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From bluefin tuna to gobies: a reconstruction of the fisheries catch statistics in Romania, 1950-2010

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Abstract

Romania's fisheries catches were fairly well reported during the Soviet era (1950-1989), which was marked by strict state-control over the fishing fleets. The quality of the data declined with the collapse of the Soviet Union, as there was administrative disorder during this time. Intense trawling leading up to this time also led to a strong decline of the stocks underpinning the fishery. However, this decline was exaggerated in the FAO data due to the poor reporting at that time. Romanian fisheries consist mostly of industrial trawl vessels and artisanal fixed net fisheries known as 'crawls', with a small amount of subsistence fishing for personal consumption. However, trawling has been banned since 2008. Total reconstructed catches are 1.3 times what is reported by the FAO on behalf of Romania. Unreported catches consist mainly of commercial discards, subsistence catches, as well as some unreported landings during the period directly following the collapse of the Soviet Union. Artisanal fisheries dominate with 66% of the catch, followed by industrial at 24% and subsistence with 10%.

Introduction

The Black Sea has a surface area of 466,200 km^2, corresponding to about 1/5 of the surface of the Mediterranean Sea (Vespremeanu 2004). The mean depth of the Black Sea is around 1,200 m for a maximum depth of around 2,200 m. Oxygenated waters, found only in the neritic zone (shallower than 200 m), represent 9.5% of the total volume, while most of the Black Sea waters (90.5%) are depleted in oxygen or anoxic, enriched in H_2S and devoid of any pluricellular organisms (Gomoiu 1996). Several large rivers (Danube, Dnieper, Southern Bug, Dniester) provide high freshwater inputs to the Black Sea and influence its hydrology and water characteristics: high water stratification, low mean salinity of the surface water layer and high enrichment in nutrients (Beşiktepe *et al.* 2001; Vespremeanu 2004; Oguz *et al.* 2006). The biodiversity of the Black Sea is low compared to other seas because of its origin and ecological particularities (Gomoiu 1996). Before the Pliocene the Black Sea was a freshwater lake. It was temporarily connected with the Mediterranean Sea during Mindel-Riss and Riss-Würm glaciations and permanently since the end of Würm glaciations.

In the north-western Black Sea, on the Romanian coast (Figure 1), inputs from rivers have created a large continental shelf (127,000 km^2) and a highly important feeding and reproduction area for many fish and invertebrate species. In this area, the Danube River plays an essential role in the functioning of the Black Sea ecosystems, being at the same time a natural enrichment factor for this marine area and a major human influence vector (Bănaru *et al.* 2007; Bănaru 2008). Danube inputs of freshwater, dissolved (DOM) and particulate (POM) organic matter modify the salinity, temperature, transparency, nutrient content and production of coastal waters. In the Mediterranean Sea, the river inputs increase the primary production of the oligotrophic waters and increase fisheries landings (Darnaude *et al.* 2004; Ferraton *et al.* 2007). For a long time, this was also the case for the Black Sea-Danube River system. However, the high degree of enclosure of this sea has resulted in an accumulation of primary production and eutrophication (de Leiva Moreno *et al.* 2000). Excessively high Danube River inputs finally induced hypoxia and a decline of fishery landings. It is thus difficult to separate the respective roles that Danube River inputs but also pollution, invasive species and overfishing have played in the decline of fisheries and changes in marine food webs (Bănaru *et al.* 2010).

For a long time Romanian fisheries were essentially composed of traditional activities. Until 1980, 'crawling' (stationary net fishing near the coast in shallow waters; Bănaru *et al.* 2010) represented the main fishing technique. The number of crawls decreased from 150 in 1965 to 55 in 1980, while landings were increasing (Figure 2 a, b). This was probably due to a higher productivity of the marine system related to increasing nutrient input through rivers by land fertilization in the agriculture sector.

During the communist period, there was a push to increase even more fisheries landings, and large-scale trawlers were introduced. Their fishing capacity and catch per unit of effort (CPUE) was much higher compared to crawl (Figure 2c), and they covered a larger area. Also, their numbers - and thus the fishing effort - increased from 2 in 1981 to 20 in 1989, and landings increased from 1985 to 1989.

In the post-communist period, Romanian fisheries entered a crisis due to the new political and economic context, but also due to the ecological changes in the marine system. Indeed, during the communist period, trawling boats and crawls were the property of the state, while during the post-communist period all these fishing gears and vessels were privatized and sold to private entities. Most of them were not properly maintained and quickly degraded within a few years as fuel prices rose and their activity was not profitable.

This period also coincided with a collapse in stocks following the intense exploitation by trawling that started in the communist period but also due to eutrophication and pollution effects and invasive species (Bănaru 2008). For these reasons, the number of fishing gears and the landings continually decreased until 2005 (Figure 2 a, b). After the entrance of Romania in the European Union in 2007, the last trawlers were removed in 2008-2009. Only one trawler, belonging to the Romanian National Institute of Research and Marine Development (INCDM) "Grigore Antipa" was maintained for scientific research.

At present Romanian fisheries represent mainly an artisanal/subsistence sector for local fishers, using some crawls, very small artisanal boats (Figure 3), and angling techniques.

METHODS

During the communist period (1950-1989), there were very good fishing data, as the state was the owner of the fleet and there was strict control of fishing activity and landings. The Romanian Institute of Marine Research (IRCM) was in charge of the database (Maximov, INCDM, pers. comm.).

In 1990, with the collapse of the former-USSR, a strong decline in Romanian FAO landings is visible. This was mainly related to data missing because of the political and administrative crisis that followed in the first year of the post-communist period. At the same time, fishing activities reduced during the reorganization from a state owner to private owners of the fishing boats and crawls. During this period the Romanian Institute of Marine Research (IRCM) became the National Institute for Marine Research and Development (INCDM) "Grigore Antipa" and they maintained the fisheries database. But the data were less reliable because there were no organized auction sales rooms, nor controls in the field (Maximov, INCDM, pers. comm.). Researchers were asking fishers who were not declaring the true landings. In this situation and without means of control, researchers were trying to increase these values to extrapolate to what they thought the landings should actually have been.

Therefore, since we know that landings did decrease after the collapse of the USSR but not as rapidly as the FAO data suggest, we interpolated from the reported data point in 1990 to the point in 1998 in order to lessen the severity of this decline.

In 2005, the Romanian government created the National Agency for Fisheries and Aquaculture (NAFA), which is in charge of collecting fishing data and sending them to FAO. Recently, they introduced licenses for fishers and they force them to submit declarations of catches but there are still no auction sale rooms and few field controls and fishers may declare whatever they want. Romanian national, and by extension FAO landings data are thus certainly underestimated since 1990.

For purposes of the *Sea Around Us*, the commercial data were split into industrial (large-scale commercial) and artisanal (small-scale commercial) catches, according to the gear information available. Trawling was considered industrial (Martín 2012) and crawling artisanal. Proportions from Figure 2a were used for 1965-2005. The artisanal proportion of 100% in 1965 was carried back to 1950 and trawl catches (industrial) were set to zero for 2008-2010 due to the closure of that fishery. Proportions were interpolated between 2005 and 2008.

Discards

European sprat (*Sprattus sprattus*), a species of low commercial value, represented the main species in the Romanian landings (about 70% between 2000 and 2010), followed by whiting (*Merlangius merlangus*, with little to no commercial value) and anchovy (*Engraulis encrasicolus*). Other species like turbot (*Scophthalmus maximus*), sturgeons (Acipenseridae), small sharks and rays were rare.

These catches, mainly taken by trawl in the north of the Romanian coast, were often mixed with jellyfish, shrimps, crabs and bivalves which represent about 25% of the catch. There are generally no fish discards except these invertebrates, which were sorted in the harbor and sometimes used as food for domesticated animals (pigs; Bănaru, pers. obs.). European sprat was often salted on board of trawlers and sold for the consumption of the local population. Therefore, we used this information to calculate that 25% of the total industrial catch was discarded and assumed that it was composed of 30% jellyfish, 20% each shrimps, crabs and bivalves, and 10% miscellaneous invertebrates.

In the southern part of the Romanian coast, crawl catches were more diverse but still dominated by small pelagic fish species, horse mackerel (*Trachurus trachurus*) and whiting. In this area, small individuals of sprat appear to have been regularly discarded (Bănaru and Harmelin-Vivien 2009a). For the artisanal crawl fishery, we assumed an average discard rate of 1.1% (Kelleher 2005, average derived from data on stationary/set/fixed nets). This rate was applied to the artisanal landings and a species breakdown consisting of small pelagics was proportionally derived from the landings.

Subsistence fishery

Information on Bulgarian subsistence fisheries (Keskin *et al.* in review) was used as a guide to derive an estimate of subsistence catch for Romania. The average of the time series of subsistence catch rates in Bulgaria (1950-2010) was used as the 1950 anchor point for Romania. Half of that rate was used as the 2010 anchor point. Rates were interpolated and applied to the coastal population of Romania. For the species composition, we used an assumed composition, derived from the Bulgarian data. We increased the emphasis on coastal species, such as sturgeon, goby and grey mullet (Table 1).

Table 1. Assumed catch composition (%) for subsistence catches in Romania from 1950-2010.

Taxon	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2010
Sarda sarda	31	27	4	1	1	1
Scomber scombrus	22	20	4	1	0	0
Pomatomus saltatrix	13	18	8	1	1	1
Trachurus mediterraneus	3	3	38	45	34	21
Mugilidae	9	9	23	30	30	38
Gobiidae	4	4	20	22	34	38
Scophthalmus maximus	9	14	1	0	0	1
Acipenseridae	9	5	2	0	0	0

Unreported catches

Romanian fishers were mainly responsible of illegal fishing on sturgeons but probably less in the marine area and more in the Danube River. These species with high commercial value have been protected since 2006. In spite of their protection, illegal catches continue because of their high value on the black market, but also probably due to corruption and the difficulty to apply higher control measures in the field. As this mainly occurs in the river, these illegal catches were not included here, as the *Sea Around Us* focuses solely on marine catches.

In post-communist years, illegal fishing for turbot has expanded, mainly by Turkish fishing boats operating in Romanian coastal waters (see Ulman *et al.* 2013). They catch not only turbot but also other species like dolphins and small sharks. Often, when they are pursued by Romanian marine police, they abandon the nets which become 'phantom nets' that continue to fish and kill marine resources over a long period ('ghost fishing'). This created many conflicts between Romanian authorities and Turkish fleet which apparently are still not solved.

Turbot generally come to reproduce and feed in the north-western Black Sea, as this area is highly productive due to river inputs and the continental shelf is larger and creates a favorable habitat for this species. This species stock decreased in the last decades because of fishing and were also highly probably impacted by pollution. During 2004-2006, 90% of the individuals studied in the north-western Black Sea presented parasites and tumors (Bănaru 2008).

RESULTS AND DISCUSSION

The reconstructed total catch was around 1.3 times the data reported by FAO on behalf of Romania. The total catch peaks in 1986 with around 19,200 t and decreases after that to a minimum of 860 t in 2010 (Figure 4a). The reconstructed total catch was 24% industrial, 66% artisanal and 10% subsistence. Discards comprised almost 7% of the total catch, with 89% of discards being from the industrial sector and the other 11% from the artisanal sector. Catches were dominated by sprat (*Sprattus sprattus*) which contributed 34.1% of the catch. Other major contributing taxa included anchovy (*Engraulis engrasicolus*; 18.6%), Mediterranean horse mackerel (*Trachurus mediterraneus*; 11.3%), and whiting (*Merlangius merlangus*; 8.0%; Figure 4b).

The biodiversity of Romanian fish communities and the associated fisheries have drastically decreased over the last decades due not only to fisheries but also to other human activities (pollution, eutrophication, species introduction) and climate change (temperature increase, modification of river flow) (Bănaru *et al.* 2010).

According to the FAO data, from 1965 to 2009, the taxonomic richness in the landings data varied between 9 (1965-1969) and 17 (1975-1979) categories with rather low variations. In 2005-2009 15 groups of species comprised the Romanian landings. However, the composition of landings was strongly modified with a decreasing percentage of anchovy and horse mackerel and increasing percentage of sprat. In total, sprat accounts for almost 38% of the reported catch, anchovy 24% and Mediterranean horse mackerel 15%. Mediterranean horse mackerel decreases to an average of 1% in the 1990s to 2010. Anchovy stays around 7%.

Small pelagic fish like sprat develop high biomass in this area in relation to river inputs which induce a productive pelagic marine system (Bănaru and Harmelin-Vivien 2009b). They represent a key element in the marine food web being consumed by pelagic, demersal and benthic predators.

Large predators have completely (tuna) or nearly (sturgeons) disappeared (see also Ulman *et al.* 2013) and the food web has become dominated by small organisms of low trophic level. Indices of diversity and equitability in the landings from this area have declined in the last decades (Bănaru *et al.* 2010).

CONCLUSION

Romania needs to implement in this area a more rigorous control in the field and to create fisheries auction sale rooms in order to improve data on landings. They also need to increase collaborations between fisheries authorities and the marine police in the field to reduce illegal fisheries.

Moreover, knowledge of trophodynamics in coastal ecosystems and how continental matter inputs by rivers influence the structure and dynamics of marine food webs is important not only for fisheries management, but also for biodiversity conservation. This is particularly crucial for the Black Sea where climate change and human activities have had drastic and detrimental consequences.

The success of fisheries management in this area in the future will depend on research focused on the mechanisms underlying ecosystem dynamics and fisheries interactions. In the present environmental and economic context in Europe, the proper understanding of these aspects is essential for the achievement of sustainable ecosystem-based fisheries management (Cury *et al.* 2008).

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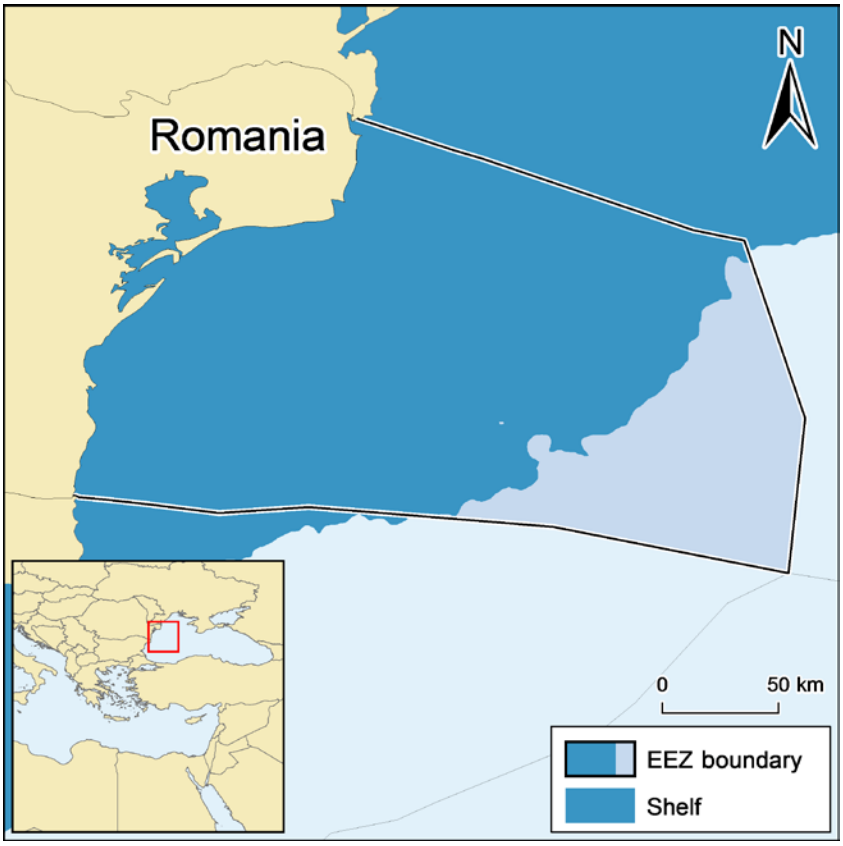

Figure 1. The Romanian Black Sea coast, with its EEZ of 20,500 km^2 and shelf waters of nearly 17,000 km^2 (to 200 m depth).

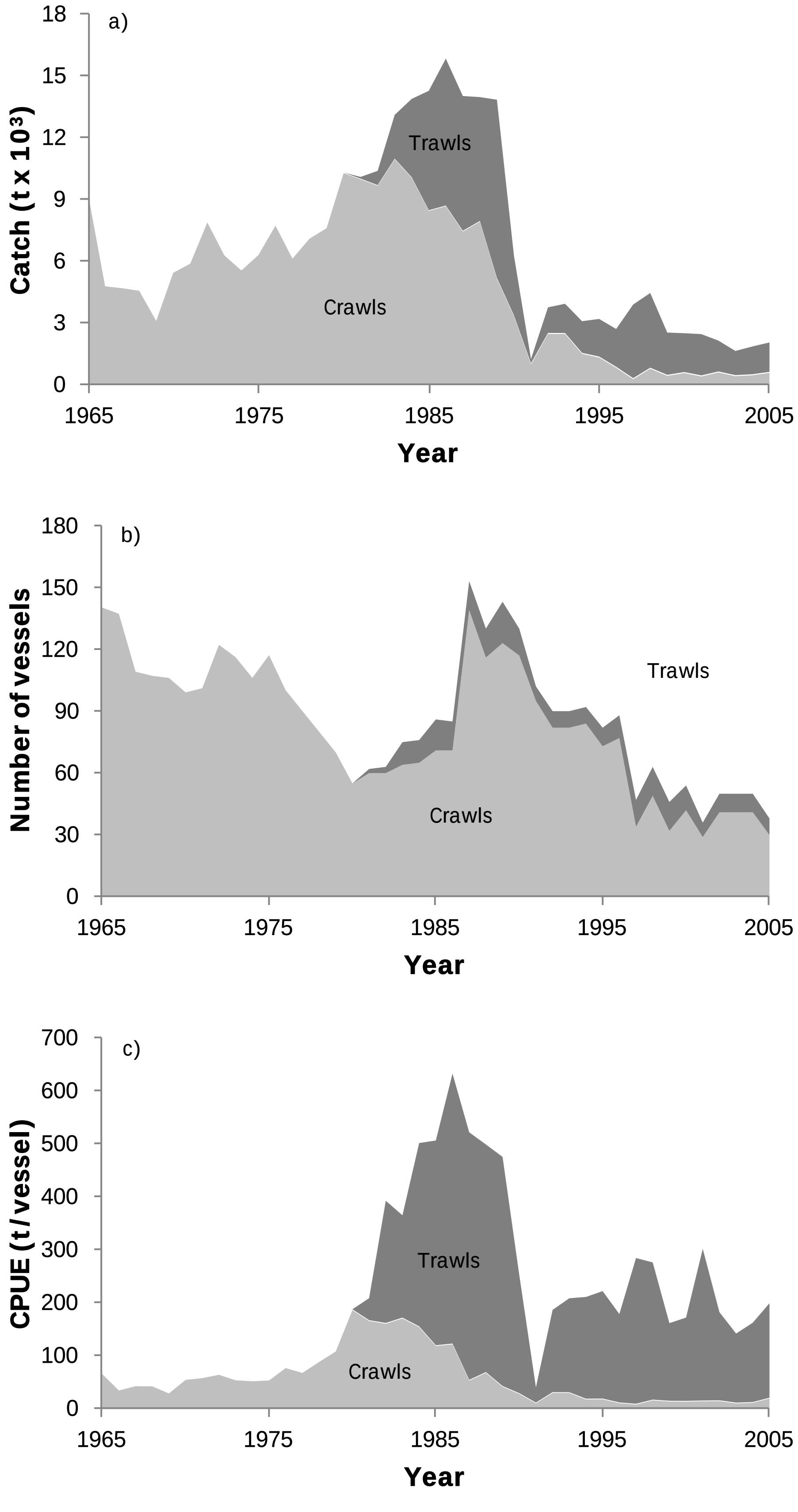

Figure 2. Contribution of trawl vessels versus crawl vessels in terms of a) total fish catches (tonnes); b) number of boats; and c) fisheries CPUE (total landings/number of crawls or trawling boats) on the Romanian Black Sea coast (G. Radu G. - INCDM, pers. comm.).

Figure 3. Artisanal fishing boat on the Romanian Black Sea coast (Sfantu-Gheorghe) in 2005 (Photo: D. Bănaru).

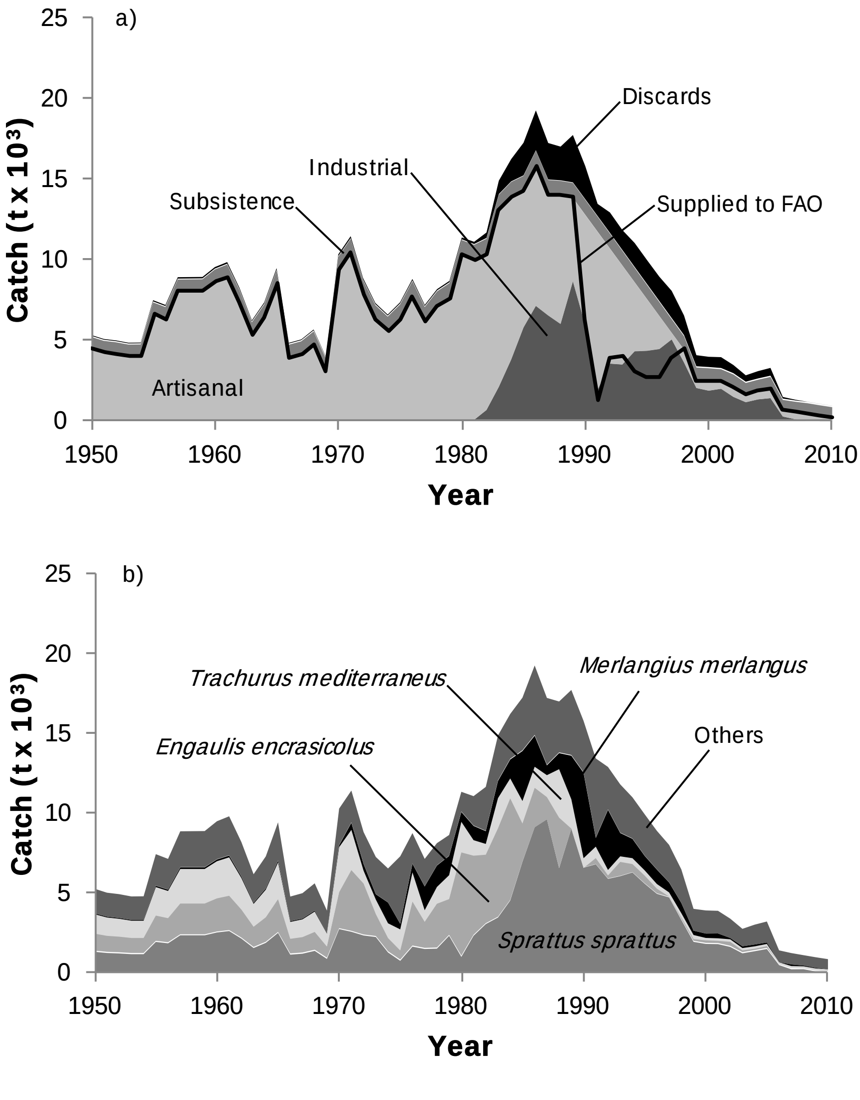

Figure 4. Reconstructed total catches by a) fishing sector with discards shown separately, and FAO data overlaid as a line graph; and b) by major taxa. 'Others' represents X additional taxonomic categories.

Appendix Table A1. Total reconstructed catch vs. FAO landings (in tonnes), for Romania, 1950-2010, as well as catch by sector with discards shown separately.

Year	FAO landings	Total reconstructed catch	Industrial	Artisanal	Subsistence	Discards
1950	4,500	5,260	0	4,500	715	50
1951	4,250	5,020	0	4,250	725	47
1952	4,150	4,930	0	4,150	734	46
1953	4,000	4,790	0	4,000	743	44
1954	4,000	4,800	0	4,000	751	44
1955	6,600	7,430	0	6,600	760	73
1956	6,300	7,140	0	6,300	768	69
1957	8,000	8,860	0	8,000	776	88
1958	8,000	8,870	0	8,000	784	88
1959	8,000	8,880	0	8,000	791	88
1960	8,600	9,490	0	8,600	798	95
1961	8,900	9,800	0	8,900	805	98
1962	7,300	8,190	0	7,300	812	80
1963	5,300	6,180	0	5,300	818	58
1964	6,401	7,300	0	6,400	824	70
1965	8,500	9,420	0	8,500	830	94
1966	3,901	4,780	0	3,900	836	43
1967	4,100	4,990	0	4,100	846	45
1968	4,700	5,610	0	4,700	856	52
1969	3,000	3,900	0	3,000	865	33
1970	9,309	10,290	0	9,310	874	102
1971	10,417	11,410	0	10,420	883	115
1972	7,841	8,820	0	7,840	891	86
1973	6,290	7,260	0	6,290	899	69
1974	5,570	6,540	0	5,570	906	61
1975	6,316	7,300	0	6,320	914	69
1976	7,746	8,750	0	7,750	921	85
1977	6,142	7,140	0	6,140	927	68
1978	7,114	8,120	0	7,110	929	78
1979	7,621	8,630	0	7,620	930	84
1980	10,292	11,340	0	10,290	931	113
1981	9,997	11,060	82	9,910	931	137
1982	10,374	11,640	693	9,680	932	337
1983	13,105	14,870	2,129	10,980	932	830
1984	13,894	16,210	3,819	10,080	932	1,384
1985	14,268	17,230	5,808	8,460	932	2,029
1986	15,834	19,240	7,147	8,690	931	2,478
1987	14,016	17,210	6,554	7,460	930	2,267
1988	13,963	16,990	6,026	7,940	929	2,096
1989	13,836	17,710	8,667	5,170	928	2,946
1990	6,326	15,780	5,952	6,840	927	2,059
1991	1,288	13,420	1,938	9,810	925	754
1992	3,845	12,890	3,567	7,130	923	1,267
1993	3,952	11,800	3,512	6,140	907	1,238
1994	3,060	10,990	4,331	4,280	891	1,491
1995	2,719	9,930	4,363	3,200	875	1,490
1996	2,682	8,890	4,471	2,050	860	1,513
1997	3,872	8,010	5,066	410	844	1,693
1998	4,431	6,480	3,633	800	829	1,220
1999	2,507	4,010	2,055	450	813	690
2000	2,476	3,910	1,890	590	798	636
2001	2,431	3,890	2,008	420	783	674
2002	2,122	3,400	1,504	620	768	508
2003	1,612	2,760	1,175	440	750	397
2004	1,833	3,020	1,351	480	732	456
2005	2,022	3,220	1,427	590	714	482
2006	615	1,410	289	330	697	100
2007	519	1,240	122	400	679	45
2008	443	1,110	0	440	662	5
2009	331	980	0	330	645	4
2010	231	860	0	230	628	3

Appendix Table A2. Total reconstructed catch for Romania, 1950-2010, by major taxa. "Other" represents 30 additional taxonomic categories.

Year	*Sprattus sprattus*	*Engraulis encrasicolus*	*Trachurus mediterraneus*	*Merlangius merlangus*	Other
1950	1,320	1,110	1,250	56	1,530
1951	1,250	1,050	1,180	53	1,490
1952	1,220	1,030	1,150	51	1,490
1953	1,170	990	1,110	49	1,470
1954	1,170	990	1,110	49	1,470
1955	1,930	1,630	1,820	82	1,970
1956	1,850	1,560	1,740	78	1,920
1957	2,340	1,980	2,200	99	2,240
1958	2,340	1,980	2,200	99	2,250
1959	2,340	1,980	2,200	99	2,260
1960	2,520	2,130	2,360	106	2,380
1961	2,610	2,200	2,440	110	2,440
1962	2,140	1,810	2,010	90	2,150
1963	1,550	1,310	1,470	65	1,780
1964	1,880	1,580	1,770	79	1,990
1965	2,490	2,100	2,340	105	2,390
1966	1,140	960	1,090	48	1,540
1967	1,200	1,010	1,140	51	1,580
1968	1,380	1,160	1,300	58	1,710
1969	880	740	840	37	1,400
1970	2,730	2,300	2,860	115	2,280
1971	2,560	3,860	2,560	442	1,990
1972	2,330	3,240	840	416	1,990
1973	2,240	1,420	940	329	2,330
1974	1,280	880	950	1,305	2,120
1975	760	620	1,350	346	4,230
1976	1,640	2,800	1,860	541	1,900
1977	1,490	1,680	760	1,495	1,710
1978	1,520	2,790	1,080	1,345	1,390
1979	2,310	2,290	1,530	1,205	1,300
1980	1,000	6,530	1,950	618	1,230
1981	2,310	5,010	1,010	894	1,840
1982	3,040	4,350	710	800	2,750
1983	3,450	5,600	1,930	1,080	2,810
1984	4,500	6,420	1,290	1,192	2,810
1985	6,900	2,440	1,450	3,138	3,300
1986	9,050	2,530	1,360	1,949	4,350
1987	9,550	1,460	1,420	615	4,180
1988	6,510	3,200	3,080	1,009	3,190
1989	8,970	60	1,880	2,738	4,070
1990	6,540	10	650	5,364	3,210
1991	6,750	430	750	538	4,960
1992	5,850	240	370	3,777	2,650
1993	6,010	920	380	1,464	3,020
1994	6,240	560	400	1,216	2,580
1995	5,550	530	360	910	2,580
1996	4,920	340	320	904	2,410
1997	4,700	60	290	624	2,340
1998	3,300	150	300	640	2,100
1999	1,940	160	280	272	1,370
2000	1,810	200	180	275	1,450
2001	1,800	190	180	306	1,420
2002	1,620	300	180	85	1,210
2003	1,220	160	170	113	1,090
2004	1,350	140	170	118	1,240
2005	1,490	150	160	92	1,320
2006	490	10	150	5	750
2007	230	40	150	106	720
2008	240	20	150	55	650
2009	90	20	150	42	670
2010	30	50	140	10	630