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MARINE FISH CATCHES IN SLOVENIA BETWEEN 1950 AND 2010

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ABSTRACT

Total marine fisheries landings in Slovenia from 1950 to 2010 were reconstructed with the aim to get as detailed and species specific estimate of catch for this period as possible. Main sources of data were from the Statistical Office of the Republic of Slovenia, Ministry of Agriculture and Environment, and data gathered from interviews with fishers and from the archives of commercial fishing companies. Species breakdown was carried out for each commercial or higher taxonomic category. Recent data on landings from 2005-2012 and the data from the monitoring of fishery resources from the period 1995-2013 were used to determine the relative importance of each species. Additionally, the relative importance of each species for each type of fishing gear was calculated. Accordingly, the species-specific catchability of fishing gear was calculated. Landed quantities of commercial or higher taxonomic categories were multiplied by the relative importance of each species in order to achieve an estimate of quantities landed. The total discard for each species and fishing gear was calculated based on data from observers on board of fishing vessels. Reconstructed landings and discards quantities allowed us to estimate a species specific total reconstructed catch within the investigated period. Since the data on discards is continually updated and included in the dynamic update of catch estimates, the catch quantities on the website are updated accordingly and accessible at www.biosweb.org/index.php?task=stat#tabs-year. Overall, results from the current reconstruction show an increasing trend in the catch up to a peak of an estimated 8,700 t in 1983, after which catches declined dramatically to just under 900 t in 2010. The majority of the catch is from the industrial sector and discards were estimated to be approximately 9% of the total reconstructed catch.

INTRODUCTION

Within the investigated period, Slovenia (Figure 1) was part of different political regimes and institutional frameworks which all affected the way fishing as well as collecting and fisheries data reporting was conducted. Before WWII and until 1950, the fisheries catches in the coastal region of Slovenia amounted to around 2,200 to 2,500 t·year^{-1}. This was followed by a drop to around 560 t in 1952 due to politically induced emigration of the Italian population from Slovenia (Delise, 2010). In the early 1950s, Slovenian companies started to re-launch the fisheries by building new fishing boats and spreading its activities to Istrian (Croatia) fishing grounds. Fishing boats were wooden, 17 m purse seiners, fishing predominately European sardines (*Sardina pilchardus*) and European anchovies (*Engraulis encrasicolus*).

Figure 1: Map of Slovenia with its Exclusive Economic Zone (EEZ).

The next big step towards an increase of catches was the introduction of pelagic trawlers (fishing as pair trawlers) in the early 1980s, which replaced the purse seiners being sold to private fishers (Slovenians and Croatians) and partially turned into bottom trawlers. The pelagic trawler fleet amounted to 4 pairs (i.e., 8 boats) by the end of the 1980s, as the fleet was sold and only one pair of vessels remained up to 2012 (*Riba I* and *Riba II*) when they were scrapped under EU measures.

As a former Yugoslav republic, Slovenia performed its fishing activities not only in the Slovenian waters but also in the waters off Croatia until the dissolution of the Federal People's Republic of Yugoslavia in 1991. The fishing in Croatian waters was mostly limited to the Northern Adriatic, though bigger fishing vessels conducted occasionally fishing south to the island of Vis. Thus, the reported catches until 1991, though being reported as Slovenian catch, do not reflect solely the catches from the Slovenian waters. This should be kept in mind when trying to assess and allocate the per species catch of former Yugoslavia republics.

From 1991 onward, Slovenia reported its catches separately. In the case of Slovenia, these are reported to the Statistical Office of Slovenia. From 2004 onwards, Slovenia became part of the European Union and its fish catch per species, in accordance to FAO "ASFIS List of Species for Fishery Statistics Purposes«, are being reported by fishers via log books. An earlier attempt to allocate total Yugoslavia catch to specific republics was undertaken by Rizzo and Zeller (2007). Nevertheless, none of the reporting included data of by-catch or discards. Also no official data of recreational and subsistence

catch were (and in some extent are still not) available. Personal investigation and interviews with fishers were carried out in order to obtain as much reliable data as possible.

Basic maritime characteristics of the Gulf of Triest

The Gulf of Triest is the north-eastern most part of the Northern Adriatic. Its location and geo-morphological features give it sometimes extreme maritime characteristics. The Slovenian coastal sea consists essentially of only two major gulfs, Gulf of Koper and Gulf of Piran. Less than half of the bay is about 20 m deep, in less than a seventh the gulf depth ranges from 10 to 15 m and more than a fifth of the bay is shallower than 10 m (Orožen Adamič, 2002). All this is reflected in the significant and relatively rapid fluctuations in sea temperature, salinity, oxygen content and other parameters. The temperature ranges often from less than 9° C to higher than 26° C. The maximum measured temperature was recorded on 17th July 2010 at a depth of 2 m at 30.4° C, the lowest in February 1956 at 1.6° C (Bernot, 1990). From mid-June to early October, the mean daily sea temperature doesn't fall below 21° C.

Salinity of the Northern Adriatic and especially in the Gulf of Triest is subject to greater fluctuations than in the Middle and South Adriatic Sea. This is the result of its geo-morphological features with many freshwater tributaries that flow into this part of the Adriatic. Salinity during the year ranges between 33 and 37‰, the highest values are reached in September and February, the lowest due to the influx of fresh waters in May and December.

All these parameters influence the composition of the ichthyofauna and other marine organisms in this part of the Adriatic, which certainly are one of the key factors that have to be taken in consideration.

METHODS

Data review

The reconstructed data represents an estimate of total catch by Slovenian fishing vessels. Catch volumes are reported as whole numbers with kilograms as the unit of measure, however all data presented here is in tonnes unless specified otherwise. The data are broken down by year, type of fishing gear used, species categories, and species. Detailed data are illustrated in tables. Numerals are rounded to the nearest whole number, thus quantities of less than 0.5 kilograms are displayed as '0'. Such small quantities are a result of the data reconstruction since higher taxonomic and commercial categories were broken down by species and fishing gear. Empty data fields in the table are indicated with '/'.

Reconstruction of landings data from the Statistical Office of the Republic of Slovenia

The aim of the landings reconstruction was to breakdown the statistical data of the quantities landed between species and fishing gear. Despite the different levels of data aggregation, the data from two periods was reconstructed in the same manner.

The period 1939, 1948-1981

The time series data are comprised of the year 1939 and the years from 1948 to 1981. The data were published in the Statistical Yearbooks of the Republic of Slovenia issued during the period from 1955 to 1982. Data on landings were presented on an annual basis and aggregated in different years in different categories: 'blue fish'; 'other fish, crustaceans, and mollusks'; 'marine fish, crustaceans, and mollusks'; 'cephalopods, crustaceans, and mollusks'; 'crustaceans and shellfish'; 'other fish'; 'pelagic fish'; 'fish'; 'other fish'; and 'mixed fish'.

Period 1982-2004

The time series data are comprised of the years 1982 to 2004. For the period up to 1997, information provided by the Statistical Office of the Republic of Slovenia was used. The data were prepared in the same form as they were later published in reports. For the period 1998 to 2004, we used data published in 'Rapid Reports 15 - Agriculture and Fishing', issued during the period 1999 to 2005. All data were recorded on a monthly basis and broken down by species or higher taxonomic categories.

Preparation of data for reconstruction

Taxonomic breakdown of higher categories

For each commercial or higher taxonomic category, we determined the associated species for each year and assessed the relative importance of each species. We used recent data on landings from 2005-2012 and the data from the monitoring of fishery resources from the period 1995-2013, carried out by the Fisheries Research Institute of Slovenia. The relative importance of each species was evaluated according to the landed weight.

The number of species in the period 1939-1981 varied from 92 to 99. The reason for the change in the number of species was the different commercial categories used in the original data, which we analyzed with a different number of species. In the period 1982-2004, the number of species varied from 64 to 108. During this period, detailed information was already available, mostly at the species level and sometimes at the level of higher taxonomic categories.

The importance of fishing gear in each year

The importance of fishing gear has changed over time. Some fishing gears have been abandoned, new ones introduced, while others have remained in use throughout. For each year in the period 1972-2004, based on historical data on the number of active vessels, we assessed the relative importance of each type of fishing gear. For the period 1939-1971, we used the relative importance of each type of fishing gear in 1972. Historical data were gathered from interviews with fishers and from the archives of commercial fishing companies.

The number of active vessels was determined by counting vessels that used purse seines (PS), bottom otter trawls (OTB) and midwater pair trawls (PTM). The relative importance of all the other gears is based on the difference between the published landing data and landing by the Riba Company,

estimated at 0.05. The share of 0.05 was further divided into shares, which in the period 2005-2012 had the remaining fishing gear.

The importance of species for each type of fishing gear

Based on data from log-books we have produced a list of species caught by each type of fishing gear. The relative importance of each species for each type of fishing gear was calculated on the basis of data on the quantities landed in the period 2005-2012. The exception was the relationship between the European pilchard (*Sardina pilchardus*), European anchovy (*Engraulis encrasicolus*), and European sprat (*Sprattus sprattus*), which was calculated for the period 1939-1981, according to the data on landings by the company Riba between 1971-1976. In that period, the landings of the company Riba accounted for at least 92.9% of the total commercial landings. If the data from the log-books contained higher taxonomic categories, we broke these down into species based on data from the monitoring of fishery resources.

Reconstruction

List of species and assessment of the quantities landed

Commercial or higher taxonomic categories were divided into related species, where the landed quantity was multiplied by the relative importance of each species. In this manner we determined for each species an estimate of quantities landed.

Species-specific catchability of fishing gear

Species-specific catchability of fishing gear in a calendar year represents the weight which in a given year affects the type of fishing gear on a species. We calculated it from the data on the importance of fishing gear in a given year and the importance of species for each type of fishing gear.

From the importance of fishing gear in a given year we have compiled a diagonal matrix O, and from the importance of species for each type of fishing gear the matrix V. The species-specific catchability of fishing gear was calculated as

$$L = \hat{O} \times V$$

For each year, species, and the type of fishing gear the sum of species-specific catchability was always equal to one.

Breakdown of quantities of species landed between types of fishing gear

The quantity of species landed was broken down between fishing gear in a way so that the landed quantity of species was multiplied by the specific catchability of the fishing gear.

Reconstruction of landings data from the Ministry of Agriculture and Environment

Data on landings were collected from log-books. Most of the data were species-specific, with the exception of the data on landings related to higher taxonomic categories. The aim of the landings

reconstruction was the breakdown of higher taxonomic categories on the species and the allocation of landed quantities to that species.

The period after 2005

Time series data began with the year 2005 and are updated regularly. We used data from the Fisheries Information System (InfoRib), managed by the Ministry of Agriculture and the Environment. The data are broken down to levels of the fishing trip, fishing gear, and species or higher taxonomic categories.

Preparation of data for reconstruction

Breakdown of higher taxonomic categories on species and determination of their relative importance

The breakdown was done similarly to that of the data from the period 1939-2004. In this case, the breakdown of the higher taxonomic categories also took into account fishing gear. Selectivity of fishing gear and the area in which it was used determine the range and importance of the species that make up a particular higher taxonomic category. The list and the importance of the species were estimated from species-specific data for each type of fishing gear. Where this was not possible, we used data from the monitoring of fisheries resources.

Reconstruction

List of species and estimates of their quantities landed

Higher taxonomic categories were divided into related species, where the landed quantity was multiplied by the relative importance of each species for the type of fishing gear. In this way we determined for each type of fishing gear and species an estimate of the quantities landed.

Discards

The objective was an assessment of a catch through reconstructed data of landings. Since catch is the sum of landings and discards, we first needed to assess the weight of discards, which was then added to the weight of the landings. The total discard for each species and fishing gear was calculated based on data from observers on board of fishing vessels.

$$D = L\left(\frac{d}{k}\right)$$

D – total discards; L – total landings; d – sum of observed discards; k – sum of observed retained catch.

Data from observers on board of fishing vessels have been available since 2006 and are updated regularly. Samples were taken on fishing vessels that used the most important types of fishing gear: purse seine (PS), bottom otter trawls (OTB), midwater pair trawls (PTM), trammel nets (GTR) and set gillnets (GNS). In the period 2005-2012, landings with these fishing gears accounted for 99.1% of total landings.

If we were unable to estimate discards, we used landed quantities as a proxy. This occurred in three cases: (1) for species caught by fishing gear that was not subject to sampling; (2) for species which weren't caught during sampling; and (3) when it was clear from the data sampling that a species was completely discarded, but still cited in the landing.

Since the data on discards is continually updated and included in the dynamic update of catch estimates, the catch quantities on the website are updated accordingly.

Subsistence

Subsistence fishing was estimated by applying 50% of Croatia's subsistence per capita rate (Matić-Skoko *et al.* 2014) to Slovenia's coastal population for each year 1950-2010. Coastal population was calculated as 1% of Slovenia's population, based on anchor points from (CIESIN, 2012*)*. The species breakdown of Croatia's subsistence catch in each year 1950-2010 (Matić-Skoko *et al*. 2014) was applied to the estimated annual subsistence catch.

Recreational

Recreational data was available in the national database for 2011 and 2012. Therefore we assumed that recreational catch was 0 in 1945 and interpolated linearly to the data point for 2011. Species breakdown was based on the percentage contribution of each taxa in 2011, which we applied to the estimated recreational total for 1950-2010.

Spatial Allocation

In order to address the issue of Slovenia fishing heavily outside of their EEZ equivalent waters in the years prior to the dissolution of Former Yugoslavia, it was estimated that 90% of commercial catches were taken from what are now Croatia's waters from 1950-1991, and the remaining 10% was caught in what are now Slovenia's waters. We understand that this is a broad assumption and this is an area that requires further investigation in the future.

RESULTS AND DISCUSSION

The fisheries in Slovenia in the period from 1950 to 2010 can be divided into four periods:

- The immediate post-WW II period: from 1945 to 1956 – the period of economic and fisheries re-establishment ;
- The period from 1957 to 1980 – period of fisheries development, wooden purse seine vessel construction;
- The period from 1981 to 1991 – period of industrial fisheries with pelagic trawlers and bottom trawlers; and
- The period from 1992 to the present– Slovenian independence, loss of fishing grounds.

Each of above mentioned periods had its type of fishing fleet thus affecting not only the total fishing effort and catch but also the species of fish being fished.

As mentioned earlier, there was a political induced emigration in the post-war period of the Italian population from this region which affected also Italian fishers who moved to Italy, and thus caused a decline of total catch to 600 t in 1952 (Figure 2).

Fisheries started to recover slowly after 1953 when new wooden fishing boats were constructed, mainly being used as purse seiners. These were about 17m long, and equipped with 80 to 200 hp diesel engines. At the same time, new equipment (i.e., echo sounders, electric generators for lighting, radio stations to communicate between fishing vessels...) was introduced to facilitate the fishing. Primarily small pelagic fish were fished, with sardines (*Sardina pilchardus*) and anchovies (*Engraulis encrasiholus*) being the basis for the canning industry located in the town of Izola. The fleet was based in Izola (now Slovenia) and other ports in the Istria region (now Croatia). In the winter period, when sardines and anchovies migrate south, the purse seine fleet switched to bottom trawling and gill net fishing, although their total “non pelagic” catch represented less than 0.8% of total catch. The total catch was rising to a peak of 5,400 t in 1976 (Figure 2).

The next significant step in the increase of total catches was the introduction of bigger pelagic trawlers at the beginning of the 1980s. There were 4 pairs of pelagic trawlers fishing small pelagic fish in the Northern and Central Adriatic Sea, occasionally also in the South Adriatic Sea. A couple of vessels moved to tuna fishing in the Central Adriatic Sea, in the late 1980s, this resulted in the peak of tuna catches (*Thunnus thynnus*) 1988. This period was characterized also by a maximum catch of 8,700 t being recorded in 1983 (Figure 2). In this period, wooden purse seiners switched to bottom trawling until 1990, the year just before the break-up of Yugoslavia (Figure 2). At the end of this period, most wooden purse seiners (and trawlers) were sold to Croatian fishers, so with the onset of pelagic trawler fishing only few wooden boats remained in Slovenia.

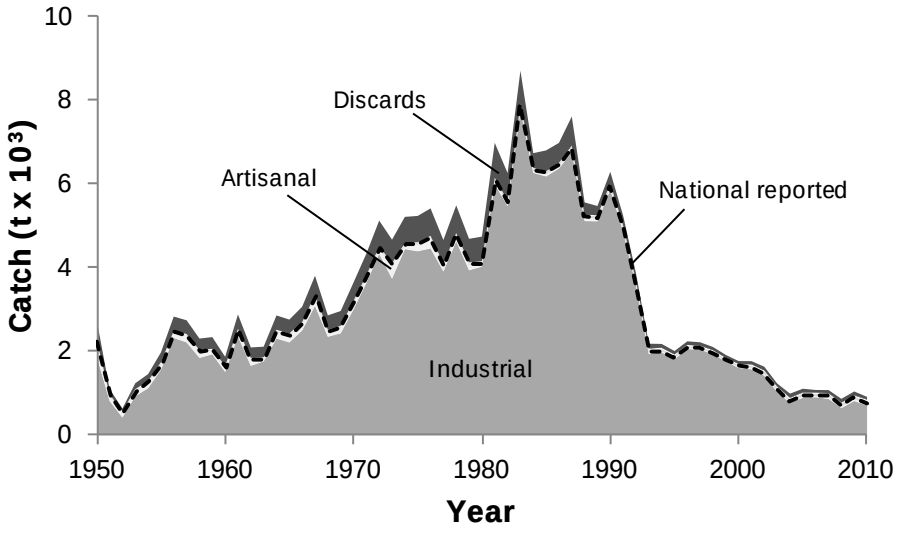

Figure 2. Reconstructed catch for Slovenia, 1950 to 2010 for Slovenia, by sector, with discards shown separately. National reported landings are overlaid as a line graph.

The most dramatic change in Slovenian commercial fisheries occurred after the dissolution of the Federal People's Republic of Yugoslavia in 1991. Slovenia lost access to its most important fishing grounds, which became Croatian national waters. In the first years following the dissolution of Yugoslavia, Slovenian fleet still tried to fish in the waters off the Istria peninsula, but this soon became impossible due to several disputes between Slovenia and Croatia. However, a drop in catches was noticed already some years before the dissolution of Yugoslavia. This is due to the fact that by the end of the 1980s and the beginning of the 1990s, the pelagic trawler fleet, owned by Riba Izola, was sold to Croatian fishers.

This change is reflected in the catch declining from 7,600 t in the late 1980s to around 2,100 $t \cdot year^{-1}$ in the mid-1990s and then to less than 1,000 $t \cdot year^{-1}$ by the end of the present time period (Figure 2).

Taxonomic composition

The reconstruction was able to assign catches to over 100 individual taxa belonging to different taxonomic groups including Gastropoda, Bivalvia, Cephalopoda, Crustacea, Chondrichthyes and Osteichthyes.

The Slovenian catch is mostly dependent on the catch of small pelagic fish although there is a wide variety of demersal species which are very important for the small scale coastal fisheries. The 'top' four species, belonging to small pelagic fish, accounted for 91% of total catch; these being sardine (*Sardina pilchardus*, 68%), anchovy (*Engraulis encrasicolus*, 11%), sprat (*Sprattus sprattus*, 9%) and Mediterranean horse mackerel (*Trachurus mediterraneus*, 3%) (Figure 3).

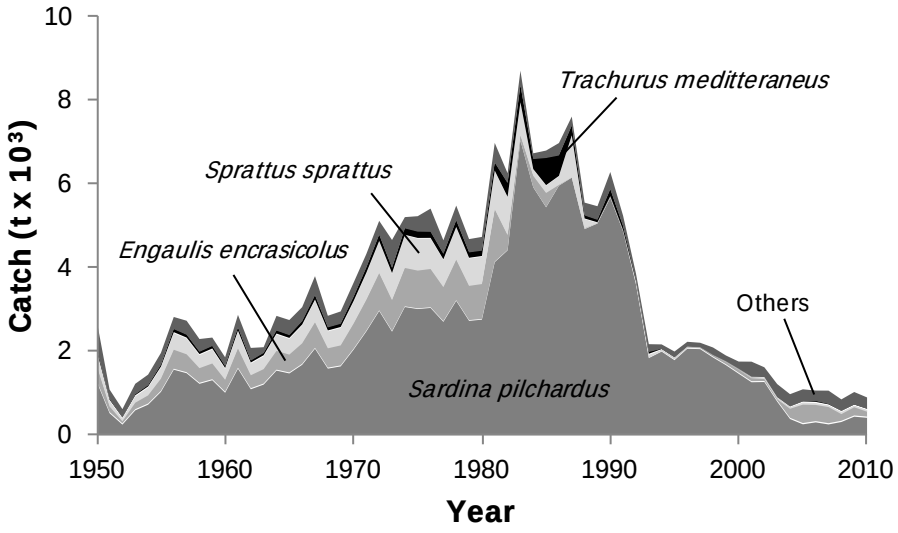

Figure 3. Taxonomic composition of reconstructed catches for Slovenia for 1950 to 2010. The grouping 'others' consists of 98 additional taxa not presented separately here.

By far the most important single species is sardine (*Sardina pilchardus*) whose catch increased from around 1,300 t in 1950 to a peak of 7,000 t in 1983, before declining to around 400 t by 2010 (Figure 3).

Sprat (*Sprattus sprattus*) catch rose more slowly, with the peak catches in 1981 and 1987, followed by a drop of catch which never recovered and in the late 2000s averages 40 t·year^{-1}. This is primarily due to the low economic value of sprat, which is not a prized species in Slovenia, and thus not popular or targeted. In the period from 1950 to 1988, sprat was used for fish meal production and export to Serbia. Sprat was fished with purse seiners as well as pelagic trawlers. Especially in winter time when sardine and anchovy migrate southern, sprat was fished, thus also enabling a steady fish supply for food consumption and prime material supply for the fish meal industry at the time being located in the town of Izola. Only a small part of the sprat catch was distributed for direct human consumption. With the end of fish meal production and cessation of sprat exports, the interest for sprat fishing decreased thus causing the drop in sprat catches. Thus, although in recent years there is a high abundance of sprat in the waters of the North Adriatic, there are low catches of this species due to its low economic value.

Anchovy and mediterranean horse mackerel catch have similar structure as sprat. Anchovy catch has recovered after a drastic drop from 350 t in 1985 to 35 t in 1986. The catch, still being unstable, reached its next peak of 470 t in 2005, still being fished mainly by the last pair of pelagic trawlers. The economic value of anchovy is higher than sprat and it is sold fresh to Slovenian and mainly to Italian market. The excess catch was in the past used by the processing industry, mostly for salting and filleting. Although this is a well known specialty, its production ceased in the late 1980s.

Examination of the demersal catches showed the highly variable characteristics of North Adriatic ichtyofauna and benthic organisms (Figure 4). There were 86 taxa reported from different taxonomic groups. Although they represent a minor share of total catch in the investigated period, these are species which are very important for the small-scale coastal fisheries (i.e., artisanal and subsistence sectors). Many of them have high economic value and though being fished in relative low quantities are of great importance for the local fishers economic livelihoods.

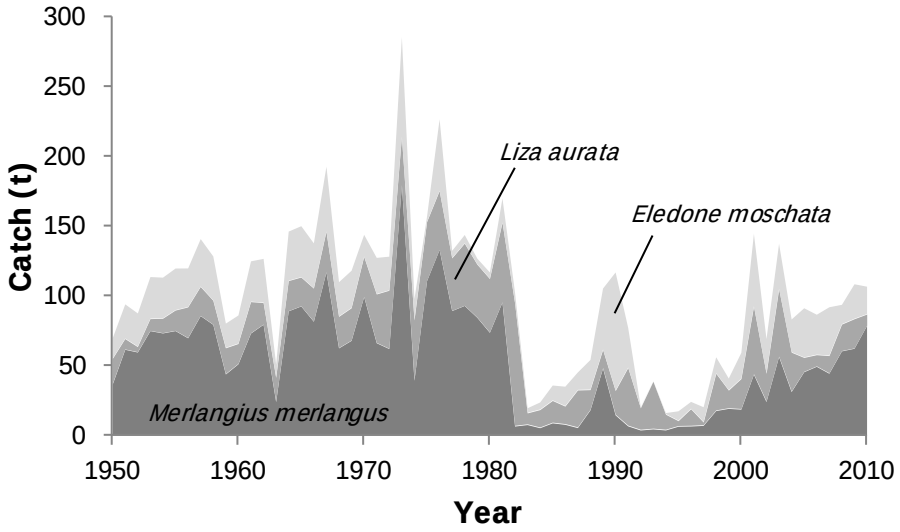

Figure 4: Catch of the three major benthic species in Slovenia from 1950 to 2010.

The three most important species are the whiting (*Merlangius merlangus*), the musky octopus (*Eledone moschata*), and the golden grey mullet (*Liza aurata*; Figure 4). Whiting and musky octopus were (and still are) fished by bottom trawlers. Golden grey mullet was traditionally fished in the Portorose fish reserve during winter months representing an important income for fishers in otherwise bad fishing winter months.

The increase in landings at the beginning of the 1980s of these species is mainly due to the introduction of bottom trawlers. We should mention here also poor cod (*Trisopterus minutus*) being fished with whiting (Bolje, 1991). The landings of this fish have been surpassed by whiting landings in the last 15 years as the whiting catch has risen considerably and is now approaching some 70 t·year^{-1}.

There is a peak of 220 t of picarel (*Spicara flexuosa*) catch in 1983. Picarel is a common inhabitant of North Adriatic waters and present in landings throughout all years. We could not verify deeper this reported landing which could be a data mistake. As at the time there were no logbooks, we could not search deeper in this figure. We left it as reported but would need further investigation in order to confirm or deny its credibility.

Among demersal species with relative low catch values but high economic value, we should mention common sole (*Solea solea*), seabass (*Dicentrarchus labrax*), common pandora (*Pagellus erythrinus*), seabream (*Sparus aurata*) and turbot (*Psetta maxima*). Although these species are present all year

round in catches, some have seasonal peaks due to migration patterns. Such is the example of sole which good autumn catch may have positive effect on the local small scale fishery economy.

Elasmobranchii (sharks and rays) is an interesting group of fish in the Slovenian catch data. Besides its economic value for the local fisheries economy their study is interesting also for the understanding of the environment processes and changes in the North Adriatic ichthyofauna. Among them, the most important species is smooth-hound (*Mustelus mustelus*) (Figure 5).

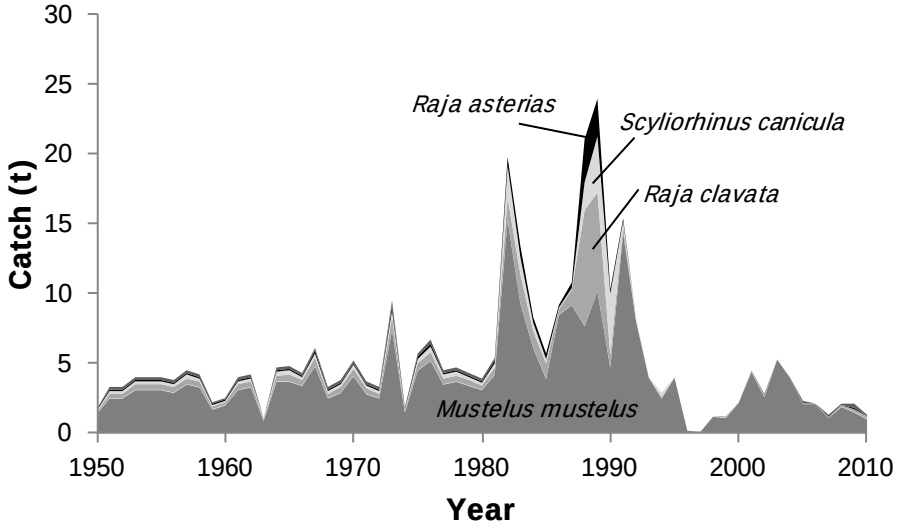

Figure 5: Major taxa of sharks and rays (Elasmobranchii) catch in Slovenia between 1950 and 2010.

Smooth-hound is cought mainly by gill nets with small fishing boats. The main drop in catch is due to cessation of fishing activities in Istrian waters, although yearly catches continue to decline.

CONCLUSIONS

The Slovenian fisheries catch passed through different socio-political periods, which are also reflected in the data history: from an artisanal pre-WWII fisheries to a well-developed industrial fleet, with substantial declines in catches after the dissolution of the former Yugoslavia, and associated loss of access to Croatian fishing grounds.

With this reconstruction we tried to estimate the total per species landings of Slovenian fisheries fleet, although the lack of specific catch and fleet data was an obstacle on this path. Further work on this matter, trying to achieve additional data source is a challenge for further investigation.

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