UNIVERSITY OF ÉVORA

Academic Year 2011-2012

"Fishing on Alentejo rocky shores - intensity, yield and protection effects"

André Bento Costa

Master thesis submitted for the fulfillment of the title of

Master of Management and Conservation of Natural Resources

Sines, December 2012

Supervisor:

Prof. Dr. João J. Castro (University of Évora)

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I hereby confirm that I have independently composed this Master thesis and that no other than the indicated aid and sources have been used. This work has not been presented to any other examination board

Tuesday, December 18th of 2012, André Bento Costa

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“UNDERWATER ANGLING” - an adaptive response to protective measures?

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ABSTRACT

Fishing activities are traditional in Portugal and, in the Southwest continental coast, fishermen generally exploit intertidal or shallow subtidal rocky shores targeting shellfish and teleost fishes. Since 1995, the Portuguese SW continental coast is partially protected by a natural park (Southwest Alentejo and Vicentine Coast Natural Park - PNSACV). In this park, a series of fishing management measures has been implemented since 2006 and, more recently, a new management plan was adopted, adding more restrictive regulations. This study aims to analyse spatial and temporal variation of intensity and yield of fishing activities on Alentejo rocky shores and evaluate effects of protective measures implemented on these activities. The opinion of Alentejo rocky shores fishermen was evaluated on the existing fishing management laws and their fishing activity was characterized. Roving creel surveys were used for the analysis of fishing intensity. Fishing yield was estimated with direct inquiries and 30' anglers' observations. Information on fisheries characterization and fishermen opinion was obtained with direct inquiries. The field work took place between January and July of 2012. Sampling was made in six areas and was stratified by: day type (weekdays, banning period, weekends/holidays); park (areas outside and inside PNSACV park); sea bream closure season (before, during, after) and Easter period (before, during, after). Using previously published data, interannual comparisons between 1995, 1996 and 2012 Easter periods were performed to evaluate effects of protective measures on fishing intensity. The main fishing activities documented on Alentejo rocky shores, during the sampled period were shore angling and shellfish harvesting. Global mean value of intensity of all human activities was 1.32 users.km^{-1}.day^{-1}. Higher global mean values of users were registered during weekends/holidays, especially in areas outside the park. Park areas showed a significant decrease of fishermen.km^{-1} during banning period. However, during the sea bream closure season, an expected cutback in the number of shore anglers was not observed in the protected area. A high intensity of shellfish harvesting and total predation during Easter period were reported, matching the year's prior protective measures. Interannual comparisons revealed variation among areas and periods regarding the intensity of all

fishing activities. A total yield of fishing activities of about 3 tons of fish and shellfish was recorded, providing an average yield of 0.15 $kg.h^{-1}$ per fisher. Areas inside the park presented a higher yield regarding total predation when compared with areas outside the park. The yield value of 0.21 $kg.h^{-1}$ per angler, obtained with the inquiries doubled the yield value of 0.08 $kg.h^{-1}$ per angler obtained with anglers' observations. Alentejo rocky shores fishermen are mostly male, employed in manufacturing sectors or pensioners/unemployed/students above 30 years old, residents or with reported birthplace in municipalities with territory enclosed in the natural park and target mainly shellfish and teleost fish. The majority are aware of Portuguese recreational fishing laws and the protective measures implemented in the park. The most common protective measures referred by fishermen that affect their activity are: *all measures*, *sea bream closure season* and *minimum size/weight of preys*. In reverse, fishermen that agree with protective measures listed as more accurate measures *closure (all seasons)*, *mandatory fishing licenses* and *minimum prey sizes*. Although recently established protection measures in park areas, might have caused some reduction in fishing intensity, it is still premature to assess the full effects of such measures. Therefore, in order to assess and evaluate accurate effects of protective measures a constantly monitoring of fishing activities should be implemented.

RESUMO

"Pesca no litoral rochoso alentejano - intensidade, rendimento e efeitos da protecção"

Actividades de pesca são tradicionais em Portugal e, na costa sudoeste continental Portuguesa, os pescadores geralmente exploram zonas rochosas intertidais ou subtidais pouco profundas, capturando peixes teleósteos e diversos invertebrados marinhos. Desde 1995, que esta costa está parcialmente protegida por um parque natural (Parque Natural do Sudoeste Alentejano e Costa Vicentina - PNSACV). Uma série de medidas de gestão de pesca têm vindo a ser implementados desde 2006 e mais recentemente, foi adoptado um novo plano de ordenamento do parque natural, que acrescenta normas ainda mais restritivas. Este estudo tem como objectivo analisar a variação espacial e temporal da intensidade e do rendimento das actividades de pesca no litoral rochoso Alentejo e avaliar os efeitos das medidas de protecção implementadas a essas actividades. Foi também avaliada a opinião dos pescadores, sobre as leis de gestão de pesca existentes e foi caracterizada a sua actividade. Para a análise da intensidade de pesca foi utilizado o método de "roving creel survey". O rendimento das actividades de pesca foi estimado através de entrevistas directas a pescadores e observações de 30 minutos a pescadores à linha. Informação relativa à opinião dos pescadores e caracterização das suas actividades foram obtidas através de inquéritos. O trabalho de campo decorreu entre Janeiro e Julho de 2012. A amostragem foi efectuada em seis áreas e estratificada por: tipo de dia (dias de semana, período semanal de interdição, fins-de-semana/feriados); áreas (fora do parque; dentro do parque); período de defeso do sargo (antes, durante, depois) e período da Páscoa (antes, durante, depois). Usando dados publicados anteriormente, foi realizada uma comparação interanual relativamente ao período da Páscoa entre os anos de 1995, 1996 e 2012 de forma a avaliar os efeitos das medidas de protecção. As principais actividades de pesca documentadas no litoral rochoso Alentejo foram a pesca à linha e o marisqueio. O valor médio global de intensidade para todas as actividades humanas foi de 1,32 utilizadores.km^{-1}.dia^{-1}. Foram registados valores globais superiores durante fins-de-semana e/ou feriados, especialmente em áreas fora do parque. Durante o período semanal de interdição as áreas do parque registaram

uma diminuição significativa no número de pescadores.km^{-1}. No entanto, durante o defeso do sargo, a redução esperada no número pescadores à linha não foi observada em áreas protegidas. Foi observado elevados valores de intensidade e predação total durante o período da Páscoa, evidenciado em anos anteriores à implementação das medidas de protecção. A comparação interanual revelou uma variação da intensidade de pesca entre área e períodos para todas as actividades. Foi obtido um rendimento de cerca de 3 toneladas de pescado (peixes e mariscos), proporcionando um rendimento médio de 0.15 kg.h^{-1} por pescador. As áreas do parque apresentaram um rendimento superior relativo à predação total. O valor de rendimento obtido com as entrevistas directas, a pescadores à linha foi aproximadamente o dobro do valor obtido com as observações de 30 minutos. Os pescadores do litoral rochoso Alentejano são maioritariamente do sexo masculino com idades superiores a 30 anos, estão empregados no sector industrial ou são reformados/desempregados/estudantes, residem ou possuem naturalidade em concelhos com territórios abrangidos pelo parque natural, e capturam sobretudo peixes teleósteos e mariscos. A maioria conhece as leis portuguesas relativas à pesca recreativa e as medidas de protecção implementadas no parque. As medidas de protecção que afectam as suas actividades mais mencionadas pelos pescadores são: *todas as medidas*, *período de defeso do sargo*, e *tamanhos e pesos mínimos do pescado*. Em sentido contrário os pescadores que concordam com as medidas de protecção referem que as medidas mais acertadas são: todos os períodos de defeso, obrigatoriedade de licenças de pesca e tamanhos mínimos do pescado. Embora as medidas de protecção, recentemente estabelecidas no parque natural possam ter causado uma certa redução da intensidade de pesca, ainda é prematuro concluir sobre a totalidade dos efeitos de tais medidas. Como tal, para analisar e avaliar os efeitos precisos de medidas de protecção é indispensável uma constante monitorização das actividades de pesca.

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1. INTRODUCTION

In the fisheries sector the main goal of management strategies is to find long-term sustainability for fisheries resources (Ruckes, 2001). To achieve long-term sustainability it is vital to determine, a priori, which is the best use and development plan for specific natural resources (Silbly, 2001). All fishing activities have an impact on the ecosystem but the level of this impact and the necessary recovery time of the system are frequently unknown (Diogo, 2007).

Removing individuals from the natural population can have consequences for biological diversity and ecosystem functioning, independently of whether this capture reached levels that threaten the species with global or local extinction. Therefore, it is necessary to obtain a reasonable balance between the interests of the environment and fisheries (C.C.E., 2001).

Harvest regulations in fisheries are normally introduced to improve the quality of the fishery and/or to protect vulnerable species of fish from overexploitation (Nãslund et al., 2010). Regulations can be based on several types of actions; including bait or gear restrictions, minimum size limits, slot limits, bag limits and closed seasons. This aims to reduce the total harvest for the individual fisherman (Nãslund et al., 2010). At a basic level, regulations must restrict the harvest so that enough fish remains to maintain a sustainable fish population and fishery (Nãslund et al., 2010). An abundance of case studies from around the world demonstrate how species abundance, biomass, size, species richness, reproductive potential, and community structure have benefited from protection (e.g. Halpern & Warner, 2002; Gell & Roberts, 2003; Halpern & Warner, 2003; Claudet et al., 2008; Lester et al., 2009). Understanding how fishing effort responds to management interventions is important for conserving threatened fisheries resources (Beardmore et al., 2011). This knowledge prevents a robust management advice as to the suitability of different variants of common harvest regulations to jointly meet conservation and fishing quality objectives (Arlinghaus et al., 2010).

Therefore, precise and accurate estimates of catch and harvest from surveys are needed to effectively manage fish populations (Cardona-Pons et al., 2010). Correct management decisions related with the oceans are dependent on sound and clear scientific knowledge (Diogo, 2007). The application of political decisions depends on reliable information about the functioning of the system (Merrel, 1995).

In response to social change, the importance of commercial capture fishing is decreasing and recreation is becoming the more important beneficiary of fish stocks (Kelly, 2012). In most developed countries, recreational fishing is now the main form of exploitation of most inland and many coastal waters. Approximately, a tenth of the population across all countries engages regularly in recreational fishing, providing many social, economic and ecological benefits to society and harvesting millions of fish on a global scale (Kelly, 2012). Unfortunately, in the context of international policy on the management and conservation of resources and ecosystems, recreational fisheries have been largely ignored, probably in the belief that they are less valuable than commercial fisheries, but recent awareness has clearly challenged this perspective and the situation is being addressed (Kelly, 2012).

It has become urgent to obtain systematic scientific information regarding the actual recreational fishing activity, considering that it has yet to be determined whether this activity has an impact in global fishing management (Oliveira, 2003). This aspect is particularly relevant since this information is still scarce in the Portuguese context.

The Portuguese SW continental coast is partially protected by the Southwest Alentejo and Vicentine Coast Natural Park ("Parque Natural do Sudoeste Alentejano e Costa Vicentina – PNSACV", Figure 1; park hereafter) since 1995. A marine zone 2 km wide has been designated along the coast of this park (ca. 130 km) with oceanic sandy beaches, extensive rocky shores, and small estuaries and coastal lagoons (Castro & Cruz, 2009). In this marine park, intensive and traditional fisheries affect several target species for subsistence, commercial use or recreation (Castro, 2004). In addition, this park is also used for tourism activities, such as beach tourism, scuba diving and marine wildlife watching.

Castro (2004) states that Alentejo coast exploiters of intertidal or shallow subtidal living resources frequently sought out prey in habitats dominated by hard substrate. This exploitation is practiced mainly for leisure-recreational purposes, predominantly dedicated to shellfish harvesting that provides a direct source of food to fishermen (Castro, 2004). According to this author the observed importance of day type in the abundance of users on rocky shores of Alentejo (higher in weekends or holidays) suggests that the recreational and entertainment component of these fishing activities is quite important (see Recreational fisheries general overview, presented in chapter 2).

Considering the recreational and touristic importance of Alentejo rocky shores, these fishing activities are more common and involve more people during holiday periods, being summer the main one (Castro, 2004). However, these activities can also be quite intense in spring, particularly during Easter, when collecting seafood is more intense, especially for sea urchin harvesting (in winter and early spring, sea urchin gonads are larger and ripe; Castro, 2004). This activity is practiced by groups of family and/or friends who, after harvesting, usually cook and eat the gonads of sea urchins in outdoor gatherings, especially on holidays or weekends (Castro, 2004). This high density of harvesters attest the importance of those gathering activities, during Easter, in the rocky coast of Alentejo (Castro, 2004). In central Chilean rocky shores, Durán et al. (1987) witnessed an increased intensity of sea urchin harvesting during autumn, precisely when the gonads of Chilean sea urchins (*Loxechinus albus*) reach larger sizes. These authors report that the preference for periods in which the gonads are more developed is partly due to the limited food that these invertebrates supply to humans (Durán et al, 1987).

Since 2006, several restrictions to recreational fishing activities are enforced in continental Portugal, including those made on rocky shores of the PNSACV natural park. These activities are currently regulated by several laws (Ordinance. 144/2009, of February 5th, modified by Ordinance no. 458-A/2009, of May 4th), some of them specific to PNSACV natural park (Ordinance no. 143/2009, of February 5th, modified by Ordinance no. 458-A/2009, of May 4th; Ordinance no. 115-A/2011, of March 24th). These laws established a series of management specifications to which recreational

fishers must obey, concerning, for example, size limits and catch limits per species and day, and in PNSACV closed seasons (for fishes like sea breams *Diplodus sargus* and *Diplodus vulgaris* and wrass *Labrus bergylta*, and for the stalked barnacle *Pollicipes pollicipes*), a weekly period of fishing ban (Wednesdays, except public holidays) and limitations to fishing within protected areas considered ecologically important (favored sites for spawning and juvenile growth; shelter and protection to predators and feeding of many marine species).

With the revision of the management plan (MP) of the PNSACV natural park (Resolution no. 11-B/2011, of February 4th), it became necessary to harmonise the provisions of Ordinance no. 458-A/2009, of May 4th, with the revision of the MP, especially regarding ban areas of recreational fishing. So, in 2011, a new law on recreational fishing (Ordinance no. 115-A/2011, of March 24th) was enforced in the PNSACV natural park. That MP specifies and adds restrictive regulations regarding all fishing activities, including marine protected areas (MPAs) with different protection levels (total, partial and complementary). These different levels of protection are known as "zoning" and involve designating highly protected areas within a MPA (e.g., no access or no extraction), surrounded by zones allowing for a range of different uses and intensities (Gray et al., 2010).

MPAs are commonly employed to mitigate anthropogenic impacts on marine ecosystems. A MPA is ''*a clearly defined geographical space, recognized, dedicated, and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values*'' (Dudley, 2008). A number of studies have shown that no-take reserves (where no extraction is permitted) can have beneficial impacts on marine species (Gray et al., 2010). However, opposition by fishermen and some fisheries managers to these new MPAs is a global phenomenon, occurring in commercial, subsistence, and often to an even greater extent, recreational fishery sectors (Kenchington & Bleakley, 1994; Himes, 2003; Coleman et al., 2004). For most recreational and many commercial fishermen, sanctuary zones are the only areas where fishing is banned (Lynch, 2006). Given this, the challenge in many MPAs is how to sufficiently protect the marine

environment while providing for an acceptable range of sustainable human use (Gray et al., 2010).

- **OBJECTIVES**

The assessment of the intensity and yield of fishing on the Alentejo coast is of great importance, since the rocky shores (intertidal and shallow subtidal habitats, up to about 20 m depth dominated by hard substrate) of Alentejo is frequently and heavily used by humans for the exploitation of living resources (Castro, 2004). This activity is subject to various restrictions in this coast, namely in terms of: spatial restrictions (permanent no-take zones); temporal constraints (closed seasons, the weekly period of banning); bag size daily limits; dimensional constraints (minimum sizes); taxonomic constraints (species caught); logistics (tools used) and social constraints (place of birth or residence). The selection of rocky shores of Alentejo for the study was based in the fact that since the protective measures implemented since 2006, few data regarding fishing activities (mainly commercial ladings and number of fishing boats or fishing licenses) have been produced, in order to assess its impact on fishing activities. Furthermore, the use of Alentejo rocky shores enables comparisons with data obtain prior to protective measures (e.g. Castro, 2004).

The present study aims to: (1) analyse patterns of spatial and temporal variation of intensity and yield of fishing activities carried on rocky shores of Alentejo; (2) assess effects of the protective measures, implemented since 2006 and the effects of recreative fishing laws on the intensity and yield of fishing activities; and (3) evaluate the opinion of Alentejo rocky shores fishermen on the existing fishing management laws and characterize their fishing activity.

In order to analyse patterns of spatial and temporal variation of intensity and yield of fishing activities (aim 1) and evaluate effects of protective measures implemented (aim 2), the subsequent data was collected:

- **Weekly period of banning in the park (Wednesday, except public holidays)**

The application of a weekly banning period of recreative fishing (**Bp**), within the park, probably affects the intensity of these recreational activities: negatively and directly in the park; positively and indirectly in neighbor areas outside de park.

- **Closure season of** *Diplodus sargus* **(white sea bream) and** *Diplodus vulgaris* **(common two-banded sea bream) recreative fishing in the park (periods before, during and after)**

Since 2009, a sea bream closure season is applied to recreational fishing in the natural park PNSACV. A cutback, during closure season in the number of shore anglers on park areas is expected, hence outside the park the number of shore anglers may increase in neighbor areas, as these two species of sea bream are considered to be of major importance to recreational fishing in the coast of Alentejo (Castro, 2004). In addition, some anglers may engage other fishing activities on rocky shores inside the park, due to sea bream closure season, producing an increase in the intensity of shellfish harvesting during this closure.

- **Easter period (periods before, during and after)**

Castro (2004) reported a high intensity of fishing activities during Easter, in the rocky shores of Alentejo. Shellfish harvesting during this specific period is typically practiced by family groups and/or friends who, after harvesting (namely sea urchins), usually cook and eat in outdoor gatherings, especially on holidays or weekends. The above referred laws regulating recreational fishing in continental Portugal since 2006, and the new management plan of the park created in 2011 that specifies and adds more restrictive regulations regarding fishing, may have caused an impact in this long time tradition on areas outside and inside the park. Therefore, these regulations may affect the variation of the intensity, by matching the number of harvesters between periods.

- **Interannual comparisons (1995, 1996, 2012)**

Interannual comparisons between 1995 and 1996 (years prior to protective measures; Castro, 2004) and 2012 (with protective measures applied since 2006), should point to

a higher decrease in the intensity of shellfish harvesting (more constraints applied to this activity) and a slight decrease in shore angling due to these protective measures.

- **Yield of the fishing activities (interviews and 30' anglers observation)**

The protective measures implemented have a potential greater impact on the intensity of fishing activity in park areas. As a result of this impact, a higher yield is expected in park areas comparing with areas outside the park.

The evaluation of opinion on the existing fishing management laws by Alentejo rocky shores fishermen (aim 3) was made in order to determine the level of acceptance and the fishermen's willingness to comply with those management laws. Their opinion and information on their fishing activity, as well as results of intensity and yield analyses, were used to make recommendations to improve the management of Alentejo rocky shores fishing towards the sustainable use of their resources.

2. RECREATIONAL FISHERIES GENERAL OVERVIEW

2.1. Definition of recreational fisheries

Recreational fisheries are often synonymous with angling (the activity of catching or attempting to catch fish on hooks, predominantly by rod and line or hand-held line), free-diving fishing (e.g. capture of fish or shellfish by divers with spear guns or other fishing tools, with no breathing apparatuses), bait collecting (e.g. hand-gathering of shellfish or algae from the beach or shore, to be used as bait or lure in angling) and shellfish harvesting (e.g. hand-gathering of shellfish from the beach or shore) (Pawson et al., 2008). These activities are carried out by solitary individuals, small groups, and in the case of competitive angling, during organised events (Dillon, 2004).

In Portugal, recreational fishing is officially defined as the non-commercial capture of marine species, animal or vegetal, and it can be carried out from land, boat and even underwater (Decree law no. 246/2000 of September 29th). In the southwest coast of continental Portugal (Figure 1), the most common fishing activities are shore angling,

boat angling, free-diving fishing and shellfish and bait harvesting, besides commercial fishing normally carried out with boats (Castro & Cruz, 2009).

2.2. Origin and evolution of recreational fisheries

Historically, there have been some fishing practices with characteristics of recreational fisheries that subsequently became the base of the modern recreational fishing (Brandt, 1984). As a direct food source, coastal areas in Europe have been used by man since the lower Paleolithic, some hundreds of thousands years ago (Tavares da Silva & Soares, 1997). At least 300.000 years ago, prehistoric populations of the Mediterranean coasts of Europe fed on marine intertidal animals (Siegfried, 1994). According to Raffaelli & Hawkins (1996), widespread harvesting of shellfish for subsistence was common in Europe, from prehistoric times until the late middle Ages.

In the particular case of the Portuguese southwest continental coast, the use of rocky coastlines and estuaries for harvesting dates back to the Epipaleolithic, about 10.400 years ago (Tavares da Silva & Soares, 1997).

Recreational fishing for sport or leisure gained popularity during the 16th and 17th centuries (Cowx, 2002), although the point in history where fishing could first be said to be recreational is not clear (Schullery, 1987).

2.3. Importance and revenue of recreational fisheries

Recreational fisheries constitute the dominant use of wild fish stocks in all freshwater and many coastal zones in all industrialised nations (Arlinghaus et al., 2002; Arlinghaus & Cooke, 2009). This fishing sector is potentially a significant contributor to local economies in coastal areas (Dillon, 2004). This activity is well-recognised worldwide as an industry, dominated by the United States, Europe and Canada, and associated with disbursements of US$ 5-38 billion per year (Cowx, 2002), though no precise global catch data are available. Coates (1995) gave an initial estimate of 2 million tons annually. Recreational fishing across Europe is believed to exceed €25 billion a year (Dillon, 2004). Collecting such data is a demanding task as some countries, including Portugal, do not officially order the collection of this basic information for management purposes (Diogo, 2007). While commercial landing records have been

collected over long periods of time, the same is not true for recreational catches. It is much more difficult to collect such data on recreational fishing. For example, marine anglers unlike commercial fishermen do not land their catches at specific points or markets where records are kept. This poses a difficulty for estimating recreational catch and, consequently, for sensing historical trends in recreational catches (Diogo, 2007). In addition, there are many methods of recreational fishing and, simultaneously, the fishermen demonstrate high temporal and spatial distribution, which makes them difficult to survey (Gartside et al., 1999; Sullivan et al., 2006). This diversity creates methodological difficulties when it comes to engaging recreational fishermen in efforts to measure recreational fishing activity and estimate its impacts on fish populations (Cardona-Pons et al., 2010).

Combining all these aspects, results in marine recreational fisheries are being monitored with less accuracy than commercial fisheries. However, as concerns about the effects of all types of fishing have grown since recreational catches exceed commercial catches in a number of major stocks (Coleman et al., 2004), more attention has been paid to the possible impacts (e.g. such as overexploitation) of marine recreational fisheries. Recreational fishing targets large, top-level predatory fish in the ocean and other aquatic systems. Removal of these fish can create dramatic changes in ocean food webs and cause cascading effects that alter the overall productivity and health of marine ecosystems (Coleman et al., 2004). In addition, some fish populations have dropped to such low numbers that they have been considered for placement on the threatened and endangered species lists (SeaWeb, 2004). The increasing awareness in the effects of recreational fishing on fish stock size and composition has led to increased demands for timely and accurate data (Kearney et al., 1996; O'Neill & Faddy, 2003).

2.4. Recreational fisheries in Portugal

In Portugal, recreational fishing is a significant leisure activity, both economically and socio-culturally (Marta et al., 2001). Until the 2006 law (Ordinance no. 868/2006 of August 29th) requiring saltwater fishing licenses, there was little or no data available on the number of saltwater fishermen in continental Portugal (Rangel & Erzini, 2007).

According to official statistics from the Portuguese Fisheries Governmental Agency ("Direcção-Geral de Recursos Naturais, Segurança e Serviços Marítimos – DGRM"), concerning the Portuguese mainland, a total of 175.334 saltwater fishing licenses were issued in 2011, and 76.098 just in the first semester of 2012 (DGRM - http://www.dgrm.min-agricultura.pt). It has been estimated that 6% of the Portuguese population participate in recreational fishing of some kind (Hurkens & Tisdell, 2006), with this number likely to increase in the future (Marta et al., 2001).

Subsistence and recreational fishing are traditional in Portugal and in the SW continental coast fishermen often exploit intertidal or shallow subtidal rocky shores and target shellfish and teleost fishes (Castro, 2004). According to the same author, in this coast shellfish collecting is mainly done on the low level of rocky shores and during spring low tides (except in free-diving fishing) and shore angling is the most frequent fishing activity on rocky shores, but at a lower intensity at both low and high tide. Other common diurnal fishing activities on rocky shores of this region, besides commercial boat fishing, are bait harvesting during low tide, boat angling and free-diving fishing. Fishing competitions generally involve shore angling or spear fishing (Castro & Cruz, 2009). According to DGRM, the number of valid licenses issued for recreational fishing in the Alentejo region (Figure 1) was 9.715 in 2011.

No official fisheries statistics are known on catches made for subsistence, recreation or sport in Portugal. Veiga et al. (2010) provided estimates of total catch, harvest and effort from recreational shore fishing made in the Southwest Alentejo and Vicentine Coast Natural Park ("Parque Natural do Sudoeste Alentejano e Costa Vicentina – PNSACV", Figure 1), on Portuguese SW continental coast. According to this author, between August 2006 and July 2007 an estimated value of 147 t of fishes were harvested with an overall catch per unit effort (CPUE) of 0.21 $kg.h^{-1}$ per angler. Castro (2004) presented estimates of intensity and yield of fishing activities made on Alentejo rocky shores (except boat angling). During 1994-96, mean daily values of intensity of all human activities, shore angling and low tide shellfish gathering were, respectively, 7.8, 2 and 9.4 persons per kilometre of coastline (Castro, 2004). In the same period Castro (2004) estimated a total annual yield of 5.9 tons per km^2 for the coast of Alentejo, considering recreational (on rocky shores) and commercial fisheries. This author states

that Alentejo presents a higher or similar intensity and yield values of fishing activities made on its rocky shores when compared with other similar coastal habitats. According to Castro (2004) human use of rocky shores of Alentejo is regular, but generally more intensive during summer and weekends/holidays, on shores near sandy beaches, related to the recreative (usually bathing) use of the shore due to a higher abundance of people on those periods. However, the regularity of human predation suggests that the predatory use of the shore may also be important for subsistence.

Scientific knowledge on the biology and ecology of the exploited populations and their communities, and on the impacts of these activities (commercial and recreational), is still scarce for the marine PNSACV (Castro, 2004). However, studies made on this coast (Canário et al., 1994; Castro, 2004) have found stocks fully or intensively fished (e.g. white sea bream; stalked barnacle), stocks in risk of overexploitation (e.g. common two-banded sea bream) and an overexploited stock (e.g. sea bass).

2.5. Management of recreational fisheries

Coastal ecosystems are the most productive on the planet (Martinez et al., 2007) and rocky shores represent an extensively habitat subject to coastal erosion due to wave action (Crowe et al., 2000). They are both considered open ecosystems, with interface between land and sea, and exposed to strong environmental gradients, establishing a high degree of connectivity with other coastal ecosystems (Thompson et al., 2002) and importing and exporting materials (debris) or propagules (larvae, spores, etc.; Small & Gosling, 2001). The high level of biodiversity found in these areas creates a high level of biological activity, which has attracted human activity for thousands of years.

There is a long held belief that the individual catches of recreational fishermen could never take a significant bite out of the ocean's abundance. However, catches may greatly exceed the commercial sector in some cases (Cooke & Cowx, 2004; Coleman et al., 2004). Recreational fishermen today are equipped with modern technologies (e.g. sonar devices, global positioning systems and powerful boats) to find fish, that make them every bit as effective as their commercial counterparts (SeaWeb, 2004).

While the cumulative impact of commercial fishermen is constrained by limits on who, where, when and how much fish they can catch, in certain countries, there are no controls on the growing impact of recreational fishermen (SeaWeb, 2004). Current management of saltwater recreational fisheries focuses primarily on the individual fisherman, setting limits on the number and size of fish one can bring in without restricting the number of people allowed to fish (SeaWeb, 2004).

Commercial and recreational fishing have similar demographic and ecological effects on fished populations, and they can have equally serious ecological and economic consequences (Coleman et al., 2004). If the goal of fisheries management is to sustain viable populations and ecosystems, recreational and commercial fishing require effective regulation (Morales-Nin & Moranta, 2005). To achieve long-term sustainability it is vital to determine, *a priori*, which is the best use and development plan for specific natural resources (Silbly, 2001).

Management measures to achieve these goals commonly include size and bag limits, with both applying to some species, areas closure (MPAs), banning periods and gear restrictions (Kirkegaard & Gartside, 1998). A large number of studies (e.g. Moreno et al., 1984; Castilla & Duran, 1985; Clark et al., 1989; Yamasaki & Kuwahara, 1990; Stoner & Ray, 1996; Sluka et al., 1997; Babcock, 1999; Edgar & Barrett, 1999; Ferraz et al., 2001) made on reserves worldwide shows that protection from fishing leads to rapid increases in biomass, abundance, and average size of exploited organisms and to increased species diversity (Roberts et al., 2001). In the reserves studied, abundance approximately doubled, biomass increased to two and half times that in fished areas, average body size increased by approximately one third, and the number of species present per sample increased by a third (Roberts & Hawkins, 2000).

In Sumilon Island reserve in Philippines, Alcala (2004) reported a rapid and sustained increase in abundance of large, predatory fish. When the reserve was reopened to fishing, catches collapsed in nearby areas, suggesting that the reserve had previously supported fisheries, though catches rose again after renewed compliance (Alcala & Russ, 1990; Russ & Alcala, 1999). Several studies have demonstrated a recovery of fish populations were no-fishing zones have been declared (Roberts, 1995; Russ & Alcala,

1996; McClanahan & Kaunda-Arara, 1996; Wantiez et al., 1997) and fished and unfished areas have been shown to diverge in abundance, biomass, and numbers of species (Watson and Ormond, 1994; Rakitin and Kramer, 1996; Roberts and Hawkins, 1997; Babcock et al., 1999; McClanahan et al., 1999; Chiappone et al., 2000).

In Florida, reserve zones in the Merritt Island National Wildlife Refuge have supplied increasing numbers of world record–sized fish to adjacent recreational fisheries since the 70s (Roberts et al., 2001). This study reports a rapid impact, of protective measures on reef fish populations, revealing that combined biomass of five commercially important fish families tripled, in reserves and adjacent fishing areas, only in 3 years. Johnson et al. (1999) also showed that protection from fishing at Merritt Island has benefited several game-fish species. In Australia, recreational fishing outside a marine park resulted in reduced biomass and community composition relative to protected areas within the park (Westera et al., 2003).

Coleman et al. (2004) say that "*recreational fishing is important to many people. For some it's a way to commune with nature, for others it fulfills a deep desire to hunt. But if societies want to continue recreational fishing, we all need to support management of both commercial and recreational fisheries that will allow fish populations to recover and protect the structure and function of marine systems"*.

Compliance with fishing regulations, designed to protect recreational fisheries from overexploitation, is generally difficult to measure (Nãslund et al., 2010) and can fail to produce the desired effects (Post et al., 2003), an outcome all the more likely when basic data are lacking. So correct management decisions related with the oceans are dependent on sound and clear scientific knowledge (Merrel, 1995; Diogo, 2007). The application of political decisions depends on reliable information about the functioning of the system (Merrel, 1995). Fishermen refusing to participate, hiding fish or not telling the truth while answering questionnaires are examples of potential problems (Schill & Kline, 1995).

3. MATERIALS AND METHODS

3.1. Study area

Most of the Portuguese SW continental coast is protected by a natural park designated in 1995 (PNSACV, between latitudes 36° 59‘N and 37° 55‘N, and the longitudes 8° 40‘W and 9° 00‘W; Figure 1). This is a large protected area (131.000 ha), with terrestrial and marine areas, integrating the coastal zone of two administrative regions of Portugal: Alentejo and Algarve.

This natural park contains several types of habitats, including natural and semi-natural habitats such as high and steep cliffs, beaches, numerous islets and reefs, the estuary of Mira river, the Cape Sardão, the peninsula of Sagres and Cape São Vincente, sand dunes, moors, marshes, salt pans, temporary ponds and gullies (valleys with dense vegetation cover) (Resolution no. 11-B/2011, of February 4th). This physical diversity allows the occurrence of an extraordinary rich fauna and flora, including endemic, rare and endangered species (Resolution no. 11-B/2011, of February 4th).

The marine area of PNSACV extends 2 km offshore all along its coastline, with a length of ca. 130 km. It comprises oceanic sandy beaches, extensive rocky shores, small estuaries and coastal lagoons (Castro, 2004). The climate is Mediterranean, with a strong maritime influence. Air temperatures are mild throughout the year, with dry and warm summer seasons, and moderate winters (Teixeira, 2006), except during periods of rising winds, when they may rise or fall sharply. The shoreline is characterized by rougher sea conditions and a coastline with high cliffs, inaccessible by land in many parts.

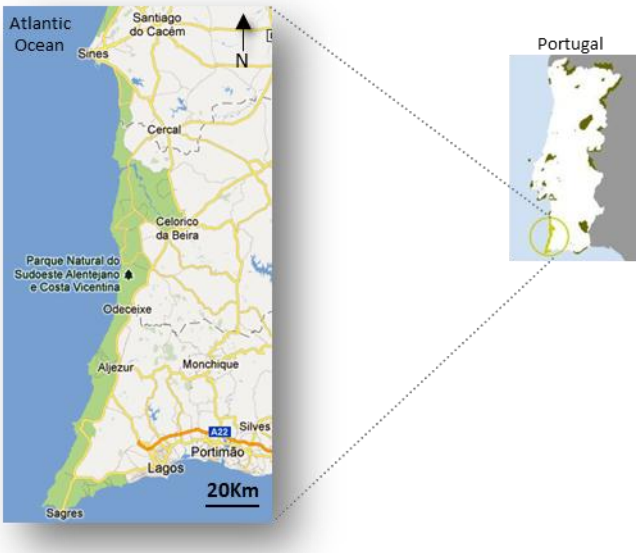

Figure 1 – The Southwest Alentejo and Vicentine Coast Natural Park ("Parque Natural do Sudoeste Alentejano e Costa Vicentina – PNSACV") in continental Portugal. *Adapted from Portuguese Institute for Nature Conservation and Forest, "Instituto de Conservação da Natureza e Florestas - ICNF" and Google maps 2012.*

Castro (2004) sampled areas were used to enable interannual comparisons between 1995, 1996 and 2012. Two areas located outside the park, but close to this protected area, were considered (Cabo de Sines - **CSI** and Vale Marim - **VMA**). Four areas were sampled inside the park: two northern areas (Amoreiras/Oliveirinha - **ACO**; Burrinho/Porto Covo – **BPC**); and two southern areas (Nascedios – **NAS** and Almograve - **ALM**) (Figure 2).

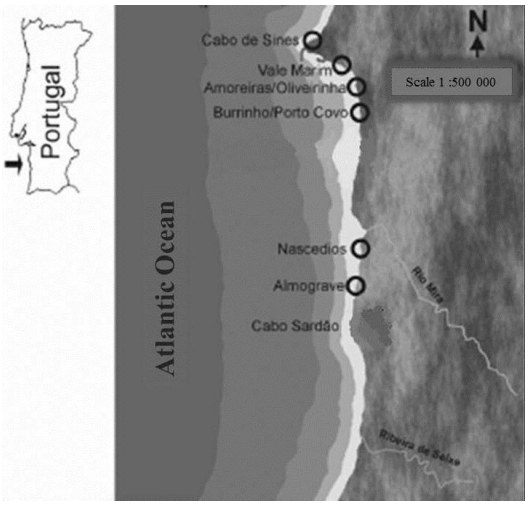

Figure 2 – Areas sampled in the coast of Alentejo, SW continental Portugal: two areas located outside the park (Cabo de Sines - CSI; Vale Marim – VMA); four areas located inside the park (Amoreiras/Oliveirinha – ACO; Burrinho/Porto Covo - BPC; Nascedios – NAS and Almograve – ALM). *Adapted from Castro (2004).*

A sampling area was considered a stretch of coast, with a few kilometers in length along the coast, and was chosen in the study area so that:

- encompassed an intertidal zone dominated by hard substrate with a few kilometers long;
- human activities on the shore could be quickly observed at a distance of tens or hundreds of meters, enabling the sampling of several areas in the same tidal conditions;
- would be representative of areas from the coast under study.

Based on these characteristics, the six sampled areas can be grouped as follows (Castro, 2004):

- Cabo de Sines (CSI) is close (less than 1 km) to the larger urban zone in the study area, is more than 2 km away from touristic sandy beaches, and its access by land is moderately difficult;
- Vale Marim (VMA) and Amoreiras/Oliveirinha (ACO) have easier access by land, urban areas over 3 km and nearby touristic sandy beaches (0.5 to 2 km, VMA) or very close touristic sandy beaches (<0.5 km, ACO);

- Burrinho/Porto Covo (BPC) and Almograve (ALM) have moderately difficult access by land, touristic sandy beaches within 0.5 km and urban areas nearby (1 km, BPC) or very close (<1 km, ALM);
- Nascedios (NAS) has the worst access by land, closest urban area over 3 Km and touristic sandy beaches over 2 km.

Coastline areas length was estimated using Quantum GIS (QGIS 1.7.4 – Wroclaw, 2011) in a scale of 1:1700 (Table I).

Table I. Estimates of coastline length per sampling area made with Quantum GIS (the scale used in the measurements is 1:1700).

Study area	length (km)	Coordinate Reference System	Layer
Cabo de Sines (CSI)	7.025	Google Mercator	Google Satellite
Vale Marim (VMA)	1.749		
Amoreiras/Oliveirinha (ACO)	3.427		
Burinho/Porto Covo (BPC)	3.573		
Nascedios (NAS)	5.126		
Almograve (ALM)	4.987		
Total	25.887		

In addition to these features, sampling areas also vary regarding hydrodynamics, potentially greater in capes and lower in regions sheltered by capes (e.g. Carter, 1989; Raffaelli & Hawkins, 1996). In the Alentejo coast, this shelter is mainly given in relation to the WNW and NW swell, dominant in Sines (Costa, 1994). In this context, the VMA and ACO areas are considered more sheltered than CSI, situated in the Cape of Sines. Sea roughness has a major influence in fishing activities, particularly those developed in low tide levels, like some shellfish harvesting activities (e.g. stalked barnacle or sea urchin harvesting), and free-diving fishing, preferably practiced in lower roughness periods (Castro, 2004). In spite of CSI upholding the hydrodynamics higher potential, the irregularity of its coastline gives shelter to several sites dominated by hard substrate, which presents similar hydrodynamics as the remaining areas (Castro, 2004). All fishing activities usually performed on Alentejo rocky shores (shellfish or bait collecting during low tide, shore angling and free-diving fishing) can be made in the set

out sampling areas, although stalked barnacle (*Pollicipes pollicipes*) harvesting is typically performed in very exposed areas with high hydrodynamics, where this species is most abundant (Cruz, 2000). In the six areas sampled, *P. pollicipes* collecting is frequent in the Cape of Sines, Porto Covo and Almograve (Castro, 2004).

3.2. Intensity of fishing activities

3.2.1. Sampling method

The intensity of fishing activities was assessed by roving creel surveys conducted by car, during a seven month's period from January to July 2012. The visual count method used is similar to the sampling technique referred in other similar studies (e.g. Murray-Jones & Steffe, 2000; Castro, 2004; Snook & Dieterman, 2006; Diogo, 2007; Rangel & Erzini, 2007; Marcelino, 2010; Van Zyl, 2011).

Surveys were performed in the following conditions: during spring tide (low tide height less than 0.9 m; starting one hour before predicted low or high tide, and ending before two hours after starting time; tidal predictions were obtained in the website of http://www.hidrografico.pt/), daytime, calm sea (forecasted wave height less than 1.5 m; forecasts were obtained in the day before using the websites of http://www.meteo.pt/, http://www.hidrografico.pt/ and/or http://www.windguru.cz/) and with no rain (forecasts were obtained in the day before using the websites of http://www.meteo.pt/, http://www.windguru.cz/ and/or http://climetua.fis.ua.pt/). In some cases, high tide surveys were made with rough sea (forecasted wave height higher than 1.5 m; forecasts obtained as above mentioned). High tide surveys were done for the analysis of free-diving fishing and shore angling intensity. Shore angling is not dependent on sea condition as free-diving fishing or low tide shellfish collecting is (Castro, 2004). On each survey, starting point and sampling direction were selected randomly.

People using the shore were counted at a distance of tens or hundreds of meters, using 7x50 mm binoculars. Their main activity and instruments used were registered in predefined categories such as: shore anglers; free-diving fishers; bait harvesters; shellfish harvesters (fishing octopuses, crabs, stalked barnacles, mussels, limpets,

topshells or sea urchins) and amenity users (Appendix I). Although shellfish collected on rocky shores of Alentejo can be used as bait or lure in afterward shore angling (Castro, 2004), in the present study bait harvesting included mainly the collection of polychaete annelid worms digging sediment underneath boulders or pebbles or close to rocky hard substrate.

3.2.2. Experimental design

In the Southern areas (NAS and ALM) intensity data was not evaluated due to logistic constraints.

To analyse the spatial and temporal variation in the intensity of fishing activities and to evaluate the effects of protective measures in this variation, the subsequent sampling designs were establish (Table II).

Table II. Summary of sampling designs used for the analyses of intensity and yield of fishing activities on rocky shores of Alentejo. Areas inside the park are ACO, BPC, NAS and ALM; areas outside the park are CSI and VMA (Figure 2).

		Activities	Orthogonal fixed factors	Random factor	Number of replicates (n)
Intensity	**Weekly period of banning**	**High tide** - Shore angling **Low tide** - Shellfish harvesting, Shore angling and bait harvesting and Total predation	**Day** - Weekdays and Banning period **Park** - Inside and outside	**Area** - CSI, VMA, ACO and BPC, nested in **Park**	Shore angling **(n=8)** Shellfish harvesting, Shore angling and bait harvesting and Total predation **(n=7)**
	Closure season	**High tide** - Shore angling **Low tide** - Shore angling, Shellfish harvesting, Amenity use and Total predation **High + Low tide** - Free-diving fishing	**Period** - before closure season, closure season and after closure season **Park** - Inside and outside **Day -** weekdays and weekends or holidays **(Free-diving fishing)**	**Area** - CSI, VMA, ACO and BPC, nested in **Park**	Weekdays **(n=4)** Weekend/Holidays **(n=2)** Free-diving fishing **(n=5)**
	Easter period	**Low tide** - Shellfish harvesting, Shore angling and bait harvesting, Total predation and Amenity	**Period** - before Easter, Easter, after Easter **Park** - Inside and outside **Day** - weekdays and weekends or holidays	**Area** - CSI, VMA, ACO and BPC, nested in **Park**	All activities **(n=2)**
	Interannual comparisons	**Low tide** - Shellfish harvesting, Shore angling and bait harvesting, Total predation and Amenity	**Year** - 1995, 1996 and 2012 **Period** - before Easter, Easter and after Easter **Park** - Inside and outside	**Area** - CSI, VMA, ACO and BPC, nested in **Park**	All activities **(n=2)**
Yield	**Interviews**	**Low tide** - Shellfish harvesting, Shore angling and Total predation	**Park** - Inside and outside		Shellfish harvesting **(n=17)** Shore angling **(n=16)** Total predation **(n=34)**
	30' anglers observation	**High + Low tide** - Shore angling	**Park** - Inside and outside		Shore angling **(n=17)**

- **Weekly period of banning in the park (Wednesdays, except public holidays)**

Surveys were performed in weekdays (Wd; except Wednesdays) and banning period (Bp; Wednesdays, except public holidays), in areas inside and outside the park. Analyses of this interaction were made, in high tide, considering shore angling intensity and in low tide considering the intensity of shellfish harvesting, shore angling and bait harvesting (these two activities were analysed together due to the fact that after collecting bait during low tide, most fishermen normally angle for fish; see Castro, 2004), and total predation (all fishing activities). Analyses considered the factors Day (orthogonal fixed factor with two levels – Wd and Bp), Park (orthogonal fixed factor with two levels - inside and outside the park) and Area (random factor with two levels, nested in Park).

- **Closure season of *Diplodus sargus* (white sea bream) and *Diplodus vulgaris* (common two-banded sea bream) recreative fishing in the park (periods before, during and after)**

To assess the impact of sea bream closure season, three periods were established: bCS – before closure season (January 6Th to 31Th); CS - closure season (February 1Th to March 15Th); and aCS – after closure season (March 16Th to July 10Th). Data was collected in these periods to assess the impact of this measure on the intensity of the following activities: shore angling (during high tide and low tide); free-diving fishing (each replicate includes observations made during low tide and/or high tide in a single day; arithmetic mean was used when low and high tide data was used); shellfish harvesting, amenity use and total predation in low tide. Analyses considered the factors Period (orthogonal fixed factor with three levels – bCS, CS and aCS), Park (orthogonal fixed factor with two levels - inside and outside the park) and Area (random factor with two levels, nested in Park). Comparisons between periods were made independently to weekdays and weekends/holidays, exception made to free-diving fishing were day type was considered an orthogonal fixed factor with two levels (Wd and Bp; see above).

- **Easter period (periods before, during and after)**

To assess the impact of the 2009 law and the new management plan of the park in fishing activities during Easter, three periods were established: bE – before Easter (January 6Th to February 27Th); E – Easter (March 14Th to May 5Th); and aE – after Easter (May 19Th to July 10Th). The Easter period was chosen in order that the Easter Sunday is approximately in the middle of this period. The other periods have the same length (53 days) and approximately the same gap between them and the Easter period (15 and 13 days, respectively). This temporal organization was chosen in order to allow comparisons with similar data obtained by Castro (2004), who sampled in 1995 and 1996 from January 19th to July 7th, using three periods of 47 to 55 days and gaps of 11 days between them.

Data was collected on the intensity of: shellfish harvesting, shore angling and bait harvesting, total predation and amenity use during low tide, in areas inside and outside the park, regarding weekdays and weekends/holidays. Analyses considered the factors Period (orthogonal fixed factor with three levels – bE, E and aE), Park (orthogonal fixed factor with two levels - inside and outside the park), Day (orthogonal fixed factor with two levels - Wd and Bp; see above) and Area (random factor with two levels, nested in Park).

- **Interannual comparisons (1995, 1996, 2012)**

To allow interannual comparisons among fishing intensity data obtained in 1995 and 1996 (Castro, 2004), prior to the implementation of protective measures applied since 2006, and 2012, after the implementation of such protective measures, observations made in weekends/holidays were taken into account. This interannual analysis was made using data on intensity of shellfish harvesting, shore angling and bait harvesting, total predation and amenity use in low tide, during weekends/holidays. Analyses considered the factors Year (orthogonal fixed factor with three levels – 1995, 1996 and 2012), Period (orthogonal fixed factor with three levels – bE, E and aE; see above), Park (orthogonal fixed factor with two levels - inside and outside the park) and Area (random factor with two levels, nested in Park).

- **Environmental analyses**

On each area and survey, a record of environmental conditions, according to several variables (sea roughness, turbidity of seawater, wind speed and nebulosity/precipitation), was made, using a semi-quantitative scale (Table III).

Table III. Semi-quantitative scale used in the record of environmental conditions made on each area and survey of intensity of human activities on rocky shores of Alentejo.

Variable/Scale	1	2	3	4
Sea roughness	calm	moderately rough	rough	very rough
Seawater turbidity	clear	moderately turbid	turbid	very turbid
Wind speed	low	moderate	high	very high
Nebulosity/Precipitation	no clouds	partly cloudy	very cloudy/ hazy/foggy	very cloudy and rainy

This method, also used by Castro (2004), was used to allow environmental comparisons between years, complementary to the interannual analyses of fishing intensity above referred. Analyses considered the factors Year (orthogonal fixed factor with three levels – 1995, 1996 and 2012), Period (orthogonal fixed factor with three levels – bE, E and aE; see above), Park (orthogonal fixed factor with two levels - inside and outside the park) and Area (random factor with two levels, nested in Park) (Table IV).

Table IV. Summary of sampling design used for the analyses of environmental variables quantified on rocky shores of Alentejo. Areas inside the park are ACO and BPC; areas outside the park are CSI and VMA (Figure 2).

Variable	Orthogonal fixed factors	Random factor	Number of replicates (n)
Sea roughness	**Year** - 1995, 1996 and 2012 **Period** - before Easter, Easter and after Easter **Park** - Inside and outside	**Area** - CSI, VMA, ACO and BPC, nested in **Park**	2
Turbidity of seawater			
Wind speed			
Nebulosity/precipitation			

3.3. Yield of fishing activities

3.3.1. Sampling method

The revenue of fishing activities was assessed by fishermen interviews and observations of anglers' activities during 30', normally performed at the end of fishermen counts.

Normally after roving creel surveys, individual interviews were made to randomly chosen fishermen that were fishing on rocky shores or leaving the shore after fishing. These interviews were directly conducted by researchers of the University of Évora, and the questionnaire used is presented in the Appendix II. All fishing activities were considered, except free-diving fishing due to the difficult access to fishermen during their fishing activity. Information obtained included fishing time, fishing method and species caught. Whenever possible, all species caught and retained by fishermen were identified, counted and weight estimated (fresh weight was visually estimated together with the fisherman/fishermen interviewed). For this analysis of yield only interviews to fishermen that had been fishing for more than half an hour were considered.

A minimum period of 30 minutes observation, during flooding tide, was conducted to assess and characterise anglers catch and bycatch on rocky shores of Alentejo. Information obtained included: fishing time, use of bait and lure, tools used, species caught (both retained and discarded), weather conditions and fishing area (Appendix III). All species retained and discarded by fishermen were identified, counted and their length visually estimated. Observations were made at a distance of tens or hundreds of meters, using 7x50 mm binoculars, in order to not disturb the fishermen during sampling.

3.3.2. Experimental design

- **Interviews**

Using data obtained in the interviews above mentioned, the yield (fresh weight) was calculated per hour and fisherman (see data analysis) in each interview, separating

activities (shore angling and shellfish harvesting) and areas (inside and outside the park). Analyses considered data obtained in each fishing activity, including total predation (in this case, total predation is the sum of the number of observations made in the fishing activities considered: shellfish harvesting and shore angling.), and the factor Park (orthogonal fixed factor with two levels - inside and outside the park; Table II). Data obtained in areas outside (CSI and VMA) and inside the park (ACO, BPC, NAS and ALM) were randomly selected in order to have the same number of replicates in each level of Park factor (Table V).

Table V. Number of interviews per sampling area, randomly selected for the analysis of the yield of fishing activities on rocky shores of Alentejo. Areas inside the park are ACO, BPC, NAS and ALM; areas outside the park are CSI and VMA (Figure 2). In this case, total predation is the sum of the number of observations made in the fishing activities considered: shellfish harvesting and shore angling.

	Area	Shellfish harvesting	Shore angling	Total predation
no-park areas	CSI	7	13	20
	VMA	10	3	14
Park areas	ACO	5	6	11
	BPC	8	7	16
	NAS	1	no obs.	1
	ALM	3	3	6

- **30' anglers observation**

Yield (fresh weight) was calculated per half an hour and angler (see data analysis) observed, separating areas (inside and outside the park). Analyses considered the factor Park (orthogonal fixed factor with two levels - inside and outside the park; Table II). Data obtained in areas outside (CSI – 17 observations) and inside the park (ACO, BPC and ALM – 10, 4 and 3 observations, respectively) were randomly selected in order to have the same number of replicates in each level of Park factor.

3.4. Opinion of Alentejo rocky shores fishermen on the existing fishing management laws and characterization of their fishing activity

Individual interviews were made to randomly chosen Alentejo rocky shores fishermen (when fishing, arriving or leaving the shore). These interviews were directly conducted in Portuguese by researchers of the University of Évora, and the questionnaire used is presented in the Appendix II, translated to English. Information obtained included baseline characteristics of the fishermen (age, sex, place of birth, membership of fishing clubs, fishing experience and place of residence) and fishing trip (fishing time, bait/lure used, target species, fishing method, tools used and species caught). Questions about fishing management and the management plan for the PNSACV natural park were also performed, such as the establishment of MPAs, other restrictions that affect the fishing activities, and proficiency of enforcement by the authorities. The measures listed along with the questionnaire (Appendix IV, translated to English) are a short summary of the existing laws for recreational fishing. This list was created in order to support the interviews performed on fishermen and to enable the organization of results.

3.5. Data analysis

The observed species caught during anglers 30' observation period were grouped, based on most abundant fished species in the Alentejo coast (Veiga et al., 2010) as presented in Table VI. Total catch (fresh weight) was calculated (1) using parameters (Table VI) of fish length-weight relationship for observed species presented by FishBase (Froese & Pauly, 2011), as described in Table VII. Yield of shore angling, in areas inside and outside the park, was calculated per half an hour. Analyses considered the factor Park (orthogonal fixed factor with two levels - inside and outside the park; Table II). Data obtained in areas outside (CSI and VMA) and inside the park (ACO, BPC, NAS and ALM) were randomly selected in order to have the same number of replicates in each level of Park factor.

(1) $$W = a \cdot L^{b}$$

W= fresh weight; a and b = species parameters and L = length

Table VI. Observed species (Portuguese and English common name) caught during anglers 30' observation period and the species used to calculate the fish length-weight rate, based on the most abundant fished species in the Alentejo coast (Veiga et al., 2010).

Observed species	Most abundant fished species	Species used
Robalos (Sea basses)	*Dicentrarchus labrax* *Dicentrarchus punctatus*	*Dicentrarchus labrax*
Sargos (Sea breams)	*Diplodus spp.* *Spondyliosoma cantharus*	*Diplodus sargus*
Burrinhos (Wrasses)	*Ctenolabrus rupestris* *Symphodus bailloni* *Symphodus melops*	*Symphodus melops*
Cabozes (Blennies)	*Gobius spp.* *Parablennius tentacularis* *Lipophrys pholis*	*Lipophrys pholis*
Cavalas (Mackerels)	*Scomber japonicus* *Scomber scombrus* *Scomberomorus cavalla*	*Scomber japonicus*
Tainhas (Mullets)	*Chelon labrosus* *Liza aurata* other *Mugilidae*	*Chelon labrosus*

Table VII. Fish length-weight relationship parameters **a** and **b** used in equation (1), considering species referred in Table VI (Froese & Pauly, 2011; **n** - number of individuals examined in the population).

Species	Country	Region	Sex	a	b	Length (cm)	n
Dicentrarchus labrax	Portugal	South-west coast, 1992-94	unsexed	0.0083	3.039	33.5 - 80.5	799
Diplodus sargus	Portugal	South-west coast, 1992-94	unsexed	0.0101	3.168	15.0 - 47.0	1159
Symphodus melops	Portugal	Arade estuary, central Algarve, 2004-2007	unsexed	0.0112	3.170	4.5 - 18.0	No data
Lipophrys pholis	France	No data	unsexed	0.0093	3.000	No data	No data
Scomber japonicus	Portugal	Nazaré to St André, 1997	unsexed	0.0020	3.442	19.5 - 46.4	323
Chelon labrosus	Portugal	Arade estuary, central Algarve, 2004-2007	unsexed	0.0080	3.100	8.0 - 34.2	No data

Comparisons between mean values of intensity of fishing activities (mean values of users.Km^{-1}) and yield of fishing activities (mean values of $kg.h^{-1}.fisher^{-1}$ – interviews and kg per 30' - anglers 30' observation period) according to Table II were carried out by nested ANOVA. These statistical analyses were made according to Underwood (1997), after having satisfied the requirements for parametric analysis (Cochran's Test), and using "GMAV5 software for Windows" (Institute of Marine Ecology, University of Sydney). Student-Newman-Keuls (SNK) test was performed for the multiple comparisons of means, in accordance with Underwood (1997), using the referred software. Comparisons among years regarding environmental analyses were also carried out by ANOVA and SNK tests.

The assumption of homogeneity of variances was verified with Cochran's test (Winer et al., 1991), and the transformation of data was used when it was able to eliminate or reduce the heterogeneity of variances. However, some analyses of variance performed reveal significant heterogeneity, even after transformation of the data, thus violating the assumption of homogeneity of variances required for this type of analysis (Underwood, 1997). According to this author, the significant differences detected in those cases can be deceptive, because the heterogeneity of variances increases the probability of rejecting the null hypothesis when it is true (type I error). Nevertheless, the analysis of variance is robust against violation of the assumption when data are balance (sizes of samples are all made the same) and where samples are relatively large (Underwood, 1997). The same author believes that the samples can be considered to be relatively large when there are more than five treatments and six replicates. Benedetti-Cecchi (2004) state that these problems are resolved if the analysis involves more than forty degrees of freedom in the residual variation.

4. RESULTS

4.1. Intensity of fishing activities

A total of 63 roving creel surveys were performed along the sampling period, from January 6Th to July 10Th 2012: 29 surveys were made during spring low tides (13

weekdays, except Wednesdays, 7 Wednesdays, and 9 weekend days or public holidays) and 34 during spring high tides (17 weekdays, except Wednesdays, 8 Wednesdays, and 9 weekend days or public holidays).

A total of 1890 observations of fishermen carrying out fishing activities were made, 67.6% (1277 observations) of them were made in areas located outside the park, and 32.4% (613 observations) were made in areas located inside the park. Low tide surveys registered 1096 fishing activities and high tide surveys 794.

Shore angling (43.5%) and shellfish harvesting (35.7%) were the most frequently observed human activities, representing 79.2% of the total observations of people using rocky shores of Alentejo during spring low and high tides. The other activities using rocky shores of Alentejo in decreasing order of number of observations made, were free-diving fishing (10.9%), amenity use (using the shore without fishing; 10%) and bait collecting (3.5%).

Throughout a seven month sampling period, a global mean value of 1.32 users.Km^{-1}.day^{-1} was observed on rocky shores of Alentejo (Table VIII). During weekends/holidays a globally higher number of users was recorded when compared with weekdays (inside the park – weekdays, except Wednesdays).

Areas outside the park showed a global more intensive fishing use than park areas (Tables VIII and IX). The same pattern was observed regarding day type, with areas outside the park reporting a higher global number of users when compared with areas inside the park (Table VIII).

Table VIII. Global mean values of users.Km^{-1}.day^{-1} observed during spring tides on rocky shores of Alentejo from January 6Th to July 10Th 2012 (park – PNSACV natural park, see Figure 1).

	users.Km^{-1}.day^{-1}		
	Both areas	**Outside Park**	**Inside Park**
Sampling period	1.32	1.65 (n=63)	0.99 (n=48)
Weekdays	0.93	1.19 (n=45)	0.66 (n=30)
Weekends/holidays (n=18)	3.37	2.80	1.54

Table IX. Global mean values of users.Km^{-1}.day^{-1} during low and high spring tides in areas inside (weekdays, except Wednesdays, and weekends/holidays) and outside the park (weekdays and weekends/holidays) by activity, observed on rocky shores of Alentejo from January 6Th to July 10Th 2012 (park – PNSACV natural park, see Figure 1): low tide – shellfish harvesting, shore angling and bait harvesting, amenity use and total predation; low and high tide – free-diving fishing.

	users.Km^{-1}.day^{-1}		
	Total	**Outside park (n=63)**	**Inside park (n=48)**
Shellfish harvesting	0.89	0.51	0.39
Shore angling and bait harvesting	1.20	0.86	0.34
Free-diving fishing	0.29	0.18	0.11
Total predation	2.38	1.55	0.84
Amenity use	0.26	0.10	0.15

- **Weekly period of banning in the park**

The weekly period of banning analyses results are presented in Figure 3. Anova performed revealed a significant interaction **Day X Park** for shore angling and bait harvesting and total predation (Appendix V; Figure 3). In spite of the heterogeneous variance reported, even after transformation of the data, in the total predation ANOVA, the analysis can be considered robust, since the degrees of freedom of residual variation is higher than forty (Benedetti-Cecchi, 2004). Shore angling and shellfish harvesting ANOVA revealed significant differences in factor **Area** (Appendix V).

The results of SNK tests on the **Day X Park** interaction (Appendix V; Figure 3) showed that the number of fishermen.Km^{-1} in areas inside the park (ACO, BPC), was higher during weekdays (expect Wednesdays) than in the banning period (Wednesdays except public holiday). The number of fishermen.Km^{-1} in areas outside the park was similar, yet during banning period these areas reported a higher number of fishermen.Km^{-1} when compared with park areas. The SNK tests made to the factor **Area** showed differences in number of fishermen.Km^{-1} practicing shore angling (CSI>VMA) and shellfish harvesting (CSI<VMA; Appendix V).

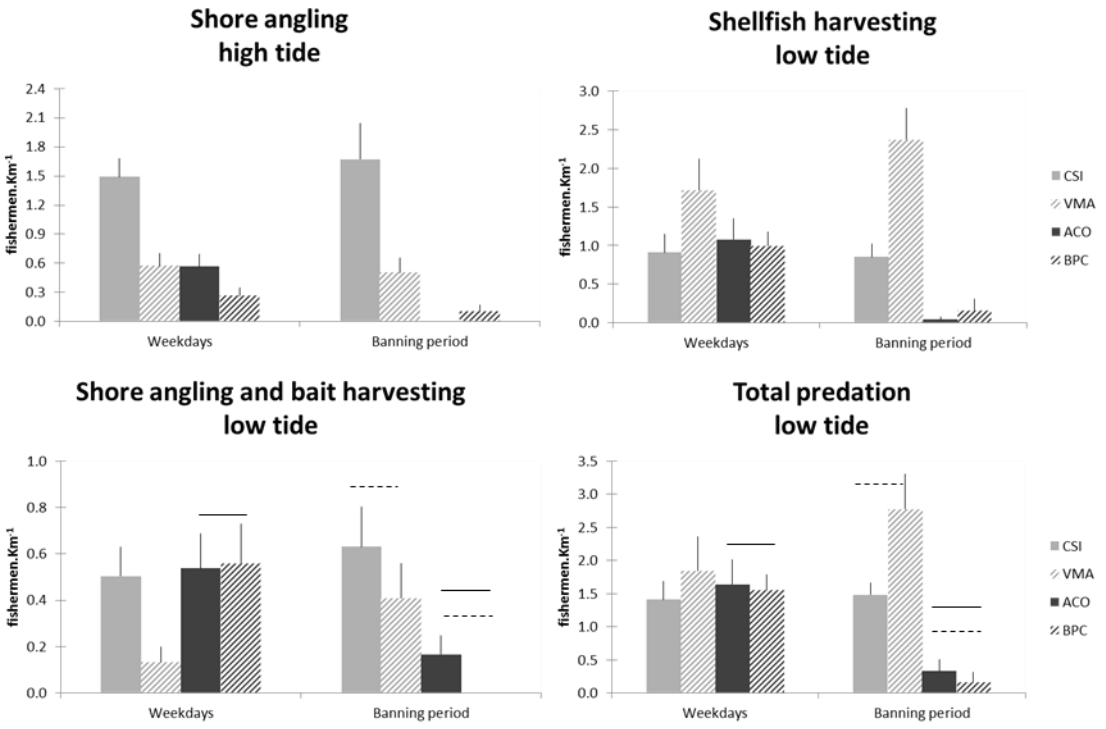

Figure 3 – Number of fishermen.Km^{-1} (mean+SE) by activity made on rocky shores of Alentejo during weekdays (except Wednesdays) and weekly banning period (Wednesdays; except holidays) in areas outside (CSI, VMA) and inside the park (ACO, BCP). According to significant interaction between the factors day and park detected by ANOVA, SNK tests allowed the identification of two groups per variable in the intensity of shore angling and bait harvesting, and total predation (horizontal line segments; Appendix V).

- **Closure season of** *Diplodus sargus* **and** *Diplodus vulgaris* **in the park**

Results on number of users/fishermen.Km^{-1} during the sea bream closure season, both on weekdays and weekend/holiday, regarding shore angling, free-diving fishing, shellfish harvesting, amenity use and total predation, are presented in Figure 4. The analyses of data obtained in weekdays (except Wednesdays) and weekends/holidays were made separately (Appendix VI). In the case of free-diving fishing, each replicate includes observations made during low tide and/or high tide in a single day (Appendix VI). ANOVA performed revealed a significant interaction **Period X Area** in the intensity of low tide shore angling and shellfish harvesting during weekends/holidays, and in the

intensity of amenity use during weekdays (Appendix VI). ANOVA also revealed significant differences in factor **Area** in shore angling (low and high tide), shellfish harvesting and total predation, during weekdays, and in high tide shore angling during weekends/holidays (Appendix VI). ANOVA performed to data on free-diving fishing didn't reveal significant factors or interactions (Appendix VI).

The significant heterogeneity variance reported, in weekdays low tide shore angling ANOVA, even after transformation of the data, affects the significant differences detected in factor **Area**. In this analysis, the number of replicates is four and the number of treatments is five, even more the degrees of freedom of residual variation is lower than forty. Consequently, the significant differences detected can be deceptive since we may incur in a type I error as indicated by Underwood (1997).

The SNK tests performed to assess **Period X Area** interaction (Appendix VI) showed that: the intensity of low tide shore angling in CSI, on weekends/holidays, was higher in the period after closure season; number of fishermen.Km^{-1} regarding shellfish harvesting in VMA, on weekends/holidays, showed an increase along the periods (before<during<after), and amenity use in ACO, during closure season on weekdays, was higher than in periods before and after.

The SNK tests made to the factor **Area** showed significant differences in number of fishermen.Km^{-1} in the following cases: shellfish harvesting (CSI<VMA) during weekdays; low and high tide shore angling (CSI>VMA), during weekdays; high tide shore angling (CSI>VMA) during weekends/holidays; and total predation (CSI<VMA), during weekdays.

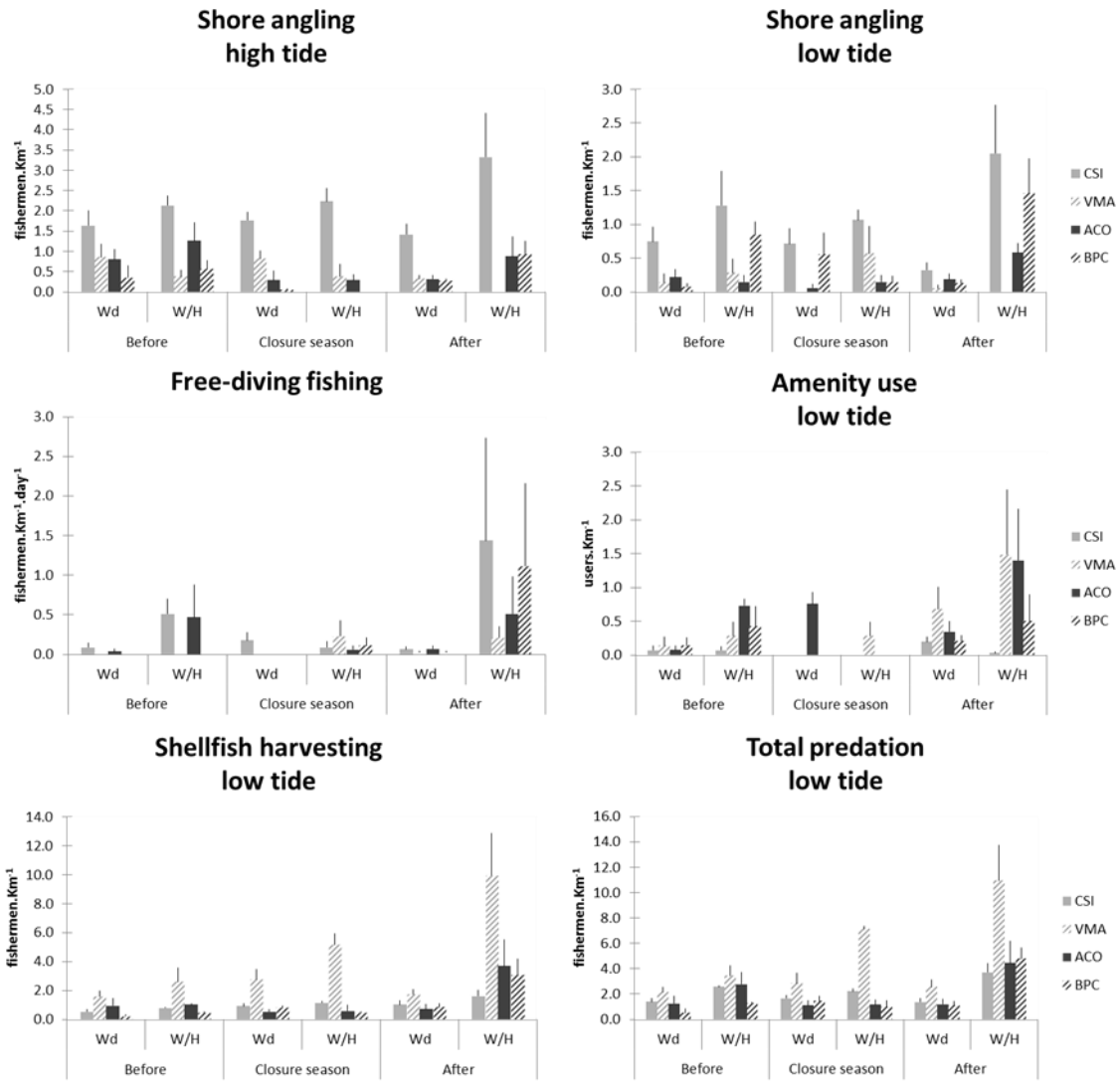

Figure 4 – Number of users/fishermen.Km^{-1} (mean+SE) by activity made on rocky shores of Alentejo during weekdays (Wd; except Wednesdays) and weekend/holidays (W/H) in areas outside (CSI; VMA) and inside the park (ACO; BCP) concerning the study of the effects of the sea bream closure season applied to recreational fishing in the natural park PNSACV (before closure - January 6Th to 31Th, closure - February 1Th to March 15Th, after closure - March 16Th to July 10Th; periods sampled in 2012 during spring tides; analyses of data obtained in weekdays and weekends/holidays were made separately).

- **Easter period (periods before, during and after)**

Data obtained on weekdays (except Wednesdays) and weekends/holidays, regarding the number of users/fishermen.Km^{-1} observed in the Easter 2012 period (and periods before and after) in the activities of shellfish harvesting, amenity use, shore angling and bait harvesting and total predation are offered in Figure 5. ANOVA performed reveal significant interactions **Period X Day** in shellfish harvesting and **Day X Area** in

total predation (Appendix VII). ANOVA also revealed significant differences in the following factors: **Area**, concerning shellfish harvesting; **Day**, in shore angling and bait harvesting; and **Period**, in total predation. ANOVA performed with amenity use data didn't reveal significant factors or interactions (Appendix VII).

The SNK tests performed to assess **Period X Day** interaction (Appendix VII; Figure 5) showed that in weekdays shellfish harvesting was lower during the after Easter period and in weekends/holidays shellfish harvesting was higher during the Easter period when compared to the before and after periods. The SNK tests regarding **Day X Area** interaction revealed that in VMA the total predation was higher during weekends/holidays.

The SNK tests on the factor **Area** showed significant differences in number of fishermen.Km^{-1} practicing shellfish harvesting (CSI<VMA). SNK tests also revealed significant differences in the factor **Day**, in shore angling and bait harvesting (Wd<W/H), and the factor **Period**, showed significant differences in total predation (E>bE=aE).

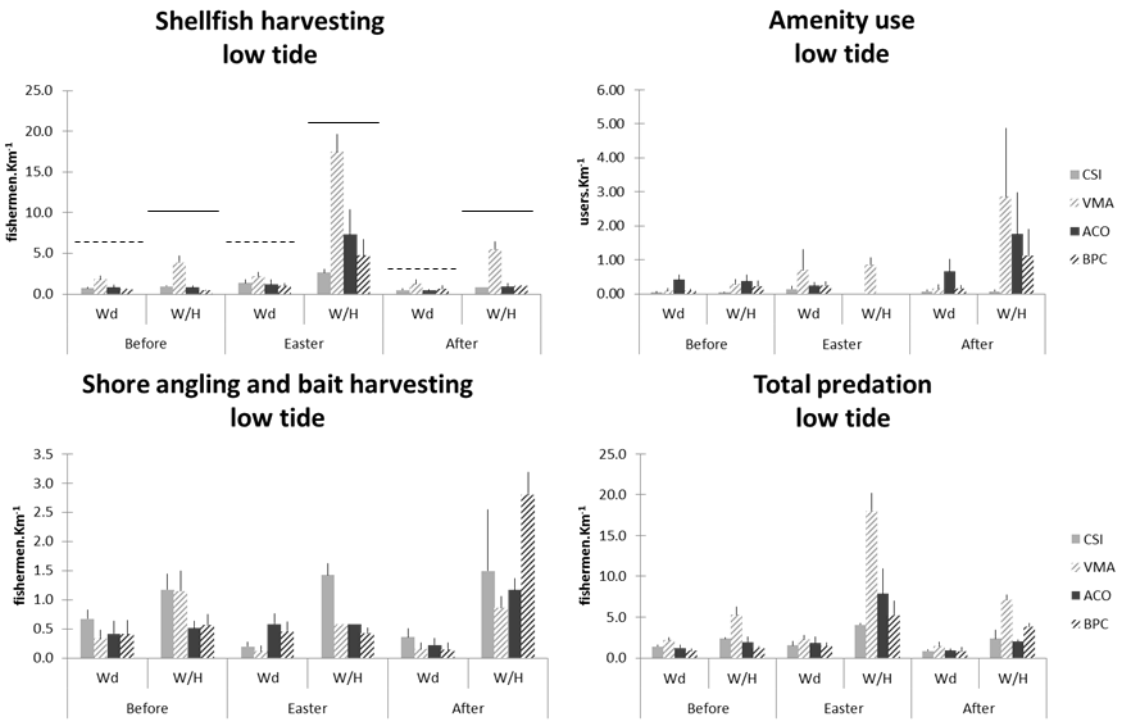

Figure 5 – Number of users/fishermen.Km^{-1} (mean+SE) by activity made on rocky shores of Alentejo during weekdays (Wd; except Wednesdays) and weekends/holidays (W/H) in areas outside (CSI; VMA) and inside the park (ACO; BCP) concerning the study of the Easter period (before Easter - January 6Th to February 27Th, Easter - March 14Th to May 5Th, after Easter - May 19Th to July 10Th; periods sampled in 2012 during spring tides). According to significant interactions between the factors period and day detected by ANOVA, SNK tests allowed the identification of groups (two on weekdays and two on weekends/holidays) in the intensity of shellfish harvesting (horizontal line segments; Appendix VII).

- **Interannual comparisons (1995, 1996 and 2012)**

Interannual comparisons among periods (only low tide weekends/holidays were taken into account) regarding shellfish harvesting, amenity use, shore angling and bait harvesting, and total predation is presented in Figure 6. ANOVA performed reveal significant interactions **Year X Period X Area** in total predation, and **Period X Area** plus **Year X Period** in shellfish harvesting and total predation (Appendix VIII). ANOVA also revealed significant differences in the factors **Area** (shore angling and bait harvesting) and **Year** (shore angling and bait harvesting). ANOVA performed with amenity use data didn't reveal significant factors or interactions (Appendix VIII).

The significant heterogeneity variance reported in the ANOVA of shellfish harvesting data, even after transformation of the data, affects the significant differences

detected. In this analysis, the number of replicates is two and the number of treatments is eight, even more the degrees of freedom of residual variation is lower than forty. Consequently the significant differences detected can be deceptive since we may incur in a type I error as indicated by Underwood (1997).

The SNK tests performed to assess **Year X Period X Area** interaction (Appendix VIII) showed that total predation in Easter of 1995 and 2012 was higher than in Easter of 1996 in the sampling areas VMA and ACO. Regarding the sampling area BPC, total predation in Easter of 1995 was higher than in Easter of 1996 and 2012. Total predation observed in Easter and in the sampling area CSI showed no significant interannual variation.

The SNK tests made to assess **Period X Area** interaction revealed that total predation and shellfish harvesting were higher during Easter in the sampling areas VMA, ACO and BPC. No significant differences were found between periods in the area CSI.

The SNK tests made to assess **Year X Period** interaction revealed that total predation in Easter of 1995 and 2012 was higher than in Easter of 1996, and that shellfish harvesting in Easter of 1995 was higher than in 2012 and 1996 (1995>2012>1996; Figure 6). No significant differences were found between years in the periods before and after Easter. In 1995 and 2012 significant differences were found among periods (E>bE=aE).

The SNK tests on the factor **Area** showed significant differences in number of fishermen.Km^{-1} in shore angling and bait harvesting (CSI>VMA). Concerning the factor **Year**, SNK tests revealed significant differences in number of fishermen.Km^{-1} practicing shore angling and bait harvesting (2012>1995>1996).

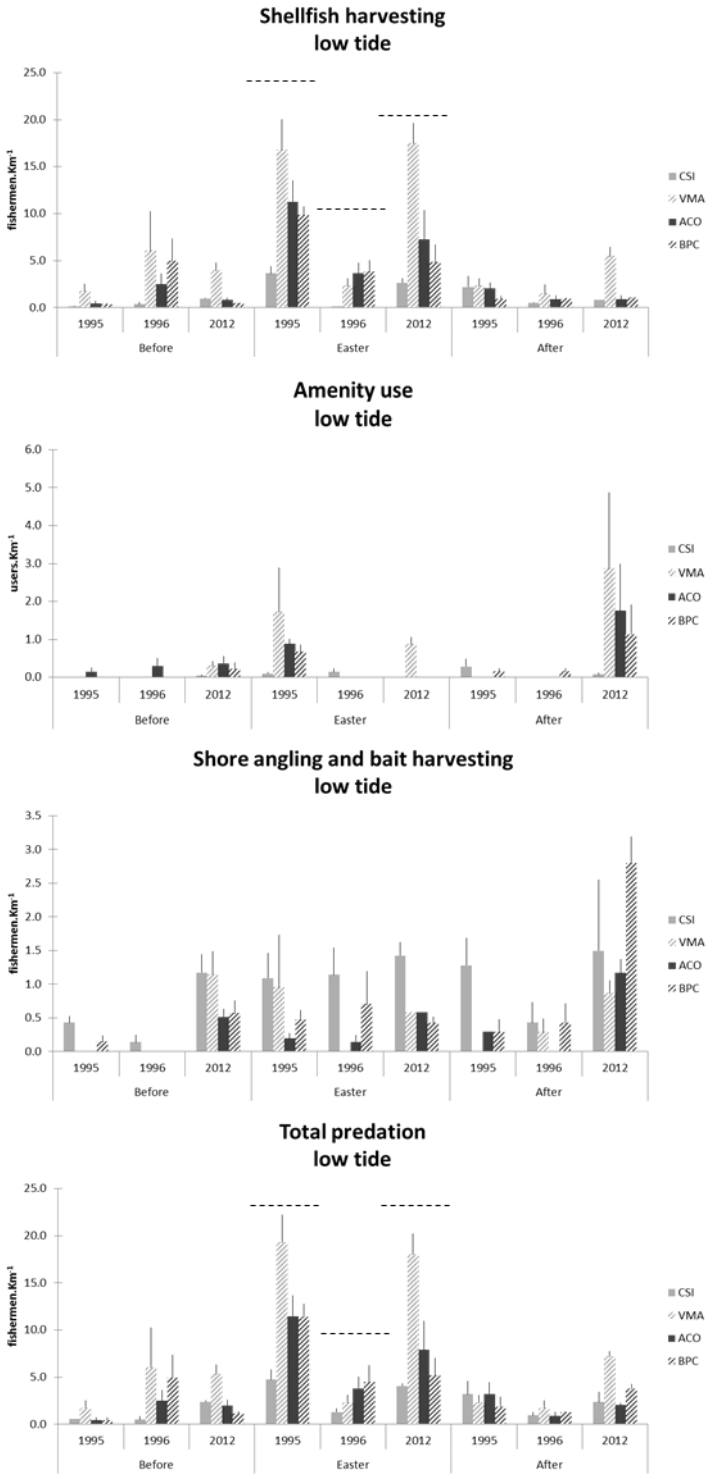

Figure 6 – Interannual comparisons (1995, 1996 and 2012) among number of users/fishermen.Km^{-1} (mean+SE) by activity made on rocky shores of Alentejo during weekends/holidays (W/H) in areas outside (CSI; VMA) and inside the park (ACO; BCP) concerning for the study of the Easter period (before Easter, Easter, after Easter). According to significant interactions between the factors year and period detected by ANOVA, SNK tests allowed the identification of groups (two on total predation and three on shellfish harvesting) in the intensity of shellfish harvesting and total predation (horizontal line segments; Appendix VIII).

- **Environmental analyses**

Data regarding environmental analyses is depicted in Figure 7. ANOVA performed reveal significant interactions **Year X Period** in sea roughness, turbidity of seawater and nebulosity/precipitation, and **Year X Area** in sea roughness (Appendix IX). ANOVA also revealed significant differences in factor **Area, Period and Year** (wind speed).

The SNK tests performed to assess **Year X Period** interaction (Appendix IX; Figure 7) showed that in the before Easter period the sea roughness, turbidity of seawater and nebulosity/precipitation were higher in the years of 1995 and 1996. During Easter period, sea roughness, turbidity of seawater and nebulosity/precipitation were higher in 1996. However, turbidity of seawater was different in all years (1996>2012>1995) during the same period. In the after Easter period no significant differences were found regarding sea roughness. Turbidity of seawater was higher in 1996 (1996>1995>2012), and nebulosity/precipitation was greater in 1995 (1995>1996), during the same period. The SNK tests made to assess **Year X Area** interaction revealed that sea roughness was higher in 1996 in CSI and BPC, when compared with the other two years.

Regarding wind speed, the SNK tests performed to the factors: **Period** showed significant differences in wind speed (before Easter>Easter); **Year** (1996>1995>2012); and **Area** (CSI>VMA and ACO<BPC).

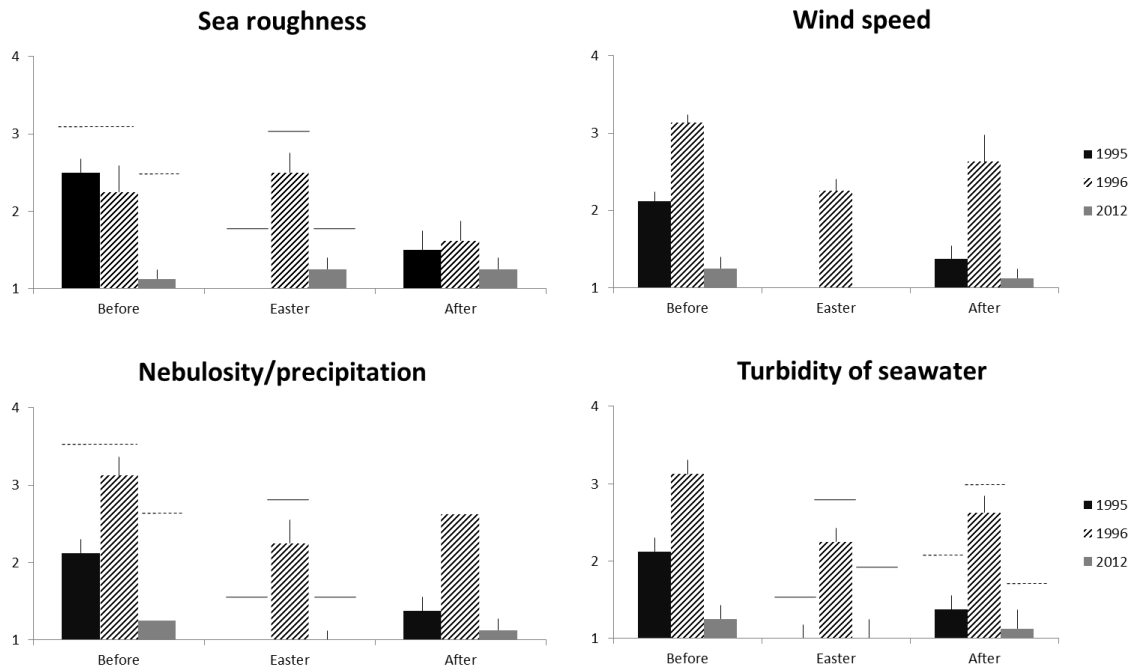

Figure 7 – Interannual comparisons (1995, 1996 and 2012) of environmental variables (sea roughness, turbidity of seawater, wind speed and nebulosity/precipitation) sampled with a semi-quantitative scale on rocky shores of Alentejo (mean+SE) during the Easter and periods before and after Easter. According to significant interactions between the factors year and period detected by ANOVA, SNK tests allowed the identification of various groups in sea roughness, turbidity of seawater and nebulosity/precipitation (horizontal line segments; Appendix IX).

4.2. Yield of fishing activities

- **Interviews**

Direct interviews revealed a total weight of approximately 3 tons (total fresh weight estimated jointly with each fisherman was 2948 kg) of marine animals captured by 122 fishermen in a 164 hours period, thus providing an global average yield of 0.15 $Kg.h^{-1}$ per fisherman.

The mean yield obtained in shellfish harvesting, shore angling and total predation in both types of area (inside and outside the park) is presented in Figure 8. Comparisons between these types of area (Appendix X; Figure 8) showed significant differences in total predation, as yield was higher in areas inside the park.

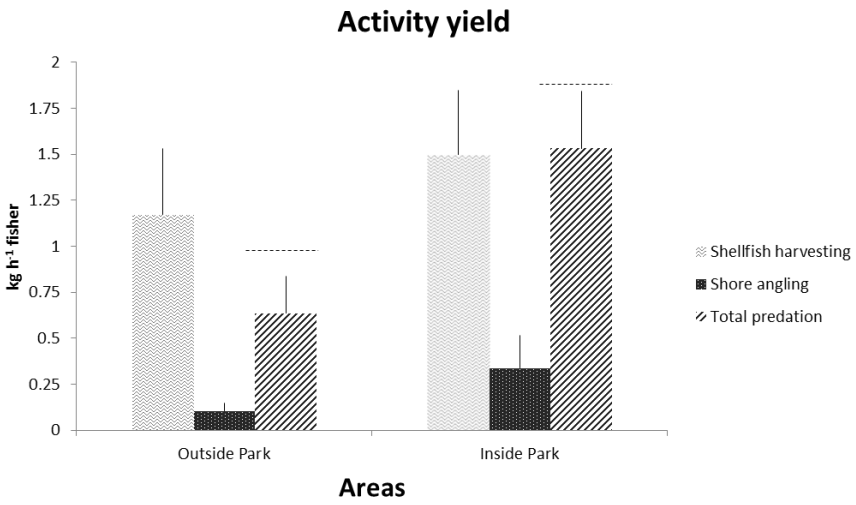

Figure 8 – Yield (mean+SE) by activity (shellfish harvesting, shore angling and total predation; one ANOVA was made in each activity) obtained during spring low tides in areas outside and inside the park PNSACV, according to direct inquiries made to fishermen exploiting rocky shores of Alentejo. According to significant interactions in the factor park detected by ANOVA, SNK tests allowed the identification of two groups in the yield of total predation (horizontal line segments; Appendix X).

- **30' anglers observation**

A total of 39 anglers were observed at least during a 30 minutes period. Approximately 2.15 Kg of fishes were captured (total time of observation was 2464 minutes), thus providing an average yield of 0.04 Kg/30'per fisherman. Species retained belong to several families such as: *Moronidae* (temperate basses); *Sparidae* (sea breams); *Labridae* (wrasses); *Blenniidae*/*Gobiidae* (combtooth blennies/gobies); *Scombridae* (mackerels); and *Mugilidae* (mullets). Only four individuals were discarded, which represented 1.7% of captures: three *Blenniidae*/*Gobiidae*, and one *Labridae*.

Obtained yield for both areas (inside and outside the park) are represented in Figure 9. Comparisons of yield mean values did not reveal significant differences between areas (Appendix XI).

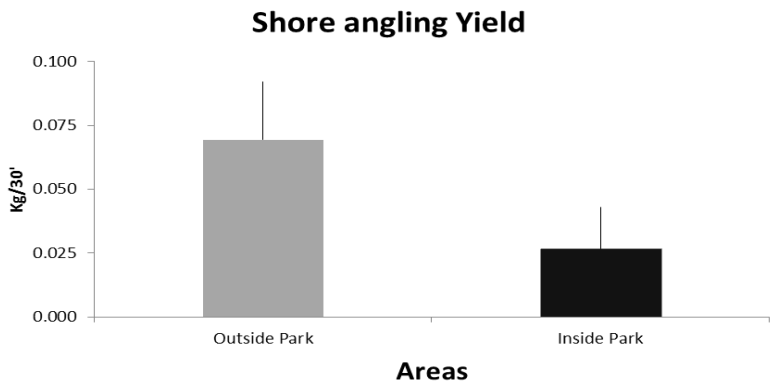

Figure 9 – Shore angling yield (mean+1SE) obtained during 30 minutes periods of daytime flooding tide in areas outside and inside the park PNSACV, according to direct observations of anglers made on rocky shores of Alentejo. No significant differences were found between the two types of area considered.

4.3. Opinion of Alentejo rocky shores fishermen on the existing fishing management laws and characterization of their fishing activity

In the sampling period, 97 fishermen were contacted to be interviewed on rocky shores of Alentejo. Of these, only two fishermen refused to be inquired, but several fishermen did not answer to some asked questions. Inquiries revealed that 92% (n=95) of fishermen interviewed usually exercise some fishing activity in the Alentejo coast. A total of 72% (n=93) acknowledges having usually exercised these activities within the natural park (PNSACV). Frequency of fishing activities on rocky shores of Alentejo varies from rarely/few days per month (56%, n=87) to daily/some days per week (42%, n=87).

Fishermen interviewed in the Alentejo coast are mostly male (98%, n=95) employed in manufacturing sectors (43%, n=85) or pensioners/unemployed/students (30%, n=85), 31 – 50 (41%, n=92) and over 50 (51%, n=92) years old.

Residents in municipalities with territory enclosed in the natural park, such as Sines and Odemira, represented 80% (n=89) of fishermen interviewed (88% were interviewed in areas outside the park and 73% in areas inside the park) and the remaining 20% were resident in municipalities with no territory within the park limits (12% were interviewed in areas outside the park and 27% in areas inside the park). About 66% (n=90) reported birthplace in municipalities with territory enclosed in the park (66% were interviewed in areas outside the park and 67% in areas inside the

park). The remaining 33% reported other birthplace (34% were interviewed in areas outside the park and 33% in areas inside the park). Of the 39 interviews performed to shellfish harvesters in park areas only 5 reported birthplace or residence in municipalities with no territory within the park limits.

Interviews revealed that 95% (n=85) of fishermen possessed one or more fishing licences (82% had a shore fishing recreative license, 8% a boat recreative license, 4.65% a commercial license, 3.5% a multipurpose recreative license and 1.2% a freshwater fishing license). However, approximately 98% (n=83) of the interviewed fishermen reported not being members of any fishing organisation. Only two reported being members of a fishing organization (Rosa do Ventos – Clube de pesca desportivas do Almograve).

Most fishermen interviewed (90%, n=95) were, had been or were going to perform shore angling or shellfish harvesting, some of them both or other activities (3% - shore angling and bait harvesting, 3% - shore angling and shellfish harvesting, and 1% - all these three activities). The remaining 3% had been or were going to perform free-diving fishing. Most fishermen declared that in shore angling they usually target two fish species (72%, n=35): *Diplodus sargus* (white seabream), and *Dicentrarchus labrax* (european sea bass). In shellfish harvesting, most fishermen (over 79%; n=58) stated that they usually target the following species: *Octopus vulgaris* (octopus), *Necora puber* (velvet swimming crab), *Paracentrotus lividus* (sea urchin) and *Pollicipes pollicipes* (stalked barnacle).

Over 90% (n=88) of fishermen said that catches are intended to be eaten by himself/herself, with family and/or friends. Most inquired fishermen acknowledged that fishing on rocky shores is important as a leisure activity (65.5%, n=88) but is also important as a food supply for himself/herself, his/her family and/or friends (30%). About 2% of recreational fisherman recognized that part of the catches is for sale, thereby assisting their economy or their own family.

About 61% (n=87) acknowledge the fact that they have exercise some fishing activity in the Alentejo coast for more than 20 years. Most fishermen considered that the catch obtained in the day they were interviewed is much lower than expected (61%, n=85),

and 74% (n=86) stated that daily catch has greatly decreased since they fish on rocky shores of Alentejo.

Over 88% (n=88) of inquired fishermen are aware of the Portuguese recreational fishing laws applied in the continent and in the natural park PNSACV. Nearly 62% (n=76) argued that some measures (one or more) of these legislations harmfully affect their fishing activity on the shores of Alentejo. Measures most referred by fishermen were: "*all measures"* (21%, n=47); and measures 17 (21%), 7 (19%), 28 (17%) and 8, 10 (14.9%; Appendix IV; Figure 10). On the other hand, 54% (n=64) of the inquired fishermen were in agreement with at least one measure of these regulations. Measures 3, 16, 17 (17%, n=35), and 18, 7 (14.3%) got the highest agreement by fishermen (Figure 11).

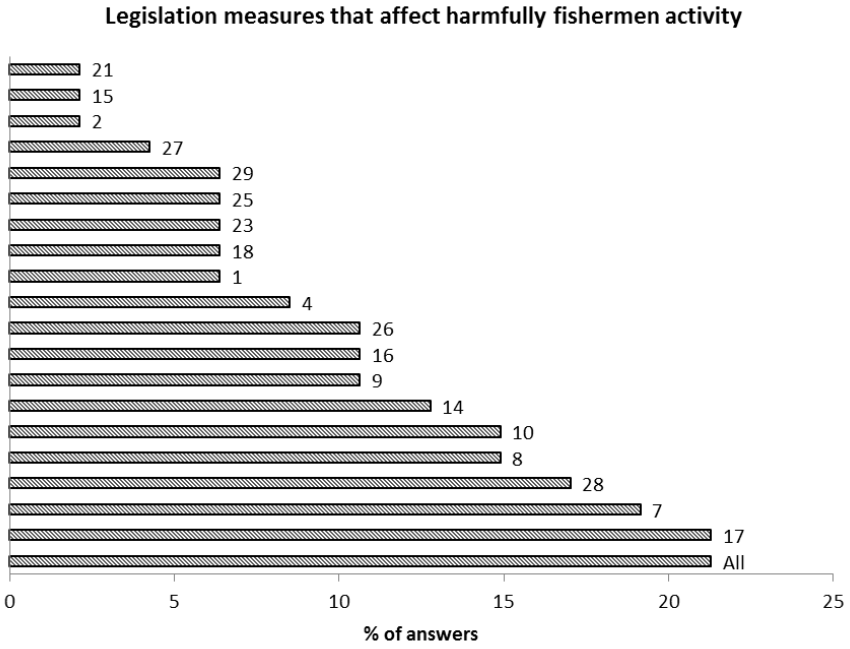

Figure 10 – Answer frequency (%) of fishermen interviewed on rocky shores of Alentejo regarding measures of Portuguese recreative fishing legislation (see list of measures on Appendix IV) that harmfully affect their fishing activity on shores of Alentejo (n=47).

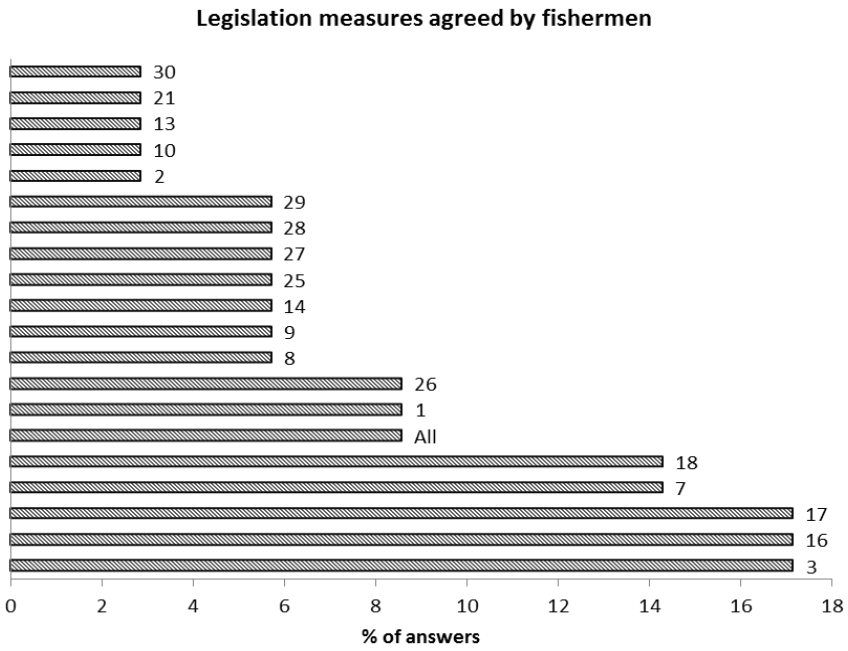

Figure 11 – Answer frequency (%) of fishermen interviewed on rocky shores of Alentejo regarding measures of Portuguese recreative fishing legislation (see list of measures on Appendix IV) they agree with (n=35).

Most (61%, n=84) inquired fishermen stated that were inspected by authorities, at least once, when they were fishing on the shore. Of these 84 fishermen, only 14% (n=52) acknowledged having been fined. Enforcement of regulation measures by the authorities on shore fishing had mixed views by the inquired fishermen (n=81): 24% said that it should be less intense; 26% said that it is made with proper intensity; 22% said that it should be more intense and 28% had no opinion.

When confronted with the MPAs newly created in PNSACV, where fishing is restricted or totally forbidden, 74% (n=75) of the inquired fishermen acknowledged their existence. From the 43% (n=69) that agreed with the creation of these MPAs, only sixteen (53%, n=30) stated the reasons for it. All these sixteen fishermen agreed that these protected areas favour the sustainability of populations' exploitation, by improving the reproduction of marine species in order to preserve fish stocks. Notwithstanding, 53% (n=84) of the inquired fishermen claimed that these MPAs harmfully affect their fishing activity on the shores of Alentejo because they used to fish on a regular basis on those areas.

5. DISCUSSION

5.1. Review of used methods

The Alentejo rocky coast contains several types of landscapes, including high and steep cliffs and numerous bays, islets and reefs, generating an additional difficulty for the surveying method used in the present study, for the analysis of fishing intensity. This may have led to a slight underestimation of the number of fishermen, as a small percentage could have not been detected. Thus, data obtained may show an error associated to the method (Pollock et al., 1997). Other methods, in future studies should be combined to minimise this problem, such as boat surveys. Combined methods should allow more accurate observations. Erzini et al. (2009) combined aerial surveys with fishermen interviews performed along a specific coast route. Other authors recommend the combination of on-site methods like "access point survey" with off-site methods (Pollock et al., 1997).

The interviews performed allowed us to estimate the catch rate and total capture of Alentejo rocky shores fishermen. There is an associated estimation error, since incomplete catch data is only obtained by overlooking the data from final catch (Pollock et al., 1997). In order to reduce estimation error this method should be combined with the "access point survey", which will allow the collection of data on final catches (Marcelino, 2010). However, in the present study several interviews were performed to fishermen during their fishing activity. Therefore, yield obtained was calculated by weight per fisher per hour opposed to weight per fisher per fishing day.

Interviews comprise some degree of uncertainty associated with the acceptance of it by respondents. In this study the refusal rate was very low (2%, n=97).

5.2. Intensity of fishing activities

- **Global mean values**

During the study period, some types of fishing activities were observed in the Alentejo rocky coast, namely: shore angling, shellfish harvesting, free-diving fishing and bait collection. Popularity of these fishing activities in the Portuguese territory is

demonstrated in other studies (Oliveira, 2003; Castro, 2004; Diogo, 2007; Marcelino, 2010).

The main activities observed were shore angling and shellfish harvesting, representing 79.2% of the observations made. Castro (2004) concludes that from all human activities made on Alentejo rocky shores, shellfish harvesting involved a larger number of people, although a high frequency of anglers has also been reported.

From observations made in 2012 on rocky shores of Alentejo, a mean value of 1.32 users.Km^{-1}.day^{1} was obtained regarding the intensity of all human activities (including amenity use), throughout the sampling period (January-July) and during spring tides (low and high tide). That global mean value obtained in 2012 is lower than the mean values recorded in 1994-1996 by Castro (2004). However, Castro (2004) observations were made also during summer, and this author concluded that human use of rocky shores of Alentejo is regular but generally more intensive during summer. Furthermore, the majority of the observations made in this study were made in the northern region of the study area.

Higher global mean values of users were recorded during weekends/holidays when compared to weekdays (except Wednesdays). According to Lasiak (1997), some studies (e.g. Kingsford et al., 1991) indicate that coastal metropolitan areas are more exploited by man during summer periods, holidays and on weekends. Underwood (1993) refers that, in weekends, the state of New South Wales (Australia) presents a higher usage of rocky shores in opposition to weekdays. The importance of day type in abundance of users in the Alentejo rocky shores, suggests that the recreational and entertainment component of fishing activities is quite important (Castro, 2004). This author states that higher intensity observed during summer periods and weekends/holidays is related to a recreational use of the shore, due to a higher abundance of people using the shore for recreational purposes (Castro, 2004). However, Castro & Cruz (2009) say that the regularity of human predation suggests that the predatory use of the shore may also be important for subsistence, was verified by interviews performed to Alentejo rocky shores fishermen, were 30% acknowledged the importance as a food supply for himself/herself, his/her family and/or friends.

When comparing human activities made during spring tides, Castro (2004) reported higher mean values, except free-diving fishing (Table X). In South Africa, Hockey et al. (1988) and Lasiak (1997) also reported higher mean values during spring tides, regarding shellfish harvesting (8.58), total predation (5.90) and total use (10.00 and 7.30 respectively). Other studies (Underwood & Kennelly, 1990; Durán et al., 1987) reported similar mean values with the present study, for shellfish harvesting, total predation, amenity use and total use. However, data from those studies were obtained in low tides, during spring and neap tides.

Table X. Intensity (global mean value of users.Km^{-1}.day^{-1}) of human activities observed on rocky shores of Alentejo in the present study (observations made from January to July 2012) and reported by Castro (2004; observations made from July 1994 to July 1996). The values presented were obtained during low tide (shellfish harvesting, shore angling and bait harvesting, total predation and amenity use) or low and high tide (free-diving fishing) of spring tides (except the intensity of amenity use reported by Castro, 2004).

	users.Km^{-1}.day^{-1}	
	Present study	**Castro (2004)**
Shellfish harvesting	0.89	7.51
Shore angling and bait harvesting	1.20	1.85 **(only shore angling)**
Free-diving fishing	0.29	0.23
Total predation	2.38	10.10
Amenity use	0.26	2.19 **(neap and spring tides)**
Total	1.32	7.77

This study revealed a higher intensive use in areas outside the park when compared with areas inside the park. This pattern could suggest that restrictions imposed by the MP and by recreative fishing regulations negatively affected the number of users in park areas. Nevertheless, this difference between areas may be related to the fact that areas outside the park are closer to the largest urban agglomeration in the study region (city of Sines), therefore presenting higher human density (Castro, 2004). This constitutes a problem when comparing areas outside and inside the park, since the Alentejo coast that is not covered by the PNSACV natural park and is not close to an urban agglomeration is dominated by sandy beaches.

Despite the importance of these activities for local communities, the reduction of the number of users may be related to the protective measures regulating recreational fishing in Portugal, implemented in 2009, and also with measures specific to the natural park adopted in 2011, through the new management plan. Additional data is required to evaluate the effect of these protective measures through a wider temporal view.

- **Weekly period of banning in the park**

The definition of a weekly banning period on recreational fishing activities made in the park probably aimed to reduce the intensity of these same activities. As expected, this study points to a significant decrease of fishermen.km^{-1} in areas inside the park during the banning period. Yet, during banning period, some users (fifteen fishermen were spotted) still engaged in fishing activities in these areas. The main reason for this could be explained by the recent character of the protective measures that leads to a poor knowledge from users, which in turn is heightened by poor disclosure by park authorities. This situation is more evident during the summer period (personal observations made during 2012 summer), since the Alentejo coast is visited by many domestic and international tourists for its sandy beaches. During low tide, beach tourists use the rocky areas near sandy beaches to gather shellfish for "*snacking*", to walk and to rest (Castro, 2004). Nevertheless, while the number of users decreased during the banning period in park areas, it was not observed a significant variation of fishing intensity in areas outside the park during the same period. This result suggests that park users did not change their usual fishing activity moving to areas outside the park during the banning period. In fact, only 12% of fishermen referred weekly period of banning as measure that affect harmfully their fishing activities on the shores of Alentejo. It is important to stress that the areas inside and outside the park used in the analysis of this effect are relatively close to each other, taking into account that most fishermen use motor vehicles to reach the shore (Castro, 2004). In fact, the sampling areas further away from each other are Cabo de Sines and Porto Covo, and the distance by road between them is ca. 15 km.

- **Closure season of** *Diplodus sargus* **and** *Diplodus vulgaris* **in the park**

The expected cutback in the number of shore anglers (fishermen.km^{-1}) during sea bream closure season in areas inside the park and the expected increase of the intensity of the same activity in areas outside the park, as the concerned two species of sea bream are of major importance to rocky shore fishermen in the study area (Castro, 2004), were not observed. This importance was confirmed by the interviews performed, since fishermen declared that in shore angling they usually target this two fish species (45% of answers). This outcome was also expected on free-diving fishing, eventually with a greater importance than in the case of shore angling since spearfishing is more species selective than angling, but it was not observed too. The impact of closure season in other activities (increase of shellfish harvesting intensity in the park due to decrease of shore angling intensity) was also not observed. These outcomes may be influenced by the fact that shore anglers (as well as free-diving fishermen), fishing in the park during this closure season continued to pursue their normal activity by simply shifting the target species (e.g. *Dicentrarchus labrax* and *Sparus aurata* – about 42% of answers) and releasing the sea breams eventually captured. On the other hand, fishermen referred that "*all measures"* (21%, n=47) or this specific closure season (21%), harmfully affect their fishing activity on the shores of Alentejo.

Gao & Hailu (2011) stated that the successful use of management strategies (e.g. area closures) involves a good understanding of the current state of impacted fisheries and ecosystems, as well as the effect of management changes on ecosystems and human communities. Management measures such as size and bag limits or seasonal closure of areas are poorly focused on outcomes (Kirkegaard & Gartside, 1998). There is little or no convincing evidence that these measures have any obvious effect on achieving their objective (Kirkegaard & Gartside, 1998). More importantly, these measures, in many cases, may be counterproductive and obstruct the comprehension of people's real motivations for participating in recreational fishing (Kirkegaard & Gartside, 1998). The key motivation derive from the activity of 'fishing' rather than 'catching fish', although of course those participating in the activity have an expectation that it is possible to catch a fish (Kirkegaard & Gartside, 1998). Therefore, any form of effective

recreational fishing regulation demands an understanding of anglers' behavioural responses to these regulations, as amendments in regulations change the attraction of a given fishing opportunity to anglers (Johnston et al., 2010; Beardmore et al., 2011).

- **Easter period (periods before, during and after Easter)**

The high intensity of shellfish harvesting during Easter of 1995 and 1996 reported by Castro (2004), in the rocky shores of Alentejo, were confirmed in the present study. Shellfish harvesting showed significant differences, in number of fishermen.km^{-1} across periods in weekends/holidays, being higher during Easter, and in weekdays, being lower after Easter. Moreover, total predation was higher during Easter period. The differences found among periods in shellfish harvesting, during weekends/holidays (E>bE=aE) and in total predation (E>bE=aE) suggest that the implementation of protective measures on fishing in the park and on recreational fishing in continental Portugal did not affect this long time tradition of fishing on the shore during Easter for direct consumption. In fact, over 90% of fishermen said that catches were intended to be eaten by himself/herself, with family and/or friends. Furthermore, 41% of fishermen acknowledged practicing more often shellfish harvesting then other fishing activity and about 76% of recorded preys captured during this study were shellfish.

- **Interannual comparisons (1995, 1996 and 2012)**

Comparisons among years allowed us to analyse the recent evolution of the intensity of fishing activities on rocky shores of Alentejo, in order to evaluate whether the protective measures had an effect on these activities. When we compared the three years information on the intensity of all fishing activities (total predation), obtained in weekends/holidays, what stands out is the variation between periods (before, during and after Easter) and sampling areas due to a significant interaction among these three factors. Significant variation among areas was recorded when comparing the intensity of total predation during Easter through years, with CSI upholding unchanged (among years or periods), BPC presenting higher values in Easter of 1995 and VMA/ACO showing a decrease in Easter of 1996 (VMA, ACO and BPC - E> bE=aE).

When we analysed total predation data the years of 1995 and 2012 report higher intensity during Easter. In spite of the significant heterogeneity variance reported in the analysis of shellfish harvesting intensity, higher values were found in 1995 and 2012 (1995>2012>1996). Considering this result, and taking also into account the higher values obtained in the intensity of total predation during 1995 and 2012, and the above mentioned results on the variation of the intensity of shellfish harvesting and total predation among Easter 2012 periods, we can assert that the intensity of shellfish harvesting and total predation during Easter has not diminished over the years. Therefore, protective measures applied to recreational fisheries in continental Portugal and in the PNSACV natural park has not yet influenced this Easter tradition. Castro & Cruz (2009) stated that since 2006, several restrictions to recreational fishing activities were enforced in continental Portugal, including those made on rocky shores. These authors say that in nowadays, shellfish collection with tools is forbidden, and several bag and size limits have been imposed. According to direct observations made on rocky shores of Alentejo during spring low tides (J. J. CASTRO, unpublished data), abundance of shellfish collectors was higher in 1995 and lower in 2007 (working days) or 2008 (weekend/holidays), but this variation was not significant in shore angling and bait collection.

The analyses made to the environmental variables, allowed us to determine that 1996 presented the worst weather and rougher sea, especially during Easter. In contrast, 1995 and 2012 exhibited the best weather conditions during Easter, when periods of calm sea with no precipitation were recorded more often. Observed weather patterns might have influenced the intensity of fishing activities on the Alentejo rocky shore, since climate may significantly affect spatial and temporal distribution patterns of recreational fisheries, as recognised by Castro (2004).

The low intensity verified in Easter of 1996 may be related to environmental variables, since higher values of sea roughness, turbidity of seawater, wind speed and nebulosity/precipitation, were recorded specially during that same period of 1996.

Sea urchin harvesting is preferably practiced during low tide in spring tides periods, when sea agitation is lower (Castro, 2004), due to higher abundance and size of this

echinoderm in lower tidal levels and subtidal (Angélico, 1990; Guiomar, 1997). Moreover, it is important the entertainment component of these activities, especially in weekends, with favorable weather conditions that can have a major influence on the abundance of fishermen (Castro, 2004).

5.3. Yield of fishing activities

This study revealed a total yield of fishing activities of about 3 tons of fish and shellfish, providing an average yield of 0.15 $kg.h^{-1}$ per fisher. The average yield value is probably underestimated, since data on final catches was not obtained in all surveys. Areas inside the park revealed a higher yield in total predation rate when compared with areas outside the park. This pattern could indicate that the protective measures recently implemented may be causing already some impact on fishing yield. However, the yield of shellfish harvesting and shore angling did not differ among areas.

Protective measures such as marine reserves have been widely promoted as conservation and fishery management tools. Numerous studies of reserves worldwide show that protection from fishing leads to rapid increases in biomass, abundance, and average size of exploited organisms and to increased species diversity, thus confirming that marine reserves can play a key role in supporting fisheries (Roberts et al., 2001). Such effects are of great interest to fishery managers, because rebuilding exploited populations in reserves offers prospects of fishery enhancement (Roberts et al., 2001). In California, protected areas had the highest density and best size structure of rockfish (*Sebastes* spp.), whereas in recreational fishing areas, densities were lowest and size structure was poor (Schroeder & Love, 2002). There are robust demonstrations of conservation benefits, but fishery benefits remain controversial (Roberts et al., 2001). Nevertheless, the MPA's created in PNSACV natural park are very recent and small. Reis (2011) concedes that the measures regulating recreative fishing in the natural park, started in 2009 has not yet elapsed time to observe the recovery of the population of limpets and top shells. Furthermore, the main MPA's are not very close to the sampled areas.

The highest yield obtained in park areas could also indicate that the higher intensity observed in areas outside the park, during the weekly period of banning (e.g. total

predation) may have an impact on fishing yield, causing it to decrease. For example, in Australia, recreational fishing outside a marine park resulted in reduced biomass and community structure when compared with protected areas within the park (Westera et al., 2003). Therefore, information on total catch is essential to any assessment of the impact of fishing on a resource. This information tell us about the removals by harvesting from the population and the related effort employed to take the catch, but at the same time provides knowledge about how a population reacts to harvest (Reid & Montgomery, 2005).

Yield obtained in fishing anglers' observations did not differ between park areas and non-park areas. Castro (2004) on rocky shores of Alentejo and Veiga et al. (2010) in PNSACV natural park estimated an overall yield of 0.40 and 0.21 $kg.h^{-1}$ respectively per angler, approximately four and two times the yield found in the present study with the anglers' observations (0.08 $kg.h^{-1}$ per angler). Though, Rangel & Erzini (2007) reported a similar yield value of 0.078 $kg.h^{-1}$ per angler in the north of Portugal. However, when compared the yield value of 0.21 $kg.h^{-1}$ per angler, obtained with the inquiries performed exclusively to anglers it doubles the yield value obtained with anglers' observations. The difference between these two yield values might be explained by the low number of carried out anglers' observations, because of the major time effort required to perform this task.

5.4. Opinion of Alentejo rocky shores fishermen on the existing fishing management laws and characterization of their fishing activity

Alentejo rocky shores fishermen are mostly male, employed in manufacturing sectors or pensioners/unemployed/students above 30 years old, residents or with reported birthplace in municipalities with territory enclosed in the natural park. The predominance of males in fishing activities was also observed in other studies (e.g. Wilde & Riechers, 1992; Wilde et al. 1998; Arlinghaus & Mehner, 2002; Oliveira, 2003; Castro, 2004; Diogo, 2007; Erzini et al., 2009). A European study concluded that the recreational fishermen in Portugal, Germany, England, Wales and Mediterranean countries tend to be mostly men (94%), whereas in northern European countries this percentage value is lower (Pawson et al., 2006). Alentejo rocky shores fishermen are

generally individuals of working age, characteristic also displayed in other studies carried out in Portugal (Oliveira, 2003; Diogo, 2007; Erzini et al., 2009).

The frequency of fishing activities, mostly shore angling and shellfish harvesting on rocky shores of Alentejo, including the PNSACV natural park varies from rarely/few days per month to daily/some days per week and target mainly shellfish and teleost fish. The periodicity of fishing activities demonstrate their leisure component but also demonstrate the high importance has food supply, point out by Castro (2004) and confirmed in the present study and in Castro & Cruz (2009), where almost all fishermen answered that captured fish or shellfish was to be eaten by themselves or by their family or friends.

Fishermen declared that in shore angling they usually target two fish species (*Diplodus sargus* and *Dicentrarchus labrax*) and in shellfish harvesting they usually target four species (*Octopus vulgaris*, *Necora puber*, *Paracentrotus lividus* and *Pollicipes pollicipes*). This species had already been identified by Castro (2004) as the main target species for Alentejo rocky shores fishermen.

Most fishermen considered that the quantity of fish or shellfish obtained in each fishing day has greatly decreased since they fish on rocky shores of Alentejo and the most popular reason stated to explain this reduction is industrial and agricultural pollution. The same result was obtained by Castro & Cruz (2009) in the coast of Alentejo, between 2005 and 2008 where direct inquiries were performed to know the opinion of rocky shore fishermen (shellfish collectors and anglers).

The majority of Alentejo rocky coast fishermen are aware of Portuguese recreational fishing laws and the protective measures implemented in the park. More than half said to be affected by at least one or more of the protective measures. The most common answers listed are *all measures*, *sea bream closure season and minimum size/weight of preys*. In reverse, fishermen that agree with protective measures listed as more accurate measures *closure (all seasons)*, *mandatory fishing licenses* and *minimum prey sizes*. Before the 2009 protective measures, Castro & Cruz (2009) performed direct inquiries to assess the opinion of rocky shores fishermen were the majority agreed that measures were necessary to be taken on rocky shores of Alentejo. The most

popular measures were: minimum size/weight of preys, one annual closed season, more and better control and continuous no-take marine reserves in some areas (Castro & Cruz, 2009).

Only a small percentage of Alentejo rocky shores fishermen acknowledged that the MPAs created in the park favour the sustainability of populations. However, more than half do not agree or express any opinions about the marine protect areas.

6. CONCLUSIONS AND RECOMMENDATIONS

Evaluating recreational fisheries obliges combined methods, such has boat surveys and/or aerial surveys, as well as the "access point survey", in order to reduce method associated error. A combination of methods should allow more accurate observations, both regarding intensity and yield of recreational fishing activities.

The importance of day type in abundance of users in the Alentejo rocky shores, confirms that the recreational and entertainment component of fishing activities is quite important, as previously suggested by Castro (2004). The observed decrease in number of users could be related to the management interventions. Therefore, a continuous and an adaptive surveying of recreational fisheries must be carried out in order to assess its progress to potential changes in the fishing regulations.

A behavioural investigation through inquiries is probably the most effective method to discriminate the effect of areas outside the park being closer to the largest urban agglomeration. Questions about why a fisherman uses a particular fishing area should be included in future interviews. This will allow the identification of the primal decision factor, regarding area or areas selection.

The protection measures recently established in park areas, particularly the weekly banning period, demonstrate a direct effect in reducing the number of fishermen during that period. However, fishing activities were still carried out during weekly period of banning (Wednesdays, except public holidays) and in MPA’s, mainly due to the poor knowledge of fishing management laws, generally from seasonal users which

is amplified by poor information and insufficient supervision from authorities, during summer periods (personal observations made during 2012 summer). Reis (2011) also observed failure to comply with fishing laws by fishermen (e.g. minimum sizes and fishing in MPA's) in the PNSACV natural park. This author states that the total lack of signs and data regarding laws in the protected areas and the rare detection of inspection agents along the shores are factors that, together with the requirement of some applied laws, facilitate infringements thereof. Nevertheless, resident users do not display a selective behaviour during this period. They choose to not carry out their fishing activities, during the weekly banning period, rather than shifting to areas outside the park. A similar behaviour is adopted by anglers when confronted with the sea bream closure season. In this case anglers perform their usually activity in park areas but probably alter target species.

Long-time traditions, such as Easter's sea urchin harvesting probably have not been affected by protective measures. The rougher weather recorded in 1996 Easter explains the low harvesting intensity, since sea urchin harvesting is exercised during low tide in spring tides periods, when sea agitation is lower (Castro, 2004). Consequently, weather conditions greatly affect its intensity. In addition, recreational fisheries are considered an entertainment activity, in spite the major importance as food supply to Alentejo rocky shores fishermen.

High variability in temporal analyses recorded in some activities may be due, partially, to a lack of a representative sample. Indeed, the number of replicates (n = 2) in the considered designs may have been insufficient for the analysis of some variables, such as amenity use or free-diving fishing, in which the abundance values observed were relatively small and/or presented a high temporal variability. On the other hand, some of these activities, such as shore angling or free-diving fishing, showed important spatial variability.

Differences reported on the fishing activities yield among areas are insufficient to conclude about the influence of protective measures. Some questions should be raised to fully understand the effects of management interventions, such as:

- Are protective measures causing a yield increase in park areas and/or a yield decrease in non-park areas?

- How is this yield variation related to the intensity of fishing activities?

- Which are the prime factors that set the selection of a fishing area?

Alentejo rocky shores fishermen have mixed and strong opinions about the existing fishing management laws. These opinions fluctuate according to several factors such as: fishermen age, fishing experience, fishing goal (e.g. leisure or subsistence) and educational degree.

To answer questions mentioned above, additional data through a broader temporal view is required, in order to assess and evaluate the effects of the protective measures implemented in Southwest Alentejo and Vicentine Coast Natural Park. It is essential to sort out scientific studies capable of supporting management decisions and develop monitoring programs to assess their effects (Thompson et al., 2002). This evaluation will judge the success of measures and consider its application in other areas.

1. BIBLIOGRAPHY

Alcala, A.C. & G.R. Russ, 1990. A direct test of the effects of protective management on abundance and yield of tropical marine resources. Journal du Conseil International pour l'Exploration de la Mer, 46: 40-47.

Alcala, A.C., 2004. Marine Reserves as Tools for Fishery Management and Biodiversity Conservation: Natural Experiments in the Central Philippines, 1974-2000. Silliman University-Angelo King Center for Research and Environmental Management, 42pp.

Angélico, M.M.P., 1990. Estudo da reprodução e crescimento de *Paracentrotus lividus* (Lamarck, 1816) (Echinodermata: Echinoidea) na costa de Sesimbra, com vista à obtenção de dados preliminares para a gestão da sua pesca. Relatório de estágio, Universidade de Lisboa, 288pp.

Arlinghaus, R., T. Mehner & I.G. Cowx, 2002. Reconciling traditional fisheries management and sustainability in industrialized countries, with emphasis on Europe. Fish and Fisheries, 3: 261–316.

Arlinghaus, R. & T. Mehner, 2002. Sócio-economic characterization of specialized common carp (Cyprinus carpio L.) anglers in Germany, and implication for inland fisheries management and eutrophication control. Fisheires Research. 1375: 1-15.

Arlinghaus, R. & S.J. Cooke, 2009. Recreational fisheries: socioeconomic importance conservation issues and management challenges. In: Dickson, B., Hutton, J., Adams, W.A. (Eds.), Recreational Hunting, Conservation and Rural Livelihoods: Science and Practice. Blackwell Science, Oxford, pp. 39–58.

Arlinghaus, R., S. Matsumura & U. Dieckmann, 2010. The conservation and fishery benefits of protecting large pike (*Esox lucius L*.) by harvest regulations in recreational fishing. Biological Conservation, 143(6): 1444–1459.

Beardmore, B., M. Dorow, W. Haider, & R. Arlinghaus, 2011. The elasticity of fishing effort response and harvest outcomes to altered regulatory policies in eel (*Anguilla anguilla*) recreational angling. Fisheries Research, 110: 136–148.

Benedetti-Cecchi, L., 2004. Increasing accuracy of causal inference in experimental analyses of biodiversity. Functional Ecology, 18: 761-768.

Brandt, A.V., 1984. Fish Catching Methods of the World. Fishing News Books Ltd. England. Ed. XIV, 418pp.

Canário, A.V.M., K. Erzini, M. Castro, J.M.S. Gonçalves, C. Galhardo, J. Ribeiro, L. Bentes, J. Cruz & P. Souto, 1994. Estudos base para a conservação dos ictiopovoamentos e gestão da pesca costeira no litoral sudoeste. Relatório final. Unidade de Ciências e Tecnologias dos Recursos Aquáticos, Universidade do Algarve, 219pp.

Cardona-Pons, F., B. Morales-Nin, & S.G. Sutton, 2010. Scientists and recreational fishers: Communication manners and its efficiency. Fisheries Research, 106: 575–578.

Carter, R.W.G., 1989. Coastal environments. An introduction to the physical, ecological and cultural systems of coastlines. Academic Press, 617pp.

Castro, J., 2004. Predação humana no litoral rochoso alentejano: caracterização, impacte ecológico e conservação. Dissertação apresentada à Universidade de Évora para a obtenção do grau de Doutor em Biologia. Évora, Portugal. 348pp.

Castro, J. & T. Crux, 2009. Marine conservation in a Southwest Portuguese natural park. Journal of Coastal Research, 56: 385–389.

C.C.E., 2001. Livro verde sobre o futuro da política comum de pesca COM(2001). Comissão das Comunidades Europeias, Bruxelas, 35 pp.

Chiappone, M., R. Sluka & K.S. Sealey, 2000. Groupers (Pisces: Serranidae) in fished and protected areas of the Florida Keys, Bahamas and northern Caribbean. Marine Ecology Progress Series, 198: 261-272.

Claudet J., C.W. Osenberg, L. Benedetti-Cecchi, P. Domenici, J.A. García-Charton, A. Pérez-Ruzafa, F. Badalamenti, J. Bayle-Sempere, A. Brito, F. Bulleri, J.M. Culioli, M. Dimech, J.M. Falcón, I. Guala, M. Milazzo, J. Sánchez-Meca, P.J. Somerfield, B. Stobart, F. Vandeperre, C. Valle & S. Planes, 2008. Marine reserves: Size and age do matter. Ecology Letters, 11: 481- 489.

Coates, D., 1995. Inland capture fisheries and enhancement: status, constraints and prospects for food security. International Conference of Sustainable Contribution of Fisheries to food Security, Kyoto, Japan KC/FI/95/TECH/3, FAO, Rome. 85pp.

Coleman, F.C., W.F. Figueira, J.S. Ueland & L.B. Crowder, 2004. The impact of United States recreational fisheries on marine fish populations. Science (New York, N.Y.), 305: 1958–60.

Cooke, S. & I. Cowx, 2004. The role of recreational fishing in global fish crises. BioScience, 54: 857–860.

Costa, M.D.S., 1994. Agitação marítima na costa portuguesa. Anais do Instituto Hidrográfico, 13: 35-40.

Cowx, I.G., 2002. Recreational fisheries. In: P. Hart & J. Reynolds (ed.) The Fisheries Handbook, Vol. II. Oxford: Blackwell Science, pp. 367–390.

Crowe, T.P., R.C. Thompson, S. Bray & S.J. Hawkins, 2000. Impacts of anthropogenic stress on rocky intertidal communities. Journal of Aquatic Ecosystem Stress and Recovery, 7: 273-297.

Cruz, T., 2000. Biologia e ecologia do percebe, *Pollicipes pollicipes* (Gmelin, 1790), no litoral sudoeste português. Tese de doutoramento, Universidade de Évora, 306pp.

Decree law no. 246/2000 of September 29th. Diário da República, 1º série, 226: 5351-5354.

Dillon, B., 2004. A Bio Economic Review of Recreational Angling for Bass (*Dicentrarchus labrax*). Scarborough Centre for Coastal Studies, University of Hull. 22pp.

Diogo, H., 2007. Contributions to the characterization of recreational fishing activities on the islands of Faial and Pico, Azores. Dissertação apresentada à Universidade dos Açores para a obtenção do grau de Mestre em Estudos Integrados dos Oceanos. Açores, Portugal. 98pp.

DGRM, 2012. Direcção-Geral de Recursos Naturais, Segurança e Serviços Marítimos – Recreational fishing licenses statistical data. Available at: http://www.dgrm.min-agricultura.pt.

Dudley, N., 2008. Guidelines for applying protected area management categories. International Union for Conservation of Nature and Natural Resources. IUCN Publications Services ISBN: 978-2-8317-1086-0, 106pp.

Durán, L.R., J.C. Castilla & D. Oliva, 1987. Intensity of human predation on rocky shores at Las Cruces in central Chile. Environmental Conservation, 14(2): 143-149.

Erzini, K., P. Veiga, J. Ribeiro, C. Almeida, F. Oliveira, L. Bentes, P. Monteiro & J. Gonçalves, 2009. Caracterização da pesca recreativa de costa do sul de Portugal, Resultados do estudo. Universidade do Algarve.

Froese, R. & D. Pauly, 2011. FishBase world wide web electronic publication www.fishbase.org, version (08/2011).

Gao, L. & A. Hailu, 2011. Evaluating the effects of area closure for recreational fishing in a coral reef ecosystem: The benefits of an integrated economic and biophysical modeling. Ecological Economics, 70: 1735–1745.

Gartside, D., B. Harrison & B. Ryan, 1999. An evaluation of the use of fishing club records in the management of marine recreational fisheries. Fisheries Research, 41: 47-61.

Gell, F.R. & C.M. Roberts, 2003. Benefits beyond the boundaries: the fishery effect of marine reserves. Trends in Ecology and Evolution, 18: 448−455.

Gray, D.L., R. Canessa, R. Rollins, C.P. Keller & P. Dearden, 2010. Incorporating recreational users into marine protected area planning: a study of recreational boating in British Columbia, Canada. Environmental management, 46: 167–80.

Guiomar, C.A.R., 1997. Aspectos da biologia e exploração do ouriço-do-mar *Paracentrotus lividus* (Lamarck, 1816) (Echinodermata: Echinoidea) na costa alentejana. Relatório de estágio profissionalizante, Universidade de Lisboa, 64pp.

Halpern, B. & R.R. Warner, 2002. Marine reserves have rapid and long lasting effects. Ecological Letters, 5: 361–366.

Halpern, B.S., 2003. The impact of marine reserves: do reserves work and does reserve size matter? Ecological Applications, 13(1): S117-S137.

Himes, A.H., 2003. Small-scale Sicilian fisheries: opinions of artisanal fishers and sociocultural effects in two MPA case studies. Coastal Management, 31: 389–40.

Hockey, P.A.R., A.L. Bosman & W.R. Siegfried, 1988. Patterns and correlates of shellfish exploitation by coastal people in Transkei: an enigma of protein production. Journal of Applied Ecology, 25: 353-363.

Hurkens, R. & C.A. Tisdell, 2006. Ecological and Socioeconomic Features of Recreational Fishing and Fishing Policies: Review and Case Studies for the Netherlands and Australia. In A. R. Burk (Ed.), Focus on Ecology Research 1st ed. (pp. 99-129) NY USA: Nova Science.

ICNF, 2012. Instituto da Conservação da Natureza e das Florestas - Portuguese Institute for Nature Conservation and Forests. Available at: http://www.icnf.pt.

Johnson, D.R, N.A. Funicelli & J.A. Bohnsack, 1999. Effectiveness of existing estuarine no-take fish sanctuary within the Kennedy Space Center, Florida. North American Journal of Fisheries Management, 19: 436-453.

Johnston, F.D., R. Arlinghaus & U. Dieckmann, 2010. Diversity and complexity of angler behaviour drive socially optimal input and output regulations in a bioeconomic recreational-fisheries model. Canadian Journal of Fisheries and Aquatic Sciences, 67: 1507–1531.

Kearney, R.E., N.L. Andrew & R.J. West, 1996. Some issues in the management of Australia's marine and coastal fisheries resources. Ocean and Coastal Management, 33: 133-146.

Kelly, D., 2012. Global Challenges in Recreational Fisheries. International journal of palliative nursing, 18(6) 307.

Kenchington, R. & C. Bleakley, 1994. Identifying priorities for marine protected areas in the insular Pacific. Marine Pollution Bulletin, 291(3): 3-9.

Kingsford, J., A.J. Underwood & S.J. Kennelly, 1991. Humans as predators on rocky reefs in New South Wales, Australia. Marine Ecology Progress Series, 72: 1-14.

Kirkegaard, I.R. & D.F. Gartside, 1998. Performance indicators for management of marine recreational fisheries. Marine Policy, 22: 413–422.

Lasiak, T., 1997. Temporal and spatial variations in the pattern of shoreline utilization in a region subject to subsistence exploitation. International Journal of Environmental Studies, 52: 21-46.

Lester, S.E., B.S. Halpern, K. Grorud-Coveret, J. Lubchenco, B.I. Ruttenberg, S.D. Gaines, S. Airamé & R.R. Warner, 2009. Biological effects within no-take marine reserves: a global synthesis. Marine Ecology Progress Series, 384: 33–49.

Lynch, T.P., 2006. Incorporation of recreational fishing effort into design of marine protected areas. Conservation biology : the journal of the Society for Conservation Biology, 20: 1466–76.

Marcelino, A., 2010. Contribuição para o estudo da pesca de lazer na península de Peniche, Portugal. Dissertação apresentada à Universidade dos Açores para a obtenção do grau de Mestre em Estudos Integrados dos Oceanos. Açores, Portugal. 91pp.

Marta, P., J. Bochechas & M.J. Collares-Pereira, 2001. Importance of recreational fisheries in the Guadiana River Basin in Portugal. Fisheries Management, 8: 345–354.

Martínez, M.L., A. Intralawan, G. Vázquez & O. Pérez-Maqueo, 2007. The coast of our world: Ecological, economic and social importance. Ecological Economics, 63: 254-272.

McClanahan, T.R., & B. Kaunda-Arara, 1996. Fishery recovery in a coral-reef marine park and its effect on the adjacent fishery. Conservation Biology, 10: 1187–1199.

McClanahan, T.R., 1999. Is there a future for coral reef parks in poor tropical countries? Coral Reefs, 18: 321-325.

Merrel, W., 1995. Science, policy and the coast – improving decision making. National Academy Press, Washington, 83pp.

Morales-Nin, B. & J. Moranta, 2005. The recreational fishery off Majorca Island (western Mediterranean): some implications for coastal resource management. ICES Journal of Marine Science, 62: 727–739.

Murray-Jones, S. & A.S. Steffe, 2000. A comparison between the commercial and recreational fisheries of the surfclam, *Donax deltoids*. Fisheries Research, Volume 44(3): 219–233.

Nãslund, I., T. Eriksson, D. Hannersjã, L. Bergwall, G. Jacobsson & K. Leonardsson, 2010. Time trends in angler compliance with harvest regulations in stream fisheries. Fisheries Management and Ecology, 17: 52–62.

Oliveira M., 2003. Contribuição para o estudo da pesca recreativa de Costa em Portugal. Instituto de Ciências Biomédicas de Abel Salazar. Tese de mestrado. Lisboa. 90pp.

O'Neill, M.F. & M.J. Faddy, 2003. Use of binary and truncated negative binomial modelling in the analysis of recreational catch data. Fisheries Research, 60(2-3): 471-477.

Ordinance no. 868/2006 of August 29th. Presidência do Conselho de Ministros e Ministérios da Defesa Nacional, do Ambiente, do Ordenamento do Território e do Desenvolvimento Regional, da Economia e da Inovação e da Agricultura, do Desenvolvimento Rural e das Pescas, Diário da República, 1º série, 166: 6278-6282.

Ordinance no. 143/2009 of February 5th (modified by Ordinance no. 458-A, of May, 4th). Diário da República, 1º série, 25: 831-834.

Ordinance no. 144/2009, of February 5th, (modified by Ordinance no. 458-A, of May, 4th). Diário da República, 1º série, 25: 834-839.

Ordinance no. 115-A/2011, of March 24th. Presidência do Conselho de Ministros e Ministérios da Defesa Nacional, da Economia, da Inovação e do Desenvolvimento, da Agricultura, do Desenvolvimento Rural e das Pescas e do Ambiente e do Ordenamento do Território. Diário da República, 1º série, 59(1668): 2-5.

Pawson, M.G., D. Tingley, G. Padda &. H. Glenn, 2006. EU contract FISH/2004/011 on Sport Fisheries (or Marine Recreational Fisheries) in the EU. Portsmouth, 213 pp.

Pawson, M.G., H. Glenn & G. Padda, 2008. The definition of marine recreational fishing in Europe. Marine Policy, 32: 339–350.

Pollock, K.H., C.M. Jones & T.L. Brown, 1994. Angler survey methods and their applications in fisheries management. American Fisheries Society Special Publications 25, Bethesda, MD.

Pollock, K.H., J.M. Hoenig, C.M. Jones, D.S. Robson & C.J. Greene, 1997. Catch Rate Estimation for Roving and Access Point Surveys. North American Journal of Fisheries Management, 17: 11–19.

Portuguese Hydrographic Institute, 2012. Port of Sines tide table 2012. Available at:http://www.hidrografico.pt/previsao-mares.php).

Post, J.R., C. Mushens, A. Paul & M. Sullivan, 2003. Assessment of alternative harvest regulations for sustaining recreational fisheries: model development and application to bull trout. North American Journal of Fisheries Management, 23: 22-34.

Quantum GIS Development Team, 2011. Quantum GIS Geographic Information System, QGIS 1.7.4 – Wroclaw. Open Source Geospatial Foundation Project. http://qgis.osgeo.org.

Raffaelli, D. & S.J. Hawkins, 1996. Intertidal ecology. Chapman & Hall, 356pp.

Rakitin, A., & D.L. Kramer, 1996. Effect of a marine reserve on the distribution of coral reef fishes in Barbados. Marine Ecology Progress Series, 131: 97–113.

Rangel, M.O. & K. Erzini, 2007. An assessment of catches and harvest of recreational shore angling in the north of Portugal. Fisheries Management and Ecology, 14: 343–352.

Reid, D.D. & S.S. Montgomery, 2005. Creel survey based estimation of recreational harvest of penaeid prawns in four southeastern Australian estuaries and comparison with commercial catches. Fisheries Research, 74: 169–185.

Reis, R., 2011. Avaliação de efeitos ecológicos da interdição da pesca lúdica no litoral rochoso alentejano. Dissertação apresentada ao Instituto Superior de Agronomia da Universidade Técnica de Lisboa para a obtenção do grau de Mestre em Gestão e Conservação de Recursos Naturais. Lisboa, Portugal. 79pp.

Resolution no. 11-B/2011, of February 4th. Resolução do Conselho de Ministros que aprova o Plano de Ordenamento do Parque Natural do Sudoeste Alentejano e Costa Vicentina (POPNSACV). Diário da República, 1º série, 25(682): 31-68.

Roberts, C.M. & J.P. Hawkins, 2000. Fully-protected marine reserves: a guide. WWF Endangered Seas Campaign, 132pp.

Roberts, C.M., J.A. Bohnsack, F. Gell, J.P. Hawkins & R. Goodridge, 2001. Effects of marine reserves on adjacent fisheries. Science (New York, N.Y.), 294(5548): 1920–1923.

Ruckes, E., 2001. Inter-relationships between fishery management and marketing arrangements. Socio-economic issues in coastal fisheries management. IPFC. pp. 84-89.

Russ, G.R. & A.C. Alcala, 1999. Management histories of sumilon and apo marine reserves, Philippines, and their influence on national marine policy. Coral Reefs, 18: 307-319.

SeaWeb (2004, August 27). Study In Science Reveals Recreational Fishing Takes Big Bite Of Ocean Catch. ScienceDaily. Retrieved October.

Schill, D.J. & P.A. Kline, 1995. Use of random response to estimate angler noncompliance with fishing regulations. North American Journal of Fisheries Management, 15: 721– 731.

Schroeder, P. & M. Love, 2002. Recreational Fishing and Marine Fish Populations. CalCOFI Report, 43: 182–190.

Schullery, P., 1987. American Fly Fishing: A History. Lyons Press, 288pp.

Sibly, H., 2001. Pricing and management of recreational activities which use natural resources. Environmental and Resource Economics, 18: 339-354.

Siegfried, W.R., P.A.R. Hockey & G.M. Branch, 1994. The exploitation of intertidal and subtidal biotic resources of rocky shores in Chile and South Africa. Pp. 1-15 in WR Siegfried (ed.) Rocky shores. Exploitation in Chile and South Africa. Springer-Verlag.

Small, M.P. & E.M. Gosling, 2001. Population genetics of a snail species complex in the British Isles: *Littorina saxatilis* (Olivi), *L. neglecta* (Bean) and *L. tenebrosa* (Montagu), using SPSSP analysis of Citochrome-B gene fragments. Journal of Molluscan Studies, 67: 69-80.

Snook, V.A. & D.J. Dieterman, 2006. A roving creel survey of selected southeast Minnesota trout streams - 2005. Completion Report for Job 737, F-29-R(P)-25. Section of Fisheries, Minnesota Department of Natural Resources, St. Paul, 75pp.

Sullivan, P.J., F.J. Breidt, R.B. Ditton, B.A. Knuth, B.M. Leaman, V.M. O´Connell, G.R. Parsons, K.H. Pollock, S.J. Smith & S.L. Stokes, 2006. Review of Recreational Fisheries Survey Methods. Committee on the Review of Recreational Fisheries Survey Methods, National Research Council ISBN: 0-309-66075-0, 202pp.

Tavares da Silva, C. & J. Soares, 1997. Economias costeiras na Pré-História do sudoeste português. O concheiro de Montes de Baixo. Setúbal Arqueológica, 11-12: 69-108.

Teixeira, S.B., 2006. Slope mass movements on rocky sea-cliffs: a power-law distributed natural hazard on the Barlavento Coast, Algarve, Portugal. Continental Shelf Research, 26: 1077–1091.

Thompson, R.C., T.P. Crowe & S.J. Hawkins, 2002. Rocky intertidal communities: past environmental changes, present status and predictions for the next 25 years. Journal of Environmental Conservation, 29(2): 168-191.

Underwood, A.J. & S.J. Kennelly, 1990. Pilot studies for designs of surveys of human disturbance of intertidal habitats in New South Wales. Australian Journal of Marine and Freshwater Research, 41:165-173.

Underwood, A.J., 1993. Exploitation of species on the rocky coast of New South Wales (Australia) and options for its management. Ocean & Coastal Management, 20: 41-62.

Underwood, A.J., 1997. Experiments in ecology. Their logical design and interpretation using analysis of variance. Cambridge University Press, 504pp.

Van Zyl, C.S., 2011. The use of a Roving Creel Survey to monitor exploited coastal fish species in the Goukamma Marine Protected Area, South Africa. A thesis submitted in fulfillment of the requirements for the degree of Masters in Technoligae, Nature Conservation. Nelson Mandela Metropolitan University, 102pp.

Veiga, P., J. Ribeiro, J. M. S. Gonçalves & K. Erzini, 2010. Quantifying recreational shore angling catch and harvest in southern Portugal (north-east Atlantic Ocean): implications for conservation and integrated fisheries management. Journal of fish biology, 76: 2216–2237.

Wilde, G.R., R.K. Riechers & R.B. Ditton, 1998. Differences in attitudes, fishing motives and demographic characteristics between tournament and nontournament black bass anglers in Texas. North American Journal of Fisheries Management, 18 :422-431.

Wilde, G.R. & R. Riechers, 1992. Demographic and social characteristics and management preferences of Texas freshwater catfish anglers. Annual Conference SEAFWA, 46: 393-401.

Winer, B.J., D.R. Brown & K.M. Michels, 1991. Statistical principles in experimental design, third edition. McGraw-Hill, 928pp.

Wantiez, L., P. Thollot & M. Kulbicki, 1997. Effects of marine reserves on coral reef fish communities from five islands in New Caledonia. Coral Reefs, 16: 215 –224.

Watson, M. & R.F.G. Ormond, 1994. Effect of an artisanal fishery on the fish and urchin populations of a Kenyan coral reef. Marine Ecology Progress Series, 109: 115-129.

Westera, M., P. Lavery & G. Hyndes, 2003. Differences in recreationally targeted fishes between protected and fished areas of a coral reef marine park. Journal of Experimental Marine Biology and Ecology, 294: 145–168.

APPENDICES

Appendix I. Log sheet used in roving creel surveys of the intensity of human activities on rocky shores of Alentejo (Wd - weekdays; Bp - banning period; W/H - weekends/holidays).

ROVING CREEL SURVEYS LOG SHEET

Area _____ Date ____/____/_____ Wd / Bp / W/H

low tide / high tide

Starting time _____: _____ Finishing time _____: _____

Wind speed	1	2	3	4
Sea roughness	1	2	3	4
Nebulosity/Precipitation	1	2	3	4
Seawater turbidity	1	2	3	4

	Number of users
Shellfish harvesters	
Bait harvesters	
Shore anglers	
Free-diving fishers	
Amenity users	

NOTES:

_____

_____

Appendix II. Questionnaire used in fishermen interviews made on rocky shores of Alentejo.

Interview of fishermen on rocky shores of Alentejo

This interview is conducted by researchers from the University of Évora, under a scientific study that aims to contribute to the sustainability of fishing resources use on the shores of Alentejo.

Inquirer name: .....

Area: ..... Date: ..... Time: .....

1- Do you usually practice this type of fishing on the Alentejo coast? ☐ Yes ☐ No

And in the Southwest Alentejo and Vicentina Coast Natural Park (PNSACV)? ☐ Yes ☐ No

How frequently do you practice this type of fishing on the Alentejo coast? …….

2a- What type of fishing do you perform more often?

	X- yes	X- most frequent
Shellfish harvesting (recreative)		
Bait harvesting (recreative)		
Shore angling (recreative)		
Boat angling (recreative)		
Free-diving fishing (recreative)		
Freshwater fishing (recreative)		
Commercial fishing		

2b- What are the main preys normally targeted by you?

In shellfish harvesting: ……In shore angling: ……

2c- When angling from the shore, do you typically use:

Turbid water/Clean water/Any Low tide/Flooding tide/High tide/Ebbing tide/Any

Spring tides/Neap tides/Any Morning/Afternoon/Night/Any

Fishing rod-Yes/No Leaded fishing line-Yes/No Buoy-Yes/No Artificial sample-Yes/No Lure-Yes/No

Fresh bait used: ……. Do you usually catch the bait you are using? ☐ Yes ☐ No

Lure used: …… Do you use *Siphonaria* as bait? Yes/No/Does not know

3- In your opinion, the amount of fish obtained in today fishing is:

much lower than expected		higher than expected	
lower than expected		much higher than expected	
same as expected		does not know / no answer	

4- How many years do you use to practice this type of fishing in the Alentejo coast? ……

5- Since you practice this type of fishing on the Alentejo coast, you think that the amount of fish obtained in each fishing day:

greatly decreased		slightly increased	
slightly decreased		greatly increased	
is approximately the same		does not know / no answer	

6a- Total weight of fish caught: .....kg (fresh weight estimated together with the fishermen)

6b- Number of fishermen involved in the amount caught: ……

6c- Main prey caught: ……

6d- Area used to fish for the amount caught: .....

6e- Time spent in fishing for the amount caught (number of hours): .....

7- The fish caught or to be caught in this type of fishing is intended to be:

eaten by yourself, with family and/or friends		sold most of it	
sold in a small part		entirely sold	

8- This type of fishing that you practice is important

to get food to be eaten by yourself, with family and/or friends		for leisure	
for the economy of yourself or your family		for other reason:	

9a- Do you know the legislation regulating recreational fishing in continental Portugal and in the Southwest Alentejo and Vicentina Coast Natural Park? ☐ yes ☐ no ☐ does not know / no answer

9b- Does some measure of this legislation (see list) affect harmfully your fishing activities on the shores of Alentejo? If yes, state which ones and why they affect this fishing activity made by you.

……

……

9c- Do you agree with some measure of this legislation (see list)? If yes, state which one(s).....

10a- Are you aware that in 2011 MPAs were created in the PNSACV, where commercial and recreative fishing is partially or totally prohibited (e.g. Ilha do Pessegueiro, Cabo Sardão, Pedra do Burrinho)?

☐ yes ☐ no ☐ does not know / no answer

10b- Do you agree with the creation of these MPAs? Say why.

……

……

10c- Does these MPAs affect harmfully your fishing activities on the shores of Alentejo? If so, say why they affect this fishing activity made by you.

……

……

11- Have you ever been inspected by authorities while fishing on the shore?

☐ Yes ☐ No ☐ does not know / no answer

Did you get fined? ☐ Yes ☐ No ☐ does not know / no answer

12- In your opinion, the enforcement of the authorities:

should be less intense	
is made with proper intensity	
should be more intense	
does not know / no answer	

13- Municipality of residence: ……

14- Are you a member of any fishermen association or organization? ☐ Yes ☐ No

Which one(s)?.....

15- Do you have any fishing license? ☐ Yes ☐ No

If yes, what type of fishing is this license for?

☐ Recreative shore fishing ☐ Recreative boat fishing ☐ Recreative free-diving fishing

☐ Overall recreative fishing ☐ Another fishing type. Which one?.....

16- Age …….years

17- Professional activity: .....

18- Birthplace (which municipality): ……

19- Have you already responded to a similar questionnaire? ☐ Yes ☐ No ☐ does not know / no answer

20- Gender: Female / Male

21- Activity that the fisherman was doing before or during the interview, or was going to do after the interview:

Shellfish harvesting	Bait harvesting	Shore angling	Other:

22- Tool(s) that the fishermen is using, were used or are going to be used to catch fish:

Hook	Hand Net	Baited stick or rope	Collecing knife	Chisel	Short-handled hoe
Hook and line with rod		Hook and line without rod		Hand	Other:

23- Status of fisherman activity:

Arriving at fishing area	Starting fishing	Fishing	Finishing fishing	Leaving fishing area	Other:

Thank you for your cooperation.

Appendix III. Shore anglers 30´observation log sheet.

SHORE ANGLERS 30' OBSERVATION LOG SHEET

Area _____ Time _____: _____

Date ____/____/_____

Tools: Fishing rod / Buoy / Reel Bait: Yes / No Lure: Yes / No

Tidal height: high tide / low tide Wind speed _____

Seawater turbidity _____ Sea roughness _____

Time	Activity	Retained species	Discarded species	Size / Weight

NOTES:

_____

_____

Appendix IV. List of measures referred in the questionnaire presented in Appendix II.

- **Legislation regulating recreative fishing in continental Portugal** (Ordinance no. 144/2009 of February 5th, modified by Ordinance no. 458-A/2009, of May 4th)

1	mandatory licensing for angling and free-diving fishing activities
2	hand collecting licensing is not mandatory
3	if licensed, collecting can be performed with tools such as collecting knife, hand net or baited stick
4	collecting cannot be done with hook
5	prohibition of recreative fishing within 100 m of the mouth of any sewage outfall, provided it is properly marked
6	prohibition of recreative fishing in concessioned beaches during bathing season, and also up to 300 m from the coastline in front of these beaches
7	same minimum sizes as those used in the commercial fishing
8	maximum total weight/day/fisherman = 10 kg of fishes and cephalopods
9	maximum total weight/day/fisherman = 2 kg of crustaceans and others
10	maximum total weight/day/fisherman = 0.5 kg of stalked barnacles
11	marking of fishes caught with a cut of the caudal fin

- **Legislation regulating recreative fishing in the Southwest Alentejo and Vicentina Coast Natural Park - PNSACV** (Ordinance no. 143/2009, of February 5th, modified by Ordinance no. 458-A/2009, of May 4th, and Ordinance no. 115-A/2011, of March 24th)

12	angling can be performed with a maximum of two rods or hand lines
13	each rod or line is allowed to have a maximum of three hooks with an aperture equal or greater than 9 mm, or a single unit of artificial bait containing simple or multiple hooks with aperture equal or greater than 9 mm
14	fishing is prohibited on Wednesdays (unless it is a national holiday)
15	in order to perform recreative fishing between sunset and sunrise, regardless where this activity is made, fishermen must wear a reflective and floating jacket
16	stalked barnacles closure season between September 15th and December 15th
17	sea bream (*Diplodus sargus, Diplodus vulgaris*) closure season between February

	1th and March 15th
18	wrasse (*Labrus bergylta*) closure season between March 1th and May 31th
19	it is only allowed the collection of topshells, limpets, mussels, velvet swimming crabs, sea urchins, stalked barnacles, octopuses and sea-worms (*polychaetes* for bait)
20	shellfish collecting can be made with collecting knife or chisel, or with hook in the case of Octopus collecting
21	maximum sizes of collecting tools
22	shellfish collecting is only allowed to recreative fishing license holders
23	shellfish collecting is only allowed to residents or persons with birthplace in the municipalities of Sines, Odemira, Aljezur or Vila do Bispo
24	specific minimum sizes for the collection of limpets, mussels and velvet swimming crabs, higher than those used in the commercial fishing
25	maximum total weight/day/fisherman = 7.5 kg of fishes and cephalopods (except the largest specimen)
26	maximum total weight/day/fisherman = 2 kg of crustaceans and others (except the largest specimen)
27	maximum total weight/day/fisherman = 3 kg of mussels
28	maximum total weight/day/fisherman = 1 kg of stalked barnacles
29	octopus collection is limited to two individuals per day per fisherman
30	in free-diving fishing, the capture of wrasse is limited to two individuals per day per fisherman

Appendix V. Results of ANOVA and SNK tests on the intensity of fishing activities made on rocky shores of Alentejo (shore angling and bait harvesting, shellfish harvesting and total predation in low tide, and shore angling in high tide) for the study of the effects of the weekly banning period. Bp – weekly banning period (Wednesdays, except holidays); Wd – weekdays (except Wednesdays); OP - outside park; IP - inside park.

Factors: Day (Da); Park (P); Area (Ar).

ANOVA								**Banning Period**						
	n=7	Shore angling and bait harvesting			Shellfish harvesting			Total predation			**n=8**	Shore angling (high tide)		
Source	DF	MS	F	*P*	MS	F	*P*	MS	F	*P*	DF	MS	F	*P*
Day (Da)	1	0.3719	13.91	0.0649	1.0094	1.31	0.3705	13.7192	17.65	0.0523	1	0.6255	7.68	0.1093
Park (P)	1	0.1690	0.44	0.5772	10.4552	2.41	0.2604	7.0534	2.78	0.2376	1	3.3520	4.16	0.1781
Area (Ar)	2	0.3880	1.79	0.1775	4.3300	5.49	**0.0071**	2.5411	2.38	0.1031	2	0.8053	7.44	**0.0014**
Da X P	1	1.4895	55.73	**0.0175**	5.8499	7.61	0,1102	19.3053	24.84	**0,0330**	1	0.2411	2.96	0,2275
Da X Ar (P)	2	0.0267	0.12	0,8841	0.7690	0.98	0,3844	0.7772	0.73	0,4877	2	0.0815	0.75	0,4757
RES	48	0.2165			0.7884			1.0664			56	0.1082		
TOT	55										63			
Cochran's Test		C = 0.2477 (not significant)			C = 0.3061 (not significant)			C = 0.4434 (significant)			C = 0.2855 (not significant)			
Transform		none			none			none			Ln (x+1)			
SNK		**Da X P**			**Ar**			**Da X P**			**Ar**			
		Bp: OP>IP			CSI<VMA			Bp: OP>IP			CSI>VMA			
		IP: Wd>Bp						IP: Wd>Bp						

DF - degrees of freedom; MS - Mean Square; F - F-test value

Appendix VI. Results of ANOVA and SNK tests on the intensity of fishing activities made on rocky shores of Alentejo during (1) weekdays or (2) weekend/holidays for the study of the effects of the closure season of sea breams *Diplodus sargus* and *Diplodus vulgaris* applied to recreational fishing in the natural park PNSACV: (3) free diving fishing (during high tide and low tide), shore angling (during high tide or low tide), shellfish harvesting, amenity use and total predation in low tide. bC - before closure; C - closure season; aC - after closure; CSI – Cabo de Sines; VMA – Vale Marim; ACO – Amoreira/Casca/Oliveirinha; BPC – Burrinho/Porto Covo.

(1) Results of ANOVA and SNK tests on the intensity of shore angling (high tide or low tide), shellfish harvesting, amenity use and total predation in low tide, during weekdays.

Factors: Period (Pe); Park (P); Area (Ar)

ANOVA		**Closure season (weekdays)**														
	n=4	Shore angling (low tide)			Shore angling (high tide)			Shellfish harvesting			Total predation			Amenity use		
Source	DF	MS	F	*P*	MS	F	*P*	MS	F	*P*	MS	F	*P*	MS	F	*P*
Period (Pe)	2	0.0553	0.49	0.6437	0.5494	4.56	0.0929	0.5362	2.47	0.2004	4.9727	5.25	0.0762	0.0123	0.20	0.8229
Park (P)	1	0.1351	0.18	0.7116	5.2347	1.71	0.3207	2.6635	0.64	0.5065	15.3834	2.23	0.2738	0.1236	3.23	0.2141
Area (Ar)	2	0.7443	5.49	**0.0083**	3.0545	7.74	**0.0016**	4.1361	4.43	**0.0190**	6.8942	3.53	**0.0398**	0.0383	4.34	0.0204
Pe X P	2	0,1142	1.02	0,4391	0.1802	1.50	0,3272	0.8424	3.88	0,1158	0.1675	0.18	0,8442	0.0392	0.65	0,5691
Pe X Ar (P)	4	0.1122	0.83	0,5163	0.1204	0.31	0,8726	0.2173	0.23	0,9180	0.9477	0.49	0,7464	0.0602	6.84	**0,0003**
RES	36	0.1355			0.3945			0.9331			1.9531			0.0088		
TOT	47															
Cochran's Test		C = 0.4336 (significant)			C = 0.1894 (not significant)			C = 0.2484 (not significant)			C = 0.2511 (not significant)			C = 0.3228 (not significant)		
Transform		none			none			none			none			Sqrt(X+1)		
SNK		**Ar**			**Ar**			**Ar**			**Ar**			**Pe X Ar (P)**		
		CSI>VMA			CSI>VMA			CSI<VMA			CSI<VMA			ACO: C>(bC=aC)		

DF - degrees of freedom; MS - Mean Square; F - F-test value

(2) Results of ANOVA and SNK tests on the intensity of shore angling (high tide or low tide), shellfish harvesting, amenity use and total predation in low tide, during weekends/holidays.

Factors: Period (Pe); Park (P); Area (Ar)

ANOVA		**Closure season (weekends/holidays)**															
	n=2	Shore angling (low tide)			Shellfish harvesting			Total predation			Amenity use			**n=3**	Shore angling (high tide)		
Source	DF	MS	F	*P*	MS	F	*P*	MS	F	*P*	MS	F	*P*	DF	MS	F	*P*
Period (Pe)	2	1.6411	1.00	0.4439	1.4422	1.82	0.2740	1.3229	2.79	0.1744	0.3459	4.20	0.1041	2	0.0988	1.66	0.2988
Park (P)	1	2.8705	0.58	0.5251	3.2732	1.00	0.4236	3.1469	1.90	0.3025	0.0227	0.12	0.7606	1	0.4561	0.35	0.6152
Area (Ar)	2	4.9298	11.02	0.0019	3.2893	40.92	0.0000	1.6604	3.38	0.0683	0.1865	0.95	0.4136	2	1.3122	19.89	**0.0000**
Pe X P	2	0,3339	0.20	0,8236	0.3959	0.50	0,6401	1.1081	2.34	0,2127	0.0268	0.33	0,7395	2	0.0762	1.28	0,3718
Pe X Ar (P)	4	1.6382	3.66	**0,0358**	0.7922	9.85	**0,0009**	0.4743	0.97	0,4609	0.0824	0.42	0,7911	4	0.0595	0.90	0,4781
RES	12	0.4473			0.0804			0.4907			0.1960			24	0.0660		
TOT	23													35			
Cochran's Test		C = 0.3190 (not significant)			C = 0.3093 (not significant)			C = 0.2726 (not significant)			C = 0.5386 (not significant)			C = 0.3525 (not significant)		
Transform		none			Sqrt(X+1)			Ln(X)			Sqrt(X+1)			Sqrt(X+1)		
SNK		**Pe X Ar (P)**			**Pe X Ar (P)**									**Ar**			
		CSI: aC>(C=bC)			VMA: bC<C<aC									CSI>VMA			

DF - degrees of freedom; MS - Mean Square; F - F-test value

(3) Results of ANOVA and SNK tests on the intensity of free diving fishing (high tide and low tide) during weekdays and weekends/holidays.

Factors: Period (Pe); Day (Da); Park (P); Area (Ar).

ANOVA		**Closure season**		
	n=5	Free-diving fishing		
Source	DF	MS	F	*P*
Period (Pe)	2	3.0200	2.08	0.2409
Day (Da)	1	0.3048	0.25	0.6693
Park (P)	1	0.6877	0.28	0.6505
Area (Ar)	2	2.4718	1.37	0.2584
Pe X Da	2	0.0531	0.03	0,9716
Pe X P	2	0,1444	0.10	0,9077
Pe X Ar (P)	4	1.4554	0.81	0,5230
Da X P	1	3.1240	2.52	0,2535
Da X Ar (P)	2	1.2410	0.69	0,5045
Pe X Da X P	2	2.3348	1.27	0,3730
Pe X Da X Ar (P)	4	1.8314	1.02	0,4026
RES	96	1.8009		
TOT	119			
Cochran's Test		C = 0.5705 (significant)		
Transform		none		
SNK				

DF - degrees of freedom; MS - Mean Square; F - F-test value

Appendix VII. Results of ANOVA and SNK tests on the intensity of fishing activities (shore angling and bait harvesting, shellfish harvesting, amenity use and total predation in low tide) made on rocky shores of Alentejo during weekdays and weekend/holidays for the study of the effects of Easter period. bE - before Easter; E - Easter; aE - after Easter; Wd – weekdays; W/H – weekends/holidays; VMA – Vale Marim; CSI – Cabo de Sines; VMA – Vale Marim; ACO – Amoreiras/Oliveirinha; BPC – Burrinho/Porto Covo.

Factors: Period (Pe); Day (Da); Park (P); Area (Ar).

ANOVA		**Easter 2012**											
	n=2	Shore angling and bait harvesting			Shellfish harvesting			Total predation			Amenity use		
Source	DF	MS	F	*P*	MS	F	*P*	MS	F	*P*	MS	F	*P*
Period (Pe)	2	0.0241	0.24	0.7943	7.0139	17.28	0.0108	1.8802	11.26	**0.0227**	2.8751	4.52	0.0940
Day (Da)	1	1.0787	25.38	**0.0372**	1.3949	1.85	0.3067	3.8691	4.50	0.1679	2.0752	1.90	0.3016
Park (P)	1	0.0142	0.43	0.5806	4.7489	0.95	0.4327	1.1883	0.55	0.5355	0.2138	0.13	0.7522
Area (Ar)	2	0.0333	0.26	0.7700	5.0040	13.24	**0.0001**	2.1599	17.76	0.0001	1.6337	1.45	0.2535
Pe X Da	2	0.3479	5.22	0.0767	1.3202	12.82	**0.0182**	0.5505	3.11	0.1529	1.2137	2.24	0.2227
Pe X P	2	0.1445	1.47	0.3328	0.2525	0.62	0.5819	0.0221	0.13	0.8799	0.2402	0.38	0.7074
Pe X Ar (P)	4	0.0985	0.78	0.5475	0.4060	1.07	0.3913	0.1669	1.14	0.3613	0.6356	0.57	0.6899
Da X P	1	0.1494	3.52	0.2016	0.6144	0.87	0.4491	0.6196	0.72	0.4853	0.6199	0.57	0.5294
Da X Ar (P)	2	0.0425	0.34	0.7167	0.7051	1.87	0.1766	0.8598	5.88	**0.0084**	1.0895	0.97	0.3936
Pe X Da X P	2	0.2640	3.96	0.1125	0.2076	2.02	0.2480	0.0407	0.23	0.8042	0.2450	0.45	0.6654
Pe X Da X Ar (P)	4	0.0666	0.53	0.7153	0.1030	0.27	0.8929	0.1767	1.21	0.3333	0.5422	0.48	0.7482
RES	24	0.1259			0.3781			0.1463			1.1235		
TOT	47												
Cochran's Test		C = 0.3169 (not significant)			C = 0.2383 (not significant)			C = 0.3285 (not significant)			C = 0.6062 (significant)		
Transform		Ln(X+1)			Ln(X)			Sqrt(X+1)			none		
SNK		**Da**			**Pe X Da**		**Ar**	**Da X Ar (P)**		**Pe**			
		Wd<W/H			Wd: (bE=E)>aE W/H: E>(bE=aE)		CSI<VMA	VMA: W/H>Wd		E>(bE=aE)			

DF - degrees of freedom; MS - Mean Square; F - F-test value

Appendix VIII. Results of ANOVA and SNK tests on the intensity of fishing activities (shore angling and bait harvesting, shellfish harvesting, amenity use and total predation in low tide) made on rocky shores of Alentejo during weekend/holidays for the study of Easter period interanual comparisons (1995, 1996 and 2012). bE - before Easter; E - Easter; aE - after Easter; VMA – Vale Marim; CSI – Cabo de Sines; VMA – Vale Marim; ACO – Amoreiras/Oliveirinha; BPC – Burrinho/Porto Covo.

Factors: Year (Y); Period (Pe); Park (P); Area (Ar).

ANOVA		**Easter interannual comparisons (1995/1996/2012)**											
	n=2	Shore angling and bait harvesting			Shellfish harvesting			Total predation			Amenity use		
Source	DF	MS	F	*P*	MS	F	*P*	MS	F	*P*	MS	F	*P*
Year (Y)	2	5.4261	89.27	**0.0005**	44.1807	3.88	0.1156	69.3779	5.06	0.0803	2.6070	3.26	0.1447
Period (Pe)	2	0.6355	2.34	0.2124	270.3372	7.33	0.0459	267.9274	7.29	0.0464	0.8032	2.42	0.2043
Park (P)	1	1.2889	0.81	0.4629	10.3920	0.07	0.8105	18.9497	0.15	0.7386	0.0528	0.02	0.8909
Area (Ar)	2	1.5897	3.75	**0.0333**	139.4360	20.44	0.0000	129.1858	17.68	0.0000	2.1919	2.30	0.1145
Y X Pe	4	1.1819	3.08	0.0823	85.1382	6.52	**0.0123**	90.2708	5.10	**0.0244**	2.8631	3.51	0.0616
Y X P	2	0.2260	3.72	0.1224	22.0523	1.94	0.2580	22.5559	1.64	0.3012	0.0553	0.07	0.9343
Y X Ar (P)	4	0.0608	0.14	0.9648	11.3824	1.67	0.1787	13.7200	1.88	0.1355	0.8004	0.84	0.5084
Pe X P	2	0.6561	2.41	0.2052	0.4933	0.01	0.9868	0.4201	0.01	0.9887	0.3348	1.01	0.4413
Pe X Ar (P)	4	0.2717	0.64	0.6372	36.8665	5.40	**0.0016**	36.7669	5.03	**0.0025**	0.3313	0.35	0.8436
Y X Pe X P	4	0.6456	1.68	0.2461	2.8858	0.22	0.9192	4.0564	0.23	0.9144	0.0283	0.03	0.9972
Y X Pe X Ar (P)	8	0.3838	0.90	0.5235	13.0547	1.91	0.0882	17.6973	2.42	**0.0331**	0.8160	0.86	0.5602
RES	36	0.4243			6.8234			7.3058			0.9518		
TOT	71												
Cochran's Test		C = 0.2925 (not significant)			C = 0.2934 (significant)			C = 0.2741 (not significant)			C = 0.4770 (significant)		
Transform		none			none			none			none		
SNK		**Y** 2012>1995>1996 **Ar** CSI>VMA			**Pe X Ar (P)** VMA, ACO, BPC: E>(bE=aE) **Y X Pe** E: 1995>2012>1996 1995, 2012: E>(bE=aE)			**Y X Pe X Ar (P)** VMA, ACO: (E1995=E2012)>E1996 BPC: E1995>(E1996=E2012) **Pe X Ar (P)** VMA, ACO, BPC: E>(bE=aE) **Y X Pe** E: (1995=2012)>1996					

DF - degrees of freedom; MS - Mean Square; F - F-test value

Appendix IX. Results of ANOVA and SNK tests on environmental variables (sea roughness, turbidity of seawater, wind speed and nebulosity/precipitation) made on rocky shores of Alentejo during weekend/holidays for the study of Easter period interanual comparisons (1995, 1996 and 2012). bE - before Easter; E - Easter; aE - after Easter; VMA – Vale Marim; CSI – Cabo de Sines; VMA – Vale Marim; ACO – Amoreiras/Oliveirinha; BPC – Burrinho/Porto Covo.

Factors: Year (Y); Period (Pe); Park (P); Area (Ar).

ANOVA		**Easter interannual comparisons (1995/1996/2012)**											
	n=2	Sea roughness			Turbidity of seawater			Wind speed			Nebulosity/precipitation		
Source	DF	MS	F	*P*	MS	F	*P*	MS	F	*P*	MS	F	*P*
Year (Y)	2	5.0417	5.85	0.0648	11.0139	793.00	0.0000	15.5139	111.70	**0.0003**	2.9306	30.14	0.0039
Period (Pe)	2	1.6250	14.63	0.0145	0.6806	49.00	0.0015	3.4306	8.82	**0.0342**	0.7222	13.00	0.0178
Park (P)	1	0.5000	0.11	0.7751	0.0556	1.00	0.4226	0.0139	0.01	0.9235	0.0000	0.00	1.000
Area (Ar)	2	4.6944	16.90	0.0000	0.0556	0.09	0.9133	1.1806	5.67	**0.0073**	0.2222	0.67	0.5196
Y X Pe	4	2.3542	26.08	**0.0001**	5.1181	147.40	**0.0000**	0.4306	1.51	0.2862	2.0139	17.06	**0.0006**
Y X P	2	0.2917	0.34	0.7313	0.0139	1.00	0.4444	0.0972	0.70	0.5487	0.0417	0.43	0.6782
Y X Ar (P)	4	0.8611	3.10	**0.0272**	0.0139	0.02	0.9989	0.1389	0.67	0.6193	0.0972	0.29	0.8815
Pe X P	2	0.0417	0.38	0.7091	0.0139	1.00	0.4444	0.1806	0.46	0.6587	0.1667	3.00	0.1600
Pe X Ar (P)	4	0.1111	0.40	0.8073	0.0139	0.02	0.9989	0.3889	1.87	0.1376	0.0556	0.17	0.9539
Y X Pe X P	4	0.0208	0.23	0.9135	0.0347	1.00	0.4609	0.1389	0.49	0.7453	0.3333	2.82	0.0988
Y X Pe X Ar (P)	8	0.0903	0.33	0.9510	0.0347	0.06	0.9999	0.2847	1.37	0.2440	0.1181	0.35	0.9376
RES	36	0.2778			0.6111			0.2083			0.3333		
TOT	71												
Cochran's Test		C = 0.2000 (not significant)			C = 0.0909 (not significant)			C = 0.2667 (not significant)			C = 0.1667 (not significant)		
Transform		none			none			none			none		
SNK		**Y X Ar (P)**			**Y X Pe**			**Ar**	**Pe**		**Y X Pe**		
		CSI, BPC:1996>(1995=2012)			E: 1996>2012>1995			CSI>VMA	bE>E		bE: (1995=1996)>2012		
		Y X Pe			aE: 1996>1995>2012			ACO<BPC			E: 1996>(1995=2012)		
		bE: (1995=1996)>2012						**Y**					
		E: 1996>(1995=2012)						1996>1995>2012					

DF - degrees of freedom; MS - Mean Square; F - F-test value

Appendix X. Results of ANOVA and SNK tests on the yield of the fishing activities (shellfish harvesting, shore angling and total predation) obtained in areas outside and inside the park PNSACV, according to direct inquiries made to fishermen exploiting rocky shores of Alentejo. OP – outside park; IP – inside park.

Factors: Park (P).

ANOVA		**Yield of the fishing activities**									
	n=17	Shellfish harvesting			**n=16**	Shore angling			**n=34**	Total predation		
Source	DF	MS	F	*P*	DF	MS	F	*P*	DF	MS	F	*P*
Park (P)	1	0.8920	0.39	0.5381	1	0.4336	1.52	0.2275	1	2.4253	8.63	**0.0046**
RES	32	2.3026			30	0.2857			66	0.2810		
TOT	33				31				67			
Cochran's Test		C = 0.5096 (not significant)			C = 0.9423 (significant)				C = 0.6245 (not significant)			
Transform		none			none				Ln(X+1)			
SNK									**Park (P)**			
									IP>OP			

DF - degrees of freedom; MS - Mean Square; F - F-test value

Appendix XI. Results of ANOVA and SNK tests on the yield of shore angling obtained in areas outside and inside the park PNSACV, according to direct observations of anglers made on rocky shores of Alentejo. OP – outside park; IP – inside park.

Factors: Park (P).

ANOVA		**30' anglers observation**		
	n=17	Shore angling		
Source	DF	MS	F	*P*
Park (P)	1	0.0156	2.22	0.1463
RES	32	0.0070		
TOT	33			
Cochran's Test		C = 0.6534 (not significant)		
Transform		none		
SNK				

DF - degrees of freedom; MS - Mean Square; F - F-test value