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# A RECONSTRUCTION OF THE UKRAINE'S MARINE FISHERIES CATCHES, 1950-2010

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## ABSTRACT

Ukraine's marine fisheries catches were re-estimated for the 1950-2010 time period using a reconstruction approach which estimated all unreported fisheries removals, i.e., catches from the industrial, artisanal, recreational, and subsistence sectors, as well as discards from major fisheries. We added these estimates to the 'official' data, which were represented by three separate baselines, the *Sea Around Us* assignment of former USSR catches to the Ukraine, expert analysis of Soviet data, and data submitted by the Ukraine to the United Nations' Food and Agriculture Organization (FAO). The reconstructed total catch for the 1950-2010 time period is 1.5 times the data officially reported, i.e., the industrial landings. Reconstructed catches consisted to 71% of industrial landings (including unreported), 11% artisanal landings, 8% recreational landings and 7% subsistence landings, while discards accounted for 3% of reconstructed total catches. Total catches increased from 51,000 t in 1950 to a peak of 174,000 t in 1988 and then declined with the collapse of the Soviet Union to about 56,000 t in 1991, which was also driven by the local invasive ctenophore population explosion in the Black Sea. In 2010, total reported marine landings for Ukraine were 70,000 t, while the reconstructed total catch was just over 110,000 t. Major unreported species in the commercial, recreational and subsistence fisheries are gobies (Gobiidae), Mediterranean horse mackerel (*Trachurus mediterraneus*), whiting (*Merlangius merlangus*), bluefish (*Pomatomus saltatrix*), and Mediterranean mussel (*Mytilus galloprovincialis*). The major components of this catch reconstruction for the Ukraine were the previously un-assessed artisanal, recreational and subsistence sectors. Accounting for all fisheries removals should help to establish a reliable baseline, better understand the fisheries, and thus assist in management.

## INTRODUCTION

### *The Black Sea*

The Ukraine shares the Black Sea basin and its biological resources with five countries: Russia, Georgia, Turkey, Bulgaria and Romania. The Black Sea is an almost fully enclosed basin, with only a limited water exchange with the Mediterranean Sea through a counter-current straits system wherein lighter, less saline water flows in a surface current from the Black Sea into the Aegean Sea; while a counter-current of denser, saltier water flows underneath that layer, towards the Black Sea. The marked density difference between the two layers inhibits mixing, leaving only depths shallower than about 150-200 m capable of supporting multicellular life. Indeed, the deeper waters (~90% volume of the Black Sea) are heavily anoxic, causing the Black Sea to be the largest anoxic body of water in the world (www.blackseascene.net).

The catchment area of the Black Sea is over 2 million km$^2$, five times the area of the sea itself (Zaitsev *et al.* 2002). The Sea of Azov, which the Ukraine shares with Russia, is 38,000 km$^2$, and averages just 7 m in depth. The Kerch Strait connects the Black Sea to the Sea of Azov. The Ukraine is also a very important

catchment area involving the Danube, Dnieper, Dnister, Southern Bug and Siverskyi Donets Rivers,[1] jointly draining much of Europe.

*The fisheries*

In the Black Sea, as the rest of the world, catch capacity dramatically increased with industrialization. Seiners were introduced to the Ukraine in 1931, which enabled catches to double and then bottom trawlers were introduced in the 1950s (Knudsen and Toje 2008). Both these industrial fishing methods gave the coastal fleet the power to expand to offshore, and later to distant-waters.

The governments of the former Soviet Union modernized the fisheries of the various Soviet Republics, including the Ukraine, by supplying trained fishers to the industrial fishery sector, which enabled industrial vessels to fulfil the successive plans involving higher catch quotas (Knudsen and Toje 2008).

However, while the catch of the Ukraine and other Black Sea countries increased until 1983, the ecosystem began showing signs of stress in the mid-1970s. Fishing pressure first caused sturgeon (Acipenseridae) and turbot (*Scophthalmus maximus*) stocks to show signs of over-exploitation, while many larger predatory fish populations crashed, notably Atlantic mackerel (*Scomber scombrus*), bluefish, and chub mackerel (*Scomber japonicas*). Later, red mullet (*Mullus barbatus barbatus*), and spiny dogfish (*Squalus acanthias*) populations (GFCM 2012) also followed suit, although red mullet stocks have somewhat recovered in the 2000s.

At first, increase in effort, and the geographical and taxonomic expansion of the fisheries masked the declining trend in local catches (Eremeev and Zuyev 2007; Pauly 2009) and thus the disappearance of the large predators went almost unnoticed. Subsequently, no management actions were taken to reverse the losses, a typical case of 'Fishing Down Marine Food Webs' (Pauly *et al.* 1998), which triggered a trophic cascade (Daskalov 2002). After the near-complete removal of large predators, their former prey, the small pelagics (anchovy *Engraulis encrasicolus*, sprat *Sprattus sprattus*, Mediterranean horse mackerel and whiting) increased their biomass, resulting in their contribution to the total Black Sea landings increasing from 70% in the 1960s-1970s to 93% in 1988 (Eremeev and Zuyev 2007).

The Ukrainian coastal fisheries consist of two main commercial sectors: artisanal (small-scale) and industrial (large-scale). The artisanal sector is characterized by small boats averaging 4-5 m in length which use passive fishing gear such as set traps ('*stavniki*') and fixed nets (Mikhailov and Papaconstantinou 2006). They operate coastally in the Ukrainian portion of the Black and Azov Seas, with more emphasis on the waters around Crimea, but have also exploited neighboring Georgian and Russian waters in the 2000s.

The artisanal inshore fishery used to mainly target valuable species such as sturgeons, which became prohibited in 2000, and the main target-species switched to *so-iuy* mullet (*Liza haematocheila*). The exploitation of grey mullet (Mugilidae) was prohibited in 1992 due to declines, but soon recovered and re-opened in 1999, albeit with stricter quotas. Goby and shad (*Alosa immaculata*) commercial fisheries in the Sea of Azov were also temporarily closed, but recovered and re-opened in 2002 and 2006, respectively. Other target species include European anchovy (*Engrulis encrasicolus*), silversides (Atherinidae) and flatfish (Pleuronectiformes). Only non-motorized vessels are permitted to target inshore shad (*Alosa immaculata*), and silversides in the Sea of Azov. Longlines and gillnets are used to catch the newly targeted dogfish (Squalidae), skates (Rajidae) and rays (Dasyatidae) (V. Shlyakhov, unpubl. data) in coastal waters. The main invertebrates caught are Mediterranean mussel (*Mytilus*

[1] http://www.fao.org/fi/oldsite/FCP/en/UKR/profile.htm

*galloprovincialis*) and the Rapa whelk sea snail (*Rapana venosa*), both collected by hand and via bottom dredges (Shlyakhov and Charova 2003).

The industrial sector operates mainly trawler-seiner vessels averaging 18-24 m in length (V. Shlyakhov, pers. obs.), as well as multi-purpose type vessels using other net-types and longlines. In 2000, there were 95 operational industrial fishing vessels in the Black and Azov Seas (Pramod and Pitcher 2006)[1], which decreased to about 80 by 2004. These vessels target mainly anchovy, sprat, goby, and *so-iuy* mullet. The sprat bottom-trawl fishery began in the mid-1970s and was at first very intensive, with over 120,000 bottom-trawl hauls conducted in the north-west portion of the Black Sea from 1979 until 1986 (Eremeev and Zuyev) [see Discards section for more details]. Although the sprat fishery has shifted from bottom trawling to pelagic trawling, the latter operate in shallow water and continue to negatively impact the seafloor.

Pre-independence, the Ukraine followed strict Soviet standards for fish product marketing, processing, and storage, and had heavily-guarded waters, with much lower accounts of illegal or unreported fishing. During the 1980s, when Ukraine was still a member of the Soviet Union, reported marine catches averaged 116,000 t·year$^{-1}$; the fisheries were subsidized by the state and not taxed. However, after Ukraine gained independence (July 16,1990), most fisheries subsidies were cancelled, and soon after, the national Monitoring, Control and Surveillance (MCS) system almost entirely collapsed (Knudsen and Toje 2008). This reduction in state aid and monitoring capabilities, combined with negative ecological factors (see Discussion for details), as well as high gas prices, led to an initial marked decline in reported fish catches, averaging 34,000 t·year$^{-1}$ from 1991-1995.

From 1992 onwards, the fisheries became privatized, and lacking state fiscal help, was unable to maintain fishing vessels and their associated infrastructures (Knudsen and Toje 2008). In 2002, a state-licensing system for commercial fisheries was established which introduced Total Allowable Catch (TAC) quotas for some rare and valuable species (Knudsen and Toje 2008). With the introduction of such quotas, some companies have been leasing out vessels and crew to help reach quota limits. From the mid-1990s, the Ukraine has been establishing new standards aimed to satisfy EU trade requirements (Sağlam and Duzguneş 2010).

While the Ukraine also has an important distant-water fleet (Zeller and Rizzo 2007), this paper deals only with Ukraine's marine catches taken exclusively from their own Exclusive Economic Zone (EEZ), which covers about 144,000 km$^2$ (Figure 1). Also, this assessment of total marine removals only deals with catches of marine and brackish-water fish and invertebrates, and does not include seaweeds, marine mammals or freshwater fisheries. The United Nation's FAO Fishstat database includes Ukraine's fisheries in FAO statistical area 37 (Mediterranean and Black Seas), and the Black Sea is then divided into sub-areas 37.4.1 (Marmara Sea, not discussed here), 37.4.2, the 'Black Sea proper', and 37.4.3, the 'Sea of Azov'.

The Ukraine is undergoing a transition from a centrally-planned economy to a market economy, and is currently divided culturally between a Russian-speaking east and a Ukrainian-speaking west. The marine resources of the Sea of Azov (Figure 1) are shared by Russia and the Ukraine, and the annual catch is decided upon by the bilateral Ukrainian-Russian Commission. Since independence in 1991, Ukraine had trouble securing sufficient fuel supplies, particularly during the winter season of 1993-1994, and Russia linked further fuel exports to a resolution of the problem of finding a Black Sea home port for their Navy. Also, the future of the Crimean Peninsula, given to the Ukraine in 1954 is an extremely contentious topic, as Russian nationalists want it back, especially the port city of Sevastopol (Pryde 1995). The Ukraine has

permitted Russia's Navy to berth in Sevastopol, Crimea, from 2017 until 2042, in return for a 30% discount on Siberian gas.[2]

Over the last 20 years, total catches from the Sea of Azov declined substantially, from ~100,000 t·year$^{-1}$ (Popovych 2011) to just over 30,000 t·year$^{-1}$ in 2010. The deterioration of this sea is largely attributable to industrial wastewater contamination, and increased salinity levels from the diversion of natural freshwater (www.ukraineatpresent.com), but may also be due to increased illegal, unreported and unregulated fishing (Popovych 2011).

In 2001, national fish consumption was 12.5 kg·person$^{-1}$·year$^{-1}$ and fish imports exceeded exports by 6 times (FAO 2004). One factor which has negatively affected the coastal fisheries is the lack of wholesale markets, resulting in very high marketing expenses[1].

In 2002, Ukrainian state funds for conducting fisheries research (of which monitoring and control are a large part) changed from a line item of the budget devoted to the "Conservation, selection and reproduction of fish stocks" to a line item on devoted "Fundamental Research" and "Applied Developments"; the associated funds were also drastically reduced, from US $1 million in 1996 to US $250,000 by 2006, thus drastically shrinking capabilities.

Following the economic recession which affected all ex-Soviet republics in the early 1990s, marine fisheries became more attractive, if only because of a lack of other opportunities. Thus, annual reported catches increased from a low of 26,000 t in 1993 to 89,000 t in 2001, partly due to some success in rebuilding the economy and also because a sizeable increase in both anchovy and sprat stocks. In 2003, Russia prohibited Ukrainian vessels from fishing anchovy in Russian waters, thus reducing Ukraine's share of catches from the Sea of Azov. By 2010, reported Ukrainian marine catches were 70,000 t (Appendix Table 1).

There are four large fishing ports in the Ukraine: Sevastopol, Ill'ichevsk, Kerch and Mariupol (Figure 1), and close to 40% of Ukraine's continental shelf and 12-mile coastal zone is made-up of no-take protected areas (Shlyakhov, unpubl. data, www.mpaglobal.org).

With the acceptance of Bulgaria and Romania into the European Union (EU), Turkey a candidate country, and the Ukraine having an association agenda with the EU, there is now a need to manage fisheries in accordance with the rules of the European Union's Common Fisheries Policy (Duzgunes and Erdogan 2008). This report aims to reconstruct total marine fishery removals for the Ukraine from 1950-2010, which will help establish a more comprehensive baseline, and can in turn aid future fisheries management efforts. The recent changes in the Black Sea fisheries are also discussed.

*Foreign fishing*

Ten to twelve Ukrainian vessels fished for anchovy in Georgian waters from 1996-2006, but this ended when Georgia introduced a non-transferable quota system (Shlyakhov, unpubl. data). These catches amounts were estimated separately and can be found in the catch reconstruction for Georgia.

*Distant water fisheries*

Approximately 9,000 people are employed in distant water fisheries, with total annual catches averaging ~150,000 t·year$^{-1}$ (Pramod and Pitcher 2006). Since independence, the vessels in this fleet have been in an increasing state of disrepair (Knudsen and Toje 2008), but this may not apply to their fish finding and

[2] http://www.guardian.co.uk/world/2010/apr/21/ukraine-black-sea-fleet-russia

navigational electronics, as the former are crucial to commercial success and the latter must meet the minimum requirements of the International Maritime Organization.[3]

The Ukraine inherited over 330 fishing vessels from the former Soviet Union, most which were resold to other countries, rebuilt to be transport vessels, or were scrapped. The fishing fleet was roughly between 29-32 years old (as of 2010), suggesting that most vessels will need to be scrapped between 2010 and 2015 (FAO 2004).

As of 2002, there were 47 oceanic large-capacity industrial vessels ranging in length from 82-128 m, 14 carrier vessels ranging in length from 124-172 m, 31 smaller carrier vessels ranging in length from 27-55 m, 39 medium-capacity trawlers ranging in length from 55-62 m (Pramod and Pitcher 2006). The catches of the Ukraine's distant-water fleet are not included in this report.

*Illegal fishing accounts*

The only nation known to commonly fish illegally in Ukrainian waters is Turkey, which has, by far the largest fishing capacity in the Black Sea. There are many accounts of such illegal activity, for example:

- In April 2007, a Turkish fishing vessel was detained by the Ukrainian Coast Guard with about 380 Black Sea turbot each one weighing up to 6 kg;[4] and
- In 2008, a Turkish fishing vessel, the '*Ozgur*' was caught in the Ukrainian EEZ with fishing nets in the ship holds and fined close to US$10,000;[5]

In 2007, Ukrainian and Turkish experts negotiated a system to help prevent Turkish fishers from poaching in Ukrainian waters. One solution they identified was that Turkish vessels were to implement a vessel monitoring system (VMS) onboard their Ukrainian-bound vessels, to alert Ukrainians of the number and location of vessels if they entered Ukrainian waters.

*Governance*

A Scientific Fisheries Council advises the central executive body - the State Committee for Fisheries or '*Derzhcomrybhosp*', tasked with monitoring and enforcement. In 2002, a fisheries license system was initiated, and in 2011, a new law was established for commercial fisheries, issuing five-year permits, but not restricting capacity (GFCM 2012). Most commercial species have non-transferable catch quotas and have Minimum Legal Landing Size (MLLS) regulations in place.

In November 2011, the Ukraine ramped up its fines for illegal fishing by 23 times, from 34 to 800 *hryvnias* (i.e., from about US $4 to about $100) for each illegally caught specimen. In a 10-month period, the department had 104,000 violations and had detained 94,000 offenders, confiscating 112,000 pieces of illegal fishing equipment.[6]

The objective of the present study was to estimate total marine fisheries catches taken by the Ukraine in Ukrainian EEZ waters between 1950 and 2010 by combining best estimates of unreported catches with reported landings data, following the general catch reconstruction approach of Zeller *et al.* (2007).

[3] www.hurriyetdailynews.com/default.aspx?pageid=438&n=bickering-with-ukraine-over-fishing-in-black-sea-ends-2007-09-08
[4] www.redorbit.com/news/international/897084/turkish_boat_detained_in_ukrainian_waters_for_illegal_fishing/
[5] www.illegal-fishing.info/item_single.php?item=news&item_id=2833&approach_id=20.
[6] http://en.for-ua.com/news/2011/11/24/130321.html

## MATERIALS AND METHODS

### *Baseline reported data*

Three data sources were used to establish a time-series of 'reported' marine catches for the Ukraine for the entire 1950-2010 period: 1) the re-allocation of former Soviet Union reported landings data to the constituent republics of the U.S.S.R. completed by Zeller and Rizzo (2007); 2) Ukrainian landings calculated by expert assessment from the official statistics of the former USSR (Shlyakhov, unpubl. data); and 3) FAO reported data.

1) The data re-allocated by Zeller and Rizzo (2007) disaggregated the marine landings reported by FAO for the former Soviet Union and re-allocated these landings to the six maritime former Soviet Republics, based on each of the newly independent Republics' initial five-year average reported catch from 1988-1992. Three of these former Soviet Republics fished in FAO Area 37 (Mediterranean and Black Sea): Georgia, the Russian Federation and Ukraine. The three year averages were re-calculated (based on expert assessment provided below in [2] from 1970-1972) and the resultant difference between the average of the first 3-years of national data and the re-allocation provided by Zeller and Rizzo (2007) was 26.84%. Therefore from 1950-1969, we assumed that 26.84% of the former disaggregated Ukrainian catches to be catches caught in the Ukrainian waters, and the remaining 73.16% were deemed to be caught elsewhere in the Mediterranean Sea;
2) Ukrainian landings calculated by expert assessment from the official statistics (Shlyakhov, unpubl. data) from 1970 to 1987; and
3) For 1988 to 2010, data reported by the Ukraine to or by FAO were used.

These three data sources were used to create our 'reported baseline' to which other types of unreported fisheries catches have been added, i.e., unreported industrial, artisanal, recreational, and subsistence landings, as well as major discards. All reported data as derived here from 1950-2010 were assumed to be industrial catches. Since fisheries under Soviet rule were highly regulated, the reported statistics for 1950 to the late 1980s are trusted to be inclusive of all industrial catches.

To improve on the taxonomic composition of reported data, the first three years of the dataset derived from the expert assessment (#2 above) were averaged (1970-1972), and each taxon's percentile contribution to the total was applied to the newly derived annual total catch for Ukraine, and applied to the years from 1950 to 1969.

The 'marine fishes nei' category was disaggregated for the 1950-1969 period into eight taxonomic groups commonly caught and reported at this time. Local expert consultation (V. Shlyakhov, pers. obs.) was used in combination with the first three years of available Turkish catch statistics from the western Black Sea (1967-1969) to improve on the poor taxonomic allocation during this time. Expert opinion (V. Shlyakhov, pers. obs.) suggested most of the catches then pertained to silversides, thus nearly two-thirds (63%) of catches were allocated to silversides. For the 1970-1987 period, the 'marine fishes nei' category was disaggregated into 10 taxonomic groups, most of which were not included in the Ukrainian statistics, but were commonly caught in the Ukrainian waters based on local expert advice (V. Shlyakhov, pers. obs., Table 2). The 1988-2010 period had the 'marine fishes nei' accepted as they were, as amounts were low.

*Estimating unreported catches*

Number of commercial fishers

To derive a time-series of commercial fishers, published accounts of total Ukrainian fishers (when available) were used in combination with actual population trends. The Ukrainian population was 37.3 million in 1950 (www.un.org/esa/population), rose to nearly 52 million by 1990 (www.populstat.info), peaked at 52.2 million in 1992 and has since declined to approximately 46 million people in 2010 (www.tradingeconomics.com).

Prior to independence, there were 80,000 fishers working in all sectors[7] (i.e., freshwater, distant water, and coastal marine fisheries), which was reduced to approximately 45,000 fishers employed in all sectors in 2001 (FAO 2004), representing, a 56% reduction in the number of fishers during this period (these ratios were used to account for the industry trend). In 2000, there were 5,600 commercial fishers in the coastal marine fleet (i.e., fishing in Ukraine's EEZ), which decreased to 4,200 by 2010 (Shlyakhov, pers. obs.). Therefore, the 5,600 fishers in 2000 was increased by 56% (same ratio used above to account for the industry trend) to obtain a number of commercial fishers for 1990 of 8,736 fishers.

To derive the number of fishers for 1950, national Ukrainian population trends were used, i.e., the number of coastal marine commercial fishers derived for 1990 (i.e., 8,736) was multiplied by 0.72 to derive an assumed number of fishers in 1950 (i.e., 6,290). Thereafter, we interpolated the number of fishers between our anchor points in 1950, 1990, 2000 and 2010.

To remain conservative, after the total number of commercial fishers was estimated, 40% of the total commercial fishers were assumed to have belonged to the industrial commercial sector (whose catches were all deemed to have been reported up to 1990), while the remaining 60% of fishers were assumed to belong to the artisanal commercial sector (whose catches have not been previously estimated). It is understood that there is no legal distinction in the Ukraine between industrial (large-scale commercial) and artisanal (small-scale commercial), and in fact, many commercial fishers are engaged in both fishing types (Shlyakhov, pers. obs.).

*Unreported industrial catches*

When the Soviet Union collapsed, regulatory agencies became incapable of performing Monitoring, Control and Surveillance (MCS) procedures, leading to essentially 'open access' fisheries in the ex-Soviet Republics bordering the Black Sea. It has been suggested that the decrease in reported catches in the 1990s (Figure 2) represents a decrease in the 'reporting' of catches, but not in 'actual' catches or effort (Knudsen and Toje 2008). In addition, due to high levels of corruption since independence, only about 20% of actual catches are thought to have been reported (S. Jatsenko, pers. obs.).

However, the Soviet-era subsidization of the fleets declined abruptly, and fleets would have been required to resume operations based on a completely different business model. Thus, in light of the above anecdotal evidence that under-reporting had indeed been occurring and likely been increasing since independence; an unreported industrial component was estimated. To remain conservative, it was assumed that there was zero industrial under-reporting in 1990 which was linearly increased to 20% industrial under-reporting by 2010. This was calculated by multiplying each annual percentage (from 1991-2010) by the industrial reported catch amounts for each year. The taxonomic allocation used was the same as for the reported catches.

[7] http://www.ilo.org/global/about-the-ilo/newsroom/news/WCMS_083074/lang--en/index.htm

*Artisanal catches*

In the Ukraine, artisanal (i.e., small-scale-commercial) fisheries have not yet been described quantitatively or properly assessed. From 1950-2010, artisanal landings were estimated using the derived time-series of number of coastal commercial fishers, 40% of which were assumed to use industrial fishing gear, thus the remaining 60% were assumed to use artisanal commercial gear. We assumed an annual artisanal catch rate of 1.5 t·fisher$^{-1}$·year$^{-1}$ which was held constant from 1990-2010, and the catch rate was doubled to 3 t fisher$^{-1}$·year$^{-1}$ for 1950-1970 to account for a much healthier ecosystem, which included larger trophic-level fish. The catch rate was then linearly decreased from 1971 to 1989. The number of fishers·year$^{-1}$ were multiplied by the assumed catch rates to determine artisanal catches.

Since the most important fish stocks in the Black Sea crashed from 1990-1992, due to a carnivorous comb jelly invasion (Daskalov 2002; Gücü 2002; GFCM 2011), the artisanal catch estimated in this fashion was reduced by 75% during 1990-1992, then was linearly increased to our 2000 anchor point. The species allocated to these catches varied annually, reflecting the natural changes in the Black Sea ecosystem and were derived using a combination of expert advice, fisheries statistics, and the recreational catch composition.

*Unreported sturgeon catches*

All sturgeon (Acipenseridae) species have been included in the Convention of International Trade of Endangered Species[8] since 1998 (Black Sea Commission 2008). According to the IUCN Red List, the six species of sturgeons native to the Danube River basin are globally classified as either 'Vulnerable', 'Endangered' or as 'Critically Endangered'.

Sturgeon abundances increased in the region in the latter half of the 20$^{th}$ century, from 0.2 million individuals in 1966 to somewhere between 5.3-6.2 million individuals by 1992-1993, due to efficient protection combined with restocking efforts for Russian sturgeon. These numbers, however, decreased to about 2 million individuals by 1998 and 1.5 million individuals by 2002 (Black Sea Commission 2008). One major hindrance to sturgeon population recovery is that juveniles are still caught in the (illegal) net fisheries targeting pike-perch and *so-uiy* mullet.

With the dissolution of the Soviet Union, poaching has increased in the Sea of Azov (Demyanenko and Diripasko 2003). The estimated abundance of the Azov sturgeon stock for 2004-2005 was only 5% of the early 1990s (FAO 2005). Experts suggest that these declines are due to a reduction of spawning grounds, illegal fishing, and the alteration of river flow regimes. Fisheries scientists in the Ukraine annually derive the Total Allowable Catch (TAC) by estimating current fishing mortality in combination with estimating unreported catches (Shlyakhov, unpubl. data). Their results suggest that the populations of Russian sturgeon and starry sturgeon are depleted because catch limits are not respected, which is not surprising, given that these two sturgeon species are the most valued on the black market. Indeed, while unreported and illegal catches occur in all sectors, they tend to be mainly associated with the most valuable fish species (Prodanov *et al.* 1997; Shlyakhov *et al.* 2005), For example, juvenile sturgeon with total lengths between 50-70 cm are common in Ukrainian fish markets, although illegal to catch, and thus are unreported (Shlyakhov 2003). Many sturgeon are also caught as incidental by-catch (Suciu 2008).

Unreported sturgeon catches were estimated from 1964 to 1992 for the north-western part of the Black Sea and the Danube (Prodanov *et al.* 1997) and for the Sea of Azov from 1988 to 2005 (Black Sea Commission 2008). We present these data in Table 3, if only to encourage further research on this topic. However, to avoid the possibility of double-counting, we have assumed that these unreported sturgeon

[8] CITES Appendix II /Notification to the Parties No. 998/13 *Conservation of Sturgeons.*

catches were accounted for in our reconstructed catch estimate for artisanal, subsistence, and recreational subsectors.

*Recreational and subsistence catches*

Recreational and subsistence fisheries share a common feature: their catch is not sold, or at least is not supposed to be sold. Here, they are initially estimated as one item, then later disaggregated to fish caught primarily for pleasure (i.e., recreational fishing) and fish caught primarily for household consumption (i.e., subsistence fishing).

An estimated 1 to 3 million people were engaged in either full-time or part-time recreational/subsistence fishing, including freshwater fishing (FAO 2004). Subsistence fishing dominates rural areas, and recreational and sports fishing dominates urban areas with > 1 million inhabitants. Data are partially collected on recreational fisheries involving 15 taxa, but the data are incomplete due to monitoring limitations, representing less than 5% of the actual fishery. However, the results showed that in 2006, 54,000 recreational fishers landed a total of 509 t of fish of the 15 taxa monitored, equating to 9.4 $kg \cdot fisher^{-1} \cdot year^{-1}$ (V. Shlyakhov, unpubl. data).

The Ukraine, together with Turkey, has the highest coastal population living on the Black Sea, estimated at 6.8 million people (Zaitsev and Mamaev 1997), or 15% of the total population. Given the economic situation of the country, the high national unemployment rate and Ukraine's extensive coastline, we made an assumption that the number of coastal marine recreational/subsistence fishers was 1% of the total population after independence, and 0.25% of the total population from 1950-1989 (V. Shlyakhov, pers. obs.). The lower proportion of marine recreational/subsistence fishers pre-independence was due to the strictly controlled coastal zone by the Soviet border regime, thus making access and fishing more difficult (Shlyakhov, pers. obs.). The 0.25% rate was linearly increased to 1% from 1990-1992.

This lead to an estimate of ~450,000 recreational/subsistence fishers in 2010, which is much lower than the FAO estimate of 1-3 million (which includes freshwater anglers). We used this estimate of marine recreational/subsistence fishers in conjunction with the only published recreational catch rate per fisher of 49 $kg \cdot fisher^{-1} \cdot year^{-1}$ for the early 2000s (FAO 2004) to determine a best catch estimate. Given the changes in taxonomic assemblages over time in the Black Sea, in which most of the large predatory fish had been removed from the Black Sea ecosystem, the catch rate was increased by 50% for 1950-1970, i.e., to 73.5 $kg \cdot fisher^{-1} \cdot year^{-1}$, and was linearly decreased to 49 $kg \cdot fisher^{-1} \cdot year^{-1}$ by 2000.

To differentiate between recreational and subsistence sectors, it was assumed that for the entire 1950-2010 period, 70% of all estimated recreational/subsistence catches were caught for subsistence purposes (i.e., primarily as a protein source), and 30% of catches were caught for recreational purposes (i.e., primarily for fun or enjoyment).

The catch composition of the recreational and subsistence catches were modified from our artisanal catch composition (V. Shyakhov, pers. obs.), in combination with Turkish western Black Sea catch data to understand when the absence of select species began. As the Black Sea species composition did change distinctly over time, a different taxonomic breakdown was applied for each year (see Table 4), and the amounts were interpolated between 1950 and 2010. Although sturgeon were a prohibited catch species for the recreational sector, they were still allotted 1% of total recreational/subsistence catches from 1950-1990 due to the existence of a 'Black market' for prohibited species.

*Industrial discards*

Discards are defined as that part of "the catch that is thrown away, or dumped at sea" (Kelleher 2005), and may include both commercial and non-commercial species. Reasons for discarding include damaged or spoiled catch, catch smaller than legal landing sizes, or having little or no market or commercial value (Rousou 2009).

A small bottom trawl fishery existed briefly in the early 1950s targeting sturgeon and turbot. However, intensive bottom trawling for sprat began in the mid-1970s, and from 1979-1986, over 120,000 trawling passes were conducted in the northwest section of the Black Sea, which either damaged or completely destroyed benthic communities from the scouring of the heavy bottom-trawl boards (Eremeev and Zuyev 2007).-The number of macrobenthos species in these silted areas declined 3.5-fold, their abundance 2.5-fold and their biomass more than 20-fold (Zaitsev *et al.* 1999)

Since no bottom trawling discard rate specific to the Ukraine could be located, a weighted bottom trawl discard rate from the Turkish Black Sea of 42% (Ceylan *et al.* 2014) was the first anchor point used. To remain conservative, the percentage was decreased to 30% and was applied only to the reported sprat catches for the intensive 1975-1986 trawling period discussed above. Of this 30% discards, 5% were allocated as damaged and juvenile sprat and whiting, while the remaining 25% were allocated as non-target (i.e., non-commercial fish) and invertebrates, to account for the disappearing macrobenthos species during the heavy trawling period. Of the 25% discard of non-target species, the taxonomic composition allocated was dogfish (Squalidae, 20%), skates (Rajidae, 20%), rays (Dasyatidae, 20%), scorpionfish (Scorpaenidae, 5%), echinoderms (10%), miscellaneous marine crustaceans (Crustacea, 10%), marine molluscs (5%), conger eels (Congridae, 2.5%), and moray eels (Muraenidae, 2.5%). Some of these taxa are no longer present in Ukrainian waters in substantial quantities, but they represent the best estimates for what was initially removed by the intensive trawling period, as no data exist on the topic. Other commonly occurring benthic species had commercial value and thus would have been retained as bycatch, and not 'discarded'. For all other industrial catches, in the absence of any information on discards, a conservative 1% of total reported catches was applied to account for some industrial discards, which undoubtedly have occurred throughout time.

Furthermore, in winter months during the bottom trawling period (1975-1986), anchovy and sprat were often landed together, and since anchovy have more-value, sprat was often discarded and not accounted for (V. Shlyakhov, unpubl. data). Thus, an additional 5% of sprat discards was calculated for reported anchovy catches during the 1975-1986 period.

During 1987-2005, the sprat fishery switched from bottom trawling to mid-water trawling, and only a 5% total discard rate (as juvenile and damaged sprat and whiting) was used for this time period, which apparently has since increased due to a higher concentration of juveniles in the catch in subsequent years (V. Shlyakhov, pers. obs.). Thus, we linearly increased the rate from 5% in 2006 to 8% by 2010.

*Artisanal discards*

Due to a total lack of information regarding the artisanal sector, a conservative 1% of artisanal catches was estimated to account for discards from this sector, composed of the juveniles of retained species and/or species with no market value.

*Illegal turbot fishing by Turkey*

It is known that Turkish fishers fished illegally for turbot in the north-western Black Sea (catching around 1,000 and 2,000 $t \cdot year^{-1}$) in Bulgarian, Romanian and Ukrainian waters between 1993-2001 and also in

2009-2010. Conflicts between the maritime police and illegal Turkish fishers temporarily stopped this illegal fishing problem. The catches were sold on the Turkish market and reported as Turkish catch. The amount of turbot caught by Turkey in distant waters in the Black Sea, outside their national waters was estimated from 1993-2001 and from 2009-2010 in a separate catch reconstruction for Turkey (Ulman *et al.* 2013). This equals an adjustment total of 11,000 t for the 11 year period which has been re-allocated equally to the EEZ's of Romania, Bulgaria and the Ukraine, in whose waters the turbot were caught.

## RESULTS

### *Baseline data*

To establish our reported data baseline from 1950-1969, the improved data of Zeller and Rizzo (2007) for the Ukraine were used; from 1970-1989, Ukrainian national data by expert assessment were used; and from 1988-2010, FAO data were used.

### *Ukraine as a whole*

The reconstructed total catch for the Ukraine averaged 51,000 t·year$^{-1}$ in the 1950s and 1960s, after which it began increasing and peaked in 1988 with 174,000 t, and then decreased to 56,000 tin 1991 due to the Black Sea fisheries crisis, and dissolution of the U.S.S.R., after which the catches partially recovered to average 102,000 t·year$^{-1}$ in the late 2000s (Figure 2a, Appendix Table 1). Thus, the reconstructed total catch was 46% higher than the reported data from 1950-2010. Our reconstruction of Ukraine's total catch from 1950 to 2010 combines the reported landings submitted to the FAO along with our best estimates of unreported industrial, artisanal, recreational, and subsistence landings, as well as major discards (Figure 2a, Appendix Table 2). Some of these estimates may not be entirely accurate, but they are better than the alternative, which is ignoring these unreported catches.

From the reconstructed total catches (inclusive of the reported data) for the 1950-2010 period (Figure 2b, Appendix Table 2), European anchovy (*Engraulis encrasicolus*; 28%), European sprat (*Sprattus sprattus*; 20%), and Black and Caspian Sea sprat (*Clupeonella cultriventris*; 8%) were the major contributors to the catches, followed by gobies (Gobiidae), whiting, Mediterranean horse mackerel (*Trachurus mediterraneus*) and Mediterranean mussel (*Mytilus galloprovincialis*).

### *Industrial landings*

Reported industrial landings for the Ukraine averaged 29,000 t·year$^{-1}$ in the 1950s, peaked in 1988 with over 157,000 t, declined substantially during 1991-1993 to 30,000 t·year$^{-1}$, and have since somewhat recovered to average 57,000 t·year$^{-1}$ in the late 2000s. In 1991, unreported industrial catches contributed 300 t which increased annually to 14,000 t by 2010 (Figure 2a, Appendix Table 1).

The major species caught by the reported industrial sector from 1950-2010 were European anchovy (40%), European sprat (27%), Black and Caspian Sea sprat (11%), gobies (6%), and Mediterranean mussel (4%). Note that small pelagics account for over 80% of total catches during this period.

### *Artisanal landings*

Artisanal landings (all deemed unreported) averaged 11,800 t·year$^{-1}$ in the 1950s, peaked in 1970 at 13,500t, then declined during 1990-1992 to just less than 2,000 t·year$^{-1}$, recovered to 7,000 t in 1993 and has since decreased to average less than 4,000 t·year$^{-1}$ in the late 2000s (Figure 2a, Appendix Table 1).

The major taxa caught by the artisanal sector from 1950-2010 were whiting (10%), sturgeon (9%), bluefish (8%), gobies (8%), Mediterranean mussel (6%), Mediterranean horse mackerel (6%), shrimps

and prawns (6%),mullets (6%), and European anchovy (5%), with 15 other taxa making up the remaining 36% of catches.

*Recreational landings*

Recreational landings (all unreported) averaged 2,400 t·year$^{-1}$ in the 1950s, peaked in 1992 with 16,500 t·, and then decreased slightly, averaging nearly 16,000 t·year$^{-1}$ in the late 2000s (Figure 2a, Appendix Table 1).

The major species caught by the recreational sector for the 1950-2010 period were Mediterranean horse mackerel (14%), gobies (12%), Mediterranean mussel (11%), so-iuy mullet, bluefish, and whiting (each at 10%), and sea snail (6%), with 14 other taxa making up the remaining 27%.

*Subsistence fisheries*

Subsistence landings (all unreported) were likely relatively stable from 1950-1970, averaging 4,700 t·year$^{-1}$, declined to a low of 3,200 t in 1989, increased to over 12,000 tjust after independence and has since declined to average 7,000 t·year$^{-1}$ in the late 2000s.

The major species we assume were caught for subsistence purposes from 1950-2010 were Mediterranean horse mackerel (14%), Mediterranean mussel (12%), bluefish (11%), gobies (10%), whiting (10%), so-iuy mullet (7%), other mullets (5%), with 14 other taxa making up the remaining 31% of catches.

*Discards*

Discards were assumed to be relatively low throughout the 1950s and 1960s, averaging 430 t·year$^{-1}$ for those decades. They increased significantly in the mid-1970s, peaking in 1980 at 18,000 t, and then declining to a low of 140 t in 1996, before increasing slightly to an average of430 t·year$^{-1}$ in the late 2000s. The taxa thought to be mainly discarded were European sprat (25%), skates, rays and dogfish (12% each), crustaceans and echinoderms (6% each), and European anchovy (5%), with 55 'other' taxa making up the remaining 22%.

## DISCUSSION

The reconstruction of the Ukraine's marine fishery catches, from 1950-2010 is a first attempt at estimating a more comprehensive picture of total marine fisheries removals for all fisheries sectors of the Ukraine, for the 1950-2010 period, much of which had not been previously studied. Assessing and understanding the scale of unreported fisheries can aid management by improving stock assessment, thus enabling the sustainability of stocks, and securing a future for these renewable resources, thus strengthening food security.

For the Ukraine as a whole from 1950-2010, the sectors which had the highest contributions to the total reconstructed catch were the industrial sector (70%), followed by the artisanal sector (11%), the recreational sector (9%), the subsistence sector (7%), and discards of both the industrial and artisanal sectors (3%).

Considering the time-series of total reconstructed catches both by sector (Figure 2a), and by taxonomic group (Figure 2b), it is apparent that the industrial sector more than doubled its catches from 1970 to 1980 due to a vast increase in the abundance of small pelagics. The estimates of post-independence unreported industrial catches are likely conservative and it is possible that unreported catches are much higher. The causes of the drastic reduction of catches in the late 1980s are explained next as many factors simultaneously contributed to the decline.

Commercial fisheries have been operating in the Black Sea for well-over two millennia (Bekker-Nielsen 2005), but in the last 50 years the system has been dramatically transformed. Since the Black Sea is a nearly isolated marine ecosystem, it provides a natural example of what can happen when the ecosystem approach is not fostered: the combined effects of pollution, eutrophication, and overfishing have resulted in a runaway trophic cascade (Daskalov 2002). The Black Sea, in particular should be exemplified as a case-study of what *not to do*, so that managers worldwide can learn from it.

*The 'Black Sea Fishery Crisis'*

The marked increase in catches in the 1980s and the subsequent sharp decline around 1990 (Figures 2 and 3) in the Black Sea resulted from a combination of the following factors, some of which led to ecosystem alterations:

1) Substantial amounts of oil (~170,000 t·year$^{-1}$) are discharged each year in the Black Sea and have contaminated the ecosystem, most notably from the discharges of the Danube (Zaitsev *et al.* 2002);
2) Increased nutrient loading of several major rivers which drain eastern Europe in the 1960s and 1970s (Ulman *et al.* 2013);
3) Increased primary productivity and phytoplankton abundances, resulting in algal blooms (Caddy 2008);
4) A decrease of the amount of dissolved oxygen in the water column;
5) Increased eutrophication and the decrease of the depth of the anoxic layer in the 1980s;
6) The removal or collapse of benthic fauna due to destructive bottom trawling and dredging, which reduced the complexity of the ecosystem (Zaitsev and Mamaev 1997);
7) The removal of large apex predators from the Black Sea in the 1970s due to overfishing (Llope *et al.* 2011; Ulman *et al.* 2013);
8) Resulting from the decline in apex predators, a substantial increase in mid-level predators, mainly of small pelagic fishes;
   Resulting from the increase in mid-level predators, a subsequent decline in primary consumers (i.e., zooplankton, likely controlled by the increase in small pelagic predators);
9) The alien ctenophore invasion (*Mnemiopsis leidyi*) which established extremely high abundances in the basin (Gücü 2002) from late 1989 until 1991, and which competed for food with small pelagics such as sprat, anchovy and horse mackerel;
10) The dissolution of the Soviet Union in 1990, which lead to several national economic recessions and funding cuts such as the 75% decrease in MCS operating costs (Knudsen 1997);
11) The cancellation of subsidies to the fisheries; and
12) High post-independence fuel prices, such as in 1992 when diesel prices rose 5-6 times faster than average industry prices (Siedenberg and Hoffman 1999).

Factors 1-7 plus 9 have negatively contributed to the overall diminished state of the ecosystem, while factors 10-12 should have helped improve ecosystem health by restricting fishing fleet capacity.

If there is to be any hope of recovery for this ecosystem, the Black Sea countries need to collaboratively control multiple anthropogenic factors including nutrient inputs, restricting overall fishing capacity and dealing with the introduction of exotic species (Caddy 2008).

## CONCLUSION

This catch reconstruction of the Ukraine illustrated some key points about the country's fisheries and their reporting practices. Firstly, it is apparent that only the larger-scale industrial fisheries are accounted for in the data reported by FAO on Ukraine's behalf. Our study is a first attempt to estimate/reconstruct

the unreported landings of the industrial, artisanal, recreational and subsistence sectors as well as major discards in order to establish a more comprehensive time-series for total fisheries removals.

The health of the Black Sea aside, the Ukraine appears to have been an international role model regarding its emphasis on and enactment of marine protected areas. It is certain that the recent elevated fines for illegal fishing may aid the monetary shortcoming of the fisheries budget two-fold if the money were re-invested in the sector: firstly by increasing the cost to the (illegal) fishers and hence discouraging further illegal activities, and secondly by increasing operating funds for the budget thus enhancing monitoring and control capabilities.

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**Table 1.** Allocation to taxa for the 'marine fishes nei' category from 1950-1969.

| Taxon or group | % |
|---|---|
| Silversides | 63 |
| Turbot | 13 |
| Shi drum | 9 |
| Gurnard | 7 |
| Garfish | 5 |
| Chub mackerel | 1 |
| Decapods | 1 |
| Swordfish | 1 |

**Table 2.** National 'marine fishes nei' taxonomic allocation from 1970-1987. Source: TURKSTAT Turkish western Black Sea fisheries statistics (1977-1979).

| Taxon or group | % |
|---|---|
| Atlantic horse mackerel | 35 |
| Bonito | 35 |
| Garfish | 5 |
| Shi drum | 5 |
| Scorpionfish | 5 |
| Brown meagre | 3 |
| Seabreams and porgies | 3 |
| Lobsters and crabs | 3 |
| Chub mackerel | 3 |
| Gurnard | 3 |

**Table 3.** Unreported sturgeon estimates in the Ukraine, 1964-2005, cited in the literature. Note that these numbers are presented for completeness but were not used in the methods to estimate unreported sturgeon in the reconstruction.

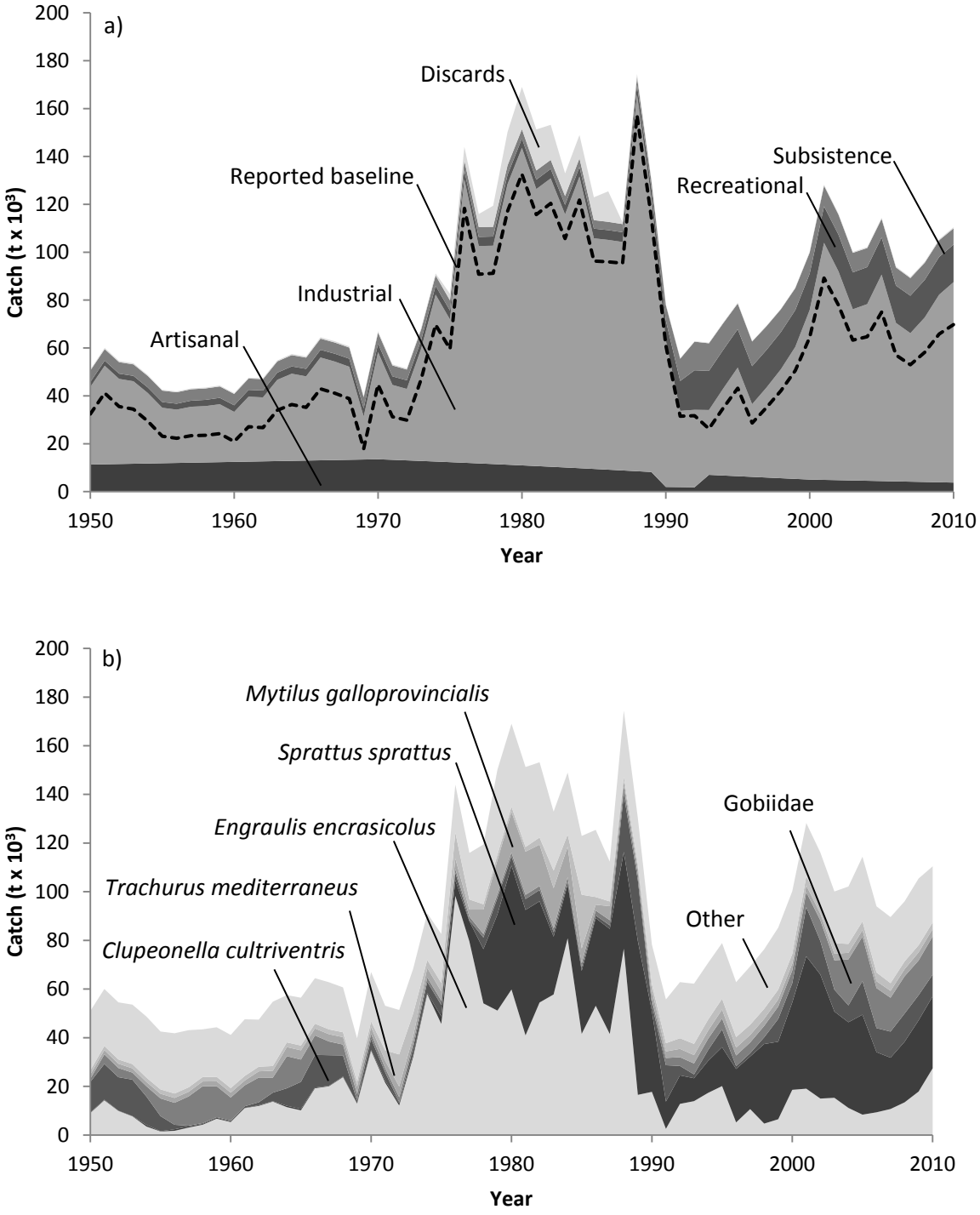
| Black Sea[1] | | | | Sea of Azov[2] | |
|---|---|---|---|---|---|
| Year | Catches (t) | Year | Catches (t) | Year | Catches (t) |
| 1964 | 60 | 1982 | 41 | 1988 | 4,814 |
| 1965 | 45 | 1983 | 41 | 1989 | 4,814 |
| 1966 | 31 | 1984 | 39 | 1990 | 4,814 |
| 1967 | 25 | 1985 | 64 | 1991 | - |
| 1968 | 1 | 1986 | 36 | 1992 | 3,213 |
| 1969 | 15 | 1987 | 55 | 1993 | 3,213 |
| 1970 | 14 | 1988 | 61 | 1994 | 3,213 |
| 1971 | 15 | 1989 | 45 | 1995 | 2,040 |
| 1972 | 10 | 1990 | 47 | 1996 | 2,040 |
| 1973 | 14 | 1991 | 55 | 1997 | 2,040 |
| 1974 | 30 | 1992 | 78 | 1998 | 984 |
| 1975 | 14 | | | 1999 | 984 |
| 1976 | 12 | | | 2000 | 984 |
| 1977 | 40 | | | 2001 | 109 |
| 1978 | 45 | | | 2002 | 109 |
| 1979 | 21 | | | 2003 | 109 |
| 1980 | 53 | | | 2004 | 54 |
| 1981 | 43 | | | 2005 | 54 |

Sources: [1] Prodanov (1997); [2] Black Sea Commission (2008).

**Table 4.** Recreational and subsistence catch allocation for 1950 and 2010, percentages mostly interpolated and adjusted based on expert advice.

| Year | 1950 | 2010 |
|---|---|---|
| Common name of species | % | % |
| Bluefish | 13 | 4 |
| Atl. Mackerel | 1 | 0 |
| Mediterranean horse mackerel | 15 | 10 |
| Mediterranean mussel | 14 | 10 |
| Shrimps | 5 | 5 |
| European flounder | 5 | 0 |
| Grey mullets | 5 | 5 |
| Red mullets | 5 | 2 |
| Gobies | 5 | 20 |
| Whiting | 10 | 10 |
| Groupers and seabream | 4 | 0 |
| Shi drum | 4 | 0 |
| Bonito | 3 | 1 |
| Garfish | 3 | 0 |
| Dogfish | 2 | 2 |
| Rays/skates | 2 | 2 |
| Turbot | 2 | 2 |
| Sturgeons | 1 | 0 |
| Crabs/lobsters | 1 | 0 |
| Sea snail | 0 | 7 |
| Pacific mullet | 0 | 20 |


**Figure 1.** The Ukrainian Exclusive Economic Zone (EEZ) and shelf waters to 200 m depth.




**Figures 2.** Reconstructed total marine catches for Ukraine by (a) sector with reported baseline overlaid as a dotted line from 1950-2010; and (b) taxon, with the 'others' group includes 58 additional taxa.

**Appendix Table A1.** Time series of reported marine fisheries landings (t) for Ukraine in the Black Sea, and reconstructed total industrial, artisanal, recreational, and subsistence landings and discards.

| Year | Reported | Total Reconstructed catch | Industrial | Artisanal | Recreational | Subsistence | Discards |
|---|---|---|---|---|---|---|---|
| 1950 | 32,406 | 51,015 | 32,406 | 11,322 | 2,056 | 4,798 | 433 |
| 1951 | 41,168 | 60,040 | 41,168 | 11,432 | 2,122 | 4,797 | 522 |
| 1952 | 35,553 | 54,542 | 35,553 | 11,542 | 2,188 | 4,795 | 465 |
| 1953 | 34,444 | 53,598 | 34,444 | 11,652 | 2,255 | 4,792 | 455 |
| 1954 | 29,406 | 48,687 | 29,406 | 11,762 | 2,323 | 4,788 | 407 |
| 1955 | 23,155 | 42,550 | 23,155 | 11,872 | 2,392 | 4,784 | 347 |
| 1956 | 22,283 | 41,846 | 22,283 | 11,982 | 2,462 | 4,778 | 340 |
| 1957 | 23,362 | 43,111 | 23,362 | 12,092 | 2,532 | 4,772 | 352 |
| 1958 | 23,525 | 43,451 | 23,525 | 12,203 | 2,604 | 4,765 | 356 |
| 1959 | 24,189 | 44,307 | 24,189 | 12,313 | 2,676 | 4,757 | 372 |
| 1960 | 20,894 | 41,159 | 20,894 | 12,423 | 2,749 | 4,748 | 345 |
| 1961 | 27,145 | 47,588 | 27,145 | 12,533 | 2,823 | 4,738 | 349 |
| 1962 | 26,716 | 47,443 | 26,716 | 12,643 | 2,898 | 4,728 | 458 |
| 1963 | 33,972 | 54,813 | 33,972 | 12,753 | 2,973 | 4,716 | 398 |
| 1964 | 36,395 | 57,507 | 36,395 | 12,863 | 3,050 | 4,704 | 495 |
| 1965 | 35,184 | 56,452 | 35,184 | 12,973 | 3,127 | 4,691 | 476 |
| 1966 | 42,942 | 64,467 | 42,942 | 13,083 | 3,206 | 4,677 | 559 |
| 1967 | 41,123 | 62,803 | 41,123 | 13,193 | 3,285 | 4,662 | 539 |
| 1968 | 38,848 | 60,684 | 38,848 | 13,303 | 3,365 | 4,647 | 521 |
| 1969 | 17,968 | 39,770 | 17,968 | 13,413 | 3,446 | 4,630 | 313 |
| 1970 | 44,753 | 66,999 | 44,753 | 13,523 | 3,527 | 4,613 | 583 |
| 1971 | 31,287 | 53,139 | 31,287 | 13,293 | 3,570 | 4,543 | 446 |
| 1972 | 29,842 | 51,412 | 29,842 | 13,056 | 3,611 | 4,474 | 429 |
| 1973 | 46,939 | 68,406 | 46,939 | 12,815 | 3,652 | 4,404 | 598 |
| 1974 | 69,721 | 91,135 | 69,721 | 12,567 | 3,691 | 4,333 | 823 |
| 1975 | 59,579 | 82,634 | 59,579 | 12,315 | 3,729 | 4,262 | 2,749 |
| 1976 | 118,324 | 144,009 | 118,324 | 12,056 | 3,767 | 4,191 | 5,672 |
| 1977 | 90,794 | 115,949 | 90,794 | 11,792 | 3,803 | 4,119 | 5,440 |
| 1978 | 91,193 | 119,414 | 91,193 | 11,523 | 3,838 | 4,048 | 8,812 |
| 1979 | 117,205 | 150,183 | 117,205 | 11,248 | 3,871 | 3,976 | 13,883 |
| 1980 | 132,633 | 169,014 | 132,633 | 10,968 | 3,904 | 3,904 | 17,605 |
| 1981 | 115,689 | 151,252 | 115,689 | 10,682 | 3,935 | 3,831 | 17,115 |
| 1982 | 120,448 | 153,213 | 120,448 | 10,391 | 3,965 | 3,759 | 14,650 |
| 1983 | 105,692 | 132,917 | 105,692 | 10,094 | 3,993 | 3,686 | 9,452 |
| 1984 | 121,796 | 148,948 | 121,796 | 9,792 | 4,021 | 3,613 | 9,726 |
| 1985 | 96,321 | 122,933 | 96,321 | 9,484 | 4,047 | 3,541 | 9,540 |
| 1986 | 95,974 | 125,425 | 95,974 | 9,171 | 4,071 | 3,468 | 12,742 |
| 1987 | 95,412 | 112,359 | 95,412 | 8,852 | 4,094 | 3,395 | 605 |
| 1988 | 157,221 | 174,446 | 157,221 | 8,528 | 4,116 | 3,322 | 1,259 |
| 1989 | 114,099 | 130,273 | 114,099 | 8,198 | 4,136 | 3,250 | 591 |
| 1990 | 61,225 | 78,297 | 61,225 | 1,966 | 8,390 | 6,416 | 300 |
| 1991 | 31,523 | 55,728 | 31,838 | 1,895 | 12,483 | 9,289 | 223 |
| 1992 | 31,724 | 62,853 | 32,358 | 1,824 | 16,501 | 11,949 | 221 |
| 1993 | 26,286 | 62,207 | 27,074 | 7,016 | 16,354 | 11,521 | 241 |
| 1994 | 34,981 | 70,711 | 36,381 | 6,733 | 16,202 | 11,104 | 291 |
| 1995 | 43,204 | 78,900 | 45,364 | 6,451 | 16,045 | 10,696 | 344 |
| 1996 | 28,634 | 62,843 | 30,352 | 6,169 | 15,883 | 10,297 | 141 |
| 1997 | 35,136 | 69,315 | 37,595 | 5,887 | 15,717 | 9,908 | 208 |
| 1998 | 42,131 | 76,354 | 45,501 | 5,604 | 15,546 | 9,528 | 175 |
| 1999 | 50,581 | 85,250 | 55,133 | 5,322 | 15,371 | 9,156 | 267 |
| 2000 | 64,376 | 100,206 | 70,813 | 5,040 | 15,191 | 8,794 | 368 |
| 2001 | 89,196 | 128,219 | 99,008 | 4,914 | 15,262 | 8,584 | 451 |
| 2002 | 77,899 | 116,113 | 87,247 | 4,788 | 15,330 | 8,376 | 372 |
| 2003 | 63,285 | 100,106 | 71,511 | 4,662 | 15,397 | 8,169 | 366 |
| 2004 | 64,727 | 102,135 | 73,789 | 4,536 | 15,462 | 7,965 | 384 |
| 2005 | 74,989 | 114,372 | 86,237 | 4,410 | 15,525 | 7,762 | 437 |
| 2006 | 57,047 | 94,006 | 66,175 | 4,284 | 15,586 | 7,561 | 400 |
| 2007 | 53,015 | 89,585 | 62,028 | 4,158 | 15,646 | 7,362 | 392 |
| 2008 | 58,242 | 96,038 | 68,726 | 4,032 | 15,703 | 7,165 | 412 |
| 2009 | 65,848 | 105,446 | 78,359 | 3,906 | 15,759 | 6,970 | 452 |
| 2010 | 69,777 | 110,437 | 83,726 | 3,780 | 15,709 | 6,733 | 489 |

**Appendix Table A2:** Reconstructed catch (t) by major taxa for Ukraine, 1950-2010. 'Others' includes 58 taxa.

| Year | *Engraulis encrasicolus* | *Sprattus sprattus* | *Clupeonella cultriventris* | Gobiidae | *Mytilus galloprovincialis* | *Trachurus mediterraneus* | Other |
|---|---|---|---|---|---|---|---|
| 1950 | 9,074 | 179 | 12,596 | 1,288 | 1,720 | 1,714 | 24,443 |
| 1951 | 14,286 | 254 | 14,685 | 3,923 | 1,736 | 1,731 | 23,426 |
| 1952 | 9,931 | 104 | 13,760 | 3,768 | 1,767 | 1,747 | 23,465 |
| 1953 | 7,696 | 104 | 14,969 | 2,896 | 1,752 | 1,763 | 24,417 |
| 1954 | 3,520 | 657 | 11,626 | 4,248 | 1,768 | 1,779 | 25,088 |
| 1955 | 1,479 | 119 | 6,194 | 7,271 | 1,918 | 1,796 | 23,773 |
| 1956 | 1,766 | 642 | 1,821 | 9,041 | 1,993 | 1,812 | 24,771 |
| 1957 | 3,083 | 478 | 298 | 12,020 | 1,905 | 1,828 | 23,499 |
| 1958 | 4,265 | 313 | 343 | 15,148 | 1,950 | 1,845 | 19,587 |
| 1959 | 6,731 | 388 | 269 | 12,694 | 1,996 | 1,861 | 20,368 |
| 1960 | 5,331 | 179 | 463 | 9,479 | 1,996 | 1,877 | 21,833 |
| 1961 | 11,080 | 45 | 716 | 8,607 | 1,967 | 1,894 | 23,278 |
| 1962 | 11,994 | 269 | 1,209 | 10,168 | 2,550 | 1,910 | 19,343 |
| 1963 | 13,759 | 149 | 3,522 | 6,177 | 2,834 | 1,926 | 26,444 |
| 1964 | 11,479 | 552 | 7,208 | 13,186 | 3,731 | 1,943 | 19,409 |
| 1965 | 10,169 | 597 | 11,089 | 9,180 | 3,806 | 1,959 | 19,652 |
| 1966 | 19,231 | 298 | 13,417 | 7,995 | 2,867 | 1,975 | 18,684 |
| 1967 | 20,055 | 194 | 12,581 | 5,630 | 2,987 | 1,992 | 19,364 |
| 1968 | 23,819 | 254 | 8,641 | 4,490 | 3,047 | 2,008 | 18,425 |
| 1969 | 12,898 | 90 | 1,194 | 2,648 | 3,033 | 2,024 | 17,884 |
| 1970 | 34,674 | 357 | 4,564 | 2,000 | 2,747 | 2,396 | 20,261 |
| 1971 | 21,566 | 854 | 3,410 | 1,719 | 3,023 | 4,249 | 18,317 |
| 1972 | 12,162 | 893 | 518 | 1,989 | 4,393 | 13,200 | 18,258 |
| 1973 | 32,209 | 887 | 2,861 | 1,957 | 2,746 | 9,379 | 18,368 |
| 1974 | 57,970 | 482 | 4,564 | 1,791 | 3,914 | 3,220 | 19,194 |
| 1975 | 45,687 | 3,046 | 4,751 | 1,745 | 3,794 | 3,471 | 20,140 |
| 1976 | 98,251 | 6,488 | 3,070 | 1,502 | 4,315 | 10,700 | 19,682 |
| 1977 | 79,569 | 8,321 | 384 | 1,530 | 2,864 | 4,155 | 19,126 |
| 1978 | 54,119 | 22,307 | 4,761 | 1,447 | 10,060 | 2,175 | 24,545 |
| 1979 | 51,154 | 39,556 | 6,763 | 1,552 | 13,972 | 2,249 | 34,938 |
| 1980 | 59,814 | 50,950 | 3,808 | 1,575 | 16,665 | 2,133 | 34,069 |
| 1981 | 40,978 | 51,558 | 4,481 | 1,730 | 17,738 | 1,908 | 32,859 |
| 1982 | 54,485 | 41,597 | 4,617 | 1,656 | 17,016 | 2,910 | 30,931 |
| 1983 | 57,786 | 23,764 | 1,784 | 1,646 | 16,520 | 7,205 | 24,214 |
| 1984 | 80,857 | 22,164 | 1,213 | 1,824 | 12,468 | 4,998 | 25,423 |
| 1985 | 41,586 | 25,875 | 1,360 | 1,719 | 6,135 | 22,099 | 24,159 |
| 1986 | 53,144 | 36,016 | 1,097 | 2,014 | 2,401 | 3,156 | 27,598 |
| 1987 | 41,559 | 43,158 | 1,471 | 2,137 | 5,748 | 1,954 | 16,333 |
| 1988 | 76,589 | 39,800 | 23,571 | 3,328 | 2,138 | 1,910 | 27,110 |
| 1989 | 16,531 | 63,239 | 24,922 | 2,490 | 2,375 | 1,862 | 18,854 |
| 1990 | 17,761 | 33,174 | 2,802 | 2,126 | 3,811 | 2,368 | 16,256 |
| 1991 | 2,561 | 11,205 | 14,938 | 2,982 | 2,699 | 3,383 | 17,961 |
| 1992 | 12,821 | 11,722 | 3,874 | 3,589 | 3,418 | 4,378 | 23,051 |
| 1993 | 13,939 | 9,429 | 1,563 | 4,510 | 3,431 | 4,607 | 24,728 |
| 1994 | 17,330 | 13,120 | 4,438 | 4,642 | 3,376 | 4,505 | 23,299 |
| 1995 | 20,137 | 15,979 | 7,360 | 4,455 | 3,678 | 4,404 | 22,889 |
| 1996 | 5,204 | 21,963 | 1,150 | 4,397 | 3,255 | 4,301 | 22,572 |
| 1997 | 10,675 | 21,623 | 1,347 | 4,419 | 3,091 | 4,206 | 23,955 |
| 1998 | 4,719 | 32,705 | 2,760 | 4,688 | 2,936 | 4,101 | 24,446 |
| 1999 | 6,510 | 31,869 | 9,362 | 5,089 | 2,955 | 4,002 | 25,463 |
| 2000 | 18,600 | 35,921 | 7,885 | 5,273 | 2,832 | 3,904 | 25,791 |
| 2001 | 19,065 | 54,394 | 20,255 | 6,103 | 2,762 | 3,757 | 21,883 |
| 2002 | 15,010 | 50,963 | 13,753 | 8,538 | 2,746 | 3,647 | 21,455 |
| 2003 | 15,312 | 35,458 | 8,991 | 12,066 | 2,720 | 4,317 | 21,242 |
| 2004 | 11,157 | 35,219 | 6,910 | 18,940 | 2,689 | 3,642 | 23,578 |
| 2005 | 8,395 | 41,063 | 13,831 | 18,265 | 2,693 | 3,566 | 26,559 |
| 2006 | 9,356 | 24,718 | 9,882 | 16,461 | 2,828 | 3,602 | 27,158 |
| 2007 | 10,720 | 21,075 | 10,740 | 13,917 | 2,831 | 3,157 | 27,144 |
| 2008 | 13,450 | 24,911 | 11,586 | 15,333 | 2,901 | 3,206 | 24,651 |
| 2009 | 17,886 | 29,279 | 10,350 | 14,261 | 3,336 | 2,938 | 27,395 |
| 2010 | 27,437 | 29,582 | 8,930 | 15,737 | 3,006 | 2,712 | 23,033 |