Mestrado em Biologia e Ecologia do Litoral Marinho

Conservation Priority Index for the Portuguese Estuarine Fish Species

Índice de Prioridade de Conservação para as Espécies de Peixes Estuarinas Portuguesas

Paulo Branco

Orientador: Prof. Doutor Pedro Raposo de Almeida

Co-orientador: Doutor José Lino Costa

Universidade de Évora

2008

Mestrado em Biologia e Ecologia do Litoral Marinho

Conservation Priority Index for the Portuguese Estuarine Fish Species

Índice de Prioridade de Conservação para as Espécies de Peixes Estuarinas Portuguesas

Paulo Branco

Orientador: Prof. Doutor Pedro Raposo de Almeida

Co-orientador: Doutor José Lino Costa

Dissertação apresentada à Universidade de Évora para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Biologia e Ecologia do Litoral Marinho.

2008

Acknowledgements

This work would not have been possible without the help and support of some persons to whom I would like to express my sincerest thanks:

To Prof. Dr. Pedro Raposo de Almeida for proposing me this work. For all the support and availability.

To Dr. José Lino Costa for always being there to help me with any problem that arose and seemed unsolvable.

To both of them for the brainstorming sessions. We came a long way since the first discussion - this is a tree mind work.

To Prof. Dr. Vanda Brotas and to Prof. Dr. Isabel Ambar for allowing me to use the Institute's facilities. To Prof. Dr. Maria José Costa for accepting me into the Marine Zoology research team.

To Prof. Dr. Teresa Ferreira for agreeing to let me keep doing this work.

To all the colleagues at the Institute of Oceanography for accepting me amongst them and for the excellent work environment provided.

To all the colleagues at the Watterlobby group of ISA, with whom I have spent most of the time, for the excellent work environment and discussions about other subjects, environmental or not.

To all my friends who help me to forget this ordeal, for the all the talks, coffees, movies and experiences shared.

To my Family for their friendship and closeness.

To my parents for their warmth and support when I told them I would like to embark on another challenge. Without your support I am powerless, thank you for everything.

To Ana for always being there for me, you are my biggest friend.

To António and Contança for all the good moments and for the moments yet to come.

To Sofia for all the love, friendship and help. Thank you for being present whenever I needed. With you everything seems easier.

Conservation Priority Index for the Portuguese Estuarine Fish Species

Abstract

Environmental awareness is increasing and more efficient methodologies in determining the conservation priorities of biological components are needed. Multimetric indices are important tools, allowing data simplification and consequently a better understanding by managers, decision makers and general public. The aim of this work is to formulate an index capable of ranking the Portuguese estuarine fish species by their conservation priority. Ten metrics were scored, with bibliography references, for 72 species of 16 estuarine systems (W and S coasts of Portugal). Index Validation was done by external means. This index is the first to specifically address the conservation priority of estuarine fish and allows an identification of the top and bottom conservation priority species adding thus the planning of estuarine fish conservation.

Resumo

A consciência ambiental está a aumentar, sendo necessárias metodologias mais eficientes para determinar as prioridades de conservação de componentes biológicos. Os índices multimétricos são ferramentas importantes que permitem simplificar os dados, facilitando a sua compreensão por parte de gestores, decisores e do público em geral. O objectivo deste trabalho é formular um índice capaz de ordenar as espécies estuarinas portuguesas de peixes de acordo com a sua prioridade de conservação. Foram calculadas 10 métricas, com base em dados recolhidos na bibliografia, para 72 espécies de 16 sistemas estuarinos (costas O e S de Portugal). A validação do índice foi feita por meios externos. Este é o primeiro índice desenvolvido para avaliar a importância conservacionista de peixes estuarinos e permite identificar as espécies com maior e menor prioridade de conservação, auxiliando o planeamento da conservação de peixes estuarinos

Table of contents

Chapter 1

General Introduction

"Before I speak, I have something important to say. "

Groucho Marx (1890-1977)

General Introduction

Estuarine systems are considered to be some of the worlds' most productive and valuable aquatic ecosystems (Costanza et al. 1997). Marine species attain here a greater growth potential, confirming thus the importance of these systems as nursery areas for comercial importante species and to other taxa (Marchand 1980; Costa & Bruxelas 1989; Blaber et al. 2000; Gillanders et al. 2003; Le Pape et al. 2003; Able 2005). Nevertheless, this importance has not yet been properly assessed (Cabral & Costa 2001; Erzini et al. 2002; Martinho 2005). Estuaries can also act as a nutrient and organic matter provider to the neighbouring coastal areas, increasing the primary and secondary production. As transitory systems, they are recognised as part of the continental coasts having extreme biological and economic importance and being stage to a large number of human activities (Houde & Rutherford 1993; Cooper et al. 1994; Marques et al. 2004).

Estuaries are very complex and are ruled by environmental gradients, most of them derive from the fact that marine salt water and river freshwater meet here (Haedrich 1983). Their mixture creates a wide range of gradients that favours the recruitment of a vast array of species with different physical and trophic characteristics/needs (Sánchez & Raz-Guzman 1997; Harris et al. 2001; Kimmerer et al. 2001). The greater content in organic matter and nutrients present in these systems favours the establishment of benthic trophic webs, resulting in a food availability increase for the juveniles of several species (Peterson et al. 2000; Grall & Chauvaud 2002; Salen-Picard et al. 2002). In fact, fish juveniles have a particular tendency to use estuaries, largely due to the advantages provided by these systems in terms of growth, survival, food availability and protection from predators (Haedrich 1983; Miller et al. 1985; Lenanton & Potter 1987).

The fish fauna present at the estuaries experience a temporal and a spatial variation. These variations occur mostly due to species migrations (Elliott et al. 1990; Maes et al. 1998), to fish zonal distribution in relation to their saline tolerance (Loneragan et al. 1986; Henderson 1989) and to species preferences regarding sediment, vegetation and food (Elliott & Dewailly 1995; Marshall & Elliott 1998). The predatory pressure also influences habitat choice (Laegdsgaard & Johnson 2001). McHugh (1967) proposed a categorization of the species present in the estuary based on their usage of the system: freshwater fishes that occasionally visit the estuary, truly estuarine species, diadromous species, marine species that regularly visit the estuary as adults, marine species that use the estuary as a nursery area and marine occasional species.

Public and political consciousness towards conservation and biodiversity is increasing, demanding more impact assessment studies, ecological monitoring programs and management plans. Conservation biology tries to keep the biodiversity level by preserving the endangered species that otherwise could be lost. Biodiversity in relation to ecosystem function is one of the emerging areas of research in environmental biology and very little is known about it at national or international level (Singh & Sharma 1998). Protection of locations with high species richness is an effective way to protect overall biodiversity and sustain key ecological functions (Scott et al. 1987; Myers et al. 2000). In other words, species richness is assumed to be an indicator of conservation value (e.g., Meir et al. 2004).

In an effort to conserve biodiversity, resources are often directed towards protecting rare species in the belief that these are the species most at risk of extinction (Gaston 1994). In the absence of detailed population viability analyses, some of the main indicators used for the assessment of extinction risk are rarity, rates of decline and degree of population fragmentation (Hartley & Kunin 2003). Qualitative methods for categorizing species according to risk (e.g., Fitter & Fitter 1987) are appealing because they are simpler and less reliant on difficult-to-gather data. However, such methods suffer from a nearly complete reliance on expert opinion and from the difficulty in assigning species to distinct categories of risk (Mace & Lande 1991). Adoption of quantitative methods has been hampered by lack of data (Ceballos & Navarro 1991; Mace 1994) but their objectivity and repeatability are desirable attributes not found in qualitative methods (Todd & Burgman 1998).

The need for a priority-setting process is driven by limited conservation resources that can only be attributed to a small percentage of all possible species in any given geographic area. This need has led to the development of practical systems for categorizing and assessing the degree of vulnerability of various components of biodiversity, particularly vertebrates (e.g., TNC 1988; Millsap et al. 1990; Master 1991; Martin 1994; Stotz et al. 1996). Prioritization systems in use or proposed vary greatly in what factors are concerned, how these factors are scored, weighted and integrated, and how the resulting information is presented and used (Mehlman et al. 2004)

Species conservation demands an intrinsic and vast knowledge of the species biology and ecology, which is impossible for most of the species. To overcome this great information demand there are multimetric indices that can prioritize species in accordance to their perceived extinction risk (e.g., Millsap et al. 1990). These methodologies are simple to use, they rank the species by conservation priority based on some easily measured metrics.

Regarding the estuarine fish species, there is not an index that allows species ordination by conservation priority. Thus the creation of such an index would be an innovation. A conservation priority index would allow decision makers to understand the data and to take a correct decision, more in line with the real state of the systems and of the species. The aim of this work is to propose a multimetric index for the conservation of the Portuguese estuarine fish species, using the available bibliographic information on the species, resulting in a complement to the red list of endangered species (Cabral et al. 2005), which does not consider most of these species.

Chapter 2

Conservation Priority Index for Estuarine Fish (COPIEF).

(submitted)

Conservation Priority Index for Estuarine Fish (COPIEF).

Paulo Branco[1,2], José Lino Costa[1] and Pedro Raposo de Almeida[1,3,§]

1 – Institute of Oceanography, Faculty of Sciences, University of Lisbon, Campo Grande, 1749-016 Lisbon, Portugal

2 – Department of Forestry, Institute of Agronomy, Technical University of Lisbon, Tapada da Ajuda, 1340-017 Lisbon, Portugal

3 – Department of Biology, University of Évora, Apartado 94, 7002-554 Évora, Portugal.

§ - Corresponding author – E-mail: pmraposo@mail.telepac.pt; Tel. +351266760800; Fax. 351266760914

Abstract:

Public awareness regarding environmental issues has been increasing in the last decades. The increasing number of impact assessment studies, management and conservation plans, as well as ecological monitoring studies, demand new and more efficient techniques. Indices are an important tool aiding biologists in studies and allowing an easier comprehension of the data by managers, decision makers and general public. This study presents the first multimetrical index for establishing a hierarchical ordination of the conservation priority of estuarine fish species using, for that, 72 species from 16 estuarine systems (W and S coasts of Portugal). The index is composed by ten metrics, comprising species' life traits, distribution and population trends. The information needed to score each metric was gathered from bibliography and the index validation was done by external means. This methodology allowed the definition of the fish species more in need of conservation planning, and those less prone to extinction in estuarine systems. The proposed index will fill a gap

in the knowledge and contributes with a useful tool to the scientific community and to the decision makers, being a breakthrough on estuarine fish species conservation planning.

Keywords: Conservation of biodiversity, multimetric index, fish species, biodiversity, estuaries and coastal lagoons, Portugal

Introduction

Coastal transition systems, such as estuaries and coastal lagoons, are vital ecosystems to marine fish stocks and a passageway for diadromous migrants. Despite their importance, estuaries are also amongst the most modified and threatened aquatic ecosystems in the world (Blaber et al. 2000), suffering from severe human impacts that imperil their natural ecological function, limiting thus the continuity of the systems' health and viability (Goldberg 1995; Costa et al. 2002; Kennish 2002).

The conservation of the natural systems is one of the most important concerns of today's world. So, conservation planning must be undertaken with extreme rigor (Fleishman et al. 2006). The maximum goal of conservation biology is to maintain the biodiversity level (Linquist 2007), once it has an incredible value to human welfare. "Endangered species are elements that contribute to a region's biological diversity and whose regional extinction represents a measurable and potentially irretrievable loss" (Maiorano et al. 2006).

Species richness has always been used as an indicator of ecological condition or conservation value, mostly due to its information availability over long periods of time and on distinct locations (Fleishman et al. 2006). The use of species richness may be more related to the information availability and to the biologists desire to produce lists than to the real ecological significance (Fleishman et al. 2006). The use of simple lists has proved to be unsuccessful, conservation wise, once it considers each species as an equivalent unit, disregarding its individual ecological role (Piraino et al. 2002). In fact, the establishment of conservation priorities requires a vast range of ecological/biological values (Fleishman et al. 2006).

Many endangered species are so because of the loss of critical habitat to one or more life stages (e.g., Wilcove et al. 1998). The ecosystems natural populations' maintenance is an effective way to maintain the biodiversity (Balmford et al. 1996; Redford & Richter 1999; Groves 2003; Rosenzweig 2003) as it is the habitat protection.

With the continuous increase in public and political awareness towards conservation (Fletcher 2005) and the profusion of impact assessment and management studies, the development of tools and techniques which help the professionals to perform a more accurate, economic and less time consuming work is very important. Conservation biology is an applied science and, as such, is based on values (Meffe & Carrol 1994; Barry & Oelschlaeger 1996). The use of indexes in this kind of works is increasing (Spellerberg 1993; Olivier & Beattie 1994), since they simplify the data (Graça & Coimbra 1998; Hartwell 1998; Harris & Silveira 1999; Ladson et al. 1999) and simplify the decision making, maintaining the scientific accuracy (Paul 2003). This simplification (Ranasinghe et al. 2002) allows a better understanding of the problems by the decision makers (Knapp et al. 2003), enabling them to take correct decisions in accordance with the real state of the communities (Karr & Chu 1999). As for any model, the merit of an index is not only measured by the reality representation fidelity, but also in relation to its interpretation capability (Gómez Orea 2002).

Quantitative methods for prioritising species regarding their conservation needs, range from easily measured simple variables (e.g., Freitag & Van Jaarsveld 1997; Cofré & Marquet 1999) to more sophisticated methods (e.g., Millsap et al. 1990). This kind of methods has had a limited expression on conservation due to the lack of data (Ceballos & Navarro 1991; Mace 1994) or due to the difficult-to-gather data, but the capability of being repeated and their intrinsic objectivity are desirable qualities not found in the traditional qualitative methods (Todd & Burgman 1998). Moreover a quantitative method can be compared across countries or across distinct geographic areas (Ceballos & Navarro 1991). A method which offers an ordination of the species, conservation wise, aids in the distribution of limited conservation efforts/resources (Mace 1995; Reyers et al. 1998; Mehlman et al. 2004), maximizing thus the beneficial outcomes. Prioritising species based on their perceived endanger and conservation needs is a popular methodology in conservation biology (Rabinowitz 1981; TNC 1988; Mace & Collar 1994; Carter et al. 2000; Stein et al. 2000).

The information gaps and lack of knowledge of some species or of some life traits characteristics is a threat to the biodiversity and imperils conservation, once there are not valid values to base the conservation efforts on (Mares 1986). Even the identification of these knowledge gaps of the species biology is an important step towards species conservation (Cofré & Marquet 1999).

There is not, as far as our knowledge, an index which allows a fish species ordination by conservation priority. Thus, the creation of such an index would be an innovation, being the information gathered from the index a complement to the Portuguese Red List of Endangered Species (Cabral et al. 2005), which has considerable knowledge gaps concerning these species, and would create an hierarchical ranking instead of a simple list. A conservation priority setting system will be as reliable as the amount of knowledge available on the species contemplated. Nonetheless, a system with a great baseline information demand tends to have a smaller application spectre (Palmeirim et al. 1994; Harcourt & Parks 2003). A multimetric index with the capacity of ranking species in regard to their conservation priority has to have metrics which integrate pertinent information to the species ordination (Jackson et al. 2000), and has to comprise the biological sensitivity of the species as well as its population relevance (Palmeirim et al. 1994). This work purposes the enunciation of the first multimetric index for the conservation priority of estuarine fish species.

Materials and methods

Estuarine systems

In this work we studied 16 Portuguese systems (Fig. 1). These are the most important estuaries and open and semi-opened coastal lagoons in both the West and South (Algarve) coasts of Portugal. The spatial coverage allowed by the use of these systems gives a good spatial confidence to the index. Portugal is a biogeographic transitional zone. The Cape Carvoeiro constitutes the border between two zoogeographic zones, the Lusitanian and the West African, these zoogeographic zones represent also two distinct coastal climatic divisions, the Western Temperate and the Subtropical (Hayden et al. 1984). The estuarine systems present different characteristics between the two geographic zones so the systems were separated into northern and southern systems, being the Tagus estuary the first southern estuary.

Fish species

In the formulation of this multimetric index we considered 72 fish species. These species were selected based on a bibliographic collection of the fish fauna composition of the 16 estuarine systems, independently. To assure that just the estuarine species (the species that use the estuary frequently and not occasionally) were assessed, only the species that were present in more than 50% of the northern or the southern systems were included in the analysis. Nevertheless, species with especial importance/relevance in one or more systems were included even if they did not fulfil the above stated premises. The species that are now considered regionally extinct in Portugal (Cabral et al. 2005) were not included in the analyses.

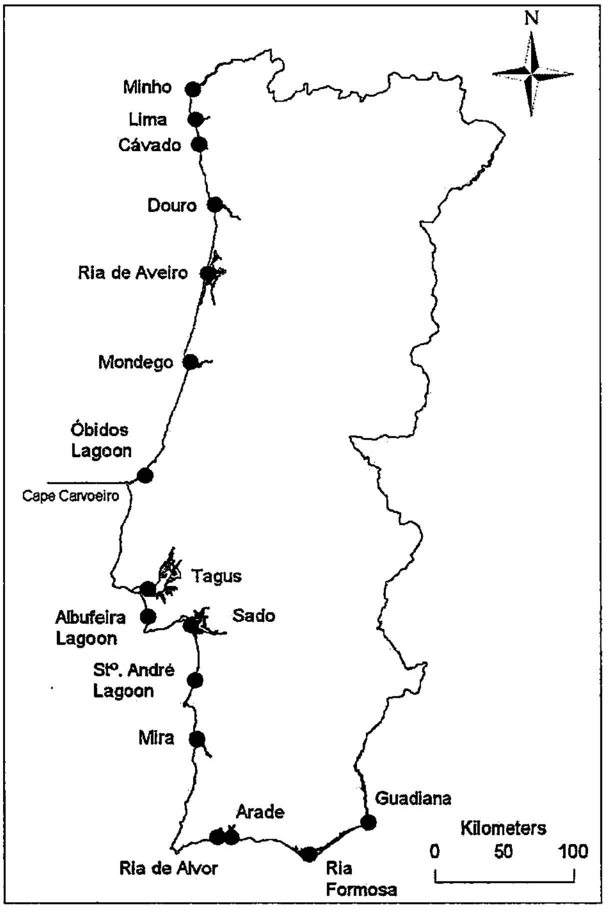

Figure 1 – Location of the 16 studied estuarine systems and of the Cape Carvoeiro that separates the northern from the southern estuarine systems.

Information gathering

The information regarding the potential metrics was gathered, selected and derived from a detailed and extensive bibliographic review (annex I). There was also punctual information facilitated by specialists of certain species or species groups.

Metric selection

In this numeric approach to the conservation of estuarine fish, several biological metrics that allow an ordination of the species in accordance to their conservation priority, were enunciated. These metrics facilitate a comprehension of the species relative sensibility. The list of potential metrics derived both from the bibliography as from the authors' personal knowledge of estuarine species. After the bibliographic search for the information on biological metrics for each species some of the original metrics were excluded from the index. The first criterion for metrics exclusion was the lack of information for many species. The second criterion for exclusion was the information redundancy input of the different metrics, which was evaluated using the Spearman's rank correlation test (Sokal & Rohlf 1995), that lead to the exclusion of one metric when it was highly correlated ($r>0.8$) with another, since both metrics were contributing with the same information input to the overall species hierarchy. The final 10 metrics selected represent the life trait of the species, their distribution and population trends.

Metric scoring

The scoring of each metric was reached taking in consideration the value attained by all the species in that metric, to better fit the score classes within the metrics' value range, and attributing a higher score to the class with greater conservation priority. The scoring process had some simple premises, the metrics had to be scored in relation to the adult fish and its survival probability. The metrics scores varied from zero (low conservation priority) to ten (high conservation priority). As the metric scoring values correspond to a class interval, when a species had an information gap it was filled, if possible, with that metrics information of a relative species (i.e., a species of the same genus or family) resulting thus in a surrogating value. When there was an impossibility to replace knowledge gaps, the value five was attributed to that metric. The value "five" was chosen as it is the central value in the metric score spectrum and it does not tend to pull the overall index score down or upwards.

Metrics

Fenology

This metric (Table 1) is based on the estuarine temporal occupation pattern of the species in Portugal. This usage evaluation was done both with resource to bibliography and with the authors and species specialists' knowledge of the species and their behaviour in Portuguese estuarine systems. The higher conservation values were attributed to the species which use the estuarine area for long periods of time, i.e., the resident species, being the lowest priority assigned to the marine species which only visit the estuary briefly for protection or foraging. The premise underlined in this scoring table is that a resident species is subjected to the same and more survival hazards as a species using the estuary only during a part of the life cycle (nursery or diadromous species) or just as an increment to their usual habitat (marine species).

In this metric the term nursery is applied to species which make an extensive use of estuarine systems as growth areas for juveniles (but that do not complete their life cycle in the estuary), since these systems grant some degree of protection from the predators and are resource richer environments.

Distribution

Regional distributional range (Table 1) – The West coast of Portugal is a zoogeographic transition region (Hayden et al. 1994) and, as such, many fish species have in Portugal their latitudinal distribution limit. Bearing this in mind, a species which finds in Portugal its distributional limit has to have a higher conservation value than one that does not. A species that finds here its southern limit has to be more protected than one that finds here its northern limit of distribution, due to the climatic changes (rising temperatures) and the noticeable latitudinal changes of the species distributions in the last decades. This scoring methodology is based on the premise that a species with its distribution limit in Portugal is more likely to disappear from this coast than a species without its distribution limit in Portugal.

Local distributional range (Table 1) – This metric refers to the dispersion of a species in Portuguese estuarine systems. The fundamental premise here is that a distribution restricted species has to have a higher conservation priority than a national widespread one. By the same principal referred to the regional distribution, species with a clear northern distribution were ranked higher than southern species.

Intra-estuarine zonation (Table 1) - This metric refers to the space usage done by the species in the estuarine system. A species that uses the entire estuary has lower conservation priority than one that uses only a part of the estuary, or a specific habitat. The species which occur at the mouth of the estuary have a greater capability to use the marine environment, having thus greater habitat availability, not deserving a high conservation value. The species with a seagrass beds zonal distribution had the highest score in this metric since this habitat availability is narrower.

Trophic ecology

This metric (Table 1) is based on the species trophic level and has as a premise the food availability in the system, and the energy needed to harvest that food item. Bearing this in mind, the species which consume less available items and feed at a higher trophic level have a greater score than the species whose food items are abundant. That is why the species with some trophic plasticity have a lower score than more specialized ones. Piscivores and parasites have the highest score value followed by species which are mainly piscivores but which have an important invertivore component in their diet. Following these species in the metric score, are the mainly invertivore species, then the species which feed primarily on invertebrates but vegetated matter is an important food item for them. The lower two metric classes are composed by herbivores and by the plankton and detritic feeders.

Maximum size

The metric (Table 1) scoring is, in this case, based on the size of the animal; large animals score higher than small ones. The underlined premise is that larger animals need more resources as well as greater vital areas. This is a valid simple assessing way to evaluate the vital area extension, once that this information is not available for many species. It was thus considered that species which attained larger sizes are more vulnerable than species with smaller sizes. For every species it was used the highest valid size found in the bibliography.

Reproduction strategy

Age at first maturity (Table 1) - The ranking scores in this metric relate to the probability of a successful reproduction. The premise is that a species with a younger age at first maturity has a higher probability of survival and of reproductive success than a species which matures later in the life span, scoring thus a lower conservation priority. For every species it was used the highest valid age at first maturity found in the bibliography.

Reproductive guilds (Table 1) - The reproductive guild metric is directly related to the degree of protection done by the adults to the hatch, implying thus greater or smaller energy consumption by the progenitors. The premise here is that a higher degree of protection leads to the increase in energy expenditure; therefore, there is a higher vulnerability of these species, scoring a higher conservation value.

Spawning frequency (Table 1) - The spawning frequency relates to conservation in the way that a species which spawns several times in its life is more likely to overcome, as a species, adverse conditions for the survival of the juveniles/eggs than a species which only spawns once in a lifetime, fitting, thus, in a lower scoring class.

Reproductive guilds and spawning frequency were pooled into one metric to avoid overweighting reproduction strategy.

Species national trends

This was a very hard metric (Table 1) to calculate, once this information is largely unknown by the scientific community. So, there were a lot of information gaps and these were filled using information from the National Fisheries Department (DGPA) and abundance data found in the bibliography. These data allowed the determination with some degree of certainty the probable trends of the species in the Portuguese territory. Nevertheless, the scoring classes for the extrapolated trends were kept nearer the "unknown" class (Table 1) than of the extremes of the metric, granting thus a minor interference of the extrapolation of the data on the final index result. Even though the difficulty in determining the species trends, this metric was kept in the index, once it is the only one that allows an integration of the actual state of the population.

Taxonomic importance

This metric (Table 1) is very precise and direct, it uses only the systematic position of a given species. The premise underlined here is that a species which is the sole representative of its family or genus is of greater conservation value than a species which shares its higher taxonomic level with more species. The loss of a family or genus is of greater importance to the biodiversity than the loss of a species.

Index calculation

The information provided by the metrics used to enunciate the index only makes sense when pooled together. Only the metrics' values integrated grant a unified view on the species relative sensibility. The Conservation Priority Index for Estuarine Fish (COPIEF) is a holistic way to define conservation priorities. The index is calculated by averaging the values attained by a species in all the metrics.

Validation

To assess the robustness and accuracy of the index, it was validated by external means. The first validation step was to validate our results with the criteria of the IUCN (IUCN 2001). The second route of validation was supported by experts' knowledge. In this second validation methodology the species list was delivered to five specialists of Portuguese estuarine fish (see acknowledgments). The specialists were asked to give a priority conservation value from 1 to 3 (being 1 the lowest priority and 3 the higher) in accordance with their knowledge of the species. The specialists' rankings were averaged to get an overall accordance specialists' index. Then this ranking was compared (Spearman's rank correlation test) to the one accomplished by the purposed index to assert if there were common views between the index and the experts informed insight.

In order to further validate the index results, this multimetric methodology was applied on a recently regionally extinct species (*Acipenser sturio* Linnaeus, 1758), just to make an index estimative. Theoretically, an extinct species should attain a high conservation priority score on the proposed index.

Table 1. Metrics ranking scores for the Conservation Priority Index for Estuarine Fish (COPIEF)

Metric	Score
Fenology	
Resident	10
Nursery + Diadromous	5
Marine	0
Regional Distribution	
Southern distribution limit	10
Northern distribution limit	5
Widespread	0
Local Distribution	
Restricted	10
Predominantly Northern	7
Predominantly Southern	4
Widespread	0
Intra-estuarine Zonation	
Mainly at seagrass beds	10
Mainly at middle or upper estuary	5
Mainly at the estuary mouth or all the estuary	0
Trophic Ecology	
Parasite + Piscivore	10
Piscivore and Invertivore	8
Invertivore	6
Invertivore and Herbivore	4
Herbivore	2
Plankton feeders + Detritic feeders	0
Maximum Size	
> 100 cm	10
71 – 100 cm	8
51 – 70 cm	6
21 – 50 cm	4
11 – 20 cm	2
5 – 10 cm	0
Age at First Maturation	
> 10 years	10
9 – 10 years	8
6 – 8 years	6
3 – 5 years	4
1 – 2 years	2
< 1 year	0
Reproduction Strategy	
Reproductive Guilds	
Internal transportation	5
Parental protection	4
Benthic eggs (sticky/shells)/nesting	2
Pelagic spawner	0

(Cotinued on next page)

Table 1 (continued)

Metric	Score
Spawnning Frequency	
Smelparous	5
Iteroparous	0
National Population Trends	
Decreasing	10
Unknown but possibly decreasing	7
Unknown	5
Unknown but possibly stable or increasing	3
Increasing or stable	0
Taxonomic Relevance	
Sole family representative in Portuguese estuaries	10
Sole genus representative in Portuguese estuaries	5
Multispecifc genus in Portuguese estuaries	0

Results

Although the difficulty to find data to correctly score the species in all the metrics (Table 2), only five values (0.63%) out of 792 were scored as unknown, due to lack of information on the species or their relatives. The Sperarman rank correlation test showed that there were not any high correlations between the chosen metrics, meaning that there is not information redundancy within those metrics.

The index score varies from 0.9 to 7.1, having a wide score spectrum and allowing a good species segregation. The upper and lower ends of the index distribution are clearly isolated from the middle bulk of the ranking, which groups all the species that present only slight score variation, resulting in a continuous decrease instead of a step fall.

Validation

This multimetric index ranking system had to be validated by external means. It was tried to validate the index with the IUCN criteria but the kind of information needed to do that does not exist. So, in view of this, it was impossible to pursue this validation route. The way found to accomplish this task was to request the assistance of five Portuguese estuarine fish species experts. The index ranking and the experts ranking are positively correlated with high significance ($r = 0.49$, $N = 72$, $p < 0.001$).

To corroborate this finding it was calculated the conservation priority index value for the regionally extinct species *A. sturio* which scored 7.4. This value would place it in the first ranking position just before the salmon (*Salmo salar* Linnaeus, 1758).

Table 2. Species ranked by the value attained in the Conservation Priority Index for Estuarine Fish (COPIEF), with indication of the score attained by each species in each metric.

#	Species	FEN	RD	LD	ID	TE	MS	FM	RG	RF	NT	TAX	COPIEF
1	*Salmo salar* Linnaeus, 1758	5	10	10	5	8	10	6	2	5	10	0	7.1
2	*Anguilla anguilla* (Linnaeus, 1758)	5	0	0	5	8	10	10	0	5	10	10	6.3
3	*Lampetra fluviatilis* (Linnaeus, 1758)	5	0	10	0	10	4	6	2	5	10	5	5.7
3	*Petromyzon marinus* Linnaeus, 1758	5	0	7	0	10	10	6	2	5	7	5	5.7
5	*Argyrosomus regius* (Asso, 1801)	5	0	10	0	10	10	4	0	0	7	10	5.6
6	*Conger conger* ([Artedi, 1738] Linnaeus, 1758)	5	0	0	0	8	10	10	0	5	7	10	5.5
6	*Raja undulata* Lacepède, 1802	5	0	4	0	6	8	8	4	0	10	10	5.5
8	*Salmo trutta* Linnaeus, 1758	5	0	10	5	8	10	4	2	0	10	0	5.4
9	*Gasterosteus aculeatus* (Linnaeus, 1758)	5	0	7	5	6	2	2	2	5	7	10	5.1
10	*Alosa alosa* (Linnaeus, 1758)	5	0	0	5	8	8	8	0	5	10	0	4.9
10	*Ciliata mustela* (Linnaeus, 1758)	5	10	7	0	6	4	2	0	0	5	10	4.9
12	*Dicentrarchus labrax* (Linnaeus, 1758)	5	0	0	5	8	10	8	0	0	10	0	4.6
13	*Plathicthys flesus* (Linnaeus, 1758)	5	0	0	5	8	6	4	0	0	7	10	4.5
14	*Alosa fallax* (Lacepède, 1803)	5	0	0	5	8	6	8	2	0	10	0	4.4
14	*Halobatrachus didactylus* (Bloch & Schneider, 1801)	10	0	4	0	8	6	2	4	0	0	10	4.4
14	*Monochirus hispidus* Rafinesque, 1814	10	5	4	5	6	2	2	0	0	5	5	4.4
17	*Ammodytes tobianus* (Linnaeus, 1758)	10	10	0	0	0	2	2	2	0	7	10	4.3
17	*Serranus hepatus* (Linnaeus, 1758)	5	0	4	0	8	4	5	0	0	7	10	4.3
19	*Callionymus lyra* Linnaeus, 1758	5	0	0	0	6	4	6	0	5	5	10	4.1
19	*Symphodus bailloni* (Valenciennes, 1839)	10	0	0	10	6	4	2	4	0	5	0	4.1
21	*Trigla lucerna* Linnaeus, 1758	5	0	0	0	8	8	2	0	0	7	10	4.0
22	*Sarpa salpa* (Linnaeus, 1758)	5	0	0	10	2	6	4	0	0	7	5	3.9
22	*Symphodus cinereus* (Bonnaterre, 1788)	10	0	0	10	6	2	2	4	0	5	0	3.9
24	*Dicentrarchus punctatus* (Bloch, 1792)	5	0	4	0	8	6	8	0	0	7	0	3.8
24	*Diplodus puntazzo* (Cetti, 1777)	5	5	4	0	4	6	2	0	0	7	5	3.8
26	*Nerophis lumbriciformis* (Jenyns, 1835)	10	0	0	10	0	2	0	5	0	5	5	3.7
27	*Scorpaena notata* Rafinesque, 1810	0	0	4	0	8	4	5	0	0	5	10	3.6
28	*Belone belone* (Linnaeus, 1761)	0	0	0	0	8	8	2	2	0	5	10	3.5

(Continued on next page)

Table 2 (continued)

#	Species	FEN	RD	LD	ID	TE	MS	FM	RG	RF	NT	TAX	COPIEF
28	*Scophthalmus rhombus* (Linnaeus, 1758)	0	0	0	0	8	8	2	0	0	7	10	3.5
28	*Trachurus trachurus* (Linnaeus, 1758)	0	0	0	0	8	6	4	0	0	7	10	3.5
31	*Hippocampus hippocampus* (Linnaeus, 1758)	10	0	0	10	0	2	0	5	0	7	0	3.4
31	*Hippocampus ramulosus* Leach, 1814	10	0	0	10	0	2	0	5	0	7	0	3.4
31	*Syngnathus acus* Linnaeus, 1758	10	0	0	10	0	4	0	5	0	5	0	3.4
31	*Syngnathus typhle* Linnaeus, 1758	10	0	0	10	0	4	0	5	0	5	0	3.4
35	*Solea senegalensis* Kaup, 1858	5	0	0	5	6	6	4	0	0	7	0	3.3
35	*Solea solea* (Linnaeus, 1758)	5	0	0	5	6	6	4	0	0	7	0	3.3
37	*Buglossidium luteum* (Risso, 1810)	0	0	10	0	6	2	4	0	0	5	5	3.2
37	*Pagellus bogaraveo* (Brünnich, 1768)	0	0	0	0	8	6	6	0	0	7	5	3.2
37	*Pagrus pagrus* (Linnaeus, 1758)	0	0	0	0	8	8	4	0	0	7	5	3.2
40	*Atherina boyeri* Risso, 1810	10	5	0	5	0	2	2	2	0	5	0	3.1
40	*Gobius paganellus* Linnaeus, 1758	10	0	0	0	6	2	4	4	0	5	0	3.1
40	*Microchirus azevia* (Capello, 1867)	0	5	4	0	6	4	4	0	0	3	5	3.1
40	*Mugil cephalus* Linnaeus, 1758	5	0	0	0	0	10	6	0	0	5	5	3.1
44	*Boops boops* (Linnaeus, 1758)	5	0	0	10	2	4	4	0	0	0	5	3.0
44	*Mullus surmuletus* Linnaeus, 1758	5	0	0	0	6	4	2	0	0	3	10	3.0
44	*Parablennius pilicornis* (Cuvier, 1829)	10	5	0	0	4	2	2	2	0	5	0	3.0
44	*Pomatoschistus marmoratus* (Risso, 1810)	10	5	0	0	6	0	2	2	0	5	0	3.0
44	*Pomatoschistus microps* (Krøyer, 1838)	10	0	0	0	6	0	2	4	5	3	0	3.0
49	*Aphia minuta*(Risso, 1810)	10	0	0	0	0	0	2	2	5	5	5	2.9
49	*Engraulis encrasicolus* (Linnaeus, 1758)	10	0	0	0	0	2	2	0	0	5	10	2.9
49	*Parablennius gattorugine* (Linnaeus, 1758)	10	0	0	0	4	4	2	4	0	5	0	2.9
49	*Syngnathus abaster* Risso, 1826	10	0	0	5	0	4	0	5	0	5	0	2.9
53	*Spondyliosoma cantharus* (Linnaeus, 1758)	5	0	0	0	6	6	4	2	0	0	5	2.8
54	*Gobius Niger* Linnaeus, 1758	10	0	0	0	6	2	2	2	0	5	0	2.7
54	*Sparus aurata* Linnaeus, 1758	5	0	0	0	4	6	4	0	0	3	5	2.7
56	*Diplodus bellottii* (Steindachner, 1882)	5	5	4	0	6	4	2	0	0	0	0	2.6
57	*Chelon labrosus* (Risso, 1826)	5	0	0	0	0	6	4	0	0	5	5	2.5
57	*Diplodus cervinus* (Lowe, 1841)	0	0	4	0	4	6	4	0	0	7	0	2.5

(Continued on next page)

Table 2 (continued)

#	Species	FEN	RD	LD	ID	TE	MS	FM	RG	RF	NT	TAX	COPIEF
57	*Pomatoschistus minutus* (Pallas, 1770)	10	0	0	0	6	2	0	4	0	3	0	2.5
57	*Pomatoschistus pictus* (Malm, 1865)	10	0	0	0	6	0	2	2	0	5	0	2.5
61	*Liza saliens* (Risso, 1810)	5	0	0	5	0	4	4	0	0	5	0	2.3
62	*Diplodus sargus* (Linnaeus, 1758)	5	0	0	0	4	4	2	0	0	7	0	2.2
63	*Arnoglossus laterna* (Walbaum, 1792)	0	0	0	0	8	4	4	0	0	5	0	2.1
63	*Arnoglossus thori* Kyle, 1913	0	0	4	0	8	2	2	0	0	5	0	2.1
63	*Echiichthys vipera* (Cuvier, 1829)	0	0	0	0	0	2	4	0	0	5	10	2.1
63	*Solea lascaris* (Risso, 1810)	0	0	0	0	6	4	4	0	0	7	0	2.1
67	*Liza aurata*(Risso, 1810)	5	0	0	0	0	6	4	0	0	5	0	2.0
67	*Liza ramado* (Risso, 1826)	5	0	0	0	0	6	4	0	0	5	0	2.0
69	*Diplodus annularis* (Linnaeus, 1758)	0	0	0	0	6	4	2	0	0	7	0	1.9
70	*Diplodus vulgaris* (E. Geoffrey Saint-Hilaire, 1817)	5	0	0	0	6	4	2	0	0	0	0	1.7
71	*Sardina pilchardus* (Walbaum, 1792)	0	0	0	0	0	4	4	0	0	0	5	1.3
72	*Atherina presbyter* Cuvier, 1820	0	0	0	0	0	2	0	2	0	5	0	0.9
	Acipenser sturio Linnaeus, 1758 (*)	5	10	10	5	6	10	6	2	0	10	10	7.4

FEN – Fenology; RD – Regional Distribution; LD – Local Distribution; ID – Inter-estuarine Distribution; TE – Trophic Ecology; MS – Maximum Size; FM – Age at First Maturation; RG – Reproductive Guilds; SF – Spawning Frequency; NT – National Population Trends; TAX – Taxonomic Relevance; (*) – Regionally extinct.

Discussion

The proposed methodology allowed the ranking of the Portuguese estuarine fish species. This ordination enabled the identification of the next species up for extinction, as it did for the species with least conservation concern. The top 11 ranked species are species with real conservation hazards that, due to their life trait characteristics, their distribution and their population trends, are on the road to a possible regional extinction. These 11 species are ranked higher in the conservation hierarchy because they feed at a high taxonomic level, have a scattered or restricted local distribution and most of them have a decreasing national population trend, attain a high body size and are smelparous. All the species ranked in the top 11 positions are diadromous or use the estuarine system as a nursery ground, having all of them the same fenology score. From these 11 species, seven are listed as endangered species in the Portuguese Red List of Endangered Species (Cabral et al. 2005), the four remaining are marine species which are not contemplated in the former list, this reveals that COPIPEF is a valid methodology. These 11 species are the ones in which the conservation plans should be focused. The bottom ranked species are species which have a greater capacity to persist as a species, not needing an urgent conservation plan dedicated to them. On the other hand, it is possible to detect in the lower end of the ranking a step in the index values which allows a separation of the 12 last species. These species fit in such a low ranking position because they have a widespread regional, local, and intra-estuarine distribution, and they spawn several times during their life, having some other favourable life traits. The combination of favourable characteristics places these species in a low concern position, once they grant them a certain resistance against extinction pressures. Nevertheless, this does not mean that they are endless resources to be exploited. They can in fact be exploited with a certain degree of safety but, due to global changes and environmental pressures their hierarchical position may be altered in a way that they can not be recovered from. So, even species with a low conservation priority, still have to be integrated in general conservation startegy and, when exploited it has to be done with caution and in a sustained way. The low ranking species must never be neglected since they maintain fisheries and are on the base of the food web, contributing for the existence of various estuarine and coastal processes (Piraino et al. 2002). For instance *Sardina pilchardus* (Walbaum, 1792) represented, in the last 10 years, 83.6±12.1% of all the fish captured by the Portuguese fishing fleet (DGPA 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006) and *Liza ramado* (Risso, 1826) is one of the most important species in what regards to estuarine biomass availability (Almeida et al. 1993) and have a valuable ecological role in these systems. So, even though their low ranking, these species are very important for the maintenance of the coastal biodiversity and stocks, being essential links of the systems' processes.

An index such as COPIPEF has to pass through a validation process to allow a certain confidence in the results. The fact that the insight of five independent experts, without any knowledge of the methodology followed to enunciate this index, is positively correlated with the ranking positions of the species attained by the use of the proposed index, is a clear indication of the index closeness to the true conservation priorities. The correlation value is quite high if considered that the specialists based their opinion on the known or perceived population trend of each species; and that each specialist is more knowledgeable of certain species or certain species groups. This results in an external validation of the index, confirming thus the accurateness of this multimetric approach to the conservation priority of the estuarine fish species. The index value for the *A. sturio* was calculated, and if it was not extinct in Portugal, it would be ranked as the top species most in need of a conservation strategy. This further reinforces the index accuracy, since that species did in fact go extinct. Bering this in mind, the top priority species really need to be protected, as should their habitats. The salmon is the next inline for the regional extinction, it is very fragile and its capacity to overcome future problems is limited. It has a high commercial value linked to a decreasing population trend and the southern limit of its distribution at the North of Portugal, being thus locally affected by the global climate changes. All these factors associated with unfavourable life trait characteristics, gravely imperil this species.

The impossibility of asserting the conservation status of the considered species by the IUCN criteria, due to the lack of information, reinforces the need of an index such as the one proposed in this paper. This index uses available information based on the species life traits, ecology, distribution and population trends, instead of population numbers, expected percentages of population decrease and distribution range limitation. Even the identification of knowledge gaps is the first step to conservation (Cofré & Marquet 1999). Identifying these gaps allowed a greater index validation as it will allow a classification, conservation wise, of certain species that otherwise would not be possible to classify. The Conservation Priority Index for Estuarine Fish gives new insight into estuarine fish species conservation, and it could function as a tool for fish species conservation planning alongside with the Portuguese Red List of Endangered Species (Cabral et al. 2005). Vertebrate ecology is still incompletely known, so all ranking systems are imperfect (Báldi et al. 2001). Nevertheless, a ranking system such as the one developed in this work is a very important tool for ecologists. The work is easier and more doable than without this kind of methodologies. The proposed index is the first conservation priority ranking system for estuarine fish species and it is a breakthrough in terms of conservation biology. There are several indices of conservation priorities related to areas (Freitag et al. 1997; Bonn & Gaston 2005; Fox & Beckley 2005; Bani et al. 2006) or to other animal (Cofré & Marquet 1999; Polasky et al. 2001; Knapp et al. 2003; Mehlman et al. 2004; Keith et al. 2007) or plant groups (Martínez et al. 2006). Fish are under-represented in this kind of methodologies and there is the risk of neglegting fish conservation, or doing it inadequately. This index is thus of extreme importance, once that now there is the possibility to detect which species are most in need of a concentrated effort in conservation. A methodology such as this can work even on another level, it can be used to calculate sensitivity zones within estuaries and to identify relevant systems in terms of fish communities conservation. By adding the index values of the species found in each territorial area it is possible to have an local/system sensitivity index; the higher the value the more sensitive a zone is.

The Conservation Priority Index for Estuarine Fish establishes a new perspective in terms of fish conservation, being a new methodology applicable to other countries. "The analysis of priorities for conservation and threat of particular fauna is intrinsically a never-ending dynamic process. Species are continually moving among categories depending on the amelioration or increase in particular factors that impose on their numbers and distribution" (Cofré & Marquet 1999). Thus, further work must be done. The information gaps need to be filled to allow an even greater closeness of the index to the reality. And, as time goes by, the species ranking position, may alter themselves, due to climate changes, habitat degradation and reduction, and the alteration of anthropogenic pressures; so, periodical recalculation of the species index score must be done. The index should be widen to other areas creating a regional or a global index, it should also be applied, with slight modifications, to other environments such as coastal marine areas and freshwater systems

Acknowledgments

The authors would like to express their thanks to Drs. H. Cabral, K. Erzini, L. Gordo, M. J. Costa and P. Cunha for their expert insight and availability. The authors are also thankful to Dr. G. Pestana for the availability to discuss some questions concerning the Sparidae family.

Literatue cited

Almeida, P. R., F. Moreira, J. L. Costa, C. A. Assis, and M. J. Costa. 1993. The feeding strategies of *Liza ramada* (Risso, 1826) in fresh and brackish water in the river Tagus, Portugal. Journal of Fish Biology **42**:95-107.

Báldi, A., G. Sorba, and Z. Korsós. 2001. Setting priorities for the conservation of terrestrial vertebrates in Hungary. Biodiversity and Conservation **10**:1283-1296.

Balmford, A., G. M. Mace, and N. Leader-Williams. 1996. Designing the ark: setting priorities for the captive breeding. Conservation Biology **10**:719-727.

Bani, L., D. Massimino, L. Bottoni, and R. Massa. 2006. A multiscale method for selecting indicator species and priority conservation areas: a case study for broadleaved forests in Lombardy, Italy. Conservation Biology **20**(supplement 2):512-526.

Barry, D., and M. Oelschlaeger. 1996. A science for survival: values and conservation biology. Conservation Biology **10**: 905–911

Blaber, S. J. M., D. P. Cyrus, J. J. Albaret, C. V. Ching, J. W. Day, M. Elliot, M. S. Fonseca, D. E. Hoss, J. Orensanz, I. C. Potter, and W. Silvert. 2000. Effects of fishing on the structure and functioning of estuarine and nearshore ecosystems. ICES Journal of Marine Science **57**:590-602.

Bonn, A., and K. J. Gaston. 2005. Capturing biodiversity: selecting priority areas for conservation using different criteria. Biodiversity and Conservation **14**:1083-1100.

Cabral, M. J. (coordenator), P. R. Almeida, T. Dellinger, N. Ferrand de Almeida, M. E. Oliveira, J. M. Palmeirim, A. I. Queiroz, L. Rogado, and M. Santos-Reis, editors. 2005. Livro Vermelho dos Vertebrados de Portugal. Instituto da Conservação da Natureza, Lisboa.

Carter, M. F., W. C. Hunter, D. N. Pashley, and K. V. Rosenberg. 2000. Setting conservations priorities for landbirds in the United States: the partners in flight approach. Auk **117**:541-548.

Ceballos, G., and D. Navarro. 1991. Diversity and conservation of Mexican mammals. pages 167-198 in M. A. Mares and D. J. Schmidly, editors. Latin American Mammalogy. University of Oklahoma Press, Norman, OK.

Cofré, H., and P. A. Marquet. 1999. Conservation status, rarity, and geographic priorities for conservation of Chilean mammals: an assessment. Biological Conservation **88**:53-68.

Costa, M. J., H. N. Cabral, P. Drake, A. N. Economou, C. Fernandez-Delgado, L. Gordo, J. Marchand, and R. Thiel. 2002. Recruitment and production of commercial species in estuaries. Pages 54-123 in M. Elliott and P. A. Henderson, editors. Fishes in estuaries. Blackwell.

DGPA – Direcção-Geral das Pescas e Aquicultura.1997. Recursos da pesca. Vol. 11. Direcção-Geral das Pescas e Aquicultura, Lisboa.

DGPA – Direcção-Geral das Pescas e Aquicultura.1998. Recursos da pesca. Vol. 12. Direcção-Geral das Pescas e Aquicultura, Lisboa.

DGPA – Direcção-Geral das Pescas e Aquicultura.1999. Recursos da pesca. Vol. 13. Direcção-Geral das Pescas e Aquicultura, Lisboa.

DGPA – Direcção-Geral das Pescas e Aquicultura. 2000. Recursos da pesca. Vol. 14. Direcção-Geral das Pescas e Aquicultura, Lisboa.

DGPA – Direcção-Geral das Pescas e Aquicultura. 2001. Recursos da pesca. Vol. 15. Direcção-Geral das Pescas e Aquicultura, Lisboa.

DGPA – Direcção-Geral das Pescas e Aquicultura. 2002. Recursos da pesca. Vol. 16. Direcção-Geral das Pescas e Aquicultura, Lisboa.

DGPA – Direcção-Geral das Pescas e Aquicultura. 2003. Recursos da pesca. Vol. 17. Direcção-Geral das Pescas e Aquicultura, Lisboa.

DGPA – Direcção-Geral das Pescas e Aquicultura. 2004. Recursos da pesca. Vol. 18. Direcção-Geral das Pescas e Aquicultura, Lisboa.

DGPA – Direcção-Geral das Pescas e Aquicultura. 2005. Recursos da pesca. Vol. 19. Direcção-Geral das Pescas e Aquicultura, Lisboa.

DGPA – Direcção-Geral das Pescas e Aquicultura. 2006. Recursos da pesca. Vol. 20. Direcção-Geral das Pescas e Aquicultura, Lisboa.

Fleishman, E., R. F. Noss, and B. R. Noon. 2006. Utility and limitations of species richness metrics for conservation planning. Ecological Indicators **6**:543-553.

Fletcher, W. J. 2005. The applicayion of qualitative risk assessment methodology to prioritize issues for fisheries management. ICES Journal of Marine Sciences **62**:1576-1587.

Fox, N., and L. E. Beckley. 2005. Priority areas for conservation of western Australia coastal fishes: A comparison of hotspots, biogeographical and complementarity approaches. Biological conservation **125**:399-410.

Freitag, S., and A. S. Van Jaarsveld. 1997. Relative occupancy, endemism, taxonomic distinctiveness and vulnerability: prioritizing regional conservation actions. Biodiversity and Conservation **6**:211-232.

Goldberg, E. D. 1995. Emerging problems in the coastal zone for the twenty first century. Marine Pollution Bulletin **31**:152–8.

Gómez Orea, D. 2002. Ordenación territorial. Mundiprensa, Madrid.

Graça, M. A. S., and C. N. Coimbra. 1998. The elaboration of indices to assess biological water quality. A case study. Water Research **32**:380–392

Groves, C. R. 2003. Drafting a conservation blueprint: A practicioner's guide to planning for biodiversity. Island Press, Washington, DC.

Harcourt, A. H., and S. A Parks. 2003. Threatened primates experience high human densities: adding an index of threat to the IUCN Red List criteria. Biological Conservation **109**:137-149

Harris, J. H., and R. Silveira. 1999. Large-scale assessments of river health using Index of Biotic Integrity with low-diversity fish communities. Freshwater Biology **41**:235–252.

Hartwell, S. I., editor. 1998. Biological Habitat Quality Indicators for Essential Fish Habitat, Workshop Proceedings, 14–15 July 1997, Charleston, SC. NOAA Technical Memorandum NMFS/SPO-32, NOAA/NMFS, Silver Spring, MD.

Hayden, B. P., G. C. Ray, and R. Dolan. 1984. Classification of coastal marine environments. Environmental Conservation **11**:199-207.

IUCN – International Union for the Conservation of Nature. 2001. IUCN Red List Categories and Criteria: Version *3.1*. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, U.K.

Jackson, L. E., J. Kurtz, and W. S. Fisher, editors. 2000. Evaluation Guidelines for Ecological Indicators. EPA/620/R-99/005, US Environmental Protection Agency, Office of Research and Development, Research Triangle Park, North Carolina.

Karr, J. R., and E. W. Chu, editors. 1999. Restoring Life in Running Waters, Better Biological Monitoring. Island Press, Washington, DC.

Keith, M., C. T. Chimimba, B. Reyers, and A. S. van Jaarsveld. 2007. A comparitive analysis of components incorporated in conservation priority assessments: a case study based on South African species of terrestrial mammals. African Zoology **42**(supplement 1):97-111.

Kennish, M. J. 2002. Environmental threats and environmental future of estuaries. Environmental Conservation **29**:78–107.

Knapp, S. M.; Russel, R. E., and Swihart, R. K. (2003). Setting priorities for conservation: the influence of uncertainty on species rankings of indiana mammals. Biological Conservation **111**: 223-234.

Ladson, A. R., L. J. White, J. A. Doolan, B. L. Finlayson, B. T. Hart, P. S. Lake, and J. W. Tilleard. 1999. Development and testing of an index of stream condition for waterway management in Australia. Freshwater Biology **41**:453–468.

Lindquist, S. 2007. But is it progress? On the alleged advances of conservation biology over ecology. Biology & Philosophy DOI 10.1007/s10539-007-9082-x

Mace, G. M. 1994. Classifying threatened species: means and ends. Philosophical Transactions of the Royal Society of London **344**:91-97.

Mace, G. M. 1995. Classification of threatened species and its role in conservation planning. Pages 197-213 in J. H. Lawton and R. M. May, editors. Extinction rates. Oxford university press, New York.

Mace, G. M., and Collar, N. J. 1994. Extinction risk assessment for birds through quantitative criteria. Conservation Biology **11**:849-856.

Maiorano, L., A. Falcucci, and L. Boitani. 2006. Gap Analysis of terrestrial vertebrates in Italy: Priorities for conservation planning in a human dominated landscape. Biological conservation **133**:455-473.

Mares, M. A. 1986. Conservation in south America: problems, consequences and solutions. Science **233**:743-749.

Martínez, G. J., A. M. Planchuelo, E. Fuentes, and M. Ojeda. 2006. A numerical index to establish conservation priorities for medical plants in the Paravachasca Valley, Córdoba, Argentina. Biodiversity and Conservation **15**:2457-2475.

Meffe, G. K., and C. R. Carroll. 1994. The design of conservation reserves. Pages 265-304 in G. K. Meffe and C. R. Carroll, editors. Principles of conservation biology. Sunderland, Sinauer Associates.

Mehlman, D. W., K. V. Rosenberg, J. V. Wells, and B. Robertson. 2004. A comparison of North American avian conservation priority ranking systems. Biological Conservation **120**:383-390.

Millsap, B. A., J. A. Gore, D. E. Runde, and S. I. Cerulean. 1990. Setting priorities for the conservation of fish and wildlife species in Florida. Wildlife Monographs **111**:1-57.

Olivier, I., and A. J. Beattie. 1994. A possible method for the rapid assessment of biodiversity. Pages 133-136 in P. L. Forey, C. J. Humphries and R. I. Vane-Wright, editors. Systematics and Conservation Evaluation. Clarendon Press, Oxford.

Palmeirim, J. M., F. Moreira, and P. Beja. 1994. Estabelecimento de prioridades de conservação de vertebrados terrestres a nível regional: o caso da costa sudoeste portuguesa. Pages 167-199 in Professor Germano da Fonseca Sacarrão. Museu Bocage, Lisboa.

Paul, J. F. 2003. Developing and applying an index of environmental integrity for the US Mid-Atlantic region. Journal of Environmental Management **67**:175-185.

Piraino, S., G. Fanelli, and F. Boreo. 2002. Variability of species' roles in marine communities: change of paradigms for conservation priorities. Marine Biology **140**:1067-1074.

Polasky, S., B. Csuti, C. A. Vossler, and S. M. Meyers. 2001. A comparison of taxonomic distinctness versus richness as criteria for setting conservation priorities for North American birds. Biological Conservation **97**:99-105.

Rabinowitz, D. 1981. Seven forms of rarity. Pages 205-217 in H. Synge, editor. The biological aspects of rare plant conservation. Wiley, Chichester, UK.

Ranasinghe, J. A., J. B. Frithsen, F. W. Kutz, J. F. Paul, D. E. Russel, R. A. Batiuk, J. L. Hyland, J. Scott, and D. M. Dauer. 2002. Application of two indices of benthic community condition in Chesapeake Bay. Environmetrics **13**:499-511.

Redford, K. H., and B. D. Richter. 1999. Conservation of biodiversity in a world of use. Conservation Biology **13**:1246-1256.

Reyers, B., A.Van Jaarsveld, and M. A. McGeoch. 1998. National biodiversity risk assessment: a composite multivariate and index approach. Biodiversity and Conservation **7**:945-965.

Rosenzweig, M. L. 2003. Win-win ecology: How the Earth's species can survive in the mist of human enterprise. Oxford University Press, Oxford, UK.

Sokal, R. R., and F. J. Rohlf. 1995. Biometry: the principles and practice of statistics in biological research. 3rd edition. W. H. Freeman, New York, USA.

Spellerberg, I. F., editor. 1993. Monitoring ecological change. Cambridge University Press, Cambridge.

Stein, B. A., L. S. Kutner, and J. S. Adams, editors. 2000. Precious heritage: the status of biodiversity in the United States. Oxfordx University Press, New York.

TNC (The Nature Conservancy).1988. Natural heritage program operations manual. Then Natural Conservancy, Arlington, Virginia.

Todd, C. R. and M. A. Burgman. 1998. Assessment of threat and conservation priorities under realistic levels of uncertainty and reliability. Conservation Biology **12**:966-974.

Wilcove, D. S., D. Rosthstein, J. Dubow, A. Phillips, and E. Losos. 1998. Quantifying threats to imperil species in the United States. BioSciense, **48**(supplement 8):607-615.

Chapter 3

General conclusions

General conclusions

Conservation planning is one of the most urgent and difficult matters on the worlds' agenda. Assessing the species' risk of extinction is essential to regional conservation initiatives and to the allocation of limited resources for conservation (Master 1991; Mace 1995). The results of this study clearly show that it is possible to rank Portuguese estuarine fish species in accordance with their conservation priorities, maintaining a natural accurateness. In fact, the experts' knowledgeable insight is positively correlated with the list produced by the COPIPEF calculation, resulting this fact in an extern index validation. Furthering this validation route, it was calculated the index score for *A. sturio*, which is extinct, and it scored 7.4, placing this species at the top of the list. This fact acts as a second validation, once that the most endangered species did in fact go extinct. Of this validation methodology arises extra conservation concerns to *S. salar*, which scored 7.1. The unfavourable life traits characteristics of this species allied to a reduced local distribution, decreasing population trend and its great commercial value, gravely endanger the species survival, being this species on the edge of regional extinction. The ten other top ranked species are also extinction sensible, due to their unfavourable life traits, decreasing national trends, the fact that they feed at a high taxonomic level and that most of them attain a high body size and are smeleparous. These eleven species urgently need to be actively presevered. This preservation can be made by designing specific conservation and restoration plans for the species and species' habitats. The bottom ranked species are more resistent to extinction pressures due to their widespread regional, local, and intra-estuarine distribution, and the fact that they spawn several times during their life, having addicional favourable life traits. However, these species are keystones in the estuarine and coastal trophic webs and are responsible for maintaining the fisheries. Therefore, they must be considered in conservation plans elaboration. Only looking at the system as a hole can the protection of its' species and of its' processes be successful.

The methodology presented in this work provides an easy way to define conservation priorities and enables the ranking of estuarine zones and of estuarine systems (site-specific score) (Freitag et al. 1997) based on the fish species present, by adding their COPIPEF scores. The list of species and priorities produced by the index will allow to orientate and define the type of ecological research, as well as the contribution to perform local conservation activities (Martínez et al. 2005). This index, being the first index for estuarine fish species, provides a starting point in terms of methodology and metrics for other country-based estuarine fish conservation priority indexes and it is a proof that multimetric approaches to estuarine fish are executable, viable and are a good alternative to local Red Lists specially as it responds to the need of conservation priority assessments (Dunn et al. 1999).

The next step following this study is the establishment of sensitivity zones on the 16 studied systems, simplifying thus, even further, the action of conservation planners and decision makers. The knowledge gaps that still remain after this information gathering should be filled with the continuous search of bibliography valid values. In order to provide a more accurate picture of the conservation priority of the estuarine fish species, the index should incorporate all new valid insights to the species knowledge, transforming the list presented here in an evolving organism, altering the ranking as the knowledge grows and the environmental and anthropogenic pressures change. In the future this index shoul be widen and transformed into a regional or global index and it should be applied, with some alterations, to the marine coastal area and to the freshwater environment.

Chapter 4

References

References

Able, K. W. 2005. A re-examination of fish estuarine dependence: evidence for connectivity between estuarine and ocean habitats. Estuarine and Coastal Shelf Science **64**:5-17.

Blaber, S. J. M., D. P. Cyrus, J. J. Albaret, C. V. Ching, J. W. Day, M. Elliot, M. S. Fonseca, D. E. Hoss, J. Orensanz, I. C. Potter, and W. Silvert. 2000. Effects of fishing on the structure and functioning of estuarine and nearshore ecosystems. ICES Journal of Marine Science **57**:590-602.

Cabral, H., and M. J. Costa. 2001. Abundance, feeding ecology and growth of 0 group sea bass, *Dicentrarchus labrax*, within the nursery areas of the Tagus estuary. Journal of the Marine Biological Association of the United Kingdom **81**:679–82.

Cabral, M. J. (coordenator), P. R. Almeida, T. Dellinger, N. Ferrand de Almeida, M. E. Oliveira, J. M. Palmeirim, A. I. Queiroz, L. Rogado, and M. Santos-Reis, editors. 2005. Livro Vermelho dos Vertebrados de Portugal. Instituto da Conservação da Natureza, Lisboa.

Ceballos, G., and D. Navarro. 1991.Diversity and conservation of Mexican mammals. Pages 167-198 in M. A. Mares and D. J. Schmidly, editors. Latin American Mammalogy. University of Oklahoma Press, Norman, OK.

Cooper J. A. G., A. E. L. Ramm, and T. D. Harrison. 1994. The Estuarine Health Index — a new approach to scientific-information transfer. Ocean Coastal Management **25**:103–41.

Costa, M. J., and A. Bruxelas. 1989. The structure of fish communities in the Tagus Estuary, Portugal, and its role as a nursery for commercial fish species. Scientia Marina **53**(supplement 2-3): 561-566.

Costanza, R., R. d'Arge, R. de Groot, S. Faber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R. V. O'Neill, J. Paruelo, R. G. Raskin, P. Sutton, M. van der Belt. 1997. The value of the world's ecosystems and natural capital. Nature **387**:253–260.

Dunn, E. H., D. J. T. Hussel, and D. A. Welsh. 1999. Priority-setting tool applied to Canada's landbirds based on concern and responsibility for species. Conservation Biology **13**:1404-1415.

Elliott, M., M. G. O'Reilly, and C. J. L. Taylor. 1990. The Forth estuary: a nursery and overwintering area for the North Sea fishes. Hydrobiologia **195**: 89-103.

Elliott, M., and F. Dewailly. 1995. The structure and components of European fish assemblages. Netherlands Journal of Aquatic Ecology **29**:397-417.

Erzini, K., L. Bentes, R. Coelho, C. Correia, P. G. Lino, P. Monteiro, J. Ribeiro, and J. M. S. Goncalves. 2002. Recruitment of sea breams (Sparidae) and other commercially important species in the Algarve (Southern Portugal). Final Report, DG XIV/C/1, Ref 99/061. University of the Algave, Faro.

Fitter, R. and M. Fitter, editors. 1987. The road to extinction. World Conservation Union and United Nations Environmental Programme, Gland, Switzerland.

Freitag, S., A. S. Van Jaarsveld, and H. C. Biggs. 1997. Ranking priority areas: an iterative conservation value-based approach. Biological Conservation **82**:263-272.

Gaston, K. J. 1994. Rarity. Chapman and Hall, London.

Gillanders, B. M., K. W. Able, J. A. Brown, D. B. Eggleston, and P. F. Sheridan. 2003. Evidence of connectivity between juvenile and adult habitats for mobile marine fauna: an important component of nurseries. Marine Ecological Progress Series **247**:281-295.

Grall, J., and L. Chauvaud. 2002. Marine eutrophication and benthos: the need for new approaches and concepts. Global Change Biology **8**:813–830.

Haedrich, R L. 1983. Estuarine fishes. Pages 183-208 in B. H. Ketchu, editor. Ecosystems of the world 26 estuaries and enclosed seas. Elsevier, Amsterdam.

Harris, S. A., D. P. Cyrus, and L. E. Beckley. 2001. Horizontal trends in larval fish diversity and abundance along an ocean estuarine gradient on the northern KwaZulu-Natal coast, South Africa. Estuarine, Coastal and Shelf Science **53**:221-235.

Hartley, S., and W. E. Kunin. 2003. Scale dependecy of rarity, extinction risk, and conservation priority. Conservation biology **17**(supplement 6):1559-1570.

Henderson, P. A. 1989. On the structure of the inshore fish community of England and Wales. Journal of the Marine Biological Association of the United Kingdom **69**:145-163.

Houde, E., and E. S. Rutherford. 1993. Recent trends in estuarine fisheries: predictions of fish production and yield. Estuaries **16**:161-176.

Kimmerer, W. J., J. H. Cowan Jr., L. W. Miller, and K. A. Rose. 2001. Analysis of an estuarine striped bass population: effects of environmental conditions during early life. Estuaries **24**:556-574

Laegdsgaard, P., and C. Johnson. 2001. Why do juvenile fish utilise mangrove habitats. Journal of Experimental Marine Biology and Ecology **257**:229–253.

Le Pape, O., J. Holley, D. Guérault, and Y. Désaunay. 2003. Quality of coastal and estuarine essential fish habitats: estimations based on the size of juvenile common sole (*Solea solea* L.). Estuarine, Coastal and Shelf Science **58**:793-803.

Lenanton, R. C. J., and I. C. Potter. 1987. Contribution of estuaries to commercial fisheries in temperate Western Australia and the concept of estuarine dependence. Estuaries **10**:28–35.

Loneragan, N. R., I. C. Potter, R. C. J. Lenanton, and N. Caputi. 1986. Spatial and seasonal differences in the fish faunal in the shallows of a large Australian estuary. Marine Biology **92**:575-586.

Mace, G. M. 1994. Classifying threatened species: means and ends. Philosophical Transactions of the Royal Society of London **344**:91-97.

Mace, G. M. 1995. Classification of threatened species and its role in conservation planning. Pages 197-213 in J. H. Lawton and R. M. May, editors. Extinction rates. Oxford university press, New York.

Mace, G. M., and R. Lande. 1991. Assessing extinction threats:towards a re-evaluation of IUCN threatened species categories. Conservation Biology **5**:148-157.

Maes, J., A. Taillieu, P. A. van Damme, K. Cottenie, and F. Ollevier. 1998. Seasonal patterns in the fish and crustacean community of a turbid temperate estuary (Zeeschelde estuary, Belgium). Estuarine, Coastal and Shelf Science **47**:143-151.

Marchand, J. 1980. Seasonality abundance and diversity of the ictiofauna of the lower Loire Estuary in 1977-1978 (France). Annalles de l'Institute Oceanographic Paris **56**:127-137.

Marques, M., M. F. da Costa, M. I. D. Mayorga, and P. R. C. Pinheiro. 2004. Water environments: anthropogenic pressures and ecosystem changes in the Atlantic drainage basins of Brazil. Ambio **33**:68–77.

Marshall, S., and M. Elliott. 1998. Environmental influences on the fish assemblage of the Humber estuary, U.K. Estuarine, Coastal and Shelf Science **14**:489-499.

Martin, C. M. 1994. Recovering endangered species and restoring ecosystems: conservation planning for the twenty-first century in the United States. Conservation Biology **137**:198-203.

Martínez, G. J., A. M. Planchuelo, E. Fuentes, and M. Ojeda. 2005. A numeric index to establish conservation priorities for medicinal plants in the Paravachasca Valley, Córdoba, Argentina. Biodiversity and Conservation **15**:2457-2475.

Martinho F. 2005. O estuário do Mondego como viveiro para a ictiofauna: ecologia dos juvenis de *Dicentrarchus labrax*, *Platichthys flesus* e *Solea solea*. MSc Thesis, Universidade de Coimbra, Faculdade de Ciências e Tecnologia. Coimbra.

Master, L. L. 1991. Assessing threat and setting priorities for conservation. Conservation Biology **5**:559-563.

McHugh, J. L. 1967. Estuarine nekton. Pages 581-620 in G. H. Lauff, editor. Estuaries. American Association for the Advancement of Science Publications. **83**:581-620.

Meir, E., S. Andelman, and H. P. Possingham. 2004. Does conservation-planning matter in a dynamic and uncertain world? Ecology Letters **7**:615-622.

Mehlman, D. W., K. V. Rosenberg, J. V. Wells, and B. Robertson. 2004. A comparison of North American avian conservation priority ranking systems. Biological Conservation **120**:383-390.

Miller J. M., L. B. Crowder, and M. L. Moser. 1985. Migration and utilization of estuarine nurseries by juvenile fishes: an evolutionary perspective. Contributions in Marine Sciende **27**:338–52.

Millsap, B. A., J. A. Gore, D. E. Runde, and S. I. Cerulean. 1990. Setting priorities for the conservation of fish and wildlife species in Florida. Wildlife Monographs **111**:1-57.

Myers, N. R. A. Mittermeier, C. G. Mittermeier, G. A. B. daFonseca, and J. Kent. 2000. Biodiversity hotspots for conservation priorities. Nature **403**:853-858.

Peterson, C. H., H. C. Summerson, E. Thomson, H. S. Lenihan, J. Grabowski, L. Manning, F. Micheli, and G. Johnson. 2000. Synthesis of linkages between benthic and fish communities as key to protecting essential fish habitat. Bulletin of Marine Science **66**:759–774.

Salen-Picard, C., A. M. Darnaude, D. Arlhac, and M. L. Harmelin-Vivien. 2002. Fluctuations of macrobenthic populations: a link between climate-driven run-off and sole fishery yields in the Gulf of Lions. Oecologia **133**:380–388.

Sánchez, A., and A. Raz-Guzman. 1997. Distribution patterns of tropical estuarine brachyuran crabs in the Gulf of Mexico. Journal of Crustacean Biology **17**:609-620.

Scott, J. M., B. Csuti, J. D. Jacobi, and J. E. Estes. 1987. Species richness. BioScience **37**:782-788.

Singh, D., and R. C. Sharma. 1998. Biodiversity, ecological status and conservation priority pf the fish of the river Alaknanda, a parent stream of the River Ganges (India). Aquatic Conservation: Marine and Freshwater Ecosystems **8**:761-772.

Stotz, D. F., J. W. Fitzpatrick, T. A. Parker III, and D. K. Moskovits. 1996. Neotropical birds: ecology and conservation. The University of Chicago Press, Chicago.

TNC (The Nature Conservancy).1988. Natural heritage program operations manual. The Natural Conservancy, Arlington, Virginia.

Todd, C. R. and M. A. Burgman. 1998. Assessment of threat and conservation priorities under realistic levels of uncertainty and reliability. Conservation Biology **12**:966-974.

Annex I

Species and reference number of the references used to score each species metrics

Alosa alosa (Linnaeus, 1758) – 23, 28, 55, 56, 71, 86, 90, 91, 97, 98, 99, 132, 178, 195, 197, 207, 224, 259, 272, 281, 302, 333

Alosa fallax (Lacepède, 1803) – 7, 13, 17, 24, 26, 29, 32, 34, 71, 91, 93, 96, 97, 98, 99, 101, 107, 108, 132, 160, 178, 207, 237, 259, 269, 333

Ammodytes tobianus (Linnaeus, 1758) – 32, 44, 91, 93, 96, 101, 134, 178, 195, 197, 204, 259, 266, 267, 268, 269, 278, 280, 318, 330

Anguilla anguilla (Linnaeus, 1758) – 12, 13, 17, 22, 24, 25, 26, 27, 32, 43, 54, 55, 62, 66, 71, 80, 91, 93, 95, 96,98, 100, 101, 108,110, 112, 132, 134, 136, 160, 178, 195, 197, 203, 224, 225, 237, 259, 269, 274, 278, 289, 303, 313, 315, 316, 317, 318, 330

Aphia minuta (Risso, 1810) – 13, 24, 32, 33, 77, 80, 93, 98, 101, 107, 108, 110, 174, 178, 190, 195, 197, 203, 213, 220, 234, 237, 259, 269, 294, 309, 313, 318

Argyrosomus regius (Asso, 1801) – 55, 68, 93, 95, 98, 205, 260, 313, 318

Arnoglossus laterna (Walbaum, 1792) – 13, 18, 62, 66, 69, 70, 93, 98, 108, 127, 157, 160, 203, 210, 234, 237, 242, 294, 313, 318

Arnoglossus thori Kyle, 1913 –13, 18, 28, 62, 70, 80, 93, 101, 108, 152, 157, 224, 237, 242, 294, 313

Atherina boyeri Risso, 1810 – 41, 56, 65, 71, 98, 108, 110, 134, 160, 178, 195, 197, 234, 259, 262, 269, 307, 324

Atherina presbyter Cuvier, 1820 – 13, 17, 21, 24, 25, 26, 32, 38, 56, 88, 91, 93, 96, 98, 100, 101, 107, 108, 128, 132, 178, 195, 197, 214, 224, 225, 237, 250, 254, 259, 262, 269, 313, 318

Belone belone (Linnaeus, 1761) – 17, 32, 55, 62, 63, 66, 96, 98, 101, 108, 123, 153, 160, 173, 178, 195, 224, 225, 237, 259, 269, 278,

Boops boops (Linnaeus, 1758) – 12, 13, 24, 26, 44, 45, 66, 93, 98, 01, 107, 108, 110, 158, 159, 162, 195, 197, 204, 224, 225, 227, 237, 259, 294, 313

Buglossidium luteum (Risso, 1810) – 44, 66, 70, 96, 108, 110, 115, 160, 203, 244, 261, 280, 313

Callionymus lyra Linnaeus, 1758 – 32, 66, 82, 91, 93, 96, 98, 100, 101, 108, 110, 148, 178, 183, 195, 224, 237, 259, 269, 313, 314, 318, 330

Chelon labrosus (Risso, 1826) – 13, 24, 26, 32, 52, 55, 58, 62, 80, 93, 96, 98, 100, 101, 107, 110, 132, 134, 160, 178, 195, 203, 222, 224, 225234, 237, 259, 269, 278, 318, 313

Ciliata mustela (Linnaeus, 1758) – 13, 32, 54, 66, 93, 98, 100, 108, 150, 178, 195, 204, 269, 300, 318,

Conger conger ([Artedi, 1738] Linnaeus, 1758) – 12, 13, 32, 47, 66, 93, 98, 101, 108, 166, 178, 195, 197, 203, 204, 224, 225, 237, 247, 291, 294, 313, 318, 332

Dicentrarchus labrax (Linnaeus, 1758) – 13, 17, 32, 55, 62, 65, 76, 84, 88, 91, 93, 94, 95, 96, 98, 100, 101, 108, 110, 132, 134, 137, 160, 173, 177, 178, 182, 189, 195, 197, 203, 204, 215, 224, 225, 237, 259, 269, 280, 278, 294, 310, 313, 318, 329, 330

Dicentrarchus punctatus (Bloch, 1792) – 17, 44, 55, 62, 98, 101, 108, 125, 189, 224, 225, 237, 259, 310

Diplodus annularis (Linnaeus, 1758) – 6, 13, 17, 24, 26, 45, 46, 55, 62, 66, 80, 88, 93, 98, 100, 101, 108, 110, 129, 197, 204, 224, 225, 237, 251, 259, 269, 271, 278, 294

Diplodus bellottii (Steindachner, 1882) – 45, 55, 62, 66, 80, 98, 100, 101, 129, 203, 204, 224, 225, 237, 240, 271, 278, 294, 313

Diplodus cervinus (Lowe, 1841) – 13, 24, 26, 45, 93, 101, 108, 110, 129, 204, 224, 252, 253

Diplodus puntazzo (Cetti, 1777) – 24, 26, 44, 45, 62, 73, 80, 88, 93, 101, 107, 108, 110, 129, 204, 216, 224, 225, 237, 294

Diplodus sargus (Linnaeus, 1758) – 11, 12, 13, 17, 24, 25, 26, 44, 45, 55, 62, 66, 80, 88, 91, 96, 98, 100, 101, 107, 108, 110, 129, 160, 178, 195, 203, 204, 225, 237, 259, 269, 278, 294,313, 318

Diplodus vulgaris (E. Geoffrey Saint-Hilaire, 1817) – 12, 13, 17, 24, 26, 32, 44, 45, 55, 62, 66, 80, 88, 93, 96, 98, 100, 101, 107, 108, 110, 129, 134, 160, 178, 195, 203, 204, 224, 225, 237, 259, 269, 278, 283, 294, 318, 313

Echiichthys vipera (Cuvier, 1829) –13, 44, 93, 96, 98, 100, 110, 178, 195, 197, 237, 259, 269, 280, 312, 313, 318

Engraulis encrasicolus (Linnaeus, 1758) – 13, 17, 24, 26, 32, 55, 62, 66, 88, 93, 96, 98, 100, 101, 107, 108, 110, 160, 178, 195, 197, 224, 225, 231, 237, 259, 265, 269, 278, 280, 294, 318, 334, 335

Gasterosteus aculeatus (Linnaeus, 1758) – 9, 32, 39, 71, 91, 102, 132, 176, 178, 187, 195, 219, 234, 256, 269, 279, 285, 330, 313

Gobius niger Linnaeus, 1758 – 12, 13, 24, 25, 26, 32, 54, 55, 62, 66, 80, 88, 93, 96, 98, 100, 101, 106, 107, 108, 110, 131, 160, 178, 195, 197, 203, 220, 224, 234, 237, 259, 269, 271, 278, 294, 321, 313

Gobius paganellus Linnaeus, 1758 – 12, 13, 16, 24, 26, 32, 35, 61, 62, 66, 80, 93, 96, 98, 107, 108, 110, 171, 204, 213, 219, 220, 221, 237, 269, 294, 313

Halobatrachus didactylus (Bloch & Schneider, 1801) – 3, 13, 24, 25, 26, 55, 62, 66, 88, 93, 98, 101, 107, 108, 120, 203, 205, 224, 237, 271, 277, 278, 282, 294, 313

Hippocampus hippocampus (Linnaeus, 1758) – 13, 62, 63, 66, 80, 93, 96, 98, 101, 108, 110, 111, 145, 160, 178, 204, 205, 211, 224, 237, 259, 278, 294

Hippocampus ramulosus Leach, 1814 – 13, 24, 26, 93, 97, 98, 100, 101, 107, 108, 110, 111, 145, 178, 195, 197, 204, 211, 224, 237, 269

Lampetra fluviatilis (Linnaeus, 1758) – 8, 56, 71, 98, 272, 274, 325

Liza aurata (Risso, 1810) – 13, 17, 24, 25, 26, 32, 52, 53, 55, 58, 62, 66, 80, 88, 93, 96, 98, 100, 101, 107, 108, 110, 160, 166, 167, 178, 195, 224, 237, 259, 269, 278, 304, 313, *Liza ramado* (Risso, 1826) – 13, 17, 24, 25, 26, 32, 52, 55, 58, 66, 93, 96, 98, 100, 101, 107, 108, 110, 134, 160, 163, 178, 195, 197, 203, 222, 224, 237, 259, 269, 274, 313, 318

Liza saliens (Risso, 1810) – 13, 24, 26, 37, 44, 52, 55, 58, 62, 80, 95, 96, 101, 110, 149, 160, 197, 224, 237, 259, 269, 278

Microchirus azevia (Capello, 1867) –13, 19, 20, 48, 66, 93, 96, 97, 98, 108, 110, 160, 179, 203, 204, 237, 260, 261, 294

Monochirus hispidus Rafinesque, 1814 – 17, 62, 66, 80, 81, 97, 105, 108, 110, 204, 224, 260, 261, 278, 294

Mugil cephalus Linnaeus, 1758 – 13, 17, 24, 25, 26, 32, 52, 55, 58, 66, 91, 93, 96, 98, 101, 107, 108, 110, 130, 132, 160, 163, 178, 195, 224, 225, 237, 256, 259, 269, 273, 288, 305, 306, 313

Mullus surmuletus Linnaeus, 1758 – 13, 17, 24, 25, 26, 32, 44, 55, 62, 66, 76, 80, 88, 93, 96, 98, 100, 101, 107, 108, 110, 160, 164, 168, 178, 195, 204, 224, 225, 237, 259, 278, 294, 313, 318

Nerophis lumbriciformis (Jenyns, 1835) – 13, 63, 80, 93, 108, 110, 111, 178, 194, 195, 197, 201, 203, 204, 226, 294

Pagellus bogaraveo (Brünnich, 1768) – 13, 17, 45, 62, 64, 80, 93, 96, 98, 108, 110, 160, 188, 204, 217, 269, 294, 313

Pagrus pagrus (Linnaeus, 1758) – 13, 45, 46, 66, 93, 97, 98, 104, 108, 110, 156, 178, 185, 195, 197, 199, 208, 218, 237, 238, 284

Parablennius gattorugine (Linnaeus, 1758) – 13, 44, 62, 63, 66, 80, 93, 96, 98, 108, 110, 154, 160, 195, 197, 203, 234, 237, 269, 294, 336

Parablennius pilicornis (Cuvier, 1829) – 13, 26, 42, 62, 63, 80, 93, 108, 109, 110, 154, 178, 237, 241, 294, 296, 318, 336

Petromyzon marinus Linnaeus, 1758 – 4, 14, 71, 91, 132, 178, 269, 325

Plathicthys flesus (Linnaeus, 1758) – 2, 13, 17, 30, 32, 66, 69, 71, 91, 93, 98, 100, 104, 108, 110, 132, 151, 178, 195, 197, 234, 243, 274, 280, 204, 259, 269, 313, 318, 330

Pomatoschistus marmoratus (Risso, 1810) –13, 24, 26, 93, 107, 108, 110, 213, 220, 259, 270

Pomatoschistus microps (Krøyer, 1838) – 13, 26, 32, 55, 62, 65, 66, 80, 91, 93, 96, 98, 108, 110, 160, 178, 184, 195, 196, 197, 203, 204, 219, 220, 259, 276, 278, 294, 318, 313

Pomatoschistus minutus (Pallas, 1770) – 13, 24, 27, 32, 55, 62, 65, 66, 80, 91, 93, 96, 98, 100, 106, 110, 132, 155, 160, 178, 195, 196, 197, 220, 237, 259, 265, 269, 274, 278, 294, 313, 318, 330

Pomatoschistus pictus (Malm, 1865) – 13, 24, 26, 32, 62, 80, 93, 96, 98, 106, 107, 108, 110, 160, 178, 195, 197, 220, 234, 294

Raja undulata Lacepède, 1802 – 13, 59, 62, 63, 66, 85, 89, 93, 98, 103, 108, 294, 297, 298, 313, 318

Salmo salar Linnaeus, 1758 – 71, 91, 132, 236, 272, 301

Salmo trutta Linnaeus, 1758 - 71, 72, 132, 191, 200, 235, 248, 272, 274, 301, 313, 330

Sardina pilchardus (Walbaum, 1792) – 13, 15, 17, 24, 25, 26, 32, 55, 62, 66, 80, 93, 96, 98, 101, 107, 108, 110, 160, 161, 171, 195, 203, 212, 224, 225, 237, 259, 269, 278, 280, 294, 313, 318, 326, 333

Sarpa salpa (Linnaeus, 1758) – 13, 24, 25, 26, 44, 45, 62, 66, 69, 80, 88, 93, 96, 98, 100, 101, 107, 108, 110, 165, 194, 204, 224, 225, 237, 278, 322

Scophthalmus rhombus (Linnaeus, 1758) – 13, 18, 24, 26, 32, 62, 70, 74, 91, 93, 96, 98, 100, 101, 107, 108, 110, 160, 175, 178, 195, 204, 224, 232, 234, 237, 259, 269, 278, 286, 318, 313, 330

Scorpaena notata Rafinesque, 1810 – 13, 44, 55, 62, 66, 80, 88, 93, 101, 108, 170, 224, 225, 228, 230, 233, 237, 284, 294, 313

Serranus hepatus (Linnaeus, 1758) – 13, 24, 26, 55, 62, 66, 80, 93, 98, 101, 103, 107, 108, 110, 192, 203, 224, 225, 237, 255, 290, 294, 311, 327

Solea lascaris (Risso, 1810) – 13, 20, 32, 62, 70, 93, 96, 98, 108, 115, 116, 118, 160, 178, 224, 257, 259, 261, 269, 278, 280, 313, 318

Solea senegalensis Kaup, 1858 – 13, 17, 18, 20, 24, 25, 26, 32, 55, 62,65, 66, 67, 69, 93, 96, 98, 100, 107, 108, 110, 117, 118, 134, 160, 178, 195, 203, 205, 223, 224, 238, 239, 259, 261, 269, 278, 313, 318

Solea solea (Linnaeus, 1758) – 18, 13, 31, 55, 65, 66, 67, 69, 91, 93, 95, 96, 98, 100, 101, 108, 115, 117, 118, 134, 160, 178, 193, 195, 197, 202, 204, 223, 224, 237, 245, 259, 260, 261, 269, 280, 295, 313, 318, 331

Sparus aurata Linnaeus, 1758 – 13, 17, 24, 26, 32, 45, 55, 62, 66, 79, 80, 88, 93, 96, 98, 100, 101, 107, 108, 110, 129, 134, 146, 160, 178, 195, 204, 224, 225, 234, 258, 259, 264, 269, 237, 278, 287, 294, 313, 337

Spondyliosoma cantharus (Linnaeus, 1758) – 12, 13, 17, 24, 26, 32, 55, 62, 66, 88, 80, 93, 96, 98, 101, 107, 108, 110, 160, 178, 195, 197, 203, 204, 224, 225, 237, 249, 258, 259, 261, 269, 271, 278, 283, 294, 313

Symphodus bailloni (Valenciennes, 1839) – 12, 13, 24, 25, 26, 32, 51, 55, 62, 66, 80, 93, 96, 98, 100, 101, 108, 110, 134, 160, 178, 195, 197, 237, 259, 263, 269, 271, 278, 284, 294, 313

Symphodus cinereus (Bonnaterre, 1788) – 12, 13, 24, 26, 44, 51, 62, 66, 80, 93, 101, 107, 108, 110, 237, 259, 263, 271, 294

Syngnathus abaster Risso, 1826 – 13, 24, 26, 32, 62, 63, 66, 80, 93, 97, 98, 101, 107, 108, 110, 111, 134, 178, 195, 211, 224, 237, 259, 265, 269, 278, 294, 308, 318

Syngnathus acus Linnaeus, 1758 – 12, 13, 24, 26, 32, 55, 62, 63, 66, 80, 91, 93, 96, 98, 100, 101, 107, 108, 110, 111, 132, 160, 178, 195, 197, 203, 211, 224, 234, 237, 259, 269, 271, 278, 294, 308, 313, 318

Syngnathus typhle Linnaeus, 1758 – 12, 13, 24, 26, 32, 44, 49, 62, 63, 66, 75, 88, 93, 98, 101, 107, 108, 110, 111, 147, 178, 195, 197, 203, 211, 224, 225, 234, 237, 246, 259, 269, 271, 308, 313

Trachurus trachurus (Linnaeus, 1758) – 13, 24, 26, 32, 55, 60, 62,66, 88, 92, 93, 98, 101, 107, 108, 110, 178, 180, 195, 197, 203, 224, 225, 237, 259, 280, 292, 293, 313, 318, *Trigla lucerna* Linnaeus, 1758 – 1, 13, 17, 26, 27, 32, 40, 44, 62, 66, 91, 93, 96, 98, 100, 101, 107, 108, 110, 126, 134, 160, 169, 178, 195, 224, 237, 259, 269, 280, 313, 318

Acipenser sturio Linnaeus, 1758 – 10, 122, 198, 275

References used for metrics scoring

1. Abdallah, M., and S. N. Faltas. 1998. Reproductive biology of *Trigla lucerna* and *Trigloporus lastoviza* in the Egyptian Mediterranean waters. Bulletin of the National Institute of Oceanography and Fisheries (Egypt) **24**:285-304.

2. Abookire, A. A., and B. J. Macewicz. 2003. Latitudinal variation in reproductive biology and growth of female Dover sole (*Microstomus pacificus*) in the North Pacific, with emphasis on the Gulf of Alaska stock. Journal of Sea Research **50**:187-197.

3. Acedo, V. G. 1979. Actividad proteolítica del aparato digestivo de pez sapo (*Halobatrachus didactylus*, Schneider, 1801). Graduate thesis. Faculdad de Ciencias de Cádiz, Cádiz, España.

4. Afonso, A., and P. Vaz-Pires. 1992. A pesca da lampreia (*Petromyzon marinus*) no estuário do Rio Lima. Colóquio - Conservação dos Recursos Vivos Marinhos. Publicações avulsas do Instituto Nacional de Investigação das Pescas N° **17**:179-197, Instituto Nacional de Investigação das Pescas, Lisboa.

5. Afonso-Dias, I., C. Reis, and J. P. Andrade. 2005. Reproductive aspects of *Microchirus azevia* (Risso, 1810) (Pisces: Soleidae) from the south coast of Portugal. Scientia Marina **69**(supplement 2):275-283.

6. Ak, Y., B. Hossucu. 2001. Diversity, distribution and abundance of pelagic eggs and larvae of teleost fishes in Izmir Bay. Journal of fisheries and aquatic sciences **18**(supplement 1-2):155-173.

7. Alexandrino, P. J. B. 1996. Estudo de populações de sável (*Alosa alosa* L.) e savelha (*Alosa fallax* Lacépède). Análise da diferenciação interespecífica, subestruturação e hibridação. Faculdade de Ciências da Universidade do Porto, Porto.

8. Allardi, J., and P. Keith. 1991. Atlas préliminaire des poissons d'eau douce de France. Collection Patrimoines Naturels, vol. 4. Secrétariat Faune Flore, Muséum National d'Histoire Naturelle, Paris.

9. Allen, J. R. M., and R. J. Wootton. 1982. Age, growth and rate of food consumption in an upland population of the three-spined stickleback, *Gasterosteus aculeatus* L.. Journal of Fish Biology **21**:95-105.

10. Almaça, C. 1988. On the sturgeon, *Acipenser sturio*, in the Portuguese rivers and sea. Folia Zoologica **37**:183-191.

11. Almada, F. J. O. 1996. Contribuição para o estudo em ecologia e comportamento de *Diplodus Sargus* (Linnaeus, 1758) e *Diplodus vulgaris* (E. Geoffrey Sanit-Hilaire, 1817) (Pisces:Sparidae). Graduate thesis.

Faculdade de Ciências da Universidade de Lisboa, Lisboa.

12. Almeida, A. J. 1988. Estrutura, dinâmica e produção da macrofauna acompanhente dos povoamentos de *Zostera noltii* e *Zostera marina* do estuário do Rio Mira. Phd thesis. Universidade de Lisboa, Lisboa, Portugal.

13. Almeida, P. R. 1996. Ecologia e biologia de *Liza ramada* (Risso, 1826) e *Chelon labrosus* (Risso, 1826) (Pisces, Mugilidade), no estuário do Mira (Portugal). Inter-relações com o ecossistema estuarino. Phd thesis. Universidade de Lisboa, Lisboa, Portugal.

14. Almeida, P. R., B. R. Quintella, and N. M. Dias. 2002. Movement of radio-taged anadromus sea lampreys during the spawning migration in the River Mondego (Portugal). Hydrobiologia **483**:1-8.

15. Amenzoui, K., F. Ferhan-Tachinante, A. Yahyaoui, S. Kifani, and A. H. Mesfioui. 2006. Analysis of the cycle of reproduction of *Sardina pilchardus* (Walbaum, 1792) off the Moroccan Atlantic coast. C. R. Biologies **329**:892-901.

16. American Society of Ichthyologists and Herpetologists. 1984. Ontogeny and systematics of fishes. Based on an international symposium dedicated to the memory of Elbert Halvor Ahlstrom, Special Publication No. 1. 760 p. American Society of Ichthyologists and Herpetologists, La Jolla, California.

17. Amorim, A. S. 1982. Contribuição ao estudo da ictiofauna pelágica do estuário do Rio Sado. Graduate thesis. Faculdade de Ciências da Universidade de Lisboa, Lisboa.

18. Andrade, J. P. 1989. The flatfishes of the Ria Formosa: Results of a three year survey. Scientia Marina **53**:671-676.

19. Andrade, J. P. 1998. Age and growth of the bastard sole, *Microchirus azevia* (Capello, 1868) (Pisces Soleidae) from the South coast of Portugal. Fisheries Research **34**:205-208.

20. Andrade, J. P., and S. Andrade. 1990. A Importância da Ria Formosa no ciclo biológico de *Solea senegalensis* Kaup 1858, *Solea vulgaris* Quensel 1806, *Solea lascaris* (Risso, 1810) e *Microchirus azevia* (Capello, 1868). Faro.

21. Andrade, J. P., I. Periquito, F. Soares, and D. Matias. 1992. Espécies sedentárias da Ria Formosa: Aspectos da biologia de *Atherina presbiter* Cuvier, 1829. Colóquio - Conservação dos Recursos Vivos Marinhos. Publicações avulsas do Instituto Nacional de Investigação das Pescas **17**:305-318. Instituto Nacional de Investigação das Pescas, Lisboa.

22. Antunes, J. C. 2002. Monitoring of glass eel recruitment in Portugal. Pages 219-226 in W. Dekker, editor. Monitoring of glass eel recruitment, Volume 2B: Country Reports, Southern Part, Report C007/02-WD. Netherlands Institute of Fisheries Research, Ijmuiden.

23. Antunes, J. C., and M. Weber. 1990. A pesca profissional no estuário do rio Minho resultados da pesca experimental. Actas do 1° simpósio sobre a protecção e revalorização da faixa costeira do Minho ao Liz.

24. Antunes, M., and P. L. Cunha. 1986. Estudo dos recursos haliêuticos na Ria de Alvor, relatório de síntese. Pages 204-282 in M. C. Peneda (coordenator). Caracterização ecológica da "ria" de Alvor. Plano geral director de aproveitamento valorização da ria de Alvor. Relatório não publicado. Laboratório Nacional de Engenharia e Tecnologia Industrial - LNETI, Sacavém.

25. Antunes, M., and P. L. Cunha. 1988. A ecologia da ictiofauna na Ria de Alvor. Pages 721-725 in V Congresso do Algarve, Racal Clube, Silves.

26. Antunes, M., P. L. Cunha, A. P. Duarte, and E. P. Mendonça. 1988. Ria de Alvor as a spawning place and nursery ground. Journal of Fish Biology **33**(supplement A):185-190.

27. Antunes, M., P. L. Cunha, and D. Moura (Scientific coordination: M. C. Peneda). 1991. Estudo do impacte dos efluentes urbano-industriais nas comunidades de peixes e crustáceos decápodes no estuário do Sado 1987/88. Relatório não publicado, Laboratório Nacional de Engenharia e Tecnologia Industrial - LNETI, Lisboa.

28. Aprahamian, M. W., S. M. Lester, and C. D. Aprahamian. 1997. Shad conservation in England and Wales. Environment Agency, Warrington.

29. Aprahamian, M. W., J.-L. Baglinière, M. R. Sabatié, P. Alexandrino, R. Thiel, and C. D. Aprahamian. 2003. Biology, satus, and conservation of the andromous atlantic twaite shad *Alosa fallax fallax*. American Fisheries Society Symposium **35**:103-124.

30. Arntz, W. E. 1978. Predation on benthos by flounders, *Platichthys flesus* (L.) in the deeper parts of Kiel Bay. Meeresforsch **26**:70-78.

31. Arruda, L. M. 1985. Dados sobre a ictiofauna da Ria de Aveiro. Pages 65-67 in C. S. Gomes (coordenator). Jornadas da Ria de Aveiro Vol II. Câmara Municipal de Aveiro, Aveiro, Portugal.

32. Arruda, L. M., J. P. Andrade, and M. M. Cunha. 1988. Abundance, diversity, and community structure of the fish population in the Ria de Aveiro (Portugal). Oceanologica Acta *11*:235-240.

33. Arruda, L. M., J. N. Azevedo, and A. I. Neto. 1993. Abundance, age-structure and growth, and reproduction of gobies (Pisces: Gobiidae) in the Ria de Aveiro Lagoon (Portugal). Estuarine and Coastal Shelf Science **37**:509-523.

34. Assis, C. A., P. R. Almeida, F. Moreira, J. L. Costa, and M. J. Costa.1992. Diet of the twaite shad *Alosa fallax* (Lacépède) (Clupeidae) in the River Tagus Estuary, Portugal. Journal of Fish Biology **41**:1049-1050.

35. Azevedo, J. N. M., and A. M. V. Simas. 2000. Age and growth, reproduction and reproduction of a sublittoral population of the rocky goby *Gobius paganellus* (Teleostei, Gobiidae). Hydrobiologia **440**:129-135.

36. Bagliniere, J. L. 2000. Le genre Alosa. Pages 3-30 in J. L. Bagliniere, and P. Elie, editors. Les aloses (*Alosa alosa* et *Alosa fallax* spp.). INRA-CEMAGREF, Paris.

37. Baltz, D. M. 1991. Introduced fishes in marine systems and inland seas.

Biological Conservation **56**:151-177.

38. Bamber, R. N., and P. A. Henderson. 1985. Morphological variation in British atherinids, and the status of *Atherina presbyter* Cuvier (Pisces: Atherinidae). Biological Journal of the Linnean Society **25**:61–76.

39. Banister, K. 1986. Gasterosteidae. Pages 640-643 in P. J. P. Whitehead, M.-L. Bauchot, J.-C. Hureau, J. Nielsen and E. Tortonese, editors. Fishes of the north-eastern Atlantic and the Mediterranean. volume 2. UNESCO, Paris.

40. Baron, J. 1985. Les Triglidés (Téléostéens, Scorpaeniformes) de la baie de Douarnez. II. La reproduction de *Eutrigla gunardus*, *Trigal lucerna*, *Trigloporus lastoviza* et *Aspitrigla cuculus*. Cybium **9**(supplement 3):255-281.

41. Bartulović, V., B. Glamuzina, A. Conides, A. Garvilović, and J. Dulčić. 2006. Maturation, reproduction and recruitment of the sand smelt, *Atherina boyeri* Risso, 1810 (Pisces: Atherinidae) in the estuary of Mala Neretva River (southeastern Adriatic, Croatia). Acta Adriatica **47**(supplement 1):5-10.

42. Bath, H. 1990. Blenniidae. Pages 905-915 in J. C. Quero, J. C. Hureau, C. Karrer, A. Post, and L. Saldanha, editors. Check-list of the fishes of the eastern tropical Atlantic (CLOFETA) Vol. 2. JNICT, Lisbon, SEI, Paris, and UNESCO, Paris.

43. Bauchot, M.-L. 1986. Anguillidae. Pages 535-536 in P. J. P. Whitehead, M.-L. Bauchot, J.-C. Hureau, J. Nielsen and E. Tortonese, editors. Fishes of the north-eastern Atlantic and the Mediterranean Vol. 2. UNESCO, Paris.

44. Bauchot, M.-L. 1987. Poissons osseux. Pages 891-1421 in W. Fischer, M. L. Bauchot, and M. Schneider, editors. Fiches FAO d'identification pour les besoins de la pêche. (rev. 1). Méditerranée et mer Noire. Zone de pêche 37. Vol. II. Commission des Communautés Européennes and FAO, Rome.

45. Bauchot, M.-L., and J. C. Hureau. 1986. Sparidae. Pages 883-907 in P. J. P. Whitehead, M. L. Bauchot, J. C. Hureau, J. Nielsen, and E. Tortonese, editors. Fishes of the north-eastern Atlantic and the Mediterranean Vol 2. UNESCO, Paris.

46. Bauchot, M.-L., and J. C. Hureau. 1990. Sparidae. Pages 790-812 in J. C. Quéro, J. C. Hureau, C. Karrer, A. Post, and L. Saldanha, editors. Check-list of the fishes of the eastern tropical Atlantic (CLOFETA) Vol. 2. JNICT, Lisbon, SEI, Paris, and UNESCO, Paris.

47. Bauchot, M.-L., and L. Saldanha. 1986. Congridae (including Heterocongridae). Pages 567-574 in P. J. P. Whitehead, M. L. Bauchot, J. C. Hureau, J. Nielsen, and E. Tortonese, editors Fishes of the north-eastern Atlantic and the Mediterranean Vol 2. UNESCO, Paris.

48. Belaid, B,. and J. Y. Marinaro. 1983. Biologie de la reproduction de *Microchirus azevia* (Capello) (Téléostéen soléidé). Rapports et Proces-Verbaux des Reunions Commission Internationale pour l'Exploration Scientifique de la Mer Mediterranee **28**(supplement 5):59-60.

49. Bell, J. D., and M. L. Harmelin-Vivien. 1983. Fish fauna of French

Mediterranean *Posidonia oceanica* seagrass meadows. 2. Feeding habits. Tethys **11**:1-14.

50. Bentes, L. M. C. F. 1996. Crescimento, reprodução e ecologia alimentar de *Mullus surmeletus* L. 1758, salmonete, na costa Sudoeste de Portugal. Relatório de estágio. Universidade do Algarve, Faro.

51. Bentivegna, F., and F. Benedetto. 1993. Histological study on the gonochorism of *Symphodus cinereus* (Labridae). Cybium **17**(supplement 1):17-22.

52. Ben-Tuvia, A. 1986. Mugilidae. Pages 1197-1204 in P. J. P. Whitehead, M. L. Bauchot, J. C. Hureau, J. Nielsen, and E. Tortonese, editors. Fishes of the North-eastern Atlantic and Mediterranean. Vol 3. UNESCO, Paris.

53. Berg, L. S. 1965. Freshwater fishes of the U.S.S.R. and adjacent countries. Vol. 3. 4th edition. Israel Program for Scientific Translations Ltd, Jerusalem.

54. Bertolini, F. U. D'Ancona, E. Padoa Montalenti, S. Ranzi, L. Sanzo, A. Sparta, E. Tortonese, and M. Vialli. 1956. Uova, larve e stadi giovanili di Teleostei. Fauna Flora Golfo Napoli Monogr. **38**:1-1064.

55. Bexiga, C. M. 2002. Comunidade ictiológica estuarina do Guadiana e sapal de Castro Marim. M.S. Thesis, Faculdade de Ciências do Mar e do Ambiente da Universidade do Algarve, Faro.

56. Billard, R. 1997. Les poissons d'eau douce des rivières de France. Identification, inventaire et répartition des 83 espèces. Delachaux & Niestlé, Lausanne.

57. Bodington, P. 2000. Enterprise experiences in the culture of new sparids. in B. Basurco and M. Pedini, editors. Cahiers Options Méditerranéennes. Pages 135-139 in Mediterranean Marine Aquaculture Finfish Species Diversification, Vol. 47. C.I.H.E.A.M, Zaragoza, Spain.

58. Boglione, C., C. Costa, M. Giganti, M. Cecchetti, P. Di Dato, M. Scardi, and S. Cataudella. 2006. Biological monitoring of wild thicklip grey mullet (*Chelon labrosus*), golden grey mullet (*Liza aurata*), thinlip mullet (*Liza ramada*) and flathead mullet (*Mugil cephalus*) (Pisces: Mugilidae) from different Adriatic sites: meristic counts and skeletal anomalies. Ecological Indicators **6**:712-732.

59. Bor, P. 2002. Egg-capsules of sharks and skates. Available from http:www.rajidae.tmfweb.nl/rogtabel.html (acessed December 2006)

60. Borges, F., H. Dinis, and C. Monteiro. 1977. Résultats preliminaires sur la ponte, composition des tailles et l'état du stock du chinchard (*Trachurus trachurus* L.) de la côte continentale portugaise. International Council Exploration of the Sea, Pelagic Fish Commitee, 14.

61. Borges, R., C. Faria, F. Gil, E. J.Gonçalves, and V. C. Almada. 2003. Embryonic and larval development of *Gobius paganellus* (Pisces: Gobiidae). Journal of the Marine Biological Association of the United Kingdom **83**(supplement 5):1151-1156.

62. Botelho, P. 2004. Contribuição para o estudo da ictiofauna do sistema lagunar da ria Formosa. Graduate thesis. Universidade do Algarve -

Faculdade de Ciências do Mar e do Ambiente, Faro.

63. Breder, C. M., and D. E. Rosen. 1966. Modes of reproduction in fishes. T.F.H. Publications, Neptune City, New Jersey.

64. Buxton, C. D., and P. A. Garratt. 1990. Alternative reproductive styles in seabreams (Pisces: Sparidae). Environmental Biology of Fishes **28**(supplement 1-4):113-124.

65. Cabral, H. N. 1998. Utilização do estuário do Tejo como área de viveiro pelos linguados, *Solea solea* (L., 1758) e *Solea senegalensis* Kaup, 1858, e robalo, *Dicentrarchus labrax* (L., 1758). PhD Thesis. Universidade de Lisboa, Lisboa.

66. Cabral, H. N. 1999. Ictiofauna do estuário do Sado. Relatório cientifico e técnico. Instituto de Investigação das Pescas e do Mar **47**:1-30.

67. Cabral, H. N. 2000. Comparative feeding ecology of sympatric *Solea solea* and *S. senegalensis*, within the nursery areas of the Tagus estuary, Portugal. Journal of Fish Biology **57**:1550-1562.

68. Cabral, H. N., and B. Ohmert. 2001. Diet of juvenile meagre, *Argyrosomus regius*, within the Tagus estuary. Cahiers de Biologie Marine **42**:289-293.

69. Cabral, H. N., M. J. Costa, and J. P. Salgado. 2001. Do the Tagus estuary fish community reflects environmental changes? Climate research **18**:119-126.

70. Cabral, H. N., M. Lopes, and R. Loeper. 2002. Trophic niche overlap between flatfishes in a nursery area on the Portuguese coast. Scientia Marina **66**(supplement 3):293-300.

71. Cabral, M. J. (Coordenator); P. R. Almeida, T. Dellinger, N. Ferrand de Almeida, M. E. Oliveira, J. M. Palmeirim, A. I. Queiroz, L. Rogado, and M. Santos-Reis, editors. 2005. Livro Vermelho dos Vertebrados de Portugal. Instituto da Conservação da Natureza, Lisboa.

72. Cadwallader, P. L., and G. N. Backhouse. 1983. A guide to the freshwater fish of Victoria. Government Printers, Melbourne.

73. Caggiano, M., S. Canese, A. Lupo, and A. Cirillo. 1993. Experiences of artificial reproduction and larval rearing of sheepshead bream (*Diplodus puntazzo*) in the south of Italy. Special Publication, European Aquaculture Society.

74. Cal, R. M., S. Vidal, C. Gómez, B. Álvarez-Blázquez, P. Martínez, and F. Piferrer. 2006. Growth and gonadal development in diploid and triploid turbot (*Scophthalmus maximus*). Aquaculture **251**:99-108.

75. Campolmi, M., P. Franzoi, and A. Mazzola. 1996. Observations on pipefish (Syngnathidae) biology in the Stagnone lagoon (west Sicily). Publicaciones especiales del Instituto Español de Oceanografía **21**:205-209.

76. Canário, A. V. M., K. Erzini, M. Castro, J. M. S. Gonçalves, C. Gaçhardo, J. Ribeiro, L. Bentes, J. Cruz, and P.Souto. 1994. Estudos Base para a conservação dos ictiopovoamentos e gestão da pesca costeira no litoral sudoeste. Universidade do Algarve - Unidade de Ciências e Tecnologias dos Recursos Aquáticos.

77. Caputo, V., G. Candi, M. La Mesa, and B. Arneri. 2000 Pattern of gonad maturation and the question of semelparity in the paedomorphic goby *Aphia minuta*. Journal of Fish Biology **58**:656–669.

78. Carcupino, M., A. Balsacci, G. Corso, P. Franzoi, M. Pala, and M. Mazzini. 1999. Testis structure and symplastic spermatid formation during spermatogenesis of pipefishes. Journal of Fish Biology. **55**:344-353.

79. Carnevali, O., R. Carletta, A. Cambi, A. Vita, and N. Bromage. 1999. Yolk formation and degradation during oocyte maturation in seabream *Sparus aurata*: involvement of two lysosomal proteinases. Biology of reproduction **60**(supplement 1):140-146.

80. Carvalho, G. 2003. Caracterização da Ictiofauna dos esteiros e enclaves do sapal da Ria Formosa. Graduate Thesis. Universidade do Algarve - Faculdade de Ciências do Mar e Ambiente, Faro.

81. Cau, A., and A. M. Deiana. 1980. Note sulla crescimento e la biologia trofica e riproduttiva di *Monochirus hispidus* Rafinesque, 1814 (Osteichthyes Pleuronectiformes). Quaderni Civica Stazione Idrobiologia Milano nº 8. Milano.

82. Chang, H. W. 1951. Age and Growth of *Callionymus lyra* L.. Journal of the Marine Biological Association **30**:281-297.

83. Claridge, P. N., and D. C. Gardner. 1978. Growth and movements of the Twaite Shad, *Alosa fallax* (Lacepede), in the Severn Estuary. Journal of Fish Biology **12**:203–211.

84. Claridge, P. N., and I. C. Potter. 1983. Movements, abundance, age composition and growth of bass, *Dicentrarchus labrax*, in the Severn estuary and inner Bristol Channel. Journal of the Marine Biological Association of the United Kingdom **63**:871-879.

85. Coelho, R., and K. Erzini. 2006. Reproductive aspects of the undulate ray, *Raja undulata*, from the south coast of Portugal. Fisheries Research **81**:80-85.

86. Collares-Pereira, M. J., I. G. Cowx, T. Sales Luís, N. Pedrosa, and M. Santos-Reis. 1999. Observations on the ecology of a landlocked population of allis shad in Aguieira Reservoir, Portugal. Journal of Fish Biology **55**(supplement 2):658-664.

87. Collette, B. B., and N. V. Parim. 1986. Pages 604-609 in P. J. P. Whitehead, M.-L. Bauchot, J.-C. Hureau, J. Nielsen and E. Tortonese, editors. Fishes of the North-eastern Atlantic and Mediterranean Vol. 2. UNESCO, Paris.

88. Comissão Coordenadora Regional do Algarve. 1984. Programa de Ordenamento e Desenvolvimento da Ria Formosa Vol. 1 - Caracterização, objectivos e acções. Ministério da Administração Interna.

89. Correia, J. P. S., and M. F. L. Smith. 2003. Elasmobranch landings for the Portuguese commercial fishery from 1986–2001. Marine Fisheries Review **65**:32–40.

90. Correia, M. J., J. L. Costa, C. Teixeira, P. R. Almeida, I. Domingos, and M. J. Costa. 2001. Feeding habits and condition of two landlocked populations of allis shad (*Alosa alosa*) in Portugal. Bulletin francais de la

peche et de la pisciculture **362/363**:823-835.

91. Correia, M. L. M., and M. L. Fidalgo. 1995. Estudo de avaliação da vulnerabilidade da capacidade de recepção das águas e zonas costeiras em Portugal. Instituto de Ciências Biomédicas de Abel Salazar – ICBAS/ Instituto de Zoologia "Dr. Augusto Nobre", Porto.

92. Costa, A. M. 2001. Contribuição para o estudo da fecundidade temporal e espacial do carapau (*Trachurus trachurus* L.) na costa Portuguesa. Dissertação original apresentada para acesso à Categoria de Investigador Auxiliar, IPIMAR.

93. Costa, J. L. 2004. A biologia do xarroco *Halobatrachus didactylus* (Bloch & Schneider, 1801) e o seu papel na estrutura e funcionamento dos ecossistemas em que se insere; referência especial à população do estuário do Mira. PhD Thesis. Universidade de Lisboa, Lisboa.

94. Costa, M. J. 1981 Food and Sexual Maturity of *Dicentrarchus labrax* (Pisces; Serranidae) in "Tejo Estuary" - Arquivos do Museu Bocage Série B, Notas, **1**(supplement 1):1-8.

95. Costa, M. J. (coordenator). 2000. Efeito das alterações dos caudais dulçaquícolas nas comunidades ictíicas dos estuários do Douro, Tejo e Guadiana e das zonas costeiras adjacentes. Previsões ecológicas e socioeconómicas. ERIC (Projecto nº 15263), Relatório de Progresso, Instituto de Oceanografia - IO/Faculdade de Ciências da Universidade de Lisboa, Lisboa.

96. Costa, M. J. (coordenator); L. S. Gordo, C. A. Assis, J. L. Costa, and P. R. Almeida. 1994. Estudo de impacto ambiental (componente ictiofaunistica) fixação da embocadura da Lagoa de Óbidos ao mar. Instituto de Oceanografia - IO/ Faculdade de Ciências da Universidade de Lisboa - FCUL, Lisboa.

97. Costa, M. J., C. Pestana, C. Perreira, F. Jorge, G. Silva, J. P. Salgado, J. L. Costa, L. S. Gordo, and P. R. Almeida. 1996. Relatório trimestral de monitorização ambiental da construção da ponte Vasco da Gama. Bentos/macroinvertebrados aquáticos e ictiofauna, Vol 1. Instituto de Oceanografia - IO/ Faculdade de Ciências da Universidade de Lisboa - FCUL, Lisboa.

98. Costa, M. J., C. Pestana, C. Perreira, F. Jorge, G. Silva, J. P. Salgado, J. L. Costa, L. S. Gordo, and P. R. Almeida. 1998. Relatório do 3º ano de monitorização ambiental da construção da ponte Vasco da Gama. Bentos/macroinvertebrados aquáticos e ictiofauna. Instituto de Oceanografia - IO/ Faculdade de Ciências da Universidade de Lisboa - FCUL, Lisboa.

99. Costa, M. J., P. R. Almeida, I. M. Domingos, J. L. Costa, M. L. Correia, C. M. Teixeira. 2001. Present Status of shads populations in Portugal. Bulletin francais de la peche et de la pisciculture **362/263**:1109-1116.

100. Costa, M. J., J. L. Costa, M. L. Chaves, and P. M. Chainho. 2004. Bases metodológicas para a análise da qualidade ecológica da água em rios e estuários portugueses. QUERE. Relatório não publicado, Instituto de Oceanografia – IO / Faculdade de Ciências da Universidade de Lisboa -

FCUL, Lisboa.

101. Costa Monteiro, C. 1989. La Faune Ichtyologique de la lagune Ria Formosa (Sud Portugal). Répartition et organisation saptio-temporelle des communautés: application à l'aménagement de ressources. Phd Thesis. Université des Sciences et Techniques du Languedoc. Languedoc.

102. Crivelli, A. J., and R. H. Britton. 1987. Life history adaptations of *Gasterosteus aculeatus* in a Mediterranean wetland. Environmental biology of fishes **18**(supplement 2):109-125.

103. Crowley, P. H., and M. K. Hart. 2007. Evolutionary stability of egg trading and parceling in simultaneos hermafrodites: The chalk bass revisited. Journal of Theoretical Biology **246**:420-429.

104. Cunha, M. M. F. M. 1984. Ciclo reproductivo de *Platichthys flesus flesus* (L.1758) (Pisces, Pleuronectidae) na Ria de Aveiro (Costa Portuguesa). Actas do Ivº Simpósio Ibérico de Estudos do Benthos Marinho, Lisboa **3**:23-34.

105. Cunha, P. L. 1984a. Alguns aspectos da relação entre o regime alimentar e a morfologia do tubo digestivo em *Monochirus hispidus* Rafinesque, 1814 (Pisces; Soleidae); Actas do IV Simpósio Ibérico de Estudos do Benthos Marinho, Lisboa, 1984, **3**:43-50.

106. Cunha, P. L. 1984b. Estudo comparativo do regime alimentar de *Gobius niger* Linné 1758, *Pomatochistus minutos* (pallas, 1770) e *P. pictus* (Malam, 1865) (pisces; Gobiidae); Actas do IV Simpósio Ibérico de Estudos do Benthos Marinho, Lisboa, 1984, **3**:35-42.

107. Cunha, P. L. 1987. A Ictiofauna da Lagoa de Albufeira e da Ria de Alvor. Relatório de Síntese para as provas de acesso a assistente de investigação. Laboratório Nacional de Engenharia e Tecnologia Industrial LNETI, Sacavém.

108. Cunha, P. L. 1994. Estrutura e Dinâmica da Ictiologia do estuário do Sado. Phd Thesis. Faculdade de Ciências da Universidade de Lisboa, Lisboa.

109. Cunha, P. L., and M. M. Antunes. 1987. Ichthyofauna from "Ria" de Alvor (Portugal). Laboratório Nacional de Engenharia e Tecnologia Industrial LNETI, Sacavém, Portugal.

110. Cunha, P. L., and M. M. Antunes, 1991. Estudo da influencia dos impactes antropogénicos na ecologia da ictiofauna e crustáceos decápodes no Estuário do Sado - 1989. DEII 22/91.

111. Dawson, C. E. 1986. Syngnathidae. Pages 628-639 in P. J. P. Whitehead, M. L. Bauchot, J. C. Hureau, J. Nielsen, and E. Tortonese, editors. Fishes of the north-eastern Atlantic and the Mediterranean Vol. 2. UNESCO, Paris.

112. Deelder, C. L. 1984. Synopsis of biological data on the eel, *Anguilla anguilla* (Linnaeus, 1758). FAO Fish. Synop. **80**(supplement 1).

113. Dekker, W. 2003a. Did lack of spawners cause the collapse of the European Eel, *Anguilla anguilla*? Fisheries Management and Ecology **10**:365-376.

114. Dekker, W. 2003b. Eels in crisis. ICES CIEM Newsletter **40**:10-11.

115. Deniel, C. 1984. Relations entre l'activite reproductrice et la croissance chez les poissons plats de la Baie de Douarnenez. Cybium **8**(supplement 1):83-93.

116. Deniel. C., C. Le Blanc, and A. Rodriguez. 1989. Comparative study of sexual cycles, oogenesis and spawning of two Soleidae, *Solea lascaris* (Risso, 1810) and *Solea impar* (Bennet, 1831), on the western coast of Brittany. Jounal of Fish Biology **35**(supplement 1):49-58.

117. Desoutter, M. 1990. Soleidae. Pages 1037-1049 in J. C. Quero, J. C. Hureau, C. Karrer, A. Post, and L. Saldanha, editors. Check-list of the fishes of the eastern tropical Atlantic (CLOFETA) Vol.2. JNICT, Lisbon; SEI, Paris; and UNESCO, Paris.

118. Dinis, M. T. 1986. Quatre Soleidae de Léstuaire du Tage Reprodution et Croissance. Essai d'elevage de *Solea senegalensis* Kaup. Université de Bretagne Occidentale.

119. Dinis, M. T., L. Ribeiro, L. Florbela, and C. Sarasquete. 1999. A review on the cultivation potencial of *Solea senegalensis* in Spain and Portugal. Aquaculture **176**:27-38.

120. Diouf, P. S. 1996. Les peuplements de poissons des milieux estuariens de l'Afrique de l'Ouest: L'exemple de l'estuaire hyperhalin du Sine-Saloum. Université de Montpellier II. Thèses et Documents Microfiches No.156. ORSTOM, Paris.

121. Direcção Geral das Pescas e Aquicultura (DGPA). 2007. Datapescas Nº 70.

122 Doadrio, I. 2001. Atlas y Libro Rojo de los Peces Continentales de España. Dirección General de Conservación de la Naturaleza. España.

123. Dorman, J. A. 1991. Investigations into the biology of the garfish, *Belone belone* (L.), in Swedish waters. Journal of Fish Biology **39**(supplement 1):59-69.

124. Drake, P., A. M. Arias, and R. B. Rodrígues. 1982. Estudio del crescimento y la alimentación de la baila, *Dicentrachus punctatus* Bloch, 1892 (Osteichthyes, Serranidae), Esteros de las salinas de Cádiz. Inv. Pesq. **46**(supplement 3):335-347.

125. Dumas, F., and P. Prouzet. 2003. Variability of demographic paraqmeters and population dynamics of Atlantic salmon (*Salmo salar* L.) in a southwest French river. ICES Journal of Marine Science **60**:356-370.

126. Duque, J. C. D. 2000. Ecologia Alimentar da Faneca, *Trisopterus luscus* (L., 1758) e do Ruivo, *Trigla lucerna* L., 1758, na zona adjacente ao estuário do Tejo. Graduate Thesis. Faculdade de Ciências da Universidade de Lisboa, Lisboa.

127. Ehrenbaum, E. 1904. Eier und Larven von Fischen der deutschen Bucht. III. Fische mit festsitzenden Eiern. Wiss. Meeresunters. Abt. Kiel und Abt. Helgol. (n.s.) **6**(supplement 2):127-200.

128. Ehrenbaum, E. 1905. Eier und Larven von Fischen. Pages 1-414 in Lipsius, and Tischer. Plankton 1. Kiel - Leipzig.

129. Erzini, K., L. Bentes, R. Coelho, C. Correia, P. G. Lino, P. Monteiro, J.

Ribeiro, and J. M. S. Gonçalves. 2001. Fisheries biology and assessment of demersal species (SPARIDAE) From the South of Portugal. Commission of the European Communities DG XIV/C/1. Universidade do Algarve - Centro de Ciências do Mar Faculdade de Ciências do Mar e do Ambiente. Faro, Portugal.

130. Eschmeyer, W. N., E. S. Herald, and H. Hammann. 1983. A field guide to Pacific coast fishes of North America. Houghton Mifflin Company, Boston, U.S.A.

131. Fabi, G., C. Froglia. 1983. Food and Feeding of *Gobius niger* L. in the Central Adriatic Sea (Osteichthyes: Gobiidae). Rapports et Proces-Verbaux des Reunions Commission Internationale pour l'Exploration Scientifique de la Mer Mediterranee **28**(supplement 5):99-102.

132. Fidalgo, M. L., and M. L. Correia (coordenators). 1995. Estudo de Avaliação da vulnerabilidade da capacidade de recepção das águas e zonas costeiras em Portugal. Meios receptores e suas características. Estuários e sistemas lagunares. Região norte. Relatório não publicado, Instituto de Zoologia "Dr. Augusto Nobre" da Universidade do Porto, Porto, Portugal, and Instituto de Ciências Biomédicas de Abel Salazar da Universidade do Porto, Porto, Portugal.

133. Fletcher, D. A., and R. J. Wootton. 1995. A hierarchical response to differences in ration size in the reproductive performance of female three-spined sticklebacks. Journal of Fish Biology **46**(supplement 4):657-668.

134. Fonseca, L. C., A. M. Costa, and J. M. Bernardo. 1989. Seasonal variation of benthic and fish communities in a shallow land-locked coastal lagoon (St. André, Sw Portugal). Topics in Marine Biology. Scientia Marina **53**(supplement 2-3):663-669.

135. Food and agriculture organization of the United Nations, Rome. Available from http://www.fao.org/figis/servlet/species?fid=2106 (accessed February 2007)

136. Food and agriculture organization of the United Nations, Rome. Available from http://www.fao.org/figis/servlet/species?fid=2203 (accessed February 2007)

137. Food and agriculture organization of the United Nations, Rome. Available from http://www.fao.org/figis/servlet/species?fid=2291 (accessed February 2007)

138. Food and agriculture organization of the United Nations, Rome. Available from http://www.fao.org/figis/servlet/species?fid=2306 (accessed February 2007)

139. Food and agriculture organization of the United Nations, Rome. Available from http://www.fao.org/figis/servlet/species?fid=2370 (accessed February 2007)

140. Food and agriculture organization of the United Nations, Rome. Available from http://www.fao.org/figis/servlet/species?fid=2384 (accessed February 2007)

141. Food and agriculture organization of the United Nations, Rome. Available

from http://www.fao.org/figis/servlet/species?fid=2385 (accessed February 2007)

142. Food and agriculture organization of the United Nations, Rome. Available from http://www.fao.org/figis/servlet/species?fid=2550 (accessed February 2007)

143. Food and agriculture organization of the United Nations, Rome. Available from http://www.fao.org/figis/servlet/species?fid=2994 (accessed February 2007)

144. Food and agriculture organization of the United Nations, Rome. Available from http://www.fao.org/figis/servlet/species?fid=3207 (accessed February 2007)

145. Forteeth, N. 1997. The large bellied seahorse, *Hippocampus abdominalis*, a candidate for aquaculture. Australian Aquaculture **11**:52–54.

146. Francescon, A., A. Barbara, L. Colombo, G. Bozzato, S. Chiereghin, P. Belvedere. 1994. Induction of multiple spawning in the gilthead seabream, *Sparus aurata* L., by LH-RH analogue treatments and their influence on egg quality. Rivista Italiana di Acquacoltura **29**:109-120.

147. Freire, T. J. C. 2004. Ecologia reproductiva de *Syngnathus typhle*, Linnaeus 1758 (Pisces, Syngnathidae) na Ria Formosa. Graduate Thesis. Universidade do Algarve, Faro.

148. Fricke, R. 1986. Callionymidae. Pages 1086-1093 in P. J. P. Whitehead, M. L. Bauchot, J. C. Hureau, J. Nielsen, and E. Tortonese, editors. Fishes of the North-eastern Atlantic and the Mediterranean Vol. 3. UNESCO, Paris.

149. Frimodt, C. 1995. Multilingual illustrated guide to the world's commercial warmwater fish. Fishing News Books, Osney Mead, Oxford, England.

150. Froese, R. and D. Pauly, editors. 2007.FishBase, Makati City. Available from http://filaman.ifm-geomar.de/Reproduction/MaturityList.cfm?ID=1290&GenusName=Ciliata&SpeciesName=mustela&fc=505 (accessed February 2007)

151. Froese, R. and D. Pauly, editors. 2007.FishBase, Makati City. Available from http://filaman.ifm-geomar.de/Reproduction/MaturityList.cfm?ID=1341&GenusName=Platichthys&SpeciesName=flesus&fc=440 (accessed February 2007)

152. Froese, R. and D. Pauly, editors. 2007.FishBase, Makati City. Available from http://filaman.ifm-geomar.de/Reproduction/MaturityList.cfm?ID=43&GenusName=Arnoglossus&SpeciesName=thori&fc=439 (accessed February 2007)

153. Froese, R. and D. Pauly. Editors. 2007.FishBase, Makati City. Available from http://filaman.ifm-geomar.de/Reproduction/MaturityList.cfm?ID=47&GenusName=Belone&SpeciesName=belone&fc=207 (26/02/2007)

154. Froese, R. and D. Pauly editors. 2007.FishBase, Makati City. Available from http://filaman.ifm-geomar.de/Reproduction/MaturityList.cfm?ID=48&GenusName=Parablen

nius&SpeciesName=gattorugine&fc=392 (accessed March 2007)

155. Froese, R. and D. Pauly, editors. 2007.FishBase, Makati City. Available from http://filaman.ifm-geomar.de/Summary/speciesSummary.php?ID=1345&genusname=Pomatoschistus&speciesname=minutus (Acessed January 2007)

156. Frostier, A. (coordenator), P. Y. Le Bail, B. Breton, M. Kentouri, P. Divanach, M. Pavlidis, L. Kokokiris, A. Canario, and F. Le Menn. 1996. Sexual cycles and growth preformance in the common sea-bream, *Pagrus pagrus*, in rearing conditions: application to spawners breeding and spawning induction. Final Report 1993-1996.

157. Gibson, R. N., and I. A. Ezzi. 1980. The biology of the scaldfish, *Arnoglossus laterna* (Walbaum) on the west coast of Scotland. Journal of Fish Biology **17**:565-575.

158. Gordo, L. 1992. Contribuição para o conhecimento da biologia e do estado de exploração do stock de boga [*Boops boops* (L., 1758)] da costa Portuguesa. PhD Thesis. Faculdade de Ciências da Universidade de Lisboa, Lisboa.

159. Gordo, L. S. 1995. Gametogenesis in *Boops boops* (L., 1758). Boletim do Instituto Português de Investigação Marítima **1**:79-91. Lisboa.

160. Gordo, L. S., and H. N. Cabral. 2001. The fish assemblage structure of a hydrologically altered coastal lagoon: the Óbidos lagoon (Portugal). Hydrobiologia **459**:125-133.

161. Grilo, C. 2002. Evolução da Frequência de Postura da Sardinha (*Sardina pilchardus* Walbaum, 1792) nas Costa Sul e Ocidental Norte de Portugal. Graduate Thesis. Faculade de Ciências da Universidade de Lisboa, Lisboa.

162. Groot, S. J. D. 1990. The former Allis and Twaite Shad fisheries of the lower Rhine, the Netherlands. Journal of Applied Ichthyology **6**:252–256.

163. Guerra, M. I. F. P. 1976. Contribuição para o estudo da biologia de *Mugil cephalus* Linné e de *Liza ramada* (Risso) do Rio Tejo. Relatório de Estágio. Faculdade de Ciências da Universidade de Lisboa, Lisboa.

164. Hashem, M. T. 1973. Some biological studies on the goat fish (*Mullus surmuletus* L.) in the Egyptian Mediterranean waters. Bulletin of the Institute of Oceanography and Fisheries. Cairo. **3**:95-115.

165. Havelange, S., G. Lepoint, P. Dauby, and J. M. Bouquegneau. 1997. Feeding of the sparid fish *Sarpa salpa* in a seagrass ecosystem: diet and carbon flux. Marine Ecology **18**(supplement 4):289-297.

166. Horie, N., Y. Yamada, A. Okamura, S. Tanaka, T. Utoh, N. Mikawa, A. Akazawa, H.-P.Oka. 2003. Effective hormonal treatments for induction of ovarian maturation and ovulation in the common Japanese conger *Conger myriaster*. Bulletin of the Japanese Society of Scientific Fisheries **69**(supplement 3):337-346.

167. Hotos, G. N., D. Avramidou, and I. Ondrias. 2000. Reproduction biology of *Liza aurata* (Risso, 1810), (Pisces Mugilidae) in the lagoon of Klisova (Messolonghi, W. Greece). Fisheries Research **47**(supplement 1):57-67.

168. Hureau, J. C. 1986. Mullidae. Pages 877-882 in P. J. P. Whitehead, M. L. Bauchot, J. C. Hureau, J. Nielsen and E. Tortonese, editors. Fishes of the north-eastern Atlantic and the Mediterranean, Vol.2. UNESCO, Paris.

169. Hureau, J. C. 1986. Triglidae. Pages 1230-1238 in P. J. P. Whitehead, M. L. Bauchot, J. C. Hureau, J. Nielsen and E. Tortonese, editors. Fishes of the north-eastern Atlantic and the Mediterranean, Vol.3. UNESCO, Paris.

170. Hureau, J. C., and N. I. Litvinenko. 1986. Scorpaenidae. Pages 1211-1229 in P. J. P. Whitehead, M. L. Bauchot, J. C. Hureau, J. Nielsen and E. Tortonese, editors. Fishes of the North-eastern Atlantic and the Mediterranean, Vol. 3. UNESCO, Paris.

171. ICES. 2006. Report of the ICES Advisory Committee on Fishery Management, Advisory Committee on the Marine Environment and Advisory Committee on Ecosystems, 2006. ICES Advice. Books 1 - 10. Vol. 7.

172. ICES. 2006. Report of the ICES Advisory Committee on Fishery Management, Advisory Committee on the Marine Environment and Advisory Committee on Ecosystems, 2006. ICES Advice. Books 1 - 10. Vol. 9.

173. IGFA, 2001 Database of IGFA angling records until 2001. IGFA, Fort Lauderdale, USA.

174. Iglesias, M., and B. Morales-Nin. 2001. Life cycle of the pelagic goby *Aphia minuta* (Pisces: Gobiidae). Scientia Marina **65**(supplement 3):183–192.

175. Imsland, A. K., M. Dragsnes, and S. O. Stefansson. 2003. Exposure to continuous light inhibits maturation in turbot (*Scophthalmus maximus*). Aquaculture **219**:911-919.

176. Jones, J. W., and H. B. N. Hynes. 1950. The age and growth of *Gasterosteus aculeatus*, *Pygosteus pungitius* and *Spinachia vulgaris*. Journal of Animal Ecology **19**:59- 73.

177. Jonsson, G. 1992. Islenskir fiskar. Fiolvi, Reykjavik.

178. Jorge, I. 1991. Contribuição para o conhecimento da ictiofauna do estuário do Mondego. Relatórios Técnicos e Científicos No. 44. Instituto Nacional de Investigação das Pescas. Lisboa.

179. Kailola, P. J., M. J. Williams, P. C. Stewart, R. E. Reichelt, A. McNee, and C. Grieve. 1993. Australian fisheries resources. Bureau of Resource Sciences, Canberra, Australia.

180. Karlou-Riga, C., P. S. Economidis. 1997. Spawning frequency and batch fecundity of horse mackerel, *Trachurus trachurus* (L.) in the Saronikos Gulf (Greece). Journal of Applied Ichthyology **13**(supplement 3):97-104.

181. Kelly, F. L. and J. J. King. 2001. A review of the ecology and distribution of three lamprey species, *Lampetra fluviatilis* (L.), *Lampetra planeri* (Bloch) and *Petromyzon marinus* (L.): a context for conservation and biodiversity considerations in Ireland. Biology and Environment: Procedings of the Royal Irish Academy **101**B(supplement 3):165-185.

182. Kennedy, M., and P. Fritzmaurice. 1972. The Biology of the bass,

Dicentrarchus labrax, in the Irish waters. Journal of the Marine Biological Association of the United Kingdom **52**:557-597.

183. King, P. A., J. M. Fives, and D. McGrath. 1994. Reprduction, Growth and Feeding of the Dragonet *Callionymus lyra* (Teleostei: Callionymidae), in Galway Bay, Ireland. Journal of the Marine Biological Association of the United Kingdom **74**:513-526.

184. Knijn, R. J., T. W. Boon, H. J. L. Heessen, and J. R. G. Hislop. 1993. Atlas of North Sea fishes. International Council for the Exploration of the Sea, Copenhagen, Denmark.

185. Kokokiris, L., S. Bruslé, M. Kentouri, and A. Fostier. 1999. Sexual maturity and hermaphroditism of the red porgy *Pagrus pagrus* (Teleostei: Sparidae). Marine Biology **134**:621– 629.

186. Kolios, P., S. Kiritsis, and N. Katribusas. 1997. Larval-rearing and growth of the red porgy (*Pagrus pagrus*) in the Riopesca hatchery (Greece). Hydrobiologia **358**:321–325.

187. Kottelat, M. 1997. European freshwater fishes. Biologia. **52**(Supplement 5):1-271.

188. Krug, H. M. 1990. The Azorean blackspot seabream, *Pagellus bogaraveo* (Bruennich, 1768) (Teleostei, Sparidae). Reproductive cycle, hermaphroditism, maturity and fecundity. Cybium. Paris. **14**(supplement 2):151-159.

189. Ktari, M. H., A. Bouain, and J. P. Quinard. 1978. Régime alimentaire de loups (Poisson, Téléosteéns, Serranidae) *Dicentrachus labrax* (Linné, 1778) et *Dicentrarchus punctatus* (Bloch, 1892) de côtes tunisiennes. Bulletin de L'institut natioonal scientifique et technique d'Oceanographie et de Peche de Salammbô **5**(supplement 1-4):5-15.

190. La Mesa, M., E. Arneri, V. Caputo, and M. Iglesias. 2005. The transparent goby, *Aphia minuta*: review of biology and fisheries of a paedomorphic European fish. Reviews in Fish Biology and Fisheries **15**:89-109.

191. L'Abée-Lund, J. H., and K. Hindar. 1990. Interpopulation variation in reproductive tarits of anadromous female brown trout, *Salmo trutta* L.. Journal of Fish Biology **37**:755-763.

192. Labropoulou, M., G. Tserpes, and N. Tsimenides. 1998. Age, growth and feeding habits of the brown comber *Serranus hepatus* (Limmaeus, 1758) on the Creatan Shelf. Estuarine, Coastal and Shelf Science **46**:723-732.

193 Lagardére, J. P. 1987 Feeding ecology and daily food consumption of common sole, *Solea vulgaris* Quensel, juveniles on the French Atlantic coast. Journal of the Fish Biology **30**:91-104.

194. Lahaye, J. 1971. (ogenesis in *Nerophis lumbriciformis* (Pennant, 1776). The sexual cycle. Cahiers de Biologie Marine **12**(supplement 2):239-254.

195. Leitão, R. J. 2005. Ecologia da ictiofauna do estuário do Mondego: variação na composição e estrutura ao longo da última década. Master Thesis. Faculdade de Ciências e Tecnologia da Universidade de Coimbra, Coimbra.

196. Leitão, R., F. Martinho, J. M. Neto, H. Cabral, J. C. Marques, and M. A. Pardal. 2006. Feeding ecology, population stucture and distribution of *Pomatoschistus microps* (KrØyer, 1838) and *Pomostachistus minutus* (Pallas, 1770) in a temperate estuary, Portugal. Estuarine Coastal and Shelf Science **66**:231-239

197. Leitão, R., F. Martinho, H. N. Cabral, J. M. Neto, I. Jorge, and M. A. Pardal. 2007. The fish assemblage of the Mondego estuary: composition, strutucture and trends over the past two decades. Hydrobiologia **587**:269-279.

198. Lepage, M., and E. Rochard. 1995. Threatened fishes of the world: *Acipenser sturio* Linnaeus, 1758 (Acipenseridae). Environmental Biology of Fish. **43**(supplement 1):28.

199. Lieske, E., and R. Myers. 1994. Collins Pocket Guide. Coral reef fishes. Indo-Pacific & Caribbean including the Red Sea. Harper Collins Publishers, New York.

200. Lobón-Cerviá, J., C. Montañés, and A. Sostoa. 1986. Reproductive ecology and growth of a population of brown trout (*Salmo trutta* L.) in a aquifer fed stream of Old Castille (Spain). Hydrobiologia **135**:81-94.

201. Lyons, D. O., and J. J. Dunne. 2004. Inter- and intra-gender analyses of feeding ecology of the worm pipefish (*Nerophis lumbriciformis*). Journal of the Marine Biological Association of the United Kingdom **84**(supplement 2):461-464.

202. Lythgoe, J., and G. Lythgoe. 1971. Fishes of the sea. Blandford. London.

203. Machado, D. M. 2003. Contribuição para o estudo da Fauna Ictiológica do estuário do Rio Arade. Graduate Thesis. Faculdade de Ciências do Mar e do Ambiente da Universidade do Algarve, Faro.

204. Magalhães, F., and L.Rogado (coordenators). 1993. Livro vermelho dos vertebrados de Portugal. Vol III - Peixes marinhos e estuarinos. Instituto da Conservação da Natureza, Lisboa, Portugal.

205. Maigret, J., and B. Ly. 1986. Les poissons de mer de Mauritanie. Science Naturel, Compiègne.

206. Maitland, P. S., and T. W. Hatton-Ellis. 2003. Ecology of the Allis and Twaite Shad. Conserving Natura 2000 Rivers Ecology Series No. 3. English Nature, Peterborough.

207. Maitland, P. S., and A. A. Lyle. 2005. Ecology of Allis Shad *Alosa alosa* and Twaite shad *Alosa fallax* in the Solway Firth, Scotland. Hydrobiologia **534**:205-221.

208. Manooch, C. S. 1976. Reproductive cycle, fecundity, and sex ratios of the red porgy, *Pagrus pagrus* (Pisces: Sparidae) in North Carolina. Fishery Bulletin NMFS/NOAA. **74**(supplement 4):775-781.

209. Manooch, C. S., and W. M. Hassler. 1978. Synopsis of biological data on the red porgy, *Pagrus pagrus* (Linnaeus). FAO Fisheries Synopsis **116**:1–19.

210. Marlin. The marine biological association, Plymouth. Available from http://www.marlin.ac.uk/species/Arnoglossuslaterna.htm (accessed

February 2007)

211. Marques, J. M. C. S. 1990. Contributos para o conhecimento da biologia, ecologia e sistemática dos Syngnathidae (PISCES) (Estuário do Tejo). Uma prespectiva ecotoxicológica. Graduate Thesis. Faculdade de Ciências Universidade de Lisboa, Lisboa.

212. Marques, V., A. Morais, and G. Pestana. 2003. Distribuição, abundância e evolução do manancial de Sardinha presente na plataforma continental Portuguesa entre 1995 e 2002. Relatórios cientificos e técnicos No.10. Instituto Nacional de Investigação Agrária e das Pescas - INIAP, Lisboa.

213. Maugé, L.A., 1986 Gobiidae. Pages 358-388 in J. Daget, J. P. Gosse and D. F. E. Thys van den Audenaerde, editors. Check-list of the freshwater fishes of Africa (CLOFFA) Vol.2. ISNB, Brussels; MRAC, Tervuren; and ORSTOM, Paris.

214. Maugé, L. A. 1990. Atherinidae. Pages 604–605 in J. C. Quero, J. C. Hureau, C. Karrer, A. Post, and L. Saldanha, editors. Check List of the Fishes of the Eastern Tropical Atlantic. Clofeta II , UNESCO, Paris.

215. Mayer, I., S. E. Shackley, and P. R. Witthames. 1990. Aspects of the reproductive biology of the bass, *Dicentrarchus labrax* L. II. Fecundity and pattern of oocyte development. Journal of Fish Biology **36**:141-148.

216. Micale, V., F. Perdichizzi, and G. Basciano. 1996. Aspects of the reproductive biology of the sharpsnout seabream *Diplodus puntazzo* (Cetti, 1777) . I. Gametogenesis and gonadal cycle in captivity during the third year of life. Aquaculture **140**:281-291.

217. Micale, V., G. Maricchiolo, and L. Genovese. 2004. Gonadal maturation in the blackspot seabream *Pagellus bogaraveo*: a comparison between a farmed and a wild broodstock. Journal of Fish Biology. **65**(supplement 1):332.

218. Mihelakakis, A., T. Yoshimatsu, and C. Tsolkas. 2001. Spawning in captivity and early life history of cultured red porgy, *Pagrus pagrus*. Aquaculture **199**:333–352.

219. Miller, P. J. 1975. Age-structure and life-span in the common goby, *Pomatoschistus microps*. Journal of Zoology **177**: 425-448.

220. Miller, P. J. 1986. Gobiidae. Pages 1019-1085 in P. J. P. Whitehead, M. L. Bauchot, J. C. Hureau, J. Nielsen, and E. Tortonese editors. Fishes of the North-Eastern Atlantic and the Mediterranean, Vol. 3. UNESCO, Paris.

221 Miller, P. J. 1990. Gobiidae. Pages 925-951 in J. C. Quero, J. C. Hureau, C. Karrer, A. Post and L. Saldanha, editors. Check-list of the fishes of the eastern tropical Atlantic (CLOFETA) Vol. 2. JNICT, Lisbon, SEI, Paris; and UNESCO, Paris.

222. Modrušan, Z., E. Teskeredžić, and D. Marguš. 1991. First maturity, seasonal variations of gonadosomatic index, spawning time and annual migrations of grey mullets *Liza* (liza) *ramada* Risso, 1826 and *Chelon labrosus* Risso, 1826 from the Eastern Adriatic. Oebalia. **17**:145-157.

223. Molinero, A., E. Garcia, and R. Flos. 1991. Comparative study of feeding habits for two species of sole: *Solea vulgaris* and *Solea senegalensis*.

Aquaculture and the Environment **14**:219-220.

224. Monteiro, C. C. 1986.Contribuição para o conhecimento das comunidades ictiológicas da Ria Formosa. Boletim Instituto Nacional de Investigação das Pescas **14**:59-94.

225. Monteiro, C. C., T. Lam Hoai, and G. Lasserre. 1987. Distribution chronologique des poissons dans deux stations de la lagune Ria Formosa (Portugal). Oceanol. Acta **10**:359-371.

226. Monteiro, N., V. C. Almada, A. M. Santos, and M. N. Vieira. 2001. The breeding ecology of the pipefish *Nerophis lumbriciformis* and its relation to latitude and water temperature. Journal of the Marine Biological Association of the United Kingdom **81**(supplement 6):1031-1033.

227. Monteiro, P., L. Bentes, R. Coelho, C. Correia, J. M. S. Gonçalves, P. Lino, J. Ribeiro, and K. Erzini. 2006. Age and growth, mortality, reproduction amd relative yiels per recruit of the bogue, *Boops boops* Linné, 1758 (Sparidae), from the Algarve (southern Portugal) longline fishery. Journal of Applied Ichthyology **22**(supplement 5):345-352.

228. Morato, T., P. Afonso, P. Lourinho, J. P. Barreiros, R. S. Santos, and R. D. S. Nash. 2001. Lenght-weight relationships for 21 coastal fish species of the Azores, north-eastern Atlantic. Fisheries Reserch **50**:297-302.

229. Moreira, F., J. L. Costa, P. R. Almeida, C. Assis, and M. J. Costa. 1991. Age determinationin *Pomatoschistus minutus* (Pallas) and *Pomatoschistus microps* (Krøyer) (Pisces:Gobiidae) from the upper Tagus estuary, Portugal. Journal of Fish Biology **13**:433-440.

230. Morte, S., M. J. Redon, and A. Sanz-Brau. 2001. Diet of *Scorpaena porcus* and *Scorpaena notata* (Pisces: Scorpaenidae) in the western Mediterranean. Cahiers Biology Marine **42**:333-344.

231. Motos, L. 1996. Reproductive biology and fecundity of the Bay of Biscay anchovy population (*Engraulis encrasicolus* L.). Scientia Marina **60**(supplement 2):195-207.

232. Mugnier, C. M. Guennoc, E. Lebegue, A. Fostier, and B. Brenton. 2000. Indiction and synchronisation of spawning in cultivated Turbot (*Scophthalmus maximus* L.) broodstock by implantation of a sustained-release GnRH-a pellet. Aquaculture **181**: 241-155.

233. Munoz, M., M. Casadevall, and S. Bonet. 2002. The ovarian morphology of *Scorpaena notata* shows a specialized mode of oviparity. Journal of Fish Biology **61**(supplement 4):877-887.

234. Muus, B. J., and J. G. Nielsen. 1999. Sea fish. Scandinavian Fishing Year Book, Hedehusene, Denmark.

235. Muus, B. J., and P. Dahlström. 1967. Guide des poissons d'eau douce et pêche. GEC Gads Forlag, Copenhague.

236. Muus, B. J., and P. Dahlström. 1974. Collins guide to the sea fishes of Britain and North-Western Europe. Collins, London, UK.

237. Muzavor, S., L. N. Arruda, J. P. A. S. Andrade. 1993. Roteiro Ecológico da Ria Formosa (II - Peixes). Algarve Em Foco Editora. Faro.

238. Mylonas, C. C., M. Papadaki, M. Pavlidis, and P. Divanach 2004. Evaluation of egg production and quality in the mediterranean red porgy (*Pagrus pagrus*) durinh two consecutive spawning seasons. Aquaculture **232**:637-469.

239. Mylonas, C. C., and Y. Zohar. 2001. Use of GnRHa-delivery systems for the control of reproduction in fish. Reviews in Fish Biology and Fisheries **10**:463–491.

240. Neves Santos, M., C. Costa Monteiro, K. Erzini, and G. Lasserre. 1998. Maturation and gill-net selectivity of two small sea breams (genus Diplodus) from the Algarve coast (south Portugal). Fisheries Research **36**:185-194.

241. Nieder, J. 1997. Seasonal variation in feeding patterns and food niche overlap in the Mediterranean blennies Scartella cristata, *Parablennius pilicornis* and *Lipophrys trigloides* (Pisces: Blenniidae). Marine Ecology **18**(supplement 3):227-237.

242. Nielsen, J.G. 1986. Bothidae. Pages 1294-1298 in P. J. P. Whitehead, M. L. Bauchot, J. C. Hureau, J. Nielsen, and E. Tortonese, editors. Fishes of the North-eastern Atlantic and the Mediterranean, Vol. 3. UNESCO, Paris.

243. Nielsen, J.G. 1986. Pleuronectidae. Pages 1299-1307 in P. J. P. Whitehead, M. L. Bauchot, J. C. Hureau, J. Nielsen, and E. Tortonese, editors. Fishes of the North-eastern Atlantic and the Mediterranean, Vol. 3. UNESCO, Paris.

244. Nottage, A. S., and E. J. Perkins. 1983. The biology of solenette, *Buglossidium luteum* (Risso), in the Solway Firth. Journal of Fish Biology **22**(1):21-27.

245. Nunez Rodriguez, J. 1985. Contribuition à l'étude de la biologie de la reproduction de la sole (*Solea vulgaris*, Quensel, 1806): approche ultrastructurale et physiologique. PhD Thesis. Univ. Bordeaux.

246. Oliveira, F., K. Erzini, and J. M. S. Gonçalves. 2006. Feeding habits of the deep-snouted pipefish *Syngnathus typhle* in a temperate coastal lagoon. Estuarine Coastal and Shelf Science **20**:1-11.

247. O'Sullivan, S., C. Moriarty, R. D. FitzGerald, J. Davenport, and M. F. Mulcahy. 2003. Age, growth and reproductive status of the European conger eel, *Conger conger* (L.) in Irish coastal waters.Fisheries Research **64**:55-69.

248. Otto, C. 1976. Size, growth, population density and food of brown trout *Salmo trutta* L. in two sections of a south Swedish stream. Journal of Fish Biology **8**(supplement 6):447-488.

249. Pajuelo, J. G., and J. M. Lorenzo. 1999. Life history of black seabream, *Spondyliosoma cantharus*, off the Canary Islands, Central-east Atlantic. Environmental Biology of Fishes **54**:325-336.

250. Pajuelo, J. G., and J. M. Lorenzo. 2000. Biology of the sand smelt, *Atherina presbyter* (Teleostei: Atherinidae), off the Canary Islands (central-east Atlantic). Environmental Biology of Fishes **59**:91-97.

251. Pajuelo, J. G., and J. M. Lorenzo. 2001. Biology of the annular seabream, *Diplodus annularis* (Sparidae), in coastal waters of the Canary Islands. Journal of Applied Ichthyology **17**:121-125.

252. Pajuelo J. G., J. M. Lorenzo, and R. Domínguez-Seoane. 2003. Age estimation and growth of the zebra seabream *Diplodus cervinus cervinus* (Lowe, 1838) on the Canary Islands shelf (Central-east Atlantic). Fisheries Research **62**:97–103.

253. Pajuelo, J. G., J. M. Lorenzo, R. Dominguez, A. Ramos, M. Gregoire. 2003. On the population ecology of the zebra seabream *Diplodus cervinus cervinus* (Lowe 1838) from the coasts of the Canarian archipeligo, North West Africa. Environmental Biology of Fishes **67**(supplement 4): 407-416.

254. Palmer, C. J., and M. B. Culley. 1984. The egg and early life stages of the sand smelt *Atherina presbyter* Cuvier. Journal of Fish Biology **24**:537–544.

255. Petersen, C. W., and E. A. Fischer. 1986. Mating system of the hermaphroditic coral-reef fish, *Serranus baldwini*. Behavioral Ecology and Sociobiology **18**(supplement 3):171-178.

256. Pinder, A.C. 2001. Keys to larval and juvenile stages of coarse fishes from fresh waters in the British Isles. Scientific Publication No. 60. Freshwater Biological Association. The Ferry House, Far Sawrey, Ambleside, Cumbria.

257. Pinhão, A. M. P. R. 2003. Biologia e Ecologia do Linguado da areia, *Solea lascaris* (Risso, 1810), na costa Portuguesa. Graduate Thesis. Faculdade de Ciências da Universidade de Lisboa, Lisboa.

258. Pinto, C., S. Gamito, and K. Erzini. 2002. Feeding habits of the gilthead seabream (*Sparus aurata*) from the ria Formosa (Southern Portugal) as compared to the Black Seabream (*Spondyliossoma canthaurus*) and the annular seabream (*Diplodus annularis*). Journal of Applied Ichthyology **18**:81-86.

259. Pombo, L., M. Elliott, and J. E. Rebelo. 2004. The Structure and Functioning of Fish Communities in the Ria de Aveiro, Portugal – Temporal and Spatial variation and the Influence of Abiotic Factors. Cahiers de Biologie Marine **45**:197-211.

260. Quéméner, L. 2002. Le maigre comum (*Argyrosomus regius*) Biologie, pêche, marché et potencial aquacole. Ifermer, Paris.

261. Quéro, J. -C., M. Desoutter, and F. Lagardére. 1986. Soleidae. Pages 1308-1324 in P. J. P. Whitehead, M. L. Bauchot, J. C. Hureau, J. Nielsen and E. Tortonese, editors. Fishes of the north-eastern Atlantic and the Mediterranean, Vol. 3. UNESCO, Paris.

262. Quignard, J. P. and A. Pras. 1986. Atherinidae. Pages 1207-1210 in P. J. P. Whitehead, M. L. Bauchot, J. C. Hureau, J. Nielsen and E. Tortonese, editors. Fishes of the north-eastern Atlantic and the Mediterranean, Vol. 3. UNESCO, Paris.

263 Quignard, J. P. and A. Pras. 1986. Labridae. Pages 919-942 in P. J. P. Whitehead, M. L. Bauchot, J. C. Hureau, J. Nielsen and E. Tortonese,

editors. Fishes of the north-eastern Atlantic and the Mediterranean, Vol. 2. UNESCO, Paris.

264. Ramos, M. A. 1985. Age, growth and reproductive cycle in *Sparus aurata* L. Jornadas sobrea nutrição em aquacultura. INIP. Lisboa

265. Ré, P., A. Farinha, and I. Meneses. 1983. Anchovy Spawning in Portuguese Estuaries (*Engraulis encrasicolus*, Pisces: Engraulidae). Cybium 7(supplement 1):29-38.

266. Reay, P. J. 1970. Synopsis of biological data on North Atlantic sandeels of the genus Ammodytes. FAO Fisheries Synopsis. No.82.

267. Reay, P. J. 1973. Some aspects of the biology of the sand-eel, *Ammodytes tobianus* L., in the Langstone Harbour, Hampshire. Journal of the Marine Biological Association of the United Kingdom **53**(supplement 2):325-342.

268. Reay, P. J. 1986. Ammodytidae. Pages 945-950 in P. J. P. Whitehead, M. L. Bauchot, J. C. Hureau, J. Nielsen and E. Tortonese, editors. Fishes of the north-eastern Atlantic and the Mediterranean, Vol. 2. UNESCO, Paris.

269. Rebelo, J. E. 1992. The ictiofauna and abiotic hydrological environment of the ria de aveiro, Portugal. Estuaries **15**(supplement 3):403-413.

270. Reshetnikov, Y. S. 2003. Atlas of Russian freshwater fishes, Vol. 2. Moscow Nauka.

271. Ribeiro, J., L. Bentes, R. Coelho, J. M. S. Gonçalves, P. G. Lino, P. Monteiro, and K. Erzini. 2006. Seasonal, tidal and diurnal changes in fish assemblages in the Ria Formosa lagoon (Portugal). Estuarine Coastal and Shelf Science **20**:1-14.

272. Riede, K. 2004. Global register of migratory species - from global to regional scales. Final Report of the R&D-Projekt 808 05 081. Federal Agency for Nature Conservation, Bonn, Germany.

273. Robins, C. R., and G. C. Ray. 1986. A field guide to Atlantic coast fishes of North America. Houghton Mifflin Company, Boston, U.S.A.

274. Rochard, E., and P. Elie. 1994. La macrofaune aquatique de l'estuaire de la Gironde. Contribution au livre blanc de l'Agence de l'Eau Adour Garonne. Pages 1-56 in J. L. Mauvais and J. F. Guillaud, editors. État des connaissances sur l'estuaire de la Gironde. Agence de l'Eau Adour-Garonne, Éditions Bergeret, Bordeaux, France.

275. Rochard, E., M. Lepage, and L. Meauzé. 1997. Identification et caractérisation de l'aire de répartition marine de l'esturgeon européen *Acipenser sturio* à partir de déclarations de captures. Aquatic Living Resources **10**:101-109.

276. Rogers, S. I. 1989. Seasonal variations in fecundity and egg size of the common goby, *Pomatoschistus microps*. Journal of the Marine Biological Association of the United Kingdom **69**(supplement 3):535-543.

277. Roux, C. 1986. Batrachoididae. Pages 1360-1361 in P. J. P. Whitehead, M. L. Bauchot, J. C. Hureau, J. Nielsen and E. Tortonese, editors. Fishes of the North-eastern Atlantic and the Mediterranean, Vol. 3. UNESCO, Paris.

278. Ruano, M. 2004. Caracterização da fauna ictiológica das margens e sapal do estuário do rio Arade. Graduate thesis. Universidade do Algarve - Faculdade de Ciências do Mar e Ambiente, Faro.

279. Rubidge, E. 2000. Variability within the Gasterosteus species complex in Coastal B.C. Royal British Columbia Museum. Belleville Street, Victoria, B.C.

280. Russell, F. S. 1976. The eggs and planktonic stages of British marine fishes. Academic Press, London, UK.

281. Sabatié, M. R. 1990. Croissance linéaire de l'alose vraie, Alosa alosa Linné, 1758 (Clupeidae), dans l'oued sebou (Façade nord-Atlantique du Maroc). Cybium **14**(supplement 2):131-142.

282. Sanches, J. G. 1991. Catálogo dos principais peixes marinhos da República de Guiné-Bissau. Publicações avulsas do INIP No. 16.

283. Santos, M. N., C. C. Monteiro, K. Erzini, and G. Lasserre. 1998. Maturation and gillnet selective of two small sea breams (genus Diplodus) from the Algarve coast (south Portugal). Fisheries Research. **36**:185-195.

284. Santos, M. N., M. B. Gaspar, P. Vasconcelos, and C. C. Monteiro. 2002. Weight-lenght relationships for 50 selected fish species of the Algarve coast (southern Portugal). Fisheries Research. **59**:289-295.

285. Scott, W. B., and E. J. Crossman. 1973. Freshwater fishes of Canada. Bulletin Fisheries Research Board of Canada **184**:1-966.

286. Scotton, L. N., R. E. Smith, N. S. Smith, K. S. Price, and D. P. de Sylva. 1973. Pictorial guide to fish larvae of Delaware Bay: with information and bibliographies useful for the study of fish larvae. Delaware Bay Report Series Vol. 7. College of Marine Studies, University of Delaware, Delaware.

287. Seixas, S. I. F. B. P. 1988. Contribuição para o conhecimento da postura e do desenvolvimento embrionário e prélarvar de Sparus aurata Linnaeus, 1758 (Pisces, Sparidae). Graduate thesis. Faculdade de Ciências da Universidade de Lisboa, Lisboa.

288. Shehadeh, Z. H., and J. E. Ellis. 1970. Induced spawning of the striped mullet *Mugil cephalus* L. Journal of Fish Biology **2**:355-360.

289. Simon, J. 2007. Age, growth and condition of European eel (*Anguilla anguilla*) from six lakes in the River Havel system (Germany). ICES Jouranl of Marine Science **64**:1414-1422.

290. Smith, C. L. 1981. Serranidae. in W. Fischer, G. Bianchi and W. B. Scott, editors. FAO species identification sheets for fishery purposes, Vol. 4. Eastern Central Atlantic; fishing areas 34, 47 (in part). Department of Fisheries and Oceans Canada and FAO.

291. Smith, D. G. 1990. Congridae. Pages 156-167 in J. C. Quero, J. C. Hureau, C. Karrer, A. Post and L. Saldanha, editors. Check-list of the fishes of the eastern tropical Atlantic (CLOFETA), Vol. 1. JNICT, Lisbon; SEI, Paris; and UNESCO, Paris.

292. Smith-Vaniz, W. F. 1986. Carangidae. Pages 638-661 in M. M. Smith and P.

C. Heemstra, editors. Smiths' sea fishes. Springer-Verlag, Berlin.

293. Smith-Vaniz, W. F. 1986. Carangidae. Pages 815-844. In P. J. P. Whitehead, M. L. Bauchot, J. C. Hureau, J. Nielsen and E. Tortonese, editors. Fishes of the north-eastern Atlantic and the Mediterranean, Vol. 2. UNESCO, Paris.

294. Soares, J. 2002. Organização das comunidades ictiológicas demersais dos canais proncipais e secundários da Ria Formosa. Graduate thesis. Universidade do Algarve - Faculdade de Ciências do Mar e do Ambiente, Faro.

295. Sobral, D. V. 1992. Regime alimentar do linguado *Solea vulgaris* (Quensel, 1806) no estuário do sado (Portugal). Estudos de Biologia e Conservação da Natureza No. 5. Serviço Nacional de Parques, Reservas e Conservação da Natureza, Lisboa.

296. Springer, V. G. 1986. Blenniidae. Pages 742-755 in M. M. Smith and P. C. Heemstra, editors. Smiths' sea fishes. Springer-Verlag, Berlin.

297. Stehmann, M. 1990. Rajidae. Pages 29-50 in J. C. Quero, J. C. Hureau, C. Karrer, A. Post and L. Saldanha, editors. Check-list of the fishes of the eastern tropical Atlantic, Vol. 1. Junta Nacional de Investigaçao Cientifica e Tecnológica, Lisbon, Portugal.

298. Stehmann, M., and D. L. Bürkel. 1984. Rajidae. Pages 163-196 in P. J. P. Whitehead, M. L. Bauchot, J. C. Hureau, J. Nielsen and E. Tortonese, editors. Fishes of the north-eastern Atlantic and Mediterranean, Vol. 1. UNESCO, Paris.

299. Stergiou, K. I., E. D. Christou, D. Georgopoulos, A. Zenetos, and C. Souvermezoglou. 1997. The Hellenic seas: physics, chemistry, biology and fisheries. Oceanography and Marine Biology: an Annual Review **35**:415-540.

300. Svetovidov, A. N. 1986. Gadidae. Pages 680-710 in P. J. P. Whitehead, M. L. Bauchot, J. C. Hureau, J. Nielsen and E. Tortonese, editors. Fishes of the north-eastern Atlantic and Mediterranean, Vol. 2. UNESCO, Paris.

301. Svetovidov, A. N. 1986. Salmonidae. Pages 373-385 in P. J. P. Whitehead, M. L. Bauchot, J. C. Hureau, J. Nielsen and E. Tortonese, editors. Fishes of the north-eastern Atlantic and Mediterranean, Vol. 1. UNESCO, Paris.

302. Taverny, C. 1991. Pêche, biologie, écologies des aloses dans le système Gironde-Garonne-Dordogne. PhD Thesis, University of Bordeaux, Bordeaux.

303. Tesch, W. W. 1977. "The eel", Biology and management of anguilled eels. Chapman & Hall, London.

304. Thomson, J. M. 1986. Mugilidae. Pages 344-349 in J. Daget, J. P. Gosse and D. F. E. Thys van den Audenaerde, editors. Check-list of the freshwater fishes of Africa (CLOFFA), Vol. 2. ISNB, Brussels, MRAC; Tervuren; and ORSTOM, Paris.

305. Thomson, J. M. 1990. Mugilidae. Pages 855-859 in J. C. Quero, J. C. Hureau, C. Karrer, A. Post and L. Saldanha, editors. Check-list of the fishes of the eastern tropical Atlantic (CLOFETA), Vol. 2. JNICT,

Lisbon; SEI, Paris; and UNESCO, Paris.

306. Timoshek, N. G., and A. K. Shilenkova. 1974. The nature of the oogenesis and spawning of black sea mullet. Journal of Icthyology **14**:727-734.

307. Tingilis, G. 2001. Biological and morphological characters of Lake Kourna sandsmelt (*Atherina boyeri*, Risso, 1810). Pages 285-288 in Crete, Greece. 10th Panellenic Congress of Ichthyologists, Chania, Greece. Proceedings. Praktika. Proceedings of Panellenic Congres of Ichthyologists.

308. Tomasini, J. A., J. P. Quinard, C. Capapé, and J.-L. Bouchereau. 1991. Facteurs du succès reproductif de *Syngnathus abaster* Risso, 1926 (Pisces, Teleostei, Syngnathidae) en milieu lagunair méditerranéen (lagune de Mauguio, France). Acta Ecologica **12**(supplement 3):331-355.

309. Tortonese, E. 1975. Osteichtyes. Pesci Ossei. Parte seconda. Faun d'Italia XI. Edizione Calderini, Bologna.

310. Tortonese, E. 1986. Moronidae. Pages 793-796 in P. J. P. Whitehead, M. L. Bauchot, J. C. Hureau, J. Nielsen and E. Tortonese, editors. Fishes of the north-eastern Atlantic and the Mediterranean, Vol. 2. UNESCO, Paris.

311. Tortonese, E. 1986. Serranidae. Pages 780-792 in P. J. P. Whitehead, M. L. Bauchot, J. C. Hureau, J. Nielsen and E. Tortonese, editors. Fishes of the north-eastern Atlantic and the Mediterranean, Vol. 2. UNESCO, Paris.

312. Tortonese, E. 1986. Trachinidae. Pages 951-954 in P. J. P. Whitehead, M. L. Bauchot, J. C. Hureau, J. Nielsen and E. Tortonese, editors. Fishes of the north-eastern Atlantic and the Mediterranean, Vol. 2. UNESCO, Paris.

313. Valente, A., and P. Alexandrino. 1989. Estudo ecológico do estuário do Rio Lima. IV. A ictiofauna dos canais de Darque com especial referência à biologia do peixe-rei, *Atherina presbyter* Cuvier, 1829 (Pisces: Atherinidae). Pages 415-424 in Actas do colóquio luso-espanhol sobre bacias hidrográficas e recursos zoológicos. Instituto de Zoologia e Estação de Zoologia Marítima "Dr. Augusto Nobre". Faculdade de Ciências da Universidade do Porto, Porto.

314. Van Der Veer, H. W., F. Creutzberg, R. Dapper, G. C. A. Duineveld, M. Fonds, B. R. Kuipers, G. J. Van Noort, and J. I. J. Witte. 1990. On the Ecology of the Dragonet *Callionymus lyra* L. in the Southern North Sea. Netherlands Journal of Sea Research **26**(supplement 1):139-150.

315. van Ginneken, V. B. Muusze, J. Klein Breteler, D. Jansma, and G. van den Thillart. 2005. Microelectronic detection of activity level and magnetic orientation of yellow European eel (*Anguilla anguilla* L.) on a pond. Environmental Biology of Fish **72**:313–320.

316. van Ginneken, V. J. T., and G. E. Maes. 2005. The European eel (*Anguilla anguilla*, Linnaeus), its lifecycle, evolution and reproduction: a literature review. Reviews in Fish Biology and Fisheries **15**:367-398.

317. van Ginneken, V., G. Vianen, B. Muusze, A. Palstra, L. Verschoor, O. Lugten, M. Onderwater, S. van Schie, P. Niemantsverdriet, R. van Heeswijk, E. P. Eding, and G. van den Thillard. 2005. Gonad development and spawning of artificially-matured European eel (*Anguilla anguilla* L.). Animal Biology **55**(supplement 3):203-218.

318. Vasconcelos, R. M. 2001. Composição e estrutura das comunidades ictiícas dos estuários do Douro e Tejo. Graduate thesis. Faculdade de Ciências da Universidade de Lisboa, Lisboa.

319. Vassilopoulou, V., and C. Papaconstantinou,.1992. Age, growth and mortality of the red porgy, *Pagrus pagrus*, in the Eastern Mediterranean Sea (Dodecanese, Greece). Vie Milieu **42**:51–55.

320. Vaughan, D. S., and M. H. Prager. 2002. Severe decline in abundance of the red porgy (*Pagrus pagrus*) population of the southeastern United States. Fish Bulletim **100**:351–375.

321. Vesey, G., and E. Langford. 1985. The biology of the black goby, *Gobius niger* L. in na English south-coast bay. Journal of Fish Biology **27**:417-429.

322. Villamil, M. M., J. M. Lorenzo, J. G. Pajuelo, A. Ramos, and J. Coca. 2002. Aspects of the Life History of the Salema, *Sarpa salpa* (Pisces, Sparidae), off the Canarian Archipelago (Central-East Atlantic). Environmental Biology of Fishes **63**(supplement 2):183-192.

323. Vincent, A., I. Ahnesjö, A. Berglund, and G. Rosenqvist. 1992. Pipefishes and Seahorses: are they all sex role reversed? Trends in Ecology and Evolution **7**:237-241.

324. Vizzini, S., and A. Mazzola. 2005. Feeding ecology of the sand smelt *Atherina boyeri* (Risso, 1810) (Osteichthyes, Atherinidae) in the Western Mediterranean: evidance for spatial variability based on the stable carbon and nitrogen isotopes. Environmental Biology of Fishes **72**:259-266.

325. Vladykov, V. D. 1984. Petromyzonidae. Pages 64-67 in P. J. P. Whitehead, M. L. Bauchot, J. C. Hureau, J. Nielsen and E. Tortonese, editors. Fishes of the north-eastern Atlantic and Mediterranean, Vol.1. UNESCO, Paris.

326. Voulgaridou, P., and K. I. Stergiou. 2003. Trends in various biological parameters of the European sardine, *Sardina pilchardus* (Walbaum, 1792), in the Eastern Mediterranean Sea. Scientia Marina **67**(supplement 1):269-280.

327. Wague, A., P. S. Economidis, C. Papaconstantinou. 1997. La reproduction du serran hepate, *Serranus hepatus* (L., 1758) (Pisces, Serranidae) dans le golfe de Thermaikos Gulf (Mer Égée, Grèce). Oebalia **23**:61-73.

328. Wallace, R. A., and K. Selman. 1981. Cellular and dynamic aspects of oocyte growth in teleosts. American Zoologist **21**:325–343.

329. Wassef, E., and H. El Emary. 1989. Contribution to the biology of Bass, *Dicentrarchus labrax* L. in the Egyptian Mediterranean waters off Alexandria. Cybium **13**(supplement 4):327-345.

330. Weber, M. 1982. Para a estrutura do ecossistema do estuário do rio Minho (costa Oeste da Ibéria). Instituto de Ciências Biomédicas, Porto.

331. Wheeler, A. 1969. The fishes of the British Isles and Northwest Europe. MacKillan, London.

332. Wheeler, A. 1978. Key to the Fishes of Northern Europe. Warne, London.

333. Whitehead, P. J. P. 1985. FAO species catalogue. Vol. 7. Clupeoid fishes of the world (suborder Clupeioidei). An annotated and illustrated catalogue of the herrings, sardines, pilchards, sprats, shads, anchovies and wolf-herrings. Part 1 - Chirocentridae, Clupeidae and Pristigasteridae. FAO Fish. Synop. **125**(7/1):1-303.

334. Whitehead, P. J. P. 1986. Engraulidae. Pages 282-283 in P. J. P. Whitehead, M. L. Bauchot, J. C. Hureau, J. Nielsen and E. Tortonese, editors. Fishes of the north-eastern Atlantic and Mediterranean, Vol.1. UNESCO, Paris.

335. Whitehead, P. J. P., G. J. Nelson, and T. Wongratana. 1988. FAO species catalogue. Vol. 7. Clupeoid fishes of the world (Suborder Clupeoidei). An annotated and illustrated catalogue of the herrings, sardines, pilchards, sprats, shads, anchovies and wolf-herrings. Part 2 - Engraulididae. FAO Fish. Synop. **125**(7/2):305-579.

336. Zander, C. D. 1986. Blenniidae. Pages 1096-1112 in P. J. P. Whitehead, M. L. Bauchot, J. C. Hureau, J. Nielsen and E. Tortonese, editors. Fishes of the north-eastern Atlantic and Mediterranean, Vol.3. UNESCO, Paris.

337. Zohar, Y., M. Harel, S. Hassin, A. Tandler. 1995. Gilt-head seabream, *Sparus uuraru*. Pages 94-117 in N. R. Bromage and R. J. Roberts, editors. Broodstock management and egg and larval quality. Institute of Aquaculture University of Stirling, Scotland, Blackwell Science.