



**UNIVERSIDADE DO ALGARVE**  
FACULDADE DE CIÊNCIAS E TECNOLOGIA

**Recreational shore fishing in southern Portugal:  
biological and socio-economic aspects and  
perspectives for management.**

PEDRO FILIPE DUARTE ALVES DA VEIGA



Doutoramento em Ciências da Terra, do Mar e do Ambiente, ramo de Ciências e Tecnologias das Pescas (CTP),  
especialidade de Avaliação e Gestão de Recursos

Thesis for the degree in Doctor of Philosophy in Fisheries Sciences and Technology,  
specialty in Resources Management and Assessment



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TÍTULO DA TESE: A pesca recreativa de costa no sul e sudoeste de Portugal: Componente socioeconómica, biológica e perspectivas de gestão

## Resumo

O problema de sobrepesca que se tem assistido em muitas partes do globo foi, durante muito tempo, apenas associado à pesca comercial, com pouca ou nenhuma atenção dirigida à potencial contribuição da pesca recreativa. Estudos recentes têm demonstrado, no entanto, que o impacto da pesca recreativa em algumas espécies em particular pode ser considerável e que, como tal, avaliações e gestão de recursos que não incluam esta componente podem ser enviesadas e ineficazes na protecção dos recursos. Em Portugal, as primeiras medidas restritivas para a pesca recreativa só recentemente foram implementadas. No entanto, e à semelhança do que se verificou em outros países Europeus, as restrições careceram de suporte científico, dada a escassez de estudos em relação à actividade até ao momento. Este projecto, dirigido à pesca recreativa de costa (PRC) no sul e sudoeste de Portugal, teve como objectivos principais: 1) caracterizar a actividade nas suas vertentes biológica e socioeconómica; 2) avaliar a eficácia e a aceitação da legislação no que diz respeito às várias medidas restritivas; e 3) fazer recomendações que permitam uma melhor gestão e conservação dos recursos costeiros em Portugal.

A caracterização da pesca recreativa de costa foi efectuada com recurso a duas metodologias complementares: 1) entrevistas nos locais de pesca, para obtenção de informação sobre as saídas de pesca (p.ex. capturas) e informação socioeconómica; e 2) levantamentos aéreos de distribuição de pescadores, para obtenção de dados de esforço de pesca. A análise das capturas dos pescadores indicou que, no geral, o cumprimento dos limites diários de pesca (10 kg pescador<sup>-1</sup> dia<sup>-1</sup>) foi elevado, com apenas 0.5% dos pescadores entrevistados a excederem este limite. Em relação aos tamanhos mínimos de captura, verificou-se que apenas 11,5% dos peixes retidos pelos pescadores estavam abaixo do tamanho mínimo de desembarque estabelecido por lei. Não obstante, para algumas espécies como o robalo em particular, a percentagem de indivíduos abaixo do limite legal para espécie (36 cm) foi elevada (73%). A nível do impacto da pesca recreativa de costa, verificou-se que as capturas totais anuais estimadas representaram menos de 1% das quantidades desembarcadas pela pesca comercial, para o mesmo período e para espécies capturadas por ambos os tipos de pesca. Uma análise

por espécie indicou no entanto que as capturas de sargo legítimo pela pesca recreativa de costa foram consideráveis, correspondendo a 65% dos valores comerciais desembarcados para a mesma espécie (39,4% das capturas totais). Em termos das opiniões dos pescadores em relação a legislação específica para a pesca recreativa, verificou-se que a maioria dos pescadores aceitava a existência de algum tipo de legislação, mas que em geral não concordava com as actuais restrições. Uma grande parte dos pescadores considerou que esta legislação tinha sido desenvolvida sem envolvimento dos mesmos, e que algumas das restrições (p.ex. proibição de pesca nos molhes) careciam de justificação fundamentada.

Numa mesma fase foram também investigadas as competições de pesca desportiva de costa a decorrer no sul de Portugal, visando identificar diferenças com a vertente recreativa, e avaliar tendências de longo prazo nas capturas a partir de dados históricos. Verificou-se que em geral as competições de pesca desportiva eram diferentes das da pesca recreativa a nível do número de espécies capturadas e das espécies mais importantes nas capturas (no caso das competições: tainhas e peixe-agulha). Tal diferença atribuiu-se à possibilidade de uma estratégia diferente entre os dois tipos de pescadores relativamente às espécies-alvo. As competições de pesca desportiva foram também caracterizadas por grandes percentagens de espécimens abaixo do tamanho mínimo de desembarque (robalo em particular, 100% abaixo do limite), possivelmente como resultado da utilização de um único tamanho mínimo de 15 cm para todas as espécies.

No último estudo, realizaram-se pescas experimentais para testar as taxas de mortalidade pós-libertação de três espécies identificadas como importantes na pesca recreativa de costa do sul de Portugal: Safia *Diplodus vulgaris*; Choupa *Spondyliosoma cantharus*; e Dourada *Sparus aurata*. As taxas de mortalidade observadas foram em geral baixas (0-12%). A análise por modelos aditivos generalizados indicou a localização do anzol como o principal predictor da mortalidade, sendo que em 63% das douradas que morreram o anzol se encontrava profundamente alojado no tubo digestivo (estômago, esófago). Estes resultados suportam a decisão de libertar o peixe capturado, voluntariamente ou por medidas restritivas legais.

Em suma, neste projecto demonstrou-se que o impacto da pesca recreativa de costa em algumas espécies é significativo, em particular o sargo, devendo ser tido em conta para efeitos de avaliação de gestão de recursos. Foram também realçados vários problemas com a corrente legislação que deveriam ser devidamente analisados de forma a promover medidas de gestão mais adequadas e prevenir futuras situações de incumprimento da lei. Como recomendação final, considera-se que uma monitorização periódica da pesca recreativa em Portugal, nas suas várias modalidades (pesca submarina, pesca embarcada e pesca de costa) e dimensões (biológica e socioeconómica), seria benéfica para um acompanhamento adequado da dinâmica da actividade, e suporte de futuras medidas de gestão.

**Palavras-chave:** Pesca recreativa de costa, impacto, gestão, esparídeos, Portugal

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THESIS TITLE: Recreational shore fishing in southern Portugal: biological and socio-economic aspects and perspectives for management.

### **Abstract:**

Although overfishing is a concern for many fish stocks, it was for a long time only associated with commercial fishing exploitation, with less or no attention being given to the recreational fisheries. Recent research has shown however that the impact of recreational fishing on particular species can be considerable, and that the recreational harvest needs to be taken into account if fisheries are to be accurately assessed and effectively managed. In Portugal, the first recreational fishing regulations were only recently implemented. However, mirroring other European countries, regulations lacked scientific support, and specific knowledge of the activity was limited to a few studies with limited coverage. This thesis aimed to characterize the biological and socioeconomic aspects of the recreational shore angling activity in southern Portugal, to investigate whether the regulations in place were adequate and effective, and to provide recommendations for improved management and conservation of the inshore fisheries resources.

A combined aerial-roving survey was conducted to gather data on fishing effort, catch, fishing trips and socioeconomic aspects (including anglers' perceptions of regulations) of the recreational angling activity. The analysis of anglers' catches suggested that compliance with daily bag limits was high, with less than 0.5% of creels exceeding the 10 kg angler<sup>-1</sup> day<sup>-1</sup> bag limit. Overall, 11.5% of the retained fishes were undersized, but non-compliance with minimum size limits was found to be high for some species (e.g. seabass, 73% undersized). In terms of the impact of recreational shore angling, the total estimated catches corresponded to less than 1% of the commercial landings for the same period (shared species). However, shore angling catches for white sea bream (*Diplodus sargus*) were found to be considerable, corresponding to 65% of the commercial landings (39.4% of total catch). In terms of anglers' perceptions about the recreational fishing regulations in Portugal, the present study has shown that the majority of anglers accepted the existence of some kind of SRF regulations, but in general there was a partial or total disagreement with the recreational fishing restrictions recently put in place. Most anglers perceived themselves as not being involved in the decision-making process and claimed that some restrictions lacked a meaningful rationale (e.g. prohibition of fishing from piers/jetties). Fishers' awareness with regard to specific

aspects of the restrictions (such as the rationale for minimum size limits) was found to be very limited.

During the same period, catches from sport fishing competitions were examined to test for differences with the recreational activity in terms of catches, and evaluate long term trends in catch and mean size of fish. Catches of the sport fishing competitions were found to be different from those observed for recreational fishing, being dominated by different species (e.g. garfish, mullets), and suggesting different fishing strategies of the the two types of anglers. High percentages of undersized fish were observed to be captured (and retained) during the competitions (in particular seabass, with 100% undersized), probably as a result of a single allowable minimum size (AMS) of 15 cm for all species in use in competitions.

Lastly, catch and release fishing experiments were carried out to assess post-release mortality of three recreationally important species: two banded sea bream *Diplodus vulgaris*; black sea bream *Spondylisoma cantharus*; and gilthead sea bream *Sparus aurata*. Post-release mortalities were found to be low (0-12%). The main predictor of mortality for *Sparus aurata* was anatomical hooking location, with 63% of the fishes that died being deeply hooked. The results support the release of fish, either from mandatory (e.g. minimum landing sizes) or voluntary practices.

In summary, this thesis has demonstrated that the impact of recreational fishing for particular species is significant and needs to be taken into account for more effective management and stock assessment purposes. It has also highlighted several management issues that should be addressed in order to promote more adequate regulations in the future and prevent non-compliance issues. A periodic monitoring of the recreational fishing activity including all fishing modes (i.e. spear fishing, boat, and shore angling) would also be beneficial to ensure a timely knowledge on the global recreational fishing activity and support future management actions.

**Keywords:** shore angling, impact, management, Sparidae, Portugal

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**Table of Contents**


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<b>Resumo .....</b>	<b>I</b>
<b>Abstract: .....</b>	<b>III</b>
<b>Acknowledgements .....</b>	<b>VII</b>
<b>Table of Contents.....</b>	<b>IX</b>
<b>List of Figures .....</b>	<b>XIII</b>
<b>List of Tables.....</b>	<b>XV</b>
<b>List of Acronyms and Abbreviations.....</b>	<b>XVII</b>
<b>CHAPTER 1: General Introduction.....</b>	<b>1</b>
<b>1.1 Introduction.....</b>	<b>3</b>
<b>1.2 Recreational fishing surveys: importance and applications in fisheries management (Literature review).....</b>	<b>5</b>
1.2.1 <i>Catch and effort related studies .....</i>	<i>6</i>
1.2.2 <i>Human dimensions of recreational fisheries.....</i>	<i>8</i>
1.2.3 <i>Hooking mortality studies .....</i>	<i>9</i>
<b>1.3 Brief overview of recreational fishing in Portugal.....</b>	<b>12</b>
1.3.1 <i>The definition of recreational fishing in Portugal.....</i>	<i>12</i>
1.3.2 <i>Historical legal framework of saltwater recreational fishing (SRF) in Portugal.....</i>	<i>13</i>
1.3.3 <i>Research gaps and significance for this study .....</i>	<i>14</i>
<b>1.4 General Objectives.....</b>	<b>16</b>
<b>1.5 Chapters Outline.....</b>	<b>17</b>
<b>CHAPTER 2: Quantifying recreational shore angling catch and harvest in the south of Portugal (North-East Atlantic): implications for conservation and integrated fisheries management .....</b>	<b>21</b>
<b>2.1 Abstract.....</b>	<b>23</b>
<b>2.2 Introduction.....</b>	<b>23</b>
<b>2.3 Methods.....</b>	<b>26</b>
2.3.1 <i>Study area.....</i>	<i>26</i>
2.3.2 <i>Sampling strategy.....</i>	<i>28</i>
2.3.3 <i>Roving creel surveys.....</i>	<i>28</i>
2.3.4 <i>Aerial surveys.....</i>	<i>29</i>
2.3.5 <i>Data analysis.....</i>	<i>29</i>
<b>2.4 Results .....</b>	<b>31</b>
2.4.1 <i>Fishing activity baseline characteristics.....</i>	<i>32</i>
2.4.2 <i>Catch and size composition.....</i>	<i>32</i>
2.4.3 <i>Spatio-temporal variation of catch per unit effort and fishing effort.....</i>	<i>37</i>
2.4.4 <i>Comparison between recreational and commercial fishing.....</i>	<i>40</i>
<b>2.5 Discussion .....</b>	<b>42</b>
2.5.1 <i>Surveys .....</i>	<i>42</i>

2.5.2	<i>Fishing activity, catches, CPUE and discarding</i> .....	43
2.5.3	<i>Spatio-temporal variation of fishing activity</i> .....	45
2.5.4	<i>Recreational vs. Commercial fishing</i> .....	46
2.5.5	<i>Management considerations</i> .....	47
<b>CHAPTER 3: From a traditionally open access fishery to modern restrictions: Portuguese anglers' perceptions about newly implemented recreational fishing regulations</b> .....		<b>51</b>
3.1	<b>Abstract</b> .....	<b>53</b>
3.2	<b>Introduction</b> .....	<b>54</b>
3.3	<b>Methods</b> .....	<b>58</b>
3.3.1	<i>Study areas</i> .....	58
3.3.2	<i>Survey</i> .....	59
3.3.3	<i>Data analysis</i> .....	63
3.4	<b>Results</b> .....	<b>64</b>
3.4.1	<i>Anglers' demographics, attributes, fishing habits, and expenditures on fishing</i> .....	64
3.4.2	<i>Opinions about the need for the existence of regulation</i> .....	65
3.4.3	<i>Perceptions about the regulation in place</i> .....	68
3.4.4	<i>Perceptions about the state of resources</i> .....	69
3.5	<b>Discussion</b> .....	<b>71</b>
3.5.1	<i>Anglers' perceptions towards regulations</i> .....	72
3.5.2	<i>Factors influencing anglers' perceptions about regulations</i> .....	76
3.5.3	<i>Management implications</i> .....	77
<b>CHAPTER 4: catches of the sport fishing competitions along the Algarve coast (Portugal): species, sizes, catch rates, and trends</b> .....		<b>81</b>
4.1	<b>Abstract</b> .....	<b>83</b>
4.2	<b>Introduction</b> .....	<b>84</b>
4.3	<b>Methods</b> .....	<b>85</b>
4.4	<b>Results and Discussion</b> .....	<b>85</b>
4.5	<b>Conclusion</b> .....	<b>91</b>
<b>CHAPTER 5: Short-term hooking mortality of three marine fish species (Sparidae) caught by recreational angling in the south Portugal</b> .....		<b>93</b>
5.1	<b>Abstract</b> .....	<b>95</b>
5.2	<b>Introduction</b> .....	<b>95</b>
5.3	<b>Methods</b> .....	<b>98</b>
5.3.1	<i>Study site</i> .....	98
5.3.2	<i>Experimental design</i> .....	99
5.3.3	<i>Data analysis</i> .....	101
5.4	<b>Results</b> .....	<b>102</b>
5.5	<b>Discussion</b> .....	<b>107</b>
<b>CHAPTER 6: General Discussion</b> .....		<b>113</b>
6.1	<b>Summary of the Results</b> .....	<b>115</b>

6.1.1	<i>Estimating the impact of saltwater shore angling compared with commercial sector ....</i>	115
6.1.2	<i>Examining Anglers' perceptions towards the newly implemented regulations.....</i>	117
6.1.3	<i>Evaluating catches of the sport fishing competitions in southern Portugal.....</i>	118
6.1.4	<i>Estimating post-release hooking mortality of fish species caught by recreational angling in the south Portugal.....</i>	119
<b>6.2</b>	<b>“So what?”: Implications and perspectives for management.....</b>	<b>120</b>
<b>6.3</b>	<b>Conclusions and future research needs .....</b>	<b>126</b>
<b>References.....</b>		<b>131</b>
<b>Appendices .....</b>		<b>149</b>



## List of Figures

Figure 2.1 Map of the study area showing the different features of the coastline.....	27
Figure 2.2. Individual angler catch (n = 1228) in the south and south-west of Portugal between August 2006 and July 2007. ↓, the legal daily bag size limit. Fishing trips < 0.5 h were excluded.....	33
Figure 2.3 Total length ( $L_T$ ) frequency distributions of the most important species of the recreational shore fishing in the south Portugal, during 2006 and 2007. (a) <i>Diplodus sargus</i> (n = 1342), (b) <i>Diplodus vulgaris</i> (n = 401), (c) Mugilidae (n = 104), (d) <i>Dicentrarchus labrax</i> (n = 63), (e) <i>Sparus aurata</i> (n = 58), (f) <i>Boops boops</i> (n = 175), (g) <i>Sarpa salpa</i> (n = 105) and (h) <i>Scomber japonicus</i> (n = 284). ↓, minimum size limit. Undersized, percentage of individuals with $L_T$ below the minimum size limit. ....	36
Figure 2.4. Mean $\pm$ SE (n = 1228) catch per unit effort (CPUE) by mass, season and area (□, south coast; ■, south-west coast) during the study period. ....	37
Figure 2.5. Mean $\pm$ SE (n = 1228) catch per unit effort by mass of the main species (▨, <i>Boops boops</i> ; ■, <i>Diplodus sargus</i> ; ▩, <i>Dicentrarchus labrax</i> ; □, <i>Sparus aurata</i> ; ◻, <i>Diplodus vulgaris</i> ) per season. ....	38
Figure 2.6. Mean $\pm$ SE number of anglers by day type (□, south coast; ■, south-west coast) and per season, from the 24 aerial surveys. ....	38
Figure 2.7 Mean $\pm$ SE estimated number of angler hours by sub-area (□, weekend; ■, weekday) and per season, calculated from the 24 aerial surveys. ....	40
Figure 2.8. Comparison of annual harvest estimates of the most important species common to both recreational shore angling and commercial fishing. Note different y-axes scales. ....	41
Figure 2.9. Reported official landings of the commercial fishery (■) and estimated recreational shore angling catches (□) of <i>Diplodus sargus</i> for the south and south-west coast of Portugal. Note: Shaded area indicates the spawning peak period. ....	42
Figure 3.1 Map of the south of Portugal showing the 2 main study areas (South and south west coast), the PNSACV Natural Park (shaded/dotted area), and the most important fishing locations (type of fishing spot: ▲, Cliff; ●, Jetty) (from Veiga <i>et al.</i> , 2010). Note: dashed line denotes the separation between the South and South west coasts).....	60
Figure 4.1 Relative frequencies of the classes of length of the taxa, <i>Diplodus sargus</i> (a), <i>Dicentrarchus punctatus</i> (b), <i>Scomber</i> spp. (c), <i>Dicentrarchus labrax</i> (d), Mugilidae (e), and <i>Belone belone</i> (f). MLS (↓) - Minimum landing size. ....	88
Figure 4.2 Number of beach angling competitions (Algarve, southern Portugal) from 1996 to 2009..	89
Figure 4.3 Mean $\pm$ SE catch per angler (kg angler <sup>-1</sup> competition <sup>-1</sup> ) for the top 10 anglers in each competition.....	90
Figure 4.4 Mean $\pm$ SE catch per angler (kg angler <sup>-1</sup> competition <sup>-1</sup> ) for the top 10 anglers in each competition.....	90
Figure 5.1. Dimensions (in mm) of the hooks used in this study. Means and standard errors are based on a sample size of 13 hooks per each size. ....	100
Figure 5.2. Length frequency distribution (cm) of <i>S. cantharus</i> (S.c.), <i>S. aurata</i> (S.a.) and <i>D. vulgaris</i> (D.v.) and percentage of each species in catches, per hook size.....	103
Figure 5.3. Catch rates per hook size (mean $\pm$ SE) of the species caught during the fishing trials.....	104
Figure 5.4. Relationship between deep hooking (yes or no) and hooking removal difficulty (easy, difficult or impossible), for <i>S. aurata</i> caught during the fishing trials.....	106
Figure 5.5. Relationship between deep hooking (yes or no) and hooking removal difficulty (Bleeding or no bleeding), for <i>S. aurata</i> caught during the fishing trials. ....	106



**List of Tables**

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Table 2.1 Catch composition of species recorded in creel surveys along the south and south-west coast of Portugal (August 2006 to July 2007). $L_T$ , total length; FO frequency of occurrence; E.V., economic value. ....	34
Table 2.2 Most important fishing locations (sections) in terms of total number of anglers, based on aerial surveys (August 2006-July 2007).....	39
Table 3.1 Legislation and measures in place which impact on recreational fishing in the south of Portugal. ....	57
Table 3.2 Characteristics of the shore anglers in the survey (n = 1298). Data is shown as means ( $\pm$ standard deviation) or percentages.....	61
Table 3.3 Perceptions and opinions of the shore anglers in the survey (n = 1298). Data is shown as percentages. ....	65
Table 3.4 Logistic model estimates for shore anglers' perceptions about the need for the existence of recreational fishing regulation.....	67
Table 3.5 Ordered logistic model estimates for shore anglers' perceptions about the recreational fishing regulation in place. ....	70
Table 4.1 Species recorded in the beach angling competitions analyzed (Algarve, southern Portugal), with minimum landing sizes. Note: percentage contribution is given in parentheses.....	86
Table 5.1. Number, mean ( $\pm$ SE) total length (TL), range and percentage of undersized fish per hook size, from the studied species caught during the angling trials. ....	102
Table 5.2. Number of fish (n) and mortality rates [Mort. (%)] per species, for the evaluated variables (categorical and continuous). ....	105
Table 5.3. Estimates of the independent variables that significantly affect the probability of occurrence of Mortality and Deep hooking in <i>S. aurata</i> , based on stepwise GLM analysis (logistic regression). Estimates and standard errors are in logits. ....	107



## List of Acronyms and Abbreviations

<b>AHL</b>	Anatomical hooking location
<b>AMS</b>	Allowable minimum size
<b>C&amp;R</b>	Catch and Release
<b>FAO</b>	Food and Agriculture Organization of the United Nations
<b>MLS</b>	Minimum landing size (same as <i>Minimum size limit</i> )
<b>MPA</b>	Marine Protected Area
<b>MRF</b>	Marine recreational fishing (same as <i>Saltwater recreational fishing</i> )
<b>MSL</b>	Minimum size limit (same as <i>Minimum landing size</i> )
<b>PNSACV</b>	Parque Natural do Sudoeste Alentejano e Costa Vicentina [ <i>PNSACV Natural Park</i> ]
<b>PRM</b>	Post-release mortality
<b>SRF</b>	Saltwater recreational fishing (same as <i>Marine recreational fishing</i> )

# CHAPTER 1:

## General Introduction





## 1.1 Introduction

Recreational fishing is one of the most ancient and popular leisure activities worldwide, with historical records almost as old as the human civilization, and presently involving millions of enthusiasts and having important socioeconomic benefits (Murray-Jones and Steffe, 2000; Ditton *et al.*, 2002; Kearney, 2002b; Lewin *et al.*, 2006; Aas and Schramm, 2008; Arlinghaus and Cooke, 2009). Overall, around 10% of the adult population in the developed countries worldwide is estimated to be engaged in this activity, with record participatory rates of as much as 50% for countries like Norway (Arlinghaus and Cooke, 2009). In Europe, the number of recreational fishers is estimated at more than 25 million, with expenditures of 8-10 billion Euros annually (anon., 2012).

Albeit its popularity and importance, recreational fishing was for a long time an over-looked activity, with most of the attention regarding the impact on the fish stocks being given to the commercial fishing sector (McPhee *et al.*, 2002; Coleman *et al.*, 2004; Cooke and Cowx, 2004; Cooke and Cowx, 2006; Lewin *et al.*, 2006). Some, if not most, of this indifference could be explained by the fact that recreational captures were generally considered insignificant when compared with commercial fishing landings, but could also be due to other factors such as: 1) difficulties in addressing recreational fishing politically because of pressure from angling lobbyists and the large number of participants; 2) or the fact that collapses induced by recreational fishing may be more difficult to detect than those caused by commercial fishing (McPhee *et al.*, 2002; Post *et al.*, 2002; Cooke and Cowx, 2004; Lewin *et al.*, 2006).

The number of studies that show the importance of recreational fishing in contributing to the decline of certain fish stocks is however increasing (Coleman *et al.*, 2004; Cooke and Cowx, 2006; Arlinghaus and Cowx, 2008; Ihde *et al.*, 2011; Zischke *et al.*, 2012). For inland and inshore waters and for some species in particular, recreational fisheries catches can rival, or

even surpass, catches from the commercial sector (West and Gordon, 1994; Gentner and Lowther, 2002; McPhee *et al.*, 2002; Schroeder and Love, 2002; Coleman *et al.*, 2004; Cooke and Cowx, 2004; Mitchell *et al.*, 2008; Zeller *et al.*, 2008). Some recreational fisheries can also result in considerable catches of smaller [juvenile] specimens (McPhee *et al.*, 2002; Pradervand, 2004; Rangel and Erzini, 2007; Beckley *et al.*, 2008; Mitchell *et al.*, 2008), more vulnerable communities (Sluka and Sullivan, 1998; Meyer, 2007; Lloret *et al.*, 2008a), and other ecosystem impacts (e.g. habitat degradation, loss of fishing gear, bait digging) (Cowx, 2008; McPhee *et al.*, 2002; Lewin *et al.*, 2006).

Although the global fisheries catch has stabilised (FAO, 2011), many of the world's largest commercial fisheries have collapsed or are collapsing (Myers and Worm, 2003; Costello *et al.*, 2008). According to the FAO latest review of state of world marine fisheries resources (FAO, 2011), more than 57% of the world stocks are fully exploited and 30% are over-exploited. As the pressure on fish stocks increases, evidence shows that management based only on data and analysis of commercial fishing, as currently practiced in most countries, may be insufficient to prevent over-exploitation in the future (Post *et al.*, 2002; Cooke and Cowx, 2004). For recreationally important species in particular, the integration of recreational fishing data could provide more reliable catch estimates but also potentially improve the stock assessments (Post *et al.*, 2002; Cooke and Cowx, 2004; Zeller *et al.*, 2008; ICES, 2010; FAO, 2012; Zischke *et al.*, 2012).

In some countries like the US, Canada, Australia, or South Africa there is already a good amount of information on recreational fishing, collected through large/local scale or regular/intermittent survey programs [Australia: (e.g. West and Gordon, 1994; Malseed and Sumner, 2001; Sumner *et al.*, 2002; Henry and Lyle, 2003; Steffe and Chapman, 2003; Sumner *et al.*, 2008; Smallwood *et al.*, 2011); Canada: (e.g. Cooke *et al.*, 2000; Duffy and Mosindy, 2001; Lester *et al.*, 2003; Mosindy and Duffy, 2007; Dempson *et al.*, 2012); South

Africa: (e.g. Clarke and Buxton, 1989; Brouwer *et al.*, 1997; Fennessy *et al.*, 2003; Beckley *et al.*, 2008); US: (e.g. Essig and Holliday, 1991; Harper *et al.*, 2000; Lockwood, 2000; Coleman *et al.*, 2004; Wilberg, 2009; Larkin *et al.*, 2010; NOAA, 2012)]. However, for most of the remaining countries, particularly for developing countries, there is still an overall lack of recreational fishing data (FAO, 2012). In Europe in particular, despite the growing perception of the importance of the recreational catches for some species (e.g. cod *Gadus morhua*, seabass *Dicentrarchus labrax*) (ICES, 2010), as well as the increasing tension between the commercial [inshore] and recreational fishermen, little attention is still being paid to recreational fishing (Arlinghaus, 2005; Pawson *et al.*, 2007). Only recently was the need to collect data on recreational fishing on a periodical basis included as a requirement in the EU Data Collection Framework (EC 199/2008).

This thesis aims to characterize recreational shore angling in southern Portugal. The study, besides contributing to a better knowledge of biological and socioeconomic aspects of the activity, using the recreational shore angling as a case study, evaluates whether the current restrictions are effective/appropriate for the reality of recreational fishing in Portugal.

## **1.2 Recreational fishing surveys: importance and applications in fisheries management (Literature review)**

Recreational fishing surveys are crucial in assisting managers in obtaining information for a given fishery (Pollock *et al.*, 1994; Sullivan *et al.*, 2006). They are the tool used by management agencies to assess the fishery characteristics in terms of catches (e.g. fishing mortality, trends in catches, most targeted and affected species), fishing effort (spatial and temporal distribution patterns), economic data (e.g. expenditures), and human dimensions (i.e. fishers characteristics, perceptions, motivations) (Guthrie *et al.*, 1991; Pollock *et al.*, 1994).

As recreational fishing surveys inherently involve some kind of interaction with fishers (i.e. *via* on-site, phone, mail, and internet surveys), they are also a great opportunity to gain public support and educate fishers on ecological, management and resource conservation aspects (Malvestuto, 1996).

### **1.2.1 Catch and effort related studies**

Recreational surveys to evaluate catch and effort are still probably the most widely used surveys for recreational fishing worldwide. Although the main purpose is generally to characterize the fishery (e.g. most important species, spatial and fishing patterns in catch and effort, catch rates) (e.g. Mann *et al.*, 2002; Rangel, 2003; Morales-Nin *et al.*, 2005; Lloret *et al.*, 2008b; Griffiths, 2012; Mann *et al.*, 2012), some surveys also have more specific purposes such as to evaluate effectiveness and compliance of specific regulations (e.g. bag limits and size limits) (e.g. Sauer *et al.*, 1997; Mann *et al.*, 2003; Prior and Beckley, 2007; Dunlop and Mann, 2012; Smallwood and Beckley, 2012), assess the success of fish stocking events (usually on lakes) (Lockwood, 2000), or to compare recreational and commercial fishing catches (e.g. West and Gordon, 1994; Zischke *et al.*, 2012).

In terms of fishery catch characteristics, while there is some obvious variability among areas (and studies), there are some common aspects across saltwater recreational fisheries worldwide (freshwater/inland fisheries are not analyzed here as they are beyond the scope of this thesis). According to the available studies, independently of the fishing mode, inshore recreational fisheries are generally multispecies fisheries, dominated by a few species (Morales-Nin *et al.*, 2005; Pradervand and Hiseman, 2006; Smallwood *et al.*, 2006). The peak of fishing effort either generally coincides with the seasonal abundance of some target species (e.g. Smallwood *et al.*, 2006) or the holiday period (e.g. Rangel and Erzini, 2007).

In terms of surveys comparing commercial and recreational catches, such comparisons are useful as they help managers understanding the impact of each sector and make the best use

of such information to manage the resources and reduce existing conflicts (Kearney, 2001; Kearney, 2002a). However, the generally high costs associated with obtaining recreational fishing data prevents the regular collection on such data (Mitchell *et al.*, 2008), and contrasts between the two sectors are not abundant. Amid the available literature, some studies have focused solely on catch information (West and Gordon, 1994; Rangel and Erzini, 2007; Zischke *et al.*, 2012), whilst others have also addressed other aspects such as fishing allocation, fishing rights, and co-management issues (e.g. Batstone and Sharp, 1999; Kearney, 2001; Kearney, 2002a; Williams and Blood, 2003; Bess and Rallapudi, 2007; Goodyear, 2007; Mitchell *et al.*, 2008). For studies where data is compared in terms of total catch (all shared species), recreational catches have generally been found to be smaller than the commercial landings (e.g. Morales-Nin *et al.*, 2005; Lloret *et al.*, 2008a; Lloret *et al.*, 2008b). However, when species-by-species comparisons are made a number of studies have found that for some highly valued inshore species (e.g. breams, Sparidae; snappers, Lutjanidae) the recreational catches are generally close or surpass the commercial landings (e.g. West and Gordon, 1994; Young *et al.*, 1999; Kearney, 2002a; McPhee *et al.*, 2002; Coleman *et al.*, 2004; Mitchell *et al.*, 2008). For some pelagic (oceanic) species that are not so important commercially (e.g. marlin, wahoo, sailfish), recreational catches have also been found to exceed the commercial landings in some areas (Zischke *et al.*, 2012).

Many recreational fishing surveys on catch and effort information have also been used to assess non-compliance with regulations, or test outcomes of the introduction of new restrictions (e.g. new or revisions on bag or size limits) (e.g. Sauer *et al.*, 1997; Mann *et al.*, 2003; Page *et al.*, 2004; Prior and Beckley, 2007; Beckley *et al.*, 2008; Lloret *et al.*, 2008b; Näslund *et al.*, 2010). This kind of information is usually obtained through on-site surveys such as roving creel or access point surveys, as they allow the survey clerks to check anglers' catches (Guthrie *et al.*, 1991; Pollock *et al.*, 1994). Most of the available studies have found

that daily bag limits are rarely attained and generally regarded as ineffective in restricting catches (Cowley *et al.*, 2002; McPhee *et al.*, 2002; Näslund *et al.*, 2010; Smallwood and Beckley, 2012). Compliance with minimum size limits varies with species and areas, and has generally been related to awareness (or not) regarding specific minimum size limits (Sauer *et al.*, 1997; Page and Radomski, 2006; Prior and Beckley, 2007; Beckley *et al.*, 2008). Some studies have also used angler counts information (e.g. aerial surveys) to evaluate of zoning compliance (e.g. closed areas) (Smallwood and Beckley, 2012).

### ***1.2.2 Human dimensions of recreational fisheries***

Initially, the recreational fishing surveys were mainly focused on more biological aspects such as catch and fishing effort (Aas and Ditton, 1998). Only in recent years have the recreational fishing surveys also been including more information on socioeconomic aspects, as management agencies started realizing the importance of the human dimensions information to the whole management system (Pollock *et al.*, 1994; Malvestuto, 1996; Lewin *et al.*, 2006; Ditton, 2008). Most of the recent research has been focusing on anglers' motivations for fishing (Chipman and Helfrich, 1988; Fedler and Ditton, 1994; Calvert, 2002; Schramm and Gerard, 2004; Arlinghaus, 2006), consumptive orientation (Fedler and Ditton, 1986; Aas and Kaltenborn, 1995; Arlinghaus, 2006), participation (Morey *et al.*, 1991; Fisher, 1997; Fedler and Ditton, 2001), management preferences (Schoolmaster and Frazier, 1985; Wilde and Riechers, 1992; Aas *et al.*, 2000; Arlinghaus and Mehner, 2005; Edison *et al.*, 2006), and other broad socioeconomic aspects (McConnell and Sutinen, 1979; Bohnsack *et al.*, 2002; Fisher *et al.*, 2002; Arlinghaus and Mehner, 2003; Ditton and Stoll, 2003; Johnston *et al.*, 2010; Font and Lloret, 2011a).

One of the main focuses of research on the human dimensions of recreational fisheries has been to evaluate anglers' responses or attitudes towards recreational fishing regulations (Aas

and Ditton, 1998; Radomski *et al.*, 2001; Radomski, 2003). A number of authors have observed that fishers' perceptions and opinions towards regulations may be influenced by various factors such as: 1) awareness of regulations (Greiner *et al.*, 2000; Page and Radomski, 2006); 2) the way anglers perceive regulations are meaningful and fair (Bennett, 1991; Sutinen and Kuperan, 1999; Hauck *et al.*, 2002); 3) perception of lack of involvement in rule making process (Eggert and Ellegård, 2003; Radomski, 2003; Sutinen and Johnston, 2003; Pita *et al.*, 2010); and 4) motivations for fishing (Edison *et al.*, 2006). In some studies, demographic factors such as degree of education and income are also predictors of anglers' perceptions and opinions towards regulations (Edison *et al.*, 2006).

### **1.2.3 Hooking mortality studies**

One of the challenges that management agencies face in present times is the unaccounted fishing mortality in recreational fishing as a result of catch and release (mandatory or voluntary) (Coleman *et al.*, 2004; Cooke and Cowx, 2004). Catch and release (C&R) of fish is a practice that has been increasing in importance worldwide (Bartholomew and Bohnsack, 2005; Arlinghaus *et al.*, 2007). It is estimated that each year millions of fish are released around the world, with release rates as high as 100% in some fisheries (Cooke and Cowx, 2004). With the implementation of recreational fishing regulations that imply release of fish (e.g. minimum size limits or bag limits), the total number of fish releases is expected to grow in the short term (Bartholomew and Bohnsack, 2005). As a result, there is an increasing need to understand and minimize the post-release mortality (PRM) (Bartholomew and Bohnsack, 2005), and this has been one of the research priorities for many management agencies.

In the past three decades a number of studies have been conducted on PRM, particularly in North America (Cooke and Suski, 2005). According to the available literature, PRM can be highly variable between and within species [global average: 18%, range: 0-95%; (Bartholomew and Bohnsack, 2005)], and may depend on a diverse set of environmental and

other factors specific to each fishery (Muoneke and Childress, 1994; Bartholomew and Bohnsack, 2005; Arlinghaus *et al.*, 2007). According to Bartholomew and Bohnsack (2005), the factors found to affect post release mortality can be divided in five categories: 1) intrinsic factors (e.g. fish size, maturation, behavior); 2) terminal fishing gear (e.g. hook type, hook size, bait type); 3) Fishing, handling, and release techniques (e.g. deep hook removal, playing time and handling time); 4) environmental conditions (e.g. temperature, dissolved oxygen); and 5) other factors (e.g. indirect mortality due to multiple C&R events).

The most important factors that have been shown to influence catch and release mortalities are anatomical hook location, hook removal from deeply hooked fish, hook type, depth of capture, water temperature, and excessive playing and handling (Muoneke and Childress, 1994; Bartholomew and Bohnsack, 2005). In terms of hooking location, most studies have shown that fish hooked in critical locations (i.e. eyes, esophagus, gills, brain, and stomach) had increased mortality rates. In turn, hooking location has been found to be influenced by type of bait (Erzini *et al.*, 1998; Alós *et al.*, 2009a), hook size (Erzini *et al.*, 1998; Grixti *et al.*, 2007; Alós *et al.*, 2008a), hook type (Cooke *et al.*, 2003; Lyle *et al.*, 2007; Alós *et al.*, 2008a), and fishing technique (active vs. passive fishing) (Grixti *et al.*, 2007). In deeply hooked fish, cutting the line has been found to increase post release survival, as hook removal can cause further internal injuries (Bartholomew and Bohnsack, 2005; McGrath *et al.*, 2009).

In some cases, environmental variables such as temperature and depth of capture have also been found to influence the PRM rates (Muoneke and Childress, 1994; Bartholomew and Bohnsack, 2005). Fish caught and released at warmer water temperatures, and also at greater depths, have generally higher mortality rates (Muoneke and Childress, 1994; Wilde *et al.*, 2000; Bartholomew and Bohnsack, 2005; St John and Syers, 2005). The influence of water depth in PRM rates has been found to be particularly important for some species and for

waters deeper than 20-30 m (Muoneke and Childress, 1994; St John and Syers, 2005; Götz *et al.*, 2007; Alós, 2008).

The available research is still however limited to a few species and particular regions (e.g. North America) (Cooke and Suski, 2005; Arlinghaus *et al.*, 2007). Likely differences in post release mortalities are expected for different fish species and fisheries characteristics, as mortality rates have been found to vary extensively among species and studies (Arlinghaus *et al.*, 2007). Recently, some attention has been given to the sub-lethal disturbances of catch and release (e.g. physiological changes, decreased reproductive success, swimming performance) (e.g. Landsman *et al.*, 2011), but there is still also limited research in this area (Cooke and Suski, 2005; Arlinghaus *et al.*, 2007).

Considering the importance that the type of scientific information briefly reviewed (e.g. post-release survival of discarded fish, fishers' attitudes towards management aspects) has for management agencies, and that although there may be some common features, each fishery/region has its own specificities (Cooke and Suski, 2005; Ditton, 2008), the regular collection of such information at a fishery level is crucial to lead to adequate management decisions (Aas, 2002; Cooke and Suski, 2005; Sullivan *et al.*, 2006).

## 1.3 Brief overview of recreational fishing in Portugal

### 1.3.1 *The definition of recreational fishing in Portugal*

Recreational fishing can be globally acknowledged by being “mainly for fun” (Pitcher and Hollingworth, 2002a). However, the definition *per se* can be quite complex and difficult to generalize due to social, traditional and cultural differences across countries (Ditton, 2008; Pawson *et al.*, 2008). Furthermore, the definition of recreational fishing also has implications for management, compliance and even research purposes (Ditton, 2008).

In Portugal, recreational fishing was first defined in 2000, when the first legal framework for this activity was put in place. More broadly, recreational fishing in Portugal is defined as “the capture of marine species, vegetal or animal, from land [shore], boat or underwater, without commercial purposes” (Decree Law § 246/2000; Pawson *et al.*, 2008). As for other countries (Pawson *et al.*, 2008), there are also singularities related with the fishing gear allowed for recreational fishing in Portugal. Organisms can only be collected manually, with specific shellfish collecting tools, through the use of a spear [underwater] or hooks (maximum 3 hooks per line and of 3 lines/rods per fisher). Whereas the main difference between recreational and commercial fisheries is final purpose for the catch (i.e. for recreational fishing there can be no selling of the catch), recreational fishing is then divided in two main areas: a) *sport fishing*, related with the sport fishing organized competitions (which generally involves the some kind of trophy); b) *recreational fishing*, in which the main motivation is to fish for leisure or recreation.

For the sake of consistency, and given the disparity of definitions and terms for recreational fishing for Europe for example (Pawson *et al.*, 2008), the definition adopted and used throughout this thesis are in accordance with the Portuguese legal definitions for recreational/sport fishing (Decree Law § 246/2000): i.e. the term “*sport fishing*” refers to

fishing activity related with organized competitions, and the term “*recreational fishing*” refers to fishing conducted with the main purpose of recreation (Pawson *et al.*, 2008).

### ***1.3.2 Historical legal framework of saltwater recreational fishing (SRF) in Portugal***

The first SRF regulations for Portugal were put in place in 2000, and aimed to define the legal framework for the activity and to fight alleged illicit commercial fishing activities taking place under the umbrella of recreational fishing. Among other aspects, the Decree included the legal definition of recreational fishing (see above), and the allowable fishing gears and methods.

The first “real” restrictions to control the recreational harvest were put in place in 2006 (Portaria § 896/2006) and included the most commonly used management tools such as minimum landing sizes (same as for commercial fishing; Appendix I), daily bag limits, fishing licences, and spatial restrictions (e.g. prohibition from fishing from jetties) (for details refer to Table 3.1- Chapter III). In 2009, SRF regulations were subject to new revisions and one of the major changes was the split of regulations in two coverage scales: a National regulation, which applies to the entire mainland territory of Portugal, and regional scale regulations that are only applied to specific areas. In terms of the nationwide regulations, these were last amended in 2009 (Portaria § 144/2009) and the main changes introduced were: 1) fishing from piers was allowed again for shore angling; 2) clipping of the caudal fin of all fish captured by any recreational fishing activity is mandatory (purpose: avoid illegal selling of catch); 3) some species added to the list of protected/prohibited species (e.g. spiny lobster *Palinurus elephas*, dusky grouper *Epinephelus marginatus*).

Regarding the regional scale SRF regulations, for the moment there is only one in place for the PNSACV Natural Park (“Parque Natural do Sudoeste Alentejano e Costa Vicentina,

PNSACV). The PNSACV Natural Park encompasses around 100 km of coastline in the SW coast of Portugal, and has long been a very important area in terms of natural beauty and biodiversity. It is also known as a very popular destination for recreational fishing. The first specific [regional scale] SRF regulations for this area were put in place in 2009 (Portaria § 143/2009) and amended in 2011 (Portaria § 115-A/2011), after strong public criticism of some of the restrictions. Differences from the national scale regulations include (for detailed information refer to Table 3.1- Chapter III): 1) smaller daily bag limits for both fish and other marine invertebrates; 2) closed seasons for some species (e.g. white sea bream *Diplodus sargus*); 3) fishing effort controls (no fishing on Wednesdays<sup>1</sup>); 4) closed [no-take] areas; and 5) hook size restrictions (minimum gap size of 9 mm).

### ***1.3.3 Research gaps and significance for this study***

As in most countries worldwide, recreational fishing is a very popular leisure activity in Portugal, with an estimated participation rate of around 6% of the population (freshwater and saltwater) (Hurkens and Tisdell, 2006), and possibly very important economic revenues (anon., 2012). Regarding saltwater fishing in particular, it is estimated that around 200,000 of participants engage in this activity (DGRM, 2012). According to the available statistics on licences issued from 2007-2011, the most popular fishing modes are, by decreasing order of importance (average % of licences issued), shore angling (c. 70%), boat angling (c. 28%) and spear fishing (c. 8%) (DGRM, 2012). The boat angling charter sector is also very important in some regions of Portugal (e.g. Algarve).

In terms of research, only six studies concerning saltwater recreational fishing were conducted in Portugal up to 2006 (date of the start of this study) (Diogo, 2003; Castro, 2004; Lopes, 2004; Lima, 2006; Diogo, 2007; Rangel and Erzini, 2007). In 2001, Rangel and Erzini

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<sup>1</sup> Exceptions apply for public holidays.

(2007), carried out roving creel surveys to examine the recreational shore angling activity in northern Portugal, and obtained socioeconomic characteristics of fishers and other fishing activity related information (e.g. catch, effort, target species). Both the studies of Vale (2003) and Lopes (2004) focused on the recreational shore angling activity in the Tagus estuary. In the Azores islands, a small study was carried out on the spearfishing activity on the São Miguel Island during 2001-2002 (Diogo, 2003). In 2004-2005, roving creel surveys were carried out in the Faial island (Azores) to examine all recreational fishing modes in the area (boat angling, spearfishing, shore angling) (Diogo, 2007). Lima (2006) conducted a small scale phone-access point survey in 2005, to obtain catch, effort and socioeconomic information on the boat angling fishery on northern Portugal. The only study known for southern Portugal was carried in the south-western (SW) coast by Castro (2004), but only included hand-gathering in the intertidal zone.

There is still however very limited information on this activity that can be used for management purposes. Most of the scientific data available is limited to small scale studies [with the exceptions of Rangel and Erzini (2007) and Diogo (2007)], with limited coverage in terms of fishing modes and periods. For the southern Portugal in particular, there is no scientific data on the activity other than the study by Castro (2004), which only covered hand gathering. Furthermore, despite all the SRF regulations put in place in the last decade, most studies have focused primarily on biological aspects (e.g. catch), with no attention being given to fishers' opinions towards potential or existing regulation aspects.

## 1.4 General Objectives

Considering the current scarcity of information related with this theme in Portugal, the main aim of the present study was to characterize recreational shore angling in the south and southwest (SW) Portugal, and produce baseline information that can be used for future management decisions. To address this broader goal, the thesis was divided into more specific objectives, which fit into one or more of the studies conducted:

1. To estimate recreational shore angling catch, harvest and effort in the south and southwest of Portugal, namely: investigate spatial and temporal patterns, most targeted and captured species. (Chapter II)
2. To describe the characteristics, fishing habits, preferences of the recreational shore fishers from southern Portugal (Chapters II and III)
3. To evaluate effectiveness/compliance with restrictions such as bag limits, percentage of undersized fish and possession of fishing licences (Chapters II, III and V)
4. To estimate the impact of the recreational shore angling in comparison to the commercial [artisanal] fishing sector, both in terms of global catches (common species) and most affected species (Chapter II)
5. To examine anglers' acceptance of the existence of recreational fishing regulations and the newly implemented restrictions (Chapter III)
6. To evaluate long term trends in catch rates, mean size, and diversity of fish captured, based on catch data from sport fishing competitions (Chapter IV)
7. To estimate immediate and short-term post-release hooking mortality of three of the most recreationally important species in shore angling (Chapter V)
8. To analyse and link the outcomes from all these objectives and provide recommendations for improved management and conservation of the Portuguese fisheries resources (Chapter VI)

## **1.5 Chapters Outline**

The thesis is structured in paper-style format, suitable for publication. With the exception of chapter I (General Introduction) and VI (General Discussion), each chapter has its own Introduction, Methods, Results and Discussion sections, and can be read independently. As such, some repetition is likely to occur.

Chapter II describes the recreational fishing from the shore in terms of fishing trip related data (e.g. targeted species, catch composition, trip duration), fishing effort, and fishers' socioeconomic profile. The main focus of this chapter is to provide baseline information on the activity, evaluate the impact that recreational fishing has for species shared with the commercial sector, and to evaluate how effective/adequate are the restrictions in controlling the recreational catch. If the recreational fishing catches are considerable, or the analysis of fishing trip data indicates that current regulations are not being effective/complied with, these results will have implications at the management level of the fishery.

Chapter III examines anglers' perceptions and opinions regarding recreational fishing regulations in Portugal. At the time of this study there was a sharp transition on the regulatory system of recreational fishing in Portugal, but there was no information on how fishers would accept this change, and how it could affect fisher behavior or compliance. An increasing number of studies have pointed out for the importance of including fishers' perceptions of regulations on the management implementation process, so that information can be used to develop more adequate regulations. The results from this chapter highlight the prevailing perceptions regarding the regulations in place and will contribute to inform decision makers about anglers' potential behavior towards current and future management actions.

In Chapter IV, the differences between sport fishing competitions and recreational catches are assessed and the hypothesis of long term decreases in catches per angler is tested. Several studies have suggested that historical catch records from sport fishing competitions can be a valuable indicator for assessing the status of fisheries (Gartside *et al.*, 1999; Pradervand, 2004). On the other hand, sport fishing competitions may have their own specificities in terms of catch and most affected species (Brouwer and Buxton, 2002). Detecting such differences should help developing more effective management measures. The sport fishing catches in the south of Portugal are described based on monitoring of sport fishing competitions in 2007, and historical catch records of sport fishing competitions used to assess long term trends in abundance, weight, mean size, and diversity of catches taken during sport fishing competitions

Chapter V test the hypothesis that most of the fish released by recreational fishers will survive, and examines that most important factors related with post-release mortality. Having observed that a good percentage of the recreational catch is released [discarded], voluntarily or due to mandatory rules (e.g. minimum size limits) (Chapter II) it is important to estimate the unaccounted post-release mortality. Previous research has shown that post release mortality rates can be highly variable among species and fisheries characteristics, and are dependent upon a series of factors such as anatomical hook location or excessive handling/playing times (e.g. Muoneke and Childress, 1994; Bartholomew and Bohnsack, 2005; Arlinghaus *et al.*, 2007). Experimental fishing with catch and release is conducted for three recreationally important species (*Diplodus vulgaris*, *Spondyllosoma cantharus* and *Sparus aurata*), and the post-release mortality rates analyzed. The results of this analysis provide insight into the effectiveness of regulations in place such as daily bag limits and minimum size limits, which imply the release of fish.

Chapter VI provides the general discussion and main conclusions of this thesis. The main results from each chapter are summarized, and the most important findings are discussed in terms of implications for management purposes. This chapter also revisits the initial research questions and whether they have been successfully addressed, and explores the most important limitations and constraints of the study. Finally, it provides recommendations for management and also for future research opportunities.



# CHAPTER 2:

**Quantifying recreational shore angling catch and harvest in the south of Portugal (north-east Atlantic): implications for conservation and integrated fisheries management**



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## 2.1 Abstract

Recreational shore fishing along 250 km of the south and south-west coast of Portugal was studied based on roving creel and aerial surveys. Surveys were conducted between August 2006 and July 2007, following a stratified random-sampling design and provided information on catch and effort, harvest and discards, angler demographics and fishing habits. Overall, 192 roving creel surveys, 24 aerial surveys and 1321 interviews were conducted. Based on the aerial surveys, a mean  $\pm$  SE total fishing effort of  $705\,236 \pm 32\,765$  angler h year<sup>-1</sup> was estimated, corresponding to  $166\,430 \pm 9792$  fishing trips year<sup>-1</sup>. Average time spent per fishing trip was 4.7 h. A total of 48 species, belonging to 22 families, were recorded in roving creel surveys. The most important species was *Diplodus sargus*, accounting for 44% of the total catches by number and 48% by mass. Estimated mean  $\pm$  SE total annual recreational shore fishing catch was  $160.2 \pm 12.6$  t year<sup>-1</sup> ( $788\,049 \pm 54\,079$  fishes year<sup>-1</sup>), of which  $147.4 \pm 11.9$  t year<sup>-1</sup> ( $589\,132 \pm 42\,360$  fishes year<sup>-1</sup>) was retained. Although overall shore-based recreational catches only corresponded to 0.8% of the commercial landings (only common species considered), *D. sargus* catches by recreational shore anglers were considerable, corresponding to 65% of the commercial landings. The implications of these results for integrated fisheries management and conservation are discussed, and future research proposed.

## 2.2 Introduction

Recreational fishing is one of the most popular pastimes in many countries, involving large numbers of participants all over the world (e.g. McPhee *et al.*, 2002; Beckley *et al.*, 2008; Lloret *et al.*, 2008b). In Europe, this activity constitutes an important social and economic

activity, with an average participation rate of 10% (Arlinghaus and Cooke, 2009) and considerable expenditures.

Until recently, little attention has been paid by fisheries scientists and managers to the economic importance (Pawson *et al.*, 2008) and impact on fish stocks of saltwater recreational fisheries in European Community waters and most other countries (Coleman *et al.*, 2004; Cooke and Cowx, 2004; Cooke and Cowx, 2006). Exceptions are countries such as the USA, South Africa and Australia. As a consequence, the sustainability of recreational fishing seems seldom to have been questioned or seriously addressed (McPhee *et al.*, 2002) with the prevailing perception being that this is a relatively harmless activity (Kearney, 2001).

Several factors have been attributed to explain this phenomenon, with the main being (see MCPhee *et al.*, 2002; Post *et al.*, 2002; Cooke and Cowx, 2004; Lewin *et al.*, 2006): (1) pressure from angling lobbyists has successfully shifted attention away from angling impacts; (2) the large number of participants has always made recreational fishing a difficult problem to address politically; (3) the tendency to look to the recreational fishing impact in isolation rather than assessing the cumulative result; (4) less scrutiny from the conservation movement on angling than other impacts on aquatic systems; (5) collapses induced by recreational fishing may be difficult to detect.

Evidence of the impact that recreational fishing can have on aquatic systems has, however, been emerging (West and Gordon, 1994; MCPhee *et al.*, 2002; Coleman *et al.*, 2004; Cooke and Cowx, 2004). Recreational fisheries catches may greatly exceed the commercial sector in some cases (Coleman *et al.*, 2004; Cooke and Cowx, 2004; Morales-Nin *et al.*, 2005). Therefore, the growing pressure on fish stocks suggests that management based only on data and analysis of commercial fishing, as currently practiced in most countries, may be insufficient to prevent over-exploitation in the future (Cooke and Cowx, 2004). Sound

management decisions require integration of information on stock assessment and on catch, effort and harvest for both commercial and recreational sectors.

As in other parts of the world (West and Gordon, 1994; Kearney, 2001; Pomeroy *et al.*, 2007), an increasing conflict between professional (commercial) and non-professional fishermen has been observed in Europe, with both parts blaming each other for the decrease of fisheries resources (Pawson *et al.*, 2007). Given this scenario, and the absence of guidelines for managing marine recreational fishing, Pawson *et al.* (2007) have highlighted the need to evaluate this activity at the European level, so that management strategies and measures can be implemented.

In Portugal, recreational fishing is an important leisure activity, both economically and socio-culturally (Marta *et al.*, 2001). Until the 2006 law requiring saltwater fishing licences, there was little or no information available on the number of saltwater anglers in Portugal (Rangel and Erzini, 2007). According to official statistics, a total of 201,522 saltwater fishing licences were issued in 2007, with 141,046 (70%) for shore angling. It has been estimated that 6% of the Portuguese population participates in recreational fishing of all kinds (Hurkens and Tisdell, 2006), with this number likely to increase in the future (Marta *et al.*, 2001).

Specific regulations to control saltwater angling harvest in Portugal were only implemented recently and, as in other European countries (Morales-Nin *et al.*, 2005), lacked scientific support. Limitations included the most commonly used to control recreational fishing catches, such as daily bag limits, minimum size limits and fishing licences (Mann *et al.*, 2002; Morales-Nin *et al.*, 2005; Smallwood *et al.*, 2006). In the “Parque Natural do Sudoeste Alentejano e Costa Vicentina” (PNSACV), a natural park on the south coast of Portugal, specific and more restrictive regulations regarding recreational fishing have been recently implemented, including marine protected areas, closed seasons and a limited number of fishing days per week. These laws, however, were soon reformulated after strong criticism

and public protests by the angler community, who highlighted the lack of scientific basis for the legislation.

The main purposes of this study were to estimate recreational shore angling catch, harvest and effort in the south and south-west of Portugal, including the PNSAVC, investigate spatial and temporal differences, and quantify undersized catches and discarding. We also tested the hypothesis that recreational fishing has a minor impact on commercial species by comparing our estimates of recreational harvest with commercial landings for the same species, caught in the same area.

## **2.3 Methods**

### **2.3.1 Study area**

The study area included the south and south-west coast of Portugal, from Vila Real de Santo António (37° 11' N; 7° 24' W) to Sines (37° 57' N; 8° 32' W), covering *c.* 250 km of coastline (Figure 2.1). The south of Portugal faces the Atlantic Ocean and is characterized by a temperate climate, with dry and warm summer seasons, and moderate winters (Teixeira, 2006). The coastline is divided in two distinct biogeographical areas: the south coast of Algarve and the south-west (SW) coast. The south coast comprises *c.* 150 km of coastline and is highly urbanized due to intense tourism. As a result of its protection from the north winds and swells, this area has calmer sea conditions than the west coast. It is also characterized by a number of estuaries and lagoon systems. Most anglers in this area concentrate along the piers and jetties at the mouth of these systems or surf cast on the sandy beaches.

The segment of the south-west coast encompasses *c.* 100 km of coastline that is entirely included in the PNSACV natural park, a protected area with low anthropogenic interaction,

where the main economic activities are agriculture and artisanal fishing. The shoreline is characterized by rougher sea conditions and a coastline with high cliffs (Figure 2.1), inaccessible in many parts. Anglers fish mainly from the cliffs, with no specific access points.

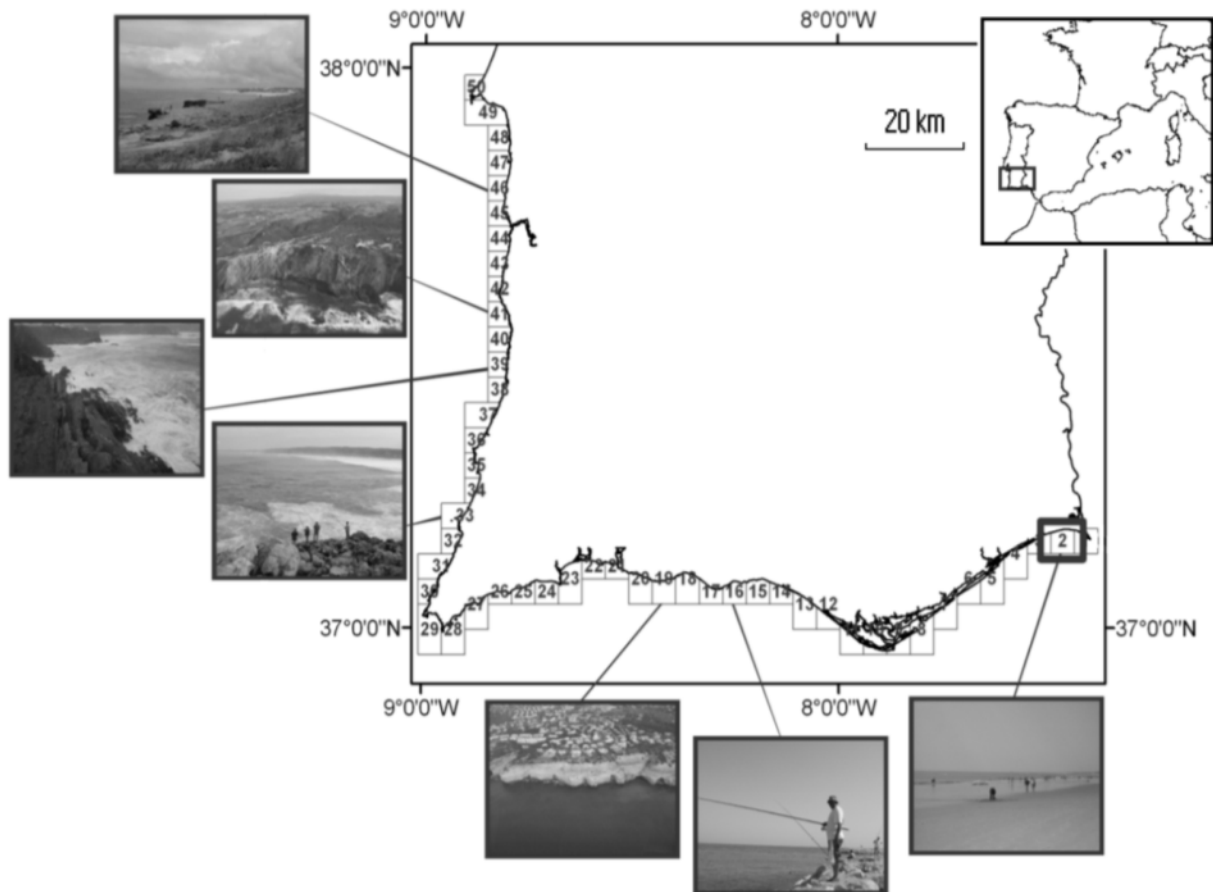


Figure 2.1 Map of the study area showing the different features of the coastline.

### 2.3.2 *Sampling strategy*

A complementary survey, using an aerial-roving design, was conducted to assess the recreational shore fishing along the south and south-west coast of Portugal, between August 2006 and July 2007. This combination of methods has been used to assess catch and effort in recreational fisheries and is an adequate approach when anglers are dispersed over large areas and there are no specific access points (Pollock *et al.*, 1997; Mann *et al.*, 2003; Vølstad *et al.*, 2006). Surveys followed a stratified random-sampling strategy and were based on methodologies previously developed in North America (Malvestuto *et al.*, 1978; Essig and Holliday, 1991; Robson, 1991; Pollock *et al.*, 1994; Hoenig *et al.*, 1997; Vølstad *et al.*, 2006).

### 2.3.3 *Roving creel surveys*

Roving creel surveys [on-site angler surveys during which anglers' harvests are examined by the survey agent (Pollock *et al.*, 1994)] were conducted following a non-uniform probability of sampling, with probabilities assigned to each section based on mean effort data of the previous months (from the aerial surveys). Given the large extent of the sampling area (*c.* 250 km), the coast was first stratified into two main sub-areas: (1) south coast, from Vila Real de Santo António to Sagres; (2) south-west coast, from Sagres to Sines; with both sub-areas further divided into 5 km sections (areas that could be covered within a 4 h shift, morning or afternoon) (Figure 2.1). In each month, two-stage probability sampling was applied (Pollock *et al.*, 1994; Malvestuto, 1996): first, 4 days per sub-area (two weekends + two weekdays) (primary sampling unit) were randomly selected, and then two shifts/sections combinations per each day. Due to logistical constraints, there was no sampling of night fishing, and roving creel surveys were only conducted between 0900 and 1800 hours (0900–1300 hours, morning; 1400–1800 hours, afternoon). On each survey, starting point and direction were

selected randomly, and anglers observed subsequently interviewed. Information obtained included baseline characteristics of the anglers: age, sex, education, marital status, nationality, monthly net income, membership of fishing clubs, fishing experience and place of residence, and fishing trip data: starting time, expected finishing time, bait, number of rods, target species, fishing method, fish caught (retained: visual observation; discarded: angler reported data) and reasons for discarding (Appendix II). All fishes retained by anglers were identified, counted and measured (total length,  $L_T$ , nearest mm); fish masses (M) were later estimated with  $L_T$  and M relationships for the study area (Gonçalves *et al.*, 1997; Santos *et al.*, 2002).

#### 2.3.4 Aerial surveys

Aerial surveys were conducted monthly, using a small fixed-wing aircraft (Cessna 210), in order to obtain instantaneous counts of the anglers in the whole sampling area (Pollock *et al.*, 1994). Flight schedules followed the same stratified random-sampling procedure as the roving creel surveys, but only two aerial surveys were conducted each month (one per day type): weekday and weekend day. Dates, starting time and flight direction were randomly selected; to minimize visibility bias, the flights were always conducted at low altitude (150–200 m) and speed (*c.* 150 km h<sup>-1</sup>) (Pollock *et al.*, 1994; Jachmann, 2002).

#### 2.3.5 Data analysis

##### RECREATIONAL FISHING

Catch and effort calculations followed the procedures of Pollock *et al.* (1994) and Lockwood *et al.* (1999). Information per strata was pooled by season, and multiple-day estimates were used for all the calculations (Lockwood *et al.*, 1999). Fishing Effort ( $E_p$ ) per stratum (expressed in angler hours) was calculated from the aerial surveys based on the product of the mean instantaneous counts for that period and the fishable hours.

$$\hat{E}_p = \alpha_{ph} * F_p$$

where  $\alpha_{ph}$  is the instantaneous mean count and  $F_p$  is the fishable hours, for period  $p$ .

Catch rate per stratum ( $\hat{R}_p$ ) was calculated using the mean-of-ratios estimator (Jones *et al.*, 1995; Hoenig *et al.*, 1997; Pollock *et al.*, 1997; Lockwood *et al.*, 1999). Short incomplete trips (< 30 min) were omitted from this analysis (Hoenig *et al.*, 1997; Pollock *et al.*, 1997).

$$\hat{R}_p = \frac{\sum_{i=1}^{K_p} \left( \frac{C_{pi}}{h_{pi}} \right)}{K_p}$$

where  $C_{pi}$  is the mass of fishes retained by the  $i$ th angler,  $h_{pi}$  is the hours spent fishing by the  $i$ th angler, and  $K_p$  is total number of anglers sampled on period  $p$ .

Estimated catch per stratum was calculated as:

$$\hat{C}_p = \hat{E}_p * \hat{R}_p$$

where  $\hat{E}_p$  is the fishing effort and  $\hat{R}_p$  is the catch rate, for period  $p$ .

Total annual catch and effort were then calculated as the sum of the individual estimates per stratum and period (Cochran, 1977).

The results are provided as the mean  $\pm$  SE. Catch composition was quantitatively described in terms of number ( $N$ ),  $M$  (kg), mean  $L_T$  (cm), frequency of occurrence ( $F_O$ ), percentage discarded (%), main reason for discarding, and percentage of anglers (%) targeting a particular species.

Two-way ANOVA was used to test for the existence of the interactive effect of season and area in the catch rates (by mass and number). Non-parametric Kruskal-Wallis tests were used to test for differences in catch rates between seasons on the dominant species. A  $t$ -test for

independent samples was used to test for differences between numbers of anglers per day type (weekend day *v.* weekday). In all cases, the significance level was 0.05.

#### *COMMERCIAL FISHING*

Commercial fishing statistics from 2006 to 2007 were compiled for the study area, from the official records of the Directorate General of Fisheries and Aquaculture (DGRM, unpubl.). For the purpose of this study, only the statistics of the species common to both sectors (commercial and recreational angling from the shore) were used for the analysis. It is important to note that the official data only takes into consideration reported catches. As noted by several authors (West and Gordon, 1994; Cabral *et al.*, 2003), these kind of data do not include estimates of discarded fishes and may also underestimate the total commercial harvests, due to under or non-reporting of catches, and black marketing of fisheries products.

## **2.4 Results**

A total of 196 roving creel surveys and 24 aerial surveys were conducted between August 2006 and July 2007. During the roving creel surveys, 1321 anglers were interviewed, with a very high response rate (95%). Usable fishing trip data were obtained from 1318 questionnaires and angler demographics information from 1201 questionnaires. Anglers used a variety of techniques, including bottom-fishing, float-fishing, spinning with artificial lures and jigging and great variety of baits.

### 2.4.1 Fishing activity baseline characteristics

Recreational fishing in the south of Portugal is conducted mostly by married employed males, in their late forties and with a low educational level (56% with <6 years of schooling). Ninety-nine per cent of the anglers were males and 1% females, usually accompanying a male relative. The mean age was 48 years, although the majority (25%) was between 50 and 59 years old. Only 10% were <29 years old. Seventy-seven per cent were resident in one of the two regions of the sampling area (Algarve or Alentejo), and fishing experience averaged 23.3 years. Membership in angling clubs was very low (9%).

Sixty-three per cent of the anglers were fishing alone at the time of the interview, with an average of 1.5 fishing rods. In 95% of the cases, catches were for personal consumption, with only 4% of the anglers admitting selling their catch. Although catch and release as a principle was a rare practice (1%), almost all anglers frequently discarded locally undesired species such as bogue *Boops boops* (L.), salema *Sarpa salpa* (L.) and wrasses (Labridae) or undersized specimens (juveniles). More than half of the anglers (55%) were targeting one (or more) specific species. With regard to regulation aspects, 92% had a valid fishing licence.

### 2.4.2 Catch and size composition

A total of 5111 fishes (1080 kg) from at least 48 teleost species and 21 families were recorded during the roving creel surveys (Table 2.1). Catches were dominated by one species, *Diplodus sargus* (L.), which accounted for 44% by number and 48% by mass of the total. *Diplodus sargus* was also the most targeted species by the anglers (68%). By number, other important species were *Diplodus vulgaris* (Geoffroy St.-Hilaire) (14%), *B. boops* (8%), chub mackerel *Scomber japonicus* Houttuyn (7%) and *S. salpa* (4%). In terms of mass, in addition to *D. sargus*, catches were dominated by *D. vulgaris* (8%), *Chelon labrosus* (Risso) (8%), *S. salpa* (7%) and *S. japonicus* (5%). Sparidae was the most targeted and caught family in this study,

accounting for 16 of the 48 recorded fish species and representing 78% of the total catches in number and 75% by mass. Ninety per cent of the anglers were targeting one (or more) species of this family. The majority of the other species were only caught occasionally.

Discards accounted for 23% (by number) of the total catches and were recorded in 28 species (58%). Most of these species (17) were primarily discarded because of their low gastronomic value, whereas for the remaining 11 only small fishes were discarded.

At the time of the interview, recorded bag sizes ranged from no catch to 11.4 kg, with the majority (88.5%) <2 kg of fish (mean  $\pm$  SE  $0.65 \pm 0.04$  kg) (Figure 2.2).

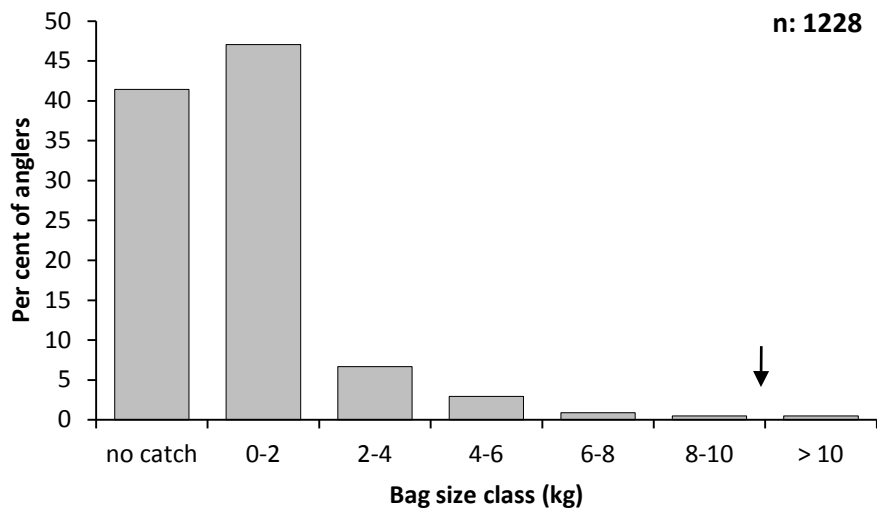


Figure 2.2. Individual angler catch ( $n = 1228$ ) in the south and south-west of Portugal between August 2006 and July 2007. ↓, the legal daily bag size limit. Fishing trips < 0.5 h were excluded.

Table 2.1 Catch composition of species recorded in creel surveys along the south and south-west coast of Portugal (August 2006 to July 2007).  $L_T$ , total length;  $F_O$  frequency of occurrence; E.V., economic value.

Family/Species	Number	Mass (kg)	Mean $\pm$ SE $L_T$ (cm)	$F_O$ (%)	Discarded (%)	Main discard reason*	% of targeting <sup>†</sup>
<b>ATHERINIDAE</b>							
<i>Atherina presbyter</i>	41	0.1	8.1 $\pm$ 1.0	0.2	0	-	
<b>BALISTIDAE</b>							
<i>Balistes capriscus</i>	83	37.8	30.8 $\pm$ 3.8	1.2	0	-	<1.0
<b>BATRACHOIDIDAE</b>							
<i>Halobatrachus didactylus</i>	25	1.8	15.0 $\pm$ 2.7	1.3	76.0	E.V.	
<b>BELONIDAE</b>							
<i>Belone belone</i>	21	1.5	36.3 $\pm$ 8.5	1.4	38.1	E.V.	
<b>BLENNIDAE</b>							
<i>Lipophrys pholys</i>	1	0.0	10.0	0.1	0	-	
<b>BLENNIDAE/GOBIIDAE</b>	27	0.9	11.8 $\pm$ 4.5	1.2	92.6	E.V.	
<b>CARANGIDAE</b>							
<i>Caranx rhonchus</i>	1	0.4	35.0	0.1	0	-	
<i>Trachinotus ovatus</i>	2	0.1	18.5 $\pm$ 0.7	0.2	0	-	
<i>Trachurus</i> spp.	1	0.0	10.0	0.1	0	-	
<i>Trachurus trachurus</i>	6	1.3	27.1 $\pm$ 3.3	0.2	0	-	
<b>CLUPEIDAE</b>							
<i>Alosa fallax</i>	1	0.3	32.0	0.1	0	-	
<b>GOBIIDAE</b>							
<i>Gobius</i> spp.	54	1.7	-	0.2	0	-	
<b>LABRIDAE</b>							
<i>Coris julis</i>	21	1.6	15.5 $\pm$ 3.9	0.8	4.8	E.V.	
<i>Ctenolabrus rupestris</i>	1	0.0	9.0	0.1	0	-	
Labridae n.id.	3	0.6	-	0.1	0	-	
<i>Labrus bergylta</i>	12	5.0	28.1 $\pm$ 4.1	0.9	16.7	E.V.	
<i>Symphodus bailloni</i>	13	0.7	14.8 $\pm$ 2.1	0.4	7.7	E.V.	
<i>Symphodus melops</i>	3	0.1	16.3 $\pm$ 2.0	0.2	0	-	
<i>Symphodus ocellatus</i>	1	0.0	11.0	0.1	0	-	
<i>Symphodus</i> spp.	101	4.1	13.4 $\pm$ 2.6	3.5	59.4	E.V.	
<b>MORONIDAE</b>							
<i>Dicentrarchus labrax</i>	113	46.4	30.1 $\pm$ 9.1	5.5	18.6	size	24.4
<i>Dicentrarchus punctatus</i>	61	13.9	27.4 $\pm$ 6.1	1.4	3.3	size	2.3
<b>MUGILIDAE</b>							
<i>Chelon labrosus</i>	137	88.4	38.7 $\pm$ 5.3	2.6	17.5	E.V.	
<i>Liza aurata</i>	3	1.1	35.0 $\pm$ 7.1	0.2	100	E.V.	
Mugilidae n.id.	7	4.1	36.3 $\pm$ 5.8	0.2	57.1	E.V.	
<b>MULLIDAE</b>							
<i>Mullus surmuletus</i>	6	1.5	37.0 $\pm$ 4.2	0.3	0	-	

Table 2.1 (cont.).

Family/Species	Number	Mass (kg)	Mean $\pm$ SE $L_T$ (cm)	$F_O$ (%)	Discarded (%)	Main discard reason*	% of targeting <sup>†</sup>
<b>SCOMBRIDAE</b>							
<i>Euthynnus alletteratus</i>	2	0.5	27.5 $\pm$ 3.5	0.1	0	-	
<i>Scomber japonicus</i>	333	48.8	25.5 $\pm$ 2.9	2.9	6.0	species	1.1
<i>Scomber scombrus</i>	1	0.2	26.5	0.1	0	-	
<b>SCOPHTHALMIDAE</b>							
<i>Scophthalmus maximus</i>	2	0.4	22.2 (3.9)	0.2	0	-	
<b>SCORPAENIDAE</b>							
<i>Scorpaena notata</i>	1	0.3	25.0	0.1	0	-	
<i>Scorpaena porcus</i>	7	1.7	23.2 $\pm$ 5.7	0.5	14.3	E.V.	<1.0
<i>Scorpaena</i> spp.	6	0.5	16.2 $\pm$ 6.3	0.5	83.3	E.V.	
<b>SERRANIDAE</b>							
<i>Serranus cabrilla</i>	2	0.2	-	0.2	0	-	
<b>SOLEIDAE</b>							
Soleidae n.id.	9	0.8	21.2 $\pm$ 1.5	0.5	11.1	size	
<b>SPARIDAE</b>							
<i>Boops boops</i>	415	36.4	20.7 $\pm$ 2.1	5.5	52.0	E.V.	<1.0
<i>Diplodus annularis</i>	4	0.3	16.0 $\pm$ 2.0	0.2	25.0	Size	
<i>Diplodus bellottii</i>	65	3.1	12.4 $\pm$ 3.0	1.7	56.9	Size	<1.0
<i>Diplodus cervinus</i>	30	7.6	23.5 $\pm$ 3.5	1.1	0	-	
<i>Diplodus puntazzo</i>	13	3.4	25.7 $\pm$ 5.2	0.8	0	-	
<i>Diplodus sargus</i>	2235	522.7	20.9 $\pm$ 7.0	41.6	18.0	Size	68.4
<i>Diplodus vulgaris</i>	733	87.5	17.6 $\pm$ 5.1	17.3	29.2	Size	7.0
<i>Lithognathus mormyrus</i>	29	2.4	15.2 $\pm$ 3.2	0.9	41.4	Size	<1.0
<i>Oblada melanura</i>	50	9.7	23.9 $\pm$ 4.7	1.2	0	-	
<i>Pagellus acarne</i>	55	11.1	23.7 $\pm$ 3.2	0.8	1.8	Size	
<i>Pagellus bogaraveo</i>	1	0.2	-	0.1	0	-	
<i>Pagellus erythrinus</i>	1	0.3	29.6	0.1	0	-	<1.
<i>Pagrus pagrus</i>	2	0.8	28.0	0.2	0	-	
<i>Sarpa salpa</i>	188	76.3	28.7 $\pm$ 6.1	5.7	23.9	E.V.	<1.0
<i>Sparus aurata</i>	79	38.5	25.2 $\pm$ 11.0	3.6	10.1	Size	9.3
<i>Spondyliosoma</i>	92	12.7	19.9 $\pm$ 3.6	3.3	10.9	Size	<1.0
<b>TRACHINIDAE</b>							
<i>Echiichthys vipera</i>	9	0.3	12.9 $\pm$ 2.1	0.6	88.9	E.V.	
<i>Trachinus draco</i>	1	0.4	30.1	0.1	0	-	
<b>TRIGLIDAE</b>							
<i>Chelidonichthys</i> spp.	1	0.0	-	0.1	100	E.V.	
<b>Total</b>	<b>5110</b>	<b>1080.2</b>					

\*The most important discard reason for each species. <sup>†</sup>Anglers targeting one or more specific species.

Less than 1% of the anglers had attained or exceeded the 10 kg daily bag limit. Although only 11.5% of the fishes were smaller than the legal minimum size limit, 73% of the retained *Dicentrarchus labrax* (L.), 29% of *Sparus aurata* L. and 17% of *D. vulgaris* were undersized (Figure 2.3). Twenty-three per cent of the anglers who had catches retained undersized fishes.

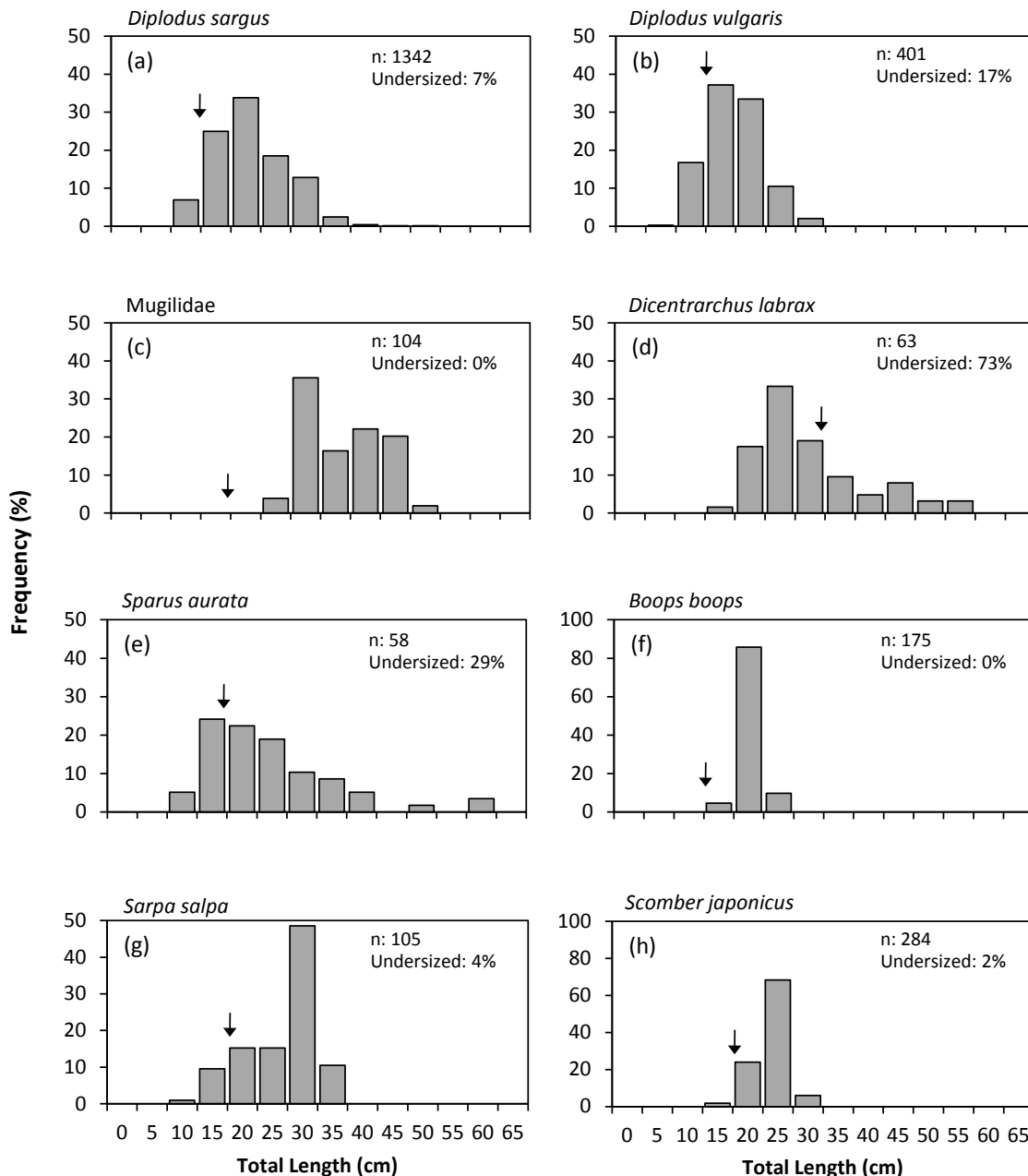


Figure 2.3 Total length ( $L_T$ ) frequency distributions of the most important species of the recreational shore fishing in the south Portugal, during 2006 and 2007. (a) *Diplodus sargus* (n = 1342), (b) *Diplodus vulgaris* (n = 401), (c) Mugilidae (n = 104), (d) *Dicentrarchus labrax* (n = 63), (e) *Sparus aurata* (n = 58), (f) *Boops boops* (n = 175), (g) *Sarpa salpa* (n = 105) and (h) *Scomber japonicus* (n = 284). ↓, minimum size limit. Undersized, percentage of individuals with  $L_T$  below the minimum size limit.

### 2.4.3 Spatio-temporal variation of catch per unit effort and fishing effort

Overall catch per unit effort (CPUE) was  $0.21 \text{ kg angler}^{-1} \text{ h}^{-1}$  and  $1.11 \text{ fish angler}^{-1} \text{ h}^{-1}$ . By mass, the estimated mean CPUE was lowest in summer (south coast) and highest in autumn, on the south-west coast (Figure 2.4), although differences in CPUE observed between seasons in both areas were not significant (two-way ANOVA, d.f. = 3,  $P > 0.05$ ). On the south-west coast, however, anglers caught significantly more fishes than on the south coast (two-way ANOVA, d.f. = 1,  $P < 0.05$ ). No statistically significant interaction was encountered between area and season (two-way ANOVA, d.f. = 3,  $P > 0.05$ ).

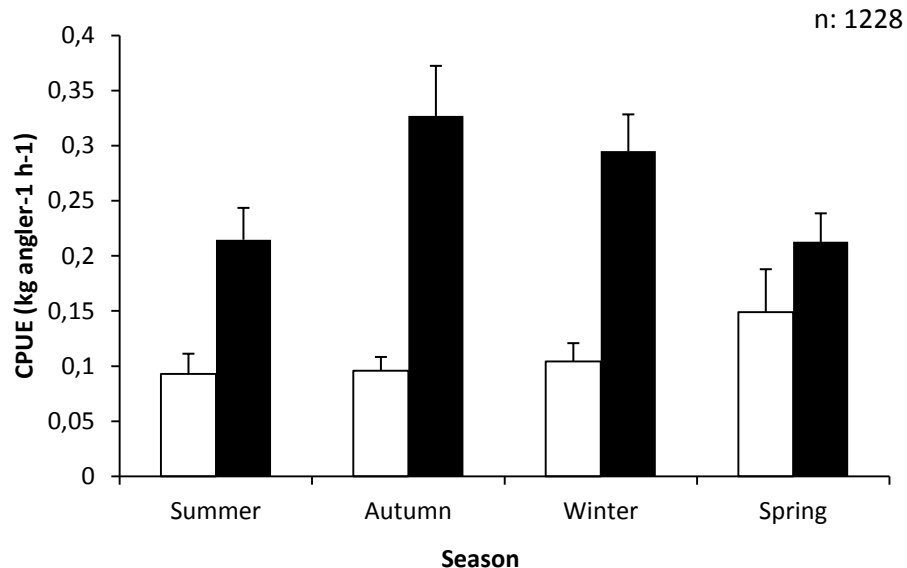


Figure 2.4. Mean  $\pm$  SE ( $n = 1228$ ) catch per unit effort (CPUE) by mass, season and area ( $\square$ , south coast;  $\blacksquare$ , south-west coast) during the study period.

The mean CPUE per season for the total catch and for the dominant species are given in Figure 2.5. Most of the species revealed low catch rates with minor fluctuations throughout the year. *Diplodus sargus* was clearly the dominant species in terms of catch rates. CPUE of this species showed a seasonal pattern, with higher values in autumn and winter seasons (Kruskal–Wallis, d.f. = 3,  $P < 0.05$ ) and clearly influenced the overall catch rates.

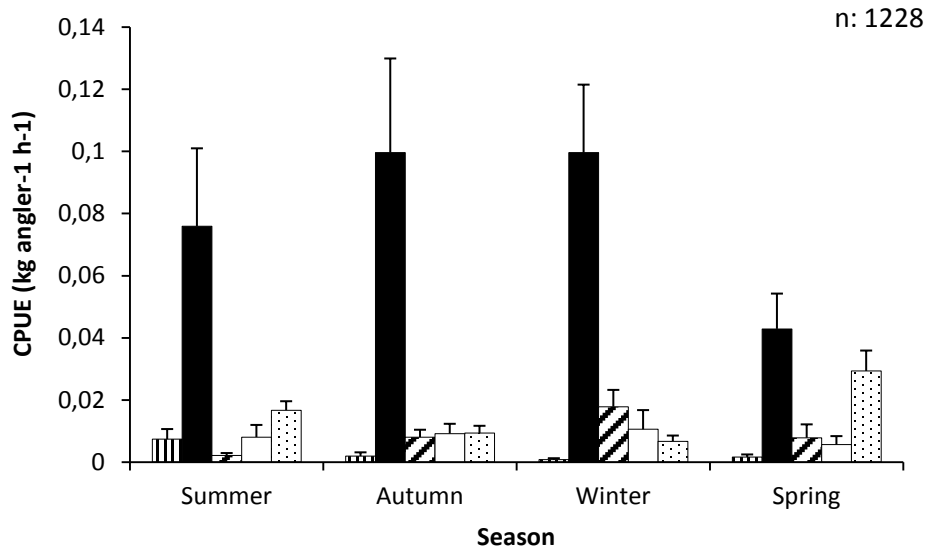


Figure 2.5. Mean  $\pm$  SE ( $n = 1228$ ) catch per unit effort by mass of the main species (▨, *Boops boops*; ■, *Diplodus sargus*; ▩, *Dicentrarchus labrax*; □, *Sparus aurata*; ▤, *Diplodus vulgaris*) per season.

During the aerial surveys, a total of 6868 anglers were recorded, with significantly higher numbers registered on weekend days ( $381 \pm 32$ ) than on weekdays ( $191 \pm 24$ ) (Figure 2.6;  $t$ -test, d.f. = 22,  $P < 0.001$ ). Seasonally, mean numbers of anglers were higher during the autumn and winter months. The preferred fishing locations were Sagres East (463 anglers), followed by Mt Clérigo (446), Sagres West (406) and Portimão (338) (Table 2.2). Most of the preferred fishing locations on the south-west coast were cliffs, while the most popular sites on the south coast were jetties and harbours.

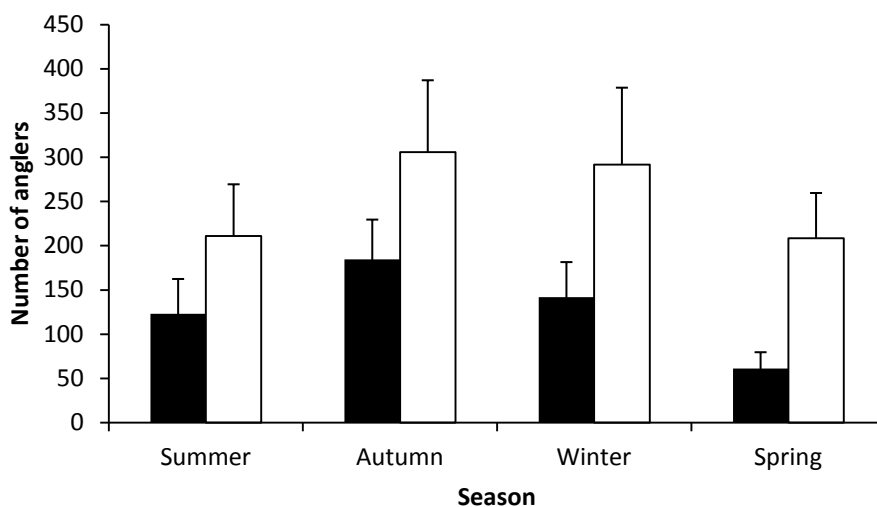


Figure 2.6. Mean  $\pm$  SE number of anglers by day type (□, south coast; ■, south-west coast) and per season, from the 24 aerial surveys.

Table 2.2 Most important fishing locations (sections) in terms of total number of anglers, based on aerial surveys (August 2006-July 2007).

Fishing location	Area	Anglers	Anglers (%)	Type of Fishing spot	Peak season
Sagres	SW coast	463	6.6	Cliff	Winter
Mts. Clérigos	SW coast	446	6.4	Cliff	Winter
Sagres W	SW coast	406	5.8	Cliff	Winter
Portimão	South coast	338	4.9	Jetty	Autumn
Carrapateira	SW coast	333	4.8	Cliff	Winter
Malhão	SW coast	317	4.5	Cliff	Autumn
V.R.S.António	South coast	275	3.9	Jetty	Summer
Quarteira	South coast	208	3.0	Jetty	Autumn
Cb. Sardão	SW coast	202	2.9	Cliff	Summer
Murração	SW coast	181	2.6	Cliff	Winter
Porto Covo	SW coast	179	2.6	Cliff	Autumn
Albufeira	South coast	169	2.4	Jetty	Autumn
<b>Total</b>		<b>6968</b>			

Based on the aerial counts and available fishing days, total annual fishing effort for the 12 month survey period was estimated as  $705\,235 \pm 32\,765$  angler hours, corresponding to  $166\,430 \pm 9792$  fishing trips. Recreational fishing activity was higher on the south-west coast and in the autumn and winter months (Figure 2.7).

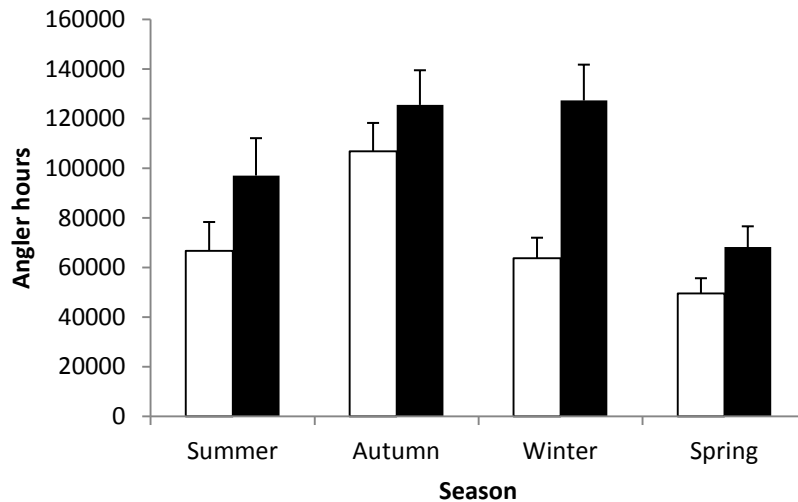


Figure 2.7 Mean  $\pm$  SE estimated number of angler hours by sub-area ( $\square$ , weekend;  $\blacksquare$ , weekday) and per season, calculated from the 24 aerial surveys.

#### 2.4.4 Comparison between recreational and commercial fishing

Overall, the estimated  $147.4 \text{ t year}^{-1}$  captured by recreational shore angling represented 0.8% of the 16 974.9 t landed by commercial fishermen in the same geographic area during the same period. At least 48 species were caught by both sectors, although only *S. japonicus* was important for both sectors, accounting for 23.8% by mass of the total commercial catches and 5% of the recreational shore catches (Figure 2.8). Of the species in common with recreational angling, the multi-gear fleet component (mostly artisanal fishing) landed 8443.9 t, corresponding to 49.7% of the total fishes landed by the commercial fleet. Individual species catches were always higher in the commercial sector, although estimated recreational catches of *D. sargus* (82 t) were close to commercial landings (127 t).

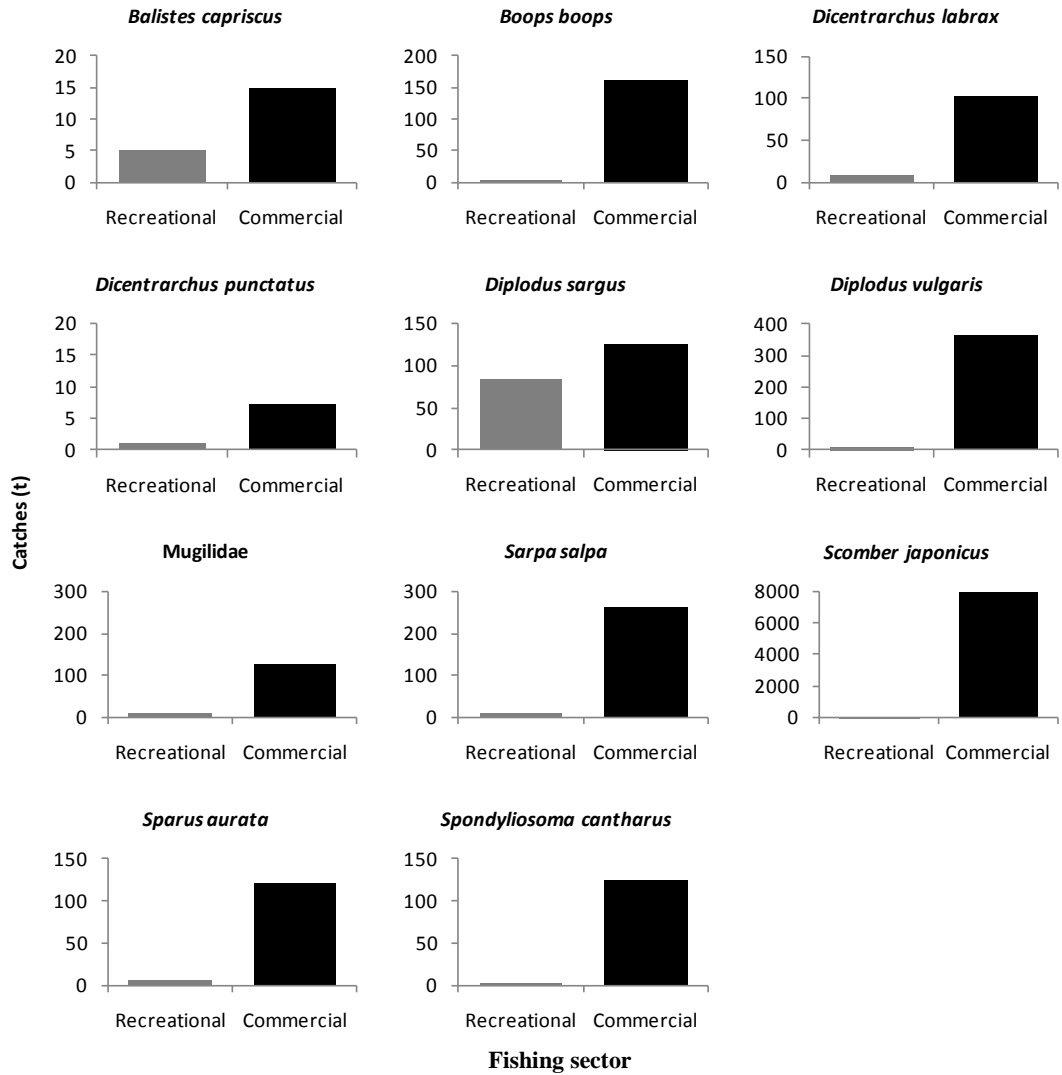


Figure 2.8. Comparison of annual harvest estimates of the most important species common to both recreational shore angling and commercial fishing. Note different y-axes scales.

The combined commercial and recreational shore catches of *D. sargus* for the study period were estimated as 209 t. Combined catches ranged from 34.8 t in summer to 69.3 t in winter, which corresponds to the peak spawning period of the species (Figure 2.9).

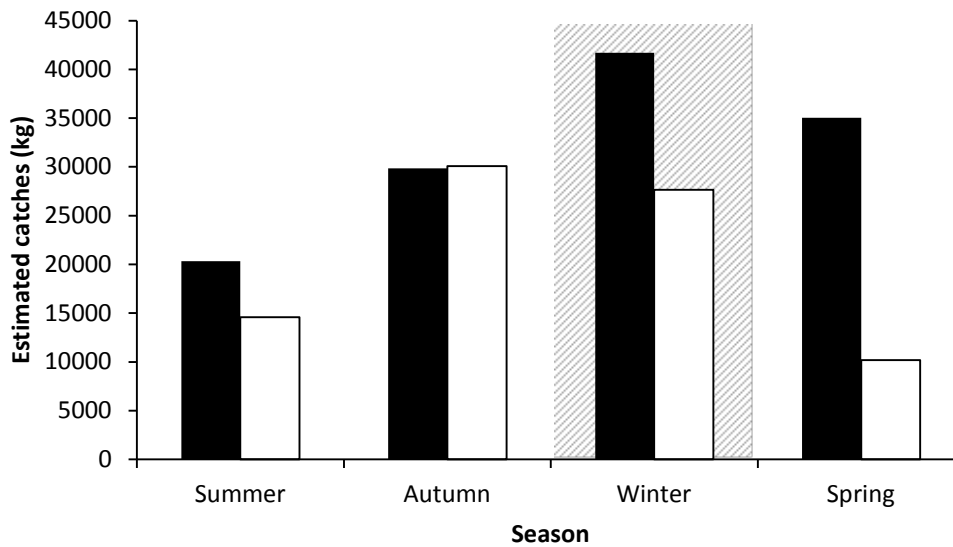


Figure 2.9. Reported official landings of the commercial fishery (■) and estimated recreational shore angling catches (□) of *Diplodus sargus* for the south and south-west coast of Portugal. Note: Shaded area indicates the spawning peak period.

## 2.5 Discussion

The purposes of the study were to provide estimates of total catch, harvest and effort from recreational shore fishing, the capture of undersized fishes and discarding activity, to evaluate spatial and temporal patterns of recreational shore-based saltwater fishing and to compare the quantities caught with commercial sector landings in the south and south-west of Portugal.

### 2.5.1 Surveys

The aerial-roving creel-complemented survey design applied is a commonly used and efficient design for extensive areas, with anglers dispersed over multiple access points (Brouwer *et al.*, 1997; Pollock *et al.*, 1997; Vølstad *et al.*, 2006). Nevertheless, constraints inherent to each of the methods may induce bias (Vølstad *et al.*, 2006). For example, a

reduced number of aerial surveys may affect the accuracy of the fishing effort estimates (Soupir *et al.*, 2006). On the other hand, it is known that incomplete trip-interview data, length-of-stay bias and avidity bias associated with roving creel surveys may overestimate the catch rate calculations (Robson, 1991; Pollock *et al.*, 1994). In this study, budget constraints only allowed two flights per month (six per season), and on a few occasions flights had to be re-scheduled because of bad weather conditions. The standard error (SE) of less than 10%, however, suggests that the accuracy of the estimates was not affected.

### **2.5.2 Fishing activity, catches, CPUE and discarding**

As in other European countries, recreational fishing from the shore in the south of Portugal is a popular leisure activity. An estimated total of 166 430 day fishing trips were conducted annually, with *c.* 147 t of fishes harvested. According to official data, 20 046 local shore-based saltwater fishing licences were purchased for this area in 2007, with a total of 60 550 licences issued for the entire national territory (including the south of Portugal) (DGPA, 2010). The number of anglers is probably much higher, given that 8% of the anglers interviewed did not have a fishing licence.

Recreational shore fishing is carried out mostly by middle-aged males, residents in the area and with many years of fishing experience. The angler profile encountered is similar to that reported by Marta *et al.* (2001) in the Guadiana River basin (south Portugal), by Rangel and Erzini (2007) for the north of Portugal and other European countries (Pawson *et al.*, 2007).

A great diversity of species (48) was caught by the recreational shore anglers in the south of Portugal during the surveys, in particular from the Sparidae family. This is consistent with studies elsewhere (Mann *et al.*, 2003; Rangel and Erzini, 2007; Beckley *et al.*, 2008) and highlights the overall multispecies nature of this kind of fishery (Brouwer and Buxton, 2002).

The dominance by a few species is also a common element to recreational shore fishing around the world (Brouwer *et al.*, 1997; Morales-Nin *et al.*, 2005; Lloret *et al.*, 2008b). This phenomenon has been explained as a result of specific targeting behaviour of recreational anglers (Hutchings *et al.*, 2008) and abundance and availability of the species (Clarke and Buxton, 1989; Steffe *et al.*, 2005; Arlinghaus *et al.*, 2008a). In fact, *D. sargus*, which was the most important species in this study, only accounted for 5% of the catches in a previous study in the north Portugal (Rangel and Erzini, 2007) and 35% in the Azores (Diogo, 2007). *Diplodus sargus* is a coastal species that makes frequent use of the surf zone, and it is probably more abundant in the south of Portugal given its subtropical biogeographical distribution (Whitehead *et al.*, 1986; Erzini *et al.*, 1996; Froese and Pauly, 2010).

The CPUE in number and in mass was approximately double those of a similar study from the north of Portugal where Rangel and Erzini (2007) reported 0.46 fishes and 0.078 kg per angler<sup>-1</sup> h<sup>-1</sup>, but similar to two studies from South Africa, where 0.20 and 0.15 fishes angler<sup>-1</sup> h<sup>-1</sup> were recorded (Clarke and Buxton, 1989; Pradervand *et al.*, 2003). The recorded catch rates in numbers are, however, low when compared to boat angling for similar multispecies complexes. Alós *et al.* (2009a) for example reported an average of 32.4 fishes and 0.82 (shrimp bait) and 0.86 (worm bait) kg angler<sup>-1</sup> h<sup>-1</sup> for Palma Bay, Mallorca (western Mediterranean Sea), where smaller sizes predominated.

The results showed an overall discard rate of 23%, which is lower than global release estimates of c. 60% of the catch (Cooke and Cowx, 2004). This result could be related to a low percentage of unwanted or undersized fishes in anglers' catches (McPhee *et al.*, 2002) or the higher catch consumption orientation of Portuguese recreational anglers (Arlinghaus *et al.*, 2007), since in more than 90% of cases, anglers' catches were for consumption. It should be noted, however, that discard data rely mostly on angler recall and angler knowledge of species

(Sullivan *et al.*, 2006), which can be under reported and subject to prestige and rounding bias (Lockwood *et al.*, 1999; Mann *et al.*, 2003).

High retention of undersized fishes was observed mostly for *D. labrax* and could be due to its commercial value, lack of knowledge of or disagreement with the established minimum size limit (MSL) of the species. Many of the interviewed anglers stated that the MSL of *D. labrax* (36 cm) was too high. As previously suggested, in this situation, efforts should be made to inform and educate anglers about the regulations and the importance of minimum size limits (Beckley *et al.*, 2008; Pradervand and Van der Elst, 2008). This is an important issue, since both in the current study and the one conducted in the north of Portugal (Rangel and Erzini, 2007), anglers complained about lack of information concerning regulations.

### ***2.5.3 Spatio-temporal variation of fishing activity***

The recreational fishing activity in southern Portugal is not spatially and temporally uniform. Higher values of anglers were recorded in the autumn and winter months, particularly on the south-west coast. These results are in contrast with those from northern Portugal (Rangel and Erzini, 2007) and Mallorca Island (Morales-Nin *et al.*, 2005), where the most intense fishing activity coincides with the summer months (holiday period).

The autumn and winter peak in angler effort coincides with the onshore spawning migration of *D. sargus* in this area, a phenomenon locally known as “*arribação*”. This is supported by the present data, which revealed higher CPUE of *D. sargus* in this period, particularly on the south-west coast. These findings are analogous to those of other regions (Clarke and Buxton, 1989; Smallwood *et al.*, 2006; Hutchings *et al.*, 2008), where the spatio-temporal distribution of anglers was more influenced by seasonal changes in abundance of particular species than by seasonal fluctuations in tourist activity. In fact, since the southern Portugal recreational

fishery is principally conducted by local anglers, and tourism is the major economic activity in the Algarve (south Portugal), the higher levels of unemployment in the winter months can also be related to increasing pressure on the fishing resources (Mann *et al.*, 2003).

#### **2.5.4 Recreational vs. Commercial fishing**

A comparison between the recreational and commercial harvests was made for the study area and period (August 2006 to July 2007), including only the shared species between the sectors. Present analysis showed that the recreational fishing annual harvest (c. 147 t) in the south Portugal corresponded to less than 1% of the official commercial landings. This percentage was smaller than in other regional areas (Coleman *et al.*, 2004; Morales-Nin *et al.*, 2005; Diogo, 2007) but was highly influenced by the large quantity of *S. japonicus* landed by the commercial fleet. Furthermore, only recreational daylight shore fishing was considered in this study.

It was found, however, that *D. sargus* was caught in large quantities by recreational anglers, especially on the south-west coast. These values would certainly have been higher if other recreational fishing activities, such as spear fishing and line fishing from boats, had been taken into consideration. For example, *D. sargus* is one of the most important target species of underwater spear fishers in Mallorca (Coll *et al.*, 2004) and Cape Creus (Lloret *et al.*, 2008a) and is regularly caught by both boat fishing and spear fishing in Portugal (P. Veiga, *pers. obs.*). Additionally, if recreational harvest of *D. sargus* was compared to landings by commercial gear type (longline, trammel and gillnets, traps and purse-seine), its importance as a recreational species would be even more evident. This would conform to a pattern already observed in other countries, where particular species are caught mainly by the recreational sector (West and Gordon, 1994; Schroeder and Love, 2002; Coleman *et al.*, 2004).

In general, most of the conflicts between the saltwater recreational anglers and the commercial sector are with the artisanal fishermen, who share the same physical space (Pawson *et al.*, 2007; Lloret *et al.*, 2008a). In this study, all the recorded species were also caught by the commercial fishing fleet, although the most important for each sector differed. These results suggest that, with the exception of *D. sargus*, in which there may be a higher degree of overlap between recreational and artisanal sectors, the competition for common resources is minimal in this geographical area. Nevertheless, other recreational activities such as spear fishing and boat fishing in southern Europe account for greater catches than shore angling (Morales-Nin *et al.*, 2005; Diogo, 2007; Rangel and Erzini, 2007), and thus competition with commercial fishing is likely to be even greater.

It should be noted that the results of this kind of comparison should be evaluated with caution. As discussed above, recreational fishing estimates have a degree of imprecision intrinsic with the sampling methods used (Robson, 1991; Pollock *et al.*, 1994), and the official landing records may be underestimated due to non-reporting of catches (West and Gordon, 1994; Cabral *et al.*, 2003; Rangel and Erzini, 2007). Such comparisons, however, are important because they reveal that both sectors contribute to fisheries declines and must be considered (McPhee *et al.*, 2002; Schroeder and Love, 2002; Coleman *et al.*, 2004).

### **2.5.5 Management considerations**

The present study was conducted when the first saltwater recreational fishing harvest control measures were implemented in Portugal (2006), and therefore, the long-term effect of the newly implemented regulations, could not be evaluated. The results are thus more likely to reflect the nature of the fishery per se rather than the effectiveness of the newly implemented measures. Nevertheless, the findings shed light on and have a number of implications for

compliance (minimum landing sizes and undersized catches, discarding, daily bag limits, fishing licences and selling the catch), effects of recreational fishing on the key species, conflicts with the commercial sector and management and conservation.

The current daily bag limit (10 kg angler<sup>-1</sup> day<sup>-1</sup>) is not realistic or likely to be effective as less than 1% of the daily bags exceeded this quantity. These results again suggest that bag limits in most cases are not effective at limiting angler catches. This is mostly because they are generally set too high (Cox *et al.*, 2002; Smallwood *et al.*, 2006), and total recreational effect in the resources is more influenced by the number of anglers than individual catches per angler (Cooke and Cowx, 2004). On the other hand, lack of a fishing licence, retention of undersized fishes and the selling of catches are problems that require greater monitoring effort and education of fishermen. Indeed, the fact that some anglers seem to make a living from selling their catch raises the question of whether such anglers are really recreational or semi-professional/commercial fishermen. Recently introduced legislation limiting the number of fishing days per week and prohibiting night fishing in the PNSACV is an attempt to limit such fishing activity.

As other studies have shown that most of these measures are ineffective in controlling recreational harvest (Attwood and Bennett, 1995; Brouwer *et al.*, 1997; Pitcher, 1999; Cox *et al.*, 2002), it would be important to conduct future studies to evaluate whether these measures are effective. Taking this into consideration, long-term monitoring of marine recreational fishing (MRF) should be carried out to evaluate trends in catches and the effectiveness of the current management regulations. To obtain a global assessment of the magnitude of MRF in Portugal, this should be done periodically (each 2–3 years) at a national scale and include all the recreational fishing sectors (spear fishing, boat fishing and shore fishing). Given the differences found with other areas of Portugal (Rangel and Erzini, 2007), specific regulations for each area (south, centre and north) would probably be most effective.

Another important aspect is the conflict between the recreational and commercial sectors. This is already a major management issue in many parts of the world (West and Gordon, 1994; Pomeroy *et al.*, 2007) and in Portugal where there is trend of decreasing commercial landings (Erzini, 2005). Although it was found that in the south of Portugal overall recreational shore fishing catches were small compared with commercial landings, considerable quantities of *D. sargus* were caught by the recreational anglers. It is not known whether the current exploitation of this specific species (by both sectors) is sustainable, particularly since the peak of catches occurs during the spawning period, when the species is more vulnerable as a result of near-shore spawning aggregations. Specific measures to control recreational harvest of this species have already been carried out in the PNSACV natural park, including the implementation of closed seasons and limited number of days of fishing per week. Yet, in order to be effective, these measures should also be extended to the commercial fishing sector. As previously suggested (Coleman *et al.*, 2004; Cooke and Cowx, 2004; Pawson *et al.*, 2007; Lloret *et al.*, 2008a), in future both recreational and commercial fishing should be included in stock assessments and management strategies for coastal fisheries resources in Portugal.

Finally, it should be noted that many local residents of the south-west coast are still dependent on recreational fishing as an extra source of income and food. In the future, management actions should therefore consider the human dimensions of this activity in this area. Education at the local community level about the value of the fishery resources and the biological limitations of the fisheries should also be promoted (Montaño *et al.*, 2005). Saltwater fishing-licence profits should be used to fund these actions and also the monitoring of recreational fishing regulations (McPhee *et al.*, 2002).



# CHAPTER 3:

**From a traditionally open access fishery to modern restrictions: Portuguese anglers' perceptions about newly implemented recreational fishing regulations**



**Submitted to *Marine Policy***

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Veiga, P., Pita, C., Leite, L., Ribeiro, J., Gonçalves, J.M.S. and Erzini, K. From a traditionally open access fishery to modern restrictions: Portuguese anglers' perceptions about newly implemented recreational fishing regulations. *Submitted to Marine Policy*.



### **3.1 Abstract**

Saltwater recreational fishing (SRF) in Portugal was for a long time an open-access activity, without restrictions of any kind. Restrictions to control the recreational harvest were first implemented in 2006 and were highly criticized by the angler community, for being highly restrictive and lacking scientific support. The present study aimed to obtain socio-economic data on the recreational shore anglers and gauge their perceptions about recreational fishing regulations and the newly implemented restrictions in Portugal. Roving creel surveys were conducted along the south and south-west coasts of Portugal, during pre and post regulation periods (2006-2007). A total of 1298 valid face-to-face interviews were conducted. Logit models were fitted to identify which characteristics influence anglers' perceptions about recreational fishing regulations. The majority of the interviewed anglers was aware and agreed with the existence of recreational fishing regulations. However, most were against the recreational fishing regulations currently in place. The logit models estimates revealed that Portuguese anglers with a higher level of formal education and income are more likely to agree with the existence of recreational fishing regulations. In contrast, anglers who perceive that more limitations and a better enforcement of commercial fishing would improve fishing in the area are less likely to agree with the existence of SRF regulations. The findings from this study will contribute to inform decision-makers about anglers' potential behaviour towards the new and future regulations. Although the existence of fishing regulations is a good starting point for effective management, the lack of acceptance and detailed knowledge of the regulations in place by fishers may result in lack of compliance, and ultimately hinder the success of recreational fishing regulations in Portugal.

### 3.2 Introduction

Recreational fishing is one of the most important pastimes worldwide, involving millions of enthusiasts (Kearney, 2002b; Sutinen and Johnston, 2003; Cooke and Cowx, 2004; Cooke and Cowx, 2006) and having considerable social and economic benefits (Arlinghaus and Cooke, 2009). Although it is difficult to provide global estimates of participation in recreational fishing, Arlinghaus and Cooke (2009) estimated that an average 10.6% of the adult population take part in recreational fishing (for countries where information is available).

Despite the relevance of recreational fishing, for a long time most of the global impact on the marine biological resources was attributed to the commercial sector (Greiner *et al.*, 2000; Pauly *et al.*, 2003). With most of the global fisheries stocks severely exploited or in decline (Worm *et al.*, 2006b; FAO, 2010), and the increasing awareness of the potential impact from recreational fishing (McPhee *et al.*, 2002; Cooke and Cowx, 2004), the tension between the commercial and recreational sectors has aggravated in many countries, which led to an increasing demand for integrated management to prevent stock depletion (Bennett, 1991; Mather *et al.*, 1995; Smith and Pollard, 1996; Kearney, 2002a; Sutinen and Johnston, 2003; Cooke and Cowx, 2004; Pawson *et al.*, 2007). In response, many management agencies worldwide (e.g. Australia, South Africa; USA) have developed input and output control measures to manage recreational harvest (Bennett, 1991; Sauer *et al.*, 1997; Radomski *et al.*, 2001; Cowley *et al.*, 2002; Kearney, 2002a). However, in many cases the recreational fishing regulations implemented were mostly developed *ad hoc* (Smith and Pollard, 1996), focusing more on the fisheries resources, and disregarding the human dimensions of recreational fisheries; and mostly fishers' perceptions about, and behaviour towards management measures, remained poorly understood (Kaiser, 2005; Richardson *et al.*, 2005).

Regulations which fail to include the human dimensions of the fishery have been shown to not be well accepted by fishers (Hauck *et al.*, 2002; Sutinen and Johnston, 2003). As reasoned by Kaiser (Kaiser, 2005), on the response of commercial fishers to the creation of Marine Protected Areas (MPAs), the imposition of regulations without due consideration of fishers' behavioural responses may cause more harm than benefit to the conservation of the fisheries resources. Effective recreational fishery management will thus depend on anglers' behaviour towards and compliance with rules and regulations (Hanna, 2001; Richardson *et al.*, 2005), and one of the key drivers for compliance is fisher acceptance of regulations and recognition of legitimacy (Hauck *et al.*, 2002; Nielsen and Mathiesen, 2003; Dimech *et al.*, 2009).

Several authors have also noticed that fishers' behaviour and/or perceptions towards management measures may be highly variable, and is generally influenced by a combination of factors, such as their attitudes towards management bodies, past management experience, social aspects (e.g. moral values, peer pressure and beliefs), and also demographic variables (e.g. their age, fishing experience, educational level, income) (Hatcher *et al.*, 2000; Hauck *et al.*, 2002; Eggert and Ellegård, 2003; Edison *et al.*, 2006; Dimech *et al.*, 2009). As such, it is likely that different recreational fishers will also have different opinions about the same management measures. Therefore, it is important to investigate both group and individual recreational fishers' perceptions towards management in order to maximize their acceptance of and compliance with management measures (Hauck *et al.*, 2002; Edison *et al.*, 2006; Frijlink and Lyle, 2010).

Research initiatives to gauge fishers' opinions on recreational fisheries management are already a common practice in some countries. For example, some studies (e.g. South Africa) have focused on fishers' perceptions about existent management measures (Sauer *et al.*, 1997; Hauck *et al.*, 2002; Mann *et al.*, 2003), while others (e.g. USA) have been generally conducted *a priori* of regulations, and explored fishers' attitudes/perceptions towards

potential management measures (Radomski *et al.*, 2001; Salz and Loomis, 2004; Salz and Loomis, 2005; Edison *et al.*, 2006). However, in Europe there is still little dedicated research on the human dimensions of recreational fisheries (Aas and Ditton, 1998) and to date only a few studies have focused on recreational fishers' perceptions and/or behaviour towards management interventions (e.g. Aas *et al.*, 2000; Arlinghaus and Mehner, 2005).

In Portugal, recreational fishing has long been an open-access activity, without regulations of any kind. Managers justified this lack of regulations with both the presumed high abundance of fisheries resources and minimal impact caused by recreational fishing when compared to commercial fishing (Decree Law § 246/2000). The observed decline in most fisheries resources and the increasing tension between the commercial, mostly artisanal, and recreational sectors resulted in the introduction of regulations for recreational fishing in 2000 (Pawson *et al.*, 2008; Veiga *et al.*, 2010). The main goal of the Decree Law § 246/2000 was to define the legal framework for recreational fishing activity (Table 3.1) and to fight alleged illicit commercial fishing activities taking place under the umbrella of recreational fishing. After a period during which little attention was given to recreational fishing regulations, specific restrictions were finally put in place in August 2006 (Portaria §. 868/2006), and included commonly used harvest controls, such as daily bag limits, minimum landing sizes, fishing licences and spatial restrictions (Smallwood *et al.*, 2006; Grixti *et al.*, 2008; Font and Lloret, 2011b). No information about the planning process (e.g. stakeholders' involvement) or the scientific rationale to support these restrictions was however made available to the public. To our knowledge, when the restrictions were implemented (2006), scientific data on the impact of the recreational fishing activity on marine resources in Portugal was sparse, and studies on the human dimensions of the Portuguese recreational saltwater fishing inexistent. This work aimed to investigate the potential responses of anglers to changes in the management of recreational fisheries in the south of Portugal and identify which individual

characteristics influence fishers' perceptions about management. Ultimately, the study aims to anticipate possible compliance issues and put forward recommendations for management.

Table 3.1 Legislation and measures in place which impact on recreational fishing in the south of Portugal.

	Measure/ Decree	Purpose	Important actions put in place	Coverage <sup>a</sup>
Before the survey	Decree Law § 246/2000	To define the legal framework for recreational fisheries in mainland Portugal; To stop illegal commercial fishing activities disguised as recreational fisheries.	Definition of the allowable recreational fishing gears; Prohibition of selling the catches.	National level
	Decree Law § 112/2005	To amend some of the aspects of Decree § 246/2000	Update values of fines.	National level
During the survey	Portaria 896/2006	§ To put into action catch restrictions for recreational fishing in mainland Portugal.	Daily bag limits (10 kg/fisher/day for fish and cephalopods, 2 kg/fisher/day for shellfish, 0.5 kg.fisher/day for barnacles; 25 kg/boat/day). Minimum landing sizes (MLS; similar to MLS for commercial fishing). Fishing licences (starting in January 2007). Area restrictions (e.g. fishing from jetties, river mouths, navigation channels, within 100m from the docks, marinas, shipyards and fish farms, ports and marinas, from beaches and within 300 m of the beach during the "beach season", within 100 m of a sewage outflow prohibited). Restrictions on the use of some shellfish gathering tools. Mandatory participation in eventual surveys carried out by the Directorate General of Fisheries and Aquaculture.	National level
After the survey	Portaria 143/2009	§ To put into action specific catch restrictions for recreational fishing within the Parque Natural do Sudoeste Alentejano e Costa Vicentina (PNSACV).	Closed seasons for several species (namely <i>Diplodus sargus</i> , 1 <sup>st</sup> January to 31 <sup>st</sup> March; <i>Labrus bergylta</i> , 1 <sup>st</sup> March to 31 <sup>st</sup> May). Closed areas (of several protection levels). Specific daily bag limits (7.5 kg.fisher/day for fish and cephalopods; 2 kg/fisher/day for shellfish; 1 kg/fisher/day for barnacles; 2 <i>L. bergylta</i> fish spearfisher/day (only for spearfishing); 25 kg.boat.day). Non-residents of the PNSACV area restricted from shellfish gathering. Closed periods for fishing (at night time, but exceptions applied; and from Monday to Wednesday).	Local level

Table 3.1. (cont.)

	Measure/ Decree	Purpose	Important actions put in place	Coverage <sup>a</sup>
After the survey	Portaria 144/2009 <sup>b</sup>	§ To review and update the current legal framework for recreational fishing in mainland Portugal, including restrictions to the activity.	Use of bait only for boat fishing. Deleted prohibition of fishing from piers. All fish captured by any recreational fishing activity has to be caudal fin-clipped. Prohibition to catch some protected/vulnerable species (e.g. spiny lobster, dusky grouper).	National level
	Portaria § 115- A/2011	To review and update the current legal framework for recreational fishing within the PNSACV.	Closed fishing periods changed from three days a week (Monday-Wednesday) to just one day a week (Wednesday, except if a national holiday). Night fishing re-allowed for angling (but the use of reflective life-vests is mandatory). Closed seasons for <i>Diplodus</i> ( <i>D. sargus</i> and <i>D. vulgaris</i> ) from 1 <sup>st</sup> February to 15 <sup>th</sup> March. Removal of restrictions to the use of some shellfish gathering tools. Specific daily bag limits for fish and cephalopods remains 7.5 kg.fisher/day, although the limit for octopus is now restricted to 2 octopus.fisher/day	Local level

<sup>a</sup> Refers to Portugal mainland only. <sup>b</sup> A new amendment for current recreational fishing regulations (Decree Law § 246/2000 and Portaria § 144/2009) is currently in preparation.

### 3.3 Methods

#### 3.3.1 Study areas

The study area comprised approximately 250 km of coastline in the south of Portugal (about 1/5 of the Portuguese mainland coast), between the localities of Vila Real de Santo António (37° 11' N; 7° 24' W) in the south, and Sines (37° 57' N; 8° 32' W) in the south-west (SW) coast (Figure 3.1). The coastline is divided into two distinct biogeographic areas: the south coast (Algarve) and the SW coast. The former has calmer sea conditions and is highly urbanized due to intense tourism. The SW coast faces the Atlantic Ocean directly and is characterized by colder waters, rougher sea conditions and an irregular coastline with high cliffs. This area is almost totally encompassed by a natural park (Parque Natural do Sudoeste

Alentejano e Costa Vicentina – PNSACV), which was designated in 1995 and includes both terrestrial and marine habitats (2 km from the shoreline) (Resolução do Conselho de Ministros n.º 11-B/2011). In consequence, it is a more pristine region where the main economic activities are agriculture and artisanal fishing (Veiga *et al.*, 2010). Recreational fishing from the shore is a very important activity in the whole SW region and is conducted all-year round, mainly by residents, who target a variety of species, in particular sea breams of the sparidae family (Veiga *et al.*, 2010). In the south coast, shore anglers tend to concentrate around the major urban areas, usually fishing from jetties, whilst in the SW coast fishing is mainly conducted from cliffs and anglers are more dispersed, although there are a few hotspots (e.g. Carrapateira, Sagres) (Figure 3.1).

### **3.3.2 Survey**

The opinions of Portuguese anglers were investigated using a questionnaire survey (Appendix II). The survey consisted of a set of questions aimed at gathering information about anglers' opinions and perceptions about: (1) the need for recreational fishing regulation, (2) being informed about the regulation, and (3) the regulation put in place. The items under investigation were measured in a three-point scale (disagree, neutral and agree; or, disagree, partially agree and agree) and in a dichotomous format (yes/no). No questions were left open-ended, as to constrain the respondents to provide an answer to every question, although the option "I don't know" was available. Additionally, the questionnaires also collected information on anglers' opinions about the state of fishing resources (only anglers with >10 years of experience were asked to respond to this set of questions), socio-demographic characteristics (e.g. age, nationality, education level) and fishing operation characteristics (e.g. experience angling, type of fishing grounds used, costs of fishing) (Table 3.2).

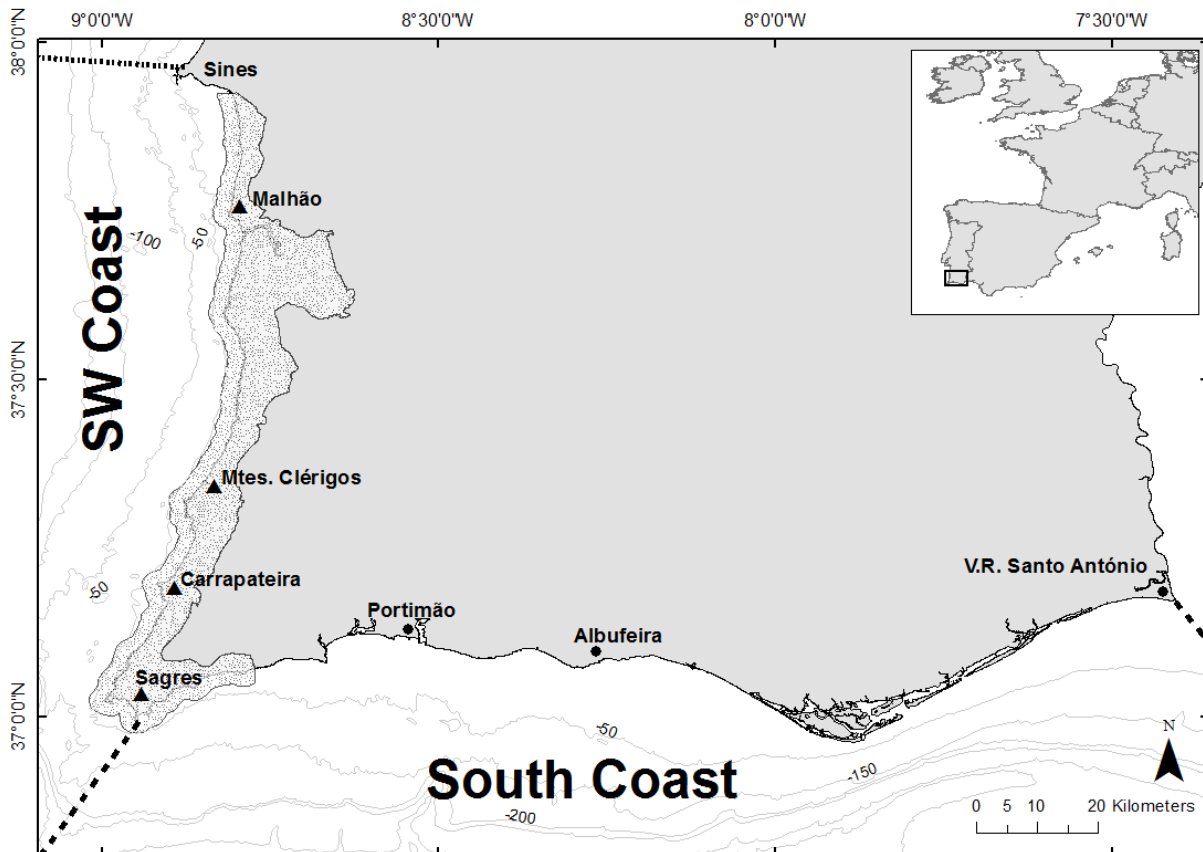


Figure 3.1 Map of the south of Portugal showing the 2 main study areas (South and south west coast), the PNSACV Natural Park (shaded/dotted area), and the most important fishing locations (type of fishing spot: ▲, Cliff; ●, Jetty) (from Veiga *et al.*, 2010). Note: dashed line denotes the separation between the South and South west coasts).

Information was obtained through face-to-face interviews, conducted during roving creel surveys carried out from July 2006 to July 2007 (see Veiga *et al.* (2010) for details on the survey methodology). Interviews followed a structured approach, but all statements made by the interviewees at any stage of the interview were noted on the questionnaire. The response rate was high (95%) and interview time ranged from 10 to 15 minutes. The survey collected information from 1298 individuals, representing 6.5% of the 19,866 local shore angling licences issued for the area (southern Portugal: Algarve and Alentejo regions) in 2007 (DGRM).

Table 3.2 Characteristics of the shore anglers in the survey (n = 1298). Data is shown as means ( $\pm$  standard deviation) or percentages.

Variables	Description of variables	All (n=1298)
<b><i>Demographic characteristics</i></b>		
Gender	= 1, if male; 0, if female	98.5%
Age	= respondent's age, in years	48 (14)
Nationality	= 1, if the respondent is a Portuguese national, 0 otherwise	96.2%
Monthly income	= monthly income of the respondent:	
	≤€500	31.0%
	€501 – ≤€1000	40.4%
	€1001– ≤€1500	18.0%
	>€1501	10.6%
Employed	= 1, if the respondent is employed; 0, otherwise	69.0%
<b><i>Fishing operation</i></b>		
Fishing area	= location where the respondent was fishing:	
	South coast	44.8%
	South west coast	55.2%
Experience angling	= number of years of experience angling	24 (16)
Experience angling from boat	= number of years of experience angling from a boat	11 (11)
Days angling per year	= number of days angling per year	65 (62)
Fishing association	= 1, if the respondent belongs to a fishing association; 0, otherwise	8.3%
Fishing in area inside marine park	= 1, if the respondent fishes inside the marine park; 0, otherwise	54.4%

Table 3.2. (cont.)

Variables	Description of variables	All (n=1298)
Distance to fishing grounds	= distance travelled to fishing grounds (km):	
	Distance is $\leq 10$ km	60.8%
	Distance is $> 10$ km	39.2%
Fishing grounds	= type of fishing ground where the respondent was fishing:	
	Beach	14.2%
	Pier/jetty	27.4%
	Cliffs/rocks	58.4%
Fishing alone	= 1, if the respondent was fishing alone; 0, otherwise	60.4%
Fishes at night	= 1, if the respondent fishes at night; 0, otherwise	48.7%
In possession of fishing licence	= 1, if the respondent is in possession of a fishing licence; 0, not in possession of fishing licence <sup>b</sup> .	91.9%
Targets Sparidae	= 1, if the respondent targets Sparidae; 0, otherwise.	88.8%
$\geq 50\%$ catch with White sea bream	= 1, if the respondent's catch is composed of $\geq 50\%$ of White sea bream ( <i>Diplodus sargus</i> ); 0, otherwise.	53.4%
Retained undersized fish in catch	= Respondents had retained undersized fish <sup>c</sup> :	
	Before legislation	21.8%
	After legislation	15.1%
Costs of fishing	= Average amounts spent on fishing (€) <sup>d</sup> :	
	Bait (per trip)	5.3 (5.9)
	Transport (per trip)	4.0 (5.8)
	Equipment (annual)	266.4 (497.6)

<sup>a</sup> Education level: 1st cycle of basic education = 4 years of schooling, Complete basic education = 9 years of schooling (current mandatory education), secondary = 12 years of schooling, higher education=university degree; <sup>b</sup> Refers only to questionnaires undertaken after the regulation was put in place (01/01/2007) (n=624); <sup>c</sup> Refers to the time before and after legislation came out (29/08/2006); <sup>d</sup> Bait and Transport refer to daily fishing expenses and Equipment refers to annual expenses.

### 3.3.3 Data analysis

First, the demographic and fishing operation characteristics, as well as fishers' perceptions and opinions were described. Following this, logistic and ordered logit regression models were fitted in order to identify which set of characteristics influence shore anglers' perceptions and opinions about (a) the need for the existence of recreational fishing regulation and (b) the regulation currently in place. For the former, since this information was collected in a binary format, a logistic regression model was fitted, using Huber–White robust standard errors, in order to identify which individual characteristics (demographic, fishing operation, perceptions and opinions) influence shore anglers' perceptions about the need for the existence of recreational fishing regulation. The logistic model is the most widely used of the discrete choice models and it identifies *ceteris paribus* (i.e. all other variables being constant) the intensity by which the explanatory variables influence the binary dependent variable (i.e. perceiving that recreational fishing regulation is needed or not) (Tabachnick and Fidell, 1996). For the later, only data collected after the implementation of fishing licences (01.01.2007) was used, and from anglers who replied they were informed about the current recreational fishing regulation (read it/had access to it) (n=492 questionnaires). In this case, ordered logit regression models were fitted using Huber–White robust standard errors, in order to identify which individual characteristics influence shore anglers' opinions about the regulation put in place. Ordered logit models were used in this case because this information was collected in a three-point scale (disagree, partially agree, agree) and ordered regression models are the most commonly used models for ordinal outcomes in the social sciences (Long and Cheng, 2004). Ordered regression models assume proportional odds (or parallel regression assumption) (i.e. they assume that the coefficients describing the relationship between each pair of outcome groups are the same). As such, the proportional odds assumption needs to be tested and this is done through Brant's Wald test (Brant test) and the

Likelihood-ratio test for ordinal responses (Long and Cheng, 2004). The dependent and independent variables included in the models are described in Table 3.2.

In both models, post-estimation analysis for multicollinearity was calculated, with tolerance and VIF (Variance Inflation Factor) and no multicollinearity was found amongst the explanatory variables.

All statistical analyses were conducted with STATA SE 10 (Data Analysis and Statistical Software, STATA Corp., College Station, Texas, USA).

## 3.4 Results

### 3.4.1 Anglers' demographics, attributes, fishing habits, and expenditures on fishing

The majority of anglers interviewed were male, in their late forties, Portuguese citizens, with a low educational level, employed and with an average monthly income of 501-1000€(excl. taxes) (Table 3.2).

Regarding fishing habits, anglers interviewed had an average of 24 years of fishing experience. Some also fished from boats, but boat fishing experience was in general lower (11 years). Most anglers went fishing year-round (average 63 days year<sup>-1</sup>), near to their area of residence ( $\leq 10$  km travelled), usually alone, and from cliffs/rocks. Almost half of the anglers reported fishing during the night period. Sea breams (Sparidae) were identified as the most targeted group of fish, in particular white sea bream, *Diplodus sargus*, which was also the most important species in the catches. In general, the catch was for fishers' own consumption, although a small percentage of anglers admitted selling their catches (even though this is illegal). Catch and release was a rare practice, but small or non-valuable species were usually rejected/discarded. Undersized fish were retained by 22% of anglers, with a decrease after

regulations put in place (15%). On each fishing trip, a typical angler spent on average €9.3 (€5.3 on bait and €4 on transport). Average annual expenditure on fishing equipment (e.g. clothes, fishing tackle) was around €66.

### 3.4.2 Opinions about the need for the existence of regulation

Most anglers (56%) were favourable to the existence of saltwater recreational fishing (SRF) regulations (Table 3.3).

Table 3.3 Perceptions and opinions of the shore anglers in the survey (n = 1298). Data is shown as percentages.

<i>Perceptions and opinions</i>	<b>All (n=1298)</b>
<b>Legislation</b>	
Agrees that there is a need for the existence of recreational fishing regulations (%)	56.4
Feels informed about the current recreational fishing regulation (read it/ had access to it) (%) <sup>a</sup>	77.7
Opinion about the current recreational fishing regulation (%) <sup>a</sup>	
Disagree	42.1
Partially agree	45.9
Agree	12.0
<b>State of resources</b>	
Catches have been decreasing in recent years (%)	72.3
Average size of fish specimens in the catch have been decreasing in recent years (%)	43.2
Responsible for decrease in catches (%) <sup>b</sup>	
Pollution	31.1
Overfishing	18.6
Commercial fishing	73.7
Other (e.g. spear fishing, global warming)	20.4
Ways to improve fishing in the area (%) <sup>b</sup>	
More limitations and better enforcement of commercial fishing regulation	46.1
Implementation of closed area	8.9
Implementation of conservation measures	4.8
Do nothing / leave as it is	14.3
Other	15.9

<sup>a</sup> Refers only to questionnaires undertaken after the recreational fishing regulation was put in place (01/01/2007) (n=624); <sup>b</sup> Since each respondent was allowed to choose more than one option, the sum accounts for more than 100%.

Results from the logistic regression indicated that the level of formal education and income, the fishing area where fishers operated from, their perception about the decreasing trend in fish size, and the existence of fishing licences influenced anglers' opinion regarding the need for the existence of SRF regulations (Table 3.5). Anglers fishing in the SW coast were more likely to agree with the existence of regulations than those fishing in the south coast. This was also the case for anglers with higher levels of formal education, when compared to those with lower levels of formal education, and for anglers with a higher monthly income when compared to those in a lower income band. In addition, the anglers interviewed after the fishing licences were compulsory (1<sup>st</sup> January 2007) were more likely to agree with the existence of regulations than those interviewed before licences were compulsory. In contrast, anglers fishing from cliffs/rocks were less likely to agree with the existence of SRF regulations than those fishing from the beach. Anglers who perceived a decreasing trend in the size of the fish they caught were also less likely to agree with the existence of regulation compared to anglers who did not perceive any decrease in fish size in recent years.

To a lesser extent anglers' opinion about the existence of SRF regulations is also influenced by the number of days angling per year and their perception about limitations to commercial fishing and enforcement of commercial fishing regulation. Anglers who spend more days fishing per year were more likely to agree with the existence of regulation. While, those who perceived that more limitations to commercial fishing and a better enforcement of commercial fishing regulation would improve fishing in the area were less likely to agree with the existence of SRF regulations.

Table 3.4 Logistic model estimates for shore anglers' perceptions about the need for the existence of recreational fishing regulation.

Variables	Agree with the existence of recreational fishing regulation	
	O.R.	[Robust SE]
<b><i>Demographic characteristics</i></b>		
Age	0.993	[0.007]
Education level (omitted: 1 <sup>st</sup> cycle basic education)		
Complete basic education	1.110	[0.238]
Secondary education	1.775**	[0.472]
Higher education	2.019	[0.862]
Employed	1.225	[0.258]
Monthly income (omitted: < 500€)		
501-1000€	1.182**	[0.343]
1001-1500€	2.314***	[0.648]
> 1501€	2.040**	[0.722]
<b><i>Fishing activity</i></b>		
Fishing area (SW coast)	2.510***	[0.575]
Days angling per year	1.003*	[0.001]
Distance to fishing grounds (>10km)	1.154	[0.203]
Fishing grounds (omitted: beach)		
Pier/jetty	0.734	[0.201]
Cliff/rocks	0.450***	[0.114]
<b><i>Attitudes and perceptions</i></b>		
Catches decreasing	0.492	[0.256]
Decreasing mean size of fish	0.614***	[0.104]
Commercial fishing responsible	1.119	[0.226]
Limitations and enforcement of commercial fishing regulation	0.741*	[0.128]
Time after fishing licences in place (01.01.2007)	1.828***	[0.307]
No. of Observations	720	
Wald $\chi^2$ (d.f.)	75.65 (18)***	
Pseudo R <sup>2</sup>	0.09	
Hosmer-Lemeshow $\chi^2$ (d.f.), p-value <sup>a</sup>	5.67 (8), p=0.684	
Mean VIF (min-max) <sup>b</sup>	1.54 (1.05-2.31)	
% correctly classified	66.5%	

<sup>a</sup> Hosmer and Lemeshow's goodness-of-fit test. Non-significant p-values indicate that the model fits the data well; <sup>b</sup> Mean variance inflation factor (VIF) (minimum and maximum VIF values).

Note: \*  $P < 0.10$ , \*\*  $P < 0.05$ , \*\*\*  $P < 0.01$

### 3.4.3 Perceptions about the regulation in place

When asked about the current recreational fishing regulations, the majority of the interviewed anglers declared to be informed about SRF regulation (i.e. read it/had some access to it) (78%). The majority stated that they either disagreed (42%) or only partially agreed (46%) with the current SRF regulations (Table 3.3). The measures to regulate recreational fishing which had higher acceptance were, by order of importance (qualitative information): fishing licences, minimum landing sizes, and the daily bag limit of 10 kg angler<sup>-1</sup> day<sup>-1</sup>. Overall, anglers accepted fishing licences, and 92% reported having a valid fishing licence. Fishing licences were not controversial as most anglers considered the annual cost for shore angling low (6 - 12€), even though part were against the existence of fishing licences *per se*.

The majority of anglers understood and accepted the existence of minimum landing sizes, but awareness of sizes for specific species was low and many admitted to using the hand span as a single size “ruler” to decide which fish to keep or release independently of the species. There were specific minimum landing sizes that were however very criticized with anglers complaining they were too high, such as for seabass *Dicentrarchus labrax* (36 cm) and black sea bream *Spondyliosoma cantharus* (23 cm). Daily bag limits were in general accepted, because shore anglers considered the 10 kg angler<sup>-1</sup> day<sup>-1</sup> limit unlikely to affect their average catches, which were generally much lower than this value. The most criticized management measure was the prohibition of fishing from piers/jetties, in particular in the south coast. Many anglers found this an unfair and unfounded restriction, which had a higher impact on shore anglers fishing in urban areas, particularly those that are unable to move away from their residential area (such as retired anglers and/or anglers with limited means of transportation).

The ordered logistic model showed that anglers' level of formal education, monthly income, opinions on ways to improve the fishing activity in the area, and the location of their fishing

grounds, influenced their opinion about the SRF regulation put in place (Table 3.5). Anglers fishing in the SW coast were more supportive of the SRF regulations put in place than anglers from the south coast. Anglers with higher income levels also showed a more positive attitude towards the regulation in place than anglers with the lowest income level. In contrast, anglers who favoured increasing limitations and a better enforcement of commercial fishing regulations as a way to improve fishing in the area were less supportive of the SRF regulation put in place compared to those who supported other ways to improve fishing in the area.

#### ***3.4.4 Perceptions about the state of resources***

Concerning the state of the resources, the majority of the interviewees felt that their catch rates have been decreasing in recent years (72%), but most did not report differences in the average size of the fish captured, with only 43% reporting a decrease in average size. The main reasons pointed out for the perceived decline in catches were commercial fishing (74%), followed by pollution (31%) and overfishing in general (18.6%). Most anglers blamed the decrease in catches on commercial fishing activities, mainly trawling and fishing with gillnets and trammel nets too close to the shore. They also stated numerous other reasons for the decrease in catches, namely climate change, illegal fishing and lack of enforcement. Interestingly, only a small percentage of anglers blamed recreational fishing (i.e. spearfishing) for the decrease in catches (3%). When asked about ways/measures that could be put in place to improve fishing success in the area, most anglers suggested “more limitations and better enforcement of commercial fishing regulations” (46%). “Do nothing / leave as it is” or “implement closed areas” were also suggested (Table 3.3).

Table 3.5 Ordered logistic model estimates for shore anglers' perceptions about the recreational fishing regulation in place.

Variables	Agree with the recreation fishing regulation put in place <sup>a</sup>	
	Coef.	[Robust SE]
<b>Demographic characteristics</b>		
Age	-0.015	[0.009]
Education level (omitted: 1 <sup>st</sup> cycle basic education)		
Complete basic education	-0.279	[0.257]
Secondary education	-0.146	[0.309]
Higher education	-0.582	[0.563]
Employed	-0.481**	[0.238]
Monthly income (omitted: < 500€)		
501-1000€	0.898***	[0.245]
1001-1500€	1.172***	[0.321]
> 1501€	1.800***	[0.509]
<b>Fishing activity</b>		
Fishing area (SW coast)	0.610**	[0.253]
Days angling per year	0.004	[0.001]
Distance to fishing grounds (>10km)	0.166	[0.199]
Fishing grounds (omitted: beach)		
Pier/jetty	0.049	[0.332]
Cliff/rocks	-0.052	[0.239]
Fishing alone	0.235	[0.205]
<b>Attitudes and perceptions</b>		
Catches decreasing	0.091	[0.273]
Decreasing mean size of fish	-0.224	[0.207]
Limitations and enforcement of commercial fishing regulation	-0.474**	[0.189]
Cut 1	0.304	[0.799]
Cut 2	2.888	[0.824]
No. of Observations	492	
Wald $\chi^2$ (d.f.)	40.46 (17)***	
Pseudo R <sup>2</sup>	0.04	
Mean VIF (min-max) <sup>b</sup>	1.6 (1.06-2.29)	

<sup>a</sup> Analysis of data collected after the recreational fishing regulation was put in place (01.01.2007) and solely from anglers who replied they were informed about the current recreational fishing regulation (read it/had access to it). Ordinal logistic regression models estimated on the 3-point scale (disagree, partially agree, agree). Likelihood-ratio test of proportionality of odds ( $\chi^2(17)=25.9$ ,  $p=0.08$ ), showing that the parallel regression assumption has not been violated; <sup>b</sup> Mean variance inflation factor (VIF) (minimum and maximum VIF values).

Note: \*  $P < 0.10$ , \*\*  $P < 0.05$ , \*\*\*  $P < 0.01$

### **3.5 Discussion**

Fishers' perceptions and attitudes towards regulations may change with time, and can also be influenced by many intrinsic (age, education, income, motivation for fishing, fishing specialization) (Hauck *et al.*, 2002; Cantrell *et al.*, 2004; Edison *et al.*, 2006) and extrinsic factors (e.g. changes in regulations, changes in the fishing experience, peer pressure) (Richardson *et al.*, 2005; Edison *et al.*, 2006). Research on fishers' perceptions about recreational fishing regulations is crucial to the success of regulations. It highlights the needs of anglers and can provide decision-makers with information that can contribute towards adjusting and/or developing more adequate and resilient regulations (Hanna, 2001; Sutinen and Johnston, 2003; Salz and Loomis, 2004; Baker, 2009), i.e. regulations aiming to protect the fisheries resources, but also meet the fishermen needs and improve their fishing experience.

This study examined Portuguese anglers' attitudes towards the existence of regulations for recreational fishing [a very important activity in the Portuguese socio-cultural context (Veiga *et al.*, 2010)] and towards the recently implemented restrictions. These restrictions, implemented in 2006, represented a sharp change in recreational fishing management in Portugal, which for a long time was an open-access activity. Conducted during the implementation of the new restrictions, our study revealed that although most recreational fishers from south Portugal accepted the need for the existence of recreational fishing regulations, the newly implemented restrictions were received with either total or partial disagreement. Overall fishers perceived that most of the specific restrictions (e.g. prohibition of fishing from piers/jetties) lacked a sound scientific rationale, and that the decision-making process took place without almost any involvement of the angling community.

### **3.5.1 *Anglers' perceptions towards regulations***

Anglers generally accepted the need for the existence of SRF regulations, which were recognized by most as inevitable due to the increased number of resource users. Comments such as “all activities that interact with common resources should be regulated” and “regulations are important to stop illegal fishing activities from taking place” were common among fishers that approved the existence of regulations and suggest some degree of awareness regarding their impact on the resources. The anglers who expressed negative perceptions about the existence of SRF regulations tended to base their argument on their belief that recreational fishing has a minimal impact compared with that of the commercial sector, and comments such as “Recreational fishing has little or no impact on the resources when compared with commercial fishing and thus should be an open-access activity as it has always been” were common. Such attitudes and beliefs are probably related to the fact that the latter group of anglers failed to perceive the cumulative impact that recreational fishing can have on fisheries resources (Coleman *et al.*, 2004; Cooke and Cowx, 2004), and probably base their opinion on their individual fishing experience (catch rates). In fact, many of these anglers blamed commercial fishing for the poor state of the resources and argued that there was a need to more effectively control commercial catches.

Regarding the newly implemented regulations, the large majority of anglers either disagreed or only partially agreed with the restrictions put in place. These restrictions represented a sharp change in the management system of recreational fishing in Portugal. The study was conducted just after the implementation of the regulations, in a period when anglers' were probably still adapting to change and apprehensive about the implications that such restrictions would have on their future fishing experience (Radomski *et al.*, 2001; Radomski, 2003). Another possible reason for the generalized lack of acceptance of regulations, was the fact that many anglers felt the new restrictions were mainly unfounded

and inadequate with regard the recreational fishing reality in Portugal, and that their voice was not heard during the decision-making process (Sutinen and Johnston, 2003; Stump and Kriwoken, 2006). Similar attitudes were observed amongst recreational and commercial fishers from other parts of the world (Smith and Pollard, 1996; Sutinen and Johnston, 2003; Stump and Kriwoken, 2006; Pita *et al.*, 2010). For example, in South Africa, Hauck *et al.* (2002) have found that the majority of subsistence and recreational fishers agreed that regulations were necessary, but were against the restrictions put in place as they were perceived as unfair and inequitable. Smith and Pollard (1996) stated that a common held perception amongst recreational fishers throughout Australia was that their opinions were not taken into consideration and had little impact in the management decisions.

In particular, an important factor that has influenced Portuguese anglers overall negative attitude towards the implemented regulations, was their total disagreement with the prohibition of fishing from piers/jetties, a restriction they found especially unfair. This prohibition was the “hot topic” during the study, being clearly the most criticized restriction. Jetties are a popular fishing spot for shore anglers from metropolitan areas in Portugal (Rangel and Erzini, 2007; Veiga *et al.*, 2010), in particular during the summer and autumn periods (Veiga *et al.*, 2010). It was apparently implemented as a safety measure to keep the navigation channels free, but this fact was not clearly explained to the angler community who did not see a valid rationale for such measure. This restriction has created great confusion among anglers who used these spots, causing feelings of resentment towards the authorities and probably influencing anglers' opinions towards regulations in general.

Interestingly, daily bag limits were neither criticized nor supported. In most cases, anglers stated that they simply did not mind this measure as the limit was much higher than what they usually caught. Veiga *et al.* (2010) reported that less than 1% of anglers attained or exceeded the current 10 kg daily bag limit. In general, daily bag limits are not controversial (Sauer *et*

*al.*, 1997; Reed and Parsons, 1999; Mann *et al.*, 2002; Edison *et al.*, 2006; Prior and Beckley, 2007), probably because the limit is set too high to be effective in limiting overall anglers' captures (Cook *et al.*, 2001; Cowley *et al.*, 2002; Mann *et al.*, 2003; Edison *et al.*, 2006; Smallwood and Beckley, 2012), and that is probably the reason why anglers usually do not criticize them (Sauer *et al.*, 1997).

As with the daily bag limits, most fishers did not oppose fishing licences, mainly due to the fact that the annual cost was perceived as affordable and not because they recognized it as a legitimate management measure. In fact, many were sceptical about the final use of the fishing licences' returns, and claimed that they would only agree with such a measure if money from fishing licences was put back in recreational fishing. Similar observations were made in several south-African and US recreational fisheries, where anglers were prepared to pay for fishing licences as long as the final use of licence earnings would be used for fisheries conservation and to improve fishing quality (Brouwer *et al.*, 1997; Sauer *et al.*, 1997; Whitehead *et al.*, 2001; Mann *et al.*, 2002; Fennessy *et al.*, 2003). Fishing licences can be an important source of economic revenue (Whitehead *et al.*, 2001), but they are also a good indicator of the number of anglers (i.e. fishing effort) (Brouwer *et al.*, 1997). Licensing schemes that are kept at a price that anglers recognize as "affordable" and regard as meaningful and legitimate have more chances of being supported.

Opinions towards minimum size limits was very interesting, as anglers generally agreed with this measure and acknowledged the importance of protecting "small fish", suggesting strong moral values with regard doing the "right thing" (Nielsen and Mathiesen, 2003). Keeping "small fish" was in fact a behaviour condemned by anglers, who generally attributed this behaviour to more inexperienced anglers. However, a lack of knowledge about specific size limits or the rationale behind size limits was evident. This was also observed by several authors investigating anglers elsewhere, who noticed that anglers seem to acknowledge the

importance of protecting “small fish” but most do not know the specific minimum landing sizes for some of these fish (e.g. Brouwer *et al.*, 1997; Mann *et al.*, 2002; Edison *et al.*, 2006; Smallwood *et al.*, 2006; Prior and Beckley, 2007; Beckley *et al.*, 2008). Many anglers actually claimed to release small fish even before the regulations were put in place, but used the hand span as a single size “ruler” to decide which fish to keep or release independently of the species. In fact, most anglers seemed to fail to understand or accept that size limits are species-specific, and heavily criticized minimum sizes for species such as the black sea bream (23 cm) and European seabass (36 cm) that were considered too high. The lack of knowledge or disregard of specific minimum landing sizes can lead to the retention of undersized fish, thus resulting in a lack of compliance with this management measure (Page and Radomski, 2006; Beckley *et al.*, 2008). This is a cause for concern because even though there was an overall decrease in the retention of undersized fish after regulations were put in place, for species where anglers disregarded the current minimum landing size, such as seabass, the retention rates of undersized fish were very high (Veiga *et al.*, 2010).

Besides the general lack of knowledge about specific minimum landing sizes, detailed knowledge about other specific aspects of the regulation appeared to also be lacking amongst shore anglers from southern Portugal. Most anglers seemed poorly informed and, in most cases, only aware of the existence of one or two “popular” management measures (such as the existence of fishing licences or daily bag limits). Knowledge about these measures was also generally obtained through conversations with fellow anglers or friends. In fact, immediately after the regulations were put in place, simple ways of disseminating basic information (e.g. signage on fishing spots, distributing flyers with the main aspects of the regulations) were not available, limiting anglers’ awareness of the regulation; in order to inform themselves about the regulation anglers had to pro-actively look for such information, e.g. in the internet, fishing magazines and legal documents. Education and dissemination programs of fishing

regulations are a key measure to increase anglers' awareness of regulations (Daoutopoulos and Pyrovetsi, 1990; Bennett, 1991; Sutinen and Kuperan, 1999; Cooke *et al.*, 2006; Cardona-Pons *et al.*, 2010; Näslund *et al.*, 2010), and should also be promoted in Portugal.

### ***3.5.2 Factors influencing anglers' perceptions about regulations***

How anglers perceived the regulations in place seemed to vary between and amongst groups of anglers. Anglers with lower incomes were less likely to agree with both the need for the existence of regulations and the SRF regulations in place. A similar correlation was observed by Edison *et al.* (2006) and Hauk *et al.* (2002), for recreational anglers from Illinois (US) and subsistence [informal] fishers in South Africa, respectively. Recreational anglers earning less may be at some point more dependent on fishing catches as an important extra source of food (Veiga *et al.*, 2010), and thus less likely to accept any restrictions that could restrain their catches. On the other hand, wealthier anglers may feel less "threatened" by specific restrictions as they are generally driven by the recreational experience rather than fishing mainly for food (Cantrell *et al.*, 2004). In fact, Edison *et al.* (2006) also found that anglers who fish for sport are more likely to agree with regulations than those fishing for food.

As with income, anglers with a lower level of formal education were also less likely to agree with the existence of recreational fishing regulations, which is probably related with a reduced knowledge regarding the rationale for the specific restrictions. According to Greiner *et al.* (2000), compliance can be increased if fishers, among other things, are informed, understand and accept the regulations in place. However, Page and Radomski (2006) noted that, among recreational anglers in Minnesota (US), awareness of regulations decreased with increased complexity of regulations. It is therefore important that efforts are made to ensure that awareness and understanding of regulations reaches all anglers, particularly in the incipient

stages of the implementation of regulations, when awareness of regulations is generally lower (Page and Radomski, 2006).

Other factors related with anglers fishing habits *per se*, such as the fishing area or the fishing spot they usually used, seemed to influence anglers' support for the SRF regulations. Anglers fishing in the south-west coast were more likely to agree with the regulations than those fishing in the south of the Algarve, whereas anglers fishing in jetties in general disagreed with the regulation more than those fishing from other spots. Most fishing spots in the SW west coast have difficult and/or remote access and are less likely to be visited by enforcement agents. Several studies have shown that anglers' compliance with regulations is affected by the enforcement effort and the probability of being caught fishing illegally (Griffiths and Lamberth, 2002; Page and Radomski, 2006; Walker *et al.*, 2007). Thus, it is likely that anglers fishing in the SW coast perceived the impact of regulations with indifference as the likelihood of being intercepted by enforcement agents is much smaller. Anglers who suggested that the way to improve fishing in the area is by increasing limitations to commercial fishing were less likely to agree with current SRF regulations, probably because they consider commercial fishing to be the main cause of the decline in fisheries resources. In summary, these findings suggest that opinions about regulations are not homogeneous among angler groups, and may be influenced by either more intrinsic factors, such as educational level or income, or other factors such as the way they perceive their fishing habits will be affected by specific restrictions.

### **3.5.3 Management implications**

According to the latest official statistics, the number of recreational fishing licences in Portugal, which can be seen as an indicator of participation in the angling activity, has been

stable at around 200 thousand licences per year since the first restrictions were put in place (2006) (DGRM). This suggests that participation in the shore angling activity in Portugal is stable and does not show signs of decreasing regardless of the implementation of restrictions. Our study revealed that awareness of most aspects of the SRF regulations was very limited, and the rationale behind most restrictions implemented by the regulations was poorly understood and in many cases not accepted by anglers (e.g. prohibition of fishing from piers). A feeling of resentment towards managers and the way the regulations were implemented, i.e. lacking active involvement from the recreational fishing community and scientific support, was also evident amongst the angling community.

Since this study was conducted, the national SRF regulation suffered a major revision in 2009 (Portaria § 144/2009), and is currently (2012) again undergoing a revision process, and yet again no scientific data other than the studies by Rangel and Erzini (2007) and Veiga *et al.* (2010) exists to support such revisions. One of main changes in the amended regulation concerns the prohibition of fishing from piers, which now only applies to boat fishing and the navigation channels between harbours and inlets. For the PNSACV natural park in particular, which encompasses almost half of the study area and most of the SRF hotspots in southern Portugal (Veiga *et al.*, 2010), stricter regulations were put in place in 2009 (Portaria § 143/2009), including smaller bag limits (7.5 kg fisher<sup>-1</sup> day<sup>-1</sup>), closed seasons for some species (e.g. white sea bream *Diplodus sargus*), and closed areas and periods. Again, after strong criticism from recreational fishers (mainly related with lack of scientific support for the restrictions put in place), some of the measures were revised again in 2009 (e.g. closed periods, Portaria § 458-A/2009) and 2011 (Portaria §115-A/2011).

The major revisions of regulations in such a short period of time show that a great amount of effort is being put in place to regulate the recreational fishing activity in Portugal. However, it also indicates that regulations are a long way from being satisfactory and acceptable to the

Portuguese recreational fishers. Information in the media (e.g. blogs, websites, newspapers, magazines) still shows obvious signs that many aspects of the regulations are still perceived negatively by many recreational fishers. These repeated revisions of the regulations, mainly driven by strong opposition from the recreational fishing community, suggests that management bodies have been failed to involve fishers in the decision-making process and take into account their fishing habits and perceptions about, and behaviour towards the regulations in place. However, the fact that the ongoing revision of regulations already includes a multi-stakeholder working group is a positive sign of change towards a more participative management approach.

The current study revealed that anglers were willing to accept the existence of regulations, as long as these were perceived as fair. This finding is encouraging and should be considered by decision-makers as a starting point for the implementation of effective regulations. Future revisions of the regulation should thus involve recreational fishers from the early stages of the decision-making process. This involvement is likely to result in fishers being more supportive and accepting of the regulations put in place (Nielsen and Mathiesen, 2003; Radomski, 2003; Dimech *et al.*, 2009). In addition, efforts should be made to make any changes in regulations meaningful and perceived as fair by the recreational fishing community. Regulations should be made as simple and clear as possible to ensure all anglers are aware and understand the key aspects. Dissemination strategies - such as pamphlets, recreational fishing guides, posting signs in main fishing spots or access sites - of the main aspects of the regulations (e.g. minimum size limits, daily bag limits, closed seasons or areas) and fishers' specific education programs, could be developed in order to promote awareness about the regulations (Daoutopoulos and Pyrovetsi, 1990; Bennett, 1991; Cooke and Suski, 2004; Edison *et al.*, 2006; Smallwood and Beckley, 2012) and, ultimately, influence angler attitudes and compliance (Sutinen and Kuperan, 1999; Sutinen and Johnston, 2003). This

would be particularly important for areas with remote access such as the SW coast of Portugal, where there is less enforcement, and effectiveness of regulations relies heavily on voluntary compliance (Smallwood and Beckley, 2012). Nonetheless, enforcement should also be increased, in order to prevent non-compliance but also to increase fishers' perception of the management system as fair and transversal to all fishing activities (Bennett, 1991; Griffiths and Lamberth, 2002; Page and Radomski, 2006).

Finally, it is important to note that our study only analysed perceptions of shore anglers from southern Portugal, and did not contemplate other activities such as spearfishing or boat fishing, which represent around 30% of the total recreational fishing licences issued annually (DGRM). Moreover, anglers' perceptions obtained in this study are specific to the restrictions implemented in 2006 and, as mentioned previously, several revisions were made to these regulations since. In order to get relevant information on fishers' perceptions towards new (or revised) regulations, periodic research should be conducted at a national scale, and preferably during all phases of the implementation process (before, during and after regulations) and including all recreational saltwater fishing activities. One of the interesting aspects found in the current study was the fact that anglers were sceptical about the final use of fishing licence fees. Fishing licences fees could be used to fund all the proposed measures, including increased enforcement, periodic monitoring of recreational fishing, group workshops involving all stakeholders during the implementation of regulations, and dissemination strategies of regulations in place to increase anglers' awareness. This would contribute greatly to improving angler acceptance of angling regulations.

# CHAPTER 4:

**Catches of the sport fishing competitions along the Algarve coast (Portugal): species, sizes, catch rates, and trends**



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(this paper resulted from the MSc thesis of Ana Guerreiro, the first author, under the supervision of P. Veiga and Dr. K. Erzini)

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## 4.1 Abstract

Stocks of many marine fishes are in decline and a number of studies suggest that for some species the impact of recreational angling may be important. To date, only recreational (leisure) fishing surveys have been conducted in Portugal, with no studies on beach angling competitions, dynamically increasing in number over the past 10 to 20 years. In view of the above, we decided to evaluate the impact of such events on the Algarve coast (southern Portugal) in terms of the abundance, diversity, and respective weight of fish species caught, and outline some conservation measures and recommendations for the management of the targeted species. Participants of 22 angling competitions taking place between February and June 2007 were surveyed. In each competition a random sample of anglers was interviewed, and the specimens caught by each participant were identified, weighed, and measured. Thirteen taxa belonging to eight families were identified, and the most common were: garfish, *Belone belone* (Linnaeus, 1761); mullets, Mugilidae (not identified); and mackerels, *Scomber* spp. A total of 563 specimens were sampled, totaling 75.4 kg of weight, with the average catch per angler weighing 0.5 0.05 SE (n = 153) kg. Differences were also observed between the length at first maturity ( $L_{50}$ ) of the specimens caught and their respective minimum Landing Size e (MLS) and Allowed Minimum Size (AMS), most particularly in the case of the European seabass, *Dicentrarchus labrax* (L.), with almost all individuals caught measuring below the species-specific  $L_{50}$ . Analysis of time series of competition results (1996–2009) showed no evidence of a decrease in catches or in mean weight. Based on the results we propose that the AMS for beach angling competitions should be increased to the MLS in order to prevent the capture of juvenile fishes, especially the sea bass. Future studies should address the size selectivity of the hooks used in beach competitions, with a view to the implementation of a minimum hook size for competitions.

## 4.2 Introduction

The available information on numerous marine stocks indicates that they are in decline, and many recreational anglers claim that their catches are decreasing in size and number as a result (Smith and Pollard, 1996; Richardson *et al.*, 2006). Fishing activity of any type, commercial or recreational, may be harmful to fish (e.g. limiting their size, age range, density, and reproduction), the trophic webs and relationships and, indirectly, all the aquatic ecosystems (Post *et al.*, 2002).

In Portugal, recreational (amateur) fishing can be divided into two types: *Leisure fishing* and *Sport fishing*. Leisure fishing is best described as a purely recreational hobby, while sport fishing is competition-oriented (Decree Law § 246/2000). Competitions based on rod and reel methods are a relatively recent phenomenon in Portugal, formally recognized in 1947 by the foundation of the Portuguese Federation of Sport Fishing (FPPD). To date only recreational (leisure) fishing surveys have been conducted in Portugal (Rangel and Erzini, 2007; Veiga *et al.*, 2010).

The main objective of this study was to describe sport fishing catches in the south of Portugal and to evaluate trends in abundance, weight, mean size, and diversity of catches taken during sport fishing competitions. Specifically we tested the following hypotheses: a) there has been no decrease in mean catch per angler over the past 15 years; b) there has been no decrease in mean weight fish caught over the past 15 years. The secondary objective was to outline potential conservation measures and make recommendations for the management of the species affected.

### 4.3 Methods

The Algarve region is located between parallels 37°35' and 36°58' N, across the meridians 7°25' and 9°00' W (DGRAH, 1986). Monitoring of the 2007 Sport Fishing Championships took place between February 24 and June 16, and included a total of 22 competitions that lasted 4 h each (anon., 2007a).

Sampling surveys consisted of two stages: 1) contestants, chosen at random, were interviewed after the end of the competition, and 2) their catches analyzed, with each fish identified to the lowest possible taxon, measured (TL, nearest mm) and weighed (precision, 2 g).

The total catch weight of the competition and the total number of individuals caught by each competition angler were used to calculate the average weight of fish caught per angler per hour (CPUE<sub>p</sub>) and the average number of fish per angler per hour (CPUEn).

Statistics for the Algarve competitions, covering the period from 1996 to 2009, were obtained from sport-fishing associations. These data were used to analyze trends in catches and sizes and to test the above-mentioned hypotheses. Specifically, we evaluated trends in mean weight of the 10 largest fish caught, the mean catch for the top ten anglers per competition, the weight of the largest fish caught, and the mean total catch per competition.

### 4.4 Results and Discussion

Monitoring of 22 sport fishing competitions lasting 4 hours each took place between February 24 and June 16 2007. In total, 563 fish belonging to 13 taxa were recorded during the surveys, between February and June 2007. The most important taxa, both in terms of abundance and weight, were: garfish, *Belone belone* (Linnaeus, 1761); mullets, Mugilidae (not identified); and mackerels *Scomber* spp. (Table 4.1). In comparison, Rangel and Erzini (2007), in the

northern Portugal beach angling, identified sea bream *Diplodus* spp. and European seabass, *Dicentrarchus labrax* (L.), as the most important species caught by recreational anglers. More recently, Veiga *et al.* (2009) conducted a study on recreational fishing from the shore in the south of Portugal, which included our study area, and described white sea bream, *Diplodus sargus* (L.), as the dominant species, accounting for 48% of the total catches by number and being caught all across the study area and year round.

Table 4.1 Species recorded in the beach angling competitions analyzed (Algarve, southern Portugal), with minimum landing sizes. Note: percentage contribution is given in parentheses

Family	Scientific name	MLS [TL, cm]*	Number	Weight [kg]	Conservation status
Belonidae	<i>Belone belone</i>	none	236 (42.0)	24.8 (32.7)	II <sup>***</sup>
Scombridae	<i>Scomber</i> spp.	20	100 (18.0)	15.5 (20.4)	II <sup>***</sup>
Mugilidae		20	107 (19.0)	25.0 (32.9)	NA <sup>**</sup>
Moronidae	<i>Dicentrarchus labrax</i>	36	74 (13.2)	4.3 (6.0)	CT <sup>***</sup>
	<i>Dicentrarchus punctatus</i>	20	13 (2.2)	2.4 (3.1)	II <sup>***</sup>
Sparidae	<i>Diplodus sargus</i>	15	12 (2.0)	1.6 (2.1)	CT <sup>***</sup>
	<i>Diplodus bellottii</i>	15	4 (0.7)	0.4 (0.5)	CT <sup>***</sup>
	<i>Sparus aurata</i>	19	3 (0.5)	0.6 (0.7)	CT <sup>***</sup>
	<i>Spondylisoma cantharus</i>	23	1 (0.2)	0.1 (0.1)	CT <sup>***</sup>
Soleidae	<i>Pegusa lascaris</i>	24	3 (0.5)	0.2 (0.2)	CT <sup>***</sup>
Carangidae	<i>Trachinotus ovatus</i>	none	3 (0.5)	0.1 (0.1)	NA <sup>***</sup>
Trachinidae		none	7 (1.2)	0.5 (0.6)	NA <sup>***</sup>
TOTAL			563	75.4	

MLS = minimum landing size; CT = commercially threatened; II = incomplete information, NA = not assessed ([www.iucnredlist.org](http://www.iucnredlist.org)); \* anon. (2007b); \*\* Collares Pereira *et al.* (2000); \*\*\* IUCN (2011).

The differences with the current study could be explained by different strategies adopted by the recreational (leisure) and sport anglers, considering target species. Probably sport anglers target the more abundant species in beaches such as mullets, garfish, and mackerel. In contrast, recreational anglers are probably more interested in sea breams and bass that have higher gastronomic value and are more abundant in the areas often chosen for this type of

fishery, such as jetties or cliffs (where the rocky topography provides refuge for large individuals of European seabass and sea breams). In fact, Pradervand and Govender (2003) found the same dichotomy in catches between recreational and sport anglers, with the latter group being generally more selective.

In this study, all the European seabass caught were below the minimum landing size of 36 cm TL (Figure 4.1). This represents a high volume of illegal specimens caught, explained by the current discrepancy between the allowed minimum size (AMS) for competitive sport angling and the minimum landing size for commercial and recreational fishing. 69% of the spotted sea bass, *Dicentrarchus punctatus*, (L.) and 4% of the mullets (Mugilidae) were also below the MLS.

In this study, the average catch rates, in number and weight, of sport fishermen in competitions were 0.91 fish per angler per hour and 0.12 kg per angler per hour. In the south and south-west coast of Portugal, Veiga *et al.* (2010) recorded 1.11 fish per angler per hour and 0.21 kg per angler per hour for recreational anglers, which were also higher than the corresponding values of 0.46 fish per angler per hour and 0.08 kg per angler per hour recorded by Rangel and Erzini (2007) for recreational anglers in the north of Portugal. The differences in catch rate value previously mentioned reflect a greater similarity between the recreational and the competition fishing in the South and Southwest of Portugal, which is higher compared with the values found by Rangel and Erzini (2007) for the north. Compared with this study, the difference might be due to the generally higher fishing success of anglers participating in competitions (Brouwer and Buxton, 2002; Pradervand and Baird, 2002), while in the study of Veiga *et al.* (2010) it might be related to the kind of habitat, beaches and cliffs, whereas in Rangel and Erzini (2007) only beaches were fished.

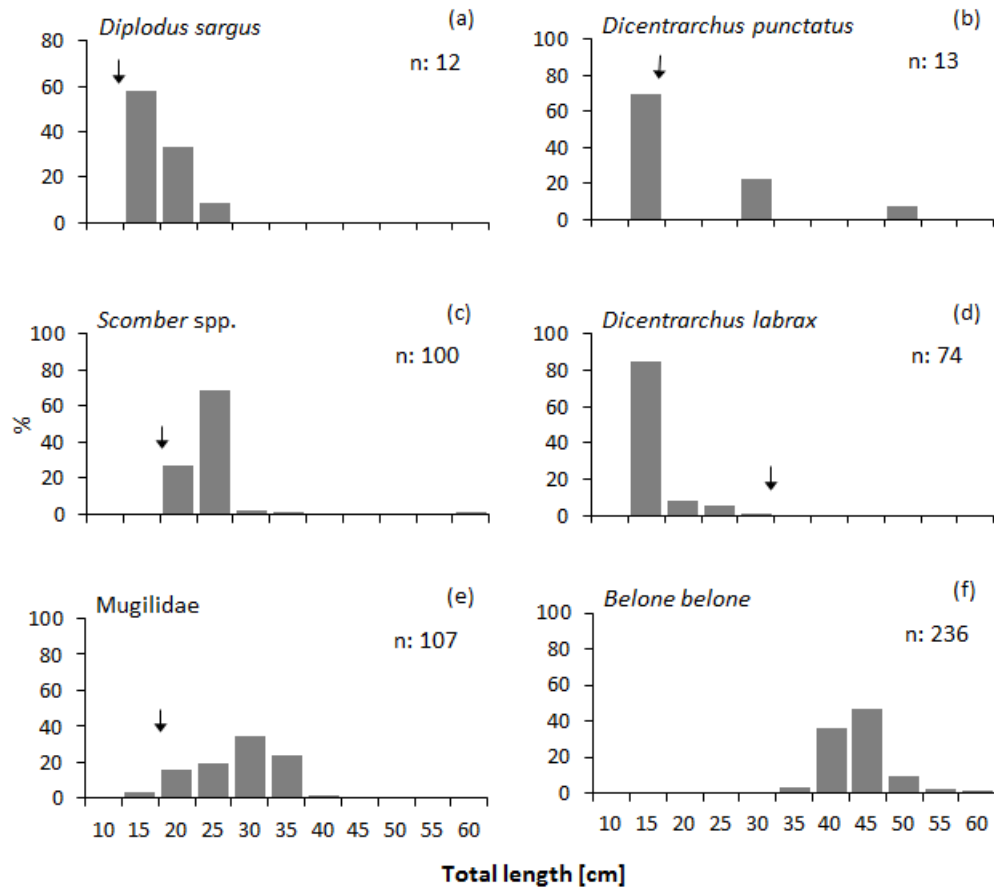


Figure 4.1 Relative frequencies of the classes of length of the taxa, *Diplodus sargus* (a), *Dicentrarchus punctatus* (b), *Scomber* spp. (c), *Dicentrarchus labrax* (d), Mugilidae (e), and *Belone belone* (f). MLS (↓) - Minimum landing size.

The mean number of beach angling competitions increased from 2 in 1996 to more than 40 in 2007 (Figure 4.2). In the period from 1996 to 2000, the mean catch remained fairly constant at approximately 0.9 kg per angler per competition, then increased to approximately 1.5 kg per angler per competition for the period from 2001 to 2006 (Figure 4.3). However, the variability in some years was considerable. The largest fish caught during this period weighed 1.78 kg, but no information on the species is available (Figure 4.4).

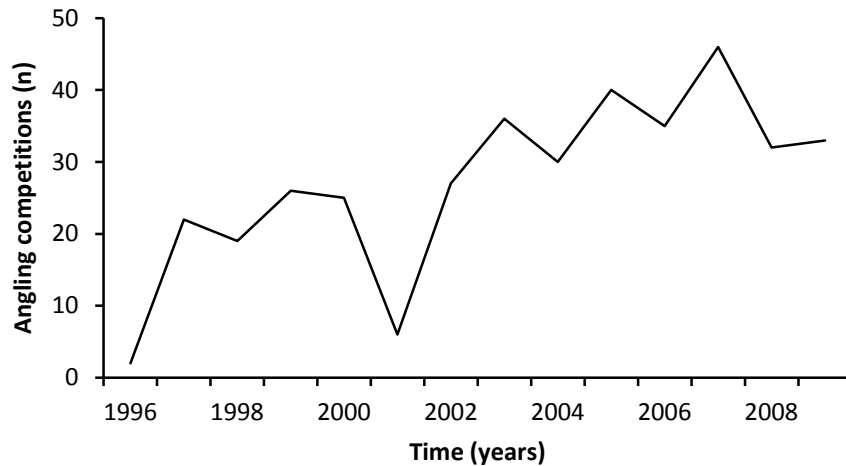


Figure 4.2 Number of beach angling competitions (Algarve, southern Portugal) from 1996 to 2009.

These results suggest that we cannot reject the null hypotheses that there have been decreases in catches or in mean weight over the past 14 years (1996–2009) in sport fishing competitions taking place on the Algarve beaches. While this contradicts the opinions and beliefs of anglers interviewed both in the north and south of Portugal (Rangel and Erzini, 2007; Veiga *et al.*, 2010), an explanation can be found in the differences between recreational and sport angling. In the latter, the anglers in competitions focus on the more abundant pelagic fish (chub mackerel and garfish) and mullets, which have little or no commercial value, in order to maximize their catches, whereas recreational anglers target the more highly prized sea breams and European seabass that are also heavily fished by the commercial fishermen. Given that commercial fishing seems to have a far greater impact than sport angling, it is therefore to be expected that there are no decreasing trends in mean sizes or in catches in angling competitions where most of the catch consists of non-commercial species.

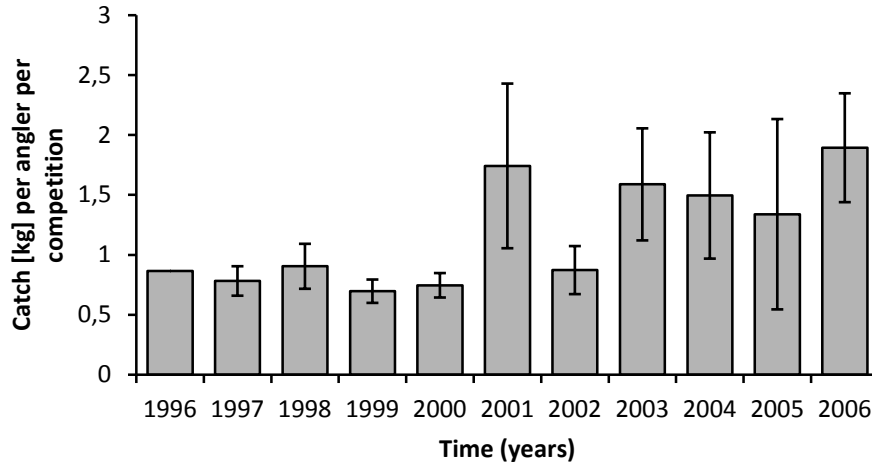


Figure 4.3 Mean  $\pm$  SE catch per angler ( $\text{kg angler}^{-1} \text{ competition}^{-1}$ ) for the top 10 anglers in each competition.

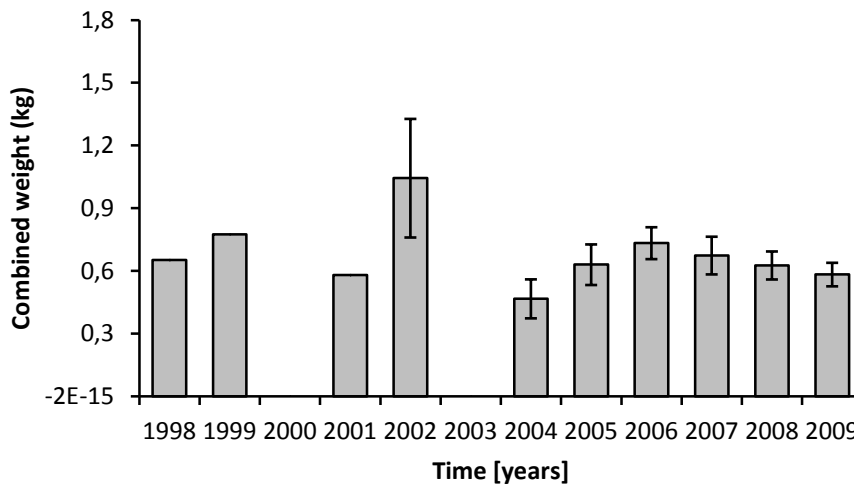


Figure 4.4 Mean  $\pm$  SE catch per angler ( $\text{kg angler}^{-1} \text{ competition}^{-1}$ ) for the top 10 anglers in each competition.

## **4.5 Conclusion**

In conclusion, there is no evidence for declining catches or mean size of the main species caught by sport fishers in competitions in the south of Portugal. Of concern, however, is the 15-cm size limit allowed in competitions for European sea bass. This is far below the legal minimum landing size for commercial and recreational fisheries and far below the length at first maturity [NW Europe: males, 32–36 cm; females, 42 cm; (Pawson and Pickett, 1996)]. Undersized sea breams (Sparidae) are also frequently caught and retained in competitions. We recommend that actual minimum legal sizes should be implemented in sport fishing competitions, rather than the current minimum sizes that allow undersized fish, particularly sea bass, to be retained. Competitions should also not take place in certain beaches and times of the year when juvenile sea bass are abundant.



# CHAPTER 5:

Short-term hooking mortality of three marine fish species  
(Sparidae) caught by recreational angling in the south Portugal



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Veiga, P., Gonçalves, J. M. S. and Erzini, K. 2011. Short-term hooking mortality of three marine fish species (Sparidae) caught by recreational angling in the south Portugal. *Fisheries Research*, **108**: 58-64.



## 5.1 Abstract

Short-term hooking mortality was evaluated for three sparid species [*Diplodus vulgaris* (Geoffroy Saint-Hilaire), *Sparus aurata* L. and *Spondylisoma cantharus* (L.)] in the Algarve, south Portugal. Fishes were caught from the shore during October 2009 at a fish farm reservoir (Ria Formosa), using three different hook sizes. The relationships between hooking mortality and seven independent variables were analyzed using logistic regression models. In all, 384 fishes representing the three target species were caught during the angling sessions. The most caught species was *S. cantharus* (n=181; 100% undersized), followed by *S. aurata* (n=137; 89% undersized) and *D. vulgaris* (n=66; 97% undersized). Mortalities ranged between 0% for *D. vulgaris* and 12% for *S. aurata* (*S. cantharus*, 3%). For *S. aurata*, anatomical hooking location was the main predictor of mortality, with 63% of the fishes that died being deeply hooked. Our results support the current mandatory practices of releasing undersized fish for the studied species, given the low post-release mortality rates observed.

## 5.2 Introduction

In Europe, recreational fishing is an important leisure activity, involving more than 10% of the population (Arlinghaus and Cooke, 2009). Based on the latest fishing licence statistics (DGRM, 2012), at least 2-3% of the Portuguese population participates in marine recreational fishing activities (shore and boat based). The growing concern with the impact of this activity on the fisheries resources recently led several EU countries to implement specific fishing regulations for saltwater recreational fishing (Pawson *et al.*, 2008). These regulations include widely used measures to control catches such as daily bag limits, minimum size limits and seasonal closures (e.g. Bartholomew and Bohnsack, 2005; Smallwood *et al.*, 2006; Lloret *et al.*, 2008b; Veiga *et al.*, 2010) and their main purpose is to reduce angling mortality for part

of the fish stock without directly reducing the fishing effort (Grixti *et al.*, 2007). Since in many cases bag limits are set too high (e.g. McPhee *et al.*, 2002; Smallwood *et al.*, 2006; Veiga *et al.*, 2010), the main outcome of these measures is generally high discard rates of immature or undersized fish.

The success of catch and release [both mandatory (i.e. regulations) and voluntary practices] depends, however, on the assumption of high survival rates and future successful reproduction of the released fish (Bartholomew and Bohnsack, 2005; Arlinghaus *et al.*, 2007). The evaluation of post-release fishing mortality is thus an essential tool for stock assessment and regulation planning purposes, given that in some cases it can have impact on the stock size structure (Pollock and Pine, 2007). As a result, studies to evaluate the fishing mortality, and techniques and terminal gears (e.g. circle hooks) to reduce it, have been a priority for several fisheries agencies using harvest control strategies (Arlinghaus *et al.*, 2007).

Hooking mortality studies have been extensively conducted in North America (Cooke *et al.*, 2001; Cooke *et al.*, 2003; Cooke and Suski, 2004; Cooke *et al.*, 2005) and Australia (Ayvazian *et al.*, 2002; Broadhurst *et al.*, 2005; Butcher *et al.*, 2006; Grixti *et al.*, 2007; Grixti *et al.*, 2010), and only recently in Europe [Spain: Alós (2008; 2009); Alós *et al.* (2008a; 2009b); Germany: Arlinghaus *et al.* (2008b)]. These studies have focused not only on the mortality rates of the species but also on the main factors that influence them: human (e.g. handling, angler experience), technical (e.g. fishing technique, terminal gear type) and environmental (e.g. temperature, depth of capture) [reviewed by Muoneke and Childress (1994); Bartholomew and Bohnsack (2005)].

Anatomical hook location (AHL) is mostly influenced by hook and bait type/size, fishing technique and fish behaviour/size (Muoneke and Childress, 1994; Grixti *et al.*, 2007) and has been reported as the most important factor affecting hooking mortality (Muoneke and Childress, 1994; Bartholomew and Bohnsack, 2005). Fish deeply hooked (e.g. stomach, gills)

have less chance of surviving than those hooked in shallow locations, such as lip or mouth (e.g. Ayvazian *et al.*, 2002; Butcher *et al.*, 2006; Alós, 2009). Other important factors are depth of capture, hook type, removal of hooks from deeply hooked fish, water temperature and handling time (Bartholomew and Bohnsack, 2005). Nonetheless, many of these factors interact during the process in which a fish is caught and then landed by an angler, and hooking mortality rates can be highly variable among species (Muoneke and Childress, 1994). As an example, hooking mortality was reviewed by Muoneke and Childress (1994), and later by Bartholomew and Bohnsack (2005), and ranged from 0% to 95%.

The complexity of factors affecting hooking mortality and the variability in mortality rates among species, suggests that nationwide management regulations may not be effective for particular species or stocks (Muoneke and Childress, 1994). Cooke and Suski (2005) proposed the creation of species-specific guidelines for catch and release (C&R) purposes. However, according to these authors, appropriate data for specific species and fisheries have to be available. Species-specific post-mortality estimates are also needed to improve stock assessments, help to develop more adequate catch and size regulations and also to increase anglers' awareness of the importance of measures such as bag limits or C&R for the conservation of fish stocks (Ayvazian *et al.*, 2002; Bartholomew and Bohnsack, 2005; Arlinghaus *et al.*, 2007).

In Portugal, Sparidae is one of the most important families in terms of landings and value, both for the commercial (Erzini *et al.*, 1996) and recreational sectors (Veiga *et al.*, 2010). In the south specifically, sparids are the most targeted group in recreational shore fishing. At least 16 species are caught by recreational shore anglers, accounting for up to 75% by weight of the total catches. A sizeable fraction of these fishes is however discarded (18-52%, top four species), consisting mostly of undersized specimens (Veiga *et al.*, 2010). The percentage of fish that survive after release is however unknown. In fact, despite the current regulations that

include minimum size limits for most of the recreational species, some anglers in south Portugal are still reluctant to release undersized fish, claiming that the great majority will die shortly after (P. Veiga, *pers. obs.*).

There is a need to estimate post-release mortality of sparids in Portugal, not only to convince anglers that releasing unwanted undersized fish is worthwhile, but also to evaluate if the current regulations involving release of fish (i.e. minimum size limits) are effective. This study aimed to: (1) estimate immediate and short-term mortality of three recreationally important sparid species, following catch and release; (2) examine the most important factors affecting the mortality and incidence of deep hooking; (3) test the null hypotheses that: (1) catch rates and fish sizes would not differ among hook size; (2) mortality and deep hooking would not differ among hook size.

## **5.3 Methods**

### **5.3.1 Study site**

This study was conducted at the water reservoir of the Aquamarim fish farm (N 37°01'58'' W 7°48'18'') in Ria Formosa, Portugal. The reservoir has an area of more than 1 ha (Gamito *et al.*, 2003) with an average depth of 1.5-2.5 m and receives water from the Ria Formosa lagoon every tidal cycle. This location was selected because it contains high abundances of juveniles of several sparid species, with no fishing pressure of any kind, and the environmental conditions and water renewal processes are similar to those of the Ria Formosa (Gamito and Erzini, 2005).

### 5.3.2 *Experimental design*

Fishing trials were conducted from the shore by six anglers in October 2009 during rising tides. Each fishing trial (active fishing) was divided into 1.5 hour fishing sessions, and in each session anglers positioned themselves randomly along the reservoir, separated from each other by at least 10 m. Three hook sizes [Absolute hook size (AS) = hook length x hook maximum width] typically used by local recreational anglers were used in the trials: A (AS: 112.8 mm<sup>2</sup>), B (AS: 153.7 mm<sup>2</sup>) and C (AS: 220.7 mm<sup>2</sup>) (Figure 5.1). The gear used by each angler consisted in a single rod and reel with a combination of two different hook sizes, selected randomly, on a running ledger (hooks attached to a swivel, below a sliding 40g egg shaped lead). Hook combinations (AB, AC, BC) and angler position were randomly assigned in each angling session to ensure that all participants used all hook sizes and with the same angling effort. The lengths of the leaders were also alternated so that for each hook pair, there were two possible combinations: smaller hook above the larger hook and smaller hook below the larger hook. Hooks were baited with a single rag worm [*Hediste diversicolor* (O.F. Müller)], covering the whole hook surface. After casting, rods were hand held to detect bites. Water temperatures were also recorded at regular intervals during the fishing trials and ranged between 20 and 24 °C over the study period.

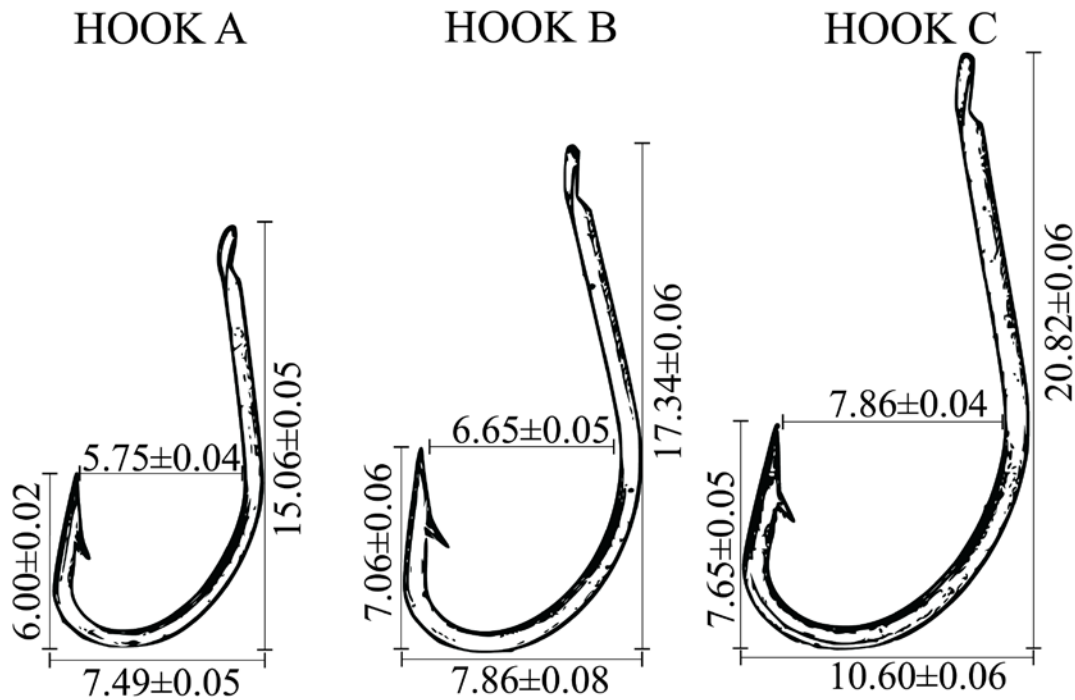


Figure 5.1. Dimensions (in mm) of the hooks used in this study. Means and standard errors are based on a sample size of 13 hooks per each size.

After being caught, each fish was unhooked, measured (TL, nearest millimetre), tagged with plastic t-bar tags (Floy brand) and then released into 1 m<sup>3</sup> sea cages made from 20 mm knotless polyamide mesh. During this process, a researcher recorded the following information: species, unhooking difficulty, anatomical hooking location (deep hooking: oesophagus, gills or stomach; shallow hooking: mouth or jaw; other: body or eyes), hook size (A, B or C), bleeding (yes, no), scale loss (yes, no) and air exposure (s). Unhooking difficulty was categorized in three classes, adapted from the criteria proposed by Cooke *et al.* (2001): “Easy”, fishes removed by hand with little effort; “Difficult”, great effort to remove the hook; “Not possible”, the line was cut because removal was not possible without causing great damage to the fish. Following release, fishes were monitored for post-release condition and kept in the sea cages for at least two hours. To minimize stress and injuries unrelated with angling (e.g. aggressive behaviour), all fish were handled using moist cloth and kept in the sea cages with densities below 40 fishes.m<sup>-3</sup> (Grixti *et al.*, 2008; Grixti *et al.*, 2010). Large fish

(>40 cm) were kept in separate sea cages at lower densities (<5 fishes.m<sup>-3</sup>). Immediate mortality was defined as the number of dead fish prior to or just after release into the cages, and short-term mortality was defined as the number of dead fishes after 2-3 hours of confinement in the sea cages (Ayvazian *et al.*, 2002).

### 5.3.3 *Data analysis*

All statistical analyses were performed using the statistical package R version 2.10.1. The Mann-Whitney Rank Sum test was used to compare the average sizes of the different species. Differences in catch rates and fish mean sizes between hook sizes, were evaluated using analysis of variance (Kruskal-Wallis statistic, followed by Dunn's *post hoc* test). In all cases non-parametric tests were used, because both normality (Shapiro-Wilk test) and homogeneity in variances (Levene test) assumptions were not met. The Chi-square test was used to test for differences in relative frequencies of catches by hook size for each species. The same test was also used to evaluate the mortality rate for each species with the overall mortality rate.

The influence of seven independent variables (categorical: Deep hooking, bleeding, unhooking difficulty, hook size and scale loss; continuous: air exposure and total length, TL) on the total hooking mortality (binary response: dead, 1; alive, 0) was analysed using a logistic regression model (GLM, family: binomial), with the 'logit' link function and maximum likelihood estimation. Optimal model selection was conducted using stepwise elimination of explanatory variables ('stepAIC' procedure of R<sup>®</sup>), with the Akaike information criteria (AIC). Comparison between saturated model and optimal (reduced) model was made using ANOVA (*Chi* test) (Crawley, 2005).

The influence of hook size and fish length on the probability of deep hooking fish was also tested using a logistic regression model, with the same optimal method selection ('StepAIC'

procedure). Logistic regression models were only performed to *S. aurata*, because it was the only species with sufficient deep hooking and mortality events to fit the model.

## 5.4 Results

Altogether, 384 fishes belonging to the three species were caught during the experimental fishing sessions: *S. cantharus* (n=181), *S. aurata* (n=137) and *D. vulgaris* (n=66). Total fish length ranged from 76 mm (*S. cantharus*) to 506 mm (*S. aurata*), and averaged  $119.3 \pm 2.0$  mm SE. The majority of fish (95.5%) were juveniles below the minimum legal sizes of 150 mm for *D. vulgaris*, 190 mm for *S. aurata* and 230 mm for *S. cantharus*), with the average length of *S. cantharus* being significantly lower than *D. vulgaris* (Mann-Whitney,  $P < 0.001$ ) and *S. aurata* (Mann-Whitney,  $P < 0.001$ ) (Table 5.1). Also, the average length of *D. vulgaris* was significantly lower than *S. aurata* (Mann-Whitney,  $P < 0.001$ ).

Table 5.1. Number, mean ( $\pm$ SE) total length (TL), range and percentage of undersized fish per hook size, from the studied species caught during the angling trials.

		Overall	<i>Spondyliosoma cantharus</i>	<i>Sparus aurata</i>	<i>Diplodus vulgaris</i>
<b>Hook A</b>	Number	147	88	37	22
	Mean TL (mm)	109.6 (0.2)	93.3 (0.6)	143.4 (4.6)	118.1 (2.2)
	Range	76-250	76-106	120-250	98-137
	% undersized	98.6	100	94.6	100
<b>Hook B</b>	Number	144	63	54	27
	Mean TL (mm)	118.9 (2.7)	93.7 (0.7)	147.7 (4.3)	120.0 (2.4)
	Range	81-310	81-119	114-310	96-151
	% undersized	96.5	100	92.6	96.3
<b>Hook C</b>	Number	93	30	46	17
	Mean TL (mm)	135.2 (5.8)	93.4 (0.9)	166.3 (9.6)	124.5 (2.9)
	Range	82-506	82-107	118-506	104-151
	% undersized	88.8	100	80.4	94.1
<b>All hook sizes</b>	Number	384	181	137	66
	Mean TL (mm)	119.3 (2.0)	93.4 (0.4)	152.8 (3.9)	120.5 (1.5)
	Range	76-506	76-119	114-506	96-151
	% undersized	95.6	100	89.1	97

Total lengths of individuals (grouped data) caught were significantly different between hook sizes (Kruskal-Wallis:  $H= 22.14$ ,  $P < 0.001$ ). *Post hoc* analysis (Dunn's test) revealed specific differences in total lengths of specimens caught between hooks A vs. B ( $Q= 2.64$ ,  $P < 0.05$ ) and A vs. C ( $Q= 4.66$ ,  $P < 0.05$ ). These differences were caused by the significantly higher proportions of *S. cantharus* caught by the smaller hook (A) (Chi-square test:  $X^2= 20.10$ ,  $P < 0.001$ ) (Figure 5.2), since intra-species differences were not significant between hook sizes. The overall catch rates averaged  $3.7 \pm 0.3$  SE fish angler hour<sup>-1</sup>.

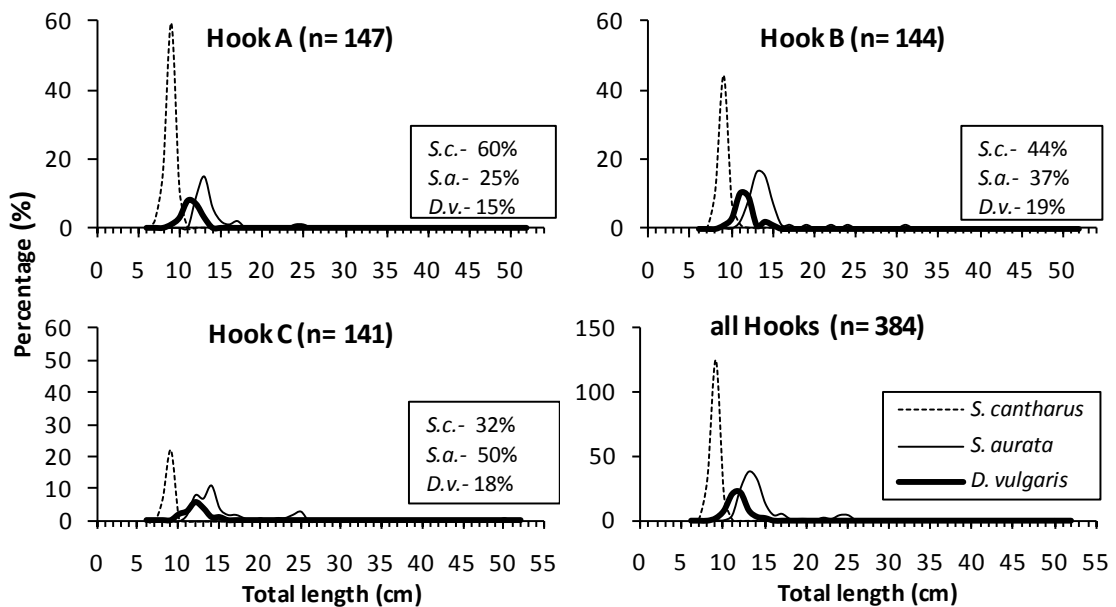


Figure 5.2. Length frequency distribution (cm) of *S. cantharus* (S.c.), *S. aurata* (S.a.) and *D. vulgaris* (D.v.) and percentage of each species in catches, per hook size.

Regarding hook size, catch rates increased with decreasing hook size, although the differences were not statistically significant (Kruskal-Wallis,  $P > 0.05$ ) (Figure 5.3).

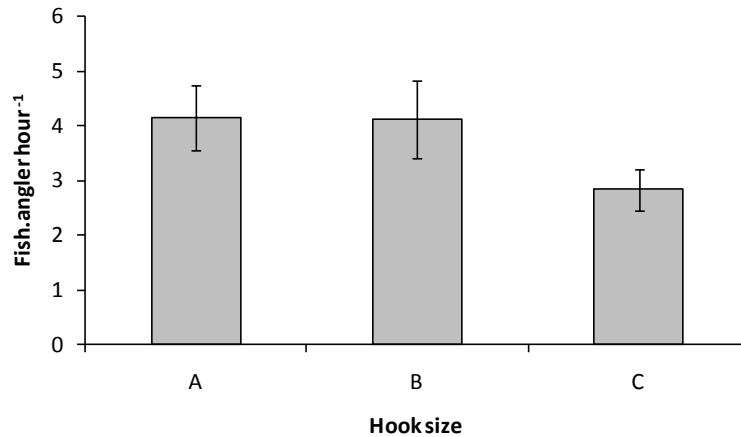


Figure 5.3. Catch rates per hook size (mean  $\pm$  SE) of the species caught during the fishing trials.

After being hooked, the majority of fish ( $n = 230$ ) were released back to the sea cages within less than one minute. Scale loss was also minimal during all the fishing sessions, with only five out of 384 fishes losing scales (Table 5.2. Number of fish ( $n$ ) and mortality rates [Mort. (%)] per species, for the evaluated variables (categorical and continuous).). In general, fish were hooked more frequently in the mouth or jaw (shallow hooking), than in the stomach or gills (deep hooking) or body (other). However, in *S. aurata* the incidence of deep hooking (20%) was significantly higher than the average of 6.5% (Chi-square test:  $X^2 = 17.3$ ,  $P < 0.001$ ). In contrast, all individuals of *D. vulgaris* were shallow-hooked.

Table 5.2. Number of fish (n) and mortality rates [Mort. (%)] per species, for the evaluated variables (categorical and continuous).

Variable	Total catch		<i>Spondyliosoma cantharus</i>		<i>Sparus aurata</i>		<i>Diplodus vulgaris</i>	
	n	Mort. (%)	n	Mort. (%)	n	Mort. (%)	n	Mort. (%)
<b>Overall</b>	384	5.5	181	2.8	137	11.7*	66	0
<b>Hook size</b>								
A	147	6.1	88	3.4	37	16.2	22	0
B	144	2.8	63	0	54	7.4	27	0
C	93	8.6	30	6.7	46	13.0	17	0
<b>Bleeding</b>								
Yes	28	35.7	4	25	24	37.5	0	0
No	356	3.1	177	2.3	113	6.2	66	0
<b>Hooking location</b>								
Shallow	351	2.6	172	1.7	114	5.3	65	0
Deep	25	44.0	2	50	23	43.5	0	0
Other	8	12.5	7	14.3	0	0	1	0
<b>Unhooking</b>								
Easy	363	2.8	178	2.2	119	5.0	66	0
Difficult	16	56.3	3	33.3	13	61.5	0	0
Impossible	5	40	0	0	5	40	0	0
<b>Scale loss</b>								
Yes	5	0	0	0	3	0	2	0
No	379	5.5	181	2.8	134	11.9	64	0
<b>Air exposure (s)</b>								
< 60	230	4.3	116	2.6	60	11.7	54	0
60 - 120	139	5.8	63	3.2	66	9.1	10	0
>= 120	15	20	2	0	11	27.2	2	0

\*Indicates mortality rate different from the overall angling mortality (5.5%),  $P < 0.05$

Overall, short-term hooking mortality for all species was 5.5%, ranging from no mortality for *D. vulgaris* to 11.7% for *S. aurata* (*S. cantharus*, 2.8%) (Table 5.2. Number of fish (n) and mortality rates [Mort. (%)] per species, for the evaluated variables (categorical and continuous)). *Sparus aurata* was the only species with mortality rates significantly higher than the average (Chi-square test:  $X^2 = 5.00$ ,  $P < 0.05$ ). Mortality rates were higher for: (a) deeply hooked fish; (b) when hook removal was difficult or impossible; and (c) fish that was bleeding after being unhooked. In *S. aurata* both the occurrence of bleeding and unhooking difficulty were significantly correlated with deep hooking (Figure 5.4 and Figure 5.5). Within

the deep-hooked fish, almost half bled and in 52% of the cases, hook removal was difficult or impossible. As a consequence, these two variables were removed from the logistic regression model, as they could confound the effect of deep hooking in the mortality (Alós *et al.*, 2008a).

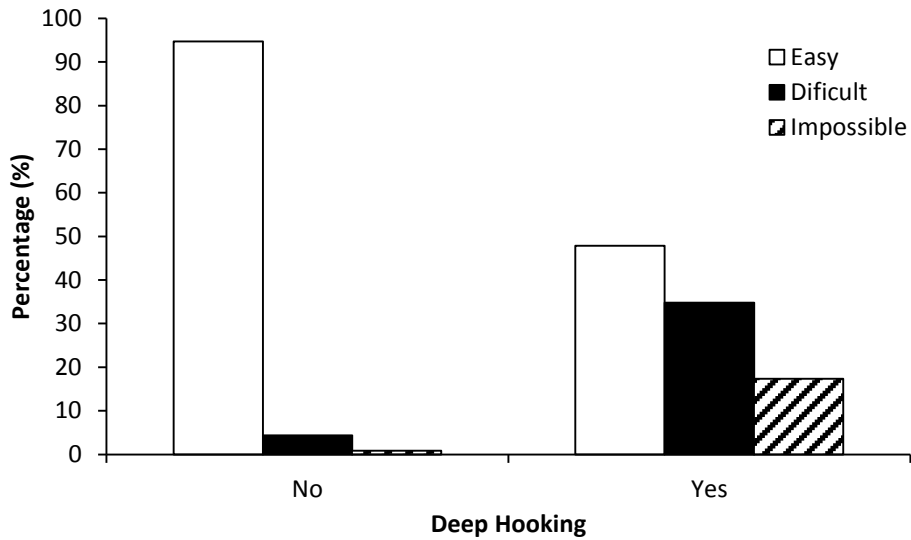


Figure 5.4. Relationship between deep hooking (yes or no) and hooking removal difficulty (easy, difficult or impossible), for *S. aurata* caught during the fishing trials.

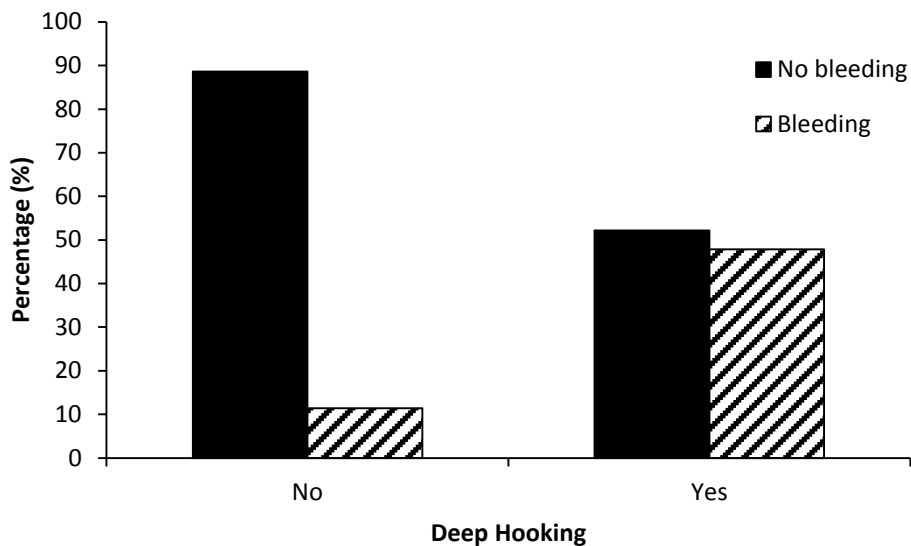


Figure 5.5. Relationship between deep hooking (yes or no) and hooking removal difficulty (Bleeding or no bleeding), for *S. aurata* caught during the fishing trials.

Deep hooking was the only significant predictor of mortality in *S. aurata*, with a mortality rate of 44% for fish that swallowed the hook, compared to 5% for shallow-hooked fish. According to the final model, a deeply hooked fish was 2.6 times more likely to die. The incidence of deep-hooking was significantly affected by fish total length and hook size (Table 5.3). Larger fish and fish hooked with the medium size hook were deeply hooked more frequently.

Table 5.3. Estimates of the independent variables that significantly affect the probability of occurrence of Mortality and Deep hooking in *S. aurata*, based on stepwise GLM analysis (logistic regression). Estimates and standard errors are in logits.

Parameters	Estimate	SE	Pr(> z )
<b>Mortality</b>			
	AIC: 82.5		
Intercept	-2.8904	0.42	***
DeepH	2.6280	0.59	***
<b>Deep hooking</b>			
	AIC: 109.86		
Intercept	-4.0674	0.98	***
Total length (mm)	0.0212	0.01	***
Hook size ('medium')	-1.8202	0.69	**
Hook size ('large')	-1.0425	0.61	0.09

DeepH, Deep hooking.

Variables in bold are the response variables and those in normal text are the independent variables included in the final model. \*\*  $P < 0.01$ ; \*\*\*  $P < 0.001$

## 5.5 Discussion

The present study provided the first estimates of post-release mortality rates for these three recreationally important sparid species in European waters, caught from the shore. We focused mainly on undersized specimens because they comprise the most important fraction of sparid discards in the south Portugal recreational fishery (Veiga *et al.*, 2010). Overall mortality rates were low (0-12%), supporting the current regulations in Portugal, which require releasing these species (i.e. bag limits, minimum size limits, closed seasons).

Mortality was mainly affected by anatomical hooking location, in particular deep hooking of the fish, which was strongly influenced by fish length and hook size.

Individual species mortality rates were considerably lower than the 20% limit suggested by Muoneke and Childress (1994), above which mortalities are considered high and of management concern. Mortalities were also lower than those encountered for other sparid species, such as *Acanthopagrus australis* (16.6%) (Broadhurst *et al.*, 2005) and *Chrysoblephus laticeps* (22.5%) (Götz *et al.*, 2007). Such differences may not only be attributed to inter-specific variability, but also variability in other factors, such as fishing methods and environmental parameters (i.e. depth of capture and temperature) (Muoneke and Childress, 1994; Ayvazian *et al.*, 2002; Bartholomew and Bohnsack, 2005). Furthermore, due to logistical constraints associated with access to the study site on the property of a commercial aquaculture facility, only short-term mortality (2-3 hours) was assessed in our study, and the real mortality rates may be slightly underestimated (Ayvazian *et al.*, 2002; Alós *et al.*, 2008a). However, other studies found that most of the mortalities occur within the first hours following release (Ayvazian *et al.*, 2002; Alós *et al.*, 2008a; Alós, 2009), particularly in sparids (Broadhurst *et al.*, 2005).

As previously reported for other marine species (Muoneke and Childress, 1994; Bartholomew and Bohnsack, 2005), mortality rates were highly variable across the studied species (0-12%). Similar results have been found in multi-species post-release mortality studies. For example, Götz *et al.* (2007) studied several reef species in South Africa and observed mortality rates from 1.3% to 22.5%. Broadhurst *et al.* (2005) observed inter-species adjusted mortality rates between 0% and 36.6% for four species in Australia. In our study, the observed inter-species variability in mortality rates may have been essentially related with the incidence of deep hooking. *S. aurata* presented the highest levels of deeply hooked fish, nearly half of which

died. In contrast, for *D. vulgaris*, where all fish were shallow-hooked, no short-term mortalities were observed.

Anatomical hooking location (AHL) has been one of the most reported factors linked to post-release mortality (PRM) (e.g. Ayvazian *et al.*, 2002; Millard *et al.*, 2003; Broadhurst *et al.*, 2005; Butcher *et al.*, 2006; Götz *et al.*, 2007; Grixti *et al.*, 2007; Alós *et al.*, 2008a), and is considered the most important factor affecting PRM (Muoneke and Childress, 1994; Bartholomew and Bohnsack, 2005). This was confirmed by our results, as AHL was the only significant predictor of mortality for *S. aurata*. According to several authors (e.g. Bartholomew and Bohnsack, 2005; Alós, 2009; Grixti *et al.*, 2010), deep-hooked fish generally suffer from severe internal haemorrhagic injuries, whose gravity increase with hook removal. This effect was also observed in our study, as bleeding incidence was higher in deep-hooked fish and when hook removal was difficult, whereas the harmful effects of deep hooking apparently were reduced when hooks were not removed. Previous studies have also found higher survival rates of fish when the leader line was cut (Bartholomew and Bohnsack, 2005; Alós, 2009; Grixti *et al.*, 2010), and suggest this as a better practice when fish are deeply hooked, since in most cases hooks end up being ejected (Broadhurst *et al.*, 2005; McGrath *et al.*, 2009). Cutting the line of deeply hooked fish could be a good guideline to implement for C&R, since it involves less handling than hook removal and is not affected by angler experience. Although this was not tested in our study, some anglers may have taken more time to remove the hook than others, and handling could have affected the overall condition of the fish (Muoneke and Childress, 1994). However, before recommending such practice, further studies comparing the effects of hook removal vs. continuance on the long term survival and behaviour of these species should be conducted, but most important is continuing to study methodologies and hook types to minimize the incidence of deep hooking.

In our study, deep hooking incidence was only evaluated for *S. aurata*. Logistic regression analysis showed that hook and fish size were significant predictors of the deep hooking of this species, with the higher probability of deep hooking for the middle size hook (B). Larger fish were more likely to be deeply hooked than smaller fish, a result that agrees with the findings of Grixti *et al.* (2007) for *A. australis* and Götz *et al.* (2007) for *C. laticeps*. The relationship between hook size and deep hooking incidence varies among studies (Muoneke and Childress, 1994), and may again be related to inter-specific variation (Arlinghaus *et al.*, 2007). However, our results are likely to be also related with the small differences between hooks in terms of sizes. According to Erzini *et al.* (1998), in most hook selectivity studies, size selectivity has only been demonstrated using hooks differing by more of 200% in hook size. Perhaps the same applies for deep hooking incidence in relation with hook size. In fact, Grixti *et al.* (2007), who found differences in deep hooking incidence of *A. australis* across hook sizes, used a range of hook sizes with the largest size 2.8 times bigger in overall size than the smallest, while in our study this ratio was only of 1.8. In the case of *D. vulgaris* and *S. cantharus*, the absence or low incidence of deep hooking can be explained by the small size of the fish and the correspondingly small mouth sizes in relation to the sizes of the hooks used.

It is important to note that the results do not reflect the overall reality of recreational fishing for the studied species. Depth of capture, for example, was not evaluated and has been referred as an important factor affecting PRM for other sparid species: *Pterogymnus lanarius* (Booth and Buxton, 1997); *C. laticeps* (Götz *et al.*, 2007). Previous studies found that fish hooked in deeper waters presented more severe signs of barotrauma and, consequently, had higher mortality rates (Götz *et al.*, 2007; Alós, 2008; Sumpton *et al.*, 2010). Therefore, our results should not be applied to boat fishing for example, particularly when a fish is hooked at greater depths (> 30 m) (Pajuelo *et al.*, 2006). Another potentially important factor for recreational shore fishing is the height from which the fish are released back to the sea. To the

best of our knowledge, this question has never been addressed before and can be quite important in countries where fishing from the cliffs is a popular practice. In Portugal, fish caught by recreational anglers from cliffs can be released from heights up to 50 meters above sea level (P. Veiga, *pers. obs.*), and most anglers argue that fish will not survive the impact after being released.

In conclusion, although only short-term mortality was evaluated, our results point to low post-release mortality rates of *D. vulgaris*, *S. cantharus* and *S. aurata*, mainly affected by deep hooking of the fish. Although no clear relationship between hook size and incidence of deep hooking or post-release mortality was found, we would still recommend the use of larger hooks as a preventive measure for reducing deep hooking and mortality, considering previous studies on this subject (e.g. Grixti *et al.*, 2007; Alós *et al.*, 2008b). However, further research should re-test the hook size effect (see Cerdà *et al.*, 2010), particularly considering the recently implemented minimum gap size of 9 mm for hooks in the largest Portuguese Natural park with a MPA (“Parque Natural do Sudoeste Alentejano e Costa Vicentina”). Future studies should address other potentially important factors such as depth of capture and height at which fish are released. Given the importance of deep hooking, different techniques and hook types (e.g. circle *vs.* J shape; barbed *vs.* barbless) used to minimize post-release mortality should also be studied. Finally, in order to promote better angling practices and increase release of undersized specimens, the dissemination of these results through the angler community would be important.



# CHAPTER 6:

## General Discussion





Given the existing gap in dedicated scientific research on recreational fishing in Portugal, the main purpose of this thesis was to contribute to increasing the knowledge of the activity and to provide baseline information to support current and future regulations. Focusing on recreational angling, the thesis provides for the first time in southern Portugal: 1) estimates on the impact of this activity in comparison with the commercial sector; 2) an evaluation of the restrictions put in place, based on the analysis of shore angling catch and effort related data; and finally, 3) an analysis of anglers' attitudes towards these restrictions, aiming at anticipate possible responses to future changes in regulations and compliance issues and put forward recommendations for management.

In this final chapter an overall summary of the main findings from this study is provided, and the implications of such findings for the management system in place discussed.

## **6.1 Summary of the Results**

### ***6.1.1 Estimating the impact of saltwater shore angling compared with commercial sector***

Owing to the growing conflict between the commercial [mainly artisanal] and the recreational fishermen, who blame each other for the decline in the fisheries resources, one of the main objectives of the restrictions implemented in 2006 was to control the recreational harvest. However, apart from a couple of studies examining recreational fishing catches in specific areas (e.g. Vale, 2003; Lima, 2006; Rangel and Erzini, 2007), there was no baseline information on the biological impact of saltwater recreational fishing compared to the commercial sector. In Chapter II, the recreational shore angling in southern Portugal (c. 250 km coastline) was used as a case study, and the total catch and effort was estimated for a period of 12 months and compared with commercial catches. One of the highlights of this study was the combined aerial-roving survey design used to estimate catch and effort, novel

for European waters. This was proven to be a very cost-effective approach in areas like the south of Portugal, where anglers are dispersed over large areas and there are no specific access points (Pollock *et al.*, 1994; Mann *et al.*, 2003; Vølstad *et al.*, 2006). The quantitative results of this study have shown that the overall estimated shore angling catches corresponded to less than 1% of the commercial landings (species in common). As previously observed in other fisheries, a species-by-species analysis revealed however that for some species in particular the recreational shore angling catches were comparable to the commercial landings (West and Gordon, 1994; McPhee *et al.*, 2002; Post *et al.*, 2002; Schroeder and Love, 2002; Coleman *et al.*, 2004). For white sea bream in particular, the most sought after and captured species by anglers in southern Portugal, the estimated recreational catches corresponded to about 65% of the commercial landings. In terms of fishing effort, the recreational fishing activity was found to be heterogeneous both at spatial and temporal scales. The peak of fishing effort was observed in the autumn and winter months, mainly related with increased numbers of local anglers in the SW coast, probably driven by the onshore spawning migration of *Diplodus sargus* in this area. Overall, the results from this chapter suggested that with the exception of *D. sargus*, competition for common resources is minimal in this geographical area. However, other recreational activities such as spear fishing and boat fishing – that have been found to account for greater catches than shore angling (Morales-Nin *et al.*, 2005; Diogo, 2007) - were not accounted for in this study, and thus competition with commercial fishing is likely to be greater.

### ***6.1.2 Examining Anglers' perceptions towards the newly implemented regulations***

Chapter III examined recreational shore fishers' perceptions towards the existence of saltwater recreational fishing regulations (SRF) and, more specifically, awareness and agreement with the newly implemented restrictions. The role of fishermen as a key player in the management implementation process (i.e. inclusion of fishers' attitudes and perceptions towards regulations, active participation of fishers' in decision making) has been regarded as one of the most important factors in developing effective regulations (Sutinen and Kuperan, 1999; Nielsen and Mathiesen, 2003; Radomski, 2003; Dimech *et al.*, 2009; Pita *et al.*, 2010). In addition, a management process that include fishers' needs, habits, and perceptions towards regulatory aspects is more likely to be perceived as meaningful, be accepted by the fishermen community and, ultimately, to be complied with (Wilde *et al.*, 1996; Hauck *et al.*, 2002; Richardson *et al.*, 2005; Baker, 2009; Jagers *et al.*, 2012). In Portugal, the restrictions implemented for saltwater recreational fishing in 2006 represented a sharp change in the reality of this activity, which had been open-access for a long time. Although no information could be found on the planning process of such regulations (i.e. different stakeholders' participation, scientific data), there was no evidence of a planned consultation of fishermen during the decision making process, or a comprehensive study on the human dimensions of the Portuguese recreational fishing activity. The study shows that the majority of anglers accepted the existence of some kind of SRF regulations, but in general there was a total or partial disagreement with the recreational fishing restrictions recently put in place. For the restrictions in place in particular, most anglers felt that the decision-making process took place without almost any involvement of the angling community. With regards to specific restrictions, despite the fact that some were more accepted (e.g. existence of minimum size limits, daily bag limit of 10 kg fisher<sup>-1</sup> day<sup>-1</sup>) than others (e.g. prohibition of fishing from piers/jetties, minimum size limit of seabass), the overall perception was that restrictions

lacked a clear rationale. In fact, fishers' awareness and understanding of specific aspects of the restrictions (such as the rationale for minimum size limits) was found to be limited. This was probably an important factor for the lack of acceptance of the restrictions in place, as found as in other studies (Greiner *et al.*, 2000; Edison *et al.*, 2006). Differences on perceptions towards SRF regulations amongst angler groups were confirmed by the results of the logistic model analysis. The analysis indicated that anglers with higher levels of formal education and income were more likely to agree with the existence of SRF regulations. On the other hand, anglers who perceived that more limitations and a better enforcement of commercial fishing would improve fishing in the area were less likely to agree with the existence of SRF regulations. The results from this study highlighted the importance of a more active involvement of the recreational angler community in the decision making process. The inclusion of anglers' perceptions of regulations in the management decisions would probably result into more adequate and effective regulations in the future. Efforts to promote increased awareness and understanding of regulations in place (e.g. dissemination strategies and anglers' educational programs) are also strongly encouraged in this study.

### ***6.1.3 Evaluating catches of the sport fishing competitions in southern Portugal***

Chapter IV describes sport fishing catches in the south of Portugal and evaluates long term trends in abundance, weight, mean size, and diversity of catches taken during sport fishing competitions. For countries such as Portugal, where historical information regarding the recreational fishing catches is scarce, fishing records from sport fishing competitions can be a cost-effective method to analyze long term trends in catch rates and effort and mean size of fish and to assess the status a fishery (Gartside *et al.*, 1999; Coll *et al.*, 2004; Pradervand *et al.*, 2007). Additionally, anglers that participate in sport fishing competitions are generally more specialized and have different motivations for fishing than the recreational fishers in

general (Loomis and Ditton, 1987; Wilde *et al.*, 1998). The results from this study indicated that the catches from sport fishers were different from those of the recreational fishers (Chapter II) (i.e. less species captured and different dominant species in the catches), suggesting probably different strategies among the two groups in terms of target species and angling strategies (Brouwer and Buxton, 2002). The analysis of the catch records did not detect any evidence for declining catches or mean size for the main species caught by sport fishermen. High percentages of undersized fish were observed to be captured (and retained) during the competitions (in particular seabass, where 100% were undersized). The study pointed to the need to adopt the minimum legal sizes already in place for recreational and commercial fishing, instead of the single allowable minimum size (AMS) of 15 cm in use in sport fishing competitions.

#### ***6.1.4 Estimating post-release hooking mortality of fish species caught by recreational angling in the south Portugal***

Chapter V provided estimates of post-release mortality (PRM) rates for three of the most important sparid species for recreational fishing in southern Portugal, and analyzed factors affecting these mortality rates. During the roving creel surveys, it was observed that a considerable fraction of fish captured by shore anglers was immediately released (from 18-52% for the top four species). One of the main reasons for the release was the low gastronomical value of some species, but in general most individuals were discarded due to their small size (Chapter II). There is thus a clear need to estimate the post-release mortality of the released fish, not only to educate anglers that releasing unwanted undersized fish was worthwhile, but also to evaluate if the restrictions in place involving the release of fish below the minimum size limit were effective in protecting juveniles. The results indicated overall low PRM rates for the three species studied. Individual species PRM rates ranged from 0%

(*Diplodus vulgaris*) - 12% (*Sparus aurata*), much below the 20% limit where mortalities are considered high and of management concern (Muoneke and Childress, 1994). For *S. aurata*, the logistic regression models indicted that deep hooking was the only significant predictor of mortality (Ayvazian *et al.*, 2002; Broadhurst *et al.*, 2005; Götz *et al.*, 2007; Alós *et al.*, 2008a). According to the final model, a deeply hooked fish was 2.6 times more likely to die than one hooked in the mouth. No clear relationship was found between hook size and the incidence of deep hooking or post-release mortality, but the use of larger hooks as a preventive measure for reducing deep hooking and mortality would still be recommended, considering that this relationship was found by other authors (e.g. Grixti *et al.*, 2007; Alós *et al.*, 2008b). The low PRM rates observed in this study support the mandatory practices of releasing undersized fish for the studied species, given the low post-release mortality rates observed. The implementation of education programs to the angler community could promote better handling practices and increase the release rates of undersized specimens.

## 6.2 “So what?": Implications and perspectives for management

With the observed decline on many of the important marine fisheries (Myers and Worm, 2003; Worm *et al.*, 2006a; Costello *et al.*, 2008), and the increasing importance of the recreational fishing sector worldwide (Post *et al.*, 2002; Aas, 2008; Zischke *et al.*, 2012), the implementation of effective management systems is crucial for the long-term sustainability of fish populations and ecosystems (Coleman *et al.*, 2004; Cooke and Cowx, 2004). It has been stressed by several authors that an effective management system is closely related to timely and adequate information on the resource use and its users (Lewin *et al.*, 2006). For the Portuguese recreational fishing management in particular, some of the findings of this study have implications for the regulations currently in place that deserve to be discussed.

One of the main findings from this study was the important contribution of recreational shore angling for the catches of white sea bream in particular, strengthening the theory that for particular species recreational fishing can have an important contribution in terms of catches (West and Gordon, 1994; Gartside *et al.*, 1999; Gentner and Lowther, 2002; McPhee *et al.*, 2002; Post *et al.*, 2002; Schroeder and Love, 2002; Coleman *et al.*, 2004; Cooke and Cowx, 2006; Lloret *et al.*, 2008b; Mitchell *et al.*, 2008; Zischke *et al.*, 2012). This finding also supports the need for specific recreational fishing management strategies and the importance of integrating recreational data into the stock assessments (McPhee *et al.*, 2002; Coleman *et al.*, 2004; Cooke and Cowx, 2004; Font and Lloret, 2011b).

For particular species, which are highly targeted/captured by both the commercial [artisanal] and the recreational sectors, the inclusion of the recreational fishing data in the stock assessments and additional species-specific management measures (e.g. species daily bag limits/TACs, closed seasons) might also be needed to protect these species from overexploitation (e.g. Hutton *et al.*, 2001; Edison *et al.*, 2006; Grixti *et al.*, 2007; ICES, 2010; Zischke *et al.*, 2012). For the white-sea bream in particular this is very important, given the existing temporal overlap in catches from both commercial and recreational sectors. The peak of captures of this species was found to correspond to the spawning periods, in which the species is generally more vulnerable to capture as a result of inshore aggregations (Kirchner *et al.*, 2001; Mann *et al.*, 2003) (Chapter II). Temporal closures for white sea bream were implemented in 2009 in the PNSACV Natural park area (SW coast of Portugal) probably because of this vulnerability (Portaria § 143/2009). This seems to be an appropriate measure and should be continued, but it currently only applies to recreational fishing and this particular area. This one-sided restriction, applicable only to the recreational fishing sector, may result in an ineffective protection of this species at the stock level and undermine its long-term sustainability. Additionally, and as observed in a recent survey (P. Veiga, *pers. obs.*), the

recreational fishing only restriction is not favored by the recreational fishing community. Most recreational fishermen perceived it as skewed and unfair, and as argued by previous studies lack of acceptance of regulation can lead to future non-compliance issues (Sutinen and Kuperan, 1999; Nielsen and Mathiesen, 2003; Richardson *et al.*, 2005). Future amendments in the regulations should thus expand the current closures to the commercial sector (with financial compensations, if necessary). The same protective measures could also extend to other species such as the European seabass, which is also known to be highly targeted by both the recreational and the commercial sectors (Rangel and Erzini, 2007; Lloret *et al.*, 2008a; ICES, 2010) (Chapter II).

The assumption of high survival rates and future reproductive success of the released fish is another important factor for the success of most of the management measures used to control recreational harvest (e.g. daily bag limits, minimum landing sizes) (Bartholomew and Bohnsack, 2005; Arlinghaus *et al.*, 2007). The results from chapter V indicate that the survival rates for three of the most important sparid species in recreational fishing were very high (88-100%), supporting regulations that may imply the release of fish. We have found, however, that there is still a good percentage of undersized fish that is retained, both in recreational and sport fishing events (Chapters II and IV). As discussed in previous chapters, this may be related to: 1) a lack of awareness or disregard of the minimum size limits in place (Smallwood *et al.*, 2006; Rangel and Erzini, 2007; Beckley *et al.*, 2008); 2) the belief of some anglers that most fish will not survive the hooking experience; or 3) the permissive regulations for the sport fishing events (e.g. a single minimum size limit applied to all species; Chapter IV). The high (and “allowed”) retention of undersized fish observed in the sport fishing competitions, for example (Chapter IV), is of concern as it results from the use of a single size limit of 15 cm for all species, including seabass, whose minimum landing size is 36 cm and size at first maturity ranges from 32-36 cm (males) to 42 cm (females) (Pawson

and Pickett, 1996). There is thus a need to align both sport fishing and recreational fishing size limits, if the protection of juvenile [undersized] fish is sought to be successful. Additionally, it is important that along with such changes in the size limits managers also develop educational programs for anglers and dissemination strategies regarding the high post-release survival rates. Educational programs to increase awareness and understanding of minimum landing sizes (amongst other aspects of regulations) have already been recommended in other recreational fisheries worldwide (e.g. Edison *et al.*, 2006; Smallwood *et al.*, 2006; Dunlop and Mann, 2012; Smallwood and Beckley, 2012), and may be an important tool to promote an increase in the release rates of undersized fish (Cooke and Suski, 2005; Cooke *et al.*, 2006; Arlinghaus *et al.*, 2007).

In such educational programs, equally as important as the incentive to release undersized/unwanted fish is the explanation on “how to release”, as this have also been found to influence the post-release survival (Cooke and Suski, 2005; Arlinghaus *et al.*, 2007). According to the available literature, amongst a multitude of factors that cannot be controlled (e.g. water temperature, water depth, dissolved oxygen, species anatomy / physiology / behavior), post-release fishing mortality has also been found to be influenced by factors that can be controlled by the angler (e.g. fishing gear/method, bait, playing time and handling practices) (Muoneke and Childress, 1994; Bartholomew and Bohnsack, 2005; Arlinghaus *et al.*, 2007; Pelletier *et al.*, 2007). Procedures such as cutting the leader line in deeply hooked fish have proven to increase the post-release survival and do not depend on the angler experience (Bartholomew and Bohnsack, 2005; Alós, 2009; Grixti *et al.*, 2010). For fish captured at greater depths, practices such as venting (i.e. piercing over-inflated swim bladders) have also been found to reduce PRM (Bartholomew and Bohnsack, 2005; St John and Syers, 2005; Alós, 2008). Efforts on the promotion of best practices in handling and releasing fish, such as the cited above, should thus be promoted in order to increase the

probability of post-release survival of hooked fish (Cooke and Suski, 2005; Sullivan *et al.*, 2006). This kind of information is already disseminated through educational programs in countries as Australia and New Zealand<sup>1</sup> (e.g. by means of recreational fishing guides that include an angler code of conduct and also tips for releasing fish), which could be used as an example.

The importance of incorporating the human dimensions of fisheries (e.g. fishers' perceptions, beliefs, preferences) in the development of management strategies has been increasingly acknowledged by a number of authors (Wilde *et al.*, 1996; Hauck *et al.*, 2002; Richardson *et al.*, 2005; Lewin *et al.*, 2006; Sullivan *et al.*, 2006; Dimech *et al.*, 2009; Pita *et al.*, 2011). Understanding fishers' perceptions and attitudes towards regulatory aspects is crucial for the success of regulations in the way that it assists managers to evaluate the adequacy of regulations and helps them to anticipate angler behavior/compliance (Bennett, 1991; Nielsen and Mathiesen, 2003; Salz and Loomis, 2005; Lewin *et al.*, 2006; Sullivan *et al.*, 2006; Jagers *et al.*, 2012). The results from chapter III highlight the significance of the attitudes and opinions which exist amongst shore anglers from southern Portugal towards the regulations in place. Anglers' poor acceptance of the regulations in place and their perception that the decision-making process took place without almost any involvement of the angling community are of concern. Additionally, the overall lack of awareness found regarding specific regulatory aspects and its rationale (e.g. specific minimum landing sizes) needs also to be taken into proper account. Awareness of specific regulatory aspects can greatly influence overall acceptance and, ultimately, non-compliance behavior (e.g. high retention rates of undersized fish) (Greiner *et al.*, 2000; McPhee *et al.*, 2002; Nielsen and Mathiesen, 2003; Page and Radomski, 2006; Prior and Beckley, 2007; Beckley *et al.*, 2008; Wilberg, 2009) (Chapters II and III). On the other hand, regulations are more likely to be accepted if

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<sup>1</sup> Examples of fishing guides or codes of conduct including best handling/releasing practices: Australia: (DoF, 2011; DPIPW, 2012; DAFF, undated); New Zealand: (MoF, 2004);

developed and implemented with extensive participation by fishers (Sutinen and Johnston, 2003; Pita *et al.*, 2010). Such an approach will provide managers with the opportunity to address fishers' own concerns and attitudes in early stages of the implementation process, and develop more appropriate regulations (Sutinen and Johnston, 2003; Salz and Loomis, 2004). Failing to have in due consideration all the aspects referred above has the potential to seriously compromise the success of the whole management purpose.

Portuguese managers now face a great challenge with regard to the whole recreational fishing regulatory system. Both the lack of acceptance of regulations in place, and the continued amendments that the recreational fishing regulations have been subject to, indicate that the current management implementation process is still far from being adequate, and that additional changes might be needed in the near future. The fact that most anglers were willing to accept the existence of regulations, as long as these were perceived as fair, and that they favoured some measures already in place (e.g. minimum landing sizes) is encouraging. However, if management of this activity is to be successful in meeting its goals, the issues highlighted in this study need to be addressed. Steps such as increased involvement of recreational fishers from the early stages of the decision-making process (Nielsen and Mathiesen, 2003; Radomski, 2003; Dimech *et al.*, 2009; Pita *et al.*, 2010), and educational programs to promote awareness about the regulations (Daoutopoulos and Pyrovetsi, 1990; Bennett, 1991; Cooke and Suski, 2004; Edison *et al.*, 2006; Smallwood and Beckley, 2012), would probably have positive outcomes such as a better support and acceptance of the regulations in place, and shape compliance behaviour (Sutinen and Kuperan, 1999; Sutinen and Johnston, 2003). In countries such as Portugal, the latter is particularly important due to the fact that recreational fishing is often conducted in areas (remote access) and periods (night fishing) in which enforcement is generally limited and effectiveness of regulations ultimately

depends on voluntary compliance (Nielsen and Mathiesen, 2003; Smallwood and Beckley, 2012).

### **6.3 Conclusions and future research needs**

In conclusion, the present thesis has many findings and has shed light on a series of aspects that if taken into proper account may contribute to support better decision making on this activity in the future. The approach of comparing annual and seasonal estimates of total catch per species with the commercial landings is novel in Europe, and may be useful for providing benchmark information on catch patterns of the two sectors (e.g. for the most affected species). Such information may assist future management decisions focused on decreasing the combined impact of the two sectors on particular species, for example during spawning periods (e.g. white sea bream).

The recreational-commercial contrast of catch per species also highlighted the importance that recreational fishing catches (shore angling specifically) have for particular species such as the white sea bream. Indeed, this is one of the most striking findings of this thesis, which strengthens the theory that, for particular species, the non-inclusion of recreational catch data can seriously distort the global catch estimates and, ultimately, the reliability of any stock assessment conducted (Cooke and Cowx, 2004; ICES, 2010; FAO, 2012; Zischke *et al.*, 2012).

This thesis has also shed light on several important aspects regarding the regulatory system in place: 1) Managers were unsuccessful in informing fishers about the specifics of the regulations; 2) Most anglers disagreed with regulations in place and felt excluded from the decision making process; 3) There was a considerable percentage of undersized [illegal] fish being captured for some species in particular, probably related with points (1) and (2); 4) The

high percentages of post-release survival observed supported the regulations that imply the release of fish. These results, that have management implications in particular, highlighted the importance of research on recreational fishing as a tool to assess the adequacy and effectiveness of the management actions.

The roving-aerial survey design used in this study to estimate catch and effort, novel in European waters, has proven to be an effective method to study SRF over large areas, providing reliable estimates on catch and effort with standard errors generally lower than 10%. Now that recreational fishing was included in the EU Data Collection Framework (EC, 199/2008), resulting in a need for recreational fishing surveys among member countries (ICES, 2010), the survey design used in the present study could be used as an example for surveys over large areas and where there is no previous information on anglers' distribution.

This study has also highlighted the importance of scientific information about all the recreational fishing modes. There is a need for research on other activities such as spearfishing and boat angling, which have their own individualities in terms of target and more captured species (e.g. Brouwer and Buxton, 2002; Morales-Nin *et al.*, 2005; Font and Lloret, 2011a; Assis *et al.*, unpubl.), and probably also in fishers' perceptions and attitudes. Other survey approaches/designs, such as the aerial-access combined survey (Pollock *et al.*, 1994) or the bus-route creel survey (Kinloch *et al.*, 1997; McGlennon and Kinloch, 1997; Chen and Woolcock, 1999), could be used.

Due to logistical constraints, it was not also possible to investigate night fishing. This period is generally overlooked because traditional methods such as intercept creel surveys (e.g. roving creel) are difficult to conduct (e.g. mostly due to safety reasons) (Smallwood *et al.*, 2006; Sullivan *et al.*, 2006; Dunlop and Mann, 2012). As pointed out by Sullivan *et al.* (2006), this has the potential to create bias, particularly in areas where night fishing is a popular activity, as is the case of several fishing spots in the Algarve region (P. Veiga, *pers.*

*obs.*). A possible way to address this kind of limitations in the future could be the use of off-site methods such as fishing logbooks, electronic diaries, and telephone/internet surveys, which rely on angler self-reported data (Pollock *et al.*, 1994; Sullivan *et al.*, 2006; Pollock, 2010; Griffiths, 2012). Although the results were not included here, a pilot study using fishing logbooks with volunteer anglers was conducted during the course of this thesis (APPENDIX IV), and it was demonstrated to be a very cost-effective methods for obtaining data from a full range of fishing activities and periods of time (day and night fishing) (Pollock *et al.*, 1994; Pitcher and Hollingworth, 2002b). However, some preliminary studies should be conducted in advance to test the reliability and bias associated with anglers' self-reported data. The use of such methods has associated complexities such as nonresponse, recall and prestige bias, which need to be taken into account (Pollock *et al.*, 1994; Pitcher and Hollingworth, 2002b; Sullivan *et al.*, 2006).

Finally, it must be noted that this study was obtained when the first restrictions were implemented in Portugal (2006), and thus more likely to reflect the nature of the fishery *per se* (i.e. fishing habits prior to regulations), as well an initial resistance to change (Sauer *et al.*, 1997; Dorr *et al.*, 2002; Radomski, 2003). In the meantime there have been several amendments in the regulations, and anglers' fishing habits and perceptions towards regulations might also have changed (Dimech *et al.*, 2009). A regular monitoring scheme of the several dimensions of the recreational fishing activity (e.g. catch and effort, fishers' perceptions) should thus be conducted in order to evaluate effectiveness of regulations and their adequacy and allow for any management adjustments if deemed necessary (Benfield and Minello, 1996; Sauer *et al.*, 1997; Salz and Loomis, 2004; Dimech *et al.*, 2009; Dunlop and Mann, 2012; FAO, 2012). As referred in chapter III, revenues from recreational fishing licences could be used to fund this monitoring scheme, an approach already in place in

countries such as US (e.g. DFG, 2012; FWC, 2012) and Australia (e.g. DoF, 2012; DPI, 2012).



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# APPENDICES





## Appendix I. Legal minimum landing sizes




**AI.** Minimum landing sizes (MLS; in cm) in place for the commercial and recreational fishing in Portugal. Source: General Directorate on Natural Resources, Safety and Maritime Affairs website <<http://www.dgrm.min-agricultura.pt>>. note: only the species recorded in the present study are included.

Scientific name	Common name (PT; EN)	MLS <sup>1</sup> (cm)
<i>Dicentrarchus punctatus</i>	PT: Baila; EN: Spotted seabass	20
<i>Pagellus acarne</i>	PT: Besugo; EN: Axillary seabream	18
<i>Pagellus erythrinus</i>	PT: Bica; EN: Common pandora	15
<i>Boops boops</i>	PT: Boga; EN: Bogue	15
<i>Trachurus</i> spp.	PT: Carapaus; EN: Horse mackerel	15
<i>Spondyliosoma cantharus</i>	PT: Choupa; EN: Black sea bream	23
<i>Conger conger</i>	PT: Congro/Safio; EN: European conger	58
<i>Argyrosomus regius</i>	PT: Corvina-legítima; EN: Meagre	42
<i>Sparus aurata</i>	PT: Dourada; EN: Gilthead sea bream	19
<i>Anguilla anguilla</i>	PT: Enguia; EN: European eel	22
<i>Lithognathus mormyrus</i>	PT: Ferreira; EN: Sand steenbras	15
<i>Solea</i> spp.	PT: Linguados; EN: Soles	24
<i>Pagrus pagrus</i>	PT: Pargo-legítimo; EN: Red porgy	20
<i>Scophthalmus maximus</i>	PT: Pregado; EN: Turbot	30
<i>Dicentrarchus labrax</i>	PT: Robalo-legítimo; EN: European seabass	36
<i>Scophthalmus rhombus</i>	PT: Rodovalho; EN: Brill	30
<i>Sarpa salpa</i>	PT: Salema; EN: Salema	18
<i>Mullus surmuletus</i>	PT: Salmonete; EN: Red mullet	15
<i>Scomber</i> spp.	PT: Sarda e Cavala; EN: Atlantic mackerel	20
<i>Diplodus</i> spp.	PT: Sargos; EN: Sea breams	15
<i>Alosa</i> spp.	PT: Sável e Savelha; EN: shads	30
<i>Mugil</i> spp. [Mugilidae]	PT: Tainhas; EN: Mulletts	20

<sup>1</sup> Relevant regulations: European (EU): Reg. (CE) n° 850/98; Portuguese: Portaria § 27/2001; Portaria n° 402/2002; Portaria § 1266/2004, Portaria § 82/2011.



## Appendix II. Questionnaire used for the face-to-face interviews during the roving creel surveys (Chapters II and III).

<h3>Recreational fishing of the Algarve and southwest coast of Portugal</h3> <p>This questionnaire is confidential. All data are used exclusively for the purpose of the study.</p>		  
<h4>Questionnaire A: Socio-economic aspects</h4>		
ID questionnaire #:	Date: / /	Time: :
Interviewer:	Section:	Sampling site/Fishing spot type:
Angler:	In group <input type="checkbox"/> with family <input type="checkbox"/> alone <input type="checkbox"/>	/
<b>1. IDENTIFICATION:</b>		
<b>1.1 Gender:</b>	<b>1.2 Age:</b> _____	<b>1.3 Marital status:</b>
Male <input type="checkbox"/>		Single <input type="checkbox"/> Widower <input type="checkbox"/>
Female <input type="checkbox"/>		Married <input type="checkbox"/> Divorced <input type="checkbox"/>
<b>1.4 Nº. people in the household:</b>		
<b>2. Education (Portuguese levels)</b>		<b>3. PROFESSIONAL ACTIVITY</b>
<input type="checkbox"/> Elementary school		<b>3.1 Professional situation</b>
<input type="checkbox"/> Middle school		<input type="checkbox"/> Employed
<input type="checkbox"/> High school		<input type="checkbox"/> Unemployed
<input type="checkbox"/> Professional course. Please specify:		<input type="checkbox"/> Retired
<input type="checkbox"/> College degree or higher		<input type="checkbox"/> Student
Please specify:		
<b>4. Monthly income</b>		
<input type="checkbox"/> no income <input type="checkbox"/> 0-500 € <input type="checkbox"/> 501-1000€ <input type="checkbox"/> 1001-1500€ <input type="checkbox"/> more than 1500€		
<b>5. FISHING EXPERIENCE</b>		<b>5.2 For how many years do you practice recreational fishing?</b>
<b>5.1 Are you a member of any fishing association?</b>		<input type="checkbox"/> boat-
<input type="checkbox"/> No		<input type="checkbox"/> shore-
<input type="checkbox"/> Yes. Please indicate:		
<b>5.3 What are your annual expenses in fishing equipment? (hooks, lines, leaders)</b>		€
<b>5.4 How much did your rod(s) and reels cost?</b>		
<b>5.5 Boat fishing:</b>		
Own boat: No <input type="checkbox"/> Yes <input type="checkbox"/>		If not, do you usually split expenses? No <input type="checkbox"/> Yes <input type="checkbox"/>
Name: _____	Brand: _____	How do you usually pay? _____
Type: _____	Size: _____	Power: _____
Monthly expenses (€/month): _____	TAB: _____	
Expenses per fishing trip (€/fishing trip): _____		
<b>5.6 How many fishing days in 2005:</b>		<b>5.5 How many fishing days last month:</b>
- Spring		
- Summer		
- Autumn		
- Winter		



## Recreational fishing of the Algarve and southwest coast of Portugal

This questionnaire is confidential. All data are used exclusively for the purpose of the study.



### Questionnaire B- Fishing trip information

ID questionnaire #: \_\_\_\_\_ Date: / / Time: \_\_\_\_ : \_\_\_\_ (hh : mm)  
 Interviewer: \_\_\_\_\_ Section: \_\_\_\_\_ Fishing spot type:  
 (other notes) Fishing spot name: \_\_\_\_\_  
 Beach  
 Harbour  
 Clif

#### Fishing was:

- leisure  shore  
 competition  boat

#### Land transportation:

- Car  walk   
 motor bike  bike

Distance travelled? on Land \_\_\_\_\_ (km) on sea \_\_\_\_\_ (nautical miles)

From what port/marina (boat fishing)? \_\_\_\_\_ Fishing trip start: \_\_\_\_\_ : \_\_\_\_\_

Fishing trip end: \_\_\_\_\_ : \_\_\_\_\_  
 (expected time) (hh : mm)

What was the average water temperature: °C  
 and transparency? clear  dirty  very dirty

#### Weather conditions (select the most adequate option(s)):

- Sunny  Mostly Cloudy  Heavy rain  Fog  
 Partly Cloudy  Light rain  Showers

#### Wind:

- Light  moderate  strong

#### Waves:

- flat  < 1m  
 1-2m  > 2m

Direction:

- Alone  Type of group. With \_\_\_ fishermen / \_\_\_ family members

#### Expenses:

- |                 |   |                 |   |
|-----------------|---|-----------------|---|
| 1. Fuel (car):  | € | 4. Snaks, beer: | € |
| 2. Fuel (boat): | € | 5. Equipment:   | € |
| 3. Bait(s):     | € | 6. Lodging:     | € |

#### type of fishing activity (and fishing method):

##### shore:

1. Floaters  
 2. sinkers  
 3. "sentir" <sup>(\*)</sup>  
 4. lure-casting

##### boat:

1. anchored boat  
 1.1 sandy bottom  
 1.2 rocky bottom  
 1.3 wrecks  
 1.4 sandy/rocky  
 2. Game fish  
 2.1 Shark  
 2.2 marlin/swordfish

3. "Pesca ao corrico" <sup>(\*)</sup>  
 4. "Palangrote" <sup>(\*)</sup>  
 7. "Pesca à pluma" <sup>(\*)</sup>  
 8. Spinning  
 9. "Deriva" <sup>(\*)</sup>

- 2.3 Tuna  
 2.4 others: \_\_\_\_\_

Bait(s) used: \_\_\_\_\_

Number of rods used: \_\_\_\_\_

<sup>(\*)</sup> Portuguese terminology.

Did you use any bait additive? If so, please indicate:

type of Hook used (during most of the fishing trip):

- Single                       Double                       Triple

Hooks size?

- Very small                       Big  
 Small                               Very big  
 Medium

Size:
Brand:

Any target species? Please indicate which?

Main purpose of this fishing trip in terms of fish caught...

- own consumption                       to sell                       Other. Please indicate:  
 catch and release                       to offer to friends / family \_\_\_\_\_

Did you release any fish today?  No  Yes. Please indicate:

Species	N	Motive	
		size	other (please specify)

How do you classify the fishing trip?

- Excellent     Good     Average     Bad     Very poor

Please discriminate the captures:

Species	N	TL (cm)	Weight (g)	Species	N	TL (cm)	Weight (g)

previous data refers to a single fisher?  Yes  No

- If not, please indicate:  
 1. Number of fishers:  
 2. Number of rods:  
 3. Hooks per rod:

Follow up interview

Gave contact:		Yes <input type="checkbox"/> No <input type="checkbox"/>		suggested time to call:					
Nome:		Phone nr:		notes:					
Call	1	2	3	Catches					
Time				Species	N	TL/Weight	Species	N	TL/Weight
Answered									
End of fishing trip:									
Fishing classification:									

For any questions, please contact:

Pedro Veiga, Universidade do Algarve, FCMA, Campus de Gambelas, 8005-139 Faro  
 phone: 289 800 900; mobile: 96 6507741; email: pveiga@ualg.pt

## Appendix III. Supporting materials for chapter II

**AIII-1.** Number of valid interviews [questionnaires] non-responses per area and day type, and response rate per month.

Year	Month	Day type	Questionnaires			Non-responses			Response rate (%)
			South coast	SW coast	Total	South coast	SW coast	Total	
2006	Aug	Weekday	62	40	102	0	0	0	100
		Weekend	38	30	68	0	0	0	
	Sep	Weekday	27	32	59	0	1	1	98.4
		Weekend	30	37	67	1	0	1	
	Oct	Weekday	24	18	42	1	0	1	94
		Weekend	42	10	52	1	4	5	
	Nov	Weekday	27	21	48	0	0	0	97.7
		Weekend	21	17	38	1	1	2	
Dec	Weekday	16	22	38	0	0	0	96.2	
	Weekend	38	50	88	0	5	5		
2007	Jan	Weekday	5	32	37	1	7	8	88.1
		Weekend	29	49	78	0	6	6	
	Feb	Weekday	22	32	54	1	0	1	98.4
		Weekend	27	45	72	0	1	1	
	Mar	Weekday	17	19	36	0	3	3	92.0
		Weekend	39	63	102	0	9	9	
	Apr	Weekday	10	23	33	0	0	0	100
		Weekend	19	20	39	0	0	0	
	May	Weekday	9	11	20	0	0	0	90
		Weekend	30	40	70	4	6	10	
	Jun	Weekday	14	39	53	1	3	4	95
		Weekend	16	27	43	0	1	1	
	Jul	Weekday	18	17	35	6	3	9	85.4
		Weekend	13	34	47	2	3	5	
<b>Total annual</b>	Weekday		251	306	557	10	17	27	94.7
			342	422	764	9	36	45	
	<b>Total</b>		<b>593</b>	<b>728</b>	<b>1321</b>	<b>19</b>	<b>53</b>	<b>72</b>	

**AIII-2.** Fishing effort estimates in terms of number of angler hours for recreational shore angling in the study area and period. Data are presented for all strata (day type, area, and season). SE, standard error.

Season	Day type	South coast		SW coast		Overall	
		Fishing effort (angler hours)	S.E	Fishing effort (angler hours)	S.E	Fishing effort (angler hours)	S.E
Summer 06/07	Weekday	41 080 ± 10 387		54 773 ± 13 958		95 853 ± 17 399	
	Weekend	25 704 ± 5 154		42 336 ± 5 649		68 040 ± 7 647	
	<b>Total</b>	<b>66 784 ± 11 595</b>		<b>97 109 ± 15 058</b>		<b>163 893 ± 19 005</b>	
Autumn 06	Weekday	54 416 ± 5 107		71 744 ± 10 695		126 160 ± 11 852	
	Weekend	52 432 ± 10 253		53 824 ± 8 977		106 256 ± 13 628	
	<b>Total</b>	<b>106 848 ± 11 454</b>		<b>125 568 ± 13 964</b>		<b>232 416 ± 18 061</b>	
Winter 07	Weekday	31 883 ± 8 015		71 736 ± 3 462		103 619 ± 8 731	
	Weekend	31 867 ± 2 167		55 600 ± 14 039		87 467 ± 14 205	
	<b>Total</b>	<b>63 749 ± 8 303</b>		<b>127 336 ± 14 459</b>		<b>191 085 ± 16 674</b>	
Spring 07	Weekday	21 989 ± 3 141		23 312 ± 7 700		45 301 ± 8 316	
	Weekend	27 608 ± 5 262		44 931 ± 3 368		72 539 ± 6 247	
	<b>Total</b>	<b>49 597 ± 6 128</b>		<b>68 243 ± 8 404</b>		<b>117 840 ± 10 401</b>	
<b>Total annual</b>	Weekday	149 368 ± 14 425		221 565 ± 19 506		370 933 ± 24 261	
	Weekend	137 611 ± 12 809		196 691 ± 17 915		334 301 ± 22 023	
	<b>Total</b>	<b>286 979 ± 19 291</b>		<b>418 256 ± 26 484</b>		<b>705 235 ± 32 765</b>	

**AIII-3.** Fishing effort estimates in terms of number of fishing trips for recreational shore angling in the study area and period. Data are presented for all strata (day type, area, and season). SE, standard error.

Summer	Day type	South coast		SW coast		Overall	
		Fishing trips	S.E	Fishing trips	S.E	Fishing trips	S.E
Summer 06/07	Weekday	10 717	± 2 957	14 042	± 3 775	24 759	± 4 795
	Weekend	7 527	± 1 692	7 766	± 1 328	15 294	± 2 151
	<b>Total</b>	<b>18 244</b>	<b>± 3 407</b>	<b>21 809</b>	<b>± 4 002</b>	<b>40 052</b>	<b>± 5 255</b>
Autumn 06	Weekday	9 403	± 1 391	21 719	± 4 114	31 122	± 4 343
	Weekend	10 281	± 2 424	11 451	± 2 211	21 731	± 3 281
	<b>Total</b>	<b>19 684</b>	<b>± 2 795</b>	<b>33 169</b>	<b>± 4 670</b>	<b>52 853</b>	<b>± 5 443</b>
Winter 07	Weekday	12 146	± 3 709	16 437	± 1 568	28 583	± 4 027
	Weekend	7 236	± 818	9 551	± 2 516	16 786	± 2 646
	<b>Total</b>	<b>19 381</b>	<b>± 3 798</b>	<b>25 988</b>	<b>± 2 965</b>	<b>45 369</b>	<b>± 4 818</b>
Spring 07	Weekday	6 872	± 1 178	4 961	± 1 685	11 833	± 2 056
	Weekend	7 888	± 3 143	8 434	± 1 146	16 322	± 3 346
	<b>Total</b>	<b>14 760</b>	<b>± 3 357</b>	<b>13 395</b>	<b>± 2 038</b>	<b>28 155</b>	<b>± 3 927</b>
<b>Total annual</b>	Weekday	39 137	± 5 081	57 159	± 6 039	96 296	± 7 893
	Weekend	32 932	± 4 392	37 202	± 3 781	70 133	± 5 795
	<b>Total</b>	<b>72 069</b>	<b>± 6 716</b>	<b>94 361</b>	<b>± 7 125</b>	<b>166 430</b>	<b>± 9 792</b>

**AIII-4.** Total harvest estimates by weight (kg) (retained catches) of recreational shore angling in southern Portugal. Data are presented for all strata (day type, area, and season). SE, standard error.

Season	Day type	South coast		SW coast		Overall	
		Catch (kg)	SE	Catch (kg)	SE	Catch (kg)	SE
Summer 06/07	Weekday	2 898	± 1 034	11 119	± 3 797	14 017	± 3 935
	Weekend	3 153	± 1 113	9 497	± 2 001	12 650	± 2 289
	<b>Total</b>	<b>6 051</b>	± <b>1 519</b>	<b>20 616</b>	± <b>4 292</b>	<b>26 667</b>	± <b>4 553</b>
Autumn 06	Weekday	6 971	± 1 442	24 260	± 6 527	31 230	± 6 684
	Weekend	4 022	± 1 074	17 151	± 4 137	21 173	± 4 274
	<b>Total</b>	<b>10 992</b>	± <b>1 799</b>	<b>41 411</b>	± <b>7 728</b>	<b>52 403</b>	± <b>7 934</b>
Winter 07	Weekday	3 718	± 1 446	24 684	± 4 676	28 402	± 4 895
	Weekend	3 148	± 629	14 924	± 4 339	18 072	± 4 385
	<b>Total</b>	<b>6 865</b>	± <b>1 577</b>	<b>39 608</b>	± <b>6 379</b>	<b>46 473</b>	± <b>6 571</b>
Spring 07	Weekday	5 145	± 2 433	6 171	± 2 275	11 316	± 3 331
	Weekend	3 026	± 958	7 504	± 1 441	10 529	± 1 730
	<b>Total</b>	<b>8 170</b>	± <b>2 615</b>	<b>13 675</b>	± <b>2 693</b>	<b>21 845</b>	± <b>3 754</b>
<b>Total annual</b>	Weekday	18 730	± 3 341	66 235	± 9 168	84 965	± 9 758
	Weekend	13 348	± 1 925	49 075	± 6 482	62 423	± 6 762
	<b>Total</b>	<b>32 079</b>	± <b>3 856</b>	<b>115 310</b>	± <b>11 229</b>	<b>147 388</b>	± <b>11 872</b>

**AIII-5.** Total harvest estimates by number of fish (retained catches) of recreational shore angling in southern Portugal. Data are presented for all strata (day type, area, and season). SE, standard error.

Season	Day type	Costa Sul		Costa SW		Geral	
		Catch (no.)	SE	Catch (no.)	SE	Catch (no.)	SE
Summer 06/07	Weekday	24 540	± 8 128	65 933	± 23 558	90 473	± 24 921
	Weekend	24 704	± 8 738	49 559	± 9 937	74 264	± 13 232
	<b>Total</b>	<b>49 244</b>	± <b>11 934</b>	<b>115 492</b>	± <b>25 568</b>	<b>164 736</b>	± <b>28 216</b>
Autumn 06	Weekday	42 739	± 9 465	75 848	± 17 444	118 586	± 19 846
	Weekend	36 600	± 9 475	56 260	± 12 930	92 860	± 16 030
	<b>Total</b>	<b>79 339</b>	± <b>13 392</b>	<b>132 108</b>	± <b>21 714</b>	<b>211 447</b>	± <b>25 511</b>
Winter 07	Weekday	15 796	± 6 071	54 263	± 7 584	70 059	± 9 715
	Weekend	20 621	± 4 759	37 697	± 10 507	58 318	± 11 534
	<b>Total</b>	<b>36 417</b>	± <b>7 714</b>	<b>91 959</b>	± <b>12 958</b>	<b>128 377</b>	± <b>15 080</b>
Spring 07	Weekday	18 754	± 5 601	22 002	± 8 101	40 756	± 9 849
	Weekend	14 258	± 4 305	29 558	± 5 234	43 816	± 6 777
	<b>Total</b>	<b>33 012</b>	± <b>7 065</b>	<b>51 560</b>	± <b>9 645</b>	<b>84 572</b>	± <b>11 956</b>
<b>Total annual</b>	Weekday	101 829	± 14 962	218 045	± 31 344	319 874	± 34 732
	Weekend	96 184	± 14 398	173 074	± 20 092	269 258	± 24 718
	<b>Total</b>	<b>198 013</b>	± <b>20 765</b>	<b>391 119</b>	± <b>37 231</b>	<b>589 132</b>	± <b>42 630</b>

**AIII-6.** Total annual catch estimates by weight (kg) (retained and released) of recreational shore angling in southern Portugal for the most important species.

Species	South Coast		SW coast		Total	
	Catch (kg)	SE	Catch (kg)	SE	Catch (kg)	SE
<i>Diplodus sargus</i>	14 726	± 1 912	70 728	± 8 061	85 454	± 8 284
Mugilidae (mullet)*	577	± 284	11 237	± 3 829	11 814	± 3 840
<i>Diplodus vulgaris</i>	3 374	± 629	7 593	± 1 203	10 967	± 1 357
<i>Sarpa salpa</i>	2 220	± 898	8 641	± 2 690	10 861	± 2 836
<i>Dicentrarchus labrax</i>	2 825	± 1 056	4 954	± 1 233	7 779	± 1 623
<i>Sparus aurata</i>	4 296	± 1 109	2 973	± 1 883	7 268	± 2 185
<i>Balistes caprisicus</i>	3 001	± 2 364	1 956	± 941	4 957	± 2 545
<i>Boops boops</i>	425	± 200	3 951	± 1 090	4 376	± 1 108
<i>Scomber japonicus</i>	1 240	± 516	2 375	± 975	3 615	± 1 103
<i>Spondyliosoma cantharus</i>	676	± 242	577	± 143	1 253	± 281
<i>Symphodus</i> spp.*	214	± 89	982	± 362	1 196	± 373
<i>Dicentrarchus punctatus</i>	902	± 392	227	± 179	1 128	± 431
<i>Diplodus bellottii</i>	506	± 179	0	± 0	506	± 179
<b>Total (all species)</b>	<b>37 248</b>	± <b>4 184</b>	<b>122 936</b>	± <b>11 835</b>	<b>160 183</b>	± <b>12 553</b>

<sup>(\*)</sup> not identified to the species level.

**AIII-7.** Total annual catch estimates by number (retained and released) of recreational shore angling in southern Portugal for the most important species.

Species	South Coast			SW coast			Total	
	Catch (no.)	SE		Catch (no.)	SE		Catch (no.)	SE
<i>Diplodus sargus</i>	132 629	± 17	183	247 681	± 24 571		380	± 29 983
<i>Diplodus vulgaris</i>	50 764	± 8 579		60 073	± 9 215		110	± 12 590
<i>Boops boops</i>	5 323	± 2 525		44 779	± 11 779		836	± 12 047
<i>Scomber japonicus</i>	13 913	± 5 683		16 529	± 7 383		50 103	± 9 317
<i>Sarpa salpa</i>	8 488	± 2 909		18 605	± 5 170		27 093	± 5 932
<i>Symphodus</i> spp *	6 880	± 2 675		19 539	± 6 737		26 419	± 7 249
<i>Dicentrarchus labrax</i>	7 201	± 2 104		11 767	± 2 325		18 968	± 3 136
Mugilidae (mulletts)*	1 329	± 669		16 001	± 5 152		17 330	± 5 195
<i>Sparus aurata</i>	11 032	± 2 335		4 287	± 1 757		15 319	± 2 922
<i>Diplodus bellottii</i>	11 166	± 3 278		0	± 0		11 166	± 3 278
<i>Spondyllosoma cantharus</i>	6.647	± 2 317		3 466	± 820		10 114	± 2 457
<i>Balistes capriscus</i>	4 131	± 2 675		5 143	± 2 971		9 274	± 3 998
<i>Dicentrarchus punctatus</i>	6257	± 2 644		464	± 340		6 722	± 2 666
<b>Total (all species)</b>	<b>295 260</b>	<b>± 29 031</b>		<b>492 789</b>	<b>± 45 626</b>		<b>788 049</b>	<b>± 54 079</b>

(\*) not identified to the species level.

**AIII-8.** Total annual harvest estimates by weight (kg) (retained) of recreational shore angling in southern Portugal for the most important species.

Species	South Coast			SW coast			Total	
	Harvest (kg)	SE		Harvest (kg)	SE		Harvest (kg)	SE
<i>Diplodus sargus</i>	13 628	± 1 836		68 847	± 7 843		82 475	± 8 055
Mugilidae (mulletts) (*)	577	± 284		10 438	± 3 780		11 015	± 3 791
<i>Diplodus vulgaris</i>	2 336	± 531		6 926	± 1 142		9 262	± 1 259
<i>Sarpa salpa</i>	1 019	± 626		7 068	± 2 421		8 087	± 2 500
<i>Dicentrarchus labrax</i>	2.688	± 1 023		4 685	± 1 225		7 373	± 1 596
<i>Sparus aurata</i>	4 242	± 1 102		2 941	± 1 883		7 183	± 2 181
<i>Balistes capriscus</i>	3 001	± 2 364		1 956	± 941		4 957	± 2 545
<i>Scomber japonicus</i>	1 026	± 473		2 279	± 966		3 305	± 1 075
<i>Boops boops</i>	87	± 86		2 331	± 882		2 418	± 886
<i>Dicentrarchus punctatus</i>	896	± 392		227	± 179		1 123	± 431
<i>Spondyllosoma cantharus</i>	538	± 228		577	± 143		1 115	± 269
<i>Symphodus</i> spp. (*)	34	± 24		809	± 355		843	± 355
<i>Diplodus bellottii</i>	408	± 173		0	± 0		408	± 173
<b>Total (all species)</b>	<b>32 079</b>	<b>± 3 856</b>		<b>115 310</b>	<b>± 11 229</b>		<b>147 388</b>	<b>± 11 872</b>

(\*) not identified to the species level.

**AIII-9.** Total annual harvest estimates by number (retained) of recreational shore angling in southern Portugal for the most important species.

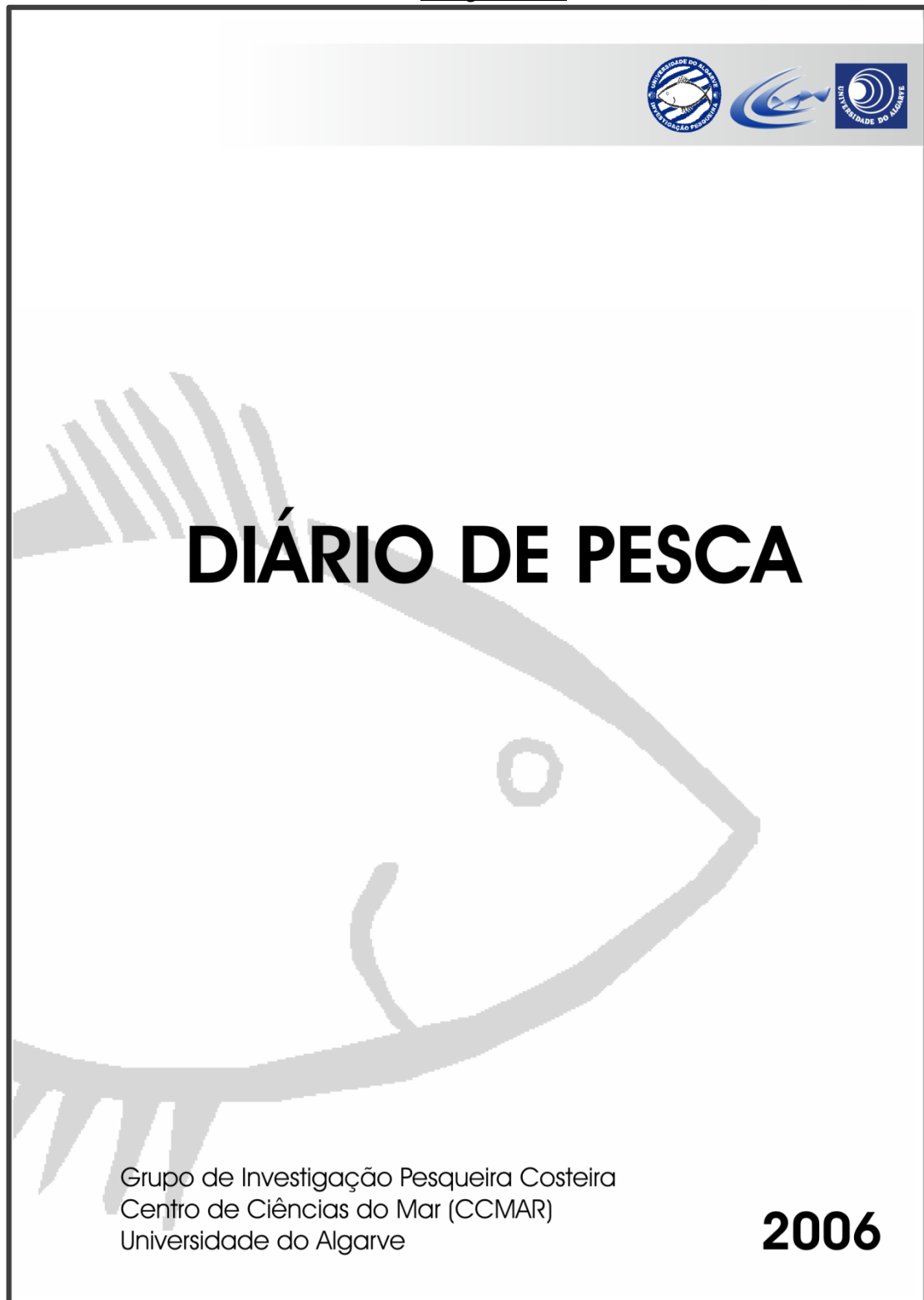
Species	South Coast		SW coast		Total	
	Harvest (no.)	SE	Harvest (no.)	SE	Harvest (no.)	SE
<i>Diplodus sargus</i>	98 657 ±	13 658	202 181 ±	20 163	300 838 ±	24 353
<i>Diplodus vulgaris</i>	28 890 ±	5 965	46 153 ±	7 714	75 042 ±	9 751
<i>Scomber japonicus</i>	11 877 ±	5 282	15 599 ±	7 271	27 476 ±	8 987
<i>Boops boops</i>	848 ±	844	23 695 ±	8 581	24 543 ±	8 623
<i>Sarpa salpa</i>	5 348 ±	2 452	15 274 ±	4 544	20 623 ±	5 163
Mugilidae (mullets) <sup>(*)</sup>	1 329 ±	669	14 636 ±	5 062	15 965 ±	5 106
<i>Dicentrarchus labrax</i>	6.119 ±	1 691	9 325 ±	2 008	15 444 ±	2 626
<i>Symphodus</i> spp. <sup>(*)</sup>	1 172 ±	890	13 750 ±	6 409	14 922 ±	6 471
<i>Sparus aurata</i>	10 029 ±	2 167	4 028 ±	1 745	14 056 ±	2 782
<i>Balistes capriscus</i>	4 131 ±	2 675	5 143 ±	2 971	9 274 ±	3 998
<i>Spondyliosoma cantharus</i>	4.306 ±	1 705	3 466 ±	820	7 772 ±	1 892
<i>Dicentrarchus punctatus</i>	6 086 ±	2 640	464 ±	340	6 551 ±	2 662
<i>Diplodus bellottii</i>	4 557 ±	1 902	0 ±	0	4 557 ±	1 902
<b>Total (all species)</b>	<b>198 013 ±</b>	<b>20 765</b>	<b>391 119 ±</b>	<b>37 231</b>	<b>589 132 ±</b>	<b>42 630</b>

<sup>(\*)</sup> not identified to the species level.

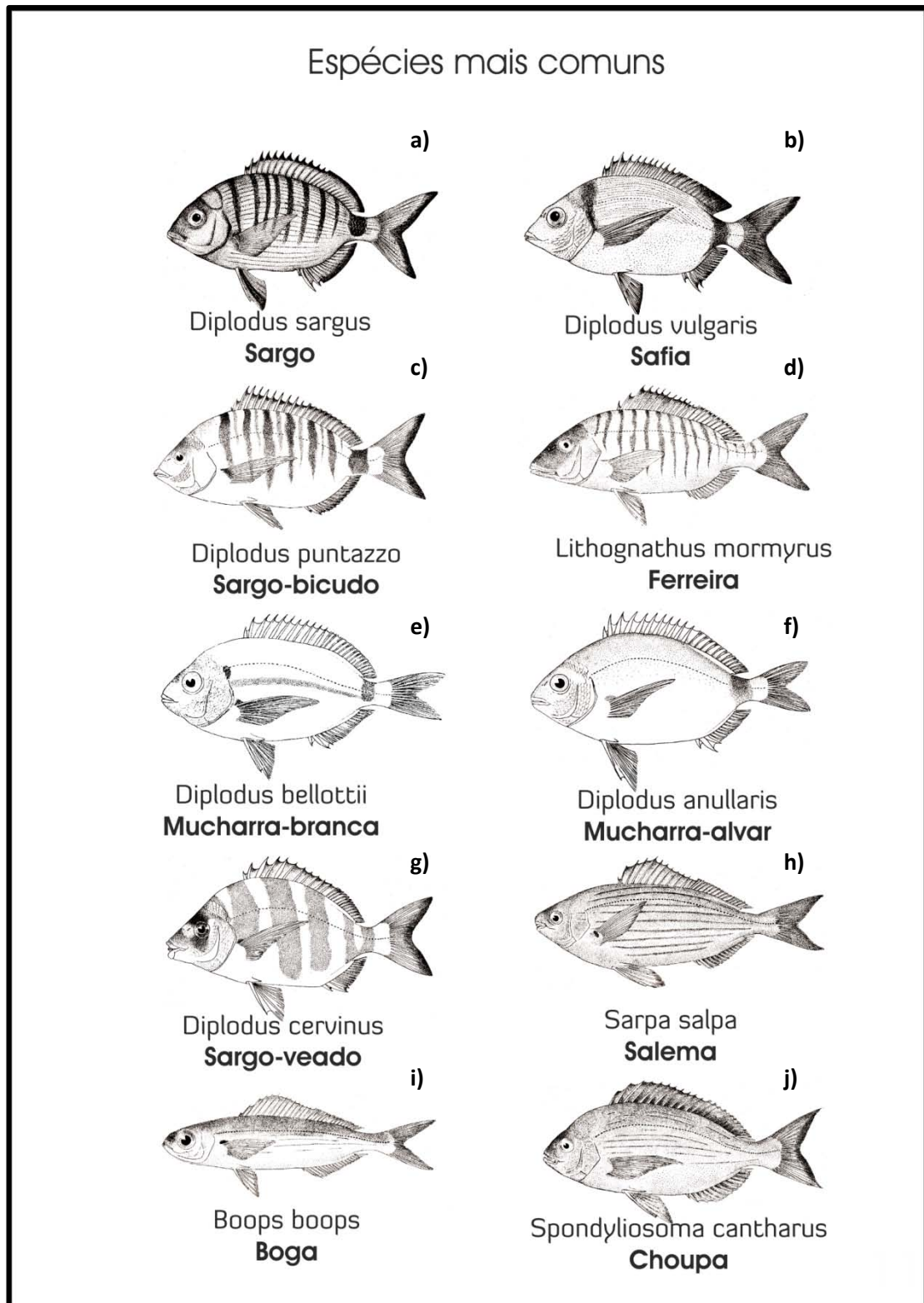


## Appendix IV. Fishing logbooks used for the pilot study on recreational shore fishing.

Design Credits: Frederico Oliveira, ©CFRG, 2007.



<b>Data:</b>	<b>Que isco(s) utilizou?</b>																																	
<b>A pescaria foi:</b> De lazer <input type="checkbox"/> Desportiva (prova) <input type="checkbox"/> De terra <input type="checkbox"/> De embarcação <input type="checkbox"/>	<b>Usou engodo? Qual?</b> Quantas canas usou? Anzois p/cana? Modelo(s) de anzol: Tamanho (Nº) de anzol:																																	
<b>Localização da pescaria:</b>																																		
<b>Que distância viajou (Km)?</b> Por terra: Por mar (barco):	<b>Tentou apanhar uma (ou mais) espécie(s) dominante(s)?</b> Sim <input type="checkbox"/> Não <input type="checkbox"/> Quais (especificar)?																																	
<b>Utilizou viatura própria?</b>																																		
<b>Início da pesca:</b>	<b>Por favor descreva a sua captura:</b>																																	
<b>Fim da pesca:</b>	<table border="1"> <thead> <tr> <th>Espécie</th> <th>Número</th> <th>Peso</th> </tr> </thead> <tbody> <tr><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td></tr> <tr><td> </td><td> </td><td> </td></tr> </tbody> </table>	Espécie	Número	Peso																														
Espécie	Número	Peso																																
<b>Condições de tempo:</b> (selecione a/as opção/ões): Céu limpo <input type="checkbox"/> Chuva moderada <input type="checkbox"/> <input type="checkbox"/> Pouco nublado <input type="checkbox"/> Chuva intensa <input type="checkbox"/> <input type="checkbox"/> Muito nublado <input type="checkbox"/> Aguaceiros <input type="checkbox"/> <input type="checkbox"/> Nevoeiro <input type="checkbox"/> <input type="checkbox"/>																																		
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<b>Vagas:</b> Sem ondulação <input type="checkbox"/> Vagas < 1m <input type="checkbox"/> <input type="checkbox"/> Vagas 1-2m <input type="checkbox"/> Vagas > 2m <input type="checkbox"/> <input type="checkbox"/>																																		
<b>Transparência da água:</b> Limpa <input type="checkbox"/> Suja <input type="checkbox"/> Muito suja <input type="checkbox"/>																																		
<b>Nesta pescaria gastou aproximadamente:</b> 1. Combustível: 2. Isco e engodo: 3. Equipamento: 4. Restauração: 5. Hotelaria:	<b>Peso total:</b>																																	
<b>Modalidade de pesca praticada:</b> 1. Pesca à boia <input type="checkbox"/> 2. Pesca ao fundo <input type="checkbox"/> 3. Sentir <input type="checkbox"/> 4. Amostras / buldo <input type="checkbox"/>	<b>Os dados no quadro anterior (capturas) são individuais (apenas de um pescador)?</b> Sim <input type="checkbox"/> Não <input type="checkbox"/> Quantos pescadores? Quantas canas?																																	
	<b>Qual o destino das capturas?</b> Consumo próprio: Venda: Rejeitados/devolvidos ao mar:																																	
	<b>Como classifica o resultado da pesca de hoje:</b> Muito bom <input type="checkbox"/> Bom <input type="checkbox"/> Médio <input type="checkbox"/> Mau <input type="checkbox"/> Muito mau <input type="checkbox"/>																																	



**Note:** English names: a) White sea bream; b) Two banded sea bream; c) Sharpnout sea bream; d) Sand steenbras; e) Senegal seabream; f) Annular sea bream; g) Zebra sea bream; h) Salema; i) Bogue; j) Black sea bream.



## Appendix V. Photographic records from the surveys.



**Figure legends.** (a) angler removing European seabass *Dicentrarchus labrax* of c. 1 kg from basket used to lift larger fish when fishing from very high cliffs; (b), “xuxas”, a bait made from sea urchin gonads, which are packed into these small balls and used to catch white sea bream; (c), creel with white sea breams *Diplodus sargus* (SW coast); (d), weighing a white sea bream caught in the SW coast. (e) and (f), anglers fishing from cliffs in Carrapateira, one of the fishing hotspots in the SW Portugal.



## Appendix V. (cont.)



**Figure legends.** (cont.) (g), Monte Gordo beach, the typical coastal landscape of E Algarve region, south Portugal; (h) and (i), Cabo Sardão/Almograve area, the typical shore landscape of the SW coast; (j), anglers fishing from a pier in Tavira (E Algarve, south Portugal); Ria Formosa lagunar system (central Algarve); calcareous cliffs alternated with sandy beaches (Albufeira), the typical landscape from central Algarve.



## Appendix V. (cont.)



**Figure legends.** (m) unhooking a gilthead sea bream *Sparus aurata*, C&R fishing trials; (n) face-to-face interview in Oura beach, Albufeira, Algarve; (o) sea cage used to release the fish, C&R fishing trials; (p) tagging a gilthead seabream, C&R fishing trials; (q) quantifying and measuring catches (sea breams) from an angler in Pipa beach, SW coast; (r) preparing chum (“Engodo”) made from sardines (*Sardina pilchardus*), sand and saltwater, and used to attract fish.



## Appendix VI. Publications related with the Thesis

### AVI-1. Peer-reviewed papers

- Veiga, P., Pita, C., Leite, L., Ribeiro, J., Gonçalves, J.M.S. and Erzini, K. *unpubl.*. From a traditionally open access fishery to modern restrictions: Portuguese anglers' perceptions about newly implemented recreational fishing regulations. *Marine Policy*. (submitted)
- Veiga, P., Gonçalves, J.M.S. and Erzini, K. 2011. Short-term hooking mortality of three marine fish species (Sparidae) caught by recreational angling in the south Portugal. *Fisheries Research*, **108**: 58-64.
- Guerreiro, A.I., Veiga, P. and Erzini, K. 2011. Catches of the sport fishing competitions along the Algarve coast (Portugal): species, sizes, catch rates, and trends. *Acta Ichthyologica et Piscatoria*, **41**: 165-169.
- Veiga, P., Ribeiro, J., Gonçalves, J.M.S. and Erzini, K. 2010. Quantifying recreational shore angling catch and harvest in the south of Portugal (Northeast Atlantic): implications for conservation and integrated fisheries management. *Journal of Fish Biology*, **76**: 2216-2237.

### AVI-2. Presentations in International Conferences

- Veiga, P., Pita, C., Leite, L., Ribeiro, J., Gonçalves, J.M.S. and Erzini, K. 2011. Attitudes and perceptions of recreational shore anglers towards the implementation of saltwater fishing regulations: a case study in the south of Portugal. *6th World Recreational Fishing Conference (WRFC)*. Humboldt-Universität zu Berlin, Berlin, Germany. 1-4 August 2011. (oral communication)
- Veiga, P., Gonçalves, J.M.S. and Erzini, K. 2010. An integrative study on the recreational shore fishing in the south of Portugal. *Transversal workshop on the monitoring recreational fisheries in the GFCM area*. Universitat de les Illes Balears, Palma de Mallorca, Mallorca, Spain. 20-22 October 2010. (oral communication)
- Veiga, P., Gonçalves, J.M.S. and Erzini, K. 2010. Short-term hooking mortality of three fish species (Sparidae) caught by recreational angling in the south Portugal. *XVI Iberian Symposium on Marine Biology*. Universidad de Alicante, Alicante, Spain. 6-10 September 2010. (oral communication)
- Veiga, P.; Ribeiro, J.; Ditton, R.B.; Gonçalves, J.M.S. and Erzini, K. 2009. Assessment of recreational shore fishing catch and effort in the south Portugal: a 12 month survey. *8th Indo Pacific Fish Conference and 2009 ASFB Workshop and Conference*. Fremantle, WA, Australia. 31 May-05 June 2009. (oral communication)
- Veiga, P.; Ribeiro, J.; Ditton, R.B.; Gonçalves, J. and Erzini, K. 2008. Recreational rod and reel fishing from the shore in the south of Portugal: a preliminary socio-economic approach. *5th World Recreational Fishing Conference: "The Angler in the Environment"*, Dania Beach, Florida, 10-13 November, 2008. (poster)

### AVI-3. other publications

- Erzini, K. (coord.); Veiga, P.; Ribeiro, J.; Almeida, C.; Oliveira, F.; Bentes, L.; Monteiro, P. and Gonçalves, J.M.S. 2008. Parte I- Caracterização da pesca recreativa de costa do sul e sudoeste de Portugal. *Final Report. FCT POCI/MAR/58157/2004*. University of Algarve, CCMAR, Faro, 82 pp + Annexes. [In Portuguese]
- Erzini, K. (coord.); Guerreiro, A.; Veiga, P.; Ribeiro, J. and Gonçalves, J.M.S. 2008. Parte II- Caracterização dos campeonatos de pesca desportiva de costa do sul e sudoeste de Portugal. *Final Report. FCT POCI/MAR/58157/2004*. University of Algarve, CCMAR, Faro, 17 pp + Annexes. [In Portuguese]