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RECONSTRUCTION OF FISHERIES CATCHES FOR BULGARIA: 1950-2010

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ABSTRACT

Bulgaria's total marine fisheries catches were estimated for the 1950-2010 time period using a reconstruction approach which accounted for all fisheries-related removals from the marine ecosystem, such as unreported landings, discards, recreational and subsistence catches. All of the unreported components were added to the 'official' data, as reported by Bulgaria to the United Nations' Food and Agriculture Organization (FAO). The total reconstructed catch for the 1950-2010 time period is almost 78% more than data reported to the FAO. Unreported landings accounted for approximately 40% of the total reconstructed catch and discards over 3%. Industrial (large-scale) catches dominated the catches with over 92% of the total reconstructed catch. Subsistence and recreational sectors make minor, but socially important contributions. Accounting for all fishery removals is critical to a better understanding of fisheries resource use, which will ultimately help in improving management of the resource.

INTRODUCTION

Bulgaria's fisheries in, and catches from, the Black Sea are best introduced after presenting the Black Sea itself, which has a surface area of 422,103 km^2, excluding the Sea of Azov. The mean and maximum depths of the Black Sea are approximately 1,300 m and 2,212 m, respectively. The Black Sea is connected to the Aegean and hence Mediterranean Sea through the two Turkish Straits; the Bosphorus, which connects to the Sea of Marmara, and then connects to the Dardanelles.

The upper layer of the Black Sea has low salinity (averaging around 17-18 psu) and warmer average summer temperatures (up to 30°C), both which inhibit the surface layer from mixing with the deeper layer, which has a salinity averaging 22-24 psu and temperatures of approximately 8.5°C. The majority of the Black Sea water column (about 90%), is deeper than 150-200 m and thus is naturally anoxic and devoid of life (Oguz *et al.* 1998). Freshwater river runoff (mainly from the Danube, Dniester and Dnieper rivers), and high-salinity waters (from the Mediterranean Sea entering the Black Sea via the Bosphorus Strait) enhance the stratification, and further inhibit mixing between surface and deeper layers. Although the lower 90% of the Black Sea basin is devoid of oxygen and contaminated with hydrogen sulphide, the upper layer is highly productive and provides suitable habitats for numerous epipelagic and neritic species (Zaitsev 2008).

The Black Sea ecosystem has suffered from several anthropogenic disturbances such as eutrophication, the introduction of alien species (*Mnemiopsis leidyi*) and the overexploitation of large pelagic predators in the late 20th century (Prodanov *et al.* 1997; Zaitsev and Mamaev 1997; Caddy 2008). Eutrophication has dramatically altered the base of the marine food web; additionally, the overexploitation and removal of some fish stocks helped provide the necessary conditions for successful alien species invasions (Daskalov 2002).

In 1946, a large sea snail, the Rapa whelk (*Rapana venosa),* was first seen in the Black Sea. *Rapana* was successful in its new environment and became widespread (except in very low salinity areas). It is a notorious predator which feeds on oysters, mussels and other bivalves, and thus exerts a major influence on local populations of malacofauna. In the 1980s, in response to an international demand for sea snails, a massive fishery for *Rapana* emerged in Turkish waters, and along the Bulgarian coast which helped reduce *Rapana*'s impact on its prey species. This may possibly be the only example of a human-induced decline in an introduced species to the Black Sea.

Despite the entire Black Sea ecosystem being affected by these and similar issues, they are all 'national' issues, because the waters of the Black Sea are under the jurisdiction of its six bordering countries (Bulgaria, Romania, Ukraine, Russia, Georgia, and Turkey), i.e., the Black Sea does not include a 'high sea' area, and there is no ecosystem-wide management authority.

The Bulgarian Exclusive Economic Zone (EEZ) is around 35,000 km^2 (Fig. 1, www.seaaroundus.org), which corresponds to just under 7% of the total Black Sea area (Popescu 2011). Also relevant may be that the Black Sea corresponds to GFCM's Major Fishing Area 37, Sub-area 37.4; Division 37.4.2, and Bulgaria's fisheries occur within Geographical Sub-area 29.

Bulgaria's continental shelf (to 100 m depth) along the Bulgarian coast is ~40 km wide; the relatively shallow fishing grounds (up to 100-120 m depth) range from Cape Kartalburun (near the Romanian border) to the Rezevo River (near the Turkish border). The exploitation of fisheries resources is limited to the upper shelf, since depths below 100-150 m are anoxic and have high amounts of H_2S, both conditions being hostile to life (FAO 2012).

Bulgarian marine fish catches have exhibited trends similar to other Black Sea countries. In the mid-1960s, Atlantic mackerel (*Scomber scombrus*)*,* bonito (S*arda sarda*)*,* and bluefish (*Pomatomus saltatrix*) were the commercially important species (Ivanov and Beverton 1985). Bluefin tuna (*Thunnus thynnus*) and swordfish (*Xiphias gladius*) were also targeted, but were less abundant. In the late 1960s and early 1970s, Atlantic mackerel, bonito and bluefish catches dramatically decreased in the Bulgarian Black Sea fisheries. Among demersal species, turbot (*Scophthalmus maximus*) was one of the most important commercial species, and catches averaged 334 $t \cdot year^{-1}$ in the 1960s, but dropped to 12 $t \cdot year^{-1}$ by the 1980s (Zaitsev and Mamaev 1997). In the 1970s, the over-exploitation of larger pelagic predators, combined with the increased euthrophication of the north-western Black Sea led to a dramatic increase in the catches of small pelagics such as sprat (*Sprattus sprattus*), anchovy (*Engraulis encrasicolus*) and Mediterranean horse mackerel (*Trachurus mediterraneus*). The sprat population saw a massive increase in biomass from the mid-1970s and 1980s, and its maximum catch was recorded in 1989, after which the stock collapsed, but rebounded later (Radu *et al.* 2010). In the late 1980s, an alien invasive species, the ctenophore *Mnemiopsis leidyi* reached its maximum abundance in the Black Sea, and thus became a powerful food competitor of adult planktivorous fish, and a significant predator of their eggs and larvae. As a consequence of this and other changes in this Large Marine Ecosystem (LME, Pauly et al., 2008; Sherman and Hempel, 2008), the Rapa whelk (*Rapana venosa*) has become, since 1995, the most commercially important taxon, closely followed by sprat.

Modernization of the Bulgarian fishing fleet began just before the 1950s. Industrial or large-scale purse seine and trawl vessels developed in the 1950s. In the 1960s, however, Bulgaria began to buy high-seas fishing and support vessels from the Soviet Union, Poland and East Germany, and began to build infrastructure for the processing of fish. From 1965 to 1990, Bulgaria owned a large high-seas distant-water fleet in the Atlantic and in the south-eastern Pacific (which consisted of 30 high-capacity trawlers and 6 transport vessels). This fleet was liquidated in the early 1990s, and the Bulgaria fishing fleet refocused their efforts on the Black Sea coastal zone (Popescu 2011).

In the 1970s, approximately 80% of marine catches came from the industrial fisheries, and the remainder came from the small-scale artisanal sector, which used mainly passive gears (Kumantsov and Raykov 2012). In 2008, the Bulgarian fleet consisted of 2,547 vessels with a total gross tonnage (GT) of 8,378 and total kilowatts (kW) of 63,860 (Table 1). The small-scale sector represented 96% of the fishing fleet, or 2,440 vessels under 12 m in length, and was responsible for landing 57.3% of the Black Sea catch (Radu *et al.* 2010). Throughout this study, we use the term 'industrial' to represent the large-scale, commercial sector, and the term 'artisanal' to represent the small-scale, commercial sector.

'Industrial' (large-scale) fishery

Sprat is targeted mainly by large-scale pelagic trawls seasonally from February to November. Whiting (*Merlangius merlangus*), turbot, anchovy, shad (*Alosa* spp.), Mediterranean horse mackerel and red mullet (*Mullus barbatus*) are incidentally caught as by-catch (Radu *et al.* 2010), but sold for their commercial value. The bottom trawl fishery began to develop for turbot in the 1950s, but was banned in 1994 to protect declining turbot stocks and also mussel beds (*Mytilus galloprovincialis*). In 2008, the fleet consisted of 108 vessels of >12 m in length. Dredge and beam trawl were used in the Rapa whelk fishery, but were also banned in 2001 to protect vulnerable benthic biotic communities such as mussel beds. Note that dredge and beam trawl fisheries may be classified as small-scale fisheries in Bulgaria as domestic classification is based on vessel size. However, for the purposes of the *Sea Around Us* (www.seaaroundus.org), any fishing gears that are actively dragged across the sea-floor or through the water column are considered 'industrial' (i.e., large-scale), also following the description of Martín (2012).

'Artisanal' (small-scale) fishery

The coastal fishery has traditionally been carried out by small vessels (<12m) which use mainly passive types of fishing gear, such as trap nets (uncovered pound nets), and beach seines in the inshore area. Here, these vessels/gears are considered 'artisanal'. Pound nets are deployed in 9 to 12 m depth in the coastal inshore waters (Radu *et al.* 2010) from March to November, and target species vary according to season: sprat is targeted during spring and the beginning of summer, and anchovy and Mediterranean horse mackerel are targeted in summer and autumn. Whiting, turbot, red mullet and other demersal species are incidentally caught as by-catch, but retained for commercial sale (Radu *et al.* 2010). The set gillnet fishery operates in the coastal and offshore waters of Bulgaria and targets primarily turbot, while spiny dogfish (*Squalus acanthias*), thornback ray (*Raja clavata*), common stingray (*Dasyatis pastinaca*) and sturgeons (Acipenseridae) are often incidentally caught as by-catch (Radu *et al.* 2010). The number of vessels operating by LOA in 2008 is given in Table 1.

MATERIALS AND METHODS

Reported FAO data

According to the reported FAO data for Bulgaria in the Mediterranean and Black Seas (FAO Area 37), total catches appeared very high for the years between 1964 and 1969. On closer inspection, it was found that duplicate 'marine fishes nei' (MMF) values had been entered for Bulgaria fishing in three other areas (the central Atlantic, south-eastern Atlantic and north-western Atlantic), i.e., the exact same values were present in all three areas. By comparing FAO data with Northwest Atlantic Fisheries Organization (NAFO) data, it was found that these MMF values were indeed incorrect. It was therefore assumed that the reported catch for FAO Area 37 (Mediterranean and Black Seas) also had these values mistakenly added on to the real MMF catch. We therefore subtracted the

duplicated MMF tonnage reported in the other areas from the MMF in FAO Area 37 for the years 1964-1969. This adjusted FAO baseline was used for the rest of the reconstruction. We suggest Bulgaria request a data correction for FAO data.

Since all taxa were reported as 'marine fishes nei' (i.e., miscellaneous marine fishes) from 1950 to 1963, we disaggregated this category taxonomically by using the mean catch composition from the adjusted FAO reported data from 1964-1968 (Table 2).

Unreported catches

Unreported catches as determined here include unreported commercial, subsistence and recreational catches, as well as discarded catch.

Commercial catches

Sprat has been the main catch for Bulgaria since 1970. However, published reports on Bulgarian fisheries have clearly documented that some commercial sprat catches have gone unreported (Mikhailov and Prodanov 2003; Daskalov and Rätz 2011). Bulgarian sprat catches were reported to be 3,266 t and 3,705 t in 1992 and 1993, respectively. On average, the expert estimates of actual catches for 1992 and 1993 were 55% higher than the reported data, and sprat catches in 1990 and 1991 and from 1994 to 1998 were assumed to have been under-reported by the same ratio. Expert assessments of sprat catches averaged 1.79 times higher than reported data and were assessed to be 7,997 t, 6,500 t, and 8,183 t in 2004, 2005 and 2006, respectively (EU 2009). An unreported sprat component was estimated using this same ratio (1.79 times higher) from 1999 to 2001 and from 2007 to 2010. The ratio was not applied to the years 2002-2003, as the reported data exhibited a spike in these years and it was assumed that reporting coverage was more complete in this time period. Therefore, we linearly interpolated the unreported tonnage from 2001 to 2004 in order to be conservative. We assumed there to be a much lower likelihood of under-reporting from 1950 to 1989 (during communist rule), and therefore assumed a conservative 10% under-reporting rate for sprat during that period.

In Bulgaria, marine bivalve catches include the striped Venus clam (*Chamelea gallina*), bean clam (*Donax* spp.) and Mediterranean mussel (*Mytilus galloprovincialis*). According to an FAO report, the 2000 FAO reported data for Rapa whelk equated to 90% of the shellfish catch (FAO 2002). We considered the remaining 10% of shellfish catches to be comprised equally (1/3 of 10%) of *V. gallina*, *Donax* spp. and *M. galloprovincialis* for the 1994 to 2010 period.

Some sturgeons are anadromous or potamodromous, as in the case of the starlet sturgeon (*Acipenser ruthenus*) (Mikhailov and Prodanov 2003), for which reason *A. ruthenus* was ignored in the present study. While the fringebarbel sturgeon (*Acipenser nudiventris*) is considered almost extinct, the beluga sturgeon (*Huso huso*) and the Russian sturgeon (*Acipenser guldenstaedti)* are commercially very important in the Bulgarian fishery. Wild caviar export data were used to estimate unreported sturgeon catches from 1998 to 2006 (Kecse-Nagy 2011; Table 3). We converted caviar weight to fresh fish weight for *Huso huso*, *A. gueldenstaedti* and *A. stellatus*, using gonado-somatic coefficients, and then estimated catches by using the sex ratio of the same three species (Tables 3 and 4).

Bulgaria became a member of the European Union (EU) in 2007, and intra-EU trade no longer appears in the CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) data for caviar exports. Caviar export to other EU countries could have continued after 2007 without being recorded in CITES data. For that

reason, the estimated unreported catch in 2006 was assumed to be the same for unreported catches from 2007 to 2010.

The Rapa whelk has become a commercially valuable resource with high demand on the international market. In Bulgaria, the *Rapana* fishery commenced in 1994, and *Rapana* were originally caught by scuba divers, but shortly after, illegal accounts of *Rapana* fishing by bottom trawlers, beam trawlers and dredgers were observed (Daskalov and Rätz 2011). Unfortunately, these destructive types of fishing gears are still illegally operating in the Rapa whelk fishery, and have pronounced negative ecological effects, especially on mussel beds (Konsulova *et al.* 2001). For the period from 2000-2010, the bulk of Rapa whelk catches were illegally taken by dredges (V. Raykov, Institute of Oceanology-BAS, Bulgarian Academy of Science, pers. comm.). We estimated an unreported catch component for Rapa whelk based on export data for the period from 2002 to 2010 (Table 5). The same percentage rate for the select processing types of Rapa whelk in 2009 (Daskalov and Rätz 2011) were used and applied to the 2002-2010 period to improve the unreported catch component. Since sea snail is exported without its shell, the exported amounts first had to be converted to equivalent weights with shell on, to account for total fishery removals, so a rate of 85.8% of total weight was added to account for this (Düzgüneş *et al.* 1988), for both the frozen meat and sweetbread Rapa whelk exported amounts. The average unreported catches for the 2002-2005 periods (12,732 t) was assessed and allocated as unreported Rapa whelk catches from 1994 to 2001.

It is widely acknowledged that Turkish fishers illegally fished for turbot in the north-western Black Sea, in Bulgarian, Romanian and Ukrainian waters (where between 1,000 and 2,000 t were taken annually), between 1993 and 2001 and also from 2009-2010. These turbot catches which were recorded as Turkish catches in the Turkish national statistics, for each of the eleven years (1993-2001, 2009-2010), were allocated as Turkish catches to the waters of the countries from which they were taken (Ulman *et al.* 2013). The minimum amount of illegally-caught turbot estimated by Ulman *et al.* (2013) was used (1,000 t·year^{-1}), and split into 333 t·year^{-1} allocated as Turkish catches in Bulgarian, Romanian and Ukrainian waters, respectively. We mention this here for information purposes only, as these catches are not deemed Bulgarian catches. They are included in the Turkish reconstruction by Ulman *et al.* (2013) and the tonnage is not included here.

An unreported turbot component taken by Bulgaria was estimated from sources stating that Bulgarian fishers also have under-reported their own turbot catches from the Bulgarian EEZ (300 t·year^{-1}, EU 2009). It was accepted as 250 t·year^{-1} to avoid over estimation, and the difference between the 250 t·year^{-1} and the reported catches was taken as unreported turbot catches for the 1994 to 2010 period (EU 2009). We also assumed some turbot catches to have been unreported throughout the 1950-1989 period, but to a much lesser extent. Thus, from 1950-1989, an additional 10% of the reported turbot catch amount was estimated to have been unreported, and added to the unreported component.

Discards

To estimate discards for the country, published reported discard rates by select fisheries from the Black Sea and eastern Mediterranean were first sought out, which included both industrial (mid-water trawl, bottom trawl, purse seine) and artisanal fisheries (gill and trammel nets, hand line, long line, fish pound net, beach seine net). These discard rates were then applied to the reported data for each of the target species for each fishery with the help of expert advice (Table 6). Given that discard rates were only applied to reported data (and thus represent minimum estimates of discards), the discards of the Rapa whelk fishery are likely considerably underestimated as there was a substantial unreported component to that fishery.

Whiting contribute greatly to the trawl catches in the Black Sea, but are not a target fishery and most whiting catches are discarded by Bulgarian fishers (V. Raykov, Institute of Oceanology-BAS, of Bulgarian Academy of Science, pers. comm.). In neighboring Romania, the whiting portion of reported demersal catches was 42% from 2000 to 2006 (Maximov and Staicu 2008). To account for discarded whiting in Bulgaria, an additional 20% was conservatively assumed to account for this component and applied to the reported catches of demersal taxa from 1950-1993 (as bottom trawling was banned in 1994).

Recreational and subsistence catches

Recreational fishing is understood here to mean fishing primarily for sport or enjoyment, while subsistence fishing is understood to mean fishing for the primary purpose of providing protein for self- or family-consumption. While the two sectors are difficult to separate, it is generally understood that subsistence fishing increasingly evolved into recreational fishing, as incomes increased and food security was not a prime concern.

In Bulgaria, recreational fishing is most popular from April to June, and from September to November. It occurs in inshore waters and targets gobies (Gobiidae), grey mullets (Mugilidae), horse mackerel, bluefish, bonito, turbot and Mediterranean horse mackerel and garfish (*Belone belone*). However, no data on the number of fishers and/or their catch rates or amounts have been collected in Bulgaria for this sector for the period 1950-2010.

There has been both recreational and subsistence fishing in Bulgaria for the 1950 to 2010 period. Since no data have been collected in Bulgaria on this topic, estimated catch rates from the neighboring Turkish portion of the Black Sea coast were used as a starting reference point (Ulman *et al.* 2013) to estimate recreational and subsistence catches, i.e. 0.258 t·fisher^{-1}·year^{-1} in 1950 and 0.129 t·fisher^{-1}·year^{-1} in 2010. To derive the number of recreational/subsistence fishers for Bulgaria, we assumed that in 1950, 2% of the coastal population fished either recreationally and/or for subsistence purposes, and this rate was linearly decreased to 1% of the coastal population by 2010 due to the declining availability of larger fish. To derive the coastal population, we started with total population data from Populstat (www.populstat.com). We assumed that only people living within 20 km from the coast were involved in these fisheries. Coastal population however, was only available for 100 km from the coastline (CIESIN and Columbia University 2012). In order to estimate how much of this population is contained within 20 km of the coast, we conservatively assumed 25% of the 100 km population, as the population will be denser closer to the coast. The catch rates used for Bulgaria were 50% of those used for Turkey in 1950, i.e., 0.129 t·fisher^{-1}·year^{-1}, and 80% in 2010, i.e., 0.103 t fisher^{-1}·year^{-1}, since recreational fishing appeared to be less intensive than in Turkey. We also made an adjustment to the catch in the early 1990s, as all fisheries were affected by the ctenophore invasion and the collapse of the pelagic fishery. Therefore, from 1989-1991, we decreased the catch by 75%. We then interpolated between the new 1991 value and 1993 as there was a quick recovery period. In order to assign the catches to the two sectors we assumed that in 1950, 70% of these catches were taken for subsistence purposes, which was linearly decreased to 30% of these totals being taken for subsistence purposes by 2010, and the remaining catches were assigned to the recreational fishery. Sturgeon, bonito, mackerel, bluefish, turbot, horse mackerel, grey mullet and gobies were the main recreational/subsistence taxa for the 1950-2010 period (Table 7).

RESULTS

The reconstructed total catch for the marine fisheries of Bulgaria for 1950-2010 was estimated to be almost 78% greater than the adjusted reported FAO catches for the Black Sea fisheries (Figure 2a). Total catches were only slightly higher than those reported by the FAO on behalf of Bulgaria up until 1993 (just before the Rapa whelk fishery commenced). Total catches increased from an annual average of almost 5,800 t·year^{-1} in the 1950s, which is only slightly higher than the 5,100 t·year^{-1} reported by the FAO on behalf of Bulgaria for the same time period. Both reconstructed total and reported catches increased to a peak in 1981, of 22,900 t·year^{-1} and 19,800 t·year^{-1}, respectively (Figure 2a). Catches then declined to a low in the early 1990s with an estimated 4,300 t·year^{-1} reconstructed total catch compared to 2,700 t·year^{-1} of reported catch. Thereafter, unreported catches increased rapidly in the mid-1990s. Unreported catches represented only an annual average of 13% of the reconstructed total catch from 1950-1989. Unreported catches rapidly took over the total catch, increasing to almost 75% in 1994 and were then, on average, 2.6 times the reported landings for the rest of the time period (Figure 2a; Appendix Table 1). The reconstructed total catch consisted of reported industrial landings (51.1%), unreported industrial landings (38.3%), industrial discards (3.1%), reported artisanal landings (5.1%), unreported artisanal landings (0.7%), artisanal discards (0.1%), subsistence catches (0.85%), and recreational catches (0.75%).

Reconstructed total catches were mostly composed of sprat (*Sprattus sprattus*; 47%), Rapa whelk (*Rapana venosa*; 31%), bonito (*Sarda sarda*; 5%), Mediterranean horse mackerel (*Trachurus mediterraneus;* 4%) and turbot (*Scophthalmus maximus*; 2%; Figure 2b).

Industrial sector

Total industrial catches increased from 4,400 t·year^{-1} in the 1950s, to a peak of 22,000 t·year^{-1} in 1981. Catches then declined to a low of 3,400 t·year^{-1} in 1993. Catches shot up in 1994 due to the opening of the Rapa whelk fishery, and averaged approximately 24,700 t·year^{-1} from 1994 to 2010 (Figure 2a). Industrial unreported catches were almost 45% of the reconstructed total industrial catch (41.3% unreported landings and 3.4% discards). Unreported landings increased throughout the time period, from 3% of the industrial catch in the 1950s to an average of 6.8% and 8.0% in the 1970s and 1980s, respectively. Unreported landings increased rapidly in the mid-1990s due to the Rapa whelk fishery and averaged 70% in the 2000s. Discards followed a generally decreasing trend, starting at 5.5% of total industrial catch in the 1950s and declining to 1.9% in the late 2000s. Sprat made up almost 50% of the total industrial catch. Sprat increased from 22.5% of the industrial catch in the 1950s, to an average of 93% in the 1980s to early 1990s. With the addition of the Rapa whelk fishery, sprat's contribution decreased to 35% in the 2000s. Although, in terms of absolute value, sprat's mean annual catch from 1994 to 2010 (7,700 t·year^{-1}) was about 35% higher than from the 1950 to 1993 period (5,700 t·year^{-1}). Other major contributing species were Rapa whelk (*Rapana venosa*; 33.8%; Table 8), bonito (4.2%) and Mediterranean horse mackerel (3.1%). Total clam catches (*Mytilus galloprovincialis*, *Chamelea gallina*, and *Donax* spp.) were estimated to be 3.2% of total industrial catch and 7.5% of unreported industrial landings (Table 8).

Artisanal sector

Total artisanal catches followed an oscillating decline followed by a rapid increasing trend (Appendix Table 1). Catches first declined from an average of 1,100 t·year^{-1} from 1950-1969, to a low of 360 t·year^{-1} in 1972. Catches increased to 1,100 t·year^{-1} in 1974, before declining to 130 t·year^{-1} in 1994. Catches increased again to 1,100 t·year^{-1} in 1995 and declined to 540 t·year^{-1} in 2006, and averaged 790 t·year^{-1} for the rest of the time period. Unreported artisanal catches were estimated to be 13.2% of the reconstructed total artisanal catches (11.5% unreported

landings, 1.7% discards). Unreported landings increased from 2% in the 1950s to an average of 4.7% in the 1980s. The unreported landing contribution increased in the 1990s, averaging 21% for that decade and 42.8% in the 2000s. The increasing trend in unreported catches was mostly due to unreported artisanal catches of turbot (*Scophthalmus maximus*; 60.4% of unreported catch). Contribution of discards remained stable over the time period, averaging 1.8% of artisanal catches per year.

Recreational and subsistence sectors

Reconstructed total recreational and subsistence catches each contributed 0.75% and 0.85% to the reconstructed total catch from 1950 to 2010 (Appendix Table 1). Recreational catches increased from almost 90 $t \cdot year^{-1}$ in 1950 to 120 $t \cdot year^{-1}$ in 1988, followed by a rapid decline in the late 1980s to early 1990s. Catches increased again in the mid-1990s up to 110 $t \cdot year^{-1}$ in 1993 and decreased slightly to 87 $t \cdot year^{-1}$ by 2010. Subsistence catches decreased gradually from just over 200 $t \cdot year^{-1}$ in 1950 to 97 $t \cdot year^{-1}$ in 1988. Again, catches decreased sharply in the late 1980s to early 1990s but increased again to almost 78 $t \cdot year^{-1}$ in 1993. Catches decreased to just less than 40 $t \cdot year^{-1}$ by 2010. Both sectors were assumed to have the same species composition. Overall, Mediterranean horse mackerel (*Trachurus mediterraneus*) constituted the largest portion of the catch with 30% over the 1950 to 2010 time period. Mediterranean horse mackerel increased from 3% contribution in the 1950s and 1960s, to 50% and 60% in the 1970s and 1980s, respectively, before decreasing to 35% in the 2000s. Other important contributing taxa were bonito (15%), grey mullet (Mugilidae; 15%), gobies (Gobiidae; 12%), mackerel (*Scomber scombrus*; 11%), bluefish (*Pomatomus saltatrix*; 10%), turbot (6%) and sturgeons (Acipenseridae; 2%).

Discards

The discards from the industrial and artisanal fisheries amounted to 3.1% and 0.1% of the reconstructed total catches (Figure 2a). Discards increased from 5,600 $t \cdot year^{-1}$ in the 1950s to almost 17,200 $t \cdot year^{-1}$ in the late 1970s to late 1980s. Discards then decreased to 6,000 $t \cdot year^{-1}$ in the early 1990s but increased again to an average of 25,600 $t \cdot year^{-1}$ for the rest of the time period. Major contributors to the discards included sprat (53%), Rapa whelk (18%), whiting (*Merlangius merlangus*; 12%), turbot (5%) and Mediterranean horse mackerel (4%).

DISCUSSION

The prospects for the marine fisheries for Bulgaria are limited by the specific characteristics and capabilities of the Black Sea ecosystem, especially by its limited shelf area. Another constraint is the limited biodiversity, which is under constant threat. There are only 134 marine species inhabiting the Bulgarian Black Sea (Stefanov 2007). During 1960-1970, 26 fish species were commercially targeted, which decreased to 5 major target species by the 1980s (Zaitsev and Mamaev 1997). The main targeted pelagic species were sprat, Black Sea horse mackerel and anchovy; while turbot, gobies, picked dogfish and most recently red mullet were the main targeted demersal taxa. In recent decades, mollusks (i.e., both the Mediterranean mussel and the introduced Rapa whelk) have gained a more prominent role in the commercial fisheries and appear to be the only two sustainable stocks (Popescu 2011). The fish species with the highest commercial value in the Black Sea are turbot, spiny dogfish, bonito, bluefish, grey mullet and sturgeons.

Total commercial catches in the Black Sea significantly decreased after the collapse of the Black Sea pelagic fisheries which occurred at the end of the 1980s (due to overfishing, a trophic cascade and the ctenophore invasion). The catch dynamics of the most important species in the Bulgarian Black Sea shelf zone illustrate a prominent decreasing trend which began in the 1990s (Figure 2b).

The reconstructed total catch is about 78% higher than the data submitted by Bulgaria to FAO. Most of the unreported catches have been assumed to have occurred after 1990, since reporting and control measures were much stricter in the 'planned economy' during the earlier socialist time period. Significantly, this study illustrated the importance of the artisanal (i.e., small-scale) sector in Bulgaria, especially involving turbot catches after the 1990s.

Bulgarian fisheries policy is covered by international fisheries agreements (UNCLOS, FAO, UN, CITES) and the European Union Common Fisheries Policy after its membership to the European Union in 2007. The country is also a member of GFCM and FAO. The National Agency for Fisheries and Aquaculture within the Ministry of Aquaculture and Food is the executive body responsible for national policy on fisheries and aquaculture and implements the Fisheries Legislation in Bulgaria. Total Allowable Catches (TACs) for sprat and turbot were set in 2008.

Some other management implementations include a licensing system for fishers, effort is controlled by limiting fishing gear, engine power and vessels; seasonal closures are imposed to protect some stocks during their reproductive periods to enable greater survival of juveniles; closed areas, restriction and bans of bottom trawling and dredging are imposed. Since 2012, beam trawling was allowed in restricted areas in Bulgarian marine area. However, according to Bulgarian fisheries legislation, no permit or licenses are required to participate in the marine recreational fishery.

This study revealed some major deficiencies which exist in the available fisheries data, such as the exclusion of some fisheries sectors, notably the absence of any published data on the subsistence and recreational fisheries. We feel that our estimates of total marine fisheries catches for Bulgaria represents a more accurate baseline, which can be improved upon through targeted studies of the previously omitted sectors, which would help to improve fisheries management in the future.

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Figure 1. Bulgaria and its Exclusive Economic Zone (EEZ) and continental shelf (100 m) in the Black Sea.

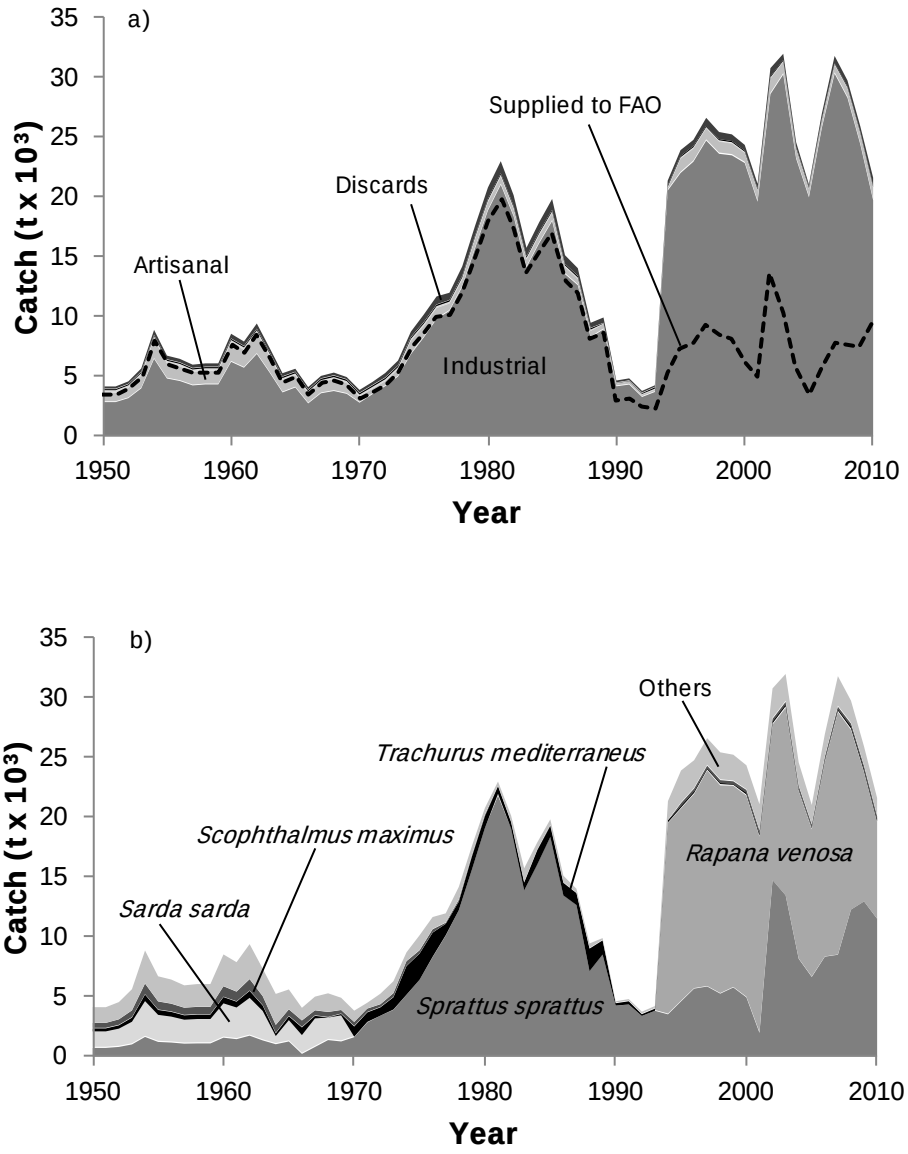

Figure 2. Total reconstructed catches for Bulgaria in the Black Sea by a) fisheries sector plus discards, 1950-2010. Officially reported data as reported by FAO (adjusted time series) on behalf of Bulgaria is overlaid as line graph. Subsistence and recreational catches are included but too small to be visible; and b) by major taxonomic category. The category 'others' consists of 36 additional, minor taxa. The significant reduction in fishing around 1990 resulted from the privatization of the fishing fleet from a state-owned industry.

Table 1. Composition of the Bulgarian fishing fleet in 2008 (Radu et al. 2010).

		Length (m)				
		< 6 m	6-12	12-18	18-24	24-40
Registered vessels		842	1598	68	27	12
Active vessels		213	434	45	13	11
Active gear	Pelagic trawlers	0	3	8	2	11
	Other gear	22	115	17	4	0
Passive gear	Hook and line	14	23	2	0	0
	Drift/fixed netters	166	224	8	1	0
	Pots/traps	3	33	1	0	0
	Other passive gear	2	11	0	0	0
Variable gear	Active and passive gear	6	25	9	6	0

Table 2. Mean catch composition from 1964 to 1968 according to FAO data, used to disaggregate 'marine fishes nei' for the years 1950 to 1963.

Taxon	Percentage
Sarda sarda	36.24
Scomber scombrus	14.15
Pomatomus saltatrix	6.49
Engraulis encrasicolus	2.76
Sprattus sprattus	18.08
Gobiidae	0.01
Liza saliens	0.01
Trachurus mediterraneus	6.48
Alosa immaculata	0.86
Scophthalmus maximus	8.84
Residual 'marine fishes nei'	6.09

Table 3. Wild origin caviar exports (kg) used to estimate sturgeon catches in Bulgaria (from the CITES Trade Database; Kecse-Nagy 2011).

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Exported caviar (kg)	2,392	2,025	2,788	992	2,337	1,563	920	1,421	667	-	-	-	-
Estimated female (t)	13	11	15	6	13	9	5	8	4	-	-	-	-
Estimated male (t)	40	34	46	17	39	26	15	24	11	-	-	-	-
Estimated total (t)	53	45	62	22	52	35	20	32	15	-	-	-	-
Unreported catch	39	33	59	22	45	31	16	30	15	15	15	15	15

Table 4. Gonado-somatic coefficients (G) and the sex ratio (female:male) for sturgeons in Bulgaria (from Jivkov et al. 2003).

Species	G (%)	Sex ratio	Species ratio
Huso huso	18	3:1	83
Acipenser gueldenstaedti	16	1:1	10
Acipenser stellatus	16	2:1	7

Table 5. Exported Rapa whelk tonnages, for 2009 the processed category percentage is given in brackets.

Type of Rapa whelk	2002	2003	2004	2005	2006	2007	2008	2009 (%)	2010
Frozen	284	343	302	269	351	436	324	146 (13)	167
Frozen sweetbread	656	792	698	620	811	1005	747	326 (30)	386
Frozen meat	1,136	1,373	1,209	1,075	1,405	1,743	1,295	572 (52)	668
Frozen meat with shell	109	132	116	103	135	168	125	59 (5)	64
Exported	2,185	2,641	2,325	2,067	2,702	3,351	2,491	1,104 (--)	1,285

Table 6. Discard rates applied to select fisheries in Bulgaria

Ecosystem	Fishing gear	Discard rate (%)
Black Sea [a]	Mid water trawler	5.1
Black Sea [b]	Purse seine	1.0
Marmara Sea [c]	Bottom trawl	16.2
Black Sea [a]	Sea snail dredge	11.5
Global [a]	Hand line	1.8
Global [a]	Bottom long line	8.2
Global [a]	Beach seine	4.4
Global [a]	Gill net and trammel net	0.5
Global [a]	Beam trawl	7.5
Global[a]	Fish pound	0.5

[a]Kelleher (2005), [b]Şahin et al. (2008), [c]Zengin and Akyol (2009).

Table 7. Assumed catch composition (%) for recreational and subsistence catches in Bulgaria from 1950-2010.

Taxon	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2010
Bonito	35	30	5	1	1	2
Atlantic Mackerel	25	22	5	2	0	0
Bluefish	15	20	10	2	1	2
Horse mackerel	3	3	50	60	50	35
Grey mullet	5	5	15	20	23	30
Goby	2	2	13	15	25	30
Turbot	10	15	1	0	0	1
Sturgeon	5	3	1	0	0	0

Table 8. Reported, exported and unreported Rapa whelk and clams catches (t) from 1994-2010.

Year	Reported	Exported	Unreported Rapa whelk	Unreported clams
1994	3,000	12,732	9,732	1,420
1995	3,120	12,732	9,612	1,420
1996	3,260	12,732	9,472	1,420
1997	4,900	12,732	7,832	1,420
1998	4,300	12,732	8,432	1,420
1999	3,800	12,732	8,932	1,420
2000	3,800	12,732	8,932	1,420
2001	3,353	12,732	9,379	1,420
2002	698	13,011	12,313	1,301
2003	325	15,726	15,401	1,573
2004	2,428	13,845	11,417	1,384
2005	511	12,308	11,797	1,231
2006	2,773	16,089	13,316	1,609
2007	4,310	19,954	15,644	1,995
2008	2,872	14,833	11,961	1,483
2009	2,214	10,647	8,433	1,065
2010	4,831	7,652	2,821	765

Appendix Table 1. FAO landings (adjusted) versus total reconstructed catch (in tonnes), and catch by sector with discards shown separately, for Bulgaria in the Black Sea, 1950-2010. Note that reconstructed items include reported data.

Year	FAO landings	Total reconstructed catch	Industrial	Artisanal	Subsistence	Recreational	Discards
1950	3,500	4,070	2,880	719	206	88	177
1951	3,500	4,060	2,880	719	202	89	177
1952	3,900	4,490	3,200	801	198	90	197
1953	4,900	5,570	4,030	1,007	196	92	247
1954	7,900	8,800	6,490	1,623	193	94	399
1955	5,900	6,640	4,850	1,212	191	96	298
1956	5,650	6,380	4,640	1,161	190	98	285
1957	5,200	5,890	4,270	1,068	186	99	262
1958	5,300	6,000	4,350	1,089	184	101	267
1959	5,300	6,000	4,350	1,089	182	103	267
1960	7,600	8,470	6,240	1,561	179	104	384
1961	7,000	7,820	5,750	1,438	177	105	353
1962	8,400	9,330	6,900	1,726	174	107	424
1963	6,500	7,280	5,340	1,335	171	108	328
1964	4,500	5,170	3,680	956	169	109	254
1965	4,880	5,550	4,100	936	166	111	234
1966	3,480	4,010	2,770	770	163	112	199
1967	4,380	4,950	3,610	869	160	113	191
1968	4,590	5,220	3,800	932	157	114	217
1969	4,280	4,850	3,570	845	155	115	171
1970	3,110	3,770	2,820	457	152	116	224
1971	3,650	4,430	3,530	392	149	117	245
1972	4,250	5,190	4,210	356	146	118	361
1973	5,220	6,230	5,020	568	143	118	389
1974	7,480	8,650	6,880	1,072	140	119	435
1975	8,620	10,080	8,270	926	137	120	618
1976	9,940	11,600	9,820	862	134	120	661
1977	10,170	11,910	10,500	551	131	121	598
1978	12,020	14,120	12,520	567	127	121	778
1979	15,110	17,520	15,750	720	124	121	804
1980	17,870	20,710	18,910	625	121	121	937
1981	19,780	22,920	21,060	611	118	122	1,008
1982	17,300	20,070	18,430	527	115	122	885
1983	13,530	15,670	14,150	583	112	122	695
1984	15,410	17,830	16,190	609	109	122	796
1985	17,030	19,760	18,030	600	106	121	904
1986	12,940	15,050	13,580	528	103	121	715
1987	12,010	13,960	12,660	446	100	121	634
1988	8,140	9,390	8,280	478	97	120	411
1989	8,600	9,840	8,960	379	24	30	440
1990	2,900	4,560	4,200	160	23	30	149
1991	3,040	4,740	4,340	189	21	28	160
1992	2,520	3,690	3,300	135	50	69	133
1993	2,320	4,160	3,720	128	78	110	121
1994	5,340	21,290	20,580	126	75	109	401
1995	7,250	23,840	22,050	1,120	72	107	491
1996	7,730	24,700	23,000	1,016	69	106	513
1997	9,360	26,550	24,770	936	66	104	671
1998	8,420	25,360	23,660	939	63	103	595
1999	8,080	25,160	23,530	909	60	102	560
2000	6,140	24,280	22,890	764	58	100	470
2001	4,880	21,020	19,650	846	54	96	381
2002	13,560	30,710	28,650	1,208	52	95	697
2003	10,210	31,910	30,300	949	50	93	519
2004	5,820	24,520	23,260	719	48	94	395
2005	3,410	20,960	20,010	615	47	94	190
2006	5,630	26,880	25,800	533	45	93	405
2007	7,830	31,730	30,370	644	43	91	582
2008	7,670	29,680	28,340	694	41	90	509
2009	7,390	25,840	24,450	804	39	89	462
2010	9,690	21,540	19,770	955	37	87	689

Appendix Table 2. Total reconstructed catch (t) by major taxa for Bulgaria, 1950-2010. 'Others' includes 39 additional taxa.

Year	*Sprattus sprattus*	*Rapana venosa*	*Sarda sarda*	*Trachurus mediterraneus*	*Scophthalmus maximus*	Others
1950	730	0	1,385	250	410	1,300
1951	730	0	1,384	250	410	1,300
1952	810	0	1,529	270	450	1,430
1953	1,020	0	1,895	340	560	1,760
1954	1,640	0	2,994	540	880	2,740
1955	1,230	0	2,261	410	670	2,080
1956	1,170	0	2,170	390	640	2,000
1957	1,080	0	2,004	360	590	1,850
1958	1,100	0	2,041	370	600	1,890
1959	1,100	0	2,041	370	600	1,890
1960	1,580	0	2,868	520	860	2,640
1961	1,460	0	2,648	480	800	2,440
1962	1,750	0	3,161	570	950	2,900
1963	1,350	0	2,465	450	740	2,280
1964	1,030	0	690	220	650	2,580
1965	1,260	0	1,784	320	530	1,650
1966	230	0	1,573	630	530	1,050
1967	800	0	2,387	220	410	1,130
1968	1,380	0	1,884	10	410	1,540
1969	1,260	0	2,182	110	290	1,010
1970	1,620	0	44	850	330	930
1971	2,850	0	55	790	270	470
1972	3,410	0	13	690	220	860
1973	3,890	0	41	1,010	310	980
1974	5,140	0	28	2,380	380	710
1975	6,400	0	13	2,180	250	1,230
1976	8,280	0	53	2,010	270	990
1977	10,070	0	57	950	80	750
1978	12,190	0	24	710	150	1,040
1979	15,580	0	13	1,090	90	740
1980	19,060	0	16	1,000	110	530
1981	21,730	0	195	640	10	350
1982	19,010	0	6	540	10	500
1983	13,830	0	27	660	10	1,140
1984	16,020	0	3	1,200	30	580
1985	18,320	0	3	920	60	450
1986	13,450	0	2	1,040	20	540
1987	12,630	0	15	990	0	320
1988	7,130	0	2	1,870	10	380
1989	8,520	0	1	1,180	0	140
1990	4,240	0	18	200	0	100
1991	4,340	0	16	260	0	120
1992	3,390	0	13	140	0	150
1993	3,820	0	10	180	0	160
1994	3,520	16,000	2	170	0	1,570
1995	4,600	16,100	27	160	250	2,650
1996	5,660	16,300	35	160	250	2,300
1997	5,840	18,100	18	120	250	2,220
1998	5,240	17,400	53	120	250	2,250
1999	5,750	16,900	23	90	250	2,150
2000	4,930	16,900	40	170	250	1,990
2001	1,970	16,400	54	190	250	2,150
2002	14,710	13,100	3	200	250	2,460
2003	13,440	15,800	27	200	250	2,240
2004	8,140	14,100	22	130	250	1,900
2005	6,630	12,400	61	80	250	1,580
2006	8,320	16,400	11	110	250	1,830
2007	8,480	20,400	4	170	250	2,460
2008	12,240	15,100	19	230	250	1,830
2009	12,930	10,900	8	230	250	1,570
2010	11,480	8,100	19	210	250	1,460

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