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Reconstructed catches and trends for mainland Portugal fisheries between 1938 and 2009: implications for sustainability, domestic fish supply and imports

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ABSTRACT

Illegal, Unreported and Unregulated catches (IUU) are an important topic in fisheries, both from an economic and environmental perspective. Here, we estimated the likely total Portuguese mainland catches between 1938 and 2009 by estimating unreported catches (i.e., missing from official statistics) using a fishery-by-fishery approach. Landings increased from 1938, peaking between 1964 and 1972 (period when landings reached highest values across the time series), and declined thereafter, reaching values below the mean after 1993. Higher misreporting (unreported values above the mean) were recorded between 1956 and 1988. Overall, we estimated that over 25,013,000 t were caught between 1938 and 2009, which is 36% (range 28.2-41.5%) higher than the 16,121,510 t officially reported for the same time period, based on annual catches of around 123,000 t·year^{-1}. Trawl fisheries accounted for the largest part of unreported catches, with 54% of total unreported catches, while accounting for 21% of total reported landings. The multi-gear fisheries accounted for the second largest percentage of estimated catches (25% of total unreported catches, 30% of reported landings). Purse seine fisheries accounted for 49% of total reported landings, but had the smallest proportion of unreported catches (19%). Unreported catches from the recreational/subsistence sector were lower, accounting for 1.5% of total unreported catches. Finfish accounted for 94% (115,000 t·year^{-1}) of unreported catches, followed by cephalopods (2,400 t year^{-1}) and crustaceans (1,800 t·year^{-1}).

1. Introduction

There is evidence that marine species are under threat of local and global decline due to the direct and indirect effects of fishing (Pitcher and Pauly, 1998; Watson and Pauly, 2001). One of the main contributors to the general failure to manage the world's fisheries sustainably is incomplete knowledge of total fishery removals (Watson et al., 2011), generally referred to as 'Illegal, Unreported and Unregulated' (IUU) catches. The IUU issue is a crucial topic in fisheries, from economic, environmental and management points of view (Alverson and Hughes, 1996; FAO, 1994, 2005, 2010). IUU implies that official landing statistics only account for a portion of what is being extracted from the marine environment (Pauly, 2009; Zeller et al., 2008). In fact, in developing and many developed countries, unreported catch can surpass official landing statistics (Kleiven et al., 2012; Zeller and Pauly, 2007).

Fishing is an integral part of the Portuguese social and cultural heritage, as one might expect in a country with a long maritime tradition and an Exclusive Economic Zone (EEZ) of 1.7 million km^2, amounting to almost 50% of the European Union (EU) EEZs. The country has long relied on fishing as a major means of subsistence, in particular for coastal communities that depend almost exclusively on fisheries and related activities. The exploitation of fisheries resources in Portuguese waters has always been strongly linked to small-scale coastal and estuarine fisheries. In fact, trawl fisheries were only introduced in 1880 (Alves, 1991).

The development of the mainland fisheries is well documented, with several historical syntheses, including those of Lobo (1812), Baldaque da Silva (1891) and Alves (1991). However, none of the historical documents published between 1800 and 1950 address by-catch and discards issues. Since the early 1980s, a number of studies have been published on the selectivity of fishing gear, by-catch and discards in Portuguese fisheries (Table 1), improving our

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Table 1
Commercial fisheries discard ratios used in the catch reconstruction per gear. * - percentage value refers to the recreational/subsistence average contribution to total yearly landings. The study area field refers to the location (North, Center and South Portuguese coast sub-divisions and Mainland, the latter when the study covers all the mainland coast) where the studies were conducted (see Fig. 1).

Gear (Sector)	Study area	% bycatch(±SD)	Study year	Scientific Source
Trawl Crustacean	Mainland	55	2009	Pérez et al., 2009
	South	70	1997	Borges et al., 2001
	South	62	1999-2001	Costa et al., 2008
	Crustacean average	62 (7.5)		
Trawl Fish	Mainland	34	2009	Pérez et al., 2009
	South	62	1997	Borges et al., 2001
	South	72,45	1999-2001	Costa et al., 2008
	Fish average	56 (20)		
Trawl average		59 (13.86)	1997-2009	
Purse Seine	Pelagic Purse Seine Algarve	27	1997	Borges et al., 2001
	Pelagic Purse Seine Center and North	8,46	2003	Wise et al., 2005
	Purse Seine average	17.7 (13.1)		
Multispecies	Demersal Purse Seine Algarve	20	1997	Borges et al., 2001
	Demersal Purse Seine Center	96,61	2003	Wise et al., 2005
	Demersal Purse Seine average	58.3 (54.2)		
	Bivalves (dredges)$^{\text{bycatch based}}$	16,7	2006	Leitão et al., 2009
	Octupus Algarve	7,02	2001	Saldanha, 2001
	Silver Scabbardfish center	2	2000-2004	Machado and Figueiredo, 2009
	Black scabbardfish center	2	2000-2004	Machado and Figueiredo, 2009
	Hake South (Hook)	27,8	1997-1998	Erzini et al., 2001
	Hake South (Gill net)	0,4	1998	Santos et al., 2002
	Hake South (Hook)	0,1	1998	Santos et al., 2002
	Hake average	9.43 (15.91)		
	Multispecies Center (trammel)	21,9	2004-2005	Baptista et al., 2009
	Multispecies South (trammel)	13	1997	Borges et al., 2001
	Multispecies South (trammel)	49,4	1999-2000	Gonçalves et al., 2007
	Multispecies average	28.1 (19)	1997-2005	
Recreational/subsistence	Saltwater Shore angling*	0.8*	2006-2007	Veiga et al., 2010

* Percentage contribution for total yearly landing

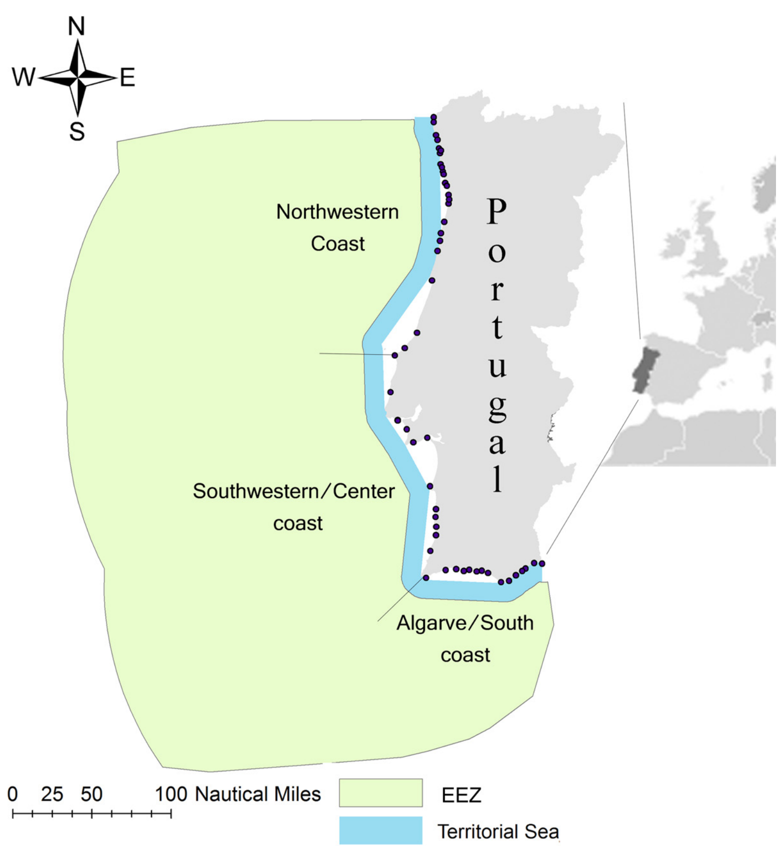

Figure 1. Map of the Portuguese mainland coastal area with the Exclusive Economic Zone (EEZ - 200 nautical miles), territorial sea (12 nautical miles) and the fishing harbors (dots).

understanding of unreported catches and providing data for technical measures such as minimum mesh sizes and gear modification. With increased awareness of fisheries problems, the issue of discards has finally lead to a debate at the European Union Level, resulting in a proposed phasing out and ultimate ban of discards in the reformed Common Fisheries Policy (CFP). In light of this, it is important to better understand the magnitude of discarding and IUU problems.

In mainland Portugal, a variety of gears are used in coastal fisheries, ranging from mobile gears such as dredges and trawls to static gears such as gill nets, trammel nets, demersal longlines and traps. Therefore, a large selection of less- or un-desirable species are captured as by-catch (Bordalo-Machado et al., 2009; Borges et al., 2001; Gaspar et al., 2003; Gonçalves et al., 2007), and the composition of unreported catches differs from gear to gear. Knowledge of the actual overall quantity of species caught in coastal marine systems (including discards) is fundamental for understanding the indirect effects of removal of particular taxa from the ecosystem. In fact, over the past two decades, a growing interest in and shift towards ecosystem-based management has emerged globally (see e.g., Pikitch et al., 2004).

The purpose of the present study is to reconstruct total marine fisheries catches for the Portuguese mainland EEZ and EEZ-equivalent waters between 1938 and 2009, by accounting for all fishing gears and activities. Estimates of unreported catches were made based on a fishery-by-fishery approach. In Portugal, IUU catch not only includes illegal fishing, but also legal activities such as recreational fishing, where catches are not reported and therefore are not part of official catch statistics (Veiga et al., 2010). Although the recreational and subsistence (i.e., personal consumption) character of such practices mostly focuses on specific target species, such activities can represent a significant proportion of catches compared to commercial activities (Coleman et al., 2004; Kleiven et al., 2012). Therefore, we estimated unreported catches for different taxa, for each commercial gear and for the recreational/subsistence fishery. Several assumptions were made to fill minor gaps in data availability, as official reported data include neither taxonomic specificity nor quantitative detail, especially for the pre-1970 time period.

2. Material and Methods

In general, we followed the approach of Zeller et al. (2007), which includes: (i) identification of existing locally reported catch time-series; (ii) identification of fisheries sectors, time-periods, species, and gears not covered in (i); (iii) search for available alternative information sources containing additional data or qualitative information related to items identified in (ii); (iv) development of data anchor points in time for missing data items; (v) interpolation for time-periods between data anchor points for missing data items; and (vi) estimation of final total catch time-series by adding (v) to (i) or its national or international equivalent (e.g., FAO FishStat data).

2.1. Data acquisition for Portuguese mainland fisheries

Data used as the reporting baseline for the catch reconstruction were obtained from the Portuguese National Statistical office (INE–Instituto Nacional de Estatistica). Data for national landings (Portugal mainland, ICES Area IXa) were collected by: 1) manually transcribing individual records from the digital library for the years 1934-1999, available online (http://winlib3.ine.pt/winlib/winlib.aspx; last accessed in April 2012); and 2) extracting available data from the recently digitalized INE series starting in 2000 (http://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_publicacoes; last accessed in April 2012). In order to better comprehend the potential socio-economic implications of the present study on the amount of unreported catches, data on imports of fish and other fishery products such as fish meal were also compiled. For a perspective on the development of the Portuguese mainland fishing fleet effort, the number of boats and fishers per year were also obtained from INE (available from 1940 to 2009). Finally, FAO data (1950-2009; Area 27) were obtained, mainly for the comparison of INE reported mainland landings with FAO landings statistics. We removed all catches of freshwater species. Taxonomic information was validated against FishBase (http://www.fishbase.org) and Sea Life Base (www.sealifebase.org) in order to remove catches of taxa not occurring in Portuguese mainland waters from the FAO dataset and to optimize our ability to compare nationally reported landings with FAO landings statistics assumed to pertain to mainland EEZ waters only.

The earlier INE data presented a weak taxonomic resolution, mostly consisting of general commercial categories, with only few species-level data (e.g. sardine, *Sardina pilchardus*). Although much of the recent data have better taxonomic resolution, most taxa are still grouped in commercial categories. From 1938 to 1969, data were not available by fishing gear. However, from 1969 to 2009, data for crustacean and fish trawls combined is available, while data for 'multi-species' fisheries (i.e., artisanal fisheries) and seine gears are available since 1973. The multi-species, or multi-gear sector, includes mostly (85.9%, according to García-Flórez et al., 2014) fiberglass open deck local boats (< 7 m long) that can operate up to 3 to 6 miles from the coast (depending on whether or not they have UHF radio), as well as coastal boats (> 7 m long; 6.1%). This sector uses static/passive gears, namely gill nets, trammel nets, pots and traps, and hook and line gears. For sardine (*S. pilchardus*) caught with pelagic purse seine, data are available since 1986. However, overall sardine landings data are available since 1938. Since the gear-specific data were less complete and taxon-specific landings usually higher than gear-specific data, likely actual catches by gear-type were derived from taxonomic landings data.

2.2. Data preparation

2.2.1. Organize landings by gear (trawl, seine and multi-gear)

The underlying principle for the estimation of unreported catches is that discards are fishery-specific, and we assumed that for commercial fisheries we only estimated discards as unreported catches. Therefore, all reported landings were assigned to the generalized gear-types (trawl, seine or multi-gear) to allow estimation of unreported discards, using available information on gear- and sometimes target-specific discard ratios.

The years for which reported landings data were available by major gear-types (i.e., 1969-2009) were used to calculate percent contributions of each gear in relation to total catches. In general, we used this gear-specific data period to assign catches to major gear-types for the earlier period/years when data per gear were not available. Given that between 1970 and 2006, the three segments of the Portuguese fleet kept their relative proportions (Baeta, 2009), we assumed that there were also no significant changes between 1938 and 1968. This is supported by the long time series of landings of sardine, the dominant species in Portuguese landings, that is caught mainly by purse seine. Moreover, the multi-gear sector fishery has been the main component of coastal fisheries (numbers of boats), with few technological changes.

2.2.1.1. Assigning pelagic purse seine landings. Reported purse seine landings for the period 1973 to 1986 were estimated by subtracting the reported multi-gear and trawl landings from total landings. For 1938 to 1972, we estimated overall purse seine landings based on sardine total landings (sardine data available since 1938).

Therefore total pelagic purse seine landings for the periods without available yearly data were estimated based on sardine percentages in pelagic purse seine landings. Sardines caught with pelagic purse seines account for 85% (SD = 10%) of the Portuguese total sardine landings between 1986 and 2009. However, sardines are also caught by demersal purse seine (multi-gear fleet). Therefore, we also estimated the percentage of sardine in demersal purse seine and pelagic purse seine landings using information when yearly data were available for both gears. Between 1973 and 2009 pelagic purse sardines accounted for 80% (SD = 7.2%) of the total sardine seine catches (demersal seine sardine was much lower, 20%). For the purpose of this study, we considered that purse seine gear catchability and selectivity are constant over time. Since the seine gear has low species and size selectivity, changes in catches over time are not expected to be associated with purse and demersal seine gear characteristics and operations.

2.2.1.2. Assigning multi-gear landings for 1979 to 1982. For 1979-1982, reported landings were only available as 'total', 'trawl' and 'purse seine' categories. Thus, multi-gear reported landings for this period were estimated by subtracting trawl and purse seine landings from total landings.

2.2.1.3. Assigning trawl and multi-gear landings for 1938 to 1968. The modern-day trawl fleet has two components: one targeting deep water crustaceans, with finfish as by-catch, and another targeting finfish on the continental shelf and upper slope, with crustaceans as by-catch (Portaria n.° 1102-E/2000. D.R. n.° 270, 2.° Suplemento, Série I-B de 2000-11-22). Crustacean taxa appear with some taxonomic detail in landings statistics since 1969, and are more specific after 1972 when the trawl fleet started to exclusively target shrimps, prawns and Norway lobster (*Nephrops norvegicus*). However, landings of the two trawl fleet components (crustacean trawl and fish trawl) are pooled in the INE statistics. As both trawl components have similar discard rates (Table 1) unreported estimates would not be biased by estimation of unreported landings from combined crustacean and finfish trawl statistics. Therefore, the percentage contribution of each gear to total landings was estimated for years with gear specific data, and used to reconstruct those trawl years where data were missing.

2.2.2. Multi-gear fisheries breakdown

Within the multi-gear fisheries, we identified specific target fisheries in order to estimate landings for each single multi-gear fishery (required because each single gear has different discard rates, affecting estimation of unreported catches, Table 1). Therefore, we estimated the average percentage contribution of a single multi-gear fishery in relation to the overall multi-gear catches, and used this for years with no gear-specific data. For this purpose, we used taxonomic multispecies gear data provide by INE statistics. The following multi-gear target fisheries were possible to identify and differentiate.

Sardine (demersal coastal near-shore purse seine): There are two fleets that target sardine (*S. pilchardus*): coastal purse seiners and multi-gear artisanal demersal purse seiners known as "rapa". Demersal purse seine landings of sardine are available since 1973. For years for which data were not available, we use the average percentages of sardine in the overall multispecies fisheries landings, from 1973 to 2009, to estimate pelagic sardine landings.

Cephalopods: Pots (e.g., targeting octopus) or traps (e.g., octopus and cuttlefish) have low discard rates compared to nets. For cuttlefish, we were able to estimate the average cuttlefish catch by nets (78.4 ± 9.5%) and jigs and traps (21.6 ± 9.5%) using the DGPA (Direcção Geral das Pescas e Aquicultura) database for 1989-2009. We used this to separate cuttlefish multispecies gears and reconstruct the time series. Cuttlefish caught with nets were added to overall multispecies catches, since they are usually caught when the gear targets fish. Octopus landings were separated from the overall multispecies landings, since this is a specific pot and trap fishery with very low discard rates (Table 1). Squid and short-fin squid were considered to be caught by jigging, with a negligible discard rate.

Bivalves (oyster, blue mussel, clams and cockles): In addition to blue mussel, oysters and cockles [the latter species is hand harvested mainly in estuaries, coastal lagoons and coastal salt marshes of southern Portugal during low tide, Ruano (1997)], the commercial group "other bivalves" is also reported in the INE database. These bivalves are caught in coastal, permanently submerged grounds with artisanal dredges, which began with Spanish fleets in 1969, extending thereafter to all coastal areas (Sobral et al., 1989). Coastal bivalves appear in INE data in 1973. Reconstruction of these catches took into account mortality of the discarded by-catch (Table 1). The "bivalves-multi-species" item does not include bivalves harvested since ancient times using a local traditional fishing gear called a harvesting-knife in the intertidal zone (Ruano, 1997). For this technique, discarding practices and/or indirect mortality is insignificant (Leitão and Gaspar, 2007). However, because it is a widely used method, we estimated the amount of cockles for the years without available data (1938-1968).

Crustaceans (Lobster): Lobster and other crustaceans were considered separately. This group is caught with traps, and despite the absence of scientific studies, the expected discard rate is likely low. Thus, no discards rate was applied. Lobsters are also caught with trammel nets that may be targeting fish. Since lobster has always been a highly prized species, we estimated landings for years without available data (1938-1972).

Other fishes (scabbardfish, large pelagics): The scabbardfish (silver *Lepidopus caudatus*, and black *Aphanopus carbo*) fisheries are recent, with landings only since the early 1970s. Mainland black scabbardfish landings are only available since 1991. This fishery has been particularly important on Madeira Island, from where the specific longline gear technology was imported to the mainland. For both scabbardfish species, only years with available landings data were used for the separation of this target multispecies fishery from the overall multispecies fisheries. Moreover, given the lack of specific studies for the white scabbardfish, and based on the senior author's personal knowledge of the longline fishery, the discard rate for both species was considered to be similar (Table 1). Scabbardfish are also caught with trawls, but these catches are included in the reconstruction of trawl catches.

Information on tuna as a commercial group is available since 1938. INE tuna landings statistics were considered to be associated with multispecies fisheries. In the past, tuna were mainly caught in tuna traps while migrating into and out of the Mediterranean (Dias and Barraca, 1971; Santos, 1989). Recently, tuna have been caught mainly as by-catch in shark or swordfish longline fisheries (Santos et al., 2002a) or in the single tuna trap operating in Portuguese waters since 1995 (Santos et al., 2002b). The observed discard rate for the Portuguese tuna trap was less than 1%, with all individuals caught above the minimum landing size being retained (Santos et al., 2002b). Therefore, no discard was estimated.

2.3. 2.3. Recreational/subsistence and big-game sport fishing:

Before 2006, no angling licenses were required in Portugal. According to official statistics, a total of 201,522 marine fishing licenses were issued in 2007, with 141,046 (70%) for shore angling. However, many people with a recreational license use recreational fishing as an additional source of subsistence (despite daily bag limits). This means that in Portugal, subsistence is confounded with recreational fishing. Here, we are not concerned with the legality of catches, but rather in the real amounts caught. Relatively little attention has been paid to the economic importance and implications of marine recreational fisheries in Portugal and in European Community waters in general. For bottom demersal sport fishing, the main targets are sea breams (of the family Sparidae) as well as cephalopods (squid, cuttlefish). Veiga et al. (2010) provide details on contribution of percentage of unreported recreational/subsistence, and we used this information to estimate unreported recreational catches (Table 1).

The Portuguese federation for boat-based sport fishing was created in October 1980 and represents the pelagic sports fishery. Although there is no data collection system, big game fishing is regulated by the International Game Fishing Association (IGFA), with catch and release as the common practice and only fish comprising new records are landed. We assumed retained catches were negligible in terms of overall tonnage.

2.4. Reconstruction of unreported catches

The discard ratios and percentage of by-catch applied for reconstructing catches by gear and fishery are presented in Table 1. The discard ratio is defined as the total weight of discarded species divided by the total weight of all species caught (FAO, 1997). The reconstruction of the overall catches caught during fishing were based on both tonnage discarded at sea for legal (e.g., quota, TAC) or economic reasons and tonnage of unreported fish rejected at auction due to economic or sanitary reasons, as follows:

Total catch = Landings (including fish rejected at auction) + unreported discards at sea + unreported catches from recreational/subsistence fisheries

In the absence of accurate gear-specific data on rejection at auction, the tonnages of fish rejected at auction were redistributed according to the average contribution of each gear to total landings.

We created different scenarios of reconstructed catches. These scenarios were created by adding to or removing from the mean catches the standard deviation obtained per gear/fishery, based on the different studies consulted. In purse seine fisheries, discarding can occur on board or while the fish are still in the net in the sea ("slipping" or underwater discards). The latter is known to result in significant sardine mortality (Stratoudakis and Marçalo, 2002; Marçalo et al., 2006). Therefore, in the case of the purse seine both discard types were considered to contribute to the purse seine discarding rate. The amount of non-commercialized fish during the auction became available since 1995, after Portugal entered the EU. For this period, the average percentage of landings rejected at auction averaged 4.2% (SD ±1.4%) of the landed catches. To the authors' best knowledge, most of the fish rejected at auction are purse seine caught sardine and other small pelagics. Due to poor preservation and processing conditions onboard vessels prior to 1994, the amount of fish reaching the auction in poor conditions was probably higher (EU subsidies after 1994 were largely for improving conditions on board, including those for conservation and processing onboard). However, we also believe that in the past, less than ideal quality of landings would not have limited the sale of fish as much as it would at present. Therefore, the average auction rejection percentage for the period available (1995 and 2009) was used for years without any available information. The final reconstructed and officially reported catch amounts for each individual sector are shown in Appendix 1.

2.5. Enhancing taxonomic resolution of Unreported catches

Literature on taxonomic detail of discards and unreported taxa was used for assigning unreported catches and discards to the best taxonomic resolution possible (Table 2). Whenever more than one study was available for the same gear and taxon, the average value was used. For the recreational/subsistence fisheries, the same procedure as that for unreported discards was used. The discard rates of unreported catches per sector are presented in Appendix 2. Fig. 1

Table 2
Studies with commercial discard rates used to estimate the discards (unreported catches) per gear and per taxa.

Gear	Scientific Source
Black scbbardfish longline	Bordalo-Machado et al., 2009
Demersal Seine ("rapa")	Borges et al., 2001
Dredge	Leitão *et al.*, 2009
Gill net and Long-line	Santos *et al.*, 2002
Trammel net	Batistas et al., 2009
	Borges et al., 2001
	Gonçalves et al., 2007
Trap	Saladanha, 2001
Purse seine (pelagic)	Borges et al., 2001
Trawl	Borges et al., 2001
	Costa et al., 2008
	Pérez et al., 2011
Recreational/subsistence	Veiga et al., 2010

3. Results

The national data from INE displayed similar trends over time as the FAO data, with some minor differences (Fig. 2), probably due to Portuguese catches outside the Portuguese EEZ. National landings (INE) increased from the late 1930s to a maximum of approximately 350,000 t·year^{-1} in 1964, thereafter declining to below 150,000 t·year^{-1} for most of the last decade of the time series (Fig. 2).

Trawl landings exhibit a substantial declining trend since 1973 without any positive peak occurring during the latter period (Fig. 3b). Multispecies near shore fisheries are characterized by oscillations over time (Fig. 3c). A significant increasing trend occurred from the 1950s to the 1970s for multispecies catches but thereafter there was a declining trend between 1969 and 1974. Purse seine catches showed an increasing trend until 1964, with a decline thereafter (Fig. 3). In fact, a significant decrease was observed until 1969, the year when the purse seine reached the lowest catches recorded in the period from the 1930s to the 1970s. Purse seine catches peaked in 1986, declining since 2003 to values never recorded before. Since 1993, overall landings show a decreasing trend that is potentially linked to that of purse seine landings for the same period (Fig. 3).

The number of boats also shows an increasing trend until the mid-1960s (Fig. 4), matching the increase in catches for this period (Fig. 2 and 3). Except for the 1970s, the number of fishers was fairly stable at around 30,000 to 35,000 until the mid 1990s, after which there was a sharp drop to approximately 11,000 fishers. In fact, overall landings trends were positively correlated with both the number of boats ($r = 0.84$; $p < 0.01$) and, more weakly, with number of fishers ($r = 0.61$; $p < 0.01$). Moreover, trends of sardine (*Sardine*

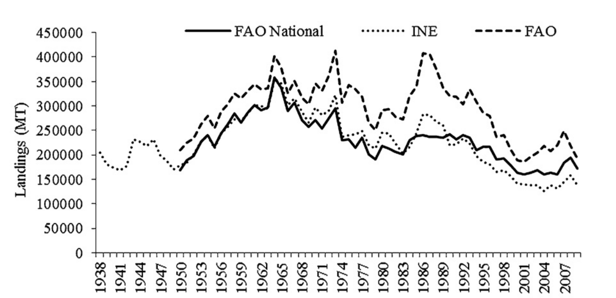

Figure 2. Total landings based on FAO data, the data after removal of non-national species (FAO National) and the INE databases used for the reconstruction.

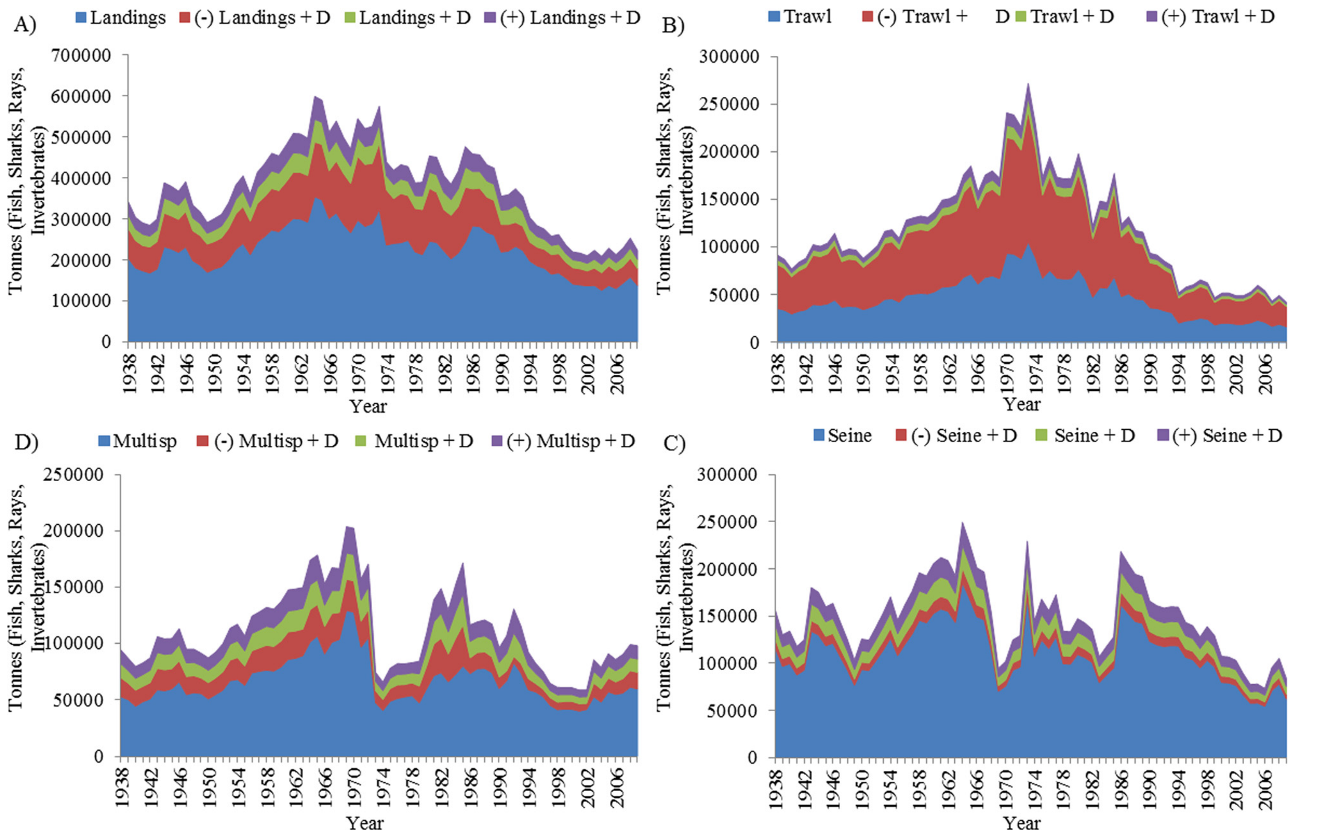

Figure 3. Landings per gear between 1938 and 2009 and associated unreported catches (including bony fish, sharks, rays and invertebrates) for: A) total, B) trawl, C) multispecies, D) seine. Total unreported catches consider the amount of discards (D) and the landed catches rejected at auction. We considered two scenarios: one regarding the Minimum (-) and the other regarding the Maximum (+) unreported catches based on the standard deviation estimated for each gear (Table 1). See Appendix 1 for details. Prior to 1968, the trawl and multispecies gears are extrapolated. Source: Portuguese National Statistical Office–INE.

pilchardus) and horse mackerel (*Trachurus trachurus*) landings, two of the most important species contributing to total landings, also match the trend of changes in effort. Both the latter species are caught in near-shore coastal fisheries by purse seiners. The horse mackerel is also caught with trawl. The increase in catches appears to be potentially related to the increase in the number of purse seiners and trawlers, with a strong .linear relationships for this period (1938-1964) between effort, in number of boats, and both sardine (*S. pilchardus* = 11.03 * Effort - 45769; $p < 0.01$; $r = 0.42$) and horse mackerel (*T. trachurus* = 5.77 * Effort–41536; $p < 0.01$; $r = 0.65$) landings. Existing data on fishing effort also showed that the number of active fishing boats decreased significantly after the mid-1980s (Fig. 4). This matches the period when all fisheries showed a marked decline in landings (Fig. 3). From 1991 on, the number of boats reached the lowest values ever recorded.

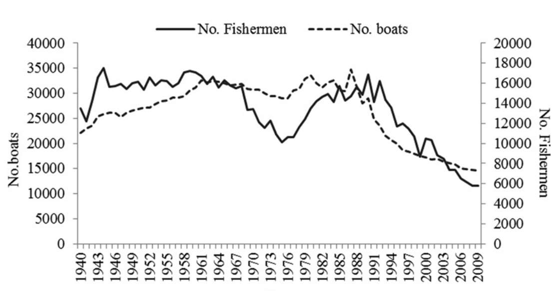

Figure 4. Evolution of fishing effort in number of boats and number of fishers for the period 1938 to 2009. Source: Portuguese National Statistical Office–INE.

Seine, multispecies and trawl account for 49%, 30% and 21% of total recorded landings (Table 3). However, trawl fisheries account for the greater part of the estimated unreported catches, with an average of approximately 54.4% of total unreported landings (Table 3). Multispecies fisheries account for the second largest percentage of estimated discards, with an average of approximately 24.8% of total unreported landings. Seine fisheries account for a minor percentage of estimated discards, on average approximately 19.3% of total unreported commercial landings, while recreational/subsistence fisheries account for only 1.5% of the unreported catches with an average, minimum and maximum of 1,791, 1,344 and 2,239 t·year^{-1} (Table 3).

Overall and considering the cumulative total catches discarded per fishing gear/fishery and recreational/subsistence fishing, the average unreported percentage is 35.5%, which corresponds to an average value of nearly 123,500 t·year^{-1} for the period between 1938 and 2009 (Fig. 5, Table 3). The estimated annual minimum and maximum overall unreported catches correspond to 28.2% and 41.5% of the landed catches, that is 88,114 and 158,876 t·year^{-1} (Fig. 5, Table 3). On average, unreported catches account for approximately half (55.2%) of the total landed catches. The estimated lower and higher percentages of unreported catches correspond to 39.4% and 71% of the total landed catches.

Finfish accounted for 94% of unreported catches (115,000 t·year^{-1}), followed by cephalopods (2,400 t·year^{-1}) and crustaceans (1,800 t·year^{-1}; see Appendix 2). It is important to note that 89% of unreported fish and shark species have commercial value. Moreover ten species, mostly small pelagics, account for approximately 74% of total unreported catches for all gears/fisheries (Fig. 6 and Appendix 2). With the exception of the trawl fisheries, the

Table 3
Annual average landings and total catches (landed + unreported) estimated for the Portuguese mainland (in tonnes) for the period between 1938 and 2009 (sub-section above) and for each gear sector (sub-section below). The plus and minus signs refer to two scenarios: one regarding the Minimum (-) and the other regarding the Maximum (+) unreported catches values and percentage (%) based on the standard deviation estimated for each gear (Table 1 Source: Portuguese National Statistical Office–INE.

	Landed	Unreported	(-) Unreported	(+) Unreported	Total Catch	Total Catch (-)	Total Catch (+)
Total*	214829	123495	88114	158876	347405	312024	382786
SD Tonnes	55968	42074	33846	50655	95609	86864	104653
Ratio IUU/Total Catch (%IUU ± SD)		35.5 (3.7)	28.2 (4.3)	41.5 (3.3)			
Ratio IUU/Total Landings (%)		55,2	39,4	71,0			
Rejected at auction	9081						
Total	223910						
Values by gear sector	Landed	Unreported	(-) Unreported	(+) Unreported	Unreported (%)	(-) Unreported (%)	(+) Unreported (%)
Trawl	45382 (21%)	67226	60751	73701	54,4	68,9	46,4
Seine	104898 (49%)	23844	9336	38353	19,3	10,6	24,1
Multispecific	64549 (30%)	30634	16684	44584	24,8	18,9	28,1
Recreational/Subsistence		1791	1344	2239	1,5	1,5	1,4
Total	214829	123495	88114	158876	100	100	100

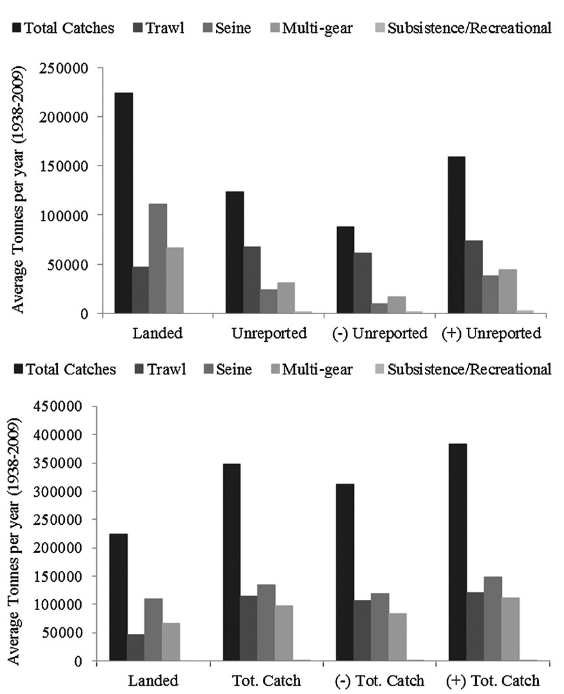

Figure 5. Average landed and unreported catches per gear for Portuguese mainland fisheries between 1938 and 2009.

same species dominate the unreported catches of the different gears/fisheries. Despite considerable overlap in the species that contribute most to unreported catches of different fisheries/gears, there are some significant differences. For instance, trawls, especially deepwater crustacean trawls, discard considerable amounts of mainly deep-water sharks such as *Scyliorhinus cannicula*, *Galeus malastomus*, *Etmoptherus pusillus* and *Hexanchus griseus* compared to other sectors (see also Appendix 2).

The estimated *per capita* consumption based on the national landings over the last two decades (1989-2009) is approximately 16.14 ± 4.2 kg·person^{-1} (Fig. 7). Based on our estimates of unreported catches between 1989 and 2009, the Portuguese mainland *per capita* domestic supply was actually 150% higher at 24.1 ± 6.18 kg·person^{-1}, if all commercial catches were landed and used.

4. Discussion

Fisheries statistics supplied by countries to the Food and Agriculture Organization (FAO) of the United Nations have been shown to under-report fisheries catches in virtually all cases (Zeller et al., 2006; Ulman et al., in press; Wielgus et al., 2010; Zeller et al., 2007, 2011a). The same seems to hold for European countries supplying data to and by ICES (Zeller et al., 2011b). This is largely due to national reporting systems failing to account for Illegal, Unreported and Unregulated (IUU) catches, as well as not accounting for discarded catches in their data collection systems, despite the focal shift to ecosystem-based fisheries management (Pikitch et al., 2004). This is true also for the Portuguese mainland, whose reconstructed catches were very different from the official INE and FAO landings statistics, with average annual unreported catches (nearly 123,500 t·year^{-1}) equivalent to a third of the average reported catch.

Trawl fisheries (crustacean and demersal finfish) account for the greater part of the estimated unreported catches (54.4%) followed by multi-gear (24.8%) and seine fisheries (19.3%), with the contribution of subsistence/recreational fisheries being by far the lowest (1.5%). Trawls typically have the highest discard rates of all fishing gear types, often producing discards in the region of 60% of total catch (EU, 2008; MRAG, 2007). This is also the case for Portuguese trawl fisheries, and given the depths and tow durations, population, community and ecosystem level impacts are likely to be significant (Kaiser and de Groot, 2000). For instance, trawls discard considerable quantities of deep-water sharks such as *Scyliorhinus cannicula*, *Galeus melastomus*, *Etmopterus pusillus* and *Hexanchus griseus*, which are highly susceptible to fishing mortality because of their life history characteristics (Borges et al., 2001; Stevens et al., 2000).

The low contribution of unreported catches in purse seines compared to other fisheries/gears may be due to gear selectivity and advances in technology (Reis et al., 2001) that improved detection of schools and identification of species composition, thereby contributing to "cleaner" assemblages selection (fish size and target species). Since the 1960s, a declining trend was observed in purse seine landings even though strong effort reduction measures have been implemented since 1997 (Reis et al., 2001). In fact, the overall trend follows the purse seine trend, showing the importance of the artisanal near-shore fisheries for mainland Portugal. A strong linear relationship between effort, in number of boats, and both sardine and horse mackerel landings suggests that the purse seine and trawler ratio was relatively constant, as initially assumed in this study and as reported by Baeta (2009), for the period from 1970 to 2006.

The unreported catches from the recreational/subsistence sector consist mostly of sea breams (Sparidae). While species such as the two-banded sea bream (*Diplodus vulgaris*) and the Senegal sea bream (*Diplodus bellottii*) are often discarded in demersal purse seine fisheries as it is considered not worthwhile taking them to

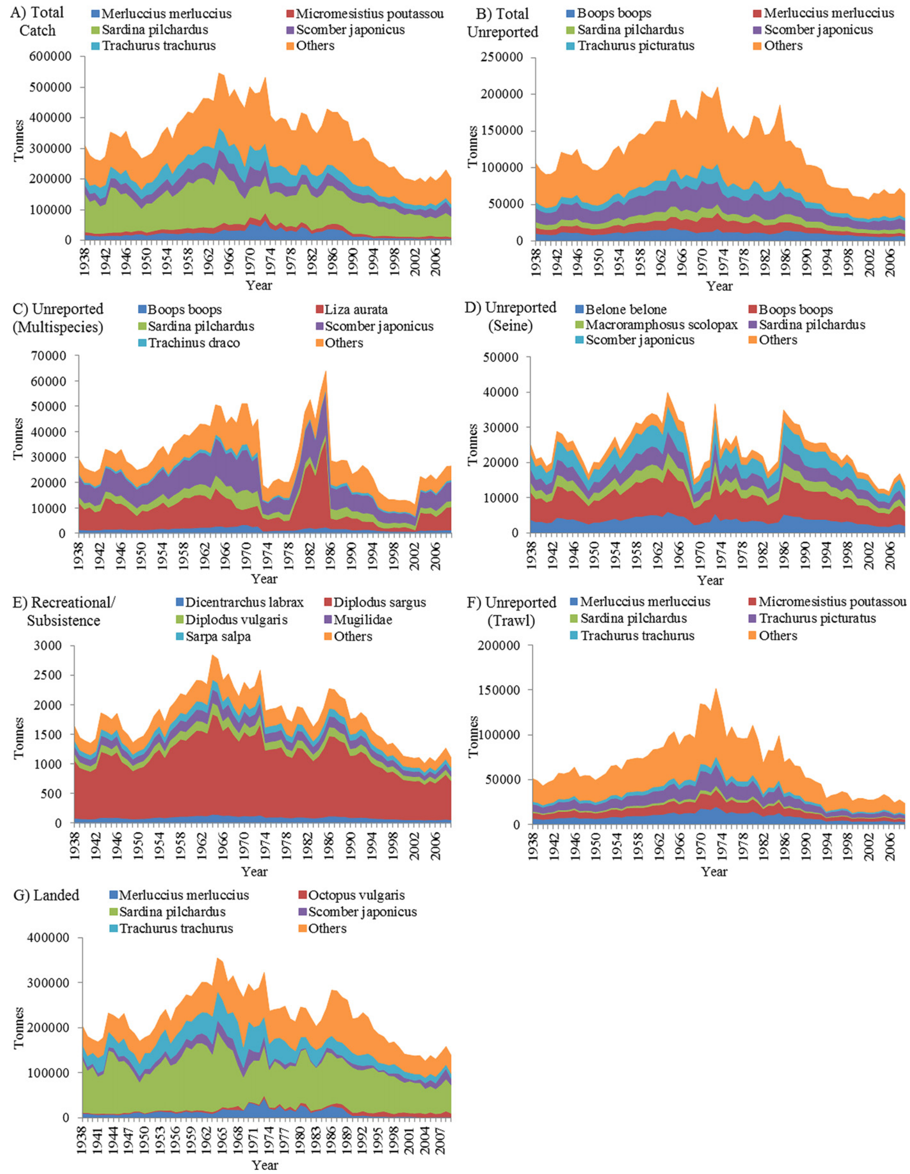

Figure 6. Catches of main species captured, unreported (including per gear) and landed, A) total catches, B) unreported, C) unreported multispecies, D) unreported purse seine, E) unreported trawl, F) unreported recreational/subsistence, G) landed. Source: Portuguese National Statistical Office–INE.

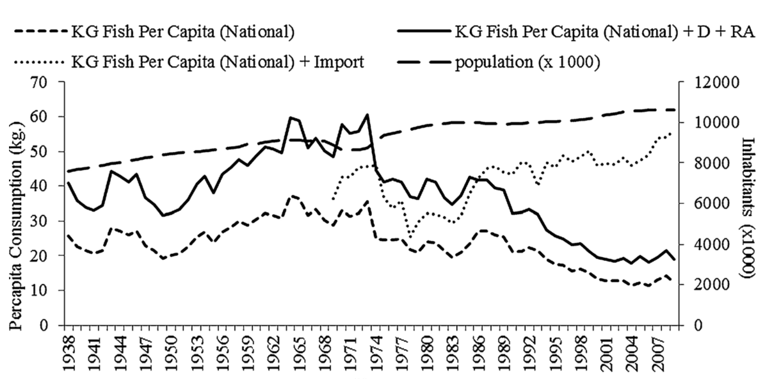

Figure 7. *Per capita* consumption considering hypothetical use of discarded marine resources (only commercial species) within the context of commercial fish imports into Portugal.

auction (Gonçalves et al., 2008), in recreational/subsistence fisheries, these species are generally kept, while others such as the white sea bream *Diplodus sargus* and the European bass *Dicentrarchus labrax* are often sold illegally.

Most of the unreported catches from Portugal are related to legal commercial activities involving discards that are not monitored and reported. In other fisheries, unreported catches are mainly due to unreported commercial landings (e.g., cheating by fishers), unmonitored small-scale catches (inadequate monitoring systems) and recreational fishing (Harper et al., 2009; Le Manach et al., 2011; Pham et al., 2013). Compared to those areas where commercial fishing is the main cause of unreported catches, the estimates obtained in this study are within similar ranges of values reported for European countries in the Baltic Sea area (Zeller et al., 2011b). In western and southern Europe, little is known for most of the countries (Spain, France, etc.) regarding total catch estimates (Moutopoulos et al., 2013). However, reconstructions such as the one presented here or by Zeller et al. (2011b) will help address this issue in the near future.

Results showed that independently of the fishery/gear, common marketable species account for most of the unreported catches. In fact, the species that most contribute to overall unreported catches are among the most frequently landed and those that most contribute to overall landings. The most important unreported species from the commercial sector include sardine, mackerel, chub mackerel and hake that are subject to total allowable catches (TACs). Difficulties in managing Portuguese fisheries are compounded by their multi-species nature and inadequate data recording and monitoring systems. Unaccounted mortality can undermine the effectiveness of the TAC system to manage species, as suggested for other European fisheries (Dann, 1997; Khalilian et al., 2010), as well as stock recovery plans.

Sustainable management of fishing resources must take place in an ecosystem context, with an anticipation of all likely effects of fishing activities (Borges et al., 1998), including unreported catches that are often not taken into account in stock assessments (Borges et al., 2005). Any effect on one stock, population or species may produce a change in another, resulting in readjustment in both populations (Borges et al., 1998; FAO, 1994; Hongskul, 1979; Kennelly, 1995; McAllister and Spiller, 1994; Saila, 1983). The knowledge on unreported catches might change the way we assess the marine ecosystem, including trophic effects of fisheries in marine environment, which are only partially understood.

Based on our estimates of unreported commercial catches, the Portuguese mainland fisheries could theoretically have supported an annual *per capita* consumption of around 24 kg rather than 16 kg based on reported landings, if all discards, including landings removed at auction, were utilised. This would have been enough to cover national seafood imports from 1969 to 1986 (Fig. 7). Under the no-discards policy in the revised European Common Fisheries Policy (CFP), there may be new economic opportunities based on the large quantities of unreported catches and discards. In fact, given the overfished state of many of the world's most important stocks (Pauly et al., 2002), there has been great interest in documenting and finding solutions to the economic, political, and ecological implications of by- catch and discarding (Costa et al., 2008). The results of this study raise some concerns regarding the future of the Portuguese fisheries sector. A marked decreasing trend in catches has been found, especially over the last two decades, while imports have increased. According to ICES working groups, many Portuguese stocks are overfished, with fishing effort still too high in many cases (ICES, 2012). Ecosystem-based management would suggest addressing and reducing/eliminating discards, limiting and eventually eliminating habitat damaging gears (e.g., bottom trawls), and removing fishing from significant (likely 20-30%) portions of all habitat types (i.e., complete no-take zones) to allow stocks and habitats to recover, in essence changing our perspective of ocean use (e.g., Russ and Zeller, 2003, Zeller, 2005).

After much debate, due in part to lack of information on unreported catches, the European Commission finally approved a new Common Fisheries Policy in May 2013 that includes a discards ban, to be implemented gradually starting in 2014. However, unless discards are reduced at the source using selective and non-destructive gears and there is adequate monitoring and enforcement, the proposed ban is unlikely to succeed and may in fact have unforeseen negative impacts not only on the commercial species but on others throughout the ecosystem (Sardà et al., 2013). We estimate that since 1950, approximately 9,000,000 t of Portugal mainland fisheries catches, mostly of commercial species, were unreported, with the greater part discarded. Thus, in light of the coming discard ban, there is a need for strategies to improve the utilization of discards for human use, through improved processing technologies, and expanding market opportunities for lower-value catches should be encouraged in an ecosystem-based management setting.

Acknowledgements

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Appendix A.

Table A1
Table A2

Table A1
Final reconstructed and official catch amounts (tonnes) for each individual gear.

Year	Total Landings	Total Discards	Recreational	Total Catch	Trawl Landings	Trawl Discards	Trawl Catch	Seine Landings	Seine Discards	Seine Catch	Multisp. Landings	Multisp. Discards	Multisp. Catch
1938	204449	105248	1636	311333	35573	51190	86763	116014	25000	141014	52862	29058	81920
1939	180738	95170	1446	277354	33780	48610	82390	96761	20851	117612	50197	25709	75906
1940	173894	89208	1391	264493	29899	43025	72924	99564	21455	121019	44431	24728	69159
1941	168641	89841	1349	259831	32601	46913	79514	87595	18876	106471	48445	24052	72497
1942	177942	94672	1424	274038	34272	49318	83590	92742	19985	112727	50929	25369	76298
1943	232621	119106	1861	353588	39729	57171	96900	133854	28844	162698	59038	33091	92129
1944	227312	116636	1818	345766	39111	56282	95393	130080	28031	158111	58120	32323	90443
1945	218936	114773	1751	335460	40377	58103	98480	118558	25548	144106	60001	31122	91123
1946	231793	123097	1854	356744	44410	63908	108318	121388	26158	147546	65995	33031	99026
1947	198596	104287	1589	304472	36814	52976	89790	107076	23074	130150	54706	28237	82943
1948	187557	101631	1500	290688	37976	54648	92624	93148	20072	113220	56433	26911	83344
1949	170006	95366	1360	266732	37514	53984	91498	76745	16538	93283	55747	24844	80591
1950	178480	94828	1428	274736	34241	49274	83515	93355	20117	113472	50884	25437	76321
1951	183860	99201	1471	284532	36805	52963	89768	92362	19903	112265	54693	26335	81028
1952	201137	107748	1609	310494	39488	56824	96312	102969	22189	125158	58680	28735	87415
1953	226288	121966	1810	350064	45172	65003	110175	113990	24564	138554	67126	32399	99525
1954	240525	127531	1924	369980	45874	66014	111888	126481	27255	153736	68170	34262	102432
1955	213433	114807	1707	329947	42376	60980	103356	108086	23291	131377	62971	30536	93507
1956	243902	132570	1951	378423	49783	71639	121422	120140	25889	146029	73979	35042	109021
1957	257012	137932	2056	397000	50711	72974	123685	130943	28217	159160	75358	36741	112099
1958	273388	144295	2187	419870	51454	74044	125498	145471	31347	176818	76462	38904	115366
1959	269483	142409	2156	414048	50902	73249	124151	142940	30802	173742	75641	38358	113999
1960	285349	150230	2283	437862	53307	76710	130017	152827	32932	185759	79215	40588	119803
1961	301477	160247	2412	464136	57911	83335	141246	157508	33941	191449	86057	42971	129028
1962	300420	160456	2403	463279	58495	84176	142671	154999	33401	188400	86925	42879	129804
1963	292595	159402	2341	454338	60079	86455	146534	143237	30866	174103	89279	42081	131360
1964	355015	188805	2840	546660	68297	98282	166579	185226	39914	225140	101492	50609	152101
1965	346732	189526	2774	539032	71807	103332	175139	168218	36249	204467	106707	49945	156652
1966	301366	163434	2411	467211	61150	87996	149146	149346	32182	181528	90870	43256	134126
1967	315383	175327	2523	493233	68113	98016	166129	146053	31473	177526	101217	45838	147055
1968	287498	168368	2300	458166	69832	100490	170322	113894	24543	138437	103772	43335	147107
1969	266667	162404	2133	431204	66901	96272	163173	70365	15163	85528	129401	50969	180370
1970	297326	201847	2379	501552	93443	134467	227910	75913	16358	92271	127970	51022	178992
1971	282049	194939	2256	479244	92573	133215	225788	92653	19966	112619	96823	41758	138581
1972	289147	191933	2313	483393	87718	126228	213946	96078	20704	116782	105351	45001	150352
1973	323120	207362	2585	533067	105433	151721	257154	170318	36702	207020	47369	18939	66308
1974	236998	168442	1896	407336	88792	127774	216566	107523	23170	130693	40683	17498	58181
1975	240646	143966	1925	386537	67173	96664	163837	124707	26873	151580	48766	20429	69195
1976	242574	155115	1941	399630	75599	108789	184388	115627	24916	140543	51348	21410	72758
1977	248227	144616	1986	394829	67269	96802	164071	128229	27632	155861	52729	20182	72911
1978	219981	137313	1760	359054	66519	95722	162241	99515	21444	120959	53947	20147	74094
1979	213315	143198	1707	358220	66742	96043	162785	99082	21351	120433	47491	25804	73295
1980	246022	168707	1968	416697	76829	110559	187388	109397	23574	132971	59796	34574	94370
1981	243127	164947	1945	410019	65575	94364	159939	106041	22851	128892	71511	47732	119243
1982	222471	142413	1780	366664	47278	68034	115312	100973	21758	122731	74220	52621	126841
1983	203056	144187	1624	348867	57481	82717	140198	79492	17130	96622	66083	44340	110423
1984	217008	156539	1736	375283	56881	81853	138734	87437	18842	106279	72690	55844	128534
1985	243988	183438	1952	429378	68792	98993	167785	95022	20476	115498	80174	63969	144143
1986	283730	132725	2270	418725	48094	69208	117302	162225	34957	197182	73412	28560	101972
1987	281722	134488	2254	418464	51134	73583	124717	152849	32937	185786	77739	27968	105707
1988	267835	125389	2143	395367	45513	65494	111007	144291	31093	175384	78031	28802	106833
1989	261357	123742	2091	387190	44825	64504	109329	142285	30661	172946	74247	28577	102824
1990	219633	102024	1757	323414	36270	52193	88463	123290	26568	149858	60073	23263	83336
1991	221910	101338	1775	325023	35514	51106	86620	119591	25770	145361	66805	24462	91267
1992	233608	99655	1869	335132	33057	47569	80626	117634	25349	142983	82917	26737	109654
1993	223632	95628	1789	321049	31235	44948	76183	118742	25587	144329	73655	25093	98748
1994	197645	76158	1581	275384	20219	29096	49315	118351	25503	143854	59075	21559	80634
1995	186100	71788	1489	259377	22500	32378	54878	106467	22942	129409	57133	16468	73601
1996	180156	70813	1441	252410	23418	33699	57117	103826	22373	126199	52912	14741	67653
1997	165548	70299	1324	237171	25432	36597	62029	94997	20471	115468	45119	13231	58350
1998	168778	70319	1350	240447	24234	34873	59107	103157	22229	125386	41387	13217	54604
1999	156418	59782	1251	217451	18183	26166	44349	96265	20744	117009	41970	12872	54842
2000	141517	59092	1132	201741	20039	28837	48876	79754	17186	96940	41724	13069	54793
2001	139340	58499	1115	198954	20054	28859	48913	79173	17061	96234	40113	12579	52692
2002	137180	55035	1097	193312	18971	27299	46270	76583	16503	93086	41627	11233	52860
2003	138230	64020	1106	203356	19013	27360	46373	66277	14282	80559	52940	22378	75318
2004	126048	63110	1008	190166	20450	29427	49877	57544	12400	69944	48054	21283	69337
2005	138446	69042	1108	208596	23286	33509	56795	57938	12485	70423	57222	23048	80270
2006	130386	63123	1043	194552	21060	30305	51365	54455	11734	66189	54872	21084	75956
2007	143986	63071	1152	208209	16779	24145	40924	71078	15316	86394	56129	23610	79739
2008	158567	70657	1269	230493	19119	27512	46631	78161	16843	95004	61287	26302	87589
2009	138188	63427	1106	202721	16329	23498	39827	62122	13387	75509	59736	26542	86278

Table A2
Taxonomic list with the average absolute and relative weight contribution of each taxa to total unreported catch, per gear, for the period between 1938 and 2009.

Species	Taxa Group	Tonnes (SD)	%
Scomber japonicus	Fish	21783,6 (±7048,2)	17.63919
Boops Boops	Fish	11162,3 (±2868,3)	9.03861
Trachurus picturatus	Fish	10659,5 (±4864,9)	8.63148
Merluccius merluccius	Fish	10270,8 (±4528,6)	8.31675
Sardina pilchardus	Fish	8692 (±2476,4)	7.03830
Liza aurata	Fish	8650,4 (±6238,9)	7.00460
Micromesistius poutassou	Fish	8500,9 (±3878,9)	6.88360
Trachurus trachurus	Fish	4502,1 (±1886,5)	3.64554
Belone belone	Fish	3614,3 (±965,6)	2.92666
Scomber scombrus	Fish	3205,3 (±1026,1)	2.59552
Macroramphosus scolopax	Fish	2901,9 (±762,7)	2.34980
Capros aper	Fish	2524,1 (±1151,5)	2.04389
Chondrichthyes	Fish	2178,2 (±994,1)	1.76379
Conger conger	Fish	1976,7 (±901,9)	1.60059
Scorpaena notata	Fish	1228,4 (±499,9)	0.99467
Scyliorhinus canicula	Sharks	1172,6 (±534,8)	0.94947
Other fish & Invertebrates	Other Fish & Invertebrates	1114,8 (±508,8)	0.90273
Octopodidae	Cephalopoda	1080,5 (±493,1)	0.87495
Diplodus sargus	Fish	1067,9 (±266,9)	0.86469
Trachinus draco	Fish	930 (±387)	0.75307
Lophius spp.	Fish	840,4 (±383,6)	0.68052
Microchirus azevia	Fish	829,7 (±345,3)	0.67188
Triglidae	Fish	792,5 (±360,8)	0.64171
Lepidopus caudatus	Fish	792,4 (±361,6)	0.64163
Cephalopoda	Cephalopoda	771,8 (±352,2)	0.62497
Gadiculus argenteus	Fish	755,5 (±344,8)	0.61177
Chelidonichthys obscurus	Fish	745,1 (±310,1)	0.60337
Phycis spp.	Fish	634,6 (±289,6)	0.51386
Parapenaeus longirostris	Crustacea	626 (±285,7)	0.50692
Halobatrachus didactylus	Fish	625 (±157,9)	0.50611
Holothuroidea	Other Invertebrates	545 (±245,5)	0.44135
Polybius henslowii	Crustacea	516 (±234)	0.41781
Serranus cabrilla	Fish	491,5 (±187)	0.39799
Pagellus acarne	Fish	464,6 (±193,3)	0.37622
Galeus melastomus	Sharks	409,7 (±186,3)	0.33174
Sarpa salpa	Fish	403,6 (±156,6)	0.32678
Trisopterus luscus	Fish	366 (±163,6)	0.29634
Mullus spp.	Fish	300,8 (±137,1)	0.24361
Sepia officinalis	Cephalopoda	267,4 (±111)	0.21649
Sphoeroides pachygaster	Fish	265,8 (±121,3)	0.21527
Maja squinado	Crustacea	260,3 (±118)	0.21074
Pagellus spp.	Fish	257,5 (±117,5)	0.20851
Trachurus spp.	Fish	257,3 (±117,4)	0.20832
Spicara flexuosa	Fish	243,8 (±64,5)	0.19744
Pagrus spp.	Fish	240,1 (±109,6)	0.19443
Citharus linguatula	Fish	229,2 (±91,4)	0.18558
Helicolenus dactylopterus	Fish	207,5 (±94,7)	0.16805
Phycis phycis	Fish	195,9 (±81,5)	0.15866
Pagrus pagrus	Fish	171,9 (±78,4)	0.13922
Spondyliosoma cantharus	Fish	171,5 (±71)	0.13891
Xiphias gladius	Fish	171,5 (±78,3)	0.13888
Octopus vulgaris	Cephalopoda	162,9 (±74,4)	0.13194
Mugilidae	Fish	142,4 (±35,6)	0.11528
Liza ramada	Fish	132 (±91,9)	0.10686
Zeus faber	Fish	130,4 (±59,1)	0.10556
Plesionika spp.	Crustacea	128,6 (±58,7)	0.10416
Diplodus vulgaris	Fish	122,6 (±30,4)	0.09925
Rajidae (+ other similars)	Rays	111,9 (±50,9)	0.09060
Tealia spp.	Other Invertebrates	102,9 (±47)	0.08333
Pagurus spp.	Crustacea	96,8 (±213,1)	0.07837
Dicentrarchus labrax	Fish	96,8 (±24,2)	0.07836
Echinoidea	Other Invertebrates	94,3 (±43,1)	0.07638
Sparus aurata	Fish	93,8 (±23,5)	0.07595
Astropecten aranciacus	Other Invertebrates	87,8 (±32,2)	0.07112
Balistes capriscus	Fish	81,7 (±21,8)	0.06618
Pleuronectes platessa	Fish	68,6 (±31,3)	0.05555
Echinocardium cordatum	Other Invertebrates	60,9 (±134)	0.04928
Diplodus bellottii	Fish	44,8 (±15,9)	0.03630
Macropipus tuberculatus	Crustacea	42,9 (±19,6)	0.03472
Benthodesmus elongates	Fish	38,4 (±15,7)	0.03107
Rossia macrosoma	Cephalopoda	35,2 (±16)	0.02847
Soleidae	Fish	34,8 (±15,8)	0.02821
Dardanus arrosor	Crustacea	34,6 (±15,7)	0.02801
Lepidorhombus spp.	Fish	25,7 (±11,7)	0.02083
Pagurus alatus	Crustacea	25,7 (±11,7)	0.02083

Table A2 (*Continued*)

Species	Taxa Group	Tonnes (SD)	%
Dosinia exoleta	Bivalvia	22,4 (±49,3)	0.01813
Etmopterus pusillus	Sharks	21,5 (±17,5)	0.01743
Tellina tenuis	Bivalvia	19,9 (±43,7)	0.01607
Cymbium olla	Gastropoda	18,9 (±7,9)	0.01533
Mullus surmuletus	Fish	17,3 (±7,9)	0.01403
Argentina sphyraena	Fish	17,2 (±7,8)	0.01390
Argobuccinum olearium	Gastropoda	17,2 (±7,8)	0.01389
Cassidaria tyrrhena	Gastropoda	17,2 (±7,8)	0.01389
Todaropsis eblanae	Cephalopoda	15,9 (±6,6)	0.01291
Callionymus lyra	Fish	15,7 (±6,6)	0.01275
Dicentrarchus punctatus	Fish	14,2 (±3,6)	0.01153
Torpedo nobiliana	Rays	12,9 (±5,9)	0.01042
Etmopterus spinax	Sharks	12,4 (±4,6)	0.01008
Solea lascaris	Fish	9,6 (±4)	0.00780
Malacocephalus laevis	Fish	9,6 (±4,4)	0.00777
Solea senegalensis	Fish	9,1 (±3,8)	0.00739
Sphaerechinus granularis	Other Invertebrates	8,6 (±3,1)	0.00700
Caelorinchus caelorhincus	Fish	8,6 (±3,9)	0.00694
Deania calcea	Sharks	8,5 (±9,3)	0.00690
Squilla mantis	Crustacea	8,2 (±18)	0.00661
Centrophorus squamosus	Sharks	7,8 (±8,5)	0.00633
Raja miraletus	Rays	7,5 (±3,1)	0.00603
Brama brama	Fish	6,7 (±2,8)	0.00543
Mola mola	Fish	6,6 (±2,7)	0.00534
Illex coindetii	Cephalopoda	5,6 (±2,4)	0.00450
Torpedo torpedo	Rays	5,5 (±2,3)	0.00446
Raja clavata	Rays	5,3 (±2,1)	0.00430
Zenopsis conchifer	Fish	4,3 (±2)	0.00347
Liocarcinus depurator	Crustacea	4 (±8,8)	0.00324
Dicologlossa cuneata	Fish	4 (±1,7)	0.00322
Myliobatis aquila	Rays	3,6 (±1,5)	0.00292
Alepocephalus bairdii	Fish	3,5 (±3,8)	0.00286
Ophisurus serpens	Fish	3,4 (±1,6)	0.00278
Sphoeroides cutaneus	Fish	3,4 (±1,6)	0.00278
Chimaera monstrosa	Fish	3,4 (±1,4)	0.00273
Atrina pectinata	Bivalvia	3,2 (±1,3)	0.00261
Chelidonichthys lucernus	Fish	3,2 (±1,3)	0.00257
Diplodus annularis	Fish	3,1 (±1,1)	0.00254
Raja undulata	Rays	3,1 (±1,3)	0.00252
Pagellus erythrinus	Fish	3 (±1,2)	0.00241
Raja brachyura	Rays	2,8 (±1,1)	0.00223
Chelidonichthys lastoviza	Fish	2,6 (±1,1)	0.00211
Eledone cirrhosa	Cephalopoda	2,6 (±1,2)	0.00208
Synaphobranchus kaupii	Fish	2,4 (±2,6)	0.00196
Donax vittatus	Bivalvia	2,3 (±5,2)	0.00190
Mugil cephalus	Fish	2,1 (±0,9)	0.00170
Phycis blennoides	Fish	1,8 (±0,7)	0.00149
Centrolophus monstrosa	Sharks	1,8 (±0,7)	0.00146
Balistes carolinensis	Fish	1,8 (±0,7)	0.00143
Trigloporus lastoviza	Fish	1,8 (±0,7)	0.00143
Lophius piscatorius	Fish	1,7 (±0,8)	0.00139
Octopus salutii	Cephalopoda	1,7 (±0,8)	0.00139
Symphodus bailloni	Fish	1,6 (±0,6)	0.00128
Lepidotrigla cavillone	Fish	1,5 (±0,6)	0.00125
Dalatias licha	Sharks	1,4 (±0,6)	0.00112
Aplysia punctata	Gastropoda	1,3 (±0,6)	0.00108
Atelecyclus undecimdentatus	Crustacea	1,2 (±2,6)	0.00095
Ensis siliqua	Bivalvia	1,1 (±2,4)	0.00087
Arnoglossus imperialis	Fish	1 (±0,4)	0.00083
Hoplostethus mediterraneus	Fish	1 (±0,4)	0.00078
Hexanchus griseus	Sharks	1 (±0,4)	0.00078
Loligo spp.	Cephalopoda	0,9 (±0,4)	0.00075
Eledone moschata	Cephalopoda	0,9 (±0,4)	0.00069
Pagellus bogaraveo	Fish	0,9 (±0,4)	0.00069
Peristedion cataphractum	Fish	0,9 (±0,4)	0.00069
Raja oxyrinchus	Rays	0,9 (±0,4)	0.00069
Ruvettus pretiosus	Fish	0,9 (±0,4)	0.00069
Trachurus mediterraneus	Fish	0,9 (±0,4)	0.00069
Scorpaena porcus	Fish	0,8 (±0,3)	0.00065
Mullus barbatus	Fish	0,8 (±0,3)	0.00062
Chelon labrosus	Fish	0,7 (±0,3)	0.00055
Centroscymnus crepidater	Sharks	0,6 (±0,7)	0.00049
Polychaetes	Other Invertebrates	0,6 (±1,3)	0.00048
Acanthocardia spinosa	Bivalvia	0,5 (±0,2)	0.00043
Alosa fallax	Fish	0,5 (±0,2)	0.00043
Pecten maximus	Bivalvia	0,5 (±0,2)	0.00042
Scophthalmus rhombus	Fish	0,4 (±0,2)	0.00034

Table A2 (*Continued*)

Species	Taxa Group	Tonnes (SD)	%
Trachyrincus scabrus	Fish	0,4 (±0,4)	0.00033
Nesiarchus nasutus	Fish	0,4 (±0,4)	0.00029
Microchirus variegatus	Fish	0,3 (±0,1)	0.00027
Marthasterias glacialis	Other Invertebrates	0,3 (±0,1)	0.00026
Hymenocephalus italicus	Fish	0,3 (±0,1)	0.00026
Lepidion guentheri	Fish	0,3 (±0,3)	0.00024
Solea solea	Fish	0,3 (±0,1)	0.00024
Serranus hepatus	Fish	0,3 (±0,1)	0.00024
Centrolabrus exoletus	Fish	0,3 (±0,1)	0.00022
Trachinus vipera	Fish	0,3 (±0,6)	0.00021
Scymnodon ringens	Sharks	0,3 (±0,3)	0.00020
Dentex dentex	Fish	0,2 (±0,1)	0.00019
Asterias rubens	Other Invertebrates	0,2 (±0,1)	0.00018
Echinus acutus	Other Invertebrates	0,2 (±0,1)	0.00018
Paracentrotus lividus	Other Invertebrates	0,2 (±0,1)	0.00017
Microchirus ocellatus	Fish	0,2 (±0,1)	0.00017
Alepisaurus ferox	Fish	0,2 (±0,2)	0.00016
Murex trunculus	Gastropoda	0,2 (±0,1)	0.00016
Spisula solida	Bivalvia	0,2 (±0,4)	0.00016
Lepidorhombus boscii	Fish	0,2 (±0,1)	0.00015
Scophthalmus maximus	Fish	0,2 (±0,1)	0.00014
Bothus podas	Fish	0,2 (±0,1)	0.00014
Dasyatis violacea	Rays	0,2 (±0,1)	0.00013
Lagocephalus lagocephalus	Fish	0,2 (±0,1)	0.00013
Aspitrigla cuculus	Fish	0,2 (±0,1)	0.00013
Dentex maroccanus	Fish	0,2 (±0,1)	0.00013
Mactra corallina stultorum	Bivalvia	0,2 (±0,4)	0.00013
Homala barbata	Crustacea	0,2 (±0,1)	0.00013
Centrophorus granulosus	Sharks	0,2 (±0,2)	0.00012
Centroscymnus coelolepis	Sharks	0,2 (±0,2)	0.00012
Lepidion spp.	Fish	0,2 (±0,2)	0.00012
Prionace glauca	Sharks	0,2 (±0,2)	0.00012
Labrus mixtus	Fish	0,1 (±0,1)	0.00011
Labridae	Fish	0,1 (±0,1)	0.00011
Diplodus spp.	Fish	0,1 (±0,1)	0.00011
Trigla lyra	Fish	0,1 (±0,1)	0.00010
Dentex spp.	Fish	0,1 (±0,1)	0.00010
Uranoscopus scaber	Fish	0,1 (±0)	0.00009
Lepidotrigla dieuzeidei	Fish	0,1 (±0)	0.00009
Naucrates ductor	Fish	0,1 (±0)	0.00009
Nephrops norvegicus	Crustacea	0,1 (±0)	0.00009
Epigonus telescopus	Fish	0,1 (±0,1)	0.00008
Dentex macrophthalmus	Fish	0,1 (±0)	0.00007
Calappa granulata	Crustacea	0,1 (±0)	0.00006
Scomber spp.	Fish	0,1 (±0)	0.00006
Arnoglossus laterna	Fish	0,1 (±0)	0.00006
Coris julis	Fish	0,1 (±0)	0.00005
Ammodytes tobianus	Fish	0,1 (±0)	0.00005
Aphanopus carbo	Fish	0,1 (±0,1)	0.00004
Centrophorus lusitanicus	Sharks	0,1 (±0,1)	0.00004
Coryphaena hippurus	Fish	0,1 (±0,1)	0.00004
Coryphaenoides rupestris	Fish	0,1 (±0,1)	0.00004
Deania profundorum	Sharks	0,1 (±0,1)	0.00004
Isurus oxyrinchus	Sharks	0,1 (±0,1)	0.00004
Thunnus alalunga	Fish	0,1 (±0,1)	0.00004
Arnoglossus spp.	Fish	0,05 (±0,02)	0.00004
Symphodus spp.	Fish	0,04 (±0,02)	0.00004
Pleuronectiformes	Fish	0,04 (±0,02)	0.00003
Nucella lapillus	Gastropoda	0,04 (±0,02)	0.00003
Venus striatula	Bivalvia	0,04 (±0,08)	0.00003
Liza spp.	Fish	0,04 (±0,01)	0.00003
Palinurus elephas	Crustacea	0,03 (±0,01)	0.00002
Ophioderma longicaudum	Other Invertebrates	0,03 (±0,01)	0.00002
Gymnammodytes cicerelus	Other Invertebrates	0,03 (±0,01)	0.00002
Carcinus maenas	Crustacea	0,02 (±0,01)	0.00001
Zeugopterus punctatus	Fish	0,01 (±0,01)	0.00001
Arnoglossus thori	Fish	0,01 (±0,01)	0.00001
Maja goltziana	Crustacea	0,01 (±0,01)	0.00001
Pagurus forbesii	Crustacea	0,009 (±0,004)	0.00001
Bothidae	Fish	0,006 (±0,002)	0.000005
Goneplax rhomboides	Crustacea	0,005 (±0,002)	0.000004
Liocarcinus holsatus	Crustacea	0,003 (±0,001)	0.000003
Callionymus reticulatus	Fish	0,002 (±0,001)	0.000002
Diplodus sargus	Fish	1068 (±267)	60
Mugilidae	Fish	142 (±36)	8
Diplodus vulgaris	Fish	120 (±30)	7
Sarpa salpa	Fish	105 (±26)	6

Table A2 (*Continued*)

Species	Taxa Group	Tonnes (SD)	%
Dicentrarchus labrax	Fish	96 (±24)	5
Sparus aurata	Fish	93 (±23)	5
Balistes capriscus	Fish	65 (±16)	4
Scomber japonicus	Fish	43 (±11)	2
Boops boops	Fish	31 (±8)	2
Dicentrarchus punctatus	Fish	14 (±4)	1
Spondyliosoma cantharus	Fish	14 (±4)	1
Liza aurata	Fish	8650,35 (±6238,89)	36.87007
Scomber japonicus	Fish	4381,95 (±2597,49)	18.67701
Sardina pilchardus	Fish	3132,53 (±1303,59)	13.35167
Trachinus draco	Fish	930 (±387,02)	3.96392
Boops boops	Fish	839,77 (±627,54)	3.57931
Microchirus azevia	Fish	829,74 (±345,29)	3.53656
Chelidonichthys obscurus	Fish	745,13 (±310,08)	3.17593
Merluccius merluccius	Fish	708,24 (±580,94)	3.01873
Scorpaena notata	Fish	614,19 (±639,06)	2.61782
Pagellus acarne	Fish	464,61 (±193,35)	1.98031
Trachurus trachurus	Fish	373,03 (±155,24)	1.58997
Serranus cabrilla	Fish	354,29 (±147,44)	1.51008
Phycis phycis	Fish	195,93 (±81,54)	0.83511
Halobatrachus didactylus	Fish	192,09 (±211,47)	0.81872
Sepia officinalis	Cephalopoda	133,68 (±154,91)	0.56978
Sarpa salpa	Fish	127,21 (±91,75)	0.54221
Citharus linguatula	Fish	113,73 (±120,13)	0.48476
Paguros spp.	Crustacea	96,79 (±213,13)	0.41254
Liza ramada	Fish	65,99 (±89,2)	0.28125
Echinocardium cordatum	Echinodermata	60,86 (±134,01)	0.25939
Astropecten aranciacus	Echinodermata	43,92 (±19,9)	0.18719
Diplodus bellottii	Fish	22,41 (±23,37)	0.09552
Dosinia exoleta	Bivalvia	22,38 (±49,29)	0.09541
Tellina tenuis	Bivalvia	19,85 (±43,71)	0.08461
Benthodesmus elongates	Fish	19,18 (±22,08)	0.08176
Cymbium olla	Gastropoda	18,93 (±7,88)	0.08068
Balistes capriscus	Fish	17,02 (±7,08)	0.07255
Callionymus lyra	Fish	15,75 (±6,55)	0.06713
Trisopterus luscus	Fish	14,37 (±5,98)	0.06126
Todaropsis eblanae	Cephalopoda	14,23 (±5,85)	0.06065
Macroramphosus scolopax	Fish	14,12 (±5,88)	0.06020
Holothuroidea	Echinodermata	13,36 (±5,56)	0.05695
Scomber scombrus	Fish	10,81 (±4,5)	0.04608
Etmopterus pusillus	Sharks	10,33 (±13,93)	0.04405
Solea lascaris	Fish	9,63 (±4,01)	0.04104
Solea senegalensis	Fish	9,13 (±3,8)	0.03892
Sphaerechinus granularis	Echinodermata	8,64 (±3,08)	0.03684
Deania calcea	Sharks	8,52 (±9,25)	0.03631
Squilla mantis	Crustacea	8,17 (±17,99)	0.03482
Centrophorus squamosus	Sharks	7,81 (±8,49)	0.03330
Raja miraletus	Rays	7,45 (±3,1)	0.03176
Brama brama	Fish	6,7 (±2,76)	0.02857
Mola mola	Fish	6,59 (±2,74)	0.02811
Etmopterus spinax	Sharks	6,22 (±5,02)	0.02652
Spondyliosoma cantharus	Fish	5,76 (±2,3)	0.02456
Torpedo torpedo	Rays	5,51 (±2,29)	0.02348
Raja clavata	Rays	4,45 (±1,85)	0.01895
Liocarcinus depurator	Crustacea	4 (±8,8)	0.01704
Myliobatis aquila	Rays	3,6 (±1,5)	0.01535
Trigla sp.	Fish	3,53 (±1,47)	0.01504
Alepocephalus bairdii	Fish	3,53 (±3,83)	0.01504
Micromesistius poutassou	Fish	3,39 (±2,83)	0.01446
Atrina pectinata	Bivalvia	3,22 (±1,34)	0.01371
Chelidonichthys lucernus	Fish	3,18 (±1,32)	0.01354
Raja undulata	Rays	3,12 (±1,3)	0.01329
Spicara flexuosa	Fish	2,98 (±1,06)	0.01271
Pagellus erythrinus	Fish	2,98 (±1,24)	0.01270
Raja brachyura	Rays	2,75 (±1,15)	0.01173
Chelidonichthys lastoviza	Fish	2,6 (±1,08)	0.01109
Synaphobranchus kaupii	Fish	2,42 (±2,63)	0.01031
Donax vittatus	Bivalvia	2,34 (±5,15)	0.00998
Diplodus vulgaris	Fish	2,2 (±0,78)	0.00939
Mugil cephalus	Fish	2,1 (±0,87)	0.00895
Capros aper	Fish	2,03 (±0,84)	0.00863
Dicologlossa cuneata	Fish	1,99 (±2,31)	0.00846
Centrolophus monstrosa	Sharks	1,81 (±0,74)	0.00769
Balistes carolinensis	Fish	1,76 (±0,73)	0.00752
Trigloporus lastoviza	Fish	1,76 (±0,73)	0.00752
Zeus faber	Fish	1,72 (±0,72)	0.00734
Chimaera monstrosa	Fish	1,65 (±0,68)	0.00705

Table A2 (*Continued*)

Species	Taxa Group	Tonnes (SD)	%
Galeus melastomus	Sharks	1,6 (±1,22)	0.00682
Diplodus annularis	Fish	1,57 (±1,63)	0.00668
Lepidotrigla cavillone	Fish	1,54 (±0,64)	0.00656
Belone belone	Fish	1,51 (±0,63)	0.00644
Maja squinado	Crustacea	1,49 (±1,6)	0.00636
Dalatias licha	Sharks	1,38 (±0,57)	0.00588
Aplysia punctata	Gastropoda	1,34 (±0,56)	0.00569
Illex coindetii	Cephalopoda	1,27 (±0,52)	0.00543
Conger conger	Fish	1,27 (±1,34)	0.00543
Atelecyclus undecimdentatus	Crustacea	1,17 (±2,58)	0.00499
Ensis siliqua	Bivalvia	1,07 (±2,36)	0.00456
Arnoglossus imperialis	Fish	1,03 (±0,43)	0.00439
Dicentrarchus labrax	Fish	1 (±0,42)	0.00425
Scyliorhinus canicula	Sharks	0,99 (±0,46)	0.00422
Loligo spp.	Cephalopoda	0,93 (±0,39)	0.00395
Scorpaena porcus	Fish	0,81 (±0,34)	0.00345
Symphodus bailloni	Fish	0,79 (±0,86)	0.00337
Mullus barbatus	Fish	0,77 (±0,32)	0.00327
Polybius henslowii	Crustacea	0,72 (±2,33)	0.00306
Mullus spp.	Fish	0,7 (±0,29)	0.00297
Chelon labrosus	Fish	0,68 (±0,28)	0.00291
Sparus aurata	Fish	0,61 (±0,26)	0.00261
Centroscymnus crepidater	Sharks	0,6 (±0,66)	0.00258
Polychaetes	Other invertebrates	0,59 (±1,31)	0.00253
Acanthocardia spinosa	Bivalvia	0,54 (±0,19)	0.00228
Alosa fallax	Fish	0,53 (±0,22)	0.00227
Pecten maximus	Bivalvia	0,51 (±0,21)	0.00219
Phycis blennoides	Fish	0,49 (±0,35)	0.00209
Solea spp.	Fish	0,46 (±0,19)	0.00196
Scophthalmus rhombus	Fish	0,42 (±0,17)	0.00179
Pagrus pagrus	Fish	0,41 (±0,17)	0.00176
Trachyrincus scabrus	Fish	0,4 (±0,44)	0.00172
Nesiarchus nasutus	Fish	0,35 (±0,38)	0.00150
Microchirus variegatus	Fish	0,34 (±0,14)	0.00145
Marthasterias glacialis	Echinodermata	0,32 (±0,13)	0.00138
Hymenocephalus italicus	Fish	0,32 (±0,13)	0.00136
Lepidion guentheri	Fish	0,3 (±0,33)	0.00129
Solea solea	Fish	0,29 (±0,12)	0.00125
Dardanus arrosor	Crustacea	0,29 (±0,12)	0.00122
Centrolabrus exoletus	Fish	0,27 (±0,11)	0.00116
Trachinus vipera	Fish	0,26 (±0,56)	0.00109
Scymnodon ringens	Sharks	0,25 (±0,27)	0.00107
Dentex dentex	Fish	0,23 (±0,1)	0.00098
Pagellus spp.	Fish	0,23 (±0,09)	0.00097
Asterias rubens	Echinodermata	0,22 (±0,09)	0.00095
Echinus acutus	Echinodermata	0,22 (±0,09)	0.00094
Paracentrotus lividus	Echinodermata	0,21 (±0,09)	0.00091
Microchirus ocellatus	Fish	0,21 (±0,09)	0.00088
Raja spp.	Rays	0,2 (±0,19)	0.00087
Alepisaurus ferox	Fish	0,2 (±0,22)	0.00086
Murex trunculus	Gastropoda	0,2 (±0,07)	0.00086
Spisula solida	Bivalvia	0,19 (±0,43)	0.00083
Lepidorhombus boscii	Fish	0,18 (±0,07)	0.00076
Mullus surmuletus	Fish	0,18 (±0,07)	0.00076
Scophthalmus maximus	Fish	0,17 (±0,07)	0.00073
Bothus podas	Fish	0,17 (±0,07)	0.00072
Lagocephalus lagocephalus	Fish	0,17 (±0,07)	0.00071
Malacocephalus laevis	Fish	0,17 (±0,07)	0.00071
Dasyatis violacea	Rays	0,17 (±0,07)	0.00071
Aspitrigla cuculus	Fish	0,16 (±0,07)	0.00069
Dentex maroccanus	Fish	0,16 (±0,07)	0.00069
Mactra corallina stultorum	Bivalvia	0,16 (±0,35)	0.00068
Homala barbata	Crustacea	0,16 (±0,06)	0.00068
Lepidion spp.	Fish	0,15 (±0,16)	0.00064
Centrophorus granulosus	Sharks	0,15 (±0,16)	0.00064
Centroscymnus coelolepis	Sharks	0,15 (±0,16)	0.00064
Prionace glauca	Sharks	0,15 (±0,16)	0.00064
Serranus hepatus	Fish	0,15 (±0,09)	0.00062
Labrus mixtus	Fish	0,14 (±0,06)	0.00059
Labridae	Fish	0,13 (±0,05)	0.00056
Diplodus spp.	Fish	0,13 (±0,05)	0.00056
Trigla lyra	Fish	0,12 (±0,05)	0.00053
Dentex spp.	Fish	0,12 (±0,05)	0.00051
Uranoscopus scaber	Fish	0,11 (±0,05)	0.00046
Lepidotrigla dieuzeidei	Fish	0,11 (±0,04)	0.00046
Nephrops norvegicus	Crustacea	0,11 (±0,04)	0.00045
Hoplostethus mediterraneus	Fish	0,11 (±0,04)	0.00045

Table A2 (*Continued*)

Species	Taxa Group	Tonnes (SD)	%
Naucrates ductor	Fish	0,11 (±0,04)	0.00045
Epigonus telescopus	Fish	0,1 (±0,11)	0.00043
Hexanchus griseus	Sharks	0,1 (±0,11)	0.00043
Diplodus sargus	Fish	0,09 (±0,04)	0.00038
Dentex macrophthalmus	Fish	0,09 (±0,04)	0.00036
Calappa granulata	Crustacea	0,08 (±0,03)	0.00034
Scomber spp.	Fish	0,08 (±0,03)	0.00032
Soleidae	Fish	0,07 (±0,03)	0.00031
Arnoglossus laterna	Fish	0,07 (±0,03)	0.00031
Coris julis	Fish	0,06 (±0,03)	0.00027
Ammodytes tobianus	Fish	0,06 (±0,02)	0.00025
Aphanopus carbo	Fish	0,05 (±0,05)	0.00021
Coryphaena hippurus	Fish	0,05 (±0,05)	0.00021
Coryphaenoides rupestris	Fish	0,05 (±0,05)	0.00021
Thunnus alalunga	Fish	0,05 (±0,05)	0.00021
Centrophorus lusitanicus	Sharks	0,05 (±0,05)	0.00021
Deania profundorum	Sharks	0,05 (±0,05)	0.00021
Isurus oxyrinchus	Sharks	0,05 (±0,05)	0.00021
Arnoglossus spp.	Fish	0,05 (±0,02)	0.00021
Symphodus spp.	Fish	0,04 (±0,02)	0.00019
Pleuronectiformes	Fish	0,04 (±0,02)	0.00018
Nucella lapillus	Gastropoda	0,04 (±0,02)	0.00015
Venus striatula	Bivalvia	0,04 (±0,08)	0.00015
Liza spp.	Fish	0,04 (±0,01)	0.00015
Palinurus elephas	Crustacea	0,03 (±0,01)	0.00013
Ophioderma longicaudum	Echinodermata	0,03 (±0,01)	0.00012
Gymnammodytes cicerelus	Echinodermata	0,03 (±0,01)	0.00012
Carcinus maenas	Crustacea	0,02 (±0,01)	0.00007
Argentina sphyraena	Fish	0,02 (±0,01)	0.00007
Zeugopterus punctatus	Fish	0,01 (±0,01)	0.00006
Maja goltziana	Crustacea	0,01 (±0,01)	0.00005
Arnoglossus thori	Fish	0,01 (±0,01)	0.00005
Pagurus forbesii	Crustacea	0,01 (±0,004)	0.00004
Bothidae	Fish	0,01 (±0,002)	0.00002
Goneplax rhomboides	Crustacea	0 (±0,002)	0.00002
Liocarcinus holsatus	Crustacea	0,003 (±0,001)	0.00001
Callionymus reticulatus	Fish	0,002 (±0,001)	0.00001
Boops boops	Fish	7466 (±1995)	31
Scomber japonicus	Fish	4335 (±1159)	18
Belone belone	Fish	3613 (±965)	15
Sardina pilchardus	Fish	3613 (±965)	15
Macroramphosus scolopax	Fish	2649 (±708)	11
Scomber scombrus	Fish	1445 (±386)	6
Halobatrachus didactylus	Fish	241 (±64)	1
Spicara flexuosa	Fish	241 (±64)	1
Trachurus trachurus	Fish	241 (±64)	1
Trachurus picturatus	Fish	10659,5 (±4864,9)	15.856
Merluccius merluccius	Fish	8854,3 (±4041)	13.171
Scomber japonicus	Fish	8641,6 (±3943,9)	12.855
Micromesistius poutassou	Fish	8494,1 (±3876,6)	12.635
Trachurus trachurus	Fish	3888,2 (±1774,5)	5.784
Capros aper	Fish	2522,1 (±1151,1)	3.752
Chondrichthyes	Fish	2178,2 (±994,1)	3.240
Boops boops	Fish	1985,3 (±906)	2.953
Conger conger	Fish	1974,1 (±901)	2.937
Sardina pilchardus	Fish	1946,7 (±888,4)	2.896
Scomber scombrus	Fish	1749,4 (±798,4)	2.602
Scyliorhinus canicula	Sharks	1170,6 (±534,2)	1.741
Diverse	Diverse	1114,8 (±508,8)	1.658
Octopodidae	Cephalopoda	1080,5 (±493,1)	1.607
Lophius spp.	Fish	840,4 (±383,6)	1.250
Lepidopus caudatus	Fish	792,4 (±361,6)	1.179
Triglidae	Fish	789 (±360,1)	1.174
Cephalopoda	Cephalopoda	771,8 (±352,2)	1.148
Gadiculus argenteus	Fish	755,5 (±344,8)	1.124
Phycis spp.	Fish	634,6 (±289,6)	0.944
Parapenaeus longirostris	Crustacea	626 (±285,7)	0.931
Holothuroidea	Echinodermata	531,7 (±242,7)	0.791
Polybius henslowii	Crustacea	514,5 (±234,8)	0.765
Galeus melastomus	Sharks	406,5 (±185,5)	0.605
Trisopterus luscus	Fish	351,6 (±160,5)	0.523
Mullus spp.	Fish	300,1 (±137)	0.446
Sphoeroides pachygaster	Fish	265,8 (±121,3)	0.395
Maja squinado	Crustacea	257,3 (±117,4)	0.383
Pagellus spp.	Fish	257,3 (±117,4)	0.383
Trachurus spp.	Fish	257,3 (±117,4)	0.383
Pagrus spp.	Fish	240,1 (±109,6)	0.357

Table A2 (*Continued*)

Species	Taxa Group	Tonnes (SD)	%
Macroramphosus scolopax	Fish	238,4 (±108,8)	0.355
Helicolenus dactylopterus	Fish	207,5 (±94,7)	0.309
Pagrus pagrus	Fish	171,5 (±78,3)	0.255
Sarpa salpa	Fish	171,5 (±78,3)	0.255
Xiphias gladius	Fish	171,5 (±78,3)	0.255
Octopus vulgaris	Cephalopoda	162,9 (±74,4)	0.242
Spondyliosoma cantharus	Fish	145,8 (±66,5)	0.217
Serranus cabrilla	Fish	137,2 (±62,6)	0.204
Plesionika spp.	Crustacea	128,6 (±58,7)	0.191
Zeus faber	Fish	128,6 (±58,7)	0.191
Rajidae	Rays	111,5 (±50,9)	0.166
Tealia spp.	Other invertebrates	102,9 (±47)	0.153
Echinoidea	Echinodermata	94,3 (±43,1)	0.140
Pleuronectes platessa	Fish	68,6 (±31,3)	0.102
Macropipus tuberculatus	Crustacea	42,9 (±19,6)	0.064
Rossia macrosoma	Cephalopoda	35,2 (±16)	0.052
Dardanus arrosor	Crustacea	34,3 (±15,7)	0.051
Solea spp.	Fish	34,3 (±15,7)	0.051
Pagurus alatus	Crustacea	25,7 (±11,7)	0.038
Lepidorhombus spp.	Fish	25,7 (±11,7)	0.038
Argentina sphyraena	Fish	17,2 (±7,8)	0.026
Mullus surmuletus	Fish	17,2 (±7,8)	0.026
Argobuccinum olearium	Gastropoda	17,2 (±7,8)	0.026
Cassidaria tyrrhena	Gastropoda	17,2 (±7,8)	0.026
Torpedo nobiliana	Rays	12,9 (±5,9)	0.019
Malacocephalus laevis	Fish	9,4 (±4,3)	0.014
Caelorinchus caelorhincus	Fish	8,6 (±3,9)	0.013
Illex coindetii	Cephalopoda	4,3 (±2)	0.006
Zenopsis conchifer	Fish	4,3 (±2)	0.006
Ophisurus serpens	Fish	3,4 (±1,6)	0.005
Sphoeroides cutaneus	Fish	3,4 (±1,6)	0.005
Eledone cirrhosa	Cephalopoda	2,6 (±1,2)	0.004
Octopus salutii	Cephalopoda	1,7 (±0,8)	0.003
Todaropsis eblanae	Cephalopoda	1,7 (±0,8)	0.003
Chimaera monstrosa	Fish	1,7 (±0,8)	0.003
Citharus linguatula	Fish	1,7 (±0,8)	0.003
Lophius piscatorius	Fish	1,7 (±0,8)	0.003
Eledone moschata	Cephalopoda	0,9 (±0,4)	0.001
Hoplostethus mediterraneus	Fish	0,9 (±0,4)	0.001
Pagellus bogaraveo	Fish	0,9 (±0,4)	0.001
Peristedion cataphractum	Fish	0,9 (±0,4)	0.001
Phycis blennoides	Fish	0,9 (±0,4)	0.001
Ruvettus pretiosus	Fish	0,9 (±0,4)	0.001
Trachurus mediterraneus	Fish	0,9 (±0,4)	0.001
Raja clavata	Rays	0,9 (±0,4)	0.001
Raja oxyrinchus	Rays	0,9 (±0,4)	0.001
Etmopterus pusillus	Sharks	0,9 (±0,4)	0.001
Hexanchus griseus	Sharks	0,9 (±0,4)	0.001

References

Alverson, D.L., Hughes, S.E., 1996. Bycatch: from emotion to effective natural resource management. Rev. Fish Biol. Fish. 6 (4), 443–462.

Alves, J.F., 1991. A Pesca e os Pescadores do Litoral Portuense em 1868. Revista da Faculdade de Letras 8, 151–184 (http://ler.letras.up.pt/uploads/ficheiros/2260.pdf).

Baeta, A.F.R., 2009. Environmental impacts and sustainability of Portuguese fisheries. PhD Thesis, Faculdade de Ciências, Universidade de Lisboa, 212 pp.

Baldaque da Silva, A.A., 1891. Estado actual das Pescas em Portugal compreendendo a pesca marítima, fluvial e lacustre em todo o continente do Reino referido no ano de 1886. Lisboa.

Bordalo-Machado, P., Fernandes, A.C., Figueiredo, I., Moura, O., Reis, S., Pestana, G., Gordo, L.S., 2009. The black scabbardfish (*Aphanopus carbo* Lowe, 1839) fisheries from the Portuguese mainland and Madeira Island. Sci. Mar. 7S2, 63–76.

Borges, T.C., Fonseca, L.C., Cristo, M. et al., 1998. Biodiversity of the fisheries of Algarve (South Portugal). Impriluz, Lisboa.

Borges, T.C., Erzni, K., Bentes, L., Costa, M.E., Gonçalves, J.M.S., Lino, P.G., Pais, C., Ribeiro, J., 2001. By-catch and discarding practices in five Algarve (Southern Portugal) métiers. J. Appl. Ichthyol. 17, 104–114.

Borges, L., Rogan, E., Officer, R., 2005. Discarding by the demersal fishery in the waters around Ireland. Fish. Res. 76, 1–13.

Batistas, M.I., Teixeira, C.M., Cabral, H.N., 2009. Catches of target species and bycatches of an artisanal fishery: The case study of a trammel net fishery in the Portuguese coast. Fish. Res. 100, 167–177.

Coleman, F.C., Figueira, W.F., Ueland, J.S., Crowder, L.B., 2004. The impact of United States recreational fisheries on marine fish populations. Science 305, 1958–1960.

Costa, M.E., Erzini, K., Borges, T.C., 2008. Bycatch of crustacean and fish bottom trawl fisheries from southern Portugal (Algarve). Sci. Mar. 72 (4), 801–814.

Dann, N., 1997. TAC management in North Sea flatfish fisheries. J. Sea. Res. 37, 321–341.

Dias, M.L.,Barraca, I.F., 1971. Algumas considerações sobre a pesca de tunidios na costa de Portugal Continental e Ilhas da Madeira e dos Açores entre 1961–1970. pp. 37-54 In Boletim da junta Nacional de fomento das pescas.

Erzini, K., Gonçalves, J.M.S., Bentes, L., Lino, P.G., Ribeiro, J., 2001. The hake deepwater semi-pelagic ("pedra-bola") longline fishery in the Algarve (southern Portugal). Fish. Res. 51, 327–336.

EU, 2008. On the implementation of the policy to reduce unwanted by-catch and eliminate discards in European fisheries. Commission non-paper. 13 pp.

FAO, 1994. A global assessment of fisheries bycatch and discards. FAO Fish. Tech. Paper. 339, 233pp.

FAO, 2005. Discards in the world's marine fisheries: An update. FAO Fish. Tech. Paper. 470, 131pp.

FAO, 2010. Report of the Technical Consultation to Develop International Guidelines on Bycatch Management and Reduction of Discards. FAO Fish. and Aquac. Report 957. Rome, 32pp.

García-Flórez, L., Morales, J., Gaspar, M.B., Castilla, D., Mugerza, E., Berthou, P., Fuente, L.G., Oliveira, M., Moreno, O., Hoyo, J.J., Arregi, L., Vignot, C., Chapela, R., Murillas, A., 2014. A novel and simple approach to define artisanal fisheries in Europe. Mar. Pol. 44, 152–159.

Gaspar, M.B., Leitão, F., Chicharo, L., Santos, M.N., Monteiro, C.C., 2003. A Comparison of direct mortality inflicted on macrofaunal organisms by three types of dredges used in the Portuguese clam fishery. ICES J. Mar. Sci. 60, 733–742.

Gonçalves, J.M.S., Stergiou, K.I., Hernando, J.A., Puente, E., Moutopoulos, D.K., Arregi, L., Soriguer, M.C., Vilas, C., Coelho, R., Erzini, K., 2007. Discards from experimental trammel nets in Southern European small-scale fisheries. Fish. Res. 88, 5–14.

Gonçalves, J.M.S., Bentes, L., Monteiro, P., Coelho, R., Corado, M., Erzini, K., 2008. Reducing discards in a demersal purse-seine fishery. Aquat. Living Resour. 21, 135–144.
Harper, S., Bothwell, J., Bale, S., Booth, S., Zeller, D., 2009. Cayman Island fisheries catches: 1950-2007, in: Zeller, D., Harper, S. (Eds), Fisheries catch reconstruction: Islands, Part I. Fisheries Centre Research Reports, 17(5), pp. 3-11.
Hongskul, V., 1979. Report on the studies of multispecies systems in fisheries. In stock Assessment in Tropical Small-Scale Fisheries Fisheries, Proceedings of an international workshop, September 19-2, U.R.I., pp. 173-182.
ICES, 2012. Report of the ICES Advisory Committee 2012. ICES Advice, 2012. Book 7. 205 pp.
Kaiser, M.J., de Groot, S.J., 2000. Effects of Fishing on Non-Target Species and Habitats. Biological, Conservation and Socio-Economic Issues. Blackwell Science, Oxford.
Kennelly, S.J., 1995. The issue of bycatch in Australia's demersal trawl fisheries. Rev. Fish Biol. Fish. 5, 213–234.
Khalilian, S., Froese, R., Proelss, A., Requate, T., 2010. Designed for failure: a critique of the Common Fisheries Policy of the European Union. Mar. Policy 34, 1178–1182.
Kleiven, A.R., Olsen, E.M., Vølstad, J.H., 2012. Total catch of a red-listed marine species is an order of magnitude higher than official data. PLoS One 7, pe31216.
Le Manach, F., Dura, D., Pere, A., Riutort, J.J., Lejeune, P., Santoni, M.C., Culioli, J.M., Pauly, D., 2011. Preliminary estimate of total marine fisheries catches in Corsica, France (1950-2008), in: Harper, S., ZellerD. (Eds), Fisheries catch reconstructions: Islands, Part II. Fisheries Centre Research Reports, 19(4). pp. 3-14.
Lobo C.B.L. 1812. Memória sobre a decadência das Pescarias em Portugal. Memorias Económicas da Academia das Sciencias de Lisboa. Lisboa, 1821, Tomo IV, pp. 312-338.
Leitão, F.M.S., Gaspar, M.B., 2007. Immediate effect of intertidal non-mechanised cockle harvesting on macrobenthic communities: a comparative study. Sci. Mar. 71, 723–733.
Machado, B.P., Figueiredo, I., 2009. The fishery for black scabbardfish (*Aphanopus carbo* Lowe, 1839) in the Portuguese continental slope. Rev. Fish Biol. Fish. 19, 49–67.
Marçalo, A., Mateus, L., Correia, J.H.D., Serra, P., Fryer, R., Stratoudakis, Y., 2006. Sardine (Sardina pilchardus) stress reactions to purse seine fishing. Mar. Biol. 149, 1509–1518.
McAllister, D.E., Spiller, G., 1994. Fish habitat: Trawling and dredging impact on fish habitat and bycatch, in: Wells, P.G., Ricketts, P.J. (Eds.), Coastal Zone Canada' 94, Cooperation in the Coastal Zone: Conference Proceedings, September 20-23. 1994. Coastal Zone Canada Association, Canada, 4, pp. 1708-1717.
MRAG., 2007. Impact assessment of discard policy for specific fisheries: Final Report. European Commission Studies and Pilot Projects for Carrying Out the Common Fisheries Policy. No FISH/2006/17.
Moutopoulos, D.K., Katselis, G., Kios, K., Tsotskou, A., Tsikliras, A.C., Stergiou, K.I., 2013. Estimation and reconstruction of shore-based recreational angling fisheries catches in the Greek Seas (1950-2010). J. Biol. Res. -Thessaloniki. 20, 376–381.
Pauly, D., 2009. Beyond duplicity and ignorance in global fisheries. Sci. Mar. 73, 215–224.
Pauly, D., Christensen, V., Guénette, S., Pitcher, T.J., Sumaila, U.R., Walters, C.J., Watson, R., Zeller, D., 2002. Towards sustainability in fisheries management. Nature 418, 689–695.
Pérez, N., Prista, N., Santos, J., Fernandes, A.C., Azevedo, M., Ordoñez, T., Bellido, J., Fernández, J., 2011. Action1: Analysis and characterization of the present discards situation (LIFE08 ENV/E/000119). Deliverable 1.2.: Manual on the strategies and solutions on board to reduce discards.
Pham, C.K., Canha, A., Diogo, H., Pereira, J.G., Prieto, R., Morato, T., 2013. Total marine fishery catch for the Azores (1950-210). ICES J. Mar. Sci. 70 (3), 564–577.
Pikitch, E.K., Santora, C., Babcock, E.A., Bakun, A., Bonfil, R., Conover, D.O., Dayton, P., Doukakis, P., Fluharty, D.L., Heneman, B., Houde, E.D., Link, J., Livingston, P.A., Mangel, M., McAllister, M.K., Pope, J., Sainsbury, K.J., 2004. Ecosystem-based Fishery Management. Science 305, 346–347.
Pitcher, T.J., Pauly, D., 1998. Rebuilding ecosystems, not sustainability, as the proper goal of fishery management. In: Pitcher, T.J., Hart, P.J.B., Pauly, D. (Eds.), Reinventing fisheries management. Kluwer Academic Publishers, Dordrecht, pp. 311–329.
Reis, C.S., Lemos, R.T., Dornelas, M.A., Santos, R.A., 2001. Fisheries, in: Santos, F.D., Forbes, K., Moita, R. (Eds), Climate Change in Portugal: Scenarios, Impacts and Adaptation Measures – SIAM Project. Gradiva, Lisboa, pp. 415-452.
Russ, G.R., Zeller, D., 2003. From Mare Liberum to Mare Reservarum. Marine Policy 27 (1), 75–78.
Ruano, F.D.L., 1997. Fisheries and farming of important marine bivalves in Portugal. NOAA Tech. Rep. NMFS. 129, 191–200.
Santos, L.F.R., 1989. A pesca do Atum no Algarve. Parque Natural da Ria Formosa. Artes Gráficas Loulé., 95p.
Saldanha, H.J., 2001. Contribuição para o estudo da pesca artesanal do polvo (*Octopus vulgaris* Cuvier, 1797) com covos, no sotavento algarvio: caracterização das capturas alvo, capturas acessórias e rejeições ao mar. Licenciatura thesis. University of Algarve.
Santos, M.N., Garcia, A., Pereira, J.P., 2002a. Historical review of the by-catch from the Portuguese surface long-line swordfish fishery: observations on blue shark (Prionace glauca) and short-fin mako (Isurus oxyrinchus). Col. Vol. Sci. Pap. ICCAT. 54 (4), 1333–1340.
Santos, M.N., Saldanha, H., Garcia, A., 2002b. Observations on by-catch from a tuna trap fishery off the Algarve (Southern Portugal). Col. Vol. Sci. Pap. ICCAT. 54 (4), 1726–1732.
Saila, S.B., 1983. Importance and Assessment of Discards in Commercial Fisheries. FAO Cir. 765, 62 pp.
Sardà, F., Coll, M., Heymans, J.J., Stergiou, K.I., 2013. Overlooked impacts and challenges of the new European discard ban. Fish and Fisheries. DOI: 10.1111/faf.12060.
Sobral, M., Carvalho, M., Sobral, M., Monteiro, C., Dias, D., 1989. Breve referência à exploração de moluscos bivalves na zona litoral da costa ocidental Portuguesa. Açoriana. 7 (1), 175–207.
Stevens, J.D., Bonfil, R., Dulvy, N.K., Walker, P.A., 2000. The effects of fishing on sharks, rays, and chimaeras (chondrichthyans), and the implications for marine ecosystems. ICES J. Mar. Sci. 57, 476–494.
Stratoudakis, Y., Marçalo, A., 2002. Sardine slipping during purse-seining off northern Portugal. ICES J. Mar. Sci. 59, 1256–1262.
Ulman, A., Bekisoglu, S., Zengin, M., Knudsen, S., Ünal. V., Mathews, C., Harper, S., Zeller, D., 2012. From bonito to anchovy: A reconstruction of Turkey's marine fisheries catches (1950-2010). Med. Mar. J. Sci. Doi: http://dx.doi.org/10.12681/mms.414
Veiga, P., Ribeiro, J., Gonçalves, J.M.S., Erzini, K., 2010. Quantifying recreational shore angling catch and harvest in southern Portugal (north-east Atlantic Ocean): implications for conservation and integrated fisheries management. J. Fish Biol. 76, 2216–2237.
Watson, R., Pauly, D., 2001. Systematic distortions in world fisheries catch trends. Nature 414, 534–536.
Watson, R., Sumaila, R.U., Zeller, D., 2011. How much fish is being extracted from the oceans and what is it worth? in: Christensen, V., MacLean, J., Ecosystem Approaches to Fisheries: A Global Perspective. Cambridge University Press, Cambridge, pp. 55-71.
Wise, L., Ferreira, M., Silva, A., 2005. Caracterização da Pesca de Cerco na Costa Oeste Portuguesa. Relat. Cient. Téc. IPIMAR. Série digital, 24, 19 p.
Wielgus, J., Zeller, D., Caicedo-Herrera, D., Sumaila, U.R., 2010. Estimation of fisheries removals and primary economic impact of the small-scale and industrial marine fisheries in Colombia. Marine Policy 34, 506–513.
Zeller, D., Booth, S., Craig, P., Pauly, D., 2006. Reconstruction of coral reef fisheries catches in American Samoa, 1950-2002. Coral Reefs 25, 144–152.
Zeller, D., Booth, S., Davis, G., Pauly, D., 2007. Re-estimation of small-scale fisheries catches for U.S. flag island areas in the Western Pacific: the last 50 years. Fish. Bull. 105, 266–277.
Zeller, D., Darcy, M., Booth, S., Lowe, M.K., Martell, S.J., 2008. What about recreational catch? Potential impact on stock assessment for Hawaii's bottom fish fisheries. Fish. Res. 91, 88–97.
Zeller, D., Booth, S., Pakhomov, E., Swartz, W., Pauly, D., 2011a. Arctic fisheries catch in Russia, USA and Canada: baselines for neglected ecosystems. Polar Biol. 34, 955–973.
Zeller, D., 2005. From Mare Liberum to Mare Reservarum: Canada's opportunity for global leadership in ocean resource governance. In: Chircop, A., McConnell, M. (Eds.), Ocean Yearbook19. University of Chicago Press, Chicago, pp. 1–18.
Zeller, D., Rossing, P., Harper, S., Persson, L., Booth, S., Pauly, D., 2011b. The Baltic Sea: estimates of total fisheries removals 1950-2007. Fish. Res. 108, 356–363.
Zeller, D., Pauly, D., 2007. Reconstruction of marine fisheries catch for key countries and regions (1950-2005). Fisheries Centre Research Report. Vancouver Canada: Fisheries Centre, University of British Columbia.