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Reconstruction of total marine fisheries catches for Peru: 1950-2010

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Abstract

The purpose of this study is to assemble available information and data in order to correct catch statistics between 1950 and 2010, for industrial and artisanal commercial fisheries, as well as non-commercial fisheries for recreation and subsistence in Peru, one of the greatest fishery countries in the world. The catch re-estimation approach consisted of 7 steps including: identification of existing catch times series, identification of fishing sectors by time period and main gears for different species, unreported catches by species and years, estimation of unreported 'subsistence' and recreational catch, as well as discards, and finally the reconstruction of the total catches from 1950 to 2010. The main results are that anchoveta (*Engraulis ringens*) catches dominate the statistics as was already well known. The correction factor for unreported catches for this species reaches well over 30% in the early 1970s. While artisanal catches are low compared to anchoveta catches, they are high compared to other countries and reach over half a million tonnes in recent years. The correction factor for unreported artisanal catches fluctuates between 28 and 40%. The average total correction factor over the 60 years of study is 24% which means an underestimate of catches of about 82 million t.

Introduction

The coastal waters of Peru along the west coast of South America (Figure 1) are among the world's most productive, thanks to coastal upwelling processes. The immense planktonic production is consumed directly by species of low trophic levels like the Peruvian anchoveta (*Engraulis ringens*), which is a forage item of higher level consumers, including fishes, birds and marine mammals. The Peruvian industrial fishery development started in the 1950s, and today the fisheries sector is a key component of Peru's economy (after mining), mainly as a significant source of foreign currency. Particularly important is the marine fisheries sector, followed to a lesser degree by inland fisheries and aquaculture.

According to the official statistics, during the last decades more than 90% of marine fisheries landings consist of anchoveta, and are destined for fishmeal production. Nevertheless, these landings not necessarily correspond to actual catches (Clark 1976; Vasquez and Lam 1977; Castillo and Mendo 1987).

It is known that the data collection systems for landings or catches by the state institution in charge have some deficiencies and hence do not correctly reflect either landings or actual catches (Sueiro 2009). This is the case, most of all, for subsistence and sports (recreational) fisheries, which apparently are not registered at all. While their tonnage is admittedly low in comparison to pelagic commercial catches, such fisheries form an important socio-economic and food security function. Coastal artisanal fisheries in Peru are fundamental for local food security but also have social and cultural purposes. That is why it is necessary to estimate the real volumes of catches by these fisheries.

Figure 1: Exclusive Economic Zone (EEZ) and shelf waters (to 200 m depth) of Peru.

Both for the industrial as well as the small-scale fishery, reconstruction of actual, total catches, besides contributing to analyses from a social, cultural, and economic point of view, is of greatest importance to better understand the exploitation levels of the resources. Such understanding forms the very foundation for more sustainable management measures.

The purpose of our study was to assemble available information and data on unreported catches as well as number of fishers, in order to reconstruct the total catch series of the Peruvian fisheries from 1950 to 2010 for all relevant fisheries sectors: industrial, small-scale (artisanal and subsistence) and recreational, plus major discards.

Material and Methods

The catch re-estimation approach utilized here consists of 7 general catch reconstruction steps based largely on Zeller *et al.* (2007):

1. Identification of existing reported catch times series from, e.g., local reports, and data published by official agencies:
   a. Time series of data reported by FAO and the Ministerio de la Producción (PRODUCE) were compared to validate the quality of national-international data transfer. We

exclude certain categories from the FAO data such as turtles, marine mammals, algae, corals, etc. In years where FAO landings are reported to be higher than national data, the difference was attributed to catches outside the EEZ.

b. National data series were obtained from different sources. For 1950 to 1990, data are from the IMARPE website (www.imarpe.gob.pe). These data stem mainly from the former Ministerio de la Producción (until 2002 called Ministry of Fisheries) and are identical with the annual reports of the Ministry, but are available in digital form only on the IMARPE website. From 1991 to 2010, data are taken from the Ministry's website (www.produce.gob.pe).

c. Both series were compared to validate the quality of data transfer. Missing catch data in the official series of the Ministry were reconstructed by using data obtained via personal communications from experts and Caillaux (2011).

2. Identification of fishing sectors by time periods and main gears used for different species:

There are some species which are only fished either by the industrial or by the artisanal fleet, making separation of reported landings by sector easy for these taxa. In cases where they are fished by both sectors, we used available separate data series, e.g., for anchoveta, sardine (*Sardinops sagax*), hake (*Merluccius gayi peruanus*) and giant squid (*Dosidicus gigas*). For other species, we consulted with experts or calculated sector assignment from IMARPE data available since 1997.

The industrial bottom trawl fishery for demersal species only started in 1967. Prior to that year, all catches of demersal taxa consisted of artisanal landings. The proportion of industrial to artisanal fishery after 1967 was estimated by assuming that the percentage of species such as *Cynoscion analis, Paralabrax humeralis, Paralonchurus peruanus, Mustelus whitneyi, Isacia conceptionis, Seriolella violacea, Sciaena deliciosa* and rays in scientific surveys equaled the proportion of catches of hake by bottom trawlers. Mean values for two periods were calculated: 1967 to 1998 and 1999 to 2010. The reason for this is that after the 1997/98 El Niño event, biomass of the 'typical' demersal high-valued species declined sharply, resulting in a shift to other species.

The main fishing gears used in artisanal fisheries were determined using data published by Wosnitza-Mendo *et al.* (1988).

3. Estimation of unreported commercial catches

a. Since anchoveta is the taxon with the highest contribution to the Peruvian catches, time series were reconstructed separately using data published by Castillo and Mendo (1987), who estimated a) discards of excess catch (9.13%); b) loss of fish blood (4.91%); c) underestimation through misreporting by processing plants (10%); d) illegal landings (4.38%); and e) irregular sales (5%). The sum of all correction factors was assumed to apply to the year of maximum landing and to be proportional to the square root of landings. Thus, a time series of corrections factors was created and applied to reported landings of anchoveta to estimate a new time series of total anchoveta catch.

b. Time series of landings of other pelagic species like sardine, horse mackerel (*Trachurus murphyi*), mackerel (*Scomber japonicus*) and the main demersal species hake (*Merluccius gayi peruanus*) were corrected, assuming a correction factor of 20% of unreported catch, which includes: underestimation by misreporting in processing plants (10%), illegal landings (5%) and irregular sales (5%). In the case of species exploited by the bottom trawl fleet, estimates of unreported catch are available from on-board observers present on each vessel since 2004, when a quota system was implemented. These estimates seemed reasonable for the whole series. While with the introduction of quotas, illegal fishing on hake by vessels that had no quota increased. Also, from 1973 to 1991 foreign factory trawlers participated in this fishery (Wosnitza-Mendo *et al.* 2005), and we assume 20% of their catch was not reported to the Peruvian authorities.

c. Catch of species for direct human consumption were reconstructed using a correction factor obtained from the literature and from consultation with experts in different regions along the Peruvian coast. A mean correction factor of 35% was identified and used. This value is the same for the whole time series, as the official estimation system used by the Ministry has not changed.

d. In both cases (b and c), unreported catches for each species were calculated considering the type of fleet participation and its correction factor. See Appendix Table (1) for details on the correction factors used.

4. Discards

There are few discards in Peruvian fisheries. Only if industrial fishers fear fines for landing juveniles, do they throw them overboard, but generally they are used in fishmeal production. In the purse seine fishery for anchoveta, discards of juveniles are already considered in step 3a). We separated the anchoveta discards from the unreported component. Other discards are squat lobsters (*Pleuroncodes monodon*) which do not form part of the catch series. In the bottom trawl fishery, discards in the 1970s and 1980s could consist of searobin (*Prionotus stephanophrys*) during warmer years when it migrates south. Nevertheless, this would not exceed 1% of the total landings. During the 1997/98 El Niño, searobin was caught as replacement for hake and since then there are almost no discards any more. The total amount of annual discards was distributed among selected species which are affected by juvenile discards, mainly pelagics like sardine, horse mackerel and mackerel and the main demersal species, hake.

5. Estimation of unreported 'subsistence' catch

   We assumed that the reported landings by the artisanal fishery do not include that component of the catch that is taken home by fishers for their own or family consumption (here called 'subsistence catch'). The estimation of that catch was done by estimating the number of artisanal fishers by regions and assuming a certain food requirement per year by each fisher and his family. The process we used was as follows:

   a. Estimation of the total and coastal regional population between 1940 and 2010 using a model fitted to the available total population data from national censuses carried out by the government in 1940, 1961, 1972, 1981, 1993, 2005 and 2007.

   b. Estimation of the number of artisanal fishers in coastal regions using data of percentage of fishers obtained by IMARPE in two censuses in 1995 and 2005 (Estrella *et al.* 2010), and the population by regions for these years estimated in (a).

   c. Estimation of unreported 'subsistence' catches using an annual consumption value by each fisher. Some fishers from central and northern Peru were interviewed in an informal manner about the quantity of fish they usually take home for their own consumption. Values of 15-30 kg per month were reported for the time series, being 30 kg per month from 1950 to 1975 when catch per fisher was rising and fishers generally took greater portions home. From 1975 onwards, the amount for subsistence was interpolated according the negative trends of abundance.

   d. In order to distribute the estimated total annual amount of subsistence catch among the different species, we identified the most likely species that are taken home by the fishers and then we distributed the amount of subsistence catch for each species proportionally to their annual catch.

6. Recreational fishing

   Two main types of recreational fishing occur in Peru, underwater spear-fishing and angling from the beach using fishing rods. Sport fishers engaged in both types of recreational fishing were interviewed in order to obtain estimates about yields in different decades. Underwater fishing started only in the 1960s with the Italian community in Peru, and recreational angling from the beach is performed mainly by Japanese and Chinese migrants. The number of active spear-fishers per year was estimated based on their participation in national competitions organized by groups that promote spear-fishing, e.g., the "Submarine Hunting Federation of Peru", multiplied by the number of annual competitions. Total catch was estimated using the mean catch per spear-fisher per competition (Table 1), and conservatively assumed to represent the complete spear-fishing catches in Peru. Estimated catch for the last anchor point year (2005) was carried forward to 2010 unchanged, while catch for intervening years was linearly interpolated.

For beach anglers, we used decadal estimates from interviews in north and central Peru, which provided number of participants, frequency of events per month and mean catch per angler (Table 2). As it is known that there are between 6-8 times more anglers in the south, we increased the number of anglers by 7 to fully represent this group for the whole of Peru. Annual catch was estimated for both recreational fishing activities using the decadal data as representing the mid-point of each decade, and interpolated linearly. Estimated catches for the last year (2005) were carried forward to 2010 unchanged. The total annual catches were allocated to taxa using the catch composition per taxon provided by the interviews (Table 3).

7. Reconstruction of total catches

The final reconstructed total catch times series was obtained by combining reported catches, unreported catches of anchoveta, unreported commercial catches of fish and invertebrates, subsistence catches, discards, and recreational catches.

Table 1: Data for recreational spear-fishing in Peru, separated by 'high achievers' and 'other' participants. These data were conservatively assumed to represent total spear-fishing catches in Peru.

Year	'High achievers'		'Other participants		Average number of annual competitions	Annual catch (Kg)[a]
	Mean catch (Kg)	Average number of participants per competition	Mean catch (Kg)	Average number of participants per competition		
1950	0	0	3	0	0	0
1965	30	20	3	30	5	3,450
1975	25	60	3	90	10	17,700
1985	50	80	3	120	10	43,600
1995	25	40	3	40	7	7,840
2005	12	30	3	10	5	1,950

[a] Catch for intervening years was linearly interpolated. Catch in 2005 was carried forward unchanged to 2010.

Table 2: Data for recreational shore anglers in Peru. The number of anglers known for northern and central Peru was expanded to the whole of Peru by assuming a factor of 7 times more anglers in the south (J. Mendo, pers. obs.). These data were conservatively assumed to represent all shore-based, recreational catches.

Year	Number of anglers in north and central Peru	Total number of anglers in Peru	Catch·fisher^{-1}·month^{-1} (Kg)	Annual catch (Kg)[a]
1950	15	105	100	126,000
1965	30	210	100	252,000
1975	45	315	200	756,000
1985	50	350	60	252,000
1995	60	420	20	100,800
2005	60	420	5	25,200

[a] Catch for intervening years was linearly interpolated. Catch in 2005 was carried forward unchanged to 2010.

Table 3: Taxonomic composition applied to recreational catches, based on interview data.

Spear-fishing			Shore angling		
Common name	**Taxon**	**%**	**Common name**	**Taxon**	**%**
Peruvian morwong	*Cheilodactylus variegatus*	50	Corvina drum	*Cilus gilberti*	50
Peruvian rock seabass	*Paralabrax humeralis*	20	Flatfishes	Pleuronectiformes	20
Peruvian grunt	Haemulidae	5	Grunt	Haemulidae	10
Grape-eye seabass	Serranidae	5	Cabinza grunt	*Isacia conceptionis*	10
Other fishes	Marine fishes nei	20	Lorna drum	Sciaenidae	5
			Other fishes	Marine fishes nei	5

Results and Discussion

Official and FAO reported catch

Official reported landings data from the national government sources closely match the data available from FAO. However in certain years where FAO reported landings were higher than national sources, the differences were attributed to catches from outside the EEZ. Generally, data transfer from national to international sources seems to be well established (Garibaldi 2012). This similarity can be readily explained because landings from the industrial fishery, which are reported fully by the government agency, account for around 95% of total catch, so that differences between reported and total catch by the artisanal fishery cannot be seen (see below).

Reconstructed catch

The total reconstructed catch over the 1950-2010 time period (6,940,000 t·year^{1}) are 24.6% higher than the landings of 5,570,000 t·year^{-1} reported by national sources on behalf of the Republic of Peru (Figure 2a, Appendix Table A1). Total reconstructed catches averaged at 519,000 t·year^{1} in the 1950s, and reached its peak at 16,600,000 t in 1970. Subsequently, it declined to 5,190,000 t·year^{1} during the period 1972-1992 before increasing to approximately 9,650,000 t·year^{1} in the 2000s.

The industrial sector and specifically the anchovata (*Engraulis ringens*) fishery primarily contributes to the total reconstructed catch of Peru. These unreported catches of anchoveta accounts for nearly 66 million t of catch over the full time period. This species registers the highest landings in the world, and which represented, especially in the earlier periods, almost the total catch (78.8%). Catches of other small pelagic fishes such as the South American pilchard (*Sardinops sagax;* 12.0%), Jack mackerel (*Trachurus murphyi*; 2.3%) and Chub mackerel (*Scomber japonicus*; 1.0%) only became important in the 1980s and 1990s, while more recently, the Humboldt squid (*Dosidicus gigas; 1.2%*) has begun to contribute sizeable catches (Figure 2b, Appendix Table A2). The remainder 40 different taxas contributes to 4.8% of the total reconstructed catch.

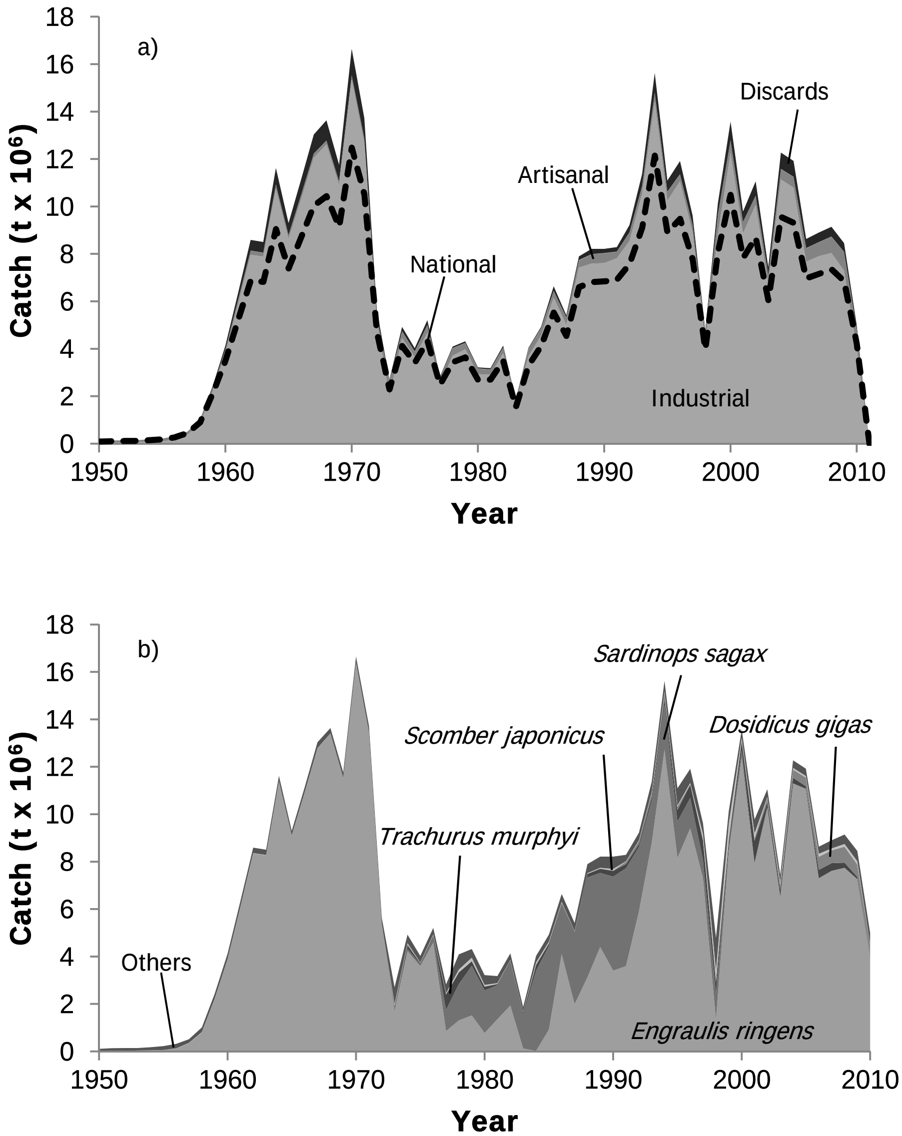

Figure 2. Reconstructed total catches for Peru for 1950-2010, by a) major fisheries sectors, with data as presented by national sources on behalf of Peru overlaid as line graph. Note that subsistence and recreational catches, although included here, are too small to show visually; and b) reconstructed total catches by major taxa, with the 'others' groupings accounting for 40 additional, minor taxa.

Commercial catches

Industrial

The industrial sector contributes to 91.0% of the total reconstructed catch. It averaged 393,000 t·year[1] in the 1950s, increased to 10,700,000 t·year[1] in the 1960s and subsequently declined to 5,310,000 t·year[1] in the 1970-1980. Catch values eventually raised to 8,610,000 t·year[1] in the 2000s.

Artisanal

If we examine the catches of the artisanal fisheries only, the differences between official and reconstructed catches are more significant, with reconstructed total catches of 297,000 t·year^{-1} (for 1950-2010) being 35.5% higher than the 219,000 t·year^{-1} officially reported (Figure 3). Noteworthy is that the total artisanal catches in Peru (Figure 3) to be consistently increasing over time, however, this is mainly because new species of less economic value are exploited, such as Humboldt squid. Artisanal fisheries in Peru are defined as vessels with a holding capacity up to 30 tonnes. In contrast, the traditional artisanal species which are fished by smaller boats nearer to the coast are trying to maintain their catch levels with some fluctuations due to climatic events like El Niños, but catch per fisher is declining as described below.

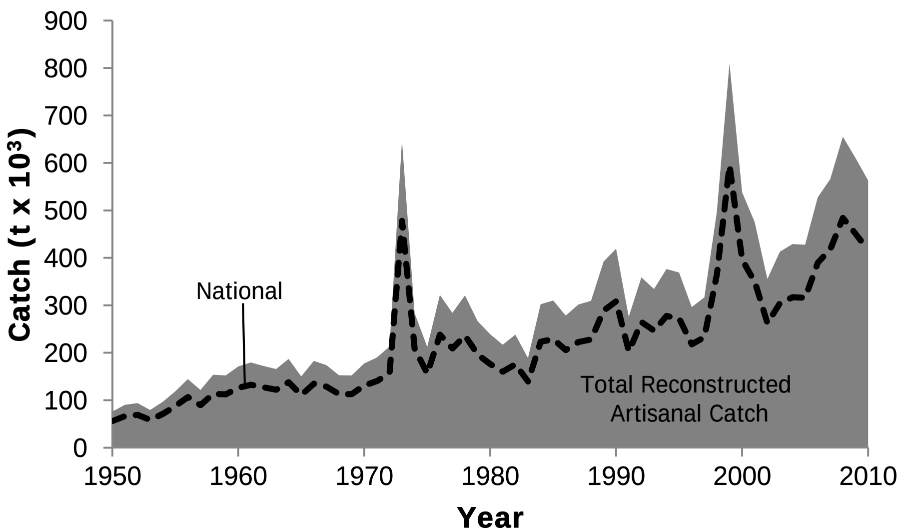

Figure 3. Official reported landings and reconstructed catch of the artisanal fisheries sector in Peru, 1950-2010.

The time series of total catch from the artisanal fishery (see Figure 3), shows an increasing trend which should mean an optimal exploitation of their stocks. The data of catch per fisher using the total catch (i.e., all taxa fished by artisanal fishers) also do not show any drastic negative trend (actually a recently increasing trend, Figure 4). However, catch per fisher estimated using the catch series of traditional species that have historically been exploited by the artisanal fishery, shows a strong decline trend over time, which suggests the overexploitation of various resources traditionally exploited by the artisanal fishery.

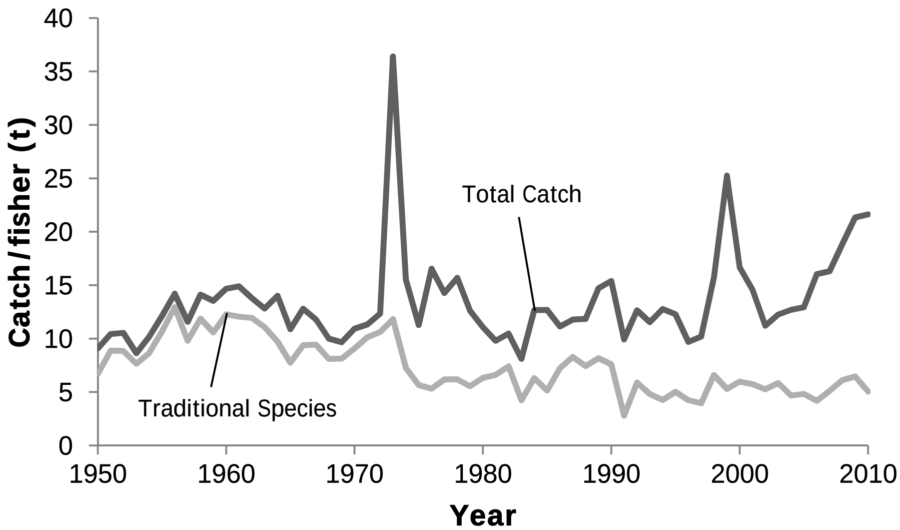

Figure 4. Catch per fisher (t) estimated for the artisanal fishery of Peru, 1950-2010. Total catch represents all taxa caught by artisanal fishers, and traditional species represent historically exploited species caught by artisanal fishers. This was estimated using reconstructed catch from species exploited by the artisanal fishery with more than 70% of contribution in relation to industrial fishery.

Careful examination of total catches by taxon, with small pelagic excluded suggests an increasing trend towards invertebrates (see Figure 2). This trend is due to an increase in Humboldt squid (*Dosidicus gigas*) landings during the last decade, while demersal and coastal fishes present decreasing trends in catches in more recent years (Figure 2).

The percentage catch contribution of artisanal fisheries was only significant during the 1950s, before the development of the high-volume anchovy fishery (Figure 5). However, the volume of catch produced by artisanal fisheries in recent years is substantial at 600,000 - 800,000 t·year^{-1} (see Figure 3), which compared to many other countries is significant.

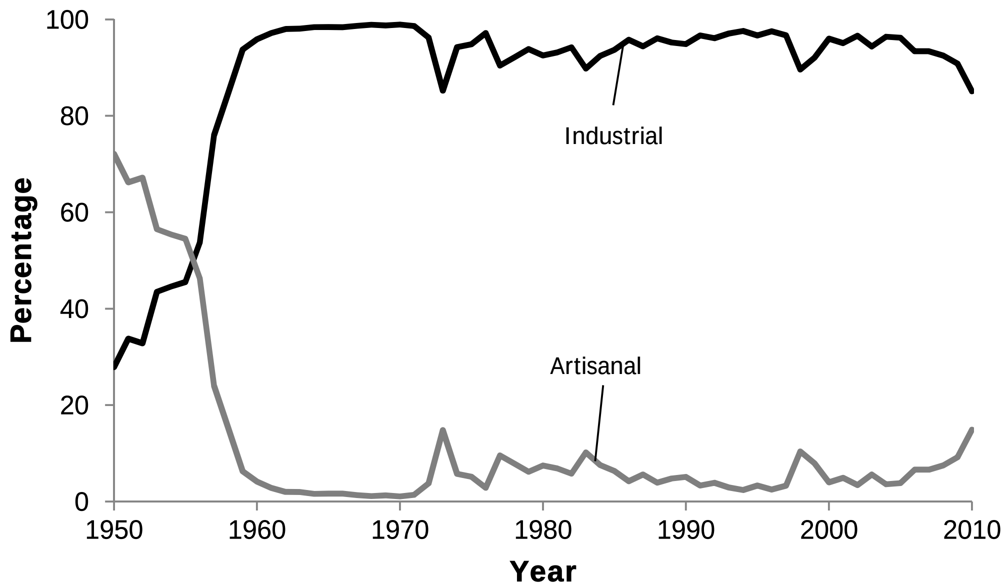

Figure 5. Percentage contribution of artisanal and industrial fishery to total catches in Peru, as estimated using reconstructed catches.

Commercial reconstructed catch including anchoveta

The correction factors used for the reconstruction of the anchoveta catches varied mostly between 15% and 35%, resulting in a peak total catch of anchoveta in 1970 of around 16.4 million t instead of the reported landings of 12.3 million t (Figure 6). This illustrates also the differences between reported and actual total catches of up to 4 million t·year^{-1} in the 1960s and early 1970, and confirms the veracity of estimated anchoveta biomasses of more than 20 million t as reported by Schweigger (1964) and Pauly *et al.* (1987). Overall, total catches of anchoveta over the entire time period were around 333.4 million t, i.e., 25% higher than reported landings of 267.5 million t (Figure 6). Recently, a study of the Legal Defense Institute (IDL) estimated the un-declared catches by fishing companies to be 10%, by comparing the declared and the weighted catches (http://idl-reporteros.pe/2011/09/17/como-se-esfuman-100-millones-en-pescado/). This confirms one of the estimates of this study and shows that the data gathering system continues to be deficient.

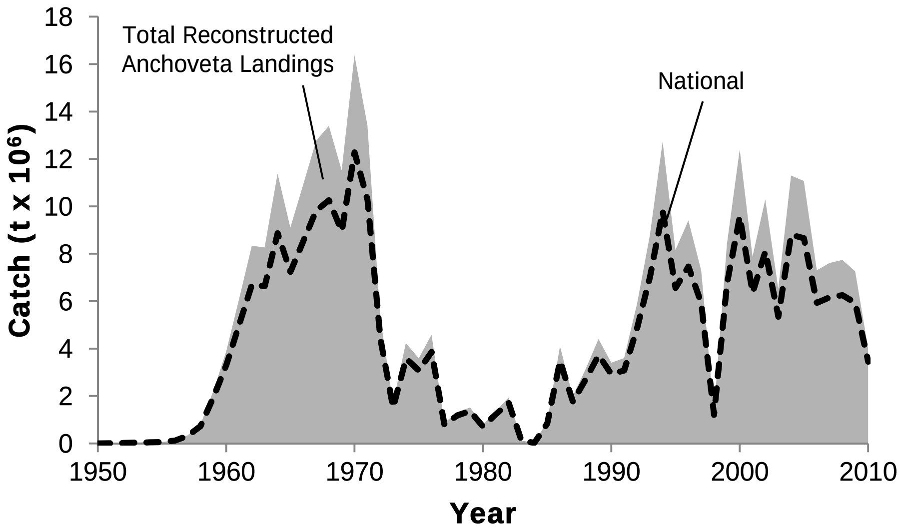

Figure 6. Official reported national landing and reconstructed total catch of *Engraulis ringens*, 1950-2010

Commercial reconstructed catch excluding anchoveta

Using the derived catch correction factors (Appendix Table A3), total commercial reconstructed catch for all other taxa, but excluding anchoveta, added to 1.47 million t·year^{1}, which was 25% higher than the landings of 1.18 million t·year^{1} officially reported for the 1950-2010 time period.

Industrial catch excluding anchoveta averaged at 54,600 t·year^{1} from 1950 to 1970 and subsequently increased in the 1970-80s to 2.07 million t·year^{1} (Figure 7). Catches peaked in 1991 at 4.36 million t before declining to around 1.8 million t·year^{-1} by 2010 (Figure 7).

Artisanal catches excluding anchovata followed a similar trend to anchovata catches. Catch differences can be seen in the 2000s, where catch including anchovata averaged at 558,000 t·year^{1} while excluding anchovata averaged at 503,000 t·year^{1} (Figure 8). This approximation is based on published information and personal communication from local experts along the coast. However, it is possible that in the artisanal sector and in certain places where catches are commercialized locally, the percentage of error could be higher than 35%. This can be observed in places where very small boats are used or fishing is done for recreational purpose. In these cases, it would be worthwhile to carry out more detailed studies in order to estimate the correction factor with more detail. Regional differences are likely to exist along the Peruvian coast. Likewise, variation could exist in relation to the economic value and magnitude of the catches of each species.

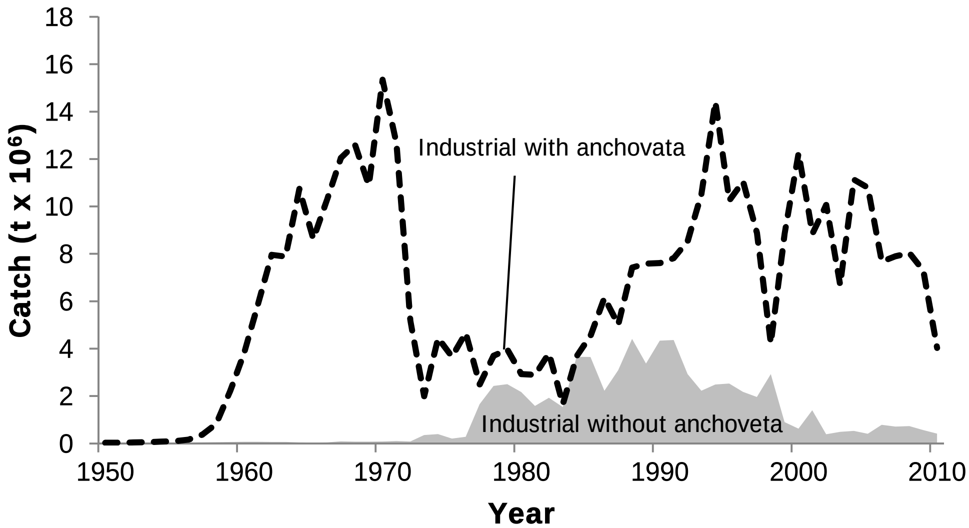

Figure 7. Industrial reconstructed catch with anchoveta, compared to without anchoveta in Peru for 1950-2010.

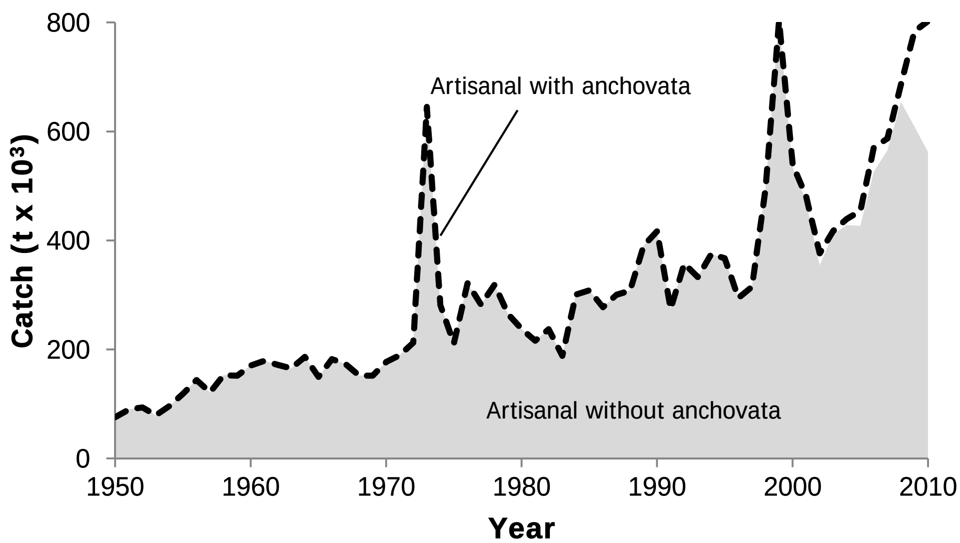

Figure 8. Artisanal reconstructed catch with anchoveta, compared to without anchoveta in Peru for 1950-2010.

Discards

The estimated discards excluding anchoveta peaked at over 45,000 t in 1990 and follow the general trends of the total catches without anchoveta (Figure 4). The correction factor for discards of 1%, although seeming low in comparison to other countries, is consistent and based on direct observations of the authors and compiled information on board of industrial vessels (IMARPE 2009). Probably, in the case of artisanal fisheries in some places and during years of great abundance, this factor is higher, but recently, due to the decline of the fisheries, we observed in different places that fishers sell almost all their catches, including small fishes, that were not commercialized previously. For example, this is the case for the camotillo seabass (*Diplectrum conceptione*), a small fish which until 2003 had no commercial importance and the catches were incidental. Although the estimated discard percentage is relatively low in comparison to fisheries in other countries, the discard volumes are high compared to other countries (Harper and Zeller 2011).

Non-commercial catches

Subsistence

The term 'subsistence' as used in this study refers to the part of the artisanal (i.e., small-scale commercial) catch that artisanal fishers use for self- and family-consumption. Thus, it is not a stand-alone 'subsistence fishery' (sensu Zeller *et al.* 2006) which is a fishery existing only or primarily for self- or family-consumption. No studies exist in Peru that would allow an estimation of the self-consumption by artisanal fishers and their families. In the distant past, the entire artisanal catch was used for family consumption and for exchange of agriculture products (Sandweiss *et al.* 1998). With the development of markets, an increasingly shrinking part of catches would be used for self-consumption. In more recent times, when declines in abundance of certain fisheries resources are more common, competition and prices increase, and fishers prefer selling the catches.

The human population in Peru has increased exponentially from around 6 million people in 1940 to nearly 37 million in 2010 (Figure 9). Accordingly, the coastal population increased rapidly from around 1.7 million in 1940 (around 28% of the total population) to 16 million in 2010 (around 55% of the total population), illustrating the increased migration of the population from inland regions to the coast. Similarly, the population of fishers increased, from around 8,000 fishers in 1940 to around 37,500 fishers by 2010.

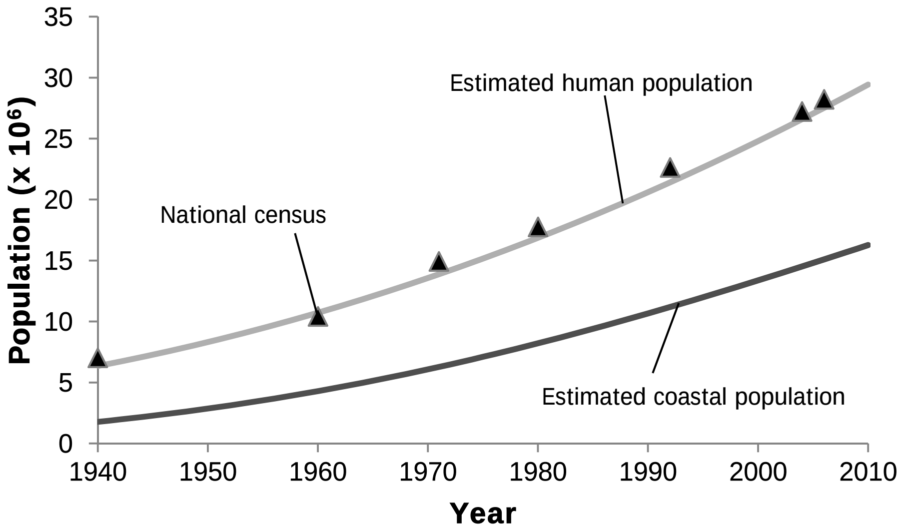

Figure 9. Total and coastal human population in Peru as obtained by adjusting population census data to a polynomial model and using proportions of coastal population from available national census data, 1940 to 2010.

Although the number of artisanal fishers along the Peruvian coast shows an exponential growth, subsistence catch does not follow the same tendency, especially in the last decades (Figure 10). This is due mainly to the reduction in fish consumption since 1975, assumed to be proportional to the catch per fisher. No studies exist about these changes in fish consumption of artisanal fishers. Nevertheless, using direct observations and interviews with fishers in different places along the coast, we know about the changed habits of fishers. Artisanal fishers increasingly prefer to sell their catches and provide their families with other (cheaper) types of protein like chicken. This makes sense if we consider the increase in prices of fish due to reductions in supply. The values of own consumption assumed in this study (15 and 30 kg·fisher^{-1}·month^{-1}) mean a *per capita* consumption of approximately 30 to 60 kg·person^{-1}·year^{-1}, which would seem high. However, these values do not differ much from those reported for artisanal fishers from other countries (e.g., Trujillo *et al.* 2011; Zylich *et al.* 2011).

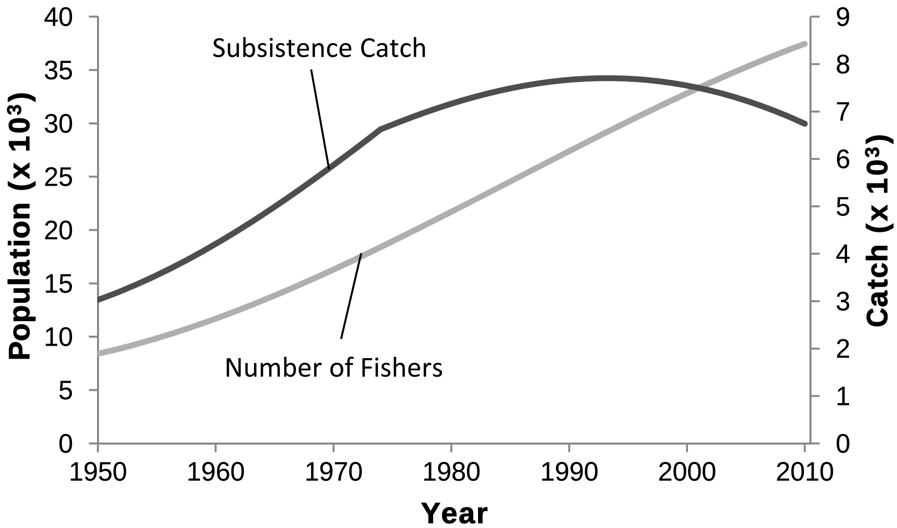

Figure 10. Number of fishers and estimated subsistence catch, 1950-2010.

Recreational

Yields for recreational fisheries peaked in 1975 with around 770 t·year[1] annually, and have declined substantially since then (Figure 11). The level of recreational catches is relatively low compared to other counties. In the shore-based angling sector, catches of some species like flatfishes and Peruvian rock seabass have declined drastically over the years and this is attributed to the use of explosives, especially in the southern part of Peru. The main targets of this fishery, besides flatfishes, are sciaenids such as the Corvina drum (*Cilus gilberti*) and haemulids such as the Cabinza grunt (*Isacia conceptionis*). The main targeted species in the spear-fishing sector were Peruvian morwong (*Cheilodactylus variegates*), Peruvian rock seabass (*Paralabrax humeralis*), Peruvian grunt (*Anisotremus scapularis*, Haemulidae) and Grape-eye seabass (*Hemilutjanus macrophthalmos*, Serranidae). Among the 'other fishes', some species have been very heavily targeted over time and show signs of depletion, like Sheepheads (*Semicossyphus darwini, Bodianus eclancheri, Bodianus diplotaenia*)*,* Halfmoon (*Medialuna ancietae*)*,* Sea Chub (*Graus nigra*)*,* Pacific Beakfish (*Oplegnathus insignis*)*,* groupers (*Mycteroperca xenarcha, Epinephelus itajara, Epinephelus labriformis*)*,* and Bumphead parrotfish (*Scarus perrico*).

The data used for the reconstruction of recreational catches are approximate. They should be taken as preliminary and a first attempt at assessing such catches. Further research and investigation into recreational fishing should be considered.

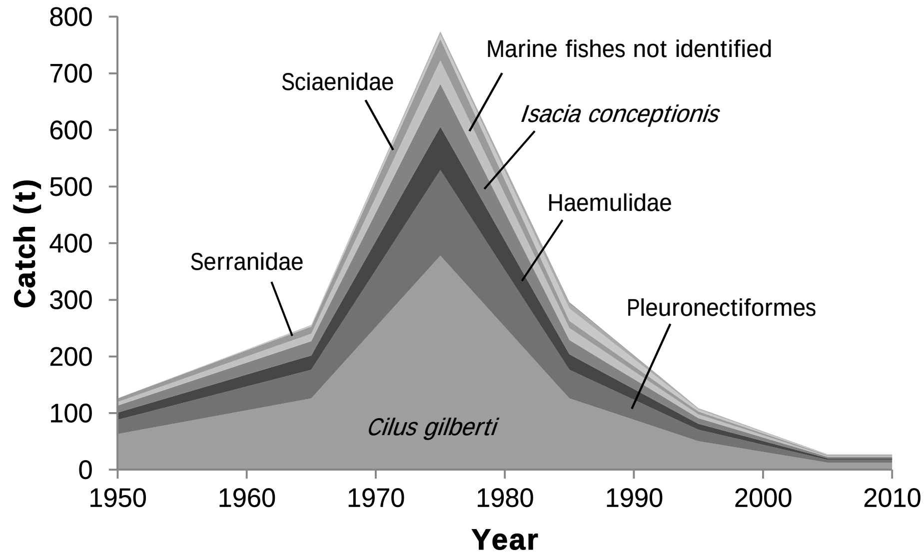

Figure 11: Recreational catches (spear-fishing and angling combined) as estimated here for Peru, by major taxa for 1950-2010.

The underestimation and under-reporting of total catches can have significant ramifications for managing Peruvian fisheries, not only with regards to socio-economic and legal impacts, but also with respect to biological and ecological aspects for managing the Peruvian upwelling ecosystem. The un-reported catches of Peru could represent in many cases the total catches of other countries, and thus should not be dismissed lightly as a minor 'accounting error'.

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Appendix A1: National vs. reconstructed catch (t), and catch by sector with discards shown separately, for Peru, 1950-2010.

Year	National	Reconstructed Catch	Industrial	Artisanal	Subsistence	Recreational	Discard
1950	83,637	109,000	29,200	75,700	3,000	126	468
1951	105,546	134,000	40,600	89,900	3,130	135	432
1952	112,991	143,000	45,700	93,500	3,210	143	569
1953	117,731	144,000	60,900	79,200	3,320	152	543
1954	146,078	178,000	77,400	96,300	3,430	161	751
1955	183,328	222,000	98,600	118,500	3,550	169	1,012
1956	267,205	316,000	166,100	144,000	3,670	178	1,788
1957	453,082	510,000	379,000	121,400	3,750	186	5,409
1958	900,115	1,009,000	834,700	153,000	3,960	195	17,324
1959	2,122,363	2,430,000	2,202,200	151,800	4,100	204	71,418
1960	3,501,410	4,130,000	3,796,900	170,600	4,190	212	157,811
1961	5,213,024	6,340,000	5,862,800	179,100	4,360	221	293,281
1962	6,881,854	8,588,000	7,959,500	171,800	4,510	230	451,952
1963	6,821,326	8,504,000	7,888,200	165,200	4,670	238	446,103
1964	9,046,750	11,621,000	10,740,700	186,400	4,820	247	688,625
1965	7,391,160	9,298,000	8,634,200	149,800	4,980	255	508,657
1966	8,708,945	11,143,000	10,304,800	182,200	5,130	307	650,146
1967	10,034,087	13,035,000	12,052,800	173,200	5,360	359	803,651
1968	10,440,363	13,633,000	12,617,600	152,100	5,490	411	857,650
1969	9,143,366	11,759,000	10,901,500	151,800	5,700	463	699,862
1970	12,481,045	16,649,000	15,343,900	177,000	5,880	515	1,122,028
1971	10,505,042	13,721,000	12,665,600	189,300	6,050	566	859,792
1972	4,674,148	5,647,000	5,181,500	212,200	6,230	618	245,961
1973	2,289,042	2,703,000	1,996,900	645,000	6,430	670	54,469
1974	4,118,745	4,922,000	4,450,600	281,400	6,570	722	182,428
1975	3,408,101	4,024,000	3,661,400	211,000	6,660	774	143,895
1976	4,336,530	5,204,000	4,672,700	321,400	6,890	726	202,642
1977	2,490,465	2,824,000	2,496,100	282,300	6,950	678	38,155
1978	3,428,431	4,092,000	3,705,600	318,800	7,020	630	59,937
1979	3,637,502	4,317,000	3,976,100	265,000	7,090	582	68,017
1980	2,695,915	3,215,000	2,930,700	237,600	7,160	535	38,945
1981	2,699,979	3,179,000	2,903,200	216,100	7,250	487	52,098
1982	3,495,745	4,131,000	3,807,600	237,200	7,310	439	78,903
1983	1,536,429	1,871,000	1,658,100	188,000	7,360	391	17,163
1984	3,287,687	4,028,000	3,681,700	300,600	7,420	343	38,054
1985	4,109,135	4,923,000	4,548,900	308,500	7,490	296	57,942
1986	5,528,523	6,632,000	6,154,700	277,500	7,490	277	192,274
1987	4,546,757	5,414,000	5,013,200	300,400	7,610	258	92,769
1988	6,597,564	7,898,000	7,421,100	308,000	7,600	240	160,914
1989	6,815,288	8,214,000	7,593,600	390,300	7,660	221	222,729
1990	6,840,571	8,211,000	7,610,100	416,800	7,700	202	176,045
1991	6,913,891	8,286,000	7,817,800	274,200	7,710	183	185,969
1992	7,569,171	9,219,000	8,542,600	357,500	7,700	165	310,715
1993	9,104,524	11,369,000	10,521,400	333,000	7,700	146	506,995
1994	12,143,730	15,627,000	14,418,000	375,100	7,700	127	825,778
1995	8,914,655	11,090,000	10,250,100	367,400	7,690	109	464,437
1996	9,479,832	11,915,000	11,057,600	294,300	7,680	100	554,750
1997	7,768,128	9,607,000	8,886,800	315,000	7,660	92	397,430
1998	3,971,207	4,791,000	4,223,300	493,600	7,630	84	66,767
1999	8,085,109	10,137,000	8,854,700	803,500	7,590	76	471,088
2000	10,488,676	13,577,000	12,248,600	539,800	7,550	68	781,198
2001	7,843,596	9,780,000	8,858,300	480,600	7,500	60	433,616
2002	8,688,099	11,055,000	10,067,400	376,400	7,440	52	603,913
2003	6,054,704	7,442,000	6,688,600	417,600	7,380	43	327,872
2004	9,562,171	12,271,000	11,138,100	439,400	7,310	35	686,335
2005	9,310,904	11,921,000	10,794,500	454,100	7,230	27	665,416
2006	6,972,773	8,630,000	7,670,900	570,400	7,150	27	381,771
2007	7,161,718	8,902,000	7,902,700	587,200	7,050	27	404,567
2008	7,350,946	9,145,000	8,037,600	687,100	6,960	27	413,525
2009	6,857,213	8,452,000	7,291,400	784,000	6,850	27	369,460
2010	4,210,112	5,000,000	4,032,100	802,700	6,740	27	158,239

Appendix A2: Reconstructed catch (t) by major taxa, for Peru, 1950-2010. 'Others' include 40 additional taxonomic categories.

Year	*Engraulis ringens*	*Sardinops sagax*	*Trachurus murphyi*	*Dosidicus gigas*	*Scomber japonicus*	Others
1950	441	81	38		2,840	105,000
1951	12,125	1,288	113		1,420	119,000
1952	16,142	515	103		4,120	122,000
1953	37,795	143	88		2,310	104,000
1954	43,879	89	79		4,410	130,000
1955	60,064	62	176		1,630	160,000
1956	122,628	139	857		4,640	187,000
1957	343,347	393	466		10,690	155,000
1958	797,369	2,715	220		15,620	193,000
1959	2,200,590	5,687	571		11,670	211,000
1960	3,884,581	3,839	358		11,710	229,000
1961	6,080,816	3,491	222		14,510	241,000
1962	8,342,521	3,904	848		16,490	224,000
1963	8,264,902	2,836	2,489		9,830	224,000
1964	11,380,221	13,009	2,188	153	2,540	223,000
1965	9,101,410	9,557	3,265	162	4,740	179,000
1966	10,905,949	2,414	5,441	165	9,390	219,000
1967	12,761,826	2,755	3,913	431	16,700	250,000
1968	13,398,472	2,378	3,557	394	8,940	220,000
1969	11,518,783	1,444	5,325	762	8,910	224,000
1970	16,380,003	578	6,004	613	10,930	251,000
1971	13,419,142	7,796	11,712	489	12,570	270,000
1972	5,341,935	8,166	23,931	48	10,820	262,000
1973	1,690,480	170,388	54,484		80,660	707,000
1974	4,230,494	93,541	164,667		78,660	354,000
1975	3,594,079	80,974	48,366		29,410	271,000
1976	4,587,245	224,948	69,113	909	50,090	272,000
1977	859,347	895,827	643,199	1	57,220	369,000
1978	1,310,396	1,526,920	492,580		126,020	636,000
1979	1,514,500	2,096,301	193,185	75	146,790	366,000
1980	778,411	1,796,931	157,270		73,460	409,000
1981	1,354,514	1,435,882	48,291	77	40,820	299,000
1982	1,935,675	1,832,471	63,753	1,125	27,460	271,000
1983	122,329	1,422,827	98,086	3	28,180	200,000
1984	23,320	3,385,028	240,719		108,330	271,000
1985	918,245	3,524,597	111,529		71,030	298,000
1986	4,101,565	2,088,865	63,551		48,140	330,000
1987	1,988,220	2,997,162	58,998		29,920	340,000
1988	3,124,852	4,212,461	150,464		31,770	378,000
1989	4,404,565	3,118,189	179,180		39,770	473,000
1990	3,403,896	3,963,476	243,367	9,429	75,430	515,000
1991	3,596,809	4,125,035	174,039	103,473	21,590	265,000
1992	5,895,025	2,722,867	123,189	135,016	22,310	320,000
1993	8,779,617	1,774,309	166,605	177,858	36,710	434,000
1994	12,726,489	1,883,643	250,840	266,074	54,880	445,000
1995	8,159,980	1,536,278	479,812	138,321	55,000	720,000
1996	9,407,804	1,282,293	559,067	10,312	61,180	594,000
1997	7,304,105	758,810	827,847	20,352	256,230	440,000
1998	1,332,695	1,102,500	492,533	693	498,490	1,365,000
1999	8,409,283	241,984	234,985	69,255	654,060	527,000
2000	12,399,837	291,547	377,914	68,169	91,070	349,000
2001	7,884,408	77,685	921,453	91,028	218,660	587,000
2002	10,296,885	8,829	196,502	185,505	40,640	327,000
2003	6,524,585	11,243	277,314	194,803	117,210	316,000
2004	11,297,306	1,985	238,744	342,610	77,380	313,000
2005	11,073,322	1,080	102,797	368,933	65,760	309,000
2006	7,300,235	115	353,663	550,296	127,170	299,000
2007	7,610,436	72	324,060	541,843	77,480	348,000
2008	7,740,045	6	215,867	675,942	115,410	398,000
2009	7,262,112	33	95,098	521,839	137,250	435,000
2010	4,011,920	22	22,369	468,638	25,430	471,000

Appendix Table A3. Sectoral assignment factors by species used to assign reported landings to industrial or artisanal sectors, and correction factors for unreported industrial catches. A fixed unreported factor of 35% was used for the artisanal sector.

Spanish common name	English common name	Scientific name	% industrial fisheries	% artisanal fisheries	Main gear (industrial/artisanal)	% unreported industrial
Pelagic fishes						
Anchoveta	Peruvian anchovy	*Engraulis ringens*	100/98	0/2[a]	Purse seine	see methods
Atún	Yellowfin tuna and others	*Thunnus albacares* and tuna nei	99[b]	1[b]	Purse seine/gill net	5
Barrilete	Striped bonito	*Katsuwonus pelamis*	99[b]	1[b]	Purse seine/gill net	5
Bonito	Eastern Pacific bonito	*Sarda chiliensis ch.*	3	97	Purse seine/gill net[c]	5
Caballa	Chub mackerel	*Scomber japonicus*	84	16	Midwater trawl/purse seine	20
Jurel	Jack mackerel	*Trachurus murphyi*	91.8	8.2	Midwater trawl/purse seine	20
Perico	Dolphin fish, mahi mahi	*Coryphaena hippurus*	0	100	Long line/gill net	0
Samasa	Anchovies	*Anchoa nasus*	100	0	Purse seine	24.29
Pez Volador[d]	Peruvian searobin	*Prionotus stephanophrys*	88.5	11.5	Bottom trawl	20
Sardina	Sardine	*Sardinops sagax*	98.8/24.8[e]	1.2/75.2[e]	Purse seine	20.0/5[e]
Sierra	Pacific sierra	*Scomberomorus sierra*	0	100	Gill net/purse seine	0
Tiburón	Sharks	Sharks nei	0	100	Gill net/long line	0
Demersal Fishes						
Ayanque	Peruvian weakfish	*Cynoscion analis*	0/13/10[f]	100/87/90[f]	Bottom trawl/purse seine and gill net[g]	20
Cabrilla	Peruvian rock seabass	*Paralabrax humeralis*	0/61[f]	100/39[f]	Bottom trawl/purse seine and gill net[g]	20
Coco	Peruvian banded croaker	*Paralonchurus peruanus*	0/24/18[f]	100/76/82[f]	Bottom trawl/purse seine and gill net[g]	20
Lenguado	Flatfishes	*Paralichthys adspersus*	0.6	99.4	Gill net and purse seine[c, g]	20
Merluza	South Pacific hake	*Merluccius gayi peruanus*	0/98/94[h]	100/2/6[h]	Bottom trawl/line (Pinta)	20
Ojo de Uva	Grape-eye seabass	*Hemilutjanus macrophthalmos*	0	100	Line[g] (pinta)[c]	0
Peje Blanco	Bighead tilefish	*Caulolatilus affinis*	0.7	98.3	Line[g] (pinta)[c]	20
Raya	Rays	Rays nei	0/56/89[f]	100/44/11[f]	Bottom trawl/gill net and purse seine[c]	20
Tollo	Humpback smooth-hound	*Mustelus whitneyi*	0/21[i]	100/79[i]	Bottom trawl/gill net and purse seine[c]	20
Coastal Fishes						
Cabinza	Cabinza grunt	*Isacia conceptionis*	0/3.2[i]	100/96.8[i]	Purse seine and gill net[c]	20
Cojinova	Palm ruff	*Seriolella violacea*	0/3/1[f]	100/97/99[f]	Bottom trawl/purse seine and gill net[c]	20
Lisa	Mullet	*Mugil cephalus*	0	100	Purse seine and gill net[c, g]	0
Corvina	Corvina drum	*Cilus gilberti* and sciaenids nei	0	100	Purse seine and gill net[c, g]	0
Chita	Peruvian grunt	*Anisotremus scapularis*	0	100	Purse seine and gill net[c, g]	0
Lorna	Lorna drum	*Sciaena deliciosa*	0/20.8[i]	100/79.2[i]	Purse seine and gill net[c, g]	20
Machete	Pacific menhaden	*Ethmidium macalatum*	0	100	Purse seine and gill net[c, g]	0
Pejerrey	Chilean silverside	*Odontesthes regia r.*	0	100	Gill net[c, g]	0
Pintadilla	Peruvian	*Cheilodactylus*	0	100	Gill net and line[c, g]	0

Appendix Table A3. Sectoral assignment factors by species used to assign reported landings to industrial or artisanal sectors, and correction factors for unreported industrial catches. A fixed unreported factor of 35% was used for the artisanal sector.

Spanish common name	English common name	Scientific name	% industrial fisheries	% artisanal fisheries	Main gear (industrial/artisanal)	% unreported industrial
	morwong	*variegatus*				
other fishes	other fishes	Marine fishes nei	0	100		0
Invertebrates						
Cangrejo	Crabs	Brachyura	0	100	diving	0
Langosta	Green spiny lobster	*Panulirus gracilis*	0	100	diving	0
Langostino	Penaeus shrimps nei	*Penaeus* spp.	0	100	trawling	0
Abalón	False abalone	*Concholepas concholepas*	0	100	diving	0
Caracol	Gastropods nei	*Thais chocolata*	0	100	diving	0
Choro	Cholga mussel	*Aulacomya ater*	0	100	diving	0
Conchas de Abanico	Scallop	*Argopecten purpuratus*	0	100	diving	35/1[j]
Macha	Macha clam	*Ensis macha*	0	100	diving	0
Almeja	Clams, etc.	*Semele* spp.	0	100	diving	0
Calamar	Squids	*Loligo* spp.	0.6	99.4	diving	0
Pota	Humbold squid	*Dosidicus gigas*	60[k]	40[k]	Jigging	5
Pulpo	Octopuses, etc.	*Octopus* spp.	0	100	diving	0
Other crustaceans	other crustaceans	Crustaceans nei	0	100	diving	0

[a)] The artisanal fishery on anchoveta gained importance only after 2007. [b)] Gladys Cárdenas, pers comm. [c)] From Wosnitza-Mendo *et al.* (1988). [d)] This species is erroneously reported as pelagic but corresponds to *Prionotus stephanophrys,* a demersal species. Since the 1970s, it is mainly reported in 'other fishes'. [e)] First value corresponds to years between 1977 and 1998 (from Cárdenas 2009) and the second before and after that period (from IMARPE database). [f)] 1950-1966/1967-1998/1999-2010. [g)] Artisanal only. [h)] 1950 to 1966 artisanal 100%, 1967 to 1998: 2%, 1999 to 2010: 6%. [i)] 1950-1966/1967-2010. [j)] Value for artisanal fishery: Until 1982 30% , thereafter 1% (Anonymous ITP staff, pers. comm.). [k)] Mean values estimated using the series of catches for 1956-2008.