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RECONSTRUCTION OF TOTAL MARINE FISHERIES CATCHES FOR MAINLAND CHILE (1950-2010)

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ABSTRACT

Total reconstructed catches for Chile were estimated to be almost 193 million tonnes for the 1950-2010 period, increasing from 138,000 t in 1950, to a peak of 6.8 million t in 1994, before declining to 4 million t in 2010. The discrepancy between the reconstructed total catch and the reported landings was fairly steady for the whole time period, with the reconstructed catch being 16% higher than SERNAPESCA reported landings and 24% more than data reported by FAO on behalf of Chile. Reconstructed total landings in Chile show that the main pelagic species (*Trachurus murphy*, *Engraulis ringens*, *Sardinops sagax* and *Clupea bentincki*), which are mostly used for fishmeal production, account for 82% of total landings. Government monitoring and reporting systems in Chile rely on landings and tend to overlook discards, which account for a total 2.6 million tonnes (1.3% of the total catch). For the period 1950-2010, we find that most of the unreported catches are from the industrial sector. The implementation of GPS systems since 2000 for monitoring represents an improvement to fisheries management in Chile. Artisanal fleet under-reporting has increased mostly due to the fisheries crisis which has lowered artisanal quotas to a historical minimum.

INTRODUCTION

The Republic of Chile is a long but narrow country, with the Andes flanking the eastern border and the Southern Pacific and Antarctic Oceans to the west (Figure 1). This geography has resulted in a population with strong ties to the sea. Although fishing accounts for only 0.4% of the GDP of Chile and is dwarfed by mining, Chile's overall fisheries landings in 2010 were the seventh largest in the world (OEDC 2012). In addition to the mainland EEZ, which encompasses approximately 2 million km^2, Chile owns several oceanic islands: the Desventuradas Islands, 850 km from the coast (EEZ area: 449,805 km^2); the Juan Fernández, Felix and Ambrosio Islands, 890 km from the coast (EEZ area: 502,490 km^2); and Easter Island, over 3,500 km from the mainland (EEZ area: 720,395 km^2), which is known as the most remote inhabited island in the world. Here, the Chilean islands are treated separately, with Desventuradas and Juan Fernández addressed by Zylich and van der Meer (2015) and Easter Island covered by Zylich *et al.* (2014).

Figure 1. Map of Chile and its oceanic islands with their respective EEZ boundaries shown.

Mainland Chile is divided into 15 administrative 'regions', all but one of which are coastal. The northern regions include Arica, Tarapaca, Antofagasta, Atacama, Coquimbo, and Valparaiso, while the southern states include Libertador, Maule, Biobio, Araucania, Los Rios, Los Lagos, Aisen, and Magallanes. In terms of biology and biodiversity, Chile's EEZ consists of four main zones: the north, central, southern and austral zones, each characterized by specific environmental and biological conditions (Peña-Torres 1997).

The mainland EEZ component largely overlaps with the southern half of the Humboldt Current LME. The Eastern Boundary Humboldt Current (EBHC) is recognized as one of the largest and most productive marine ecosystems in the world (Mann and Lazier 1991), and is highly variable due to El Niño events. The EBHC is a classical eastern boundary zone (Parrish *et al.* 1983; Werner *et al.* 2008), where strong coastal winds drive water northward and off the coast, resulting in upwelling of deeper nutrient-rich waters and thereby allowing for an extraordinarily strong primary production (Carr and Kearns 2003). The large amount of plankton in this region allows, in turn, for a high abundance of zooplankton, which eventually translates to fish and other vertebrates, notably seabirds and marine mammals.

Thus Chile, similarly to Peru, which occupies the northern part of the Humboldt Current LME, is one of the richest countries in the world in terms of marine fisheries resources. The high fish catches that this allows, however, are concentrated on a few species, notably forage fish, sardine and anchoveta, as well as chub and horse mackerel – most of which are fed to reduction plants, i.e., turned into fishmeal and related products. Pelagic species represent 85% of the total catch, with anchoveta and South American pilchard comprising 42% of the total catch. Demersal species account for only 3.6% of the total catch and include species such as Pacific hake and Patagonian grenadier, which are of higher value and are exported as frozen or chilled seafood products.

Fisheries in Chile consist of large-scale industrial fisheries and small-scale artisanal fisheries. Industrial fisheries operate vessels greater than 18 m in length, and correspondingly, small-scale (or artisanal) fisheries refer to landings from vessels under 18 meters in length. Both industrial and artisanal fishers must be registered with the National Registry of Industrial Fisheries (NRIF) and National Registry of Artisanal Fisheries (NRAF), respectively. Over the last decade, an average of 4.76 million tonnes per year was landed in Chile. While artisanal fisheries have increased their catch, the catches of the industrial fisheries have declined, such that overall landings have decreased by an estimated 17% in the last decade (SONAPESCA 2008; CENDEC 2010).

Industrial fisheries

In terms of bulk, the major Chilean industrial fisheries are for small pelagic species, both in the north and central part of the country. In the northern regions, anchoveta account for most of the landings, followed by jack mackerel and American mackerel (OEDC 2009). The largest quantities of mackerel and sardine are caught in central and southern Chile. Up to 80% percent of the industrial landings are used by the local fishmeal industry to produce fishmeal and fish oil for salmon aquaculture, while the rest is exported chilled or frozen. In 1994, industrial landings reached a record of 7.5 million t (Figure 6) and have declined since, reaching 3.6 million t in 2010.

Chilean jack mackerel (*Trachurus murphyi)* and chub mackerel (*Scomber japonicus)* are also caught in increasing quantities outside the Chilean EEZ, a relatively recent development, which has required large vessels with substantial refrigeration capacities. The rest of the industrial fleet is composed of several factory vessels, which are allowed to fish only in the Austral zone and in international waters, and which target South Pacific hake, eels and Patagonian toothfish (i.e., 'Chilean seabass') for local consumption and export (OEDC 2012; Hugo Arancibia, pers. comm.).

Artisanal fisheries

Artisanal fisheries are widely practiced along the Chilean coastline, with participation having substantially increased in the past 10 years. Today, these fisheries contribute almost half (46%) of the fish and crustacean landings in the country. Artisanal fisheries land their products in coastal villages ('caletas') or at wharfs, most of the latter located in rural areas where most livelihoods depend directly on fishing (CENDEC 2010). Historically, artisanal fisheries have targeted shellfish such as Chilean abalone, *loco* (*Concholepas concholepas*, a snail species), mussels, and demersal fish (Gelcich *et al.* 2005). Most of the artisanal landings are used for local consumption as the *caletas* generally lack freezing capacity. The remaining fractions of the artisanal landings are directly sold to seafood exporters.

Artisanal fishers are required to register with the NRAF in the particular area where they reside and can only operate in that area. They are allocated exclusive rights to waters up to 5 nautical miles from shore. In the most southern regions, artisanal fishers are also allowed to fish in 'interior marine waters' (i.e., waters out to 12 nm) where industrial fisheries are not permitted to operate. Artisanal fishers are typically allocated free access to these zones, but once the stock is considered 'fully exploited', access can be limited (OEDC 2009).

As a result of the overexploitation of benthic resources, such as Chilean abalone or *loco,* an area-based cooperative system was introduced after the fishery was officially closed in 1989. This new form of management was established in 1997 and created the Management Areas for the Exploitation of Benthic Resources (MAERB). Through this policy, the Undersecretary of Fisheries (SUBPESCA) gives formal property rights to certain natural resources in defined geographical areas of the seabed to registered syndicates. This includes the right to exclude non-members from exploiting that area of the seabed (Gelcich *et al.* 2005). After this measure was established, the stocks recovered, and now provide steady incomes for some 50,000 artisanal fishers (Anon. 2012). This policy model is now a global example of successful spatial property rights management in fisheries.

Since December 2013, a new fisheries law was established; the law considers several measures for fisheries recovery, such as quotas being recommended by scientists and not stakeholders of the fisheries and the creation of management committees which will establish new administration measures for the recovery of overexploited fisheries, amongst others. With the new law, artisanal fishers will have for the first time an official distinction, where medium-sized boats (those between 12 and 18 meters in length) and boats that are less than 12 meters long will have satellite vessel monitoring systems (VMS) on board. The medium-sized boats represent only 10% of the artisanal fleet, but account for 90% of its catch.

Subsistence fisheries

According to the National Fisheries Service (SERNAPESCA) subsistence fishing is not practiced in Chile.

How data are gathered

The Chilean institutional structure governing the fisheries and aquaculture sector centers around three key organizations, with a number of other institutions providing additional research and enforcement support (such as the Navy). These three organizations have a degree of operational independence while performing a crucial and interlinked function within the broad institutional framework.

The Subsecretaria de Pesca (Undersecretariat of Fisheries, SUBPESCA or SSP) is positioned within the Chilean Ministry of Economy, and provides the policy settings and regulatory framework for the domestic management of the sector. It also manages policy direction and provides input into international fisheries issues.

SERNAPESCA is also based within the Ministry of Economy. It is responsible for executing national fisheries policy, for supervising its enforcement and for ensuring proper application of the legal rules and regulations on fishing. In practice, compliance is checked by Intertek Caleb Brett (Chile S.A.), acting on behalf of SERNAPESCA.

The Instituto de Fomento Pesquero (Fisheries Development Institute, IFOP) is the research arm of the institutional framework. The IFOP is a non-profit organization created in 1964 under a joint agreement between the Chilean government, the FAO, and the UN Development Program. It is the primary source of scientific advice to the SSP on fisheries and aquaculture agreement issues. Its work includes stock assessment, advising on total allowable catch levels for the wild fisheries, and the environmental and health aspects of aquaculture production. It draws a proportion of its funding from SUBPESCA but also has to compete for funding from a range of public funding sources.

SERNAPESCA is also the entity responsible for compiling fisheries data throughout the country. Artisanal fishers report their landings by writing down the weight and species caught. Since the year 2000, industrial fleets are equipped with GPS which provides a much better coverage and follow up of all fishing activities.

The methodology used by SERNAPESCA to compile data is not stated under any written protocol, thus the following description of data gathering, monitoring and corroborating was provided by a staff member of the statistical unit of SERNAPESCA. Fisheries landings declarations in Chile are done according to law 464 from 1995, where all fishing vessel owners, industrial and artisanal, must report their landings to the national fisheries' agency. They do this by specifying in handwriting the species, fishing area and volume of catch obtained at the time of landing. This form is filled in either by the fisherman himself or intermediary sellers. SERNAPESCA provides the forms in which the information must be specified. Forms are then returned to SERNAPESCA regional offices and are "validated" probing consistency to be archived electronically by staff members (Acevedo Villagra, pers. comm., SERNAPESCA, 2012). The given data are then available for monitoring. Only some declarations are verified in situ (depending on the region and catch volume); thus, inspections are constantly conducted by SERNAPESCA, external consultant agencies and certified government officers.

Data cross comparisons are performed amongst different stages along the value chain to account for data inconsistency and lack of coverage. The "Fisheries and Aquaculture Statistical Annuals" consider cross information of data gathered along the value chain and submitted by all the subsectors that constitute the fisheries industry. Detected data reporting errors along the information system are attributed to several factors such as: data not provided by informal subsectors, inconsistency in provided data in user declarations, and input errors in the translation from paper to electronic format. The detection of errors translates in a "statistical adjustment" which allows the aggregation in landing and catch values. These adjustments are generally found when examining cross information and the detection of unreported landings arise (fresh seafood sales, commercial industry etc).

For commercial species, this corroborating method is efficient and reliable, since anything that is sold or exported is tracked back to the initial point of landing. Nevertheless, for forage fish used to produce fishmeal, the methodology doesn't follow the regular path; thus, inspectors must trust the reports given by the industrial fleets. Therefore, we accounted for possible under-reporting in this fishery in our reconstruction.

METHODS

For the years 1950 to 2010, annual catches were obtained from the Anuarios Estadísticos de Pesca del Servicio Nacional de Pesca de Chile (National fisheries statistics of Chile, SERNAPESCA). For the period 1950-1995 records were extracted from paper-based registries which were photocopied and later recorded. For later years (1996-2010) data were available electronically.

It is worth mentioning, that the national artisanal fisheries registry is considered to be poorly updated and contains people who are no longer working in fisheries. This registry is still increasing since every few years SERNAPESCA incorporates all new artisanal fishers who operate "without authorization".

Although Chile's national definitions of industrial versus artisanal fisheries are determined by vessel size, for *Sea Around Us* purposes, all fishing activities which drag gear through the water (such as trawls) are considered industrial as per the standpoint set forth by Martín (2012). Therefore, in order to split the SERNAPESCA data into reported industrial and artisanal catches we used species information and general knowledge of gear type used to catch them. The small pelagic species caught for fishmeal (usually caught by mid-water trawl or purse seine) were considered industrial. This included Chilean jack mackerel (*Trachurus murphyi*), anchoveta (*Engraulis ringens*), South American pilchard (*Sardinops sagax*), Araucanian herring (*Clupea bentincki*), South Pacific hake (*Merluccius gayi gayi*), Falkland sprat (*Sprattus fuegensis*) and Patagonian grenadier (*Macruronus magellanicus*). Also included was *Scomber japonicus* which is usually taken as by-catch in the jack mackerel fishery (Anon. 2007). Other fisheries deemed to be industrial include the following: crustacean fisheries that use bottom trawl and target yellow prawn (*Cervimunida johni*), red prawn (*Pleuroncodes monodon*) and nylon shrimp (*Heterocarpus reedi);* Patagonia toothfish (*Dissostichus eleginoides*) and eels (Ophichthidae; OEDC 2012); and the swordfish (*Xiphias gladius*) longline fleet. All other species were assigned as artisanal landings. We are aware that this is a simplifying assumption and that some species are likely targeted by both fleets.

Industrial fisheries

In addition to the reported landings of the aforementioned species, unreported tonnage of the small pelagics was calculated by using fishmeal data to reconstruct what the supply of fresh fish was to that industry. Discards were also calculated for several fisheries.

Fishmeal reconstruction

For the period 1950-1978 data, on fishmeal production were extracted from historical records. These records specify species and final destination of the product. For the period 1950 to 1967 we noticed that not only pelagic fishes were used to produce fishmeal, but also demersal species and crustaceans. The latter were banned by law in 1961 to be used for fishmeal production. Data from 1968 to 2010 did not specify final destination of species, therefore total fishmeal production was gathered from IFOP data of fishmeal production and export data.

In order to convert fishmeal values to fresh fish we used an "average conversion ratio of forage fish to fishmeal". In two separate experiments, Tacon and Metian (2008) came up with a global fishmeal processing yield of 22.5% (that is for every kg of forage fish, 225 grams of fishmeal are produced). In this case, to verify forage fish to fishmeal production we used an average processing yield of 22.5%. By subtracting the amount of forage fish used for fishmeal from this value, we could determine the amount of unreported fresh fish that comes from fishmeal production.

Historically, forage fish species utilized for fishmeal production included Chilean jack mackerel, sardine and anchovies. However, since the year 2000 jack mackerel has been increasingly used for human consumption. Therefore, in our comparison of reported forage fish to total forage fish used in fishmeal production, we used the total amount of reported jack mackerel from 1950-1999, and then linearly decreased the amount of jack mackerel considered for fishmeal use to 70% by 2010. Our baseline for comparison also consisted of all the reported anchovy, Araucanian herring, South American pilchard, Falkland sprat and 60% of the reported South Pacific hake from 1950-1990 (after 1990 hake was no longer used for fishmeal production and became a large contributor to local consumption).

In 1991, modifications to the fisheries law made reporting of fishmeal production by species compulsory and thus reported fishmeal numbers became more reliable. Therefore, for the purpose of this study, and through local government citations, we decided not to consider fishmeal production data from 1976-1992 (as there would have been a transition period after the new laws came into effect in 1991). We used the unreported amounts calculated from the fish meal conversion from 1993-2010. For two years in this time period the calculations produced a negative amount of unreported fish. In those years we assumed all forage fish to be reported and had no add-on. From 1950-1992, we used the average unreported to reported ratio calculated from the 1993-2010 data, which equated to 16%. These unreported catches were assigned 40% to sardines, 40% to anchoveta and 20% to jack mackerel. The reason for this is that sardines and anchoveta are usually fished together and used entirely for fishmeal production.

It should also be noted that some of Chile's jack mackerel and South Pacific hake catch comes from their associated oceanic islands (Desventuradas and Juan Fernández). A portion of the reported and unreported landings (from fishmeal calculations) for these two species was assigned to those waters and were considered in the separate reconstruction of those islands (see, Zylich and van der Meer 2015). SUBPESCA provided spatial information which allowed us to estimate that in the years 2000-2007 approximately 30% of the jack mackerel and South Pacific hake catch was taken from the EEZ waters surrounding these islands (SUBPESCA 2012). We therefore assumed that 30% of the catch of these two species was taken from the island waters from 2000-2010 and interpolated from 0% in 1949. We assume that only a small portion of the catch is coming from the islands in the early time period, as it is known that Chile was not fishing outside of their EEZ waters that much during this period. We do, however, assume that there is some fishing occurring here despite Chile's limited excursion beyond mainland waters. Note that for all further consideration within this report, these catches have been removed and are solely discussed in Zylich and van der Meer (2015).

By-catch

In Chile, by law only landed species are declared, therefore discards are unreported. A study conducted by Oceana in 2005 reviewed by-catch information from the Chilean Fisheries Research Fund during the past ten years, presenting by-catch percentages, similarity index and diversity statistics for twelve different Chilean fisheries. In addition, it analyzed the impacts of these fisheries and their potential effects on marine biodiversity. They concluded that crustacean fisheries that use bottom trawl to capture demersal species such as yellow prawn (*Cervimunida johni*), red prawn (*Pleuroncodes monodon*) and nylon shrimp (*Heterocarpus reedi*), exhibited the highest by-catch percentages: 69%, 46% and 81% by-catch as a percentage of target landings, respectively. Other demersal species such as common hake (merluccius gayi gayi) presented 25% bycatch. The study also mentions that 73% of these species are valuable to commercialize therefore they are not discarded. We assume that only 27% are considered discards and therefore unreported. Longline pelagic fisheries such as swordfish (*Xiphias gladius*) were also identified with 79% discards, while mid-water trawl used for the Chilean jack mackerel (*Trachurus murphyi*) fishery showed the lowest levels of discards at 4%.

We identified demersal species which are by-catch in the yellow prawn, red prawn and nylon shrimp fisheries and attributed a respective proportion of those to the discards as follows: common hake, 25%; South Pacific hake, 15%; damaged/undersized red prawn, 15%; damaged/undersized yellow prawn, 25%; southern ray, 10%; and bigeye flounder 10% (Queirolo, 2014). This breakdown was used for all discards. This is a simplifying assumption and discarded species will likely differ for different fisheries. This is an area that requires further study in the future.

Spatial allocation

Chilean vessels began fishing outside of their EEZ waters starting in the 2000s (OECD 2009), although there were limited excursions beyond the EEZ prior to this (Anon. 2009). This was largely driven by the oceanographic conditions that reduced the stock of jack mackerel available inside Chile's EEZ. It was reported that in 2003 and 2004, 32% and 28% of the jack mackerel catch, respectively, was taken outside of Chile's EEZ (Anon. 2009). We therefore assumed that from 1950-1960 all of the jack mackerel and associated by-catch species chub mackerel (Anon. 2007) were taken from the mainland Chile EEZ. This percentage was then linearly interpolated to 70% in 2000, and was then carried forward unaltered to 2010. We assumed that the average of 30% (Anon. 2009) was caught outside EEZ waters during the 2000s. Again, we recognize that it is a simplifying assumption that only these two species were caught outside of EEZ waters.

Artisanal fisheries

Due to the poor monitoring of landings for the artisanal fleet it is well known that poached and under-reported catches have increased from 20% of reported landings in 1990 to 30% in 2013 due to higher market prices of seafood and lower quotas for several artisanal fisheries (personal communication between Dr. Hugo Arancibia and artisanal fishers from Caleta Cocholgue, 2014).

To all species captured by the artisanal fleet we assumed unreported catches equal to 20% of reported landings from 1950 to 1990, and 30% in 2010. We linearly interpolated the percentage from 1991-2009.

Subsistence fisheries

The small amount of unreported fishing performed under what could be considered subsistence purposes is included under artisanal unreported catches. As stated previously, true subsistence fishing was assumed to not occur in Chile.

RESULTS

Reconstructed total catches in Chile are characterized by a steady increase from 194,000 t·year^{-1} in the 1950s until 1982, when the fisheries reached the first major peak with 6.1 million t. Catches averaged 5.9 million t·year^{-1} from 1983-1997. Catches then dropped to 3.2 million t in 1998, recovered to peak of 6 million t in 2004 and then steadily declined to 4.1 million t in 2010 (Figure 2a). A notorious drop in catches between 1972 and 1973 is explained by the national political crises, which lead to fuel shortages throughout the country.

The reconstructed catch is 16% higher than the baseline SERNAPESCA data and 24% higher than the data reported by FAO on behalf of Chile (with both baselines excluding the catch allocated to the oceanic islands). The reconstructed catch is dominated by the industrial fisheries with 90% of the catch. However, this is more a reflection of the assumptions made for *Sea Around Us* purposes. Sources indicate that using Chile's national definition of industrial versus artisanal (i.e., assigning to sector by vessel size), that although historically industrial fleets account for most of the fisheries landings, in the year 2010 artisanal fisheries increased catches considerably representing 46% of total national reported catches. It was estimated that almost 12% of the total catch consists of unreported landings (with respect to national SERNAPESCA data) and that just almost 1.5% of the catch is discarded.

During the 1950s, South Pacific hake dominated the total catch, averaging 33% of the annual catch during the decade (Figure 2b). Then, in the 1960s and early 1970s, anchovy catches increased, contributing an average of 55% of the catch during that time period. However, in the next decade (1973-1985), anchovy catches dropped off and South American pilchard fisheries utilizing purse seiners in northern Chile took off, accounting for more than half of total catches from 1979-1985 (Figure 2b). South American pilchard catches steadily declined after that, being surpassed by anchovy and Chilean jack mackerel by 1989. In the last 2 decades (1990-2010) anchovy and Chilean jack mackerel each contributed 31% of the total reconstructed catch. In the year 2001 increasing recorded catches were due to an increase of jack mackerel catches in areas from Chile's outer EEZ zones (Figure 2b). If we exclude the species commonly caught for fishmeal production, other species that contributed to the catch include jumbo squid (*Dosidicus gigas*), snake eels (*Ophichthus* spp.; although these mostly just had 2 years of spike in catch in 1963 and 1964), yellow prawn, bacaladillo (*Normanichthys crockeri*), Chilean sea urchin (*Loxechinus albus*) and red prawn. Overall, reconstructed total catch was composed of: anchovy (28%), Chilean jack mackerel (26%), South American pilchard (19%), *Araucanian herring* (8.3%), chub mackerel (2.9%) and Patagonia grenadier (*Merluccius gayi gayi*; 2.1%; Figure 2b).

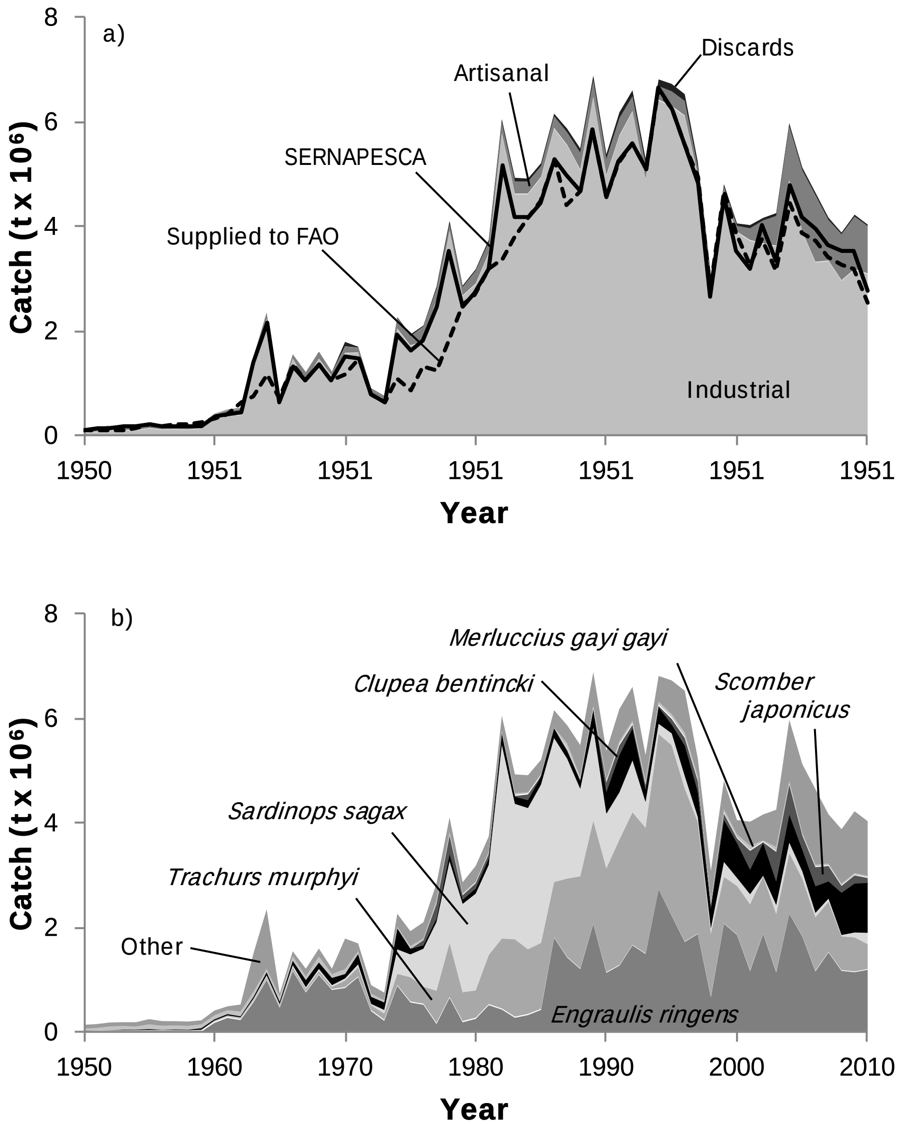

Figure 2. Reconstructed total catches for Chile's mainland EEZ, 1950-2010, a) by sector, with reported SERNAPESCA data overlaid as a solid line graph and data reported by FAO on behalf of Chile overlaid as a dashed line graph, and b) by major species. 'Other' consists of 152 additional taxonomic categories.

Discussion

Reconstructed total catches add to 193 million tonnes for the 1950-2010 time period (16% higher than SERNAPESCA; 24% more than that reported by FAO on behalf of Chile). Reconstructed total catches in Chile show that pelagic species used for fishmeal production account for almost 90% of total catch. Four fifths of total fishmeal production is used as feed for salmon aquaculture and the remainder is exported.

Government monitoring and reporting systems in Chile rely on landings and tend to overlook discards, which account for 2.6 million tonnes, and don't account for unreported catches, which were estimated here at almost 24 million t. We find that most of the unreported catches are from the industrial sector and are due to under-reported of catch used for fishmeal production. The implementation of GPS systems since 2000 and increased monitoring represent an improvement to fisheries management in Chile.

The taxonomic breakdown in Chilean historic catches of pelagic species show a clear pattern of succession. From 1960 to 1980 anchovy is the prevalent species, followed by sardine (South American pilchard). Pelagic fisheries were continuously overexploited and we can see a clear trend of species replacement once their collapse is eminent. South American pilchard had notorious peaks in 1982 and 1985 reaching 3.7 million tonnes to later decline to 28,000 t in 2008 (however, did rebound slightly to 219 thousand tonnes in 2010). In the 1990s, fishing preferences go back to anchovy and the fishmeal industry starts catching an increasing amount of jack mackerel to replace sardine catches reaching nearly 3.3 million tonnes.

The artisanal fisheries (by Chilean definition), present a greater management challenge for a number of reasons including the sheer numbers of fishers involved; the difficulties in enforcing regulations at a local level in a country with many landing sites along a very long coastline; and the high dependence on the artisanal fishing industry by coastal communities who have limited alternatives for food and income. These fisheries have been traditionally managed under an open access system and, while some progress has been made towards a more restrictive entry regime with the introduction of the National Register of Artisanal Fishermen, the artisanal sector effectively remains an open access system (OECD, 2009). Despite these obstacles there is a success story in artisanal fisheries management. Benthic resources have recovered due to the establishment of MAERB in 1997, which has allowed registered fishers to be granted property rights of select marine resources within a specified geographical region. Not only has this management measure protected the marine resource, but it has also provided local artisanal fishers with steady income and food security.

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