stronger regulations than outside unprotected areas (Horta e Costa et al., 2016). Consequently, it creates different interpretations and selections of monitoring programs (Ahmadia et al., 2015).

Hence, MPAs show different results according to different approaches. The creation of an active and adaptive management plan defines conservation objectives and allows periodic assessment and monitoring of established protection. The information obtained from the current performance makes it possible to fill protection gaps, reinforce measures and adapt objectives if necessary (Pelletier, 2020).

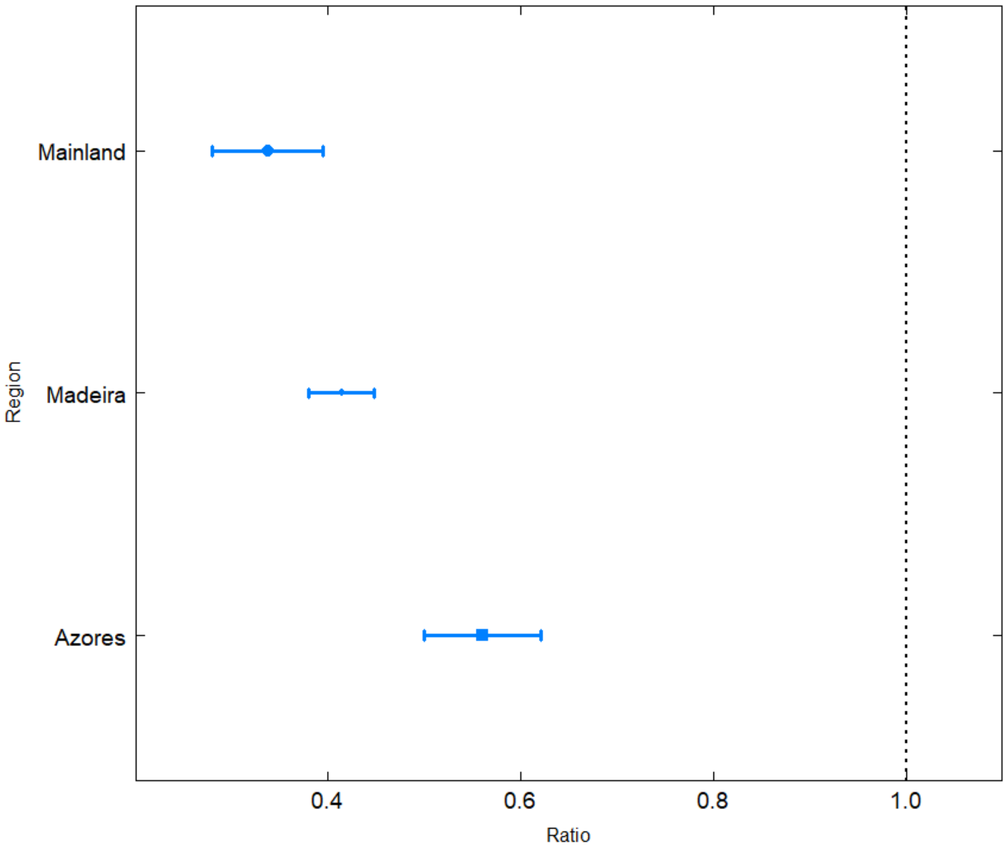

Fig. 4. Effectiveness of TW MPAs in reducing the number of uses observed in the different regions: Azores (n = 43); Madeira (n = 7); and, Mainland Portugal (n = 22). The horizontal dotted line at 1 represents an equal number of uses inside and outside the MPAs; ratio values lower than 1 indicate more uses allowed outside; ratio values greater than 1 indicate more uses allowed inside. The 95% confidence interval bars are plotted.

All Multi-use MPAs present active management plans. MPAs with current management plans showed the largest (65,5%) reduction of uses inside ($\overline{R_\iota}$ = 0.345 $\pm$ 0.049) (Fig. 5); suggesting that management plans affect the level of protection and subsequent reduction of uses. On the other hand, MPAs without any management plan or regulations in the designation decree showed the lowest (28%) reduction ($\overline{R_\iota}$ = 0.720 $\pm$ 0.038). MPAs with regulations established in the designation decree showed on average 47.1 % reduction of all uses ($\overline{R_\iota}$ = 0.529 $\pm$ 0.057). The results show that MPAs with active management plans are possibly more effective in reducing threats and achieving conservation goals.

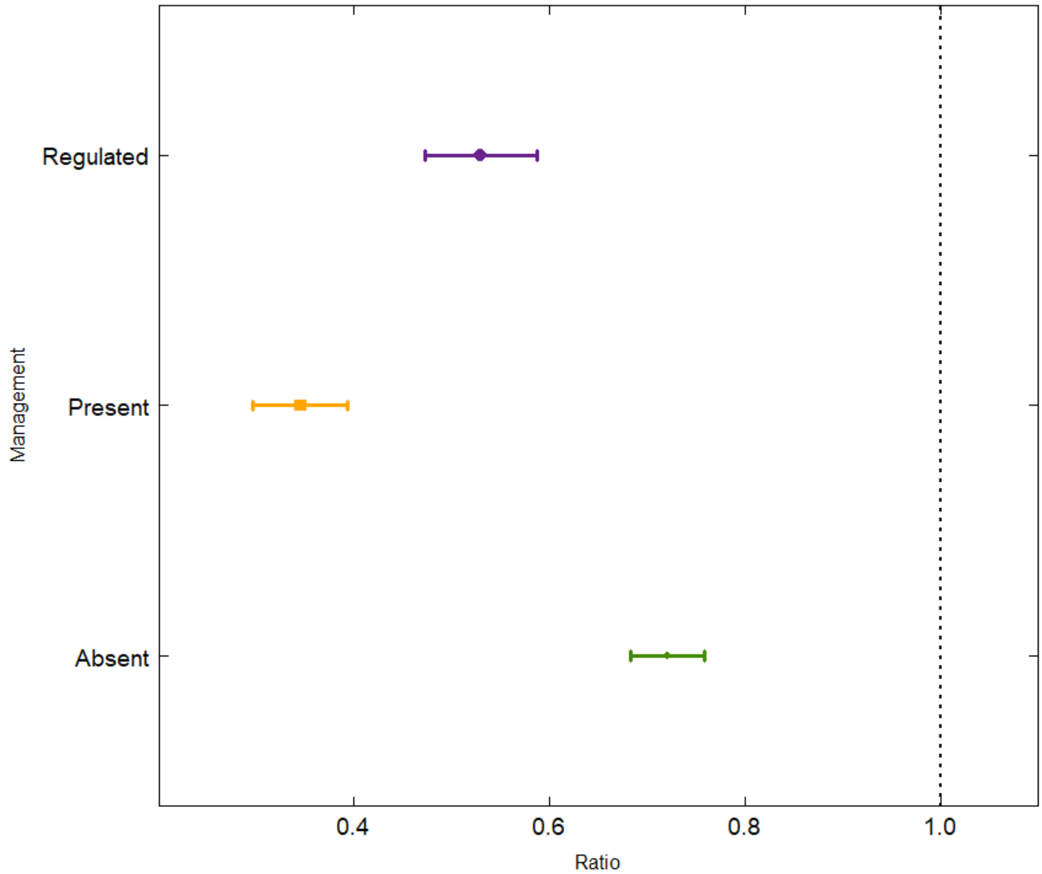

Fig. 5. Effectiveness of MPAs in reducing the number of uses with different managements: active management plan; absent management plan; and, simply designation decree with regulations without an active management plan. The horizontal dotted line at 1 represents an equal number of uses inside and outside the MPAs; ratio values lower than 1 indicate more uses allowed outside; ratio values greater than 1 indicate more uses allowed inside. The 95% confidence interval bars are plotted.

4. Conclusion

The continuous pressure on marine ecosystems, as a result of the increase in world population and demand for natural resources, has consequences for the environment.

Comparing inside and outside uses proved to be a good instrument to check whether MPAs provide extra protection or reduce uses with potential impact on biodiversity. All Portuguese MPAs showed a positive reduction to uses allowed outside in different conditions: region, ocean zone, and management approach. However, considering the number of uses allowed within an MPA is insufficient to assign a certain level of protection. Especially, when not considering the potential cumulative impact or intensity of extractive and non-extractive uses. Herein, I used the RBCS to assess whether protection levels assigned are related to inside and outside uses allowed. MPAs with vague regulations allowed more uses with higher impacts; i.e. the higher the reduction of uses the higher the level of protection shown. FPAs and HPAs show great ecological benefits (Abecasis et al., 2015; Gell & Roberts, 2003; Horta e Costa, Erzini, et al., 2013), recognized in this study to be the most effective in reducing uses with high potential impact on biodiversity; normally introduced in multipurpose systems with adaptive management plans to balance socio-economic impacts. Nonetheless, Portugal MPAs showed, on average, to reduce the same number of uses as ModPAs. As most of the ModPAs showed no improvements in protection levels.

This work provides to managers and decision-makers crucial information to increase the protection established in a given location, improve or enforce the base regulations of MPAs and achieve the international conservation targets.

References

Abecasis, D., Horta E Costa, B., Afonso, P., Gonc¸alves, E. J., & Erzini, K. (2015). Early reserve effects linked to small home ranges of a commercial fish, Diplodus sargus, Sparidae. *Marine Ecology Progress Series*, *518*, 255–266. https://doi.org/10.3354/meps11054

Ahmadia, G. N., Glew, L., Provost, M., Gill, D., Hidayat, N. I., Mangubhai, S., … Fox, H. E. (2015). Integrating impact evaluation in the design and implementation of monitoring marine protected areas. *Philosophical Transactions of the Royal Society B*, *370*, 20140275. https://doi.org/10.1098/rstb.2014.0275

Anton, I. A., Panaitescu, M., Panaitescu, F.-V., & Ghiţă, S. (2019). Impact of coastal protection systems on marine ecosystems. *E3S Web of Conferences*, *85*, 07011. https://doi.org/10.1051/e3sconf/20198507011

Brander, K. and Botsford, L.W. and Ciannelli, L. and Fogarty, M.J. and Heath, M.R. and Planque, B. and Shannon, L.J. and Wieland, K. (2010). Human impacts on marine ecosystems. *Marine Ecosystems and Global Change*.

Carter, D. W. (2003). Protected areas in marine resource management: another look at the economics and research issues. *Ocean & Coastal Management*, *46*(5), 439–456. https://doi.org/10.1016/S0964-5691(03)00017-6

Claudet, J., Loiseau, C., Sostres, M., & Zupan, M. (2020). Underprotected Marine Protected Areas in a Global Biodiversity Hotspot. *One Earth*, *2*(4), 380–384. https://doi.org/10.1016/j.oneear.2020.03.008

Coates, D. (2018). Strategic Plan for Biodiversity (2011–2020) and the Aichi Biodiversity Targets. In *The Wetland Book* (pp. 493–499). https://doi.org/10.1007/978-90-481-9659-3_119

Costello, M. J., & Ballantine, B. (2015). Biodiversity conservation should focus on no-take Marine Reserves. *Trends in Ecology & Evolution*, *30*(9), 507–509. https://doi.org/10.1016/j.tree.2015.06.011

Cunha, A. H., Assis, J. F., & Serrão, E. A. (2013). Seagrasses in Portugal: A most endangered marine habitat. *Aquatic Botany*, *104*, 193–203. https://doi.org/10.1016/j.aquabot.2011.08.007

Di Franco, A., Thiriet, P., Di Carlo, G., Dimitriadis, C., Francour, P., Gutiérrez, N. L., … Guidetti, P. (2016). Five key attributes can increase marine protected areas performance for small-scale fisheries management. *Scientific Reports*, Vol. 6. https://doi.org/10.1038/srep38135

Doney, S. C., Ruckelshaus, M., Emmett Duffy, J., Barry, J. P., Chan, F., English, C. A., … Talley, L. D. (2012). Climate change impacts on marine ecosystems. *Annual Review of Marine Science*, *4*, 11–37. https://doi.org/10.1146/annurev-marine-041911-111611

Edgar, G. J., Stuart-Smith, R. D., Willis, T. J., Kininmonth, S., Baker, S. C., Banks, S., … Thomson, R. J. (2014). Global conservation outcomes depend on marine protected areas with five key features. *Nature*, *506*(7487), 216–220. https://doi.org/10.1038/nature13022

Ferreira, A., Seixas, S., & Marques, J. C. (2015). "Bottom-up management approach to coastal marine protected areas in Portugal." *Ocean and Coastal Management*, *118*, 275–281. https://doi.org/10.1016/j.ocecoaman.2015.05.008

Friedlander, A., Afonso, P., Morato, T., Carreiro-Silva, M., Fontes, J., Abecasis, D., … Gonçalves, E. (2019). Blue Azores - The best kept secret in the Atlantic. *Scientific Report to the Regional Government of the Azores*, 1–107.

Gell, F. R., & Roberts, C. M. (2003). Benefits beyond boundaries: the fishery effects of marine reserves. *Trends in Ecology & Evolution*, *18*(9), 448–455. https://doi.org/10.1016/S0169-5347(03)00189-7

Giakoumi, S., McGowan, J., Mills, M., Beger, M., Bustamante, R. H., Charles, A., … Possingham, H. P. (2018). Revisiting "success" and "failure" of marine protected areas: A conservation scientist perspective. *Frontiers in Marine Science*, *5*(JUN), 1–5. https://doi.org/10.3389/fmars.2018.00223

Grorud-Colvert, K., Sullivan-Stack, J., Roberts, C., Constant, V., Horta E Costa, B., Pike, E. P., … Lubchenco, J. (2021). The MPA guide: A framework to achieve global goals for the ocean. *Science*, *373*(6560). https://doi.org/10.1126/science.abf0861

Halpern, B. S., & Warner, R. R. (2003). Review Paper. Matching marine reserve design to reserve objectives. *Proceedings of the Royal Society of London. Series B: Biological Sciences*, *270*(1527), 1871–1878. https://doi.org/10.1098/rspb.2003.2405

Hargreaves-Allen, V., Mourato, S., & Milner-Gulland, E. J. (2011). A Global Evaluation of Coral Reef Management Performance: Are MPAs Producing Conservation and Socio-Economic Improvements? *Environmental Management*, *47*(4), 684–700. https://doi.org/10.1007/s00267-011-9616-5

Horta e Costa, B., Claudet, J., Franco, G., Erzini, K., Caro, A., & Gonçalves, E. J. (2016). A regulation-based classification system for Marine Protected Areas (MPAs). *Marine Policy*, *72*, 192–198. https://doi.org/10.1016/j.marpol.2016.06.021

Horta e Costa, B., Erzini, K., Caselle, J. E., Folhas, H., & Gonçalves, E. J. (2013). Reserve effect within a temperate marine protected area in the north-eastern Atlantic (Arrábida Marine Park, Portugal). *Marine Ecology Progress Series*, *481*, 11–24. https://doi.org/10.3354/meps10204

Horta e Costa, B., Gonçalves, J. M. dos S., Franco, G., Erzini, K., Furtado, R., Mateus, C., … Gonçalves, E. J. (2019). Categorizing ocean conservation targets to avoid a potential false sense of protection to society: Portugal as a case-study. *Marine Policy*, *108*(August 2018), 103553. https://doi.org/10.1016/j.marpol.2019.103553

Kelleher, G., & Kenchington, R. (1992). Guidelines for Establishing Marine Protected Areas. In *A Marine Conservation and Development Report. IUCN, Gland, Switzerland* (Vol. 3). https://doi.org/10.1017/S0376892901290304

Leenhardt, P., Cazalet, B., Salvat, B., Claudet, J., & Feral, F. (2013). The rise of large-scale marine protected areas: Conservation or geopolitics? *Ocean and Coastal Management*, *85*, 112–118. https://doi.org/10.1016/j.ocecoaman.2013.08.013

Lester, S. E., & Halpern, B. S. (2008). Biological responses in marine no-take reserves versus partially protected areas. *Marine Ecology Progress Series*, *367*, 49–56. https://doi.org/10.3354/meps07599

Lewis, N., Day, J., Wilhelm, ’Aulani, Wagner, D., Gaymer, C., Parks, J., … Evans, J. (2017). Large-Scale Marine Protected Areas: guidelines for design and management. In *Best Practice Protected Area Guidelines Series No.26* (p. xxvii + 120). https://doi.org/10.2305/IUCN.CH.2017.PAG.26.en

Lubchenco, J., & Grorud-Colvert, K. (2015). Making waves: The science and politics of ocean protection. *Science*, *350*(6259), 382–383. https://doi.org/10.1126/science.aad5443

Maestro, M., Chica-Ruiz, J. A., & Pérez-Cayeiro, M. L. (2020). Analysis of marine protected area management: The Marine Park of the Azores (Portugal). *Marine Policy*, *119*(June). https://doi.org/10.1016/j.marpol.2020.104104

McLeod, E., Salm, R., Green, A., & Almany, J. (2009). Designing marine protected area networks to address the impacts of climate change. *Frontiers in Ecology and the Environment*, *7*(7), 362–370. https://doi.org/10.1890/070211

Morato, T., Machete, M., Kitchingman, A., Tempera, F., Lai, S., Menezes, G., … Santos, R. S. (2008). Abundance and distribution of seamounts in the Azores. *Marine Ecology Progress Series*, *357*, 17–21. https://doi.org/10.3354/meps07268

O’Leary, B. C., Ban, N. C., Fernandez, M., Friedlander, A. M., García-Borboroglu, P., Golbuu, Y., … Roberts, C. M. (2018). Addressing Criticisms of Large-Scale Marine Protected Areas. *BioScience*, *68*(5), 359–370. https://doi.org/10.1093/biosci/biy021

O’Leary, B. C., Winther-Janson, M., Bainbridge, J. M., Aitken, J., Hawkins, J. P., & Roberts, C. M. (2016). Effective Coverage Targets for Ocean Protection. *Conservation Letters*, *9*(6), 398–404. https://doi.org/10.1111/conl.12247

Partnership for Interdisciplinary Studies of Coastal Oceans. (2011). *The Science of Marine Reservers*. *2nd Editio*, 22. Retrieved from www.piscoweb.org

Pascual, M., Rossetto, M., Ojea, E., Milchakova, N., Giakoumi, S., Kark, S., … Melià, P. (2016). Socioeconomic impacts of marine protected areas in the Mediterranean and Black Seas. *Ocean & Coastal Management*, *133*, 1–10. https://doi.org/10.1016/j.ocecoaman.2016.09.001

Pelc, R. A., Warner, R. R., Gaines, S. D., & Paris, C. B. (2010). Detecting larval export from marine reserves. *Proceedings of the National Academy of Sciences of the United States of America*, *107*(43), 18266–18271. https://doi.org/10.1073/pnas.0907368107

Pelletier, D. (2020). Assessing the Effectiveness of Coastal Marine Protected Area Management: Four Learned Lessons for Science Uptake and Upscaling. *Frontiers in Marine Science*, Vol. 7. https://doi.org/10.3389/fmars.2020.545930

Pomeroy, R. S., Watson, L. M., Parks, J. E., & Cid, G. A. (2005). How is your MPA doing? A methodology for evaluating the management effectiveness of marine protected areas. *Ocean and Coastal Management*, *48*(7–8), 485–502. https://doi.org/10.1016/j.ocecoaman.2005.05.004

R Core Team. (2020). R: A language and environment for statistical computing. *R Foundation for Statistical Computing, Vienna, Austria*. Retrieved from http://www.r-project.org/index.html

Rife, A. N., Erisman, B., Sanchez, A., & Aburto-Oropeza, O. (2013). When good intentions are not enough...Insights on networks of “paper park” marine protected areas. *Conservation Letters*, *6*(3), 200–212. https://doi.org/10.1111/j.1755-263X.2012.00303.x

Spalding, M., Meliane, I., Milam, A., Fitzgerald, C., & Hale, L. (2013). Protecting Marine Spaces: Global Targets and Changing Approaches. *Ocean Yearbook Online*, *27*, 213–248. Retrieved from http://jncc.defra.gov.uk/pdf/Tyldesley Marine spatial planning.pdf

Taormina, B., Bald, J., Want, A., Thouzeau, G., Lejart, M., Desroy, N., & Carlier, A. (2018). A review of potential impacts of submarine power cables on the marine environment: Knowledge gaps, recommendations and future directions. *Renewable and Sustainable Energy Reviews*, *96*(August), 380–391. https://doi.org/10.1016/j.rser.2018.07.026

Thurstan, R. H., Hawkins, J. P., Neves, L., & Roberts, C. M. (2012). Are marine reserves and non-consumptive activities compatible? A global analysis of marine reserve regulations. *Marine Policy*, *36*(5), 1096–1104. https://doi.org/10.1016/j.marpol.2012.03.006

WEEKS, R., RUSS, G. R., ALCALA, A. C., & WHITE, A. T. (2010). Effectiveness of Marine Protected Areas in the Philippines for Biodiversity Conservation. *Conservation Biology*, *24*(2), 531–540. https://doi.org/10.1111/j.1523-1739.2009.01340.x

Wood, L. (2007). MPA global: a database of the world’s marine protected areas. Retrieved from Sea Around Us Project website: mpa- global.org

Zeppel, H. (2012). Climate change and tourism in the Great Barrier Reef Marine Park. *Current Issues in Tourism*, *15*(3), 287–292. https://doi.org/10.1080/13683500.2011.556247

Zupan, M., Bulleri, F., Evans, J., Fraschetti, S., Guidetti, P., Garcia-Rubies, A., … Claudet, J. (2018). How good is your marine protected area at curbing threats? *Biological Conservation*, *221*(August 2017), 237–245. https://doi.org/10.1016/j.biocon.2018.03.013

Zupan, M., Fragkopoulou, E., Claudet, J., Erzini, K., Horta e Costa, B., & Gonçalves, E. J. (2018). Marine partially protected areas: drivers of ecological effectiveness. *Frontiers in Ecology and the Environment*, *16*(7), 381–387. https://doi.org/10.1002/fee.1934

APPENDIX A

The ocean covers about 71 percent of the earth's surface, is composed of large open wide oceans and marginal seas affected by thermal and salinity gradients and river inputs. The ocean plays an important role in the hydrological cycle and climate formation (Levinton, 2017). It is a place where it is believed that life was originally developed (Arndt & Nisbet, 2012); containing more phyla and classes than terrestrial and freshwater environments (Costello & Chaudhary, 2017; Tundi Agardy, 1994). Exhibit a vast biological diversity, which according to the Convention on Biological Diversity means "the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part" (United Nations, 1992); i.e. great diversity of ecosystems, species, and genetic traits between individuals and populations. Ultimately, recent technological and scientific advances have allowed us to discover new ecosystems and species (Friedlander et al., 2019); with scientists describing around 1,635 new marine species per year, estimating that 10 to 100 million species are yet to be described in many marine environments that have not yet been sampled (Bouchet, 2006).

Throughout history, states have been establishing dominion and sovereignty over the sea for living and non-living resources, navigation, or trade. In the middle of the 1st century, the Romans began to use the term *mare nostrum* (Latin for "our sea") to the whole Mediterranean sea surrounded by roman territories (Tellegen-Couperus, 1993). During seasons of difficult navigation, it was declared as *mare clausum* (Latin for "closed sea"), although at that time the sea was not subject of possession, as it was *communis omnium naturali jure* – common to mankind (Jessup & Swarztrauber, 1972; Straumann, 2006). It was later, in the middle ages (5th-15th centuries) that some maritime republics – e.g. Venice, Genoa, and England – claimed the *mare clausum* policy favoring the view that the sea was an object of sovereignty and exclusive use (Fletcher, 1933).

The age of discovery (15th-17th centuries) brought the division of the world between the Portuguese and Spanish republics, after the treaty of Tordesillas in 1494, supported by Pope Nicholas V; guaranteeing dominion over the sea at that time. Prompt indignation and rebellion grew within other republics, refusing the exclusive right of navigation, fishing, and trade based on Christian law and papal authority (Duve, 2013). In 1609, the Dutch Hugo Grotius published *Mare Liberum* ("Freedom of the seas"; Latin for "free sea"). Originally written for the Dutch East India Company, after assaulting the Portuguese vessel *Santa Catarina*, in retaliation for Lusitanian mistreatment in the East Indies (Van Ittersum, 2003). Aligned with Dutch commercial interests, the manuscript quoted Roman law and declared natural rights to trade, navigation, and access to seemingly unlimited resources, as anything that could not be seized or enclosed was not capable of being owned and, consequently, should have been free of access to all nations (Feenstra, 2009). The Dutch quickly claimed and monopolized northern fisheries, but the Anglo-Dutch rivalry over fishing rights involved rebuttals to Grotius's arguments. John Selden on assignment from King Charles I, wrote *Mare Clausum* in 1635, arguing that by the natural law of the sea is not common to all men and it is susceptible to private property, supporting the English sovereignty over adjacent seas (Leaffer, 2017).

During the 17th and 18th centuries, an international dispute between doctrines called for an end through a dualism whereby the coastal state could effectively establish dominion through control, over and only, immediate coastal waters, with innocent right of passage to other nations; the high seas outside that territory were left *res communis*, free of use and not subject to sovereignty (Jennings, 1972). The development of the state's coastal domain was followed by the concern to define the baselines of jurisdiction, the internal waters, and the limits of the territorial sea according to their interests, whether for fishing or commerce; major maritime powers would prefer narrow territorial seas, equipped to make the most of the usable area, whilst states without such power would generally prefer wider territorial seas to secure valuable coastal waters (Jessup & Swarztrauber, 1972). In 1702, Cornelius Van Bynkershoek wrote *Dominio Maris*, the so-called cannon-shot rule, defining the boundary of the territorial sea in three nautical miles within which the land-based cannon range could effectively protect and exert dominion over it. Despite changes in cannon's range and new technological advances, the three-mile limit rule ended up traditionally developed and generally accepted by almost every state. Once certain states claimed greater limits – e.g *Cancelli promemoria* (1812) – and practiced old customs beyond the territorial sea in a "contiguous zone", the conflict over the extent of the territorial sea intensified and 42 nations failed to agree on a common limit at the first world conference, the Hague Codification Conference, in 1930 (Martens, 1975).

In the 19th and 20th centuries, the vision of an ocean lifeless in deep zones – azoic hypothesis – with infinite and unlimited resources was practically out of date (Anderson & Rice, 2006). New technological advances along with new expeditions (e.g. H.M.S Challenger) have made it possible to explore areas that were once inaccessible, distant, inhospitable, or deep (Günther, 1878). Events after World War II contributed even more to the discovery of offshore natural resources in the subsoil and seabed, leading to the strategic need of states (e.g. United-States, in 1945) to proclaim sovereignty over the continental shelf. As a result, several nations around the world (e.g: Chile, Ecuador, and Peru in the Santiago Declaration on the Maritime Zone, in 1952) abandoned the three-mile territorial sea limit to declare similar continental shelf claims with greater breadth for fishing and safety purposes. Over the next decades and after the creation of the United Nations, a long series of meetings and conventions tried to resolve maritime disputes that caused division around the world (Jessup & Swarztrauber, 1972; Martens, 1975):

- Between 1947 and 1948, the General Assembly of the United Nations instituted an International Law Commission for the codification of the law of the sea, electing members from several countries of the United Nations to discuss the limit to the territorial sea and other issues. In the absence of an agreement for the breadth of the territorial sea, the international law commission developed a set of draft articles and convening for an international conference, the extension of the territorial sea beyond twelve nautical miles shall not be permitted;
- In 1958, the first United Nations Conference on the Law of the Sea (UNCLOS I) assembled in Geneva, resulted in four treaties::
    - Convention on the Territorial Sea and Contiguous Zone – went into effect in 1969 and incorporates the compilation of rules that define the right of innocent passage through the territorial sea and limit the contiguous zone, promoted at the Hague Codification conference, up to twelve nautical miles from the baseline which the breadth of the territorial sea is measured (UN General Assembly, 1958b);
    - Convention on the Continental Shelf – went into effect in 1964 and codifies the set of rules for the exploitation of natural resources in the subsoil and seabed beyond the territorial sea to where the depth of the adjacent waters admits exploitation (~200m) (UN General Assembly, 1958e);
    - Convention on the High Seas – went into effect in 1962 and is related to the definition of high seas, starting in the contiguous zone, or within the territorial sea, and eventually continuing into the territorial sea of another state (UN General Assembly, 1958c);
    - Convention on Fishing and Conservation of the Living Resources of the High Seas – went into effect in 1966 and adopt conservation programs for the whole fishery with scientific evidence (UN General Assembly, 1958d);
- In 1960, the second United Nations Conference on the Law of the Sea (UNCLOS II) was held after no agreement was reached on some questions concerning the territorial sea and fishing areas (UN General Assembly, 1958a). However, no issue was developed, guiding to the realization of the third United Nations Conference on the

Law of the Sea (UNCLOS III) in 1973, ending in 1982 with the adoption of the United Nations Convention on the Law of the Sea (UNCLOS) (UN General Assembly, 1983) that entered into force in 1994 (UN General Assembly, 1994).

The UNCLOS's agreements replaced the four treaties agreed at UNCLOS I and marked significant developments for the current international law of the sea. Such as the definition of the limits for the territorial sea and deep seabed mining; the need for marine environment conservation programs; navigation rights; the establishment of exclusive economic zones; the legal concept of the continental shelf and, nonetheless, the high seas beyond national jurisdiction as a common heritage of humankind (UN General Assembly, 1982). Portugal signed the 1982 UNCLOS and entered into force in 1997. Under UNCLOS the coastal state jurisdiction extends beyond its internal and archipelagic waters to the following adjacent areas:

- Territorial sea, i.e. territorial waters (TW) (Part II; Section 1, 2, and 3) – Ranges from the baseline of a country's shores to up to 12 nautical miles, extending from the airspace over to the seabed and subsoil below. The state is sovereign, however innocent passage is permitted;
- Contiguous zone (Part II, Section 4, Article 33) – Extends from the edge of the TW up to 12 nautical miles. The coastal state may continue to enforce customs, fiscal, immigration, or sanitary laws, as well as any infringement of the above;
- Exclusive Economic Zone (EEZ) (Part V) – Ranges from the baseline of a country's shore out to 200 nautical miles, the coastal state has supreme rights to the exploration, exploitation, conservation, and management of all living and non-living natural resources. Foreign states have the right to navigate, overfly and place any legal framework related to the freedoms allowed in the convention;
- Continental Shelf (Part VI) – Extends beyond the state's TW through the natural prolongation of the land territory to the outer edge of the continental margin, or a distance of 200 nautical miles from the baseline, whenever the continental margin's outer edge does not reach that distance. The coastal state has rights to the living and non-living resources attached to its continental shelf beyond its EEZ, but it has no rights to the living resources of the water column. It may exceed 200 nautical miles, but shall not exceed 350 nautical miles from the baseline, nor exceed 100 nautical miles from de 2500 meter isobath. Therefore, states have been claiming extended continental shelves, e.g. Portugal in the national submission to extend the continental shelf beyond 200 nautical miles (Conselho de Ministros, 2005).

Overall, mutual agreements and cooperation were reached on the rights of mining, fishing, and oil drilling within the limits of national jurisdiction. But also on the high seas, free from the sovereignty of states, as a general duty to safeguard the marine environment and natural resources to avoid the “tragedy of the commons” (Hardin, 1968). In this scenario, where no state is the owner but can have open access to a common set of resources, the resources can be overexploited or depleted without a regulated and rational use over time; doing so compromise the management and conservation of the marine environment and, in the long term, does not benefit the states. Under the law of the sea, nations found solutions to resolve long-standing conflicts but also opened doors to new meetings for the resolution of matters of general interest (e.g. Convention on biological diversity, Ramsar Convention, OSPAR Convention). One of the most valuable is the protection of marine resources and their sustainable use.

Marine biodiversity provides humans with goods and services, such as food provision, raw materials, recreation, and leisure; playing a fundamental role in national economies (N. Beaumont, Townsend, Mangi, & Austen, 2006). A decline in marine biodiversity causes a change in ecosystem goods and services, resulting in several socioeconomic impacts in industry sectors (Kildow & McIlgorm, 2010). Especially, countries that depend heavily on the ocean economy and suffer most from changes should be concerned about protecting it. However, few integrate the ocean’s contribution to the national economy i.e. the monetary valuation of ecosystem services when possible (N. J. Beaumont, Austen, Mangi, & Townsend, 2008). In addition, marine biodiversity provides humans with climate regulation, sometimes setting higher carbon fixing rates than in many productive terrestrial systems (Tundi Agardy, 1994). Estimating the contribution of ecosystem services should be a political interest to safeguard marine biodiversity. Raising awareness of the importance of good environmental practices with ecological and socioeconomic benefits is a function of states and one that is dependently linked with ocean governance.

MPAs can be a good conservation tool in fisheries (Boudouresque et al., 2005) or ecosystem-based management (Tissot, Walsh, & Hixon, 2009); enhancing fisheries yield and protecting biodiversity. MPAs can be defined in several ways, the most common and used definition being the one provided by the International Union for Conservation of Nature (IUCN) as: “any area of intertidal or subtidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment”. The IUCN classifies MPAs according to their established management objectives *a priori*, as follows (G. Kelleher, 1999):

- Category I – “strict protection primarily for science or wilderness”;

- Category II – "protection primarily for ecosystem conservation and recreation, i.e. national park";
- Category III – "protection primarily for the conservation of natural features, i.e. natural monument";
- Category IV – "protection primarily for conservation through active management, i.e. habitat/species management area";
- Category V – "protection primarily for landscape/seascape conservation and recreation, i.e. protected landscape/seascape";
- Category VI – "protection primarily for the sustainable use of natural ecosystems, i.e. managed resource protected area";

As a result, each MPA category accommodates different objectives, which leads to different results in compliance with the target regulations (White et al., 2011). The objectives of an MPA should encompass socio-economic and ecological characteristics that include all stakeholders (e.g. policymakers, managers, the general public); as well as consistent regulations to avoid unnecessary efforts, costs, and a false sense of protection (Edgar, Russ, & Babcock, 2007). To assess the success of MPAs and whether management goals are being achieved, it is necessary to implement monitoring and research programs. They consist of periodic assessments of the ecological and socio-economic conditions of MPAs (National Research Council, 2001). It is through monitoring that the necessary data (the desired and unintended consequences) are obtained to assess the current status and the performance of the conservation measures applied (Ahmadia et al., 2015). The data obtained are essential to improve the monitoring program or enforce regulations, if necessary; and to report progress to the stakeholders. Few long-term monitoring programs currently exist; monitoring programs are required to be carried out in MPAs over a long period (at least 5 years) to allow adaptive management and successful conservation of biodiversity (Addison, 2011). Monitoring programs should be planned before or during implementation and should evaluate comparable and replicated sites under different levels of protection (Gonçalves, n.d.).

Biological indicators (e.g. habitats or species) are generally used in monitoring programs (Addison, 2011). A good biological indicator must be sensitive to applied protection and provide scientific evidence of the performance of MPAs. Information can be collected through the use of indicators: (1) structure of marine communities (e.g. species abundance, age structure, species diversity, and spatial distribution); (2) habitat complexity, maintenance, and restoration; (3) water quality and other environmental pollutants; (4) socioeconomic characteristics and impacts (Grorud-Colvert et al., 2021; National Research Council, 2001).

All information collected by indicators can be evaluated through numerical (density, census, coverage, frequency, presence/absence, biomass, species richness and diversity), demographic (survival, mortality, productivity, and sex ratio), and trophic (position, structure, and trophic diversity) measures (Geange et al., 2016). Biological indicators are important but not always self-sufficient to study the efficiency of an MPA; can lead to insignificant/insensitive results to the extra protection guaranteed by the MPA (Claudet et al., 2010).

The "reserve effect" is the increase of biological variables (e.g. biomass, abundance, species richness, size of individuals) (Lester et al., 2009). This effect occurs in MPAs under protection against the extraction of living and non-living resources, i.e. where no extraction is allowed (no-take/no-go areas). Normally classified as marine reserves and integrated into multi-use MPAs. The reserve effect is obtained by comparing the biological variables inside and outside the no-take/no-go area, before and after the implementation of the marine reserve using the Before-After-Control-Impact (BACI) method (Horta e Costa et al., 2013). The reserve effect serves as an assessment of the effectiveness of measures implemented in MPAs. The outside area is an area with a much lower level of protection, where extraction is allowed by national/regional regulations and serves as a control. When this scenario is not verified, it is possible to study the effects of protection inside and outside the marine reserve through local patterns of species movements, ranges and habitat preferences (Abecasis et al., 2015).

The implementation of no-take/no-go areas brings direct benefits in fisheries management (Kenchington et al., 2003). The biomass and/or abundance of target and non-target species compared inside and outside the marine reserve show differences (Lester et al., 2009). The absence of fishing leads to a reduction in mortality and an increase in the abundance and size of target species. Commercial predatory species cause a decrease in non-commercial species within the reserve resulting in the equilibrium of the food web (Claudet et al., 2011; Guidetti, 2006). The increase in lifespan and biomass of individuals causes an increase in fecundity and spawning; producing more larvae and juveniles causes an increase in population persistence (Fraschetti et al., 2011; Pelc et al., 2010; Russ, 2002). Consequently, it is possible to restock populations outside the reserve limits through the dispersion of eggs and larvae, and the spillover of juveniles and adults (Grüss et al., 2011; Tetreault & Ambrose, 2007). Sedentary and demersal species also benefit from the implementation of FPAs; results show an increase in density, most likely due to its distribution area being contained in the MPA (Abecasis et al., 2015).

References

Abecasis, D., Horta E Costa, B., Afonso, P., Gonc¸alves, E. J., & Erzini, K. (2015). Early reserve effects linked to small home ranges of a commercial fish, Diplodus sargus, Sparidae. *Marine Ecology Progress Series*, *518*, 255–266. https://doi.org/10.3354/meps11054

Addison, P. F. E. (2011). *A global review of long-term Marine Protected Area monitoring programmes: The application of a good framework to marine biological monitoring. A report prepared for the Joint Nature Conservation Committee*. *1*(455). Retrieved from http://jncc.defra.gov.uk/page-5958

Ahmadia, G. N., Glew, L., Provost, M., Gill, D., Hidayat, N. I., Mangubhai, S., … Fox, H. E. (2015). Integrating impact evaluation in the design and implementation of monitoring marine protected areas. *Philosophical Transactions of the Royal Society B*, *370*, 20140275. https://doi.org/10.1098/rstb.2014.0275

Anderson, T. R., & Rice, T. (2006). Deserts on the sea floor: Edward Forbes and his azoic hypothesis for a lifeless deep ocean. *Endeavour*, *30*(4), 131–137. https://doi.org/10.1016/j.endeavour.2006.10.003

Arndt, N. T., & Nisbet, E. G. (2012). Processes on the young earth and the habitats of early life. *Annual Review of Earth and Planetary Sciences*, *40*, 521–549. https://doi.org/10.1146/annurev-earth-042711-105316

Beaumont, N. J., Austen, M. C., Mangi, S. C., & Townsend, M. (2008). Economic valuation for the conservation of marine biodiversity. *Marine Pollution Bulletin*, *56*(3), 386–396. https://doi.org/10.1016/j.marpolbul.2007.11.013

Beaumont, N., Townsend, M., Mangi, S., & Austen, M. (2006). *Marine Biodiversity - An economic valuation: Building the evidence base for the Marine Bill*. (July), 1–73. Retrieved from http://www.earthmind.net/marine/docs/uk-marine-valuation.pdf

Bouchet, P. (2006). *The Exploration of Marine Biodiversity: Scientific and Technological Challenges* (C. M. Duarte, Ed.). Retrieved from https://www.fbbva.es/TLFU/dat/02 Bouchet_Exploration.pdf

Boudouresque, C. F., Cadiou, G., & Diréac'h, L. (2005). Marine Protected Areas: A Tool for Coastal Areas Management. *Strategic Management of Marine Ecosystems*, 29–52. https://doi.org/10.1007/1-4020-3198-x_2

Claudet, J., García-Charton, J. A., & Lenfant, P. (2011). Combined Effects of Levels of Protection and Environmental Variables at Different Spatial Resolutions on Fish Assemblages in a Marine Protected Area. *Conservation Biology*, *25*(1), 105–114. https://doi.org/10.1111/j.1523-1739.2010.01586.x

Claudet, J., Osenberg, C. W., Domenici, P., Badalamenti, F., Milazzo, M., Falcón, J. M., … Planes, S. (2010). Marine reserves: Fish life history and ecological traits matter. *Ecological Applications*, *20*(3), 830–839. https://doi.org/10.1890/08-2131.1

Conselho de Ministros. *Resolução nº9/2005*. , (2005).

Costello, M. J., & Chaudhary, C. (2017). Marine Biodiversity, Biogeography, Deep-Sea Gradients, and Conservation. *Current Biology*, *27*(11), R511–R527. https://doi.org/10.1016/j.cub.2017.04.060

Duve, T. (2013). Treaty of Tordesillas. In *Max Planck Encyclopedia of Public International Law (online edn)* (Rüdiger Wo).

Edgar, G. J., Russ, G. R., & Babcock, R. C. (2007). Marine protected areas. In C. S.D. & G. B.M. (Eds.), *Marine Ecology* (pp. 534–565). Retrieved from https://www.researchgate.net/profile/R_Babcock/publication/284222610_Marine_protected_areas/links/57eaf01508aeafc4e88a5864/Marine-protected-areas.pdf

Feenstra, R. (2009). Hugo Grotius Mare Liberum 1609-2009: Original Latin text and English translation. In *Hugo Grotius Mare Liberum 1609-2009: Original Latin Text and English Translation*. https://doi.org/10.1163/ej.9789004177017.i-178

Fletcher, E. (1933). John Selden (Author of Mare Clausum) and His Contribution to International Law. *Transactions of the Grotius Society*, *19*, 1–12. Retrieved from www.jstor.org/stable/742903

Fraschetti, S., Claudet, J., & Grorud-Colvert, K. (2011). MANAGEMENT – Transitioning from single-sector management to ecosystem-based management: what can marine protected areas offer? In J. Claudet (Ed.), *Marine Protected Areas* (pp. 11–34). https://doi.org/10.1017/CBO9781139049382.003

Friedlander, A., Afonso, P., Morato, T., Carreiro-Silva, M., Fontes, J., Abecasis, D., … Gonçalves, E. (2019). Blue Azores - The best kept secret in the Atlantic. *Scientific Report to the Regional Government of the Azores*, 1–107.

Geange, S., Freeman, D., Zintzen, V., & Blakemore, K. (2016). *Introduction to marine monitoring*. 1–16. Retrieved from http://www.doc.govt.nz/Documents/science-and-technical/inventory-monitoring/im-toolbox-marine-introduction-to-marine-monitoring.pdf

Gonçalves, E. J. (n.d.). *Biodiversity measurements and indicators in MPAs: monitoring procedures and evaluation methods.*

Grorud-Colvert, K., Sullivan-Stack, J., Roberts, C., Constant, V., Horta E Costa, B., Pike, E. P., … Lubchenco, J. (2021). The MPA guide: A framework to achieve global goals for the ocean. *Science*, *373*(6560). https://doi.org/10.1126/science.abf0861

Grüss, A., Kaplan, D. M., Guénette, S., Roberts, C. M., & Botsford, L. W. (2011). Consequences of adult and juvenile movement for marine protected areas. *Biological Conservation*, *144*(2), 692–702. https://doi.org/10.1016/j.biocon.2010.12.015

Guidetti, P. (2006). Marine reserves reestablish lost predatory interactions and cause community changes in rocky reefs. *Ecological Applications*, *16*(3), 963–976. https://doi.org/10.1890/1051-0761(2006)016[0963:MRRLPI]2.0.CO;2

Günther, A. (1878). II.— *Preliminary notices of Deep-Sea Fishes collected during the Voyage of H.M.S. 'Challenger.' Annals and Magazine of Natural History*, *2*(7), 17–28. https://doi.org/10.1080/00222937808682376

Hardin, G. (1968). The Tragedy of the Commons. *Science*, *162*(3859), 1243–1248. https://doi.org/10.1126/science.162.3859.1243

Horta e Costa, B., Claudet, J., Franco, G., Erzini, K., Caro, A., & Gonçalves, E. J. (2016). A regulation-based classification system for Marine Protected Areas (MPAs). *Marine Policy*, *72*, 192–198. https://doi.org/10.1016/j.marpol.2016.06.021

Horta e Costa, B., Erzini, K., Caselle, J. E., Folhas, H., & Gonçalves, E. J. (2013). Reserve effect within a temperate marine protected area in the north-eastern Atlantic (Arrábida Marine Park, Portugal). *Marine Ecology Progress Series*, *481*, 11–24. https://doi.org/10.3354/meps10204

Jennings, R. Y. (1972). A Changing International Law of the Sea. *The Cambridge Law Journal*, *31*(1), 32–49. Retrieved from http://www.jstor.org/stable/4507510

Jessup, P. C., & Swarztrauber, S. R. (1972). *The three-mile limit of territorial seas*.

Kelleher, G. (1999). Guidelines for Marine Protected Areas. *Pacific Conservation Biology*, *6*(4), 352. https://doi.org/10.1071/PC010352

Kenchington, R., Ward, T., & Hegerl, E. (2003). *The Benefits of Marine Protected Areas*. (July).

Kildow, J. T., & McIlgorm, A. (2010). The importance of estimating the contribution of the oceans to national economies. *Marine Policy*, *34*(3), 367–374. https://doi.org/10.1016/j.marpol.2009.08.006

Leaffer, R. (2017). Mare clausum (The Closure of the Sea or The Ownership of the Sea) 1635 John Selden (1584-1654). In S. Dauchy, G. Martyn, A. Musson, H. Pihlajamäki, & A. Wijffels (Eds.), *The Formation and Transmission of Western Legal Culture. 150 Books that Made the Law in the Age of Printing* (7th ed., pp. 190–194). Retrieved from https://core.ac.uk/download/pdf/80808023.pdf

Lester, S., Halpern, B., Grorud-Colvert, K., Lubchenco, J., Ruttenberg, B., Gaines, S., … Warner, R. (2009). Biological effects within no-take marine reserves: a global synthesis. *Marine Ecology Progress Series*, *384*, 33–46. https://doi.org/10.3354/meps08029

Levinton, J. S. (2017). *Marine Biology: Function, Biodiversity, Ecology* (5th ed.). Retrieved from https://lccn.loc.gov/2017013346

Martens, E. K. (1975). Evolution of Coastal State Jurisdiction: A Conflict Between Developed and Developing Nations. *Ecology Law Quarterly*, *5*(3), 531–553. https://doi.org/10.15779/Z38RZ3G

National Research Council. (2001). *Marine Protected Areas: Tools for Sustaining Ocean Ecosystems*. https://doi.org/10.17226/9994

Pelc, R. A., Warner, R. R., Gaines, S. D., & Paris, C. B. (2010). Detecting larval export from marine reserves. *Proceedings of the National Academy of Sciences of the United States of America*, *107*(43), 18266–18271. https://doi.org/10.1073/pnas.0907368107

Russ, G. R. (2002). Yet Another Review of Marine Reserves as Reef Fishery Management Tools. *Coral Reef Fishes*, 421–443.

https://doi.org/10.1016/b978-012615185-5/50024-4

Straumann, B. (2006). “Ancient Caesarian Lawyers” in a State of Nature: Roman Tradition and Natural Rights in Hugo Grotius’s “De iure praedae.” *Political Theory*, *34*(4), 328–350. Retrieved from http://bookshop.europa.eu/ro/state-of-nature-in-the-eu-pbTHAK15002/?CatalogCategoryID=iEKep2Ix3hEAAAEud3kBgSLq

Tellegen-Couperus, O. (1993). *A Short History of Roman Law* (1st ed.). https://doi.org/10.4324/9780203416464

Tetreault, I., & Ambrose, R. F. (2007). TEMPERATE MARINE RESERVES ENHANCE TARGETED BUT NOT UNTARGETED FISHES IN MULTIPLE NO-TAKE MPAS. *Ecological Applications*, *17*(8), 2251–2267. https://doi.org/10.1890/06-0161.1

Tissot, B. N., Walsh, W. J., & Hixon, M. A. (2009). Hawaiian Islands Marine Ecosystem case study: Ecosystem- and community-based management in Hawaii. *Coastal Management*, *37*(3–4), 255–273. https://doi.org/10.1080/08920750902851096

Tundi Agardy, M. (1994). Advances in marine conservation: the role of marine protected areas. *Trends in Ecology & Evolution*, *9*(7), 267–270. https://doi.org/10.1016/0169-5347(94)90297-6

UN General Assembly. (1958a). A/RES/1307. *Convening of a Second United Nations Conference on the Law of the Sea*.

UN General Assembly. (1958b). Document A/CONF. 13/39. *Conference on the Law of the Sea, III*.

UN General Assembly. (1958c). Document A/CONF. 13/40. *Conference on the Law of the Sea, IV*.

UN General Assembly. (1958d). Document A/CONF. 13/41. *Conference on the Law of the Sea, V*.

UN General Assembly. (1958e). Document A/CONF. 13/42. *Conference on the Law of the Sea, VI*.

UN General Assembly. (1982). *United Nations Convention on the Law of the Sea*.

UN General Assembly. (1983). A/RES/38/59. *Third United Nations Conference on the Law of the Sea*.

UN General Assembly. (1994). *United Nations Convention on the Law of the Sea*. *1833*(31363).

United Nations. (1992). *Convention on Biological Diversity*. Rio de Janeiro.

Van Ittersum, M. J. (2003). Hugo Grotius in context: Van Heemskerck’s capture of the Santa Catarina and its justification in De Jure Praedae (1604-1606). *Asian Journal of Social Science*, *31*(3), 511–548. https://doi.org/10.1163/156853103322895360

White, J. W., Botsford, L. W., Baskett, M. L., Barnett, L. A., Barr, R. J., & Hastings, A. (2011). Linking models with monitoring data for assessing performance of no-take marine reserves. *Frontiers in Ecology and the Environment*, *9*(7), 390–399. https://doi.org/10.1890/100138

Zupan, M., Bulleri, F., Evans, J., Fraschetti, S., Guidetti, P., Garcia-Rubies, A., … Claudet, J. (2018). How good is your marine protected area at curbing threats? *Biological Conservation*, *221*(August 2017), 237–245. https://doi.org/10.1016/j.biocon.2018.03.013

Table 1: List of all MPAs and respective zones included in this study: information, characteristics, and RBCS.

Management Plan		Yes	Yes		Yes	Regulated	Yes	No	Regulated	Regulated	No
Outside	Buffer Classif.	Weakly protected	Weakly protected		Moderately protected	Weakly protected	Weakly protected	Weakly protected	Moderately protected	Weakly protected	Weakly protected
	Zone Class	6	6		5	6	6	6	5	6	6
	Anc/boating index	2	2		2	2	2	2	2	2	2
	Aqua/Bottom index	0	1		0	1	1	2	1	2	2
	Highest FG score	8	8		6	8	8	8	6	6	8
	No. types of fishing gear	15	11		9	15	15	15	8	9	12
Inside	MPA Classif.	Moderately Protected	Moderately Protected		Highly Protected	Moderately Protected	Moderately Protected	Moderately Protected	Unprotected	Fully Protected	Unprotected
	MPA index	5	5		4	5	5	5	7	1	7
	Ratio Area	1	0,54567394	0,45432606	1	1	1	1	1	1	1
	Zone Classif.	Moderately regulated extraction	Moderately regulated extraction	Moderately regulated extraction	Highly regulated extraction	Moderately regulated extraction	Moderately regulated extraction	Moderately regulated extraction	Unregulated extraction	No-take/No-go	Unregulated extraction
	Zone Class	5	5	5	4	5	5	5	7	1	7
	Anc/boating index	1	1	2	1	1	1	2	1	0	1
	Aqua/Bottom index	1	0	0	0	0	1	0	3	0	3
	Highest FG score	6	6	6	4	6	6	6	6	0	6
	N. types fishing gear	1	2	6	2	7	5	8	8	0	9
Ocean Zone		Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters
Zone code		RNPG PP	RNID PP	RNID PPI	RNIS PP	RNSRN	RAMPPS PPII	PNMCG PP	COR02 PP	FAI01 PT	FAI10 PP
MPA code		RNPG	RNID	RNID	RNIS	RNSRN	RAMPPS	PNMCG	COR02	FAI01	FAI10
Region		Madeira	Madeira	Madeira	Madeira	Madeira	Madeira	Madeira	Azores	Azores	Azores

Regulated	Regulated	Regulated	Regulated	Regulated	No	Regulated	Regulated	Regulated	Regulated	Regulated	No
Unprotected	Unprotected	Unprotected	Unprotected	Unprotected	Unprotected	Moderately protected	Unprotected	Weakly protected	Weakly protected	Weakly protected	Moderately protected
7	7	7	7	7	7	5	7	6	6	6	5
2	2	2	2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	1	3	1	1	1	0
8	8	8	8	8	8	6	8	8	8	8	6
12	12	12	12	12	12	8	12	12	12	11	8
Moderately Protected	Moderately Protected	Moderately Protected	Moderately Protected	Moderately Protected	Moderately Protected	Highly Protected	Moderately Protected	Unprotected	Unprotected	Highly Protected	Highly Protected
5	5	5	5	5	5	4	5	7	7	4	4
1	1	1	1	1	1	1	1	1	1	1	1
Moderately regulated extraction	Moderately regulated extraction	Moderately regulated extraction	Moderately regulated extraction	Moderately regulated extraction	Moderately regulated extraction	Highly regulated extraction	Moderately regulated extraction	Unregulated extraction	Unregulated extraction	Highly regulated extraction	Highly regulated extraction
5	5	5	5	5	5	4	5	7	7	4	4
1	1	1	1	1	2	1	2	2	2	1	1
0	0	0	1	0	1	0	1	3	3	0	0
6	6	6	6	6	6	4	6	6	6	4	4
8	8	8	7	9	9	1	7	9	9	1	1
Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters
FAI11 PP	FAI12 PP	FAI13 PP	PICO20 PP	PICO21 PP	PICO22 PP	SMA01 PP	SMA11 PP	SMA12 PP	SMA13 PP	SMA02/AP ZMISM -	APZMISM - BA
FAI11	FAI12	FAI13	PICO20	PICO21	PICO22	SMA01	SMA11	SMA12	SMA13	SMA02/AP ZMISM - IV	APZMISM - BA
Azores	Azores	Azores	Azores	Azores	Azores	Azores	Azores	Azores	Azores	Azores	Azores

No	No	Regulated	Regulated	Regulated	Regulated	Regulated	Regulated	Regulated	Regulated	No	Regulated
Weakly protected	Unprotected	Unprotected	Moderately protected	Unprotected	Unprotected	Moderately protected	Weakly protected	Weakly protected	Weakly protected	Weakly protected	Unprotected
6	7	7	5	7	7	5	6	6	6	6	7
2	2	2	2	2	2	2	2	2	2	2	2
0	3	3	1	3	3	1	1	0	1	1	3
8	6	8	6	8	8	6	8	8	8	8	8
11	7	11	7	12	12	7	11	12	12	12	12
Highly Protected	Highly Protected	Moderately Protected	Moderately Protected	Highly Protected	Moderately Protected	Fully Protected	Highly Protected	Moderately Protected	Moderately Protected	Moderately Protected	Moderately Protected
4	4	5	5	4	5	2	4	5	5	5	5
1	1	1	1	1	1	1	1	1	1	1	1
Highly regulated extraction	Highly regulated extraction	Moderately regulated extraction	Moderately regulated extraction	Highly regulated extraction	Moderately regulated extraction	No-take/Regulated acess	Highly regulated extraction	Moderately regulated extraction	Moderately regulated extraction	Moderately regulated extraction	Moderately regulated extraction
4	4	5	5	4	5	2	4	5	5	5	5
1	1	1	1	1	1	1	2	2	1	2	2
0	0	0	1	1	0	0	1	1	1	1	1
4	4	6	6	0	4	0	0	6	6	6	6
1	1	2	4	0	7	0	0	9	7	7	5
Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters
APZMISM - BM	APZMISM - BP	GRA01 PP	GRA02 PP	GRA07 PT	GRA08 PP	SMG06 PT	SMG19 PT	SMG20 PP	SMG21 PP	SMG22 PP	SMG23 PP
APZMISM - BM	APZMISM - BP	GRA01	GRA02	GRA07	GRA08	SMG06	SMG19	SMG20	SMG21	SMG22	SMG23
Azores	Azores	Azores	Azores	Azores	Azores	Azores	Azores	Azores	Azores	Azores	Azores

Regulated	No	No	No	No	No	No	No	No	No	No	Regulated
Unprotected	Weakly protected	Weakly protected	Weakly protected	Weakly protected	Weakly protected	Unprotected	Moderately protected	Weakly protected	Weakly protected	Weakly protected	Moderately protected
7	6	6	6	6	6	7	5	6	6	6	5
2	2	2	2	2	2	2	2	2	2	2	2
3	0	1	0	1	1	1	1	1	1	1	0
8	8	8	8	8	8	8	6	8	8	8	6
12	12	12	12	12	12	12	7	12	11	12	8
Moderately Protected	Moderately Protected	Moderately Protected	Moderately Protected	Moderately Protected	Moderately Protected	Moderately Protected	Moderately Protected	Moderately Protected	Moderately Protected	Moderately Protected	Moderately Protected
5	5	5	5	5	5	5	5	5	5	5	5
1	1	1	1	1	1	1	1	1	1	1	1
Moderately regulated extraction	Moderately regulated extraction	Moderately regulated extraction	Moderately regulated extraction	Moderately regulated extraction	Moderately regulated extraction	Moderately regulated extraction	Moderately regulated extraction	Moderately regulated extraction	Moderately regulated extraction	Moderately regulated extraction	Moderately regulated extraction
5	5	5	5	5	5	5	5	5	5	5	5
2	2	2	2	2	2	2	2	2	2	2	1
1	0	0	0	0	0	0	0	0	0	0	0
6	6	6	6	6	6	6	6	6	6	6	6
9	7	7	7	7	9	9	7	9	9	9	4
Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	EEZ
FLO09 PP	SJO10 PP	SJO11 PP	SJO12 PP	SJO13 PP	TER15 PP	TER16 PP	TER17 PP	TER18 PP	TER19 PP	TER20 PP	PMA01 PP
FLO09	SJO10	SJO11	SJO12	SJO13	TER15	TER16	TER17	TER18	TER19	TER20	PMA01
Azores	Azores	Azores	Azores	Azores	Azores	Azores	Azores	Azores	Azores	Azores	Azores

Regulated	Regulated	No	Regulated	No	No	No	No	No	No	No	No
Unprotected	Moderately protected	Moderately protected	Moderately protected	Moderately protected	Moderately protected	Moderately protected	Moderately protected	Moderately protected	Moderately protected	Moderately protected	Moderately protected
7	5	5	5	5	5	5	5	5	5	5	5
2	2	2	2	2	2	2	2	2	2	2	2
3	0	0	0	1	1	1	1	1	0	0	0
6	6	6	6	6	6	6	6	6	6	6	6
8	8	8	8	8	8	6	6	6	8	8	8
Moderately Protected	Moderately Protected	Moderately Protected	Moderately Protected	Moderately Protected	Moderately Protected	Moderately Protected	Moderately Protected	Moderately Protected	Moderately Protected	Moderately Protected	Moderately Protected
5	5	5	5	5	5	5	5	5	5	5	5
1	1	1	1	1	1	1	1	1	1	1	1
Moderately regulated extraction	Moderately regulated extraction	Moderately regulated extraction	Moderately regulated extraction	Moderately regulated extraction	Moderately regulated extraction	Moderately regulated extraction	Moderately regulated extraction	Moderately regulated extraction	Moderately regulated extraction	Moderately regulated extraction	Moderately regulated extraction
5	5	5	5	5	5	5	5	5	5	5	5
1	1	2	1	2	2	2	2	2	2	2	2
0	0	0	0	1	1	1	1	1	0	0	0
6	6	6	6	6	6	6	6	6	6	6	6
4	4	5	4	5	5	5	5	5	8	6	6
EEZ	EEZ	Extended platform	EEZ	EEZ	EEZ	Extended platform	Extended platform	Extended platform	EEZ	EEZ	EEZ
PMA02 PP	PMA03 PP	PMA04 PP	PMA05 PP	PMA06 PP	PMA07 PP	PMA08 PP	PMA09 PP	PMA10 PP	PMA11 PP	PMA12 PP1	PMA13 PP1
PMA02	PMA03	PMA04	PMA05	PMA06	PMA07	PMA08	PMA09	PMA10	PMA11	PMA12 - EEZ	PMA13 - EEZ
Azores	Azores	Azores	Azores	Azores	Azores	Azores	Azores	Azores	Azores	Azores	Azores

No	No	No	No	Regulated	Regulated	Regulated	Regulated	Regulated	Yes	
Moderately protected	Moderately protected	Moderately protected	Moderately protected	Moderately protected	Weakly protected	Moderately protected	Unprotected	Unprotected	Unprotected	
5	5	5	5	5	6	5	7	7	7	
2	2	2	2	2	2	2	2	2	2	
0	0	1	0	1	1	1	3	3	1	
6	6	6	6	6	8	6	8	8	9	
7	7	8	8	8	11	7	11	11	16	
Moderately Protected	Moderately Protected	Highly Protected	Moderately Protected	Highly Protected	Moderately Protected	Fully Protected	Fully Protected	Fully Protected	Weakly Protected	
5	5	4	5	4	5	2	2	2	6,8742529	
1	1	1	1	1	1	1	1	1	0,06287355	0,93712645
Moderately regulated extraction	Moderately regulated extraction	Highly regulated extraction	Moderately regulated extraction	Highly regulated extraction	Moderately regulated extraction	No-take/Regulated acess	No-take/Regulated acess	No-take/Regulated acess	Moderately regulated extraction	Unregulated extraction
5	5	4	5	4	5	2	2	2	5	7
2	2	1	2	1	1	1	1	1	2	2
0	0	0	0	1	1	0	0	0	0	3
6	6	4	6	4	4	0	0	0	8	8
6	6	4	8	1	7	0	0	0	5	8
Extended platform	Extended platform	EEZ	EEZ	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters
PMA12 PP2	PMA13 PP2	PMA14 PP	PMA15 PP	PASBC PP	PASBA PT	PASD PT	PASC PT	PASS PT	PNLN PPI	PNLN PPII
PMA12 - beyond EEZ	PMA13 - beyond EEZ	PMA14	PMA15	PASBC	PASBA	PASD	PASC	PASS	PNLN	PNLN
Azores	Azores	Azores	Azores	Azores	Azores	Azores	Azores	Azores	Mainland	Mainland

Yes			Yes					Yes		
Weakly protected			Weakly protected					Weakly protected		
6			6					6		
2			2					2		
0			1					2		
9			8					8		
13			15					15		
Moderately Protected			Highly Protected					Moderately Protected		
5			4,88750209					6,74378541		
0,08290791	0,13314383	0,78394826	0,08185406	0,03481817	0,36249223	0,21511928	0,30583001	0,0021697	0,08106546	0,91676484
Moderately regulated extraction	Moderately regulated extraction	Moderately regulated extraction	No-take/No-go	Highly regulated extraction	Highly regulated extraction	Moderately regulated extraction	Unregulated extraction	No-take/No-go	Highly regulated extraction	Unregulated extraction
5	5	5	1	4	4	5	7	1	4	7
1	1	2	0	1	1	2	2	0	1	2
0	0	0	0	1	1	0	3	0	1	3
6	6	6	0	0	4	6	8	0	3	8
4	6	6	0	0	2	6	7	0	1	10
Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters
RNB PPI	RNB PPII	RNB PC	PMLS PT	PMLS PPI	PMLS PPII-IV	PMLS PCI-III	PMLS PCII	PNSACV PT	PNSACV PPI	PNSACV PC
RNB	RNB	RNB	PMLS	PMLS	PMLS	PMLS	PMLS	PNSACV	PNSACV	PNSACV
Mainland	Mainland	Mainland	Mainland	Mainland	Mainland	Mainland	Mainland	Mainland	Mainland	Mainland

Yes				Yes		Yes		Yes
Unprotected				Weakly protected		Unprotected		Weakly protected
7				6		7		6
2				2		2		2
3				1		1		1
8				8		9		8
15				15		16		15
Highly Protected				Highly Protected		Fully Protected		Unprotected
4,80728483				4,31290622		1		7
0,19271517	0,51334669	0,2926599	0,00127824	0,68709378	0,31290622	0,96427073	0,03572927	1
Highly regulated extraction	Moderately regulated extraction	Moderately regulated extraction	Moderately regulated extraction	Highly regulated extraction	Moderately regulated extraction	No-take/No-go	No-take/No-go	Unregulated extraction
4	5	5	5	4	5	1	1	7
0	1	1	1	1	2	0	0	1
0	1	1	1	0	1	0	0	3
3	8	8	8	4	8	0	0	6
1	6	6	6	2	9	0	0	5
Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters	Territorial Waters
PNRF PT	PNRF PPI	PNRF PPII	PNRF PC	RNLSAS PP	RNLSAS PC	RNDSJ PT	RNDSJ PC	AMPA PP
PNRF	PNRF	PNRF	PNRF	RNLSAS	RNLSAS	RNDSJ	RNDSJ	AMPA
Mainland	Mainland	Mainland	Mainland	Mainland	Mainland	Mainland	Mainland	Mainland

Table 2: List of all uses evaluated in this study based on Zupan et al. (2018) threat indices and Horta e Costa et al. (2016) scores.

Use	Use type	Impact
Traps (lobster/octopus/crab)	Commercial and recreational fishing gear	Low (gear score: 4)
Fish traps	Commercial and recreational fishing gear	Low (gear score: 5)
Fixed fish traps "madrague"	Commercial fishing gear	Medium (gear score: 6)
Lines (jigs, hook and line, rod, troll)	Commercial and recreational fishing gear	Low (gear score: 4)
Longlines (pelagic)	Commercial and recreational fishing gear	Medium (gear score: 6)
Longlines (bottom)	Commercial and recreational fishing gear	Medium (gear score: 6)
Purse seining (pelagic)	Commercial fishing gear	Medium (gear score: 6)
Purse seining (bottom)	Commercial fishing gear	High (gear score: 9)
Beach seines	Commercial and recreational fishing gear	Medium (gear score:8)
Trawl (pelagic)	Commercial fishing gear	Medium (gear score: 6)
Trawl (bottom)	Commercial fishing gear	High (gear score: 9)
Gillnets	Commercial and recreational fishing gear	Medium (gear score: 6)
Trammel nets	Commercial and recreational fishing gear	Medium (gear score: 8)
Surrounding nets near shore	Commercial fishing gear	Medium (gear score: 8)
Drift nets	Commercial fishing gear	Medium (gear score: 6)
Dredges (bivalves)	Commercial fishing gear	Medium (gear score: 7)
Hand dredges (bivalves)	Commercial fishing gear	Low (gear score: 5)
Spearfishing/diving	Commercial and recreational fishing gear	Low (gear score: 4)
Cast nets	Commercial and recreational fishing gear	Low (gear score: 3)
Intertidal hand captures	Commercial fishing gear	Low (gear score: 3)
Hand harvesting	Recreational fishing gear	Low (gear score: 4)
Nearshore fish cages	Aquaculture	Uses score: 3
Offshore fish cages	Aquaculture	Uses score: 2
Mussel/Oyster/Algae	Aquaculture	Uses score: 1
Mining/oil platforms/sand extraction/detonations/	Bottom exploitation	Uses score: 3
Other bottom structures	Bottom exploitation	Uses score: 1
Swimming/snorkeling	Recreational	Uses score: 0
SCUBA diving	Recreational	Uses score: 1
Boating with anchoring (fully regulated)	Recreational	Uses score: 1
Boating with anchoring (partially or unregulated)	Recreational	Uses score: 2