Ana Margarida Serra Ferreira

Coastal Zone Integrated Management, from theory to practice.

Avencas Beach, Cascais

Tese de Doutoramento em Biociências, ramo de especialização em Ecologia Marinha, orientada pelo Professor Doutor João Carlos Marques e co-orientada pela Professora Doutora Sónia Borges Seixas e apresentada ao Departamento de Ciências da Vida da Faculdade de Ciências e Tecnologia da Universidade de Coimbra

Dezembro de 2017

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Doctoral thesis in Biosciences, specialty in Marine Ecology, supervised by Professor Doutor Joao Carlos Marques and co-supervised by Professora Doutora Sónia Borges Seixas, presented to the Department of Life Sciences of the Faculty of Sciences and Technology of the University of Coimbra.

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Dezembro 2017

This thesis was supported by:

National funds through the FCT (Foundation for Science and Technology) strategic plan for MARE (Marine and Environmental Sciences Centre) under the Project UID/ MAR/04292/2013, and through the Regional Operational Programme CENTRO2020 within the scope of the project CENTRO-01-0145-FEDER-000006.

Department of Life Sciences, Faculty of Sciences and Technology (FCTUC), University of Coimbra, Portugal.

ACKNOWLEDGEMENTS / AGRADECIMENTOS

Este trabalho resulta de um sonho antigo de completar a minha formação na área de Biologia Marinha e alargar os conhecimentos a outras áreas que não apenas a Ecologia. Sem o incentivo, apoio e carinho de todos, este sonho ficaria por cumprir pelo que gostaria de agradecer a todas as pessoas aqui nomeadas e igualmente a todos os que, não particularizando, contribuíram para a realização desta tese.

Ao Professor Doutor João Carlos Marques, meu orientador, por ter aceitado este desafio de orientar uma tese “pouco comum” no panorama nacional, por todas as conversas abrangentes com o objetivo de dar a perspetiva global deste caso de estudo. Finalmente por todo o apoio, amizade e incentivo nesta fase final do Doutoramento onde é muito fácil perder o foco e dispersar.

À Professora Doutora Sónia Borges Seixas, minha co-orientadora, por me ter desafiado a seguir para Doutoramento até eu ter finalmente aceite! Por toda a amizade e apoio durante a realização da tese nos mais variados temas.

À Doutora Ana Sofia Alves, amiga de licenciatura e madrinha de coração, o meu agradecimento por todo o apoio na escrita e tratamento estatístico do terceiro artigo desta tese e por ser uma amiga sempre presente que, com o seu feitio especial, incentiva a dar o melhor de nós.

À Doutora Rute Pinto, por todo o apoio na realização do segundo artigo desta tese, orientando-me num tema completamente novo e desconhecido para mim, pela paciência na resposta às milhentas perguntas que surgiram.

A toda a equipa do MARE Coimbra e Lisboa pelos preciosos contributos nas discussões iniciais e pelo apoio administrativo durante todo o Doutoramento.

Ao Dr. Carlos Albuquerque, “Pai” da Área Marinha Protegida das Avencas que me incentivou a olhar para esta pequena área e ver o seu potencial iniciando o processo de reclassificação da área.

Ao Dr. Rui Libório, líder da EMAC- Empresa Municipal de Ambiente de Cascais que infelizmente já não se encontra entre nós, pelo incentivo inicial à realização desta tese e pelo apoio concedido pela empresa.

A toda a equipa da Agência Municipal Cascais Atlântico e mais tarde Cascais Ambiente Drª Sara Faria, Engª Andreia Rijo e Drª Sara Saraiva, pelas várias horas de campo partilhadas entre gargalhadas cúmplices e pelas eternas discussões em comunicação de ciência.

Aos meus pais, Isabel Serra e Joaquim Ferreira pelas palavras de incentivo no momento certo, pelos beijinhos e abraços nos momentos mais difíceis, por nunca me deixarem desistir deste objetivo e por me pressionarem sempre a dar o melhor de mim. São o meu exemplo de vida.

Ao Gonçalo, pela partilha desta e de outras aventuras de vida sempre com uma palavra de incentivo e carinho e, pelo apoio a nível de formatação gráfica e criação de cartografia dos artigos que constituem esta tese. Qual será a próximo sonho e aventura a cumprir?

À Sofia, por dares um novo sentido à minha vida, com o teu sorriso maroto que alegra o coração de qualquer um. Por me teres acompanhado na fase final desta tese, primeiro com os teus movimentos na minha barriga e depois com os teus olhinhos de incentivo no primeiro ano de vida.

A todos o meu sincero Obrigada!

CONTENTS

ABSTRACT

The creation of protected areas for nature conservation is usually a cause of disagreement between the different users of the territory, particularly in coastal zones, where the highest densities of human populations can be found and several economic and urbanistic interests are overlapped. The Municipalities have a growing interest in the management of these areas, assembling greater efforts to preserve its natural resources, particularly in the coastal areas that are deeply dependent of their touristic activity, aiming at an environmentally sustainable differentiated touristic product.

The Biophysical Interest Zone of Avencas created in 1998 was reclassified as Marine Protected Area in 2016 (POOC, 2016). This reclassification process used a bottom-up approach with strong engagement with the public. As a result, several changes were made to the regulation in order to approach the population’s usages and conservation objectives for this intertidal rocky shore. The recently created Marine Protected Area is now a case study that will allow to test if a correct planning, systematic surveillance, and strong local support will result in a recovery of a distressed rocky shore habitat, essential to the ecosystem equilibrium at a regional level.

Along with the biological surveys to evaluate the evolution of the intertidal communities, usage characterization enable to evaluate the short term effect of the outreach initiatives triggered in the reclassification process. Finally enquires were made to the population in order to determine the value assigned to the ecosystem services of this MPA and determine the main causes for this valuation.

Short term results indicate a greater compliance with the regulations; the local population is informed and values the several ecosystem services provided by this MPA. However the results from the biological surveys don’t show a direct recovery from the communities due to these changes in behavior.

Long series of data are necessary to verify the true biological impact of this recently created Marine Protected Area. This will be the next challenge to pursue evaluating the area, which is an innovative study both at national and international level, due to its establishment with a strong inclusive and environmental awareness process and to its posterior co-management with the several stakeholders.

Keywords: Coastal zone management, Local MPA, Bottom-up management, Contingent valuation, Rocky-shore conservation.

RESUMO

A criação de áreas protegidas para a conservação de natureza é normalmente causa de conflitos entre os vários utilizadores do território, particularmente em zonas costeiras onde a pressão antropogénica é muito elevada e vários interesses económicos e urbanísticos se sobrepõem. Os Municípios têm um crescente interesse na gestão destas áreas, reunindo vários recursos para a conservação do seu património natural, particularmente nas zonas costeiras fortemente dependentes da atividade turística, tendo como objetivo a oferta de um produto turístico diferenciado e ambientalmente sustentável.

A Zona de Interesse Biofísico das Avencas foi criada em 1998, tendo sido reclassificada como Área Marinha Protegida em 2016 (POOC, 2016). Este processo de reclassificação usou uma abordagem "bottom-up" com uma forte componente de sensibilização e comunicação com o público em geral. Como resultado, várias mudanças foram feitas ao regulamento de forma a aproximar os usos da área, dos objetivos de conservação para as costas rochosas. Esta nova Área Marinha Protegida é um caso de estudo que irá permitir testar os efeitos do correto planeamento com um forte apoio da população local, assim como da fiscalização eficiente, na recuperação de comunidades intertidais de costas rochosas essenciais ao equilíbrio do ecossistema a nível regional.

Além da monitorização biológica para avaliar a evolução das comunidades intertidais, a caracterização de usos permitiu avaliar a curto prazo o efeito das ações de sensibilização para a população em geral desencadeadas durante o processo de reclassificação. Finalmente os inquéritos à população foram realizados para determinar o valor dos serviços do ecossistema desta AMP e as causa para esta valorização.

Os resultados de curto prazo indicam um maior cumprimento dos regulamentos; a população local está informada e valoriza os vários serviços de ecossistema assegurados por esta AMP. No entanto, os resultados da monitorização biológica não mostram diretamente uma recuperação das comunidades intertidais devido a estas mudanças de comportamento.

São necessárias séries de dados longas para verificar o verdadeiro impacto biológico desta recém-criada Área Marinha Protegida das Avencas. Este será o próximo desafio para a continuação da avaliação desta área que é um caso de estudo inovador a nível nacional e internacional, quer pela sua constituição com uma forte componente inclusiva e de sensibilização ambiental quer pela sua posterior co-gestão com os seus vários stakeholders.

Palavras chave: Gestão da zona costeira, AMP local, gestão “bottom-up”, avaliação económica, conservação de costas rochosas

General Introduction

GENERAL INTRODUCTION

Protection of coastal marine ecosystems became presently a crucial necessity as a function of increasing human pressures, although not far in the past their resilience was thought to be almost infinite. Pollution effects, fishing resources depletion, habitats destruction by human constructions and, finally, the touristic pressure are just a few examples of the human impact on coastal zones.

The creation of protected areas for nature conservation is usually a cause of disagreement between the several users of the territory, which is particularly with regard to coastal zones, where the highest densities of human populations can be found. Actually, due to different interests and points of view, often conflicting, agreements are more difficult in coastal areas, compromising the prime objective of conservation, namely when is problematic, even throughout law enforcement, to ensure the compliance between human activities and existing regulations.

The first marine reserve was created in New Zeland in 1975 (Leight marine reserve) and the International Union for Conservation of Nature (IUCN) was the first organization to highlight the importance of incorporating coastal and estuarine areas in a world network of protected areas in 1982. In the following years, other international initiatives have been gathering efforts for the definition of a marine environment conservation strategy, namely through the creation of marine protected areas (e.g. Ospar and Ramsar convention, Natura Network 2000).

In Portugal, the national network of protected areas includes a total of 16 marine protected areas (MPA), most of them located in the islands of Azores and Madeira. In the main land there are three protected areas: Berlengas Natural Reserve, created in 1981, Vicentina Coast and Southeast Alentejo Natural Park, created in 1995, and the Luiz Saldanha Marine Park, created in 1998.

All of these marine protected areas are managed by the National Institute for Nature and Forests Conservation, with the support of the Municipalities where the protected areas are located. The Municipalities have a growing interest in the management of these areas, assembling greater efforts to preserve its natural resources, particularly in the coastal areas that are deeply dependent of their touristic activity, aiming at an environmentally sustainable differentiated touristic product.

Marine protected areas were initially created to protect the marine resources that were threatened by the great economic pressures. However the current MPAs can serve different purposes at the habitat level for the creation and recruitment of juveniles (Badalamenti *et al.*, 2000) and are able to generate activities with economic value such as tourism (Agardy, 1993; Davis and Tisdell, 1996).

The fishing pressure reduction leads to direct and indirect changes in the community structure (Thompson *et al.*, 2002) and the establishment of a marine reserve does not guaranty on its own the recovery of predators (Guidetti *et al.,* 2008). The expected benefits of the protection measures are the recovery of exploited populations in MPA and surrounding areas, biodiversity protection, and the fish stock maintenance (Reis, 2011). However, the absence of man as a predator does not eliminate his pressure through touristic activities (Milazzo *et al.*, 2002; Minchinton and Fels, 2013) like scuba diving or trampling in rocky shores, particularly in areas easily accessible to visitors.

Protected areas in the coastal zones can attract many tourists that seek leisure activities like family walks, picnics or just landscape contemplation. Nature activities, like snorkeling or tide pooling, are also very popular among the touristic preferences of the visitors, followed by swimming, surf, and fishing (Porter and Wescott, 2004).

In some protected areas, people might be willing to pay for its preservation for the next generations. In those cases, MPA are valued for its passive usages and many attempts have been made to quantify this value (Pinto, 2012).

Marine organisms inhabiting intertidal rocky shores are subjected to a high assortment of biotic (e.g. competition and predation) and abiotic (e.g. fast variations of temperature, salinity and water turbulence) daily changes. According to Faria (1995) there is a large spatial variation gradient in rocky shores due to the high degree of habitat fragmentation in pools and ducts, whose topography and profile are extremely variable as a function of geological conditions and sediment deposition regime.

Because of these characteristics, we may observe a strong zonation of organisms, which are distributed by the several micro-habitats, according to its specificities, contributing to the great diversity and biological productivity of the rocky shores (Martinez *et al.*, 2007). The existence of a high species transition between rocky reefs (Gladstone, 2007), confirms the importance of the intertidal habitat maintenance once there is a great community variation within a specific habitat and a significant proportion of species restricted to a particular rocky reef. The effective management of these areas should seek to limit the leisure activities of the population in order to preserve a part of the intertidal ecosystem (García-Charton *et al.*, 2008).

In intertidal rocky shores communities, decreasing biodiversity has always been assigned to direct impacts like sewage contamination (Crowe *et al.*, 2000), exotic species introduction, the construction of artificialized structures in the coast line (Thompson *et al.*, 2002), or the overexploitation of the living resources (Jackson *et al.*, 2001). However the small and punctual activities like trampling (Addessi, 1995; Minchinton and Fels, 2013), the capture of organisms for human consumption (Castro, 2004; Ferreira *et al.*, 2013), fishing bate, aquarium collectors (Griffiths and Branch, 1997); and the leisure exploration of tide pools (Addessi, 1995) can similarly affect significantly rocky shores populations (Porter and Wescot, 2010).

One of the fundamental goals of Marine Protected Areas is Nature Conservation. To neglect its social, economic and cultural impacts has led to conflicts among users, and therefore it is necessary to involve local communities in its planning since the beginning of its creation (Badalamenti *et al.*, 2000).

The respect for regulations constitutes a key feature to the success of a Marine Protected Area (Causey, 1995; Ticco, 1995), being however very difficult to achieve. The police surveillance is very important (Murray *et al.*, 1999; Guidetti *et al.*, 2008; Martins *et al.,* 2011) especially in urban coasts with a high number of external visitors. That is the case of the Avencas rocky shore, a unique habitat in an extremely urbanized coastal zone, characterized by its high marine biodiversity, which was classified by the Cidadela – São Julião da Barra Costal Management Plan in 1998 (POOC Cidadela - São Julião da Barra, 1998) as “Biophysical Interest Zone of Avencas” (ZIBA). Indeed, the regulations created in 1998 were not fully implemented because of a lack of compliance from the local population.

Actually, due to increasing human pressure from visitors and the persistence of illegal fishing activities, the biodiversity in Avencas has been declining since the 1980’s, and the fact that the area was classified in 1998 did not alter this trend (Ferreira *et al.*, 2017).

Since 2009, the Cascais Municipality is attempting to invert this situation by reclassifying the area as a Marine Protected Area with local management, implementing management measures to recover the local flora and fauna biodiversity and increase the obedience to regulations. The Biophysical Interest Zone of Avencas was reclassified in Avencas Marine Protected Area in 2016 (POOC Cidadela - São Julião da Barra, 2016), and a new regulation was created with several suggestions from the different local stakeholders (local fisherman, inhabitants, sports practitioners, and beach restaurants). Numerous outreach activities were initiated with the scholar and general public and an exhibition was created in the nearby environmental interpretation center. To minimize trampling, a visitation pathway was created and some information spots were placed at the entrance of the beach.

The recently created Marine Protected Area is now a case study that will allow to test if a correct planning, systematic surveillance, and strong local support will result in a recuperation of a distressed rocky shore habitat, essential to the ecosystem equilibrium at a regional level.

GENERAL AIMS AND THESES OUTLINE

The main aim of this thesis was to analyse, at a local scale and from a holistic perspective, the impact from the reclassification process of the Biophysical Interest Zone of Avencas into a Marine Protected Area taking different perspectives into account, namely the reaction of users and stakeholders, the response of intertidal communities, and finally the valuation of the ecosystem services provided by the marine protected area.

To achieve this main objective, the following studies were undertaken in order to respond to a set of more specific objectives:

- To appraise, from a social perspective, the new bottom-up management approach from the Municipality, at a local scale, for the Biophysical Interest Zone of Avencas, and to judge about the success of this approach in a short-term scale.

- To valuate the populations willing to pay or to give time for marine ecosystem conservation and its cultural services, from a management perspective.

- To assess the response of the Biophysical Interest Zone of Avencas, from the biodiversity point view, to a better compliance with regulations, observed since 2012, and analyse its performance in terms of resistance to an extreme event like an ocean storm.

To achieve these objectives, following this general introduction, the thesis is structured in the following way:

An abridged description of study area and of changes arising from the reclassification process, providing information regarding its Geomorphological/Hydrodynamic characteristics and usages characterization.

Three chapters presenting the main results, each one corresponding to a publication in an international scientific journal:

Chapter 1

Ferreira, A., Seixas, S., Marques, J.C., 2015. Bottom-up management approach to coastal marine protected areas in Portugal. *Ocean Coast. Manag*. 118: 275–281. doi: 10.1016/j.ocecoaman.2015.05.008.

Chapter 2

Ferreira, A., Marques, J.C., Seixas, S., 2017. Integrating marine ecosystem conservation and ecosystems services economic valuation: Implications for coastal zones governance. *Ecological Indicators*. 77: 144-122. doi: 10.1016/j.ecolind.2017.01.036

Chapter 3

Ferreira, A., Alves, A.S., Marques, J.C., Seixas, S., 2017. Ecosystem response to different management options in Marine Protected Areas (MPA): A case study of intertidal rocky shore communities. *Ecological Indicators.* 81: 471-480. doi: 10.1016/j.ecolind.2017.06.028

A general discussion, summarizing the most relevant findings of this thesis.

STUDY AREA

With 6 hectare of area, the Biophysical Interest Zone of Avencas (ZIBA) is a small marine protected area, located in Cascais Council in the Lisbon Metropolitan Area. This area was classified since 1998 by the National Coastal Management Plan - Cidadela / São Julião da Barra and comprehends both marine and terrestrial area. In 2016, the area was reclassified to a Marine Protected Area by the same National Coastal Management Plan (Fig. 1).

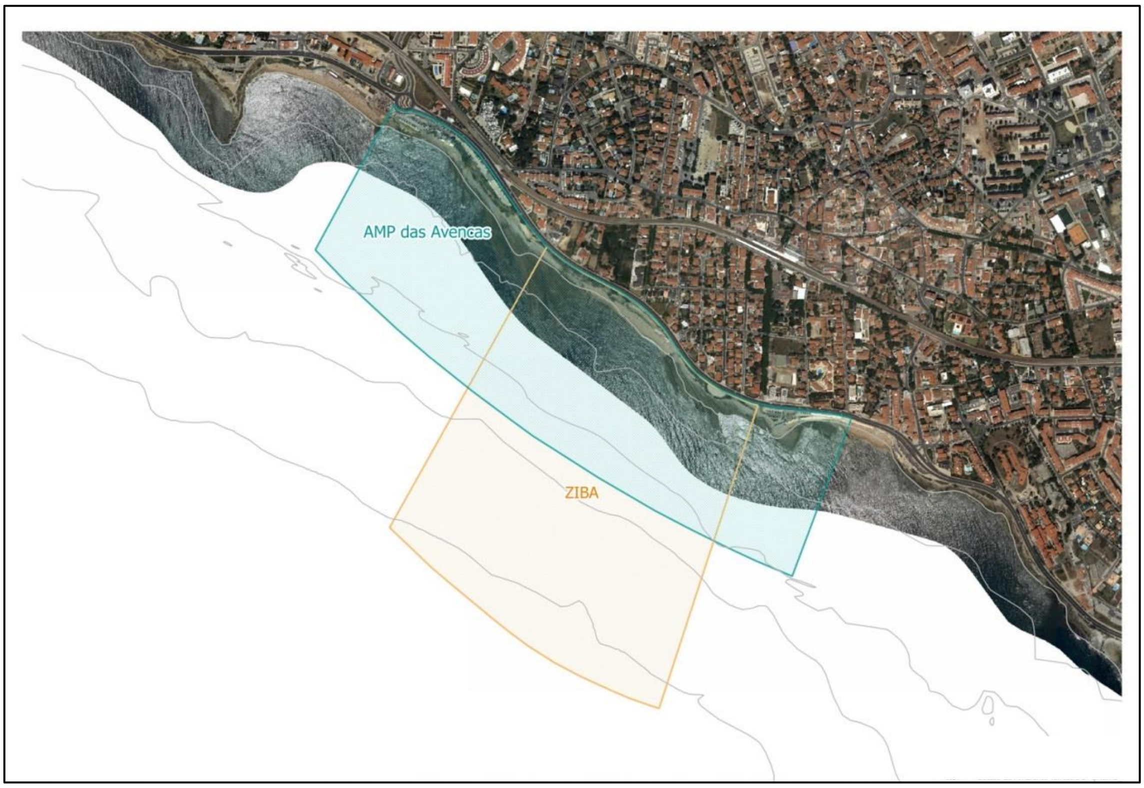


Fig. 1. Study Area with the Biophysical Interest Zone and the Marine Protected Area

The main objective of this new Marine Protected Area is to protect the intertidal habitat; therefore the area was reshaped in order to embrace a wider extension but a smaller depth. There were some changes in the regulation concerning the sports fisheries that exist in the area. Spearfishing and sports fishing are now allowed but conditioned and limited to constricted rules more conservative than the national sports fishing regime.

Fauna

Avencas communities have been studied since the 70s. The first studies conducted by Almaça in 1971 concluded that the most abundant species were the sea-urchin (*Paracentrotus lividus*) the common octopus (*Octopus vulgaris*), the mussel (*Mytillus sp*.) and a variety of crustacean like: the common prawn (*Palaemon serratus*), the velvet crab (*Necora puber*) or the european spider crab (*Maja squinado*).

However, in this same study some factors were pointed out as responsible for the biodiversity reduction at Avencas beach: pollution, animal collection for food and scientific studies, the absence of refuge for the macro-fauna communities and human pressure or "touristic pollution".

The subtidal area shows low values of diversity and abundance; however the intertidal area shows essential conditions to many species of cryptic fish common in areas of low depth (Centro de Oceanografia, 2010). Some of these species are the clingfish (*Lepadogaster purpurea* e *Lepadogaster lepadogaster*) a rare species along the Portuguese coast due to its specific needs regarding the habitat complexity (Faria, 2000).

Geomorphology

Avencas beach is surrounded by cliffs that allow the analyses of its geological formation history. Several natural fresh water fountains allow the growth of characteristic vegetation like the Maidenhair fern (*Adiantum* sp.) that gave origin to the beach name "Avencas".

The calcareous rocky platforms extend to the sea, building great surfaces of irregular shape due to its nodular structure visible at low tide for several hundred meters. These surfaces enable the existence of the characteristic intertidal habitat of the area, especially due to the layers irregularity.

The subtidal area of the study area is characterized by large surfaces of smooth rock with some large blocks rising until the water surface and some boulders nearer to shore. It is expected a high number of species with uniform abundances, associated to this type of habitat (Centro de Oceanografia, 2010). Regarding the mobile sediment, and even though there are some fluctuation all through the year, the central type of this sediment is fine sand (250 < ø < 63 µm), followed by mud (ø < 63 µm) with extremely reduced organic matter content (Centro de Oceanografia, 2010).

Coastal Dynamic and Bathing water quality

The Coastal dynamic of Cascais council is the result of the combined action of the maritime agitation, tides and ocean circulation.

Through the west coast of Portugal the maritime agitation is very energetic and it acquires unique characteristics in Cascais region, due to its geographic position with the Tagus estuary and the consequent strength of the tide entering and leaving this great estuarine system. The arrival of less dense and rich in nutrients water favors the biological productivity of this region.

The main direction of the oceanic currents in Cascais is NW and SE, which is in accordance to the expected for the region according to the coastal line direction and its depth (Instituto Hidrográfico, 2010).

The southern area of the council is protected from the events of maritime agitation from the NW–N. In the winter it is dominated by energetic waves originated in the central area of the North Atlantic, usually from the W-NW sectors that may originate wave's superior to 4m. However, it is also relatively frequent the record of events from the SW quadrant originated from subtropical depressions. This type of event is of short duration and can be very intense, leading to great changes in the sea bed. On the contrary in the spring and summer, the maritime agitation regime is influenced by the local wind regimes and a severe decrease in the wave energy, recoding average heights of 0.46m and 0.26m (Hidroprojeto, 2008).

The water quality from all of Cascais beaches are tested weakly by the Portuguese Environmental Agency between 15 of May and 15 of September (bathing season). The tests conducted in 2013, 2014, 2015 and 2016 for São Pedro do Estoril, Bafureira, Avencas and Parede beaches, revealed an excellent water quality for bathing (APA, 2017).

Coastal Usages

Table 1. Usages characterization of the study area (Ferreira *et al.*, 2012)

USAGES	PREFERENCIAL LOCALIZATION	SEASON	DAY PERIOD
Bathing	Sand and rocky areas	Bathing season	8h00 – 20h00
Surfing	São Pedro do Estoril, Bafureira and Parede beaches	All year round	8h00 – 20h00
Skimming	São Pedro do Estoril beach	All year round	8h00 – 20h00
Snorkeling	Avencas beach	All year round	8h00 – 20h00
Canoeing	São Pedro do Estoril beach	All year round	8h00 – 20h00
Summer camps	São Pedro do Estoril beach	Bathing season	8h00 – 20h00
Therapeutically treatments	Parede beach (rocky areas)	All year round	8h00 – 20h00
Botellón[1]	All study area	Bathing season	20h00 – 8h00
Research work	All study area	All year round	24h00
Environmental awareness activities	Avencas beach (rocky areas)	All year round	8h00 – 20h00
Fishing	All study area	All year round	20h00 – 8h00

Among the most common usages of Avencas beach (Table 1) Surfing, Skimming and Canoeing are the activities that cause the least environmental impact, once they are activities practiced at the surface with little or no-impact in the bottom.

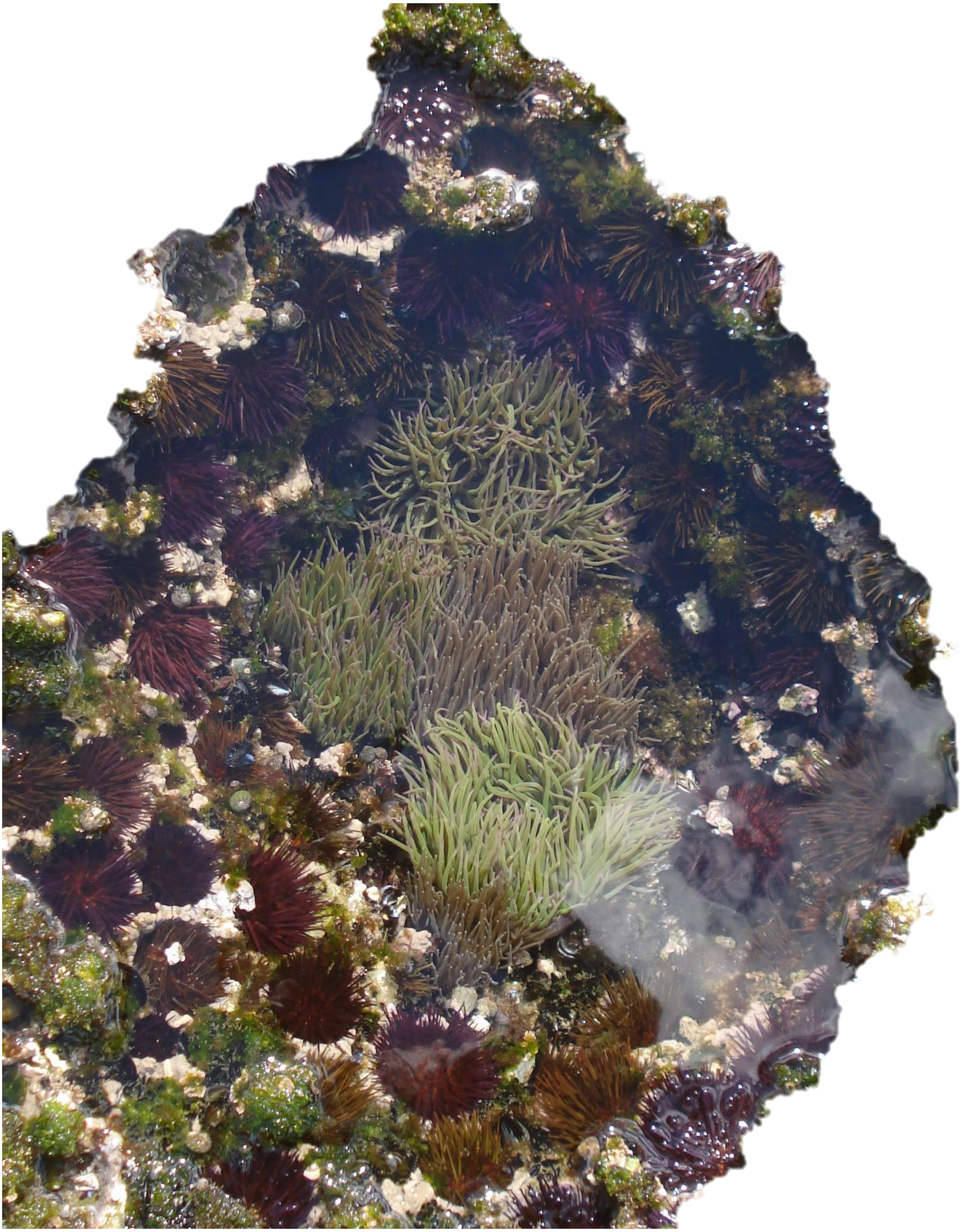
The Snorkeling activities could cause some damage to the bottom if not done carefully, as well as research work if done with no control and no limits regarding the species and quantities caught.

On the other hand, the bathing activities and summer camps don't pose a problem. However, during the bathing season, these people largely exceed the capacity of the beach and cause significant environmental impact with the trampling of the rocky shores while tidepolling.

[1] Social activity in which young people gather in public spaces, for alcoholic beverages consumption as an alternative to bars and clubs. Its name is originated from the word "bottle" in the Spanish language.

Parede beach as always been famous for its therapeutically characteristics, attracting both tourists and local habitants. This activity causes a certain level of impact because of the rock destruction to extract the limestone used in treatments.

In recent years a new activity has been emerging among the youth called "*Botellón*", where young people gather at the beach for socialization and consumption of alcoholic beverages causing some problems of pollution with the disposal of garbage in the sand and rocky shores.



Chapter 1

Bottom-up management approach to coastal marine protected areas in Portugal.

ABSTRACT

The classification and management of coastal marine protected areas is traditionally implemented without a strong public participation process in its early stage, resulting in conflicts. A bottom-up approach with public participation before defining regulations is an innovative, yet difficult process. The case study presented is a local experience of Avencas Biophysical Interest Zone in Cascais, Portugal. The objective of this paper is to evaluate a new approach, to assess the success of the management action applied in terms of the short-term response from users of the costal marine protected area.

Public participation assemblies were conducted to welcome input from the fishing community regarding the new regulation; visual census and interviews directed at different users, were used to assess the short-term effectiveness of the implemented management actions. A new regulation is underway and user management actions have been implemented: visitors' pathways through the rocky platforms and information spots at the entrance to the beach.

Positive results point to the success of this approach, as visitors either agreed or respected the various management actions implemented: 84% of them agree with information spots, and 76% agree with the pathways. Recreational fishers are now mostly located outside the protected area, though there are still some who choose to stay inside, which indicates the need to change some points in the regulation, to improve its compliance by the fishing community. The short-term evaluation methodology was effective in detecting changes in usage patterns from users when the bottom-up approach was applied.

Keywords: Coastal zone management, Marine protected areas, Bottom-up approach, Portugal.

INTRODUCTION

Many scientific papers have been written about coastal zone management and particularly about Marine Protected Areas (MPA) management. It is a complex problem with several perspectives, from the economic (Grafton *et al.*, 2004), to the social (Sanchirico *et al.*, 2002) and finally the environmental points of view (Reis *et al.*, 2014). Most of the studies are conducted at a national or regional scale (Martins *et al.*, 2011) and promoted by research groups or national organizations that intend to define a strategy for Coastal Zone Management or analyze a particular situation. The local consequences of these same studies, however, are not usually quantified. There is a lack of information about the effectiveness of global strategies at a local level, or about the adaptation of management guidelines defined for a particular problem to the local reality. The Municipality of Cascais intends to minimize this gap by promoting the evaluation of management measures applied at a local level.

The compliance of the population is essential for nature conservation purposes; usage conflicts arise whenever there are different users of the same area. One such example when creating a new protected area, is the constriction of public access to an area people are accustomed to access freely. Another example of a strong source of conflict happens whenever fishing activities are limited, while other tourist activities are permitted (eg, scuba diving, or tide pooling). In order to minimize this type of conflict it is necessary, for example, to control the number and mobility of visitors inside the area, minimizing the impact that a high number of tourists have on the environment and on local communities (Carter, 2000).

Traditionally, the conservation strategy in coastal or marine protected areas is defined in a top-bottom perspective. It was largely demonstrated however, that such strategies have severe limitations in the case of local MPA, having major gaps in its implementation (Kelleher and Kenchington, 1992; Shipman and Stojanovic, 2007; Martins *et al.*, 2011; Reis *et al.*, 2014).

Phillips (2003) states, that there have been conceptual advances for establishing/management of protected areas over the last 30 e 40 years. In theory, it is now known what needs to be done to achieve a successful management of the protected areas. The challenge as always is to apply the theory.

Top-bottom management strategy to marine protected areas is usually applied at a regional or national scale (Gaymer *et al.*, 2014), ranging from oceanic (e.g. Wilhelm *et al.*, 2014) to coastal areas (e.g. Cohen *et al.*, 2012; Garces *et al.*, 2013). In this type of marine protected area there are broader and holistic conservation objectives usually aligned with international commitments, protecting the entire ecosystem and its buffer connection to other ecosystems (Toonen *et al.*, 2013). The management strategy is centralized by the government, based in scientific knowledge and with residual public participation (Gaymer *et al.*, 2014). Because of this centralized strategy of management there is a very favourable costs/ benefit relation in the creation of the protected area (Wilhelm *et al.*, 2014) and its implementation is faster than a bottom-up approach.

A lack of compliance from the users due to a non-consultation before establishing the regulation is the main reason pointed as responsible for the failure of the conservation strategy (Sanchirico *et al.*, 2002). This is followed by a weak knowledge of the geographical limits of the area, the restrictions and negative feedback from the social, economic and cultural perspectives (Sanchirico *et al.*, 2002; Bennett and Dearden, 2014a).

The bottom-up management approach, where main stakeholders can participate, is usually applied at local scale in coastal areas, with a long lasting community based management, where users live in the proximity and experience direct impacts and benefits from the marine protected area (Gaymer *et al.*, 2014). The conservation objectives of this type of areas are at the habitat or ecosystem level and intend to resolve a specific problem (Qiu *et al.*, 2009). The bottom-up approach has a strong public participation with active engagement of communities and stakeholders (Sayce *et al.*, 2013). Therefore it is a complicated, long lasting and expensive process of creation and management of marine protected areas. An interdisciplinary approach to develop a new management methodology is essential and the problems associated with the lack of engagement between scientists, practitioners and policies makers must be overcome (Fritz, 2010).

Another disadvantage of the bottom-up management is the time it takes in biological surveys to record a change in the pattern of the biological communities. This fact can cause a discrediting of protection measures, especially when dealing with coastal zone areas that are highly dependent on the surrounding environment. Measuring the success and adequacy of marine conservation initiatives and policies is a challenge for the scientific community.

Many obstacles can be found when measuring the success of marine conservation initiatives simply by analyzing the biological community response or using a combined sets of indicators (biophysical, socio-economical and governance) (Garces *et al.*, 2013). Lack of long series of data, interference from other source of human disturbance, pollution events, or even storm events can mask any biological community response to the management measures applied. While the use of combined indicators could be compromised when applying it to other case studies, due to the lack of necessary base information. It would be more accurate to evaluate the short-term response in the human population that uses the coastal protected area once they are directly affected by the management measures and respond immediately to them.

Thompson *et al.* (2002) suggests that the simple control of human access to the coastal zones allows an effective management of marine habitats. For example, a simple stroll along a rocky shore can be a problem to this marine habitat, once individual algae can lose about 20% of their biomass with a single footstep (Schiel and Taylor, 1999). Controlling the trampling of this area will have a positive ecological benefit in a long term, therefore the human access, directly correlated to the trampling, might be a good indicator of the marine conservation initiatives in marine protected areas.

In Portugal there are “Coastal Zone Management Plans” (POOC) that operate at a regional level and define the several constrictions of land use and the environmentally sensitive areas. These management plans also define the “carrying capacity” of the beaches present in the coastal zone, in order to calculate the maximum number of visitors that allow a sustainable use of the beach without compromising its nature (POOC, 1998). The first coastal zone management plan to be implemented was located in the southern coast of Cascais (POOC Cidadela e São Julião da Barra) in 1998, and it included a unique marine protected area, Avencas Biophysical Interest Zone (Zona de Interesse Biofísico das Avencas - ZIBA). Even though this marine protected area was defined as a “no fishing zone” in the aforementioned plan, the lack of information for visitors and/or lack of compliance from the recreational fishing' community are hampering conservation objectives of the area (Ferreira *et al.*, 2012).

In 2009 the Municipality of Cascais, acknowledging the territorial enhancing of having this coastal marine protected area and the problems associated with the non-compliance with the actual regulation, started the long process of its reclassification. While taking over its management and implementing local actions, a participative process was simultaneously promoted by the Municipality, including public assemblies, to allow public participation before establishing the new regulation for the coastal protected area. Taking this into consideration, the main objective of this paper is to evaluate from a social perspective the new bottom-up management approach from the Municipality at a local level for ZIBA, and to measure the success of this approach in a short-term scale.

MATERIALS AND METHODS

This study was conducted between 2010 and 2013 in Cascais. It started with visual census in 2010 to characterize the uses of Avencas Biophysical Interest Zone. Continued throughout 2012 with visitor interviews and public participation assemblies in to analyze the compliance of the population with management measures applied in 2012 (visitor pathways and information spots). The visual census was repeated in 2013 to analyze in a short term the user's behavior under the new bottom-up management measures.

Both visual census and visitor interviews were conducted by young volunteers from the Municipal Volunteer Program that occurs every summer.

Study area

The Cascais Municipality is located in the Lisbon Metropolitan Area (Portugal). In the 2011 census, it was home to 206,479 people (INE, 2011) most of which living by the shore and working in Lisbon (CMC, 2012). Due to its privileged location at the entrance of the Tagus estuary, the extended sea shore and its geological characteristics - Sintra Mountain Rage - Cascais has a rich natural heritage to the west, with the Sintra-Cascais Natural Park; the south of Cascais is highly urbanized, and it has fourteen urban beaches all of which very popular in the spring and summer (Fig. 1).

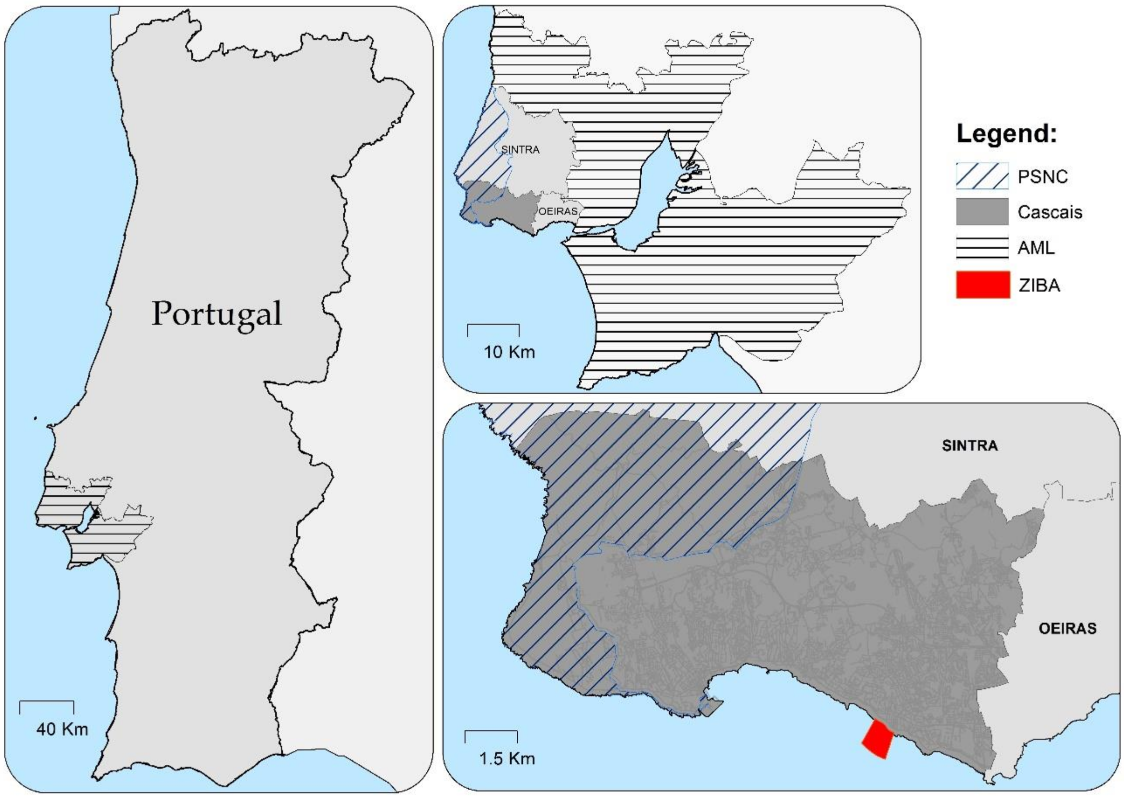


Fig. 1. Location of Cascais Municipality in Portugal and in the Metropolitan Area of Lisbon (AML). Cascais has two protected areas, one inland Sintra e Cascais Natural Park (PNSC) and another at sea, Avencas Biophysical Interest Zone (ZIBA).

ZIBA is located between two beaches, Bafureira and Parede. This area is characterized by extended calcareous rocky platforms with a small sandy beach in the middle (Avencas beach) sheltered from the dominant winds. This rocky shore is extremely rich in intertidal biodiversity, used by several schools and universities to perform their field trips. Visitors use this area in the summer for tide pooling and swimming. The rocky shore has also an historical and therapeutic interest due to its renowned health benefits in treating bone disease with natural limestone. Avencas Beach is located in the middle of the Avencas Biophysical Interest Zone and was classified as a type III beach (semi-natural beach) with a carrying capacity of 156 people in total (considering that each person occupies 12 sqm. of sand while at the beach) (POOC,1998) (Fig. 2). It has a local beach cafe open all year, with a concessional sand area between the 1st of May and the 30th of September (Fig. 2).

To inform visitors about the natural resources present in the area, information spots were setup in all entrances to the beach in June 2012. In August, visitor pathways were established in the rocky shore to prevent random trampling on the platform. Those pathways were simple ropes attached to the rocks with direction signs indicating the start of the pathway.

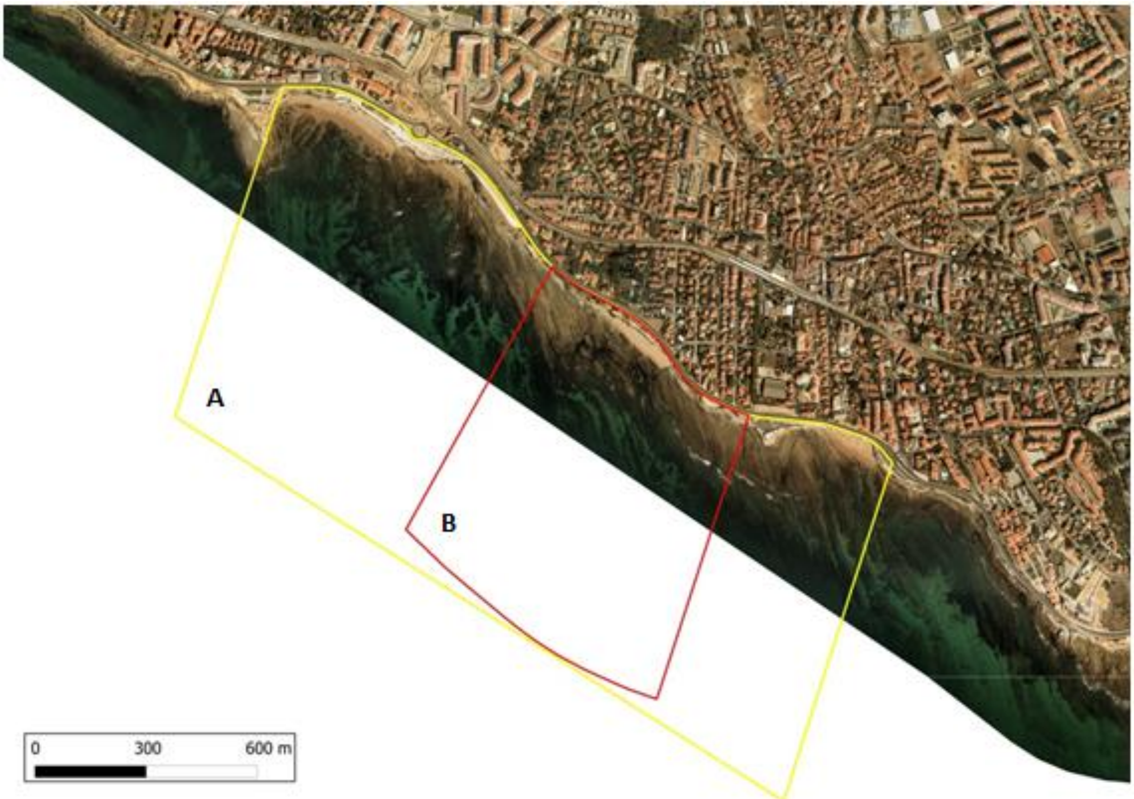


Fig. 2. Aerial picture showing the study area (A) and the Avencas Biophysical Interest Zone e ZIBA (B).

Visual census

In 2010 and 2013 visual census were conducted by young volunteers from the municipality. This census aimed to register the number of recreational fishers and visitors to the study area. After an initial training between June and September, volunteers counted users from 8 distinct seashore segments (3 segments inside ZIBA; 5 segments outside ZIBA) over two daily periods. Volunteers had fixed schedules and days for the two daily counts (9:00 and 14:00; 11:00 and 16:00; 13:00 and 18:00) as the goal was to sample the same time period users are active at the beach, regardless of tide levels. For example, on day 1 there would be a visual census at both 9:00 AM and 14:00 PM; on day 2 the visual census would be at 11:00 AM and 16:00 PM; on day

3 it would be at 13:00 PM and 18:00 PM; on day 4 it would go back to 9:00 AM and 14:00 PM. The visual census was conducted with two observers to avoid bias and regardless of weather conditions or day of the week.

After an exploratory graphical analysis, and assumptions verification tests (Normality: Shapiro-Wilks and Homoscedasticity: Levene's test) the Mann-Whitney test (a ¼ 0.05) was used to analyze differences in the number of users between 2010 and 2013 in the study area. SPSS software (IBM SPSS Statistics V21) was used for the statistics procedure.

Public participation assemblies

In 2012 three public participation assemblies took place in Cascais, promoted by the Municipality. The first one was targeted at the local recreational fishers, the second at other users of the area, and finally the third at the general public.

In the first two assemblies the same methodology was followed. Beginning with a small technical presentation of the problem, followed by a work group where the participants were asked to: name the positive and the negative elements of the Biophysical Interest Zone; contribute with some ideas to achieve the conservation objectives of the area; and to identify away of cooperation that would preserve the local biodiversity. Finally, groups were asked to present their conclusions to the audience. In the third and final assembly, a summary of the two previous ones was presented to users, followed by a debate. Representatives from: the Maritime and Municipal Police, the Environment Municipal Director of Cascais Municipality, the National Authority for Civil Protection, the Portuguese Environmental Agency and the Captain of the Port of Cascais participated in all assemblies These public participation assemblies were conducted to apply the bottom-up management approach at a local level.

Interviews to the visitors

From June to September 2012, visitors to Avencas beach (inside the Biophysical Interest Zone) were interviewed by the same municipal volunteers, in order to analyze their knowledge of the area, and their acknowledgement of management actions implemented on the beach that year.

The interview was divided in four parts: general characterization of the user, reasons for choosing the beach, knowledge about the protected area and opinion on the management actions. The final part of the interview was elaborated using the Likert scale for measurement of attitudes (Likert, 1932). All the volunteers had previous training on how to perform the interview.

The visual census and interviews to the visitors were conducted to measure the success of the applied management approach in a short-term temporal scale.

RESULTS

Visual census

Data from volunteers' observations show a clear pattern for all users of ZIBA, both in 2010 and 2013. The total observations in 2010 were 115 visual census and in 2013, 159 visual census.

The graphical analysis (Fig. 3) shows that recreational fishers, between 2010 and 2013, changed their usual fishing spots from within the Biophysical Interest Zone of Avencas to other locations. As the graphical analysis indicated, a significant statistical decrease in recreational fishing was recorded inside ZIBA when comparing 2010 to 2013 (Table 1) but this was not the case when considering the outside of the protected area.

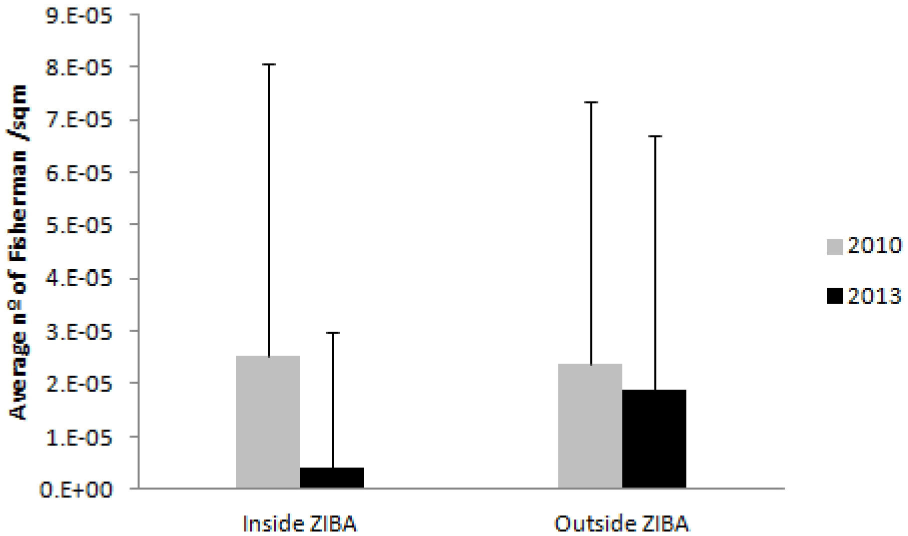


Fig. 3. Average number of recreational fishers per sqm recorded both for the inside and outside of the Biophysical Interest Zone of Avencas (ZIBA) in the years 2010 (before the implementation of management measures) and 2013 (after the implementation of management measures). The error bars represent the standard deviation.

Concerning the visitors, the graphical analysis (Fig. 4) shows a general decrease in visitors in 2013, regardless of location, inside or outside the Biophysical Interest Zone of Avencas. These differences, however, were only proven to be significant outside ZIBA (Table 1). Therefore, it can be stated that the number of visitors inside the protected area suffered a slight insignificant decrease. There is a significant preference (Table 1) for the area outside ZIBA for both years.

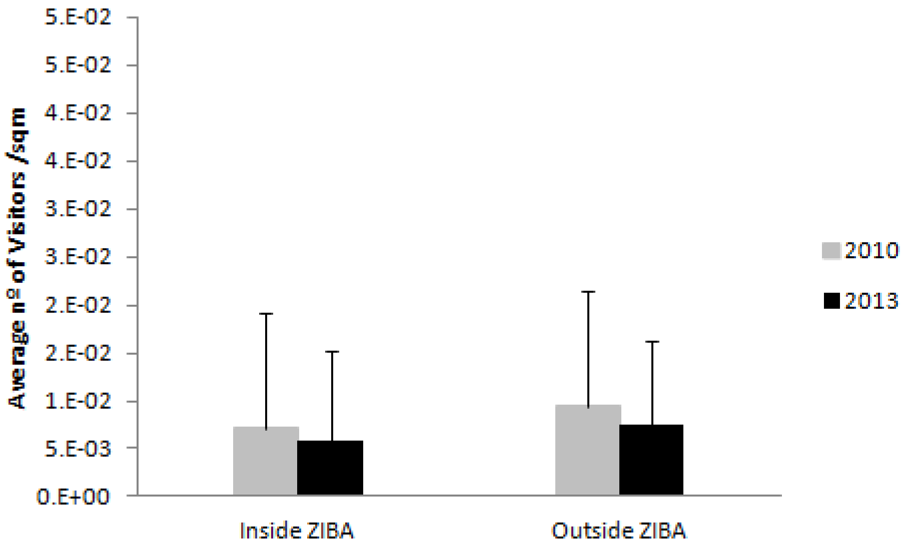


Fig. 4. Average number of visitors per sqm. recorded both for the inside and outside of the Biophysical Interest Zone of Avencas (ZIBA) in the years 2010 (before the implementation management measures) and 2013 (after the implementation of the management measures). The error bars represent the standard deviation.

Table 1: Mann-Whitney test results for the different hypothesis tested with a significance level of 0.05.

Hypothesis	Mann-Whitney test	
Equality of the average no. of recreational fishers/sqm. inside ZIBA (2010 *vs* 2013)	**U=66360**	**p=0.000**
Equality of the average no. of recreational fishers/sqm. outside ZIBA (2010 *vs* 2013)	U=213541	p=0.070
Equality of the average no. of recreational fishers/sqm. in 2010 (inside *vs* outside)	U=96149.5	p=0.732
Equality of the average no. of recreational fishers/sqm. in 2013 (inside *vs* outside)	**U=160036.5**	**p=0.000**
Equality of the average no. of visitors/sqm. inside ZIBA (2010 *vs* 2013)	U=77938	p=0.277
Equality of the average no. of visitors/sqm. outside ZIBA (2010 *vs* 2013)	**U=184069**	**p=0.000**
Equality of the average no. of visitors/sqm. in 2010 (inside *vs* outside)	**U=77869**	**p=0.000**
Equality of the average no. of visitors/sqm. in 2013 (inside *vs* outside)	**U=146147.5**	**p=0.000**

Public participation assemblies

Public participation assemblies promoted by the Municipality had more than 30 participants in each of the three sessions. A total of 50 proposals (recreational fishers = 15 proposal; area users = 21 proposals; general public = 14 proposals) were submitted by the different groups and also by some recreational fishing associations. Local decision makers were present in all sessions, answering to direct questions from participants, enabling direct resolution of some problems and conflicts discussed during the assemblies. The main focus of submitted proposals was on prohibiting fishing activities (limiting the protected area to local recreational fishers only) and on the excess of visitors in the summer (proposals included the decrease of parking space as a way of regulating visitor numbers to the protected area).

Interviews to the visitors

Individual interviews of the users of Avencas Beach (total = 163) were conducted while they were still at the beach. The sample includes 87 women and 76 men of all ages, with the most common age range between 35 and 44 years old (23%) and the less common age range, the one under 18 years of age (7%). Most people interviewed live in the Lisbon metropolitan area (96%), of which 45% live in the Cascais Municipality. The large majority of visitors travelled went to the beach by car (74%) and chose this particular beach because of its proximity to home (28%), therapeutic characteristics (24%) and physiographic characteristics that make Avencas a beach sheltered from wind (25%).

Concerning the usage of the rocky platform, 46% of beach visitors use the rocky intertidal platform; in addition, 52% prefer to freely roam the area using it for recreational activities like swimming (43%) and observation of marine life (32%) (Fig. 5).

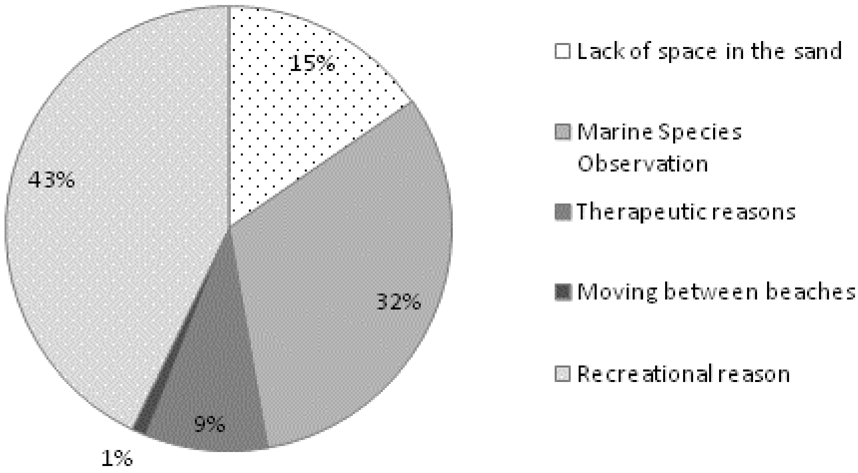


Fig. 5. Characterization of rocky shore usage in the study area (n = 163).

Regarding the knowledge of the protected area and acknowledgement of the management actions, 72% of visitors knew they were in a protected area, 63% were aware of its restricted activities, while 77% knew the consequences of such interdictions. Information spots were read by 80% of visitors, 95% of whom agreed with its location. In a scale of 1 to 5 (5 being in total agreement) 84% of visitors totally agree with the existence of information spots and 67% totally agree with the content of the spots. Regarding the adequacy of the amount of information presented, the results were not clear. There was dispersion around level 3, 4, and 5 (22%, 31% and 26%) of agreement. In terms of visitation pathways, 76% of visitors totally agree with their existence and 69% of them completely agree with the location.

DISCUSSION

In 2012 several efforts were made from the Cascais Municipality in order to enhance the conservation of the Avencas Biophysical Interest Zone (ZIBA) from a bottom-up management perspective. These efforts resulted in a new media impact that revived public opinion and led to a new cycle of this existing protected area. It was therefore necessary to assess whether or not such efforts were resulting in direct changes of usage pattern in the protected area, and if there was an increase in the number of visitors.

The Avencas Biophysical Interest Zone was a suitable place to test the proposed innovative methodology of bottom-up management in the short-term. ZIBA has the ideal area and means to conduct a study of this nature, given the youth volunteering program taking place every summer that enables the systematic collection of data. It also has the correct size for an easy daily survey, allowing for the visual census to occur from the cliffs, facilitating the data collection process.

The short-term evaluation results show that combining visual census with interviews to the visitors, allowed to test the impact and compliance of the population when faced with such management actions, showing a clear pattern from different users of the area. An increase in the number of visitors was expected with the new publicity effort, along with a decrease in the fishing activity due to the restrictions to their activity (Garcia and Smith, 2013). The visual census results, however, did not comply with the expected results in the visitors' case. There was no increase in the number of visitors to the Avencas Biophysical Interest Zone between 2010 and 2013; on the contrary, there was a decrease. In both years, for the study area, the majority of visitors were outside ZIBA. This tendency could be due to their provenance, since most of them come from nearby locations or from the Cascais Municipality itself; they are regular visitors and the increase in publicity may not have exerted great influence on them. Results from the visual census of recreational fishers show a higher compliance with the current regulation, as there is a significant decrease of practitioners inside the Avencas Biophysical Interest Zone in 2013. Recreational fishers are showing a change in their fishing spots from the inside of the protected area to other fishing areas, therefore are responding positively to the implemented management measures (e.g.

public assemblies, information spots, etc.). There was no increase in law enforcement agents in the study area and the census methodology does not allow any possible hiding from recreational fishers while the census is being conducted.

The socioeconomic aspects of establishing MPAs can be considered in an integrated way along with the ecological factors. MPA managers must identify all stakeholders, including commercial and recreational fishers and involve them at each stage of the decision-making process (Kelleher and Kenchington, 1992; Beaumont, 1997; Castilla, 2000; Sachirico *et al.*, 2002). A strong commitment from the managers of a MPA, along with the effective policing and training of responsible officers is also essential (Martins *et al.*, 2011). With the public participation assemblies, the co-management process was initiated. This process, however, takes a long time to be implemented and there are still few successful cases of this type of management approach (Martins *et al.*, 2011; Gelcich *et al.*, 2005). In Chile another solution has shown positive results to improve habitat conservation and effectively complement no-take MPA networks: the creation of Management and Exploitation Areas for Benthic Resources (MEABRs) managed solely by recreational fishers and using a bottom-up governance of marine resources (Gelcich *et al.*, 2008). In the Easter Island the example presented by Gaymer *et al.* (2014) showed how a process to manage marine resources initiated top-down by the centralized government due to its urgency, can evolve in to a bottom-up strategy for development and implementation of a management plan. In China the MPA system is characterized by decentralized designations, with management responsibilities assigned to local governments and lack of top-down objective evaluations Qiu *et al.* (2009). This model enabled a rapid and continuous increase in the number of MPA with low management effectiveness, due to limited stakeholder involvement, insufficient investment and major conflicts between conservation objectives and socio-economic and political interests. China's experience demonstrates the need for a balance between top-down and bottom-up approaches for effective management of the local MPA. In the Philippine islands it appears that a multi-disciplinary approach, involving various institutional partners and using an appropriate mix of indicators, provides a more complete assessment for measuring the success of MPA and generating results that can be utilized for adaptive management (Garces *et al.*, 2013). It seems that there isn't a perfect formula to be applied while managing marine protected areas. However there are some very balanced bottom-up perspectives that may be tested in the future.

Phillips (2003) suggests a new paradigm bottom-up oriented for protected areas, resulting from: changes in scientific understanding; cultural and social awareness; the acknowledgement of human rights; political developments; general developments in management practice; technological advances and economic forces. Cox *et al.* (2010) propose a list of eight principles adapted for community based natural resource management: clearly defined boundaries; congruence between appropriation and provision rules and local conditions; collective-choice arrangements; monitoring; graduated sanctions; conflict-resolution mechanisms; minimal recognition of rights to organize; nested enterprises. These are clear principles to guide a good bottom-up oriented management of a MPA in the future. There are however some critical reflections on this type of managements such as: the great demand of resources (staff, time and money) for the assumed essential stakeholder participation and community involvement; the difficult willingness or ability of all local communities to support conservation and sustainable use; the danger of diminishing the achievements of government-managed strictly protected areas; the risk of becoming an unmanageable area because of great interference from the population (Phillips, 2003).

As the carrying capacity of the beach was exceeded every day, the main negative impact identified for the study area was the trampling by visitors while performing their tide pooling and leisurely activities. Trampling is a major problem in rocky shore communities; individual algae can lose about 20% of their biomass with a single footstep (Schiel and Taylor, 1999). This impact is very difficult to minimize because in Portugal free beach access is a citizen's right, except in case of imminent danger. Consequently, controlling the number of visitors getting to the beach is a near impossible endeavor.

If increasing surveillance or limiting the access is not the answer to this problem, then what is? Bennett and Dearden (2014b) indicate that only with an increase in public awareness and compliance with the regulation is possible to achieve the ultimate goal of environmental conservation by the general public. This objective can be achieved by: effective communication of rules and regulations (e.g. boundaries); extensive programs of environmental education and outreach;

participatory processes of creation and management structures; acknowledge the relevance of all stakeholders; coordination with other management institutions; integration of scientific and traditional knowledge and mechanisms of conflict resolution and ensuring transparency and accountability (Bennett and Dearden, 2014b). A very positive remark was the results concerning knowledge of the protected area itself. Comparing this study results to the ones obtained by Ribeiro (2011) in the same area, there was an increase in the percentage of visitors that acknowledge they were in a protected area, moving from 58% to 72% of informed visitors. In this study, and considering a short temporal scale, the strategy of increasing the availability of information and attempting to establish an orderly visitation of the intertidal platform had a positive effect on visitors. It is therefore expected a positive impact on the biological communities in a long-term perspective.

Although easily damaged, rocky shore communities are quite resilient and are able to recover if sources of stress are removed (Crowe *et al.*, 2000). The key benefit of protected areas is the increase in resilience of the communities, i.e., the speed it takes a population to return to a former state following a negative shock (Grafton *et al.*, 2004). Such high percentage of interviewees agreeing with the orderly visitation of the intertidal platform was not expected, as the majority of visitors observed using the rocky intertidal platform for recreational activities or observation of marine life, were randomly exploring the area. According to Bennett and Dearden (2014a), when visitors suffer constraints in their usage of a protected area, there usually occurs disagreement with that decision due to their lack of awareness to the impact caused by their activity. In this case, as the majority of visitors are local inhabitants, a sense of ownership of the place is quite common, promoting its protection for generations to come. The work conducted in the Avencas Biophysical Interest Zone shows that the proposed methodology is effective in evaluating the short-term effects on the population when management measures are applied. This work focused on the summer period because of volunteer programs that allow the conduction of visual census, but it is also necessary to assess, analyze and ensure compliance during the rest of the year.

There are some problems associated with using volunteers for visual census and conduct interviews. The bias associated with different observers was reduced, by having two observers at a time, and the initial training period aims to calibrate the different observers/ interviews while applying the same methodology. This is nonetheless, an effective and expedites procedure for the Municipality to collect long-term data for coastal zone management.

The participation of the community in the early stages of decision-making in a coastal marine protected area also showed positive results, with a good short-term response from users regarding the protected area regulation. In a future scenario, a biological recovery of this protected rocky shore is expected, but new studies will need to be conducted by the Municipality in order to verify the actual recovery of the system.

Chapter 2

Integrating marine ecosystem conservation and ecosystems services economic valuation: Implications for coastal zones governance

ABSTRACT

This paper presents a preliminary attempt to estimate the awareness and value that society gives to the maintenance and protection of marine protected areas, linking the ecological and economic value scale assigned to the study. To accomplish this, we took as illustrative example the Biophysical Interest Zone of Avencas (ZIBA), in Portugal. The ZIBA spans over one ha and its coastal ecosystems present a very rich biodiversity, providing several socio-economic opportunities to society. To estimate the value that society attributes to this area we conducted a contingent valuation exercise, considering two different aspects: 1) the direct economic value that people state to conserve the ecosystem and 2) the willingness to contribute through the allocation of hours of voluntary work to its conservation. The values obtained indicate the dependence and importance of this ecosystem to local population (willing to pay to conserve it of 60 D per household per year and willing to give 3 h of voluntary work per year). The proximity of the local population to the protected area increases the willing to pay for its conservation; this could reveal a good local indicator of ecosystem valuation. This valuation exercise highlights the importance of coastal ecosystem services to society and draws attention to the benefits that local populations derive from those systems. These results have also implications in future governance actions regarding protected areas, as well as to justify for sustainable investments in coastal management efforts, to sustain the flow of coastal ecosystem services for current and future generations.

Keywords: Marine protected areas, Coastal zone conservation, Contingent valuation, Willing to pay, Voluntary work.

INTRODUCTION

Coastal zones are open land/sea interfaces, exposed to strong environmental gradients that establish high connectivity with other coastal ecosystems (Thompson *et al.*, 2002). This is an area exposed to several different environmental and human pressures. The anthropogenic pressure is continually rising due to the growing human population concentration in the shores, causing pollution problems and the overexploitation of natural resources for food purposes. It is equally an area with great richness in biological diversity and valuable habitats, like the coastal reefs. Particularly in rocky shores, the existence of several reef species that migrate between rocky reefs (Gladstone, 2007) is an important characteristic to the maintenance of the coastal ecosystem.

Marine Protected Areas (MPA) are good management instruments to maintain the coastal zone biodiversity. In Portugal, the first protected area encompassing marine territory was classified in 1981, and in the present days there is a record of 16 places with some protection status that include marine territory. Traditionally this classification occurred without a strong public participation and with many conflict of interests, transforming the management of these areas into a challenge (Ferreira *et al.*, 2015).

From the human society perspective, the coastal zones and MPA provide an innumerous range of services. They are leisure areas and an important food source, where several industrial and touristic activities take place. This intensive use of coastal areas causes competition for the occupation of these regions and requires for techniques and methods that quantify the social, ecological and economic benefits that humans take from these systems. An ecosystem total economic value (TEV) consists of use and non-use values. By use values we can have direct (like food) and indirect (like recreation) values. The non-use values are usually associated with the conservation/preservation of the ecosystem for option future uses or bequest values (Kriström, 1990; Bateman *et al.*, 2002). There are several methods to value ecosystem services to society, however this study will focus only in one methodology (contingent valuation), due to the importance for society of the non-use values in this case study: a coastal protected area easily accessible to the population where no entrance fee is collected. Contingent valuation is a survey-based technique for stating the preferences of non-use values or indirect values to society, over other items of private consumption. It is the most commonly used approach to placing a monetary value on non-use environmental resources (Boyle and Bishop, 1988; Mitchell and Carson, 1989; Bateman *et al.*, 2002).

The contribution to nature conservation in form of volunteer work could be a family activity increasingly valued by the population as a practice of teaching values and bonding with the future generations. The willing to spend time in activities like beach cleanups, invasive species eradication or native species plantation, is considered a form of leisure wile contributing to nature conservation, especially in urban nucleus were nature activities are not normally available. García-Llorente *et al.* (2015) propose willing-ness to give up time in contingent valuation studies, as a useful non-monetary technique, particularly in areas with economic limitations.

With the current scenario of economic crisis, governments have cut backs in their annual budgets. Investment is mostly in social services and local economic empowerment, with the main objective of decreasing the unemployment rate and poverty. Therefore, although nature and coastal zone ecosystem services remain indispensable to the population, during a financial and economic crisis there is a risk of that being relegated to the bottom of the political agenda priorities. Communication of the importance of these ecosystem services to the policy makers, in a simple way, could increase the importance allocated to its conservation.

When conducting a multiple indicator study to communicate similar ecological outcomes, Zhao *et al.* (2013) demonstrated that in valuation studies, when the ecological indicator of ecosystem services are equivalent, the correspondent valuation measure used, is robust to the use of alternative ecological indicators within the survey scenarios. This approach can be beneficiary when communicating with managers and policy makers once contingent valuation studies are a major tool to justify investments in nature conservation, namely in the coastal zones, because they quantify in money(in this case euros), just how much the services provided by this ecosystem are valued by the population. With this type of information, coastal zone managers can develop a cost benefit-analysis, prioritizing investments in its territory, like a specific budget to erosion problems in the shore, investments in environmental education, and investments in pollution emergency plans, or nature restoration initiatives. They can also compare the benefits of different projects or programs, maximizing the public wellbeing with the investments made.

In Chile, Gelcich *et al.* (2013) reported a 97% rate of respondents willing to pay (WTP) for the financing of a marine protected area with the charge of an entrance fee, covering 10–13% of the MPA running costs. The same tendency was reported in Croatia, over 80% of the interviewees were WTP for their holiday in support of marine conservation (Batela *et al.*, 2014). From the tourist perspective the availability to pay an extra amount while visiting a particular area for nature conservation is well recorded: sun-sea-sand tourists report a median WTP of US$ 3.77, while nature based tourists state a higher WTP value of US$ 4.38 (Gelcich *et al.*, 2013) for nature conservation. In Kentucky it was recorded a WTP value between US$ 6 and US$ 13 for a "Wetland Preservation Fund" (Whitehead, 1990), and in Spain, the results showed that the mean WTP for an improvement in water quality was about 33€ per household per year (Ramajo-Hernandez and Saz-Salazar 2012).This type of studies can never alone provide the definitive answer to any major policy question; they help to provide man- agers a more complete package of information, allowing them to make choices concerning the provision of the particular environ-mental amenity in a forward-looking manner (Carson, 1998).

The objective of this work is to determine the valuation of a protected area in a distance decay perspective and the populations (users and non-users of the area) willing to pay or to give time for marine ecosystem conservation of the area and its cultural services, from a management perspective. The use of a non-monetary technic as the willing to give up time in nature's conservation is not commonly used in contingent valuation studies, and intends to be an innovative perspective for the management of coastal protected areas.

More specifically, this study was aimed to:

1. Determine if the socio-economic characteristics, distance to the area and usage of the population, influences the willing to pay or to give time for coastal zone conservation;

2. Determine the value that people are willing to pay for costal zones conservation in € and voluntary work as a proxy to traditional willing to pay;

3. Determine the reason for that willing to pay for coastal zones conservation.

MATERIALS AND METHODS

Study area

The Biophysical Interest Zone of Avencas (ZIBA), located in Cascais municipality (Portugal) (Fig. 1), is characterized by extended calcareous rocky platforms with a small sandy beach in the middle (Avencas beach) sheltered from the dominant north winds. This beach is a type III beach (semi-natural beach) with a carrying capacity of 156 people in total (considering that each person occupies 12 sqm. of sand while at the beach) (POOC, 1998).

ZIBA was classified as a Biophysical Interest Zone in 1998 by the National Coastal Management Plan (Cidadela – São Julião daBarra) (POOC, 1998) because of its intertidal biodiversity richness and geological particularities. Activities as fishing or motor boat sailing are prohibited as a function of the statute of protected area.

Several schools and universities use this area to perform their field trips all year round (Ferreira *et al.*, 2015). Tide pooling and swimming are important activities in the summer. This rocky shore has also an historical and therapeutic interest due to its renowned health benefits in treating bone disease with natural limestone.

Avencas beach users are constantly exceeding the carrying capacity of the place. Trampling of the rocky shore, along with illegal fishing and human disturbance at the reproduction time of local marine species (spring and summer) are the main pressures identified for this protected area (Ferreira *et al.*, 2015).

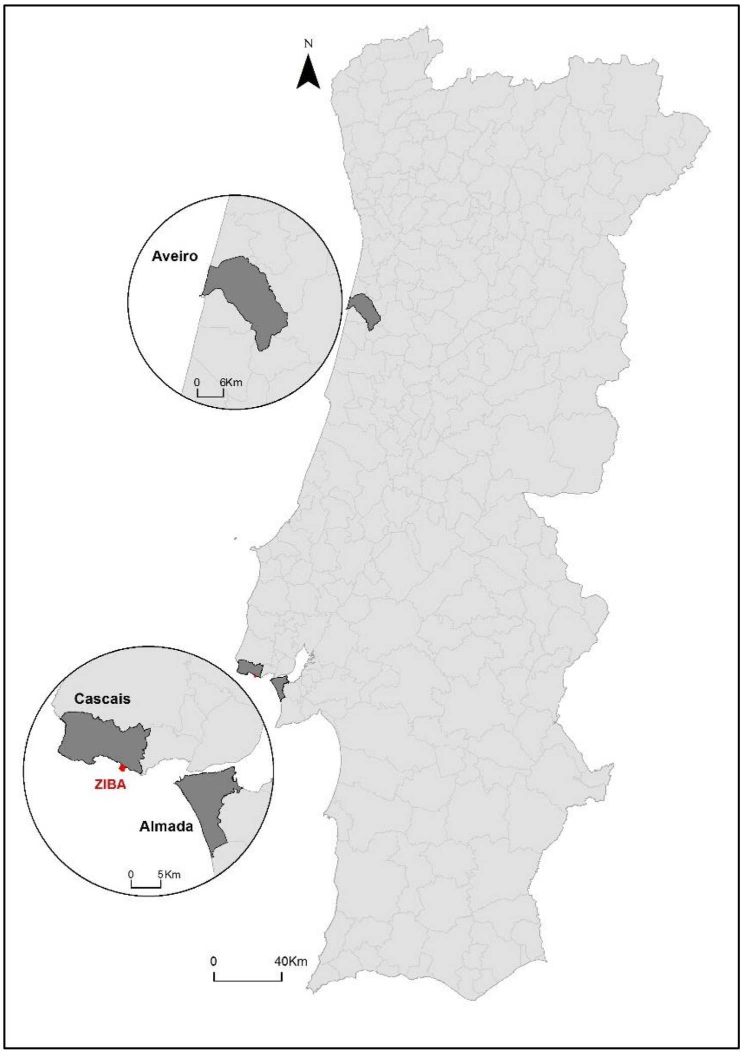


Fig. 1. Location of Cascais, Almada and Aveiro Municipalities in Portugal. The Biophysical Interest Zone of Avencas (ZIBA) is highlighted in red at Cascais Municipality

Questionnaire implementation

We conducted a pre-test before the surveys, in May 2014, to ensure that respondents understood correctly the survey questions and scenarios and to test if the classes included in the payment card were adequate. The full survey was implemented during the2014 summer season (between 1st of June and 30th of September), comprehending 300 face-to-face surveys (100 surveys at each municipality) at three different coastal municipalities with the same touristic characteristic in the summer, being visited during this season for their beaches. Cascais is the municipality of the protected area (distance = 0 km), Almada is the municipality located to a distance of 40 km and Aveiro is the most distant municipality, located to a distance of 250 km. (Fig. 1). We have chosen this period in order to ensure that most of the population targeted by the questionnaires consisted of both users (local population) and non-users (tourists) of the system. The surveys were conducted by the authors and by volunteers trained for this purpose and were performed independently. We randomly selected the respondents from public locations in the municipalities approaching every individual in the space and always ensuring that respondents were older than 18 years-old.

Questionnaire structure and scenarios

The questionnaires consisted of three sections of questions to assess the population WTP for nature conservation in a local marine protected area, the ZIBA in Cascais. The first section aimed to characterize the population usage of coastal zones, aiming to get the respondent thinking about the study area and the main benefits they obtained with it. The second section analyzed the population knowledge about ZIBA and its ecosystem services. In this section, we introduced the valuation question aiming at determining the population willing to pay for the maintenance of its non-use benefits. Finally, the last section inferred about the population socioeconomic characteristics.

We presented two scenarios to respondents to analyze their preferences towards the ZIBAs marine ecosystem conservation and maintenance. The main attributes considered in the scenarios development were increase in: a) the limits of the protected area; b) biodiversity; environmental education activities; c) leisure activities; d) environmental patrolling; and e) information spots and visitation pathways. We presented and explained these scenarios to the surveyed population, always comparing it to the status-quo situation, to estimate their willing to pay.

We considered two types of contributions: a monetary WTP and/or a voluntary time contribution, subsequently converting the last into monetary values by calculating the average income of an individual in Portugal in 2014 (5 € /h) (INE, 2011).

In the surveys, a payment card (with values ranging between 0 and >45€) was adopted as the elicitation format and the payment vehicle considered was an increase in the monthly water bill as a taxation. The survey contained two preference elicitation questions: 1) a 'yes or no' response to the tax increase proposal; and 2) an open-ended question that asked the maximum tax that the respondent would be willing to pay. We considered the following text to estimate the monetary value given by respondents: 'How much would you be willing to add to your monthly water bill, as taxation, so that ZIBA could be improved? This monthly contribution would guarantee the installation of information spots, environmental education to the scholar public, environmental outreach to the general public?' We addressed a question to infer about their ability to give time (as voluntary work) and help to conserve the system (with values between 0 and 36 h per year, assuming that each volunteering activity takes about 3 h in average). After the questions, we conducted a debriefing section to gain insight into the reasons for the response to the preference questions. Respondents were asked to state the reasons underlying their willing to pay for coastal zones conservation, though the use of a five-point Likert scale (Likert 1932), ranging from "fully agree" to "totally disagree" (Figs. 2–5).

Sensitivity to scale

For this analysis, and aiming to infer the Avencas socio-ecological importance, a distance-decay exercise was considered. Moving from the study site itself, three locations were considered: Cascais, Almada, and Aveiro. Cascais Municipality is located in the Lisbon Metropolitan Area (Portugal). In the 2011 census, it had a total population of 206,479 inhabitants (INE, 2011). Almada Municipality is also located in the Lisbon Metropolitan Area being a 40 km drive from Cascais, with a population of 174,030 inhabitants (INE, 2011). Aveiro Municipality is located farther north (about 250 km of distance from Cascais) and presented a total of 78,450 inhabitants in 2011 (INE, 2011). These three locations were selected because they present some similarities on how populations use coastal systems, typically mainly for touristic usages. Therefore, it was assumed that the local population had the same characteristic affinity towards the sea, being the only differential factor its distance to the protected area.

Statistical analysis

The survey respondents were organized into two different groups in order to determine if the socio-economic characteristics of the population influences the willing to pay for coastal zone conservation. We expected that populations' willingness to contribute to nature conservation increased as the household budget also increased. The first group (hereafter Group 1) consisted of all individuals' sampled – individuals older than 18 years-old. The second group (hereafter Group 2) consisted of all the individuals sampled older than 18 years-old, except the ones that were unemployed, students or did not have a full employment occupation – individuals older than 18 years-old with an income.

Through the surveys implementation it was possible calculate the percentage of people that were willing to pay for costal zones conservation in the form of a tax added to their water bill (measured in euros), and the percentage of people that were willing to allocate time to conduct voluntary work in coastal conservation (measured in hours). The maximum annual value was calculated for each of the classes given in the survey, using the mid-point estimates.

Additionally, Spearman correlation analyses were also per-formed to infer the main reasons influencing the respondents' WTP or to give time. The null hypothesis being tested is the inexistence of correlation between WTP or to give time and the different rea-sons presented for a positive or a negative answer. Protests were also identified through follow-up questions. Although there is not a specific methodology to identify protest answers, these can be distinguished from true zero answers through de-briefing questions, where respondents enumerate the main reasons for their refusal to contribute.

Spearman correlations were also performed to identify the main uses of the population regarding the coastal zone and its relation to WTP. The null hypothesis being tested is the inexistence of correlation between WTP and the different usages of the coastal zone considered in the questionnaire.

The Spearman correlation analyses were conducted, using the SPSS software (IBM SPSS Statistics V21).

RESULTS

Descriptive statistics of the surveyed sample

Three hundred in person surveys were conducted. From these, four were deleted due to missing information and inconsistencies in the answers. From the 296 useable surveys, 100 were from Cascais, 97 from Almada and finally 99 from Aveiro.

Descriptive statistics of the respondents' characteristics of Group 1 are reported in Table 1. The representativeness of the respondents surveyed was determined by comparing the different socio-economic parameters from the respondents sample with the national average values (2011 demographic census; INE, 2011). Small variances were found between mean ages (national = 41.16, considered municipalities = 40.18), mean house-hold size (national = 2.60 and considered municipalities = 2.86) and gender (female percentages: national = 52.20%, considered municipalities = 61.25%) for the national and regional samples. Following the same pattern, the percentage of people with a university level of education in the sample was higher than the one recorded for the entire country: 48 and 15%, respectively (Table 1). Consequently, the average monthly income per household is also higher for the surveyed population compared with the national average (most of the surveyed population falls within the 1001–2000€ income class[2] while the national average income class ranged between 500-1000€) (Table 1).

Regarding the possible differences in age of individuals from the different groups analyzed, it was recorded an average age of 40.18 years-old in Group 1 and 44.38 years old in Group 2, therefore this different characteristics of the two groups didn't influence its age homogeneity.

[2] About one third of the respondents did not report their household income. The average household income class of 1001–2000€ assumed in this study is calculated for those respondents who stated their monthly household income.

Table 1. Socio-economic parameters for all the individuals sampled over 18 years old (Group 1) in the three municipalities tested, and for the entire Portuguese population analyzed in the 2011 census (INE, 2011).

	Total	Cascais	Almada	Aveiro	Portugal
n	289	93	97	99	
Age (mean years)	40.18	44.18	39.13	37.44	41.16
Gender (%)					
Woman	61.25	65.59	60.82	57.58	52.2
Men	38.75	34.41	39.18	42.42	47.8
Education level (%)					
Elementary school	6.92	11.83	7.22	2.02	24.60
Middle school	8.30	7.53	15.46	2.02	32.40
High school	35.99	30.11	30.93	46.46	18.50
University or more	48.10	48.39	46.39	49.49	15.00
Household (average number)	2.86	2.39	3.00	2.91	2.60
Household monthly income (%)					
1-500€	5.88	11.83	6.19	0.00	14.66
500-1000€	17.65	17.20	19.59	16.16	37.37
1001-2000€	22.15	32.26	25.77	9.09	14.45
2001-3000€	6.23	13.98	5.15	0.00	14.00
>3001€	2.77	8.60	0.00	0.00	0.003

Value assigned for costal zones conservation in monetary values and voluntary work and relation with its usages

In both groups examined, the analyses of Table 2 revealed that the predisposition of the respondents to pay for an extra tax in their water bill (to contribute to nature conservation at the Biophysical Interest Zone of Avencas) decreases with distance. The maximum percentage of the individuals willing to pay an extra were located in Cascais, but this number decreases in Almada and is null in Aveiro. The major difference in medium salaries is verified between Cascais and Almada (111€ different) (Pordata, 2013). However, these were not the municipalities recording the greater differences in WTP values. The largest difference in WTP was recorded between Cascais and Aveiro, therefore the distance factor overcomes the availability of income per household.

Table 2. Results from the survey by all the individuals over 18 years old (Group 1) and by all the individuals except the ones that were unemployed, students or did not declare any form of income (Group 2).

	Total	**Cascais**	**Almada**	**Aveiro**
Group 1 (%)				
Willing to pay (€)	32.87	67.74	32.99	0.00
Not willing to pay (€)	67.13	32.26	67.01	100
Willing to pay (hr)	62.98	74.19	61.86	53.54
Not willing to pay (hr)	7.27	11.83	10.31	0.00
Group 2 (%)				
Willing to pay (€)	50.75	69.86	42.50	0.00
Not willing to pay (€)	49.25	30.14	57.50	100
Willing to pay (hr)	66.42	73.97	62.50	47.62
Not willing to pay (hr)	11.94	10.96	20.00	0.00

In Group 1, 32.87% of the respondents were willing to pay some monetary contribution to maintain and conserve the ZIBA system (Table 2). From those, 81% have chosen the minimum possibility (5€ per month, corresponding to 60€ per year) (Table 3).

In the same group, 63% of the respondents would also be available to conduct some volunteer work in nature's conservation. From these respondents, 44% of the people that chose to give time in the form of volunteer work chose the minimum time class available (Table 4). This people would give a morning or afternoon per year to nature's conservation. The correspondence with the average income of an individual in Portugal, would reveal a contribution of 15€ per year.

Table 3. Maximum annual value that people were willing to pay (WTP) for nature conservation at the Biophysical Interest Zone of Avencas.

WTP (€)	**%**
60	81.05
120	10.53
180	2.11
240	0.00
> 300	3.16

Table 4. Maximum annual number of hours allocated to volunteer work in nature's conservation at the Biophysical Interest Zone of Avencas in samples percentage. The willing to pay (WTP) estimation was calculated based on the average income of an individual in Portugal (5€ /hour).

Maximum annual value for volunteering (hr)	%	WTP (€)
3	43.81	15
18	36.19	90
36	20.00	180

Interestingly, analyzing Table 2 we can perceive a decreasing trend as we move from the protected area in the respondent's willingness to contribute with time for nature conservation, this tendency is not as marked as it was with the monetary willingness to contribute. In Group 1, about 74% of the individuals in Cascais were willing to give their time and effort to volunteer work. In Almada this percentage decreases to 62% and Aveiro records 54%of the individuals willing to give their time to volunteer work.

Comparing the results obtained for Group 1 and 2 (Table 2), itis possible to verify that in general, there are more people from Group 2 willing to pay for an extra tax in the water bill for nature's conservation, about 50%. These results are according with expected, once there is a greater availability of the family budget for nature's conservation. These numbers are not as expressive when it comes to volunteer work.

In Group 1, 67.13% of the respondents stated a zero willing to pay to conserve the ZIBA (Table 2). Given such high number of zero answers becomes essential to determine the true zero answers from the protest answers. Further scrutiny to the reasons for these answers is conducted in the next section.

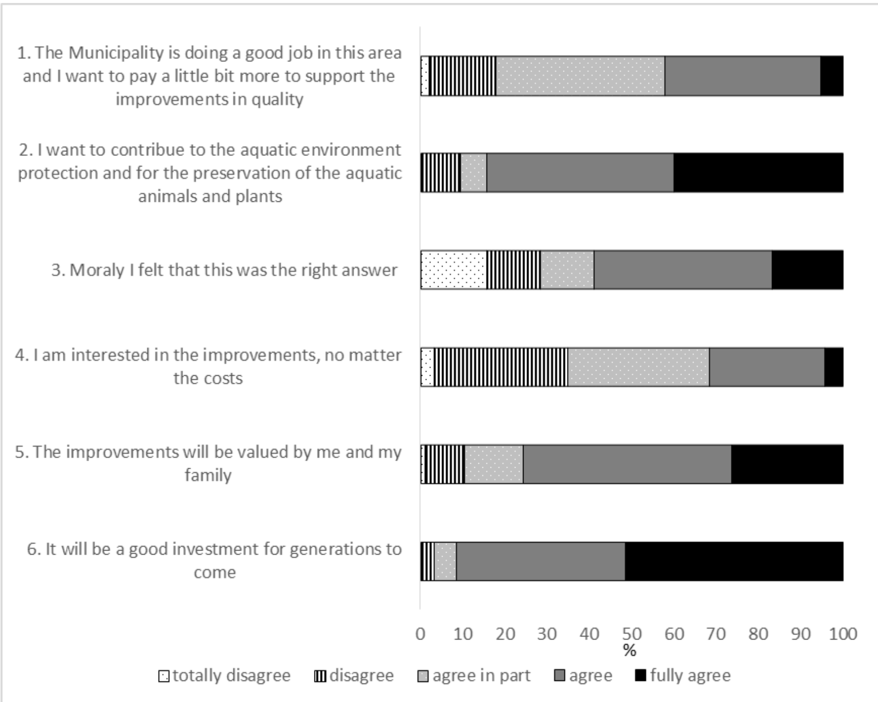
There were ten different usages quantified in the inquiries for the coastal zones including several leisure activities, fishing, boating, dog walking, nature experiences, sports, etc. The majority of the population selected swimming at the beach (63%) and outdoor walking (42%) as the two main activities while visiting the coast, indicating that the leisure activities are the principal usage for the costal zones in the study area.

Regarding the correlation with the people willing to pay for the coastal zone conservation in Group 1 and their usage of the coastal zones, they were verified for: non-motor navigation (r_s= 0.158),swimming (r_s= −0.269), sport fishing (r_s= 0.232) and nature experiences (r_s= −0.016). On the contrary, in Group 2 (population with an income), only sport fishing recorded this correlation (r_s= 0.232).

Reasons underlying respondents' willing to pay for coastal zones conservation

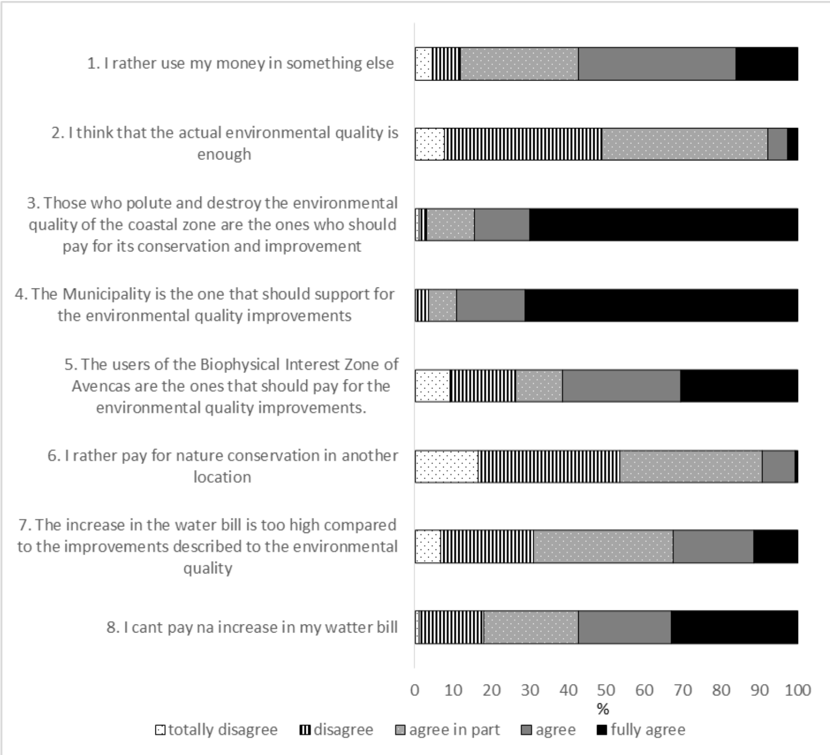
When inferring population regarding the underlying reasons that made them be willing to contribute for the system preservation is possible to perceive that it was related to bequest reasons. The respondents were concerned in conserving the good ecological quality of ZIBA for future generations (Fig. 2). This is corroborated by the high Spearman correlation registered to these variables (r_s= −0.979) comparatively to the other five options.

Fig. 2. Motives that justify a positive answer in the willing to pay for nature's conservation in the Biophysical Interest Zone of Avencas (ZIBA). The bars represent the five levels of the Likert scale in percentage values.



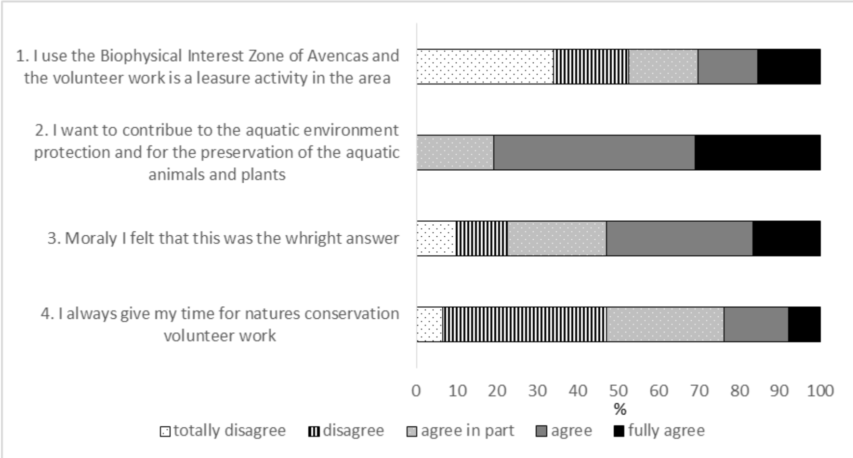
The main reason that justifies a negative answer in the willing to pay for ZIBA's conservation is the respondents' belief that it should be the Municipality to support the environmental quality improvements (Fig. 3). This is corroborated by the Spearman correlation calculated to these variables (r_s= 0.881), once it was the highest record for this set of correlations.

Fig. 3. Motives that justify a negative answer in the willing to pay for nature's conservation in the Biophysical Interest Zone of Avencas. The bars represent the five levels ofthe Likert scale in percentage values.



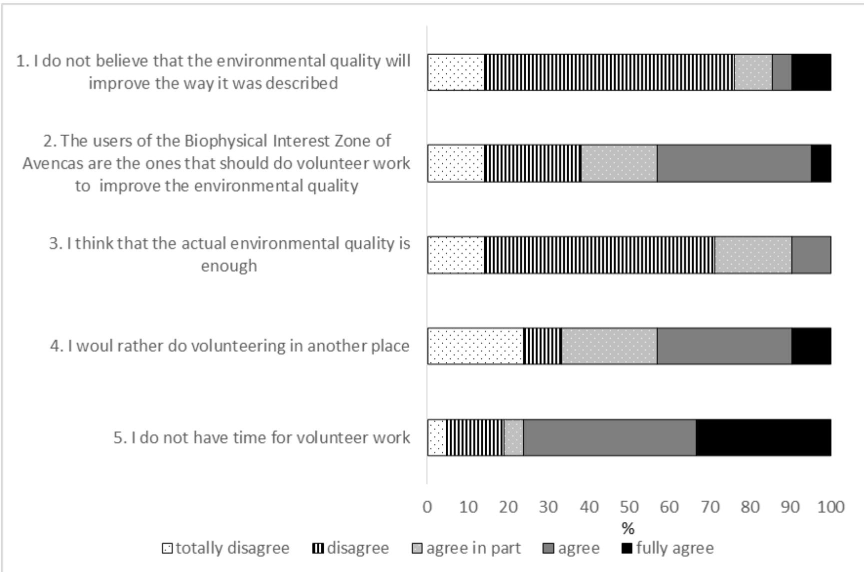
The justifications for a positive answer in the willingness to give time in form of volunteer work for ZIBA's conservation can be analyzed in Fig. 4. The motive that assembles the greater consensus is that people want to contribute to the aquatic environment protection and for the preservation of the aquatic animals and plants. This was also corroborated by the Spearman correlation (r_s= −0.571) for these two variables.

Fig. 4. Motives that justify a positive answer in the willingness to give time in form of volunteer work in nature's conservation in the Biophysical Interest Zone of Avencas. The bars represent the five levels of the Likert scale in percentage values.



On the other hand, the main motive that would justify a negative answer would be the lack of time for volunteering work (Fig. 5). The highest Spearman correlation corroborated these graphical analyses (r_s= 0.975).

Fig. 5. Motives that justify a negative answer in the willingness to give time in form of volunteer work in nature's conservation in the Biophysical Interest Zone of Avencas. The bars represent the five levels of the Likert scale in percentage values.



Aveiro Municipality respondents recorded 0% of WTP, therefore it was necessary to determine if these were true zero answers or protest answers, from the justification options provided by this particular group. The main reasons presented for this answer by the respondents from Aveiro, point to true zero answers: the firs treason stated was the “payer’s polluter” reason (98% of the respondents completely agree with this justification) and the second reason the distance factor, while 90% of the respondents completely agree with the Municipality supporting the costs of the environmental quality improvements.

DISCUSSION

There is a great societal valorization of coastal zones, and consequently of the services provided by these areas and several methods have been proposed to quantify this value. However, due to the inherent complexity of these systems, this remains a challenging task. Economists have long measured the value of goods that are routinely bought and sold in the markets, but ordinary markets do not exist for all nature goods or ecosystems services (Kahneman and Knetsch, 1992; Carson, 1998), so alternative methodologies have to be considered for these items.

With tight budgets, coastal managers face a challenge and every investment decision has to be well discussed and analyzed, nature or coastal zone conservation can be downgraded in the priority list of a public financial plan, where the wellbeing of the population must be maximized. The importance assigned by the population to the protected area is essential when evaluating the priority of investments at a national scale. The distance decay analysis of this study confirmed the expected greater affinity of the population closer to the area being valued, due to its usage and proximity (Pate and Loomis, 1997; Atkins *et al.*, 2007). People surveyed in the council of the protected area (Cascais) were the ones with the highest records of WTP however, 40 Km away from ZIBA, respondents that are not regular users of the area, are still willing to pay an extra tax for natures conservation of this place, revealing its importance in the Lisbon Metropolitan Area. The small size of this particular protected area and its ecological importance in a local level, down-grades its importance at a national scale, therefore conservation funding for this type of protected area should be assigned in local management budgets like Municipalities or regional funding.

The valuation of this protected area could also be recognizable in the time people are willing to give for coastal zone conservation, 66.42% were willing to give one morning a year. The contact with nature in urban areas can be difficult, and public parks or public beaches provide ecosystem services greatly valued by the population, namely the leisure service provided by these places, were one can avoid the daily stress. The main reasons presented by the respondents indicate a strong engagement with coastal zone conservation and mostly the lack of time is an obstacle to give time for this activity. These results are accordant to García-Llorente *et al.* (2015) were the satisfaction of conserving species is the main reason in engaging public support for conservation, particularly in urban areas. This is also an interesting result for local managers; voluntary activities involving nature's conservation in the coastal zone are not very expensive and could give a great fulfillment to local populations, being an affordable way to achieve both social and ecological objectives. The maintenance of the beach cleanness sand the improvement of social activities is referred in Turkey (Birdir *et al.*, 2013) as the main reason for WTP for conservation of the coastal zone. While in Greece, the previous respondents' participation in environmental protection programs by paying an amount was the main cause presented by the respondents (Halkos and Matsiori, 2012). However, these reasons are not always enough to engage in nature conservation, in Spain the population was not pre-pared to pay increased taxes to achieve a better quality of the urban coast of Cadiz (Alves *et al.*, 2014).

In this study, the main motivation, for a positive willing to pay in the conservation of the Biophysical Interest Zone of Avencas is the good investment for generations to come, revealing the usage proximity of the respondents. In fact, sport fishers were the ones assigning a greater willing to pay for ZIBAs conservation probably because in Portugal this particular type of user already pays a fee to fish, and have every interest in maintaining the marine ecosystem for continuation of this practice. A percentage of 50.75% of the respondents were willing to pay an extra tax in the water bill for the conservation of ZIBA. The majority of these respondents were available to give 5€ a month per household (60€ annually) mainly because they consider that this is a good investment for generations to come, expressing the importance assigned to the existence of the area (non-use value). These results are consistent with the values determined by other studies for the coastal zones (e.g. Ramajo-Hernandez and Saz-Salazar, 2012), however to determine an exact amount is very challenging.

Most commonly, economic and ecological literatures do not appear coupled, and the great test remains in communicating eco-logical changes in stated preferences surveys, were the valuation vehicle is economic. The selection of indicators in the survey design has to be transparent in the ecological outcomes that respondents are being asked to value and ways in which these relate to the eco-logical information presented (Zhao *et al.*, 2013). Bias induced by scope insensitivity, complex policy information, time constraints on a respondents valuation decision and strategic effects that arise as a respondent attempts to influence policy outcomes (Hoehn, 1987) especially in an economic crisis scenario, can also influence the obtained results. Nevertheless, a study conducted with actual payments on the willing to pay for preservation of species did not indicate that choice experiments suffer from overstatement in hypothetical willing to pay (Navrud, 1992).

In contingent valuation studies, the willing to pay is a methodology greatly applied; however, the results can be greatly influenced by the low family budget. In many empirical contingent valuation studies, household size, i.e. the number of household members, appears negatively correlated with stated household willing to pay for the maintenance of environmental projects (Ahlheim and Schneider, 2013). The willing to give up time as an alternative to traditionally willing to pay studies with a monetary contribution, can be a good alternative when facing such scenarios of populations with income limitations (García-Llorente *et al.*, 2015) particularly because the availability to pay for coastal zone conservation is not proportional to the available budget per household.

In Portugal the public access to the beach or to a protected area, as a Natural Park cannot be constrain by payment, although according to the municipal experience it would be well accepted by the tourists an entrance fee to some protected areas. The hypothetical payment vehicle adopted, in form of a tax in the water bill, was a good alternative for this contingent valuation study of the coastal zone. The results of this study highlight the importance assigned by the population to the ecosystems services of a coastal protected area and its conservation. The investment made by the government will have a local and regional impact in the living conditions of the population, therefore these considerations should be taken in to account when conducting cost benefit analysis, for allocating public funds to investments in the coastal conservation. The willing to give time as a non-monetary technique revealed to be useful and coherent with the willing to pay results in this case study. The implications of these results for the governance of the coastal zones, revealed the public support in voluntary conservation actions as well as its valuation by the population.

The scientific community is currently communicating inefficiently to policymakers and the public what is the link between biodiversity changes and human wellbeing (Adamowicz, 2004; Ressurreição *et al.*, 2012), and a more complete dialogue between all stakeholders must be undertaken in order to better manage protected areas and promote coastal zone conservation.

In this context, the next challenge would be transposing this type of studies to policymakers and coastal stakeholders, the use of comprehensive numerical language would be necessary to include in annual budgets managed by the governments in a larger temporal scale to achieve a sustainable management.

Chapter 3

Ecosystem response to different management options in Marine Protected Areas (MPA): A case study of intertidal rocky shore communities

ABSTRACT

Marine Protected Areas (MPA) can be powerful coastal management tools with several specific goals, although there is debate concerning their effectiveness. There is no consensus regarding the ideal size of MPAs, and actually there is some evidence that perhaps size is not as critical as other specific factors in determining their success in terms of populations' protection and ecological functions conservation. On the other hand, depending on the objectives, zones with different classification regimes in terms of rules and uses might enable the maintenance of the intended uses.

At this light, we examined the case of the small (605 002 m2) rocky shore area of Avencas, near Lisbon, on the Atlantic western Coast of Portugal, which was classified as Biophysical Interest Zone (ZIBA) in 1998, due to its exceptional intertidal biodiversity, after what its protection status became controversial, leading to conflicts with the local population and incompliance with extant regulations. From 2010 efforts were carried out by local authorities to reclassify Avencas as Marine Protected Area, which was achieved in 2016.

Monitoring intertidal communities in a MPA and adjacent areas is an effective and low-cost procedure to evaluate the evolution of the biodiversity of rocky shores. Therefore, antedating the creation of the new MPA, assessments of the ZIBA biodiversity were conducted from January 2013 to December 2015 on a monthly basis. This timeline was selected as a function of a change in visitors' behavior induced from 2013 by several management and outreach initiatives, which increased in a certain extent the user's compliance with regulations.

A positive evolution was expected for density and/or species diversity of the different groups analyzed (flora, sessile fauna and mobile fauna) in this three years period. However, a very strong storm occurred in 2014 produced a significant impact and changed large areas of the Avencas rocky shore. As a consequence, results did not display a recognizable recovery pattern of the intertidal communities, and following

that extreme event are not even consistent with a hypothesized enhanced recovery capability of the ecosystem in a protected area. This suggests that longer data series are necessary to obtain more robust data regarding natural variability, since alterations caused by extreme events are always likely to occur. Additionally, results illustrate that indeed size matters because it influences the MPA openness, expressed as the ratio of periphery to area, and therefore its susceptibility to external driving forces. Such considerations must be taken into account in any management plan, which in this case should encompass an increase in the intertidal protected area, a new conditioned small scale fishing regime, and an adequate monitoring program to evaluate the effectiveness of the new management scheme.

Keywords: Biophysical Interest Zone of Avencas, MPA management, Ocean storm, Intertidal

INTRODUCTION

The Ocean is a living matrix of organisms and nutrients, and small changes in the usages of sensitive coastal areas can degrade its structure and function. Marine Protected Areas (MPAs) constitute coastal management tools that aim to mitigate these threats and can be planned according to different specific objectives (Halpern, 2003). For some protected areas, the conservation objective is to maintain species biodiversity and not to export biomass for fishing purposes. In this case, several zones with distinct classification regimes, i.e., distinct rules and uses, can enable the maintenance of distinct traditional fishing activities (Horta e Costa *et al.*, 2016). Currently there are 13 674 MPAs, corresponding to 2.07% of the oceanic area worldwide (MPAtlas, 2016). However, despite the high number of classified areas several doubts arise concerning their effectiveness (Fraschetti *et al.*, 2005). A total of 1624 Km2 of European waters are Marine Reserves, wile 124 000 Km2 are MPAs with a lower classification status (Fenberg *et al.*, 2012). Most European marine reserves are small and 92% of them have areas smaller than 50 Km2; for example, in the Mediterranean Sea, MPAs are in average 4 Km2 (Halpern, 2003). MPA ideal size is not consensual and it has been suggested that size is less critical than other specific factors for the protection of the populations. For habitat forming organisms and bio-constructors, even small MPAs can have an effect in the protection of the physical structures and ecological functions of such habitats, like reproduction of fish and invertebrates (Halpern, 2003). The increase in dimension and density, biomass, and species diversity inside a MPA is also registered both European and world wide, reconnecting trophic networks at a community level (Fenberg *et al.*, 2012; Francour *et al.*, 2001; Shears and Babcock, 2002). However, these results are strongly dependent of the elapsed time since the creation of the MPA, its effective management (Claudet *et al.*, 2008), the area design, and the ecology of the protected species (Fenberg *et al.*, 2012). MPAs can be effective management tools at a local scale, especially when located at a tidal area with a wide range of micro habitats. The identification of these specific habitat and its protection regime, is an approach that could increase the proportion of protected species (Banks and Skilleter, 2002; Francour *et al.*, 2001). At a global scale a MPA could only be effective if: it is representative of the biogeographical area; works as a network and 20% of the total area is a “no fishing” area (Boersma and

Parrish, 1999). In the Mediterranean region, the creation of a MPA based on little or null scientific information and with scarce interaction with local agents and their needs is still the rule (Fraschetti *et al.*, 2005; Guidetti *et al.*, 2008). As a consequence, the local population looks at marine conservation as an obstacle to economic development, leading to a non-compliance of the established regulations of the MPA (Frachetti *et al.*, 2009).

The rocky shore area of Avencas, located in the Cascais council, near Lisbon, on the Atlantic western Coast of Portugal, was classified as Biophysical Interest Zone (ZIBA) in 1998, in the scope of the Coastal Zone Management Plan Cidadela – São Julião da Barra (POOC Cidadela - São Julião da Barra, 1998) due to its exceptional intertidal biodiversity. This protection status became controversial, leading to conflicts with the local population and incompliance with extant regulations. From 2010, efforts were carried out by local authorities to reclassify Avencas as Marine Protected Area, to be managed by the Environmental Municipal Company of Cascais, which was achieved in 2016 (POOC Cidadela - São Julião da Barra, 2016). Along with the public participation sessions conducted to gather proposals for the new regulations, several environmental awareness activities were carried out close to the scholar community and the visitors. Guided tours, information points, visitation pathways and communication campaigns improved the knowledge about the environmental importance of the ZIBA and contributed to a greater compliance with the regulation, particularly by the fishing community (Ferreira *et al.*, 2015). In this particular case, monthly biological surveying by municipal technicians is vital, not only to check for any changes in the intertidal communities but also to keep a close contact with beach users.

Marine Protected Areas tend to maintain ecosystems equilibrium when their protection regime promotes both species richness and density, the eradication of pollution sources, and reduces human pressure (Worachananant *et al.*, 2007), for instance increasing their resilience in relation to the impacts of ocean storms. The opportunity to test such assumptions, occurred during the study period; from 5 to 7 of January 2014, the Portuguese shores were heavily impacted by the storm named as "Hercules", which triggered strong sea waves with long periods, run-ups between 6–9 m, and inundation depths mostly under 1 m, corresponding to a classification of meteorological tsunami (Santos *et al.*, 2014). Damages included the destruction of coastal protection structures, roads, and sand dunes.

The present work had two main objectives: i) evaluate if the biodiversity in the ZIBA area responded positively to a greater compliance with the regulations observed since 2012; and ii) compare the development of the intertidal communities following the storm Hercules inside and outside the ZIBA area to assess possible differences in recovery rates.

MATERIALS AND METHODS

Study area

The ZIBA area, located on the west of Portugal, in the Cascais municipality, near Lisbon, covers an area of 605 002 m2 (Fig. 1), of which 111 232 m^2 are intertidal, including terrestrial and marine biotopes up to 15 m deep. The following limitations to human activities were implemented in the ZIBA area: no aquaculture activities, no water motor sports, no fishing or spearfishing, and no collection of animals of any kind, except for scientific studies duly authorized (POOC Cidadela - S. Julião da Barra, 1998). The ZIBA area is characterized by extended calcareous rocky platforms, which constitute large surfaces of irregular shape due to its nodular structure, clearly visible along several hundred meters during low tide. Such surfaces, essentially due to its irregularity, enable the existence of a distinctive intertidal habitat in the area. Maritime agitation is highly energetic and has unique characteristics close to Cascais, due to its location close to the mouth of the Tagus estuary (Fig. 1) and consequent exposition to strong tidal movements.

It was recorded a positive behavior change of ZIBAs users in the summer of 2013, after the implementation of the management measures in the Summer of 2012 (placement of information spots, creation of rope pathways to order the visitors and public participations assemblies to inform and involve the public). There were also significant differences regarding the behavior of the sports fishing community, increasing the compliance with the existing regulation (Ferreira *et al.*, 2015).

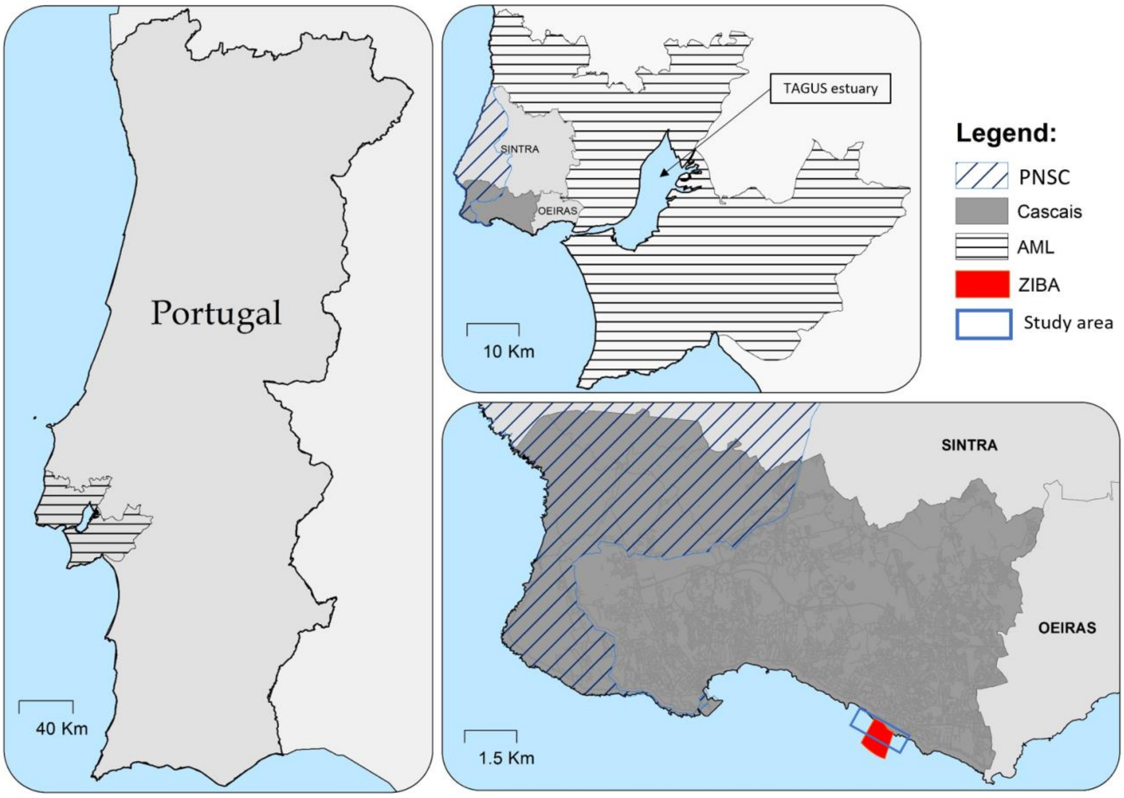


Fig. 1. Location of the study area, including the Biophysical Interest Zone of Avencas (ZIBA) and its position within the Lisbon's Metropolitan area (AML). The Sintra-Cascais National Natural Park (PNSC) is also displayed.

The field study was carried out between January 2013 and December 2015, samples being collected monthly in intertidal shores. Four sampling sections were considered: two inside the Biophysical Interest Zone of Avencas (B and D) and two outside (A and E) (Fig. 2), which were stratified in supratidal and middle-intertidal zones. The four sampling sections have similar biophysical conditions, differing only in the protection status (Faria and Ferreira, 2013) At each sampling point, 10 m long transects were considered, scanning areas of 1 m^2 on each side of the transect to estimate the population density of mobile species. Regarding the sessile species (flora and fauna), the coverage percentage of the different species was assessed through the observation of quadrats with 2500 cm^2 divided in 1 cm^2 subsets (Table 1).

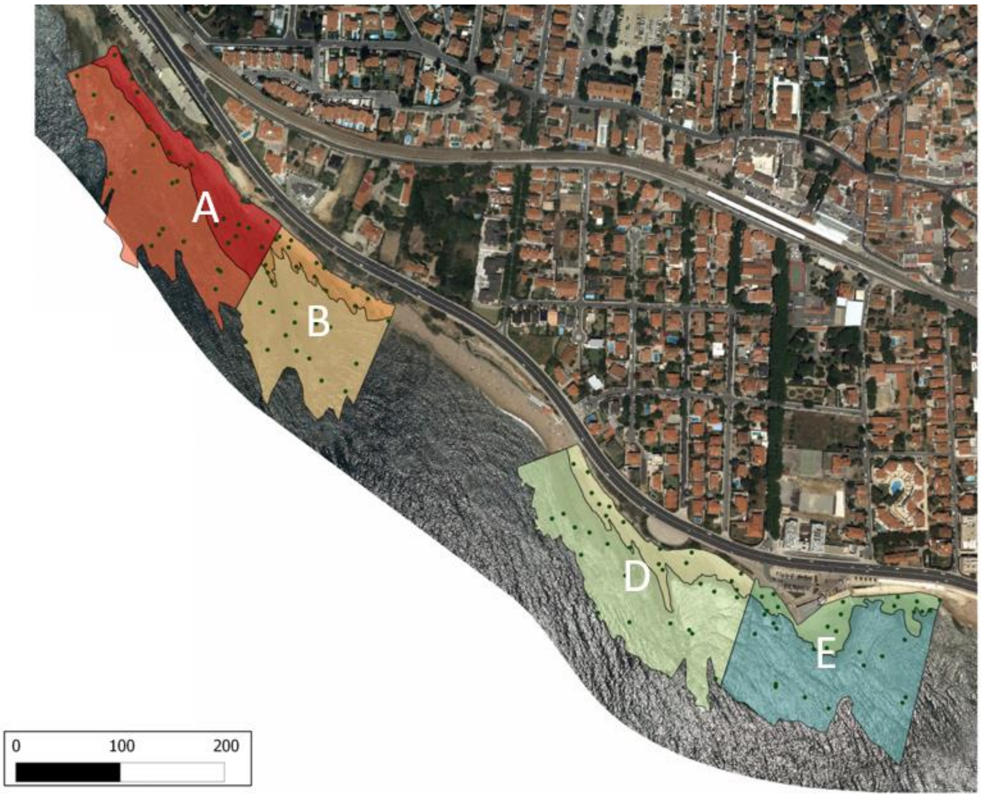


Fig. 2. Sampling design in the study area: Four sampling sections (A, B, D, E), which were stratified in supratidal and middle-intertidal areas. Sections B and D were located inside the ZIBA, while sections A and E were located outside the ZIBA.

Animals were identified to the species level whenever possible, or at least to the family level, while regarding the flora species were classified to the phylum level (rhodophyta, chlorophyta, phaeophyta) or as lichen. Areas defined as supratidal zones of each sampling section (A, B, C and D) are considerably smaller than the areas defined for the middle-intertidal zones. Therefore, a 3000 m^2 and 6000 m^2 quotient was used respectively for the supratidal and middle-intertidal zones, in order to define the number of replicates observed monthly in each section (Table 1).

Table 1. Number of 2500 cm2 squares monthly observed (replicates) at each sampling section, which varied proportionally as a function of the supratidal and middle-intertidal areas in each of the sampling sections.

Zone	Area (m^2)	N.º of Squares	N.º of Transepts
Supratidal			
A	10 327	3	3
B	4 012	1	1
D	6 500	2	2

	E	5 500	2	2
[redacted]				
	A	21 843	4	4
	B	17 700	3	3
	D	20 000	3	3
	E	25 350	4	4

Data analysis

The supratidal and middle-intertidal zones were analyzed separately since sampling had been previously stratified as a function of clear differences in species composition and populations density at each zone. In each sampling section, the average density was estimated (individuals per m^2) of the intertidal community mobile faunal species and sessile fauna and flora species in winter (Jan, Feb, Mar), spring (Apr, May, Jun), summer (Jul, Aug, Sep), and autumn (Oct, Nov, Dec) situations. A tentative graphical analysis was carried out to assess trends emerging from data preliminary analysis. Densities of sessile species were calculated through the methodology described by Deepananda and Macusi (2012), which allows the transformation of percentages of coverage in density values for each species. The Shannon-Wienner (H') (Shannon, 1948) and the Pielou (J') (Pielou, 1966) indices were equally calculated to evaluate changes in community's diversity along the study period.

In order to test the hypothesis that the community density changes spatially (between sampling sections) and seasonally, a three–way PERMANOVA analysis (Anderson *et al.*, 2008) was carried out with the following crossed factor design: "season", "year" and "area" as fixed factors, with respectively: four (winter, spring, summer and autumn), three (2013, 2014 and 2015) and two levels (outside and inside the ZIBA). Density data were square root transformed to decrease scale differences between the weights of the most and the less abundant species in the analysis. The PERMANOVA test was applied to the matrix obtained using the Bray-Curtis similarity coefficient, which includes a virtual dummy variable being 1 for all objects (Clarke *et al.*, 2006).

Furthermore, a three-way PERMANOVA was applied to test the null hypotheses that no significant spatial (between sampling sections) and temporal (between years and seasons) differences existed regarding values the diversity indices (H' and J) estimated. PERMANOVA was used as an alternative to ANOVA since its assumptions were not met, even after data transformation. All PERMANOVA tests were conducted on Euclidean-distance similarity matrices and the residuals were permutated under a reduced model (9999 permutations). The null hypothesis was rejected when the significance level p was<0.05 (if the number of permutation was lower than 150, the Monte Carlo permutation p was used). Whenever significant differences were detected, these were examined using a posteriori pairwise comparisons, using 9999 permutations under a reduced model (Clarke and Green, 1988; Clarke and Warwick, 2001).

RESULTS

When analyzing the different species densities inside and outside the protected area, the graphical analysis of data from the supratidal zone (Fig. 3) does not show a homogeneous pattern. Nevertheless, PERMANOVA results show a significant increase in the average density of mobile fauna species and flora outside the protected area (Table 2). Additionally, mobile fauna species display significant (PERMANOVA − see Tables 2 and 3) inter-seasonal fluctuations (Fig. 3–E and F), exhibiting higher densities in summer and lower densities in winter, a pattern usually found in intertidal communities, but inter-annual differences were not significant. Similar results were obtained with regard to the sessile faunal species (Table 2).

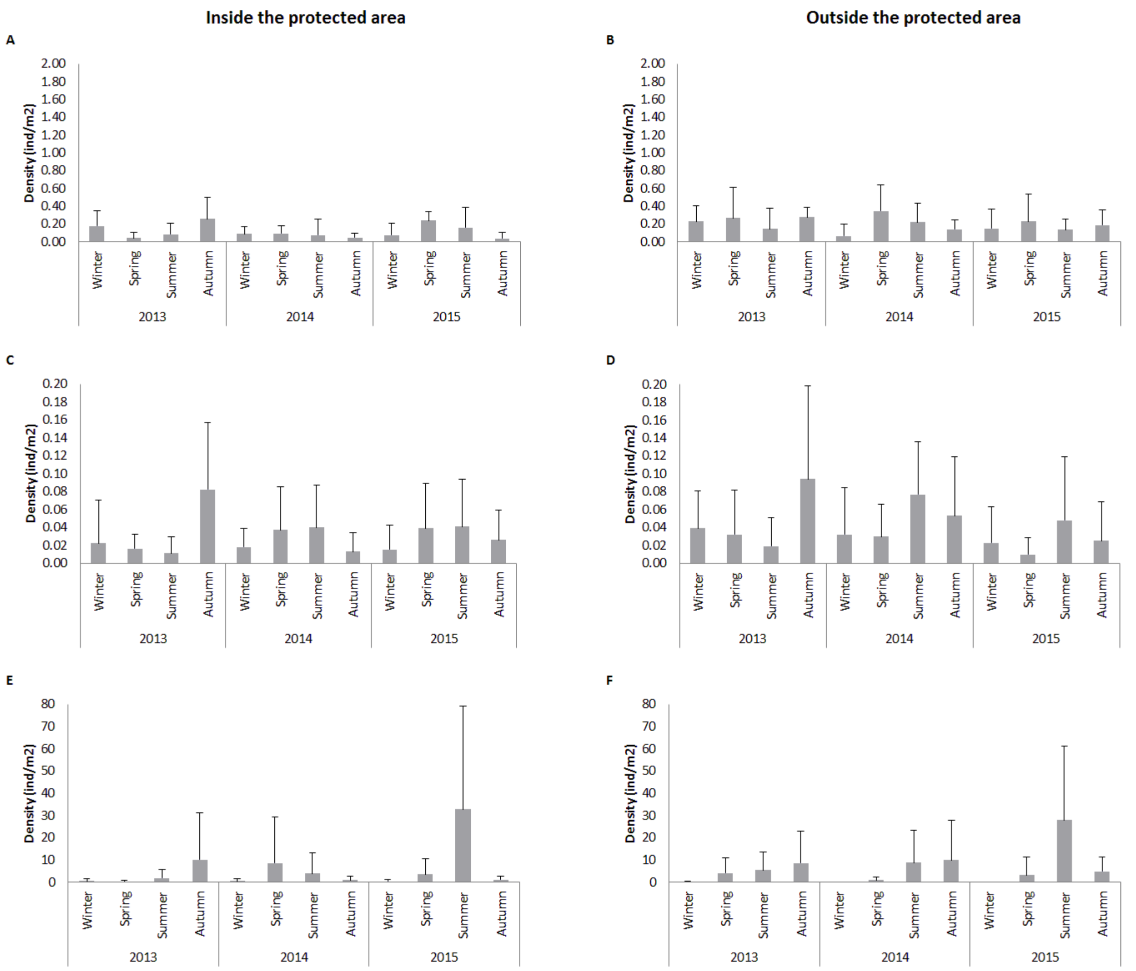


Fig. 3. Average species' densities ± standard deviation (individuals/m^2) at the supratidal zone, both inside and outside the protected area; A and B – Flora; C and D – Sessile faunal species; E and F – Mobile faunal species.

Graphical analysis of data from the middle-intertidal zone shows an increased flora density in 2014, when the Hercules storm occurred, followed by a decrease in 2015 (Fig. 4–A and B). On the contrary, sessile fauna species exhibited higher values in 2015 (Fig. 4–C and D). Regarding flora, PERMANOVA (Tables 2 and 3) results confirmed the occurrence of significant inter-annual differences, as suggested by the graphical analysis, but no significant inter-annual differences were recorded with regard to sessile faunal species (Table 2). Mobile fauna exhibited differences inside and outside of the protected area in 2013 and 2015 (Tables 2 and 3). Densities were higher inside the protected area in 2013, but just the contrary was observed in 2015 (Fig. 4–E and F).

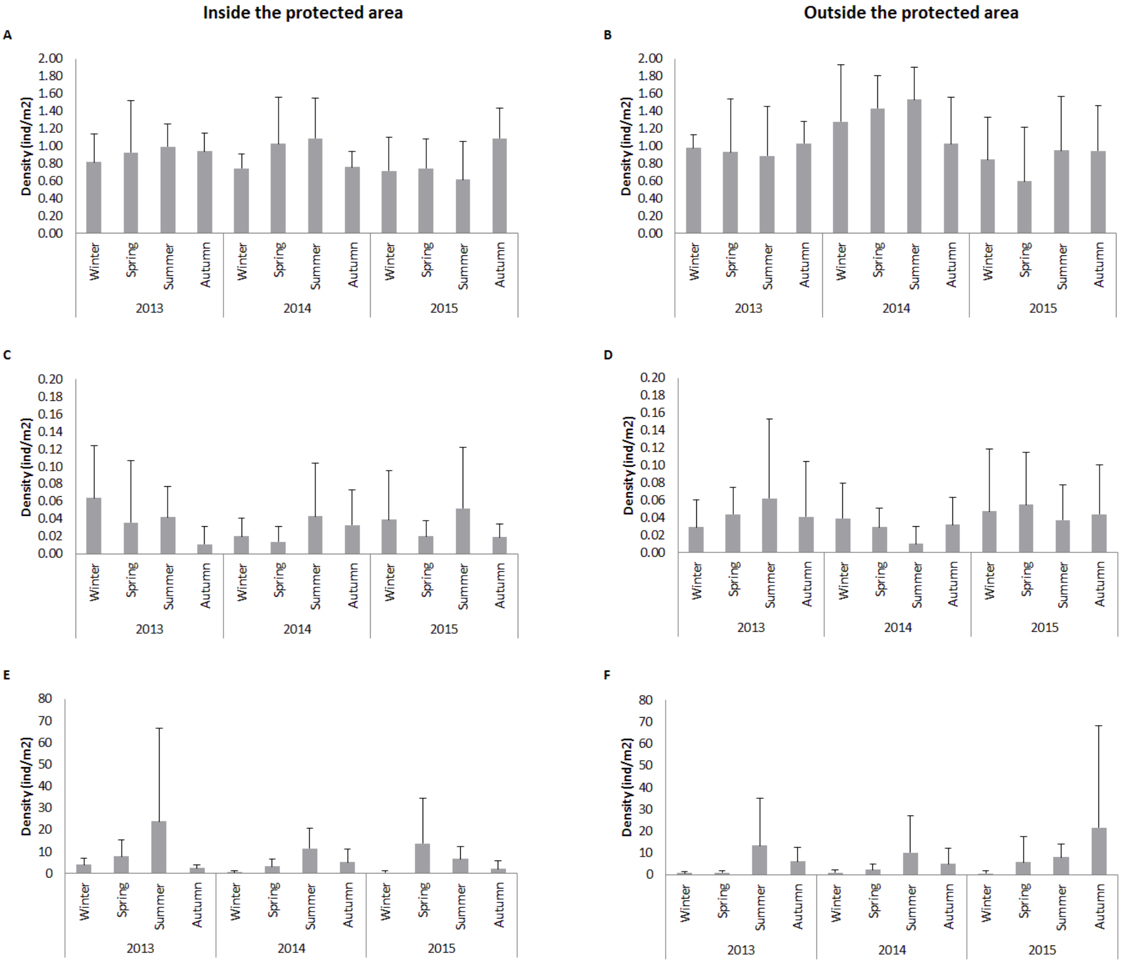


Fig. 4. Average species' densities ± standard deviation (individuals/m^2) at the middle-intertidal zone, both inside and outside the protected area; A and B – Flora; C and D – Sessile faunal species; E and F – Mobile faunal species.

Diversity and evenness measures (H' and J) estimated for supratidal communities exhibited significant seasonal variations (PERMANOVA analysis (Tables 2 and 3), except for sessile fauna, with this last observation not being consistent with natural patterns usually observed in the intertidal communities. Besides, mobile fauna also showed higher values of H' and J outside the protected area (Tables 2 and 3). Regarding middle-intertidal communities, seasonal variations were also relatively uncharacteristic (PERMANOVA- Tables 2 and 3), but in this case sessile fauna presented higher diversity and evenness inside the protected area (Tables 2 and 3).

Table 2. Details of the three-factor PERMANOVA test ("year" with 3 levels, "season" with 4 levels and "area" with 2 levels, as fixed factors) for all variables analyzed. Bold values stand for significant differences ($p < 0.05$).

	Source of variation	Degree of Freedom	Sum of Squares	Mean Squares	Pseudo-F	P (perm)
Flora supratidal						
Average density	Year	2	444.64	222.32	0.46755	0.7897
	Season	3	1144.3	381.42	0.80216	0.5821
	Area	1	1443.5	1443.5	3.0357	**0.046**
	Year x Season	6	4977.9	829.65	1.7448	0.0538
	Year x Area	2	257.5	128.75	0.27077	0.9132
	Season x Area	3	2333.5	777.85	1.6359	0.1247
	Year x Season x Area	6	2090.2	348.37	0.73264	0.7309
	Residual	114	54206	475.5		
	Total	137	66773			
J	Year	2	0.19247	9.6234E-2	0.68391	0.5057
	Season	3	7.3425	2.4475	17.394	**0.0001**
	Area	1	7.5189E-2	7.5189E-2	0.53434	0.4728
	Year x Season	6	1.0802	0.18004	1.2795	0.2711
	Year x Area	2	0.26111	0.13055	0.92781	0.4047
	Season x Area	3	5.9477E-2	1.9826E-2	0.14089	0.9316
	Year x Season x Area	6	0.37577	6.2628E-2	0.44508	0.8409
	Residual	114	16.041	0.14071		
	Total	137	25.321			
H’	Year	2	2.3036E-2	1.1518E-2	0.14323	0.8704
	Season	3	3.6603	1.2201	15.172	**0.0001**
	Area	1	4.8201E-2	4.8201E-2	0.59939	0.446
	Year x Season	6	0.49303	8.2172E-2	1.0218	0.4211
	Year x Area	2	0.13548	6.7738E-2	0.84234	0.428
	Season x Area	3	7.7939E-2	2.598E-2	0.32307	0.8039
	Year x Season x Area	6	0.26032	4.3387E-2	0.53953	0.7797
	Residual	114	9.1675	8.0416E-2		
	Total	137	13.808			
Flora - middle-intertidal						
Average density	Year	2	2193.8	1096.9	3.9818	**0.001**
	Season	3	4259.8	1419.9	5.1545	**0.0001**
	Area	1	354.94	354.94	1.2885	0.2887
	Year x Season	6	1492.6	248.77	0.90307	0.5671
	Year x Area	2	510.32	255.16	0.92625	0.4761
	Season x Area	3	164.41	54.803	0.19894	0.9804
	Year x Season x Area	6	737.29	122.88	0.44607	0.9618
	Residual	114	31404	275.48		
	Total	137	40972			
J	Year	2	0.19247	9.6234E-2	0.68391	0.5013
	Season	3	7.3425	2.4475	17.394	0.0001
	Area	1	7.5189E-2	7.5189E-2	0.53434	0.4696
	Year x Season	6	1.0802	0.18004	1.2795	0.2732
	Year x Area	2	0.26111	0.13055	0.92781	0.3963
	Season x Area	3	5.9477E-2	1.9826E-2	0.14089	0.9371
	Year x Season x Area	6	0.37577	6.2628E-2	0.44508	0.8421
	Residual	114	16.041	0.14071		
	Total	137	25.321			
H’	Year	2	2.3036E-2	1.1518E-2	0.14323	0.8694
	Season	3	3.6603	1.2201	15.172	**0.0001**
	Area	1	4.8201E-2	4.8201E-2	0.59939	0.4444
	Year x Season	6	0.49303	8.2172E-2	1.0218	0.4175
	Year x Area	2	0.13548	6.7738E-2	0.84234	0.432

	Season x Area	3	7.7939E-2	2.598E-2	0.32307	0.8087
	Year x Season x Area	6	0.26032	4.3387E-2	0.53953	0.7712
	Residual	114	9.1675	8.0416E-2		
	Total	137	13.808			

Sessile Fauna supratidal

Average density	Year	2	1239.9	619.93	0.87139	0.4485
	Season	3	2242.2	747.41	1.0506	0.3808
	Area	1	222.69	222.69	0.31302	0.7677
	Year x Season	6	6226.8	1037.8	1.4588	0.1524
	Year x Area	2	1474.4	737.21	1.0362	0.365
	Season x Area	3	723.56	241.19	0.33902	0.9234
	Year x Season x Area	6	2245.7	374.29	0.52612	0.8872
	Residual	114	81102	711.42		
	Total	137	95463			
J	Year	2	4.626E-2	2.313E-2	0.34874	0.7145
	Season	3	0.13152	4.3841E-2	0.661	0.5867
	Area	1	6.652E-3	6.652E-3	0.10029	0.7542
	Year x Season	6	0.43491	7.2486E-2	1.0929	0.3751
	Year x Area	2	0.14261	7.1307E-2	1.0751	0.3533
	Season x Area	3	0.10287	3.4289E-2	0.51698	0.6755
	Year x Season x Area	6	0.67097	0.11183	1.686	0.1318
	Residual	114	7.5611	6.6325E-2		
	Total	137	9.106			
H’	Year	2	2.2226E-2	1.1113E-2	0.34874	0.7104
	Season	3	6.3191E-2	2.1064E-2	0.661	0.5819
	Area	1	3.196E-3	3.196E-3	0.10029	0.7521
	Year x Season	6	0.20896	3.4826E-2	1.0929	0.368
	Year x Area	2	6.8519E-2	3.426E-2	1.0751	0.3498
	Season x Area	3	4.9423E-2	1.6474E-2	0.51698	0.6758
	Year x Season x Area	6	0.32237	5.3728E-2	1.686	0.1299
	Residual	114	3.6328	3.1866E-2		
	Total	137	4.375			

Sessile Fauna - middle-intertidal

Average density	Year	2	2844.9	1422.5	1.7295	0.1192
	Season	3	2322.2	774.07	0.94115	0.4618
	Area	1	1042.6	1042.6	1.2677	0.2526
	Year x Season	6	5300	883.34	1.074	0.3555
	Year x Area	2	1331.4	665.68	0.80936	0.526
	Season x Area	3	1819.5	606.49	0.7374	0.6418
	Year x Season x Area	6	2665.7	444.29	0.54018	0.9346
	Residual	114	93762	822.47		
	Total	137	1.1127E5			
J	Year	2	0.29229	0.14615	1.667	0.193
	Season	3	0.66146	0.22049	2.5149	0.0604
	Area	1	0.56834	0.56834	6.4826	**0.014**
	Year x Season	6	0.75584	0.12597	1.4369	0.2114
	Year x Area	2	0.16932	8.4659E-2	0.96564	0.3815
	Season x Area	3	0.21761	7.2536E-2	0.82736	0.4812
	Year x Season x Area	6	1.0379	0.17298	1.9731	0.0749
	Residual	114	9.9946	8.7672E-2		
	Total	137	13.649			
H’	Year	2	0.24686	0.12343	2.339	0.098
	Season	3	0.48452	0.16151	3.0606	**0.0287**
	Area	1	0.24232	0.24232	4.5921	**0.035**
	Year x Season	6	0.60819	0.10136	1.9209	0.0836

	Year x Area	2	6.0452E-2	3.0226E-2	0.57279	0.5735
	Season x Area	3	8.2672E-2	2.7557E-2	0.52222	0.671
	Year x Season x Area	6	0.53773	8.9621E-2	1.6983	0.1289
	Residual	114	6.0157	5.277E-2		
	Total	137	8.2664			

Mobile Fauna supratidal

Average density	Year	2	2139.6	1069.8	0.58568	0.6932
	Season	3	26204	8734.6	4.782	**0.0007**
	Area	1	6174.4	6174.4	3.3803	**0.0336**
	Year x Season	6	7016.5	1169.4	0.64022	0.8284
	Year x Area	2	1557.6	778.81	0.42638	0.8302
	Season x Area	3	7408.9	2469.6	1.3521	0.2217
	Year x Season x Area	6	5441.8	906.97	0.49654	0.9383
	Residual	114	2.0823E5	1826.6		
	Total	137	2.6513E5			
J	Year	2	0.36317	0.18159	2.0826	0.1268
	Season	3	0.86588	0.28863	3.3102	**0.0226**
	Area	1	0.50844	0.50844	5.8311	**0.0168**
	Year x Season	6	0.55828	9.3046E-2	1.0671	0.3856
	Year x Area	2	0.28812	0.14406	1.6522	0.1971
	Season x Area	3	0.51521	0.17174	1.9696	0.1229
	Year x Season x Area	6	0.34899	5.8165E-2	0.66708	0.6795
	Residual	114	9.9401	8.7194E-2		
	Total	137	13.357			
H’	Year	2	0.30741	0.1537	2.4903	0.0888
	Season	3	0.63219	0.21073	3.4142	**0.0195**
	Area	1	0.26011	0.26011	4.2142	**0.0421**
	Year x Season	6	0.41576	6.9293E-2	1.1227	0.3592
	Year x Area	2	0.22892	0.11446	1.8545	0.1605
	Season x Area	3	0.34969	0.11656	1.8885	0.136
	Year x Season x Area	6	0.19717	3.2861E-2	0.5324	0.7876
	Residual	114	7.0363	6.1722E-2		
	Total	137	9.3816			

Mobile Fauna - middle-intertidal

	Season	3	37021	12340	5.3592	**0.0001**
	Area	1	2148.3	2148.3	0.93295	0.4425
	Year x Season	6	16463	2743.8	1.1916	0.2314
	Year x Area	2	11392	5696	2.4737	**0.0103**
	Season x Area	3	8403.4	2801.1	1.2165	0.2505
	Year x Season x Area	6	7031.9	1172	0.50896	0.9853
	Residual	114	2.6251E5	2302.7		
	Total	137	3.5348E5			
J	Year	2	0.54787	0.27394	1.628	0.2007
	Season	3	2.0435	0.68117	4.0483	**0.0101**
	Area	1	1.2519E-2	1.2519E-2	7.4402E-2	0.7896
	Year x Season	6	0.45221	7.5369E-2	0.44793	0.8408
	Year x Area	2	0.294	0.147	0.87364	0.4222
	Season x Area	3	0.81655	0.27218	1.6176	0.1932
	Year x Season x Area	6	0.94874	0.15812	0.93975	0.4596
	Residual	114	19.182	0.16826		
	Total	137	24.351			
H’	Year	2	0.12385	6.1926E-2	0.40892	0.6627
	Season	3	2.1544	0.71812	4.7421	**0.0036**
	Area	1	5.7177E-4	5.7177E-4	3.7757E-3	0.9514
	Year x Season	6	0.44384	7.3973E-2	0.48848	0.8145
	Year x Area	2	7.5959E-2	3.798E-2	0.2508	0.7784

Season x Area	3	0.81442	0.27147	1.7927	0.1544
Year x Season x Area	6	0.76058	0.12676	0.83708	0.5495
Residual	114	17.264	0.15144		
Total	137	21.656			

Table 3. Details of the pairwise t-tests subsequently applied to PERMANOVA tests showing significant differences. Bold values stand for the significant differences (p < 0.05).

	Groups	t	P (perm)
Flora supratidal			
Average density (area)	In. Out	1.7423	**0.0467**
J (season)	winter. spring	4.9414	**0.0001**
	winter. summer	4.7018	**0.0001**
	winter. autumn	0.2899	0.7739
	spring. summer	0.121	0.9028
	spring. autumn	5.5308	**0.0001**
	summer. autumn	5.2615	**0.0001**
H' (season)	winter. spring	4.3151	**0.0002**
	winter. summer	4.0291	**0.0003**
	winter. autumn	0.5951	0.5576
	spring. summer	0.49525	0.6157
	spring. autumn	5.4944	**0.0001**
	summer. autumn	5.2615	**0.0001**
Flora - middle-intertidal			
Average density (year)	2013. 2014	0.87238	0.5202
	2013. 2015	2.0352	**0.0099**
	2014. 2015	2.5122	**0.0005**
(season)	winter. spring	2.6112	0.0005
	winter. summer	2.4698	0.0009
	winter. autumn	0.68292	0.6871
	spring. summer	0.91588	0.4744
	spring. autumn	3.0606	**0.0001**
	summer. autumn	2.7152	**0.0008**
J (season)	winter. spring	4.9414	**0.0001**
	winter. summer	4.7018	**0.0002**
	winter. autumn	0.28996	0.7745
	spring. summer	0.121	0.9029
	spring. autumn	5.5308	**0.0001**
	summer. autumn	5.2615	**0.0001**
H' (season)	winter. spring	4.3151	**0.0002**
	winter. summer	4.0291	**0.0002**
	winter. autumn	0.5951	0.5582
	spring. summer	0.49525	0.6166
	spring. autumn	5.4944	**0.0001**
	summer. autumn	5.2615	**0.0001**
Sessile Fauna - middle-intertidal			
J (area)	In. Out	2.5461	**0.0121**
H' (area)	In. Out	2.1429	**0.0362**
(season)	winter. spring	1.3863	0.1714
	winter. summer	0.89792	0.3875
	winter. autumn	1.8273	0.0738
	spring. summer	2.1163	**0.0392**
	spring. autumn	0.50428	0.6279

	summer. autumn	2.4243	**0.0197**

Mobile Fauna - supratidal

Average density (area)	In. Out	1.8386	**0.0379**
(season)	winter. spring	1.6635	0.0649
	winter. summer	3.3275	**0.0003**
	winter. autumn	3.2481	**0.0001**
	spring. summer	1.8061	0.0534
	spring. autumn	1.798	**0.0389**
	summer. autumn	0.80048	0.5469
J (area)	In. Out	2.4148	**0.0171**
(season)	winter. spring	1.6626	0.1003
	winter. summer	2.6558	**0.008**
	winter. autumn	3.0551	**0.0032**
	spring. summer	0.89283	0.3762
	spring. autumn	1.4835	0.137
	summer. autumn	0.67667	0.4986
H' (area)	In. Out	2.0528	**0.0389**
(season)	winter. spring	1.7329	0.087
	winter. summer	2.7206	**0.0078**
	winter. autumn	3.0303	**0.0034**
	spring. summer	0.72185	0.4857
	spring. autumn	1.5127	0.1364
	summer. autumn	0.95161	0.3422

Mobile Fauna - middle-intertidal

Average density (season)	winter. spring	2.0407	**0.0031**
	winter. summer	3.8953	**0.0001**
	winter. autumn	1.9634	**0.0065**
	spring. summer	2.3077	**0.0005**
	spring. autumn	1.199	0.2042
	summer. autumn	1.8607	**0.0142**
(year x area) - year	In (2013. 2014)	1.7021	**0.0201**
	In (2013. 2015)	2.0551	**0.0022**
	In (2014. 2015)	0.87322	0.5462
	Out (2013. 2014)	0.9274	0.4928
	Out (2013. 2015)	1.5311	**0.0470**
	Out (2014. 2015)	1.2500	0.1657
(year x area) - area	2013 (In. Out)	1.5959	**0.0274**
	2014 (In. Out)	1.032	0.3508
	2015 (In. Out)	1.5165	0.0511
J (season)	winter. spring	1.6256	0.1095
	winter. summer	3.4923	**0.0014**
	winter. autumn	1.3975	0.1697
	spring. summer	1.9077	0.0652
	spring. autumn	0.17247	0.8613
	summer. autumn	2.0125	**0.0469**
H' (season)	winter. spring	2.0628	**0.0451**
	winter. summer	3.8931	**0.0003**
	winter. autumn	2.0002	0.0532
	spring. summer	1.8812	0.0632
	spring. autumn	3.3398E-2	0.9736
	summer. autumn	1.7714	0.0809

DISCUSSION

The comparative analysis of intertidal communities in Marine Protected Areas and in adjacent non protected areas is an effective and cost-efficient procedure to access the effects of the applied protection constrains (Fraschetti *et al.*, 2002). Long term surveys enable this comparative analysis, aiming at the effective management of protected areas; however this type of survey is only possible when there is availability of funding and human resources.

In this case-study, it was expected a positive variation in the intertidal communities diversity and evenness within the ZIBA, between 2013 and 2015, responding positively (increasing density and diversity) to a decrease in anthropogenic pressures, as a result of a greater obedience from different ZIBA users with respect to protected area regulations since 2013 (Ferreira *et al.*, 2015). However, this expectation was only observed with regard to sessile fauna in the middle-intertidal zone, which was not consistent with the outcomes from other comparable studies (Halpern, 2003). Additionally, the seasonal variation of H' and J values has not revealed any consistent pattern regarding a positive response of the communities inside the protected area.

Regarding mobile fauna, densities were higher within the protected in 2013, while the contrary was recorded in 2015. Again, results were not consistent with the hypothesis that a greater recovery capability would be observed inside the protected area (Halpern, 2003).

It is known that heterogeneous spatial distributions of species in intertidal communities greatly depend on physical factors such as wave exposure, shores slope, and substrate complexity, along with competition, predation and herbivory (Benedetti-Cecchi *et al.*, 2003). Although it can be argued that such physical factors could have locally concealed the response of biological communities inside and outside the protected area, that is difficult to demonstrate since their influence and interactions are difficult to measure and may originate scale dependent differences (e.g. cm or Km) (Zamprogno *et al.*, 2012).

Another possible explanation for the results may lie in the design of this protected area, and actually comparable results were obtained by Fraschetti *et al.* (2005) for protected areas in the Mediterranean. The ZIBA is a very small protected area, and thus some of the most relevant habitats occurring inside ZIBA are also found immediately outside of it. Of course, in both zones they can provide refuge and nursery spaces to many of the species living in this rocky shore. Since species do not acknowledge borders, due to its small size the “edge effect” between protected vs. unprotected areas may extend to the entire study area. This might have promoted a failure in creating a true differentiated zone inside the ZIBA as a result of its openness and consequent high exchanges in energy, mater, and immigration of species through its borders (Jørgensen *et al.*, 2000; Patrício *et al.*, 2006). This reinforces the notion that adequate size constitutes a key feature that must be taken into consideration when designing a Marine Protected Area (Fraschetti *et al.*, 2005). To optimize their size, the design of Marine Protected Areas should always include a considerable effort to inform the public and promote public participation in the decision-making process, considering the human presence and its activities as an integral part of the system (Fraschetti *et al.*, 2002; Fraschetti *et al.*, 2009; Ferreira *et al.*, 2015).

Results from this study were affected by the Hercules ocean storm, which caused an immense impact on the biological communities in the study area, and requires a closer attention. For instance, the algal coverage suffered a drastic change from 2014 to 2015, while an increase of sessile fauna was observed in 2015 (although insufficient to be considered significant by PERMANOVA). A possible explanation is that the strong rarefaction of the rocky shore communities, as a consequence of physical disturbances caused by Hercules, led to a typical succession pattern of rapid colonization by the algal species (Benedetti-Cecchi and Cinelli, 1996). This resembles, up to a certain extent, to a re-colonization field experiment. For instance, Patrício *et al.* (2006), also on the Western Coast of Portugal, found that small areas (625 cm^2) artificially disturbed totally recovered in just 6 months; additionally the experiment also illustrated that the presence of algal structures increased the surface availability and complexity of the substrate. The same result was obtained for the habitat forming blue mussel, barnacles or limpets (Kim and DeWreede, 1996; Koivisto and Westerbom, 2010; Thompson *et al.*, 2002;). Evidently, in the current case, disturbance caused by Hercules distressed a very large area. Early algae colonizers (usually green algae) may have attracted herbivore species, whose pressure may have led to the subsequent decrease of the algal coverage (Benedetti-Cecchi and Cinelli, 1996). Rocky shore intertidal communities can exist in a number of apparently stable states, which may persist for periods (e.g. 7–13 years), greatly exceeding the turnover time of the resident populations (Dye, 1998). However, post disturbance equilibria may be fragile, and distressed communities may remain unstable for long periods (Dye, 1998).

Results suggest that longer data series are necessary to obtain a more robust dataset regarding natural variability, since alterations caused by extreme events are always likely to occur, and additionally illustrate that indeed MPAs size matters because it influences openness, expressed as the ratio of periphery to area (Jørgensen *et al.*, 2000; Patrício *et al.*, 2006), and therefore its susceptibility to external driving forces. The ideal monitoring programme should enable the monthly survey of the intertidal rocky shore, with two senior observers, for a minimum period of 10 years. This monitoring programme is only achievable if the entity responsible for the management of the Marine Protected Area establishes this survey as an essential activity for the objectives of the MPA, allocating internal human resources and funding for this purpose. Regarding the ZIBA, there is a deficit of information for the period before its classification as MPA, and such considerations must be taken into account in any management plan, which in this case should encompass an increase in the intertidal protected area, a new conditioned small-scale fishing regime (passing from a "no-take regime" to a conditioned fishing regime is challenging and innovative), and an adequate monitoring programme to evaluate the effectiveness of the new management scheme.

General Discussion

GENERAL DISCUSSION

The Biophysical Interest Zone of Avencas was reclassified as Marine Protected Area in 2016 (POOC, 2016), after a process that took 7 years to be completed, involving several changes made to the regulations. The current main goal of this MPA is the conservation and valorization of its natural values and its biodiversity, needed for a sustainable development, particularly the conservation and valorization of the intertidal rocky-shore habitat and the promotion of outreach activities that seek the development of a strait relation between citizens and the environment (POOC, 2016)

This thesis intends to analyze the reclassification process of the Biophysical Interest Zone of Avencas to a Marine Protected Area, applying a holistic approach that aims to integrate the coastal zone management at a local perspective.

Marine management requires approaches that allow bringing together the best research from the natural and social sciences (Borja *et al.*, 2017), and therefore several different perspectives were analyzed:

Bottom-up management approach to coastal Marine Protected Areas in Portugal

In an early stage, the response from different stakeholders to management actions implemented in the area were analyzed, aiming at a) evaluating, from a social perspective, the new bottom-up management approach undertaken by the Municipality and b) measuring the success of this approach in a short-term scale.

In 2012 several efforts were made from Cascais Municipality in order to enhance the conservation of the Avencas Biophysical Interest Zone (ZIBA) from a bottom-up management perspective. These efforts resulted in a new media impact that revived public opinion and led to a new cycle of this existing protected area.

This outreach effort resulted in positive changes regarding the compliance with regulations from the fishing community, while the anthropogenic pressure in this protected area didn't increase once the number of visitors remained the same (Chapter 1).

With the accomplishment of public participation meetings, the co-management process was initiated. This process, however, takes a long time to be implemented and there are still few successful cases of this type of management approach (Martins *et al.*, 2011; Gelcich *et al.*, 2005). It seems that there isn't a perfect formula to be applied while managing Marine Protected Areas. It requires stakeholders to be well-informed by science and to work across administrative and geographical boundaries, a feature especially important in the inter-connected marine environment (Borja *et al.*, 2017).

This objective can be achieved by a) effective communication of rules and regulations (e.g. boundaries), b) extensive programs of environmental education and outreach, c) participatory processes of creation and management structures, d) acknowledge the relevance of all stakeholders, e) coordination with other management institutions, f) integration of scientific and traditional knowledge and mechanisms of conflict resolution and ensuring transparency and accountability (Bennett and Dearden, 2014b).

The strategy of increasing the availability of information and attempting to establish an orderly visitation of the intertidal platform had a positive effect on visitors (Chapter 1). The participation of the community in the early stages of decision-making in a coastal Marine Protected Area also showed positive results, with a good short-term response from users regarding the protected area regulation.

There are some critical reflections on this type of bottom-up management that must be considered and could diminish the effectiveness of the regulations:

- The duration of the administrative process (in this case 7 years), especially in a participative process with strong engagement with the public, were expectations are created and are easily transformed in frustration by the amount of time consumed in the administrative processes;
- The great request of resources (staff, time and money) for the assumed essential stakeholder participation and community involvement;
- The difficult willingness or ability of all local communities to support conservation and sustainable use, depending in many cases of the scholar level of the local population;

- The risk of becoming an unmanageable area because of great interference from the population, especially in areas were conflicts from different stakeholders are a problem.

Integrating marine ecosystem conservation and ecosystems services economic valuation: Implications for coastal zones governance

Marine management must ensure that the natural structure and functioning of ecosystems is maintained to provide ecosystem services. Once those marine ecosystem services have been created, they deliver societal goods as long as society inputs its skills, time, money and energy to gather those benefits (Borja *et al.*, 2017).

With tight budgets, coastal managers face a challenge and every investment decision has to be well discussed and analyzed, nature or coastal zone conservation can be downgraded in the priority list of a public financial plan, where the wellbeing of the population must be maximized. The importance assigned by the population to the protected area is essential when evaluating the priority of investments at a national scale. If societal goods and benefits are to be limitless, society requires appropriate administrative, legal and management mechanisms to ensure that the use of such benefits do not impact on environmental quality, but instead support its sustainable use (Borja *et al.*, 2017).

In this study, the main motivation, for a positive willing to pay (WTP) in the conservation of the Biophysical Interest Zone of Avencas is the good investment for generations to come. Respondents were willing to pay 60€ annually and give one morning a year (66.42%) of their time and effort in voluntary work for Coastal Zone conservation (Chapter 2) expressing the importance of this Marine Protected Area (non-use value).

Voluntary activities involving nature's conservation in the coastal zone are not very expensive and could give a great fulfillment to local populations, being an affordable way to achieve both social and ecological objectives. The willing to give up time as an alternative to traditionally willing to pay studies with a monetary contribution, can be a good alternative when facing such scenarios of populations with income limitations (García-Llorente *et al.*, 2015) particularly because the availability to pay for coastal zone conservation is not proportional to the available budget per household.

The maximum percentage of the individuals willing to pay an extra were located in Cascais, but this number decreases in Almada and was null in Aveiro. The major difference in medium salaries is verified between Cascais and Almada (111€ different) (Pordata, 2013). However, these were not the municipalities recording the greater differences in WTP values. The largest difference in WTP was recorded between Cascais and Aveiro, therefore the distance factor overcomes the availability of income per household (Chapter 2).

The results of this study highlight the importance assigned by the population to the ecosystems services of a coastal protected area and its conservation. The investment made by the government will have a local and regional impact in the living conditions of the population, therefore these considerations should be taken in to account when conducting a cost benefit analysis, for allocating public funds to investments in the coastal conservation.

The willing to give time as a non-monetary technique revealed to be useful and coherent with the willing to pay results in this case study. The implications of these results for the governance of the coastal zones, revealed the public support in voluntary conservation actions as well as its valuation by the population.

In this context, the next challenge would be transposing this type of studies to policymakers and coastal stakeholders, the use of comprehensive numerical language would be necessary to include in annual budgets managed by the governments in a larger temporal scale to achieve a sustainable management. The vision for clean, healthy, biodiverse, and productive oceans and seas with sustainable resource use requires bridging the gap between policy and science in assessing the status of marine ecosystems by increasing scientific knowledge of marine ecosystems and their functioning, including humans and their role as part of the ecosystem (Borja *et al.*, 2013).

Ecosystem response to different management options in Marine Protected Areas (MPA): A case study of intertidal rocky shore communities

The final chapter of this thesis intended to close the cycle and evaluate the response of the biodiversity in the Biophysical Interest Zone of Avencas to a greater compliance with the regulations observed since 2012 and compare its resistance to an extreme event like an ocean storm. It was expected a positive variation in the intertidal communities' diversity and evenness within the ZIBA, between 2013 and 2015, responding positively (increasing density and diversity) to a decrease in anthropogenic pressures, as a result of a greater obedience from different ZIBA users with respect to protected area regulations since 2013 (Chapter 1). However, this expectation was only observed with regard to sessile fauna in the middle-intertidal zone.

Mobile fauna species displayed significant inter-seasonal fluctuations, exhibiting higher densities in summer and lower densities in winter, a pattern usually found in intertidal communities, but inter-annual differences were not significant (Chapter 3). Regarding the flora density in the study area, when the Hercules storm occurred (2014) the middle-intertidal zone showed an increased flora density, followed by a decrease in 2015. On the contrary, sessile fauna species exhibited higher values in 2015 (Chapter 3). A possible explanation is that the strong rarefaction of the rocky shore communities, as a consequence of physical disturbances caused by Hercules, led to a typical succession pattern of rapid colonization by the algal species (Benedetti-Cecchi and Cinelli, 1996). Followed by an increase in herbivorous species.

Results suggest that longer data series are necessary to obtain a more robust dataset regarding natural variability, since alterations caused by extreme events are always likely to occur, and additionally illustrate that indeed MPAs size matters because it influences openness, expressed as the ratio of periphery to area (Jørgensen *et al.*, 2000; Patrício *et al.*, 2006), and therefore its susceptibility to external driving forces.

ZIBA is a very small protected area, and thus some of the most relevant habitats occurring inside ZIBA are also found immediately outside of it. Of course, in both zones they can provide refuge and nursery spaces to many of the species living in this rocky shore. Since species do not acknowledge borders, due to its small size the "edge effect" between protected vs. unprotected areas may extend to the entire study area. This might have promoted a failure in creating a true differentiated zone inside the ZIBA as a result of its openness and consequent high exchanges in energy, mater, and immigration of species through its borders (Jørgensen *et al.*, 2000; Patrício *et al.*, 2006). The design of this Marine Protected Area should therefore be re-evaluated to increase the similar habitats surrounding the Biophysical Interest Zone.

The deficit in information before the classification of this protected area in 2016 should be taken in consideration. Rocky shore intertidal communities can exist in a number of apparently stable states, which may persist for periods (e.g. 7–13 years), greatly exceeding the turnover time of the resident populations (Dye, 1998). However, post disturbance equilibria may be fragile, and distressed communities may remain unstable for long periods (Dye, 1998). These results indicate that to manage visitor impacts on rocky shore communities, 'no-access' zones may be as important as 'no-take' zones. However, the rapid recovery seen here also indicates that perhaps rotating or seasonal closures might be an effective management strategy to protect turf communities (Huff, 2011).

Long series of data are necessary to verify the true biological impact of any MPA, this case is no exception. This is a huge challenge for any Coast Zone manager, once the public budget assign to surveys is usually very limited. On the other hand, the scientific community isn't focused on this type of biological surveys. Citizen-science could be a way to fulfill this goal, however the variability associated to coastal zone communities makes it very difficult to analyze any pattern leading to change, adding differences in observers could mask any subtly change in the communities.

Finally, as future challenges for this Marine Protected Area, several difficulties may be pointed out, due to the local management of this MPA.

A management closer to the population, with several outreach mechanisms and stronger surveillance by the authorities will lead to a greater awareness and consequently to a greater appropriation of the territory by its local users. However, several points could increase the complexity of this local management, namely a) too many stakeholders intervening, b) different governmental entities with several jurisdictions regarding the hydric public domain, c) short political cycles with changes in investment priorities, d) co-management of the area by the ludic fishing communities, and e) small area of this MPA compared with the national and international reality.

- ✓ Too many stakeholders intervening in the management of a small area, with different interests involved can lead to conflicting situations. A strong communication process must be maintained in order to minimize this difficulty;
- ✓ Different governmental entities with several jurisdictions regarding the hydric public domain are a national reality. Several obstacles can be minimized with management delegation protocols in the Municipality; however, some essential aspects must still be assured by the Maritime Police, the National Environmental Agency or the National Direction for Fishing Resources. The inclusion of all of these organizations in the management organs of this MPA is essential to promote the dialog between entities and involve every point of view in the problem solutions.
- ✓ Short political cycles with changes in investment priorities could be overcame with the existence of Management Plans for a minimum of 10 years with concrete investment priorities that must be assigned to the municipal budget projected in the Director Management Plan.
- ✓ Co-management of the area by the ludic fishing communities is an empowerment of these stakeholders that usually are not taken in consideration by decision makers. The accountability of this community for the differences in the biological communities is the great advantage of co-management, and the presence of these communities in the management organs of this MPA is again an essential aspect for the success of this innovative approach.
- ✓ The small area of this MPA compared with the national and international reality is a fragility that must be overcome. The changes in the design of this MPA is likely to increase the quality of nursery and protection habitats, therefore it is expected a positive impact in the conservation of the biologic communities. The maintenance of the biological surveys is essential to test this future

hypothesis. The inclusion of this type of action in the Management Plan of this MPA is essential to the success of the conservation efforts undertaken.

All of these points need to be further analyzed in order to test if this new management approach will have a significant impact in the recovery of the biological communities of the Avencas Marine Protected Area.

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