

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/350387315>

Peru: updated catch reconstruction for 1950–2018

Chapter · December 2020

CITATIONS

4

READS

892

3 authors, including:



[Santiago de la Puente](#)

University of British Columbia

54 PUBLICATIONS 845 CITATIONS

SEE PROFILE

Peru: updated catch reconstruction for 1950-2018*

Santiago de la Puente^a, Simon-Luc Noël^b and Rachel White^c

- a) Institute for the Oceans and Fisheries, The University of British Columbia, 2202 Main Mall, Vancouver, B.C., V6T 1Z4, Canada
- b) *Sea Around Us*, Institute for the Oceans and Fisheries, University of British Columbia, 2202 Main Mall, Vancouver, BC, V6T 1Z4, Canada
- c) *Sea Around Us – Indian Ocean*, University of Western Australia, 35 Stirling Hwy, Crawley, WA, 6009, Australia

Abstract

Peru's initial catch reconstruction, covering the 1950-2010 period, was updated to 2018. This process improved the taxonomic resolution of the catch, as well as the accuracy of *Sea Around Us*-assigned 'end use' and 'gear type' categories to the Peruvian catch. Detailed descriptions of the methods are given, mostly on a per species basis. We discuss our results, which focus on the magnitude of the unreported catch, the contribution of each sector to the national catch and the fisheries' reduced reliance on traditional target species.

Introduction

Catch statistics reported by FAO on behalf of a country are known to have limitations that lead to underestimating the full extent of fishing mortality and misinterpreting global fisheries trends (Pauly and Zeller 2016). Catch reconstructions, aim to build upon FAO's accounting of fisheries yields by using complementary, secondary sources of data (e.g., unpublished Government reports, graduate thesis, local datasets) to elaborate plausible hypotheses of the total magnitude of catches across time (Zeller *et al.* 2007; Zeller and Pauly 2016). These estimates can then be used to improve our understanding of fisheries' impacts on marine ecosystems; for example, by including them in assessments of the status of targeted stocks (Froese *et al.* 2017, 2012).

The taxonomic resolution of FAO reported data increased substantially in the latest State of the World Fisheries and Aquaculture report (SOFIA) (Pauly and Zeller 2019). This increase allowed for improvements to the existing catch reconstructions around the world, while also increasing their temporal coverage.

Peru is one of the world's major fishing countries in terms of tonnages (FAO 2018). Local fishing activities are quite diverse and essential for national revenue, employment, and food security (Christensen *et al.* 2014; Gutiérrez *et al.* 2017; Marín *et al.* 2017). However, fisheries assessment, monitoring and regulatory efforts remain almost exclusively focused on anchoveta (*Engraulis ringens*) (De la Puente *et al.* 2011; SPDA 2019), a single species responsible for 80% of the Peruvian reported catch between 1950 and 2014 (Gutiérrez *et al.* 2016).

The first catch reconstruction of Peruvian marine fisheries was completed for the 1950-2010 period by Mendo and Wosnitza-Mendo (2014). This work was subsequently updated, extending the reconstruction to 2014 (Mendo and Wosnitza-Mendo 2016). These reconstructions showed that between 1950 and 2014, 'official catches' reported by FAO on behalf of Peru accounted for 80% of likely 'total catch' estimated for Peru's economic exclusive zone (EEZ). Moreover, when the catch was assigned to the various fishing sectors, the

* Cite as: De la Puente, S., S.-L. Noël and R. White. 2020. Peru: updated catch reconstruction for 1950-2018, p. 249-278. In: B. Derrick, M. Khalfallah, V. Relano, D. Zeller and D. Pauly (eds). *Updating to 2018 the 1950-2010 Marine Catch Reconstructions of the Sea Around Us. Part II: The Americas and Asia-Pacific*. Fisheries Centre Research Report 28(6).

reconstruction revealed that 14% of the Peruvian fisheries yield was caught by artisanal vessels, while 86% was caught by industrial vessels⁶⁶.

Peru's catch reconstruction was further improved as a result of *Sea Around Us* efforts to determine the end use of the catch (e.g., direct human consumption, fishmeal and fish oil production, other uses) (Cashion *et al.* 2017) and the fishing gears used for its capture (Cashion *et al.* 2018) at a global level. However, given the scope of these efforts, country-level estimates for these parameters can sometimes be coarse and should be improved when more data becomes available.

The goal of this study was threefold: (1) extend the temporal coverage of the Peruvian catch reconstruction to 2018, (2) improve its taxonomic resolution, and (3) improve the accuracy of the assigned 'end use' and 'gear type' in the reconstructed catch.

Methods

The catch was reconstructed by following the seven-step catch reconstruction process described in Zeller *et al.* (2016) and Zeller and Pauly (2016): (1) identifying baseline reported catch time series (e.g., FAO and national data); (2) identifying missing data (e.g., the sectors, time periods, species, and gears not covered by official reports); (3) sourcing available alternative information sources on missing data (e.g., through expert elicitation and literature reviews); (4) developing data 'anchor points' in time for each missing data component; (5) interpolating for time periods between data anchor points; (6) estimating the total catch time series by combining reported catches with the additional catch estimates; and (7) quantifying the data reliability ('uncertainty') associated with each reconstruction.

Peruvian catch data were obtained from several sources, including peer-reviewed publications, annual government reports, technical reports, theses, and direct data requests⁶⁷. These data allowed us to sort the total reported catch by sectors, fishing methods (gear types) and end-use (Table 1), and to identify catches not reported by Peru to the FAO. The methods and assumptions used for these purposes in the previous reconstructions of Peruvian catch data were maintained (Mendo and Wosnitza-Mendo 2016, 2014). 'Confidence intervals' (data reliability ranges) were assigned to the reconstructed catch following the methods described in Zeller *et al.* (2016) and Zeller and Pauly (2016). However, there are some differences in our current approach, which are worth noting.

In previous iterations, a fixed ratio was used to distribute the catches among sectors for taxa caught by industrial and small-scale vessels. For example, 24% of the catch of Peruvian banded croaker (*Paralichthys peruanus*) was annually assigned to industrial vessels using trawl nets between 1967 and 1998 (Mendo and Wosnitza-Mendo 2014). Instead of this fixed ratio approach, here, we adjusted the ratio to reflect changes in industrial and small-scale fishing effort or following changes in legislation regarding quota allocations among fishing sectors. Thus, we distributed the total industrial catch of this species during this period (i.e., 24% of the total catch between 1967 and 1998) by applying a variable ratio that changed in proportion to changes in industrial fishing effort (Greer *et al.* 2019) on a year-to-year basis (e.g., 24% in 1979, 19% in 1992 and 16% in 1997).

⁶⁶ Peruvian recreational and subsistence fisheries are not important, and jointly accounted for <0.1% of the reconstructed catch of Peru between 1950-2014 (Mendo and Wosnitza-Mendo, 2014).

⁶⁷ Catch data by taxonomic group and end-use can be directly requested from the Peruvian Ministry of Production using the online forms available at: <https://www.gob.pe/850-acceso-a-la-informacion-publica-acceso-a-la-informacion-publica-del-ministerio-de-la-produccion>.

Similarly, the catch was distributed among fishing gears following the methods described by Cashion *et al.* (2018). However, the catch was distributed among artisanal fishing gears (i.e., small-scale fisheries) using Instituto del Mar del Perú (IMARPE) data (Table 1). To determine how elastic the catch-by-gear ratios were to changes in fishing effort, the ratio of the catch assigned to each fishing method for years where data were available (e.g., 1996-2012; Marin *et al.* 2017) was used in combination with annual estimates of small-scale fishing effort (De la Puente *et al.* 2020). This information was then used to predict the annual catches by gear and taxa, as a function of fishing effort, for periods between data anchor points.

Unreported subsistence catches were estimated using methods by Mendo and Wosnitza-Mendo (2014, 2016) using updated estimates of Peru's coastal population and small-scale fishers (Castillo *et al.* 2018; INEI 2018). Recreational catches were carried forward to 2018, with only minor adjustments corresponding to small recent growth of recreational fishing activities in the north of Peru (Salgado *et al.* 2015). Landings and discards from commercial fisheries were reconstructed on a taxon-by-taxon basis as follows:

1. Marine invertebrates

FAO reported landings for 18 taxonomic groups of marine invertebrates caught off Peru (FAO 2019). These included taxa for crustaceans, echinoderms, and molluscs. However, since 1990 information has been consistently displayed for 14 of these groups.

1.1. Crustaceans

FAO reported crustacean landings included 6 taxa: ‘Craylets, squat lobsters nei’, ‘Green spiny lobster’, ‘Penaeus shrimps nei’, ‘Yellowleg shrimp’, ‘Marine crabs nei’, and ‘Marine crustaceans nei’. After comparing national datasets, we produced time series for 4 crustacean taxa:

Blue spiny lobster (*Panulirus gracilis*)

FAO starts reporting blue spiny lobster catches in 1974 (FAO 2019). We used the difference between the catches reported by El Ministerio de la Producción (PRODUCE) and FAO as the unreported catch for the period 1950-1973. Since then, data reported by PRODUCE and FAO is the same. Nonetheless, given the market for this species, a significant fraction of the catch goes directly to restaurants, hotels and consumer's houses without being registered by fisheries inspectors (Christensen *et al.* 2014; Sueiro and De la Puente 2015). Thus, we assumed the reported data represented 75% of the catch from 1974 to 2000, 70% from 2001 to 2006 (due to the intensification of coastal tourism in the north of Peru), and 65% from 2007 to 2018 (due the gastronomic boom) (López de la Lama *et al.* 2018a). The only exception was 2014, when PRODUCE reported catches of 193 tonnes and FAO reported only 4. Thus, we used the difference between the two as the unreported catch. All catches of this species were assigned to artisanal divers using hands or tools. No discards were considered.

Marine crabs

Using estimated bycatch rate of marine crabs by industrial trawlers catching hake (2008-2018)⁶⁸, we were able to estimate the catch of this species by trawlers back to 1967. After subtracting the industrial catch, we split the remaining values between small-scale fishing gears. We assumed that landings represented 90% (1974-2018) of the catch and that there were no discards. In years up to 1973, we added PRODUCE's unreported catch directly on top of FAO for years when the catches by PRODUCE were higher than FAO's. We assumed that all landings were used for direct human consumption (DHC), and that there were no discards for this species.

⁶⁸ Extracted from IMARPEs daily reports on the hake fishery, available on:
http://www.imarpe.gob.pe/imarpe/detallereport.php?id_seccion=Io1310202010000000000000.

Penaeid shrimp

Penaeid shrimp landings in Peru mostly correspond to the genera *Farfantepenaeus* (47%), *Xiphopenaeus* (35%) and *Litopenaeus* (17%) (Sueiro and De la Puente 2015). However, FAO only reported landings for yellowleg shrimp (*Farfantepenaeus californiensis*) in 2017 (FAO 2019). For the rest of the time series, catches of shrimp are grouped under 'Penaeus shrimps nei'. Given that available data lack the taxonomic resolution to split shrimp catches over genera or species across the time series, we decided to group the catch of both FAO categories into one for 'Penaeid shrimp'. However, a fragment of the reported catch of shrimp in Peru may include yields from aquaculture production, particularly in recent years (Palacios-Abrantes *et al.* 2018). Given the high value of shrimp and limited distribution of its fishery, we assumed that the FAO reported data represented 85% of the total catch.

Red squat lobster (*Pleuroncodes monodon*)

Landings of 'Craylets, squat lobsters nei' were reported only for 2015-2016 (FAO 2019). These mostly correspond to red squat lobster, a species that became highly abundant off the coast of Peru since the mid-1990s (Gutiérrez *et al.* 2008). This species has been caught as bycatch by industrial purse seiners and trawlers and targeted for bait by small-scale fishing vessels. Nonetheless, its catch is rarely reported. Bycatch estimates for the industrial purse seine fleet were recently made available for the period between 1997 and 2014 (Escobedo Oblitas 2018). We used a 5-year rolling geometric mean to project the bycatch for the 2015-2018 period.

Before 1997, squat lobster abundance was smaller, and the catches were presumably reported as 'Other crustaceans' in PRODUCE (2018). However, reports of 'Marine crustaceans nei' only appear in FAO statistics since 1998 (FAO 2019).

Thus, we decided to combine both 'Craylets, squat lobsters nei' and 'Marine crustaceans nei' into this category, given that the previous crustacean taxa reported by FAO were broad enough to include all other species of crustaceans caught by Peru fisheries (Marín *et al.* 2017; Sueiro and De la Puente 2015). We used PRODUCE catch estimates (not included in FAO statistics) to reconstruct catches prior to 1997. The end-uses assigned to this species' catches were fishmeal and fish oil production (FIFO) or bait, depending on whether industrial or small-scale fishing gears caught it.

1.2. Molluscs

FAO reported mollusc landings included 10 taxa: 'Cholga mussel', 'Clams, etc. nei', 'False abalone', 'Gastropods nei', 'Jumbo flying squid', 'Macha clam', 'Marine molluscs nei', 'Octopuses, etc. nei', 'Patagonian squid', and 'Peruvian calico scallop'. We produced time series data for 11 taxa, 7 species and 4 more aggregated taxa based on available data.

1.2.1. Bivalves

All bivalves in Peru are caught by small-scale fishers (divers) using hands or tools (Sueiro and De la Puente 2015). The catch is fully retained and destined for DHC (Christensen *et al.* 2014). No discards were considered for these species (Mendo and Wosnitza-Mendo 2014).

Chilean ribbed mussel (*Aulacomya ater*)

We extended the catch time series for this species assuming that FAO data represented 70% of the total catch for this species (Mendo and Wosnitza-Mendo 2014).

Clams

Catches in this group mainly correspond to two clam species (*Gari solida* and *Semele corrugata*). However, their catch is reported jointly under a single category (i.e., ‘clams’), even in the data sets that hold the highest taxonomic resolution. Thus, we were unable to split this group any further. As FAO does not report catches before 1990, we used the difference between PRODUCE and FAO data as the unreported catch for the 1950-1989 period. For the years between 1990 and 2018, we assumed that FAO data represented 85% of the catch.

Macha clam (*Mesodesma donacium*)

FAO does not report catches of this species before 1988. Thus, we used the difference between PRODUCE and FAO data as the unreported catch for the 1950-1988 period. For the years between 1989 and 2018, we assumed that FAO data represented 85% of the catch.

Peruvian calico scallop (*Argopecten purpuratus*)

We assumed that FAO data represented 75% of the catch for the period from 1990 to 2018. However, since FAO data severely exceeded PRODUCE catch from 1950 to 1989, we did not add additional unreported catches. It is worth noting that PRODUCE sometimes report scallop aquaculture production jointly with wild-caught scallop (Palacios-Abrantes *et al.* 2018). Also, many of the ‘seeds’ (juveniles) used for aquaculture production are illegally caught and potentially double counted in national statistics (López de la Lama *et al.* 2018b). Thus, it is highly likely that these numbers are overestimating the total catch for this species.

Other bivalves

This category corresponds to the ‘Marine molluscs nei’ category reported by FAO (2019). An overwhelming majority (98%) of the mollusc catch not included in the other 10 categories for molluscs included in this reconstruction correspond to bivalves (Sueiro and De la Puente 2015). These include razor clams (*Ensis macha* and *Tagelus dombeii*), Venus clams (*Transennella pannosa*, *Leukoma thaca*), oysters (*Pteria sterna*, *Striostrea prismatica* and *Spondylus limbatus*), black bittersweet (*Glycymeris ovata*), bean clam (*Donax obesulus*), mussels (*Choromytilus chorus* and *Modiolus capax*), Mexican cockle (*Trachycardium procerum*), and arks (*Anadara tuberculosa* and *A. similis*), among others (Sueiro and De la Puente 2015). Thus, we thought it appropriate to rename this category ‘Other bivalves’.

FAO did not report catches for this category before 1965. Therefore, we used the difference between PRODUCE and FAO data as the unreported catch for the period between 1950 and 1970. For the 1971-2018 period, we assumed that FAO data represented 80% of the catch. A few notable exceptions were the years 1985, 1988, 2014 and 2016. In these years, the difference between FAO reported data and PRODUCE data exceeded our estimated underreporting. Thus, we used that difference as the unreported data for those four years.

1.2.2. Cephalopods

Changos octopus (*Octopus mimus*)

All catches of changos octopus were assigned to artisanal sector of divers using hands or tools (Christensen *et al.* 2014; Sueiro and De la Puente 2015). For 1950-1972, and 2015, we used the difference between the catches reported by PRODUCE and FAO as the unreported catches. This species is highly valued in local markets, so we assumed that the values reported by FAO represented

85% of the species between 1950 and 2005. After that, given the Peruvian gastronomic boom and the development of new value chains connecting fishers directly with restaurants and high-end retailers, we assumed that FAO data represented 80% of the catch between 2006 and 2018. No discards were considered.

Jumbo flying squid (*Dosidicus gigas*)

This large cephalopod is not only caught by the Peruvian small-scale fleet, but also appears as bycatch of the domestic industrial fleet. For a couple of decades, foreign industrial fleets targeted it.

Data corresponding to the foreign (i.e., Japanese and South Korean) fleets fishing jumbo squid within Peru's EEZ were extracted from (Paredes and De la Puente 2014). Since data were not available to divide this joint catch, it was split equally between Japan and South Korea.

To estimate the bycatch in the industrial fleet, we assumed that the catch rate of this species would be equivalent to 2% of the reported landings of Peruvian hake by industrial trawl nets and 1% of the reported landings by industrial purse seine nets targeting chub and jack mackerels. Moreover, we assumed that further bycatch would be seen in the anchoveta and sardine industrial fisheries but at a much smaller rate (0.01% of the nominal landings). All industrial catches of this species were assumed to be used for fishmeal and fish oil production.

Furthermore, we assumed 0.10 tonnes of jumbo squid used as bait for each ton of mahi-mahi (*Coryphaena hippurus*), blue shark (*Prionace glauca*), or shortfin mako (*Isurus oxyrinchus*) caught in Peru using small-scale longlines since 1990 (Alfaro-Shigueto *et al.* 2010).

Finally, roughly 15% of the weight of this species (i.e., the eyes, the ink sack and the guts) is discarded at sea. Thus, to reconstruct the full weight, we assumed only 85% of the total catch was reported in the landings.

Patagonian squid (*Doryteuthis gahi*)

Patagonian squid was assumed to be caught entirely by small-scale fishing gear and used for direct human consumption (Sueiro and De la Puente 2015). FAO data was assumed to cover 75% of the reported catch, except for 1950-1963, when catch estimates were not reported by FAO but appear in national statistics. The difference between the two data sets was used as the unreported catch. No discards were considered for this species.

1.2.3. Gastropods

The most commonly landed gastropod species in Peru include the chocolate rock shell (*Thaisella chocolate*), the swollen frog shell (*Crossata ventricosa*), the concave ear moon snail (*Sinum cymba*), the Chilean abalone (*Concholepas concholepas*) and limpets (*Fissurella* spp.) (Marín *et al.* 2017; Sueiro and De la Puente 2015).

FAO reports catch of the Chilean abalone as 'False abalone'; however, all other species were grouped under the 'Gastropods nei' category (FAO 2019). Using alternative sources of data (Appendix table 1), we extracted the limpets out of 'Gastropods nei' time series. Thus, we reconstructed the catch for three gastropods groups: Chilean abalone, Limpets and Sea snails.

All catches of these groups were assigned to artisanal divers using hands or tools. We assumed that the catch was fully landed (i.e., no discards) and exclusively used for direct human consumption (Christensen *et al.* 2014; Sueiro and De la Puente 2015).

For the remaining taxa, underreporting was estimated to be the difference between catches reported nationally vs catches reported by FAO. Moreover, we assumed that reported catches of Chilean abalone and sea snails by FAO represented 85% of these species total catch between 1950 and 2005. Due to the Peruvian gastronomic boom and the development of new value chains connecting fishers directly with restaurants and high-end retailers, we assumed that FAO data represented 80% of the catch between 2006 and 2018. Limpet catches, on the other hand, were fully unreported by FAO throughout the time series.

1.3. Echinoderms

FAO reports this category as Chilean sea urchin (*Loxechinus albus*). However, other species of echinoderms (mainly sea cucumbers) are included in Peruvian statistical reports under a category that translates to ‘Echinoderms (sea urchins and others)’ (PRODUCE 2018). Data directly requested to PRODUCE and alternative sources of information (Appendix table 1) allowed us to split the echinoderm catch into two groups: Chilean sea urchin and sea cucumbers (*Holothuroidea*). Reported catches were assumed to represent 80% of the total catch between 1990 and 2018. For years before 1990, unreported catches were considered to be the difference between national catch data and FAO reported data. Sea cucumber catches were fully unreported by FAO. All catches of this species were assigned to artisanal divers using hands or tools. No discards were considered.

2. Cartilaginous fishes

FAO reported catch data for 11 taxa of Chondrichthyes, including 7 groups of sharks, 3 groups of batoids and one for the Plownose chimaera (*Callorhynchus callorhynchus*). However, catches were reported using only 5 categories throughout the time series – except for 2017 when catches were reported using all 11 taxonomic groups (FAO 2019).

Catches of Plownose chimaera were only reported in 2017. The catch of this species was reported as part of the generic ‘Marine fishes nei’ category for the 1950-2016 period. Lacking ancillary data to extract a time series for the chimaera catches from those reported as ‘Marine fishes nei’, we decided to add the 2017 chimaera catch back to it.

It is worth noting that most of the shark and batoid catch is reported by FAO under generic taxonomic aggregations (e.g., ‘sharks, rays, skates, etc., nei’, ‘smooth-hounds nei’ and ‘rays, stingrays, mantas nei’). Thus, we proceeded to disaggregate their catch as follows:

2.1. Sharks

Expanding upon the methods developed by De la Puente (2017), we combined the reported catches of ‘sharks, rays, skates, etc., nei’ and ‘smooth-hounds nei’ into a single group. These two groups are reported as “Tollo” and “Tiburón” in PRODUCE (2018). However, these categories are built using common names and not scientific names (De la Puente 2017). Thus, we used IMARPE data to estimate the proportional contribution of shark species to the total catch, using the ratio for the period between 1997 and 2015 and 1986 and 1988 as anchors. Sharks were split into blue shark (*Prionace glauca*), shortfin mako (*Isurus oxyrinchus*), smooth hammerhead (*Sphyrna zygaena*), common thresher (*Alopias vulpinus*), humpback smooth-hound (*Mustelus whitneyi*), school shark (*Galeorhinus galeus*) and other sharks (Elasmobranchii).

Then, we split each shark catch into their corresponding fishing gears. Some shark species are dressed at sea (headed and gutted), a practice that became mainstream in the early 1980s and almost compulsory for shark species since the late 1990s, when fishing trips became longer (De la Puente 2017). We reconstructed the total catch by adding the discarded weight to blue sharks, shortfin makos, common threshers, and hammer heads. We assumed that: (1) sharks were dressed only when caught by gillnets or longlines, (2) 75% of the sharks were dressed at sea from 1983 to 1996, and (3) since 1997, 80% of the hammerheads and 100% of the other species are dressed at sea. Species-specific multipliers were used to add the relevant discards.

Humpback smooth-hounds, school sharks, and other sharks were assumed to be fully retained. Nonetheless, we assumed that the reconstructed catch for all shark species represented 90% of the total landings (due to lack of monitoring and accounting) across the time series.

Finally, catches of Pacific angelshark (*Squatina californica*) were split between small-scale fishing gears. Unreported catches were reconstructed using the difference between data reported by FAO (2019), PRODUCE (2018) and Caillaux (2011). In years when FAO data was equal to PRODUCE data (1974-1990; 1992-1995; 2000-2005; and 2008-2017) and in 2018, landings were assumed to represent 75% of the catch. In all other cases, unreported catches were estimated as the difference between reconstructed catches by Caillaux (2011) and data supplied by PRODUCE. The only exception was the period between 1967 and 1970 during which FAO data vastly exceeded PRODUCE data. Therefore, no additional landings were included to the catch.

2.2. Batoids

Peer-reviewed publications (Alfaro-Córdova *et al.* 2017) and national reports on small-scale fisheries (Marín *et al.* 2017), are beginning to include more batoid taxa in their catch descriptions. However, the catch of this group of fishes is highly aggregated in both national and FAO statistics (FAO 2019; PRODUCE 2018). Thus, catches of giant manta (*Mobula birostris*) reported in 2017 were added to those of the generic category labeled as: 'Rays, stingrays, mantas and skates (Orders: Myliobatiformes and Rajiformes)'.

This generic category includes multiple species, mainly from the order Myliobatiformes. We split the catch between industrial and small-scale gears using IMARPE data (Appendix table 1) and assumptions on decreasing bycatch levels by industrial trawlers reflecting improvements in regulations and changes to fishing effort. Reported landings by industrial trawlers were assumed to represent 90% of their catch, retaining 95% of it and discarding the remaining 5%.

Catch among small-scale gears was reconstructed as with other species. Landings by small-scale trawlers were assumed to represent 70% of the reported catch, while landings by small-scale purse seiners and handlines were assumed to cover 75% of the catch. All unreported catch by these fleets was assumed to be retained. In the case of small-scale gillnets and longlines, landings were also assumed to cover 75% of the catch. However, given that rays caught with these gears tend to be gutted and cut before being weighed on land (Sueiro and De la Puente 2015), we assumed that 80% of the unreported catch corresponded to discards.

The only other group of batoids for which a time series was produced is the Pacific guitarfish (*Pseudobatos planiceps*). Catches of this species were split between small-scale fishing gears. Unreported catches were reconstructed using the difference between FAO data, PRODUCE data, and data reconstructed by Caillaux (2011). In years that reconstructed catch data (Caillaux 2011) or PRODUCE data did not exceed the FAO reported catch, we assumed that FAO data represented 75% of the catch. Out of the unreported catch caught by gillnets, we assumed that 50% was discarded at sea because this species is frequently headed and gutted before being weighed on docks (Sueiro and De la Puente 2015).

3. Teleosts

FAO reported catches for 63 teleost taxa between 1950 and 2017 (FAO 2019). However, only 29 groups (46%) had data for all years of the time series, while catches for only 26 groups (41%) were reported in 2017. The reconstruction allowed us to estimate the catches for 41 groups of bony fishes across the time series.

Anchoveta (*Engraulis ringens*)

The end-use of anchoveta catches was allocated between DHC and FIFO using data from PRODUCE. All of the FIFO catch up to 1999 was allocated to industrial purse seiners. However, since 2000, the part of the small-scale purse seine fleet with licenses for DHC, has been illegally landing anchoveta only for FIFO production. Since changes in regulation and enforcement have made it harder for this behavior to occur (SPDA 2019; Sueiro and De la Puente 2015), and its peak was estimated to be in 2012 (IMARPE, unpublished data), we reconstructed anchovy catch assuming that: (i) DHC landings by small-scale purse seiners represented 90% of the DHC catch, and (ii) in addition to that catch, small-scale purse seiners illegally landed significant amounts of anchoveta for FIFO starting at 5000 tonnes in 2000, reaching its peak in 2012 (250,000 tonnes) and decreasing progressively since then (reaching 160,000 tonnes in 2017; Grillo *et al.* 2018).

The previous reconstruction's estimates by Mendo and Wosnitza-Mendo (2014) for unreported landings and discards by industrial purse seiners was not modified before 1999. From 1999 onward, we modified the percentage of unreported landings for anchoveta given: (i) changes in regulations (De la Puente *et al.* 2011; SPDA 2019), (ii) changes in fleet size (De la Puente 2014; De la Puente *et al.* 2020), (iii) the start of the catch shares system in 2009 (De la Puente *et al.* 2011), and (iv) 'El Niño', or more precisely El Niño Southern Oscillation (ENSO) events.

Torrejón-Magallanes *et al.* (2016) estimated the percentage of discards for excess catches by the industrial fishing sector in the Northern-Central anchoveta stock (see Mendo 2018) for a definition). These percentages were used to estimate the corresponding discards for the industrial fleet for the period between 2005 and 2014, and the geometric mean value of the last 5 years was carried forward to reconstruct discards for 2015 onward. An additional 5% per year was added to reconstructed discards because of juvenile catches between 2009 and 2016 (Paredes 2014). Due to changes in regulations regarding the reporting of bycatch in 2016 (SPDA 2019), this percentage of discarded juvenile fish is thought to be decreasing. Thus, we projected additional unreported catches of 3% and 2% in 2017 and 2018, respectively.

Pacific sardine (*Sardinops sagax*)

FAO reports landings of this species under a different common name (i.e., South American Pilchard), and no catches were reported before 1961. The statistics collected by Cárdenas-Quintana (2009) and Cárdenas-Quintana *et al.* (2015) were used to reconstruct the catch of this species across the first decade of the time series. These were assumed to reflect the total catch of this species during this time.

In the previous reconstruction (Mendo and Wosnitza-Mendo 2014), the reconstructed catch was on average 29% ($\pm 2\%$) larger than the nominal catch. This might have been true for some segments of the time series, but not for all. An error in the assignment of the sector catching Pacific sardine within the original database was corrected and now reflects that roughly 75% of the sardines were caught by the industrial purse seiners and only 25% by the artisanal sector. Small-scale landings were caught 99.99% by purse-seiners and 0.01% by gillnets (Sueiro and De la Puente 2015).

Flat rates of underreporting were previously assigned (i.e., 6% for the industrial sector and 36% for the artisanal sector) across the time series (Mendo and Wosnitza-Mendo 2014). Since sardines were landed whole and targeted by industrial and small-scale purse seiners, similar estimates for the underreporting of vessels were used for the anchoveta fishery during the same years. Given the lack of data on unreported discards per landing for the industrial sector, we assumed that 5% of the unreported catch corresponded to discards, while 95% was landed. For the small-scale sector, we applied an almost flat rate of 30% for all unreported landings.

For the end-use of the industrial catch, we assumed that approximately 7% was used for direct human consumption (Mendo and Wosnitza-Mendo 2014). However, for the small-scale catch, we assumed that 90% of sardines, not 100%, were used for this purpose (i.e., a conservative estimate) because illegal fishmeal production from the small-scale-fleets was also a problem in the 1980s and 1990s (J.C. Sueiro and M. Kisner, pers. comm.). We used data from PRODUCE to anchor the distribution of the catch between DHC and FIFO. We used estimates by Cárdenas-Quintana *et al.* (2015) together with PRODUCE to distribute the catch rates corresponding to the industrial vs small-scale fleets.

Chilean jack mackerel (*Trachurus murphyi*)

The distribution of the catch of Chilean jack mackerel between DHC and FIFO was kept constant to 1999 (Mendo and Wosnitza-Mendo 2014). For the years since, the allocation between end-use of the catch was updated using data from PRODUCE. All FIFO catch was allocated to industrial purse seine vessels. The allocation of the catch for DHC between industrial and artisanal vessels was kept as in the last reconstruction throughout the time series. However, the artisanal catch was subdivided between small-scale fleets.

In the previous reconstruction (Mendo and Wosnitza-Mendo 2014), a constant 20% underreporting rate was assumed for industrial purse seines and 26% for artisanal gears. However, we applied a rate of 20% for industrial purse seiners aiming for FMFO and 15% for industrial purse seiners for DHC. Additionally, we applied a 30% rate of underreporting for handlines and gillnets and a 20% rate for small-scale purse seiners. We assumed that 1% of the unreported catch were discarded, irrespective of gear. FAO reports no catch for 1950. Therefore, we used the same catch as in 1951 to reconstruct 1950.

Finally, catches by industrial midwater (pelagic) trawlers were registered within the Peruvian EEZ between the mid-1980s and 1991 (Ñiquen *et al.* 2013). The reported landings for this fleet were estimated to 80% of the total catch, as in the previous reconstruction (Mendo and Wosnitza-Mendo 2014).

Pacific chub mackerel (*Scomber japonicus*)

This species is mainly caught by industrial purse seiners (for DHC and FIFO) and by small-scale fisheries (for DHC only) (Christensen *et al.* 2014). The catch was divided between industrial and small-scale vessels using the following rationale: (1) industrial vessels accounted for 84% of the catch between 1950 and 2010 (Mendo and Wosnitza-Mendo 2014), and (2) all landings destined for FIFO were caught by industrial vessels (Cashion *et al.* 2017).

We used the FIFO estimates for 1950-1990 from the original reconstruction and complemented them with PRODUCE data to extend the time series to 2018. PRODUCE data was also used to estimate the industrial DHC catch for the 1997-2018 period. After subtracting the FIFO and industrial CHD catch, we applied a multiplier to meet the 84% criterion of industrial catch for the 1950-2010 period.

We proceeded to split the artisanal catch among small-scale fishing fleets. We assumed an underreporting rate of 30% for small-scale gillnets and handlines and assumed a rate of 20% for small-scale purse seiners. Moreover, we assumed that 1% of the unreported catch was discarded at sea.

Peruvian hake (*Merluccius gayi peruanus*)

Catches were first allocated between Peruvian hake caught for FIFO and those caught for DHC. FIFO catches were assigned to industrial purse seiners and were extracted from PRODUCE data. Since the 1997/1998 El Niño event – and more strongly after 2003 (which was the start of the new regulations for hake following the stock’s collapse) (SPDA 2019) – small-scale fisheries have been responsible for a larger percentage of the total hake catch in Peru. Using industrial catch data from 2004 to 2007 (Bouyer 2009), and 2006 to 2018 (IMARPE) as anchor points, we reconstructed the contribution of the industrial fleet to the total Peruvian hake landings between 2004 and 2018. For previous years, we used the same allocation of the catch in Mendo and Wosnitza-Mendo (2014). The artisanal catch was split into small-scale fishing gears.

For industrial vessels, the same underreporting rates used as in the previous reconstruction (Mendo and Wosnitza-Mendo 2014) were applied. Nonetheless, for: (i) small-scale gillnets and longlines, we applied a rate of underreporting of 20% between 1950 and 1996 and 10% between 1997 and 2018; (ii) for small-scale handlines, the applied rates were 30% (1950-1996) and 25% (1997-2018); (iii) for small-scale trawlers a flat rate of 30% was applied for all the time series, and (iv) for purse seines the rates varied from 20% between 1950 and 1996, and 30% between 1997 and 2018. These follow perceived changes in the capacity of monitoring systems covering small-scale fisheries landings (J.C. Sueiro, pers. comm.).

The *Sea Around Us*, following Martín (2012) classifies all trawlers as industrial fishing gears (although this is not the case within Peruvian regulation); thus, all catches by what are labelled as small-scale trawlers in Peru were allocated to industrial fleets. ‘Bottom trawl’ was used for vessels recognized as ‘industrial’ according to the Peruvian legislation, while ‘small-scale bottom trawl’ was used for the local artisanal trawl fleet.

Eastern Pacific bonito (*Sarda chiliensis*)

The industrial catch of Eastern Pacific bonito was allocated to industrial purse seiners. We used data provided by PRODUCE to estimate the relative contribution of the industrial fleet to the total landings between 1997 and 2016. The geometric mean of the last 3 years of data was used to project its proportional contribution to 2018. For the previous period, we assumed 25% of the annual catch was landed by industrial vessels (sensu Mendo and Wosnitza-Mendo 2014). The remaining artisanal catch was split among small-scale fishing vessels.

Industrial landings of this species were assumed to account for 95% of the industrial catch, while the artisanal sector the rate assumed was to be 75%. Discards were assumed to be 5% of the unreported industrial catch and 1% of the unreported small-scale catch.

Longnose anchovy (*Anchoa nasus*)

Landings of this species were not reported by FAO or PRODUCE before 1992. Thus, we were unable to determine the catch of this species during the 1950-1991 period. It is, however, highly likely that the

longnose anchovy catches before 1992 are included within the reported anchoveta catch statistics. We make this claim because longnose anchovies are mostly bycatch in the industrial purse seiners anchoveta fishery. Thus, all catches of this species were destined for FIFO. As with the previous reconstruction, reported landings were assumed to cover 80% of the total catch (Mendo and Wosnitza-Mendo 2014).

Common dolphinfish (*Coryphaena hippurus*)

FAO has reported landings of common dolphinfish (or mahi-mahi) since 1988 (FAO 2019). Thus, the difference between catch data reported by FAO and local sources of information was used as the unreported catch between 1950 and 1987. Since then, reported landings were assumed to cover 75% of the catch. All landings of this species were caught by the artisanal sector. However, for vessels using small-scale gillnets and longlines, we assumed that 11% of the unreported catch corresponded to discards, since dolphinfishes tend to be gutted at sea (Palacios-Abrantes *et al.* 2018; Sueiro and De la Puente 2015).

Before the mid-1990s, common dolphinfish was caught only by small-scale gill netters as bycatch. Because this species was not really known or favoured by consumers, it was almost never sold at good prices. During the 1997/1998 El Niño, many coastal stocks of traditionally harvested resources were doing poorly due to El Niño or were truly depleted and on the verge of collapse, and therefore, some fishers ventured further offshore and began fishing for dolphinfish (De la Puente *et al.* 2015, Sueiro and De la Puente 2015).

However, when fishers returned to port and started selling common dolphinfish (a white meat species) at very low prices, fishmongers of other traditional, higher priced, white meat species (e.g., flatfishes, groupers) began to spread myths that dolphinfish carried parasites that cause people to get sick. This exaggeration was due to the longer fishing trips required to catch common dolphinfish with little to no ice due to poor insulation of the small-scale vessels' holds (De la Puente *et al.* 2015, Sueiro and De la Puente 2015).

Given the continued decline of coastal stocks and the increase of fishing effort during the 2000s, vessel owners were motivated to invest in the boats and improve their insulation or buy bigger boats to catch these fish. The fleet also began to favour longlines to catch common dolphinfish, which made the fish more marketable than those caught by gillnets in which fish fight to escape nets, causing damage to their skin. Moreover, fishers started to gut the catch at sea, reducing the chances of it being spoiled before reaching port, whilst also increasing discards. (De la Puente *et al.* 2015, Sueiro and De la Puente 2015)

Moreover, circa 2003, the seafood freezing industry was heavily hit with the collapse of the Peruvian hake stock. The resulting search for alternative species to freeze and export led to the explosion of the Humboldt squid fishery, the blue and shortfin mako shark fishery and the mahi-mahi fishery. With the financial support of the industry, many small-scale vessel owners obtained loans for adapting and/or building new vessels to increase catches and compete with Ecuador. Despite all of the investments made and the substantial growth of the Peruvian fleet, Ecuador still has higher catches of this species, most likely because the stock comes much closer to the shore there (De la Puente *et al.* 2015, Sueiro and De la Puente 2015). De la Puente *et al.* (2020) described the increase in CPUE of small-scale fisheries that occurred between 1992/2006 and how it relates to the mahi-mahi fishery.

Another aspect worth noting is that most small-scale fishing trips in Peru used to last between 0-3 days before the 1997/1998 El Niño. However, fishing trips for mahi-mahi, Humboldt squid and sharks tend to be much longer (up to 20-35 days sometimes). These long expeditions change the social dynamics of fishing communities as fishers were scared to leave their families or stay at sea for so long, (this involved artisanal vessels going 60-150 or more nautical miles offshore sometimes). Thus, the recent expansion in the catches also reflects an increase in investment for making bigger vessels and equipping them with echo sounders and proper holds. (De la Puente *et al.* 2015, Sueiro and De la Puente 2015)

Flathead grey mullet (*Mugil cephalus*)

The catch of this species is reported by FAO under the ‘Mullet ne’ category FAO (2019). All landings were caught by the artisanal sector and used for direct human consumption. The catch was split among small-scale fishing gears. We assumed that reported landings of this species corresponded to 75% of the catch and that 1% of all unreported catch was discarded at sea. The only exception to this were vessels using small-scale handlines. We assumed that they fully retained the catch.

Pacific menhaden (*Ethmidium maculatum*)

We used PRODUCE data to split the catch between DHC and FIFO. FIFO catch was allocated to industrial purse seiners. The small-scale catch was divided between the small-scale purse seine and gillnet fleets. Underreporting of the catch by FAO differed among sectors. For industrial vessels, we assumed that statistics covered 90% of the total catch, while for small-scale vessels we assumed they represented 75% of the total catch. In both cases, we assumed 1% of the unreported catch was discarded at sea. Moreover, we assumed that 2% of the unreported catch by small-scale purse seiners was landed and sold as bait.

Lumptail searobin (*Prionotus stephanophrys*) and flyingfishes (Exocoetidae)

Landings of lumptail searobin and other flyingfish species are regularly grouped together in catch statistics because they are labeled ‘volador’ in Spanish. These species appear within FAO statistics as one category (‘Flyingfishes ne’) between 1950 and 2016 and as two categories in 2017 (‘Flyingfishes ne’ and ‘Gurnards, searobins ne’) (FAO 2019).

Lumptail searobins are mainly caught by industrial trawlers targeting Peruvian hake (Mendo and Wosnitza-Mendo 2014), although they are also caught by small-scale trawl nets and gillnets. Flyingfishes, on the other hand, are exclusively caught by artisanal fishers. The small-scale fleet targets flyingfishes using gillnets or handlines, while a growing trap fishery now targets them for their roe (Marín *et al.* 2017; Sueiro and De la Puente 2015).

The catch was split between the two species using data provided by IMARPE and PRODUCE. All landings associated with FIFO were assigned to lumptail searobin. No industrial catch of this species was recorded before 1970, coinciding with the development of the Peruvian trawl fleet (Guevara-Carrasco and Leonart 2008). All landings of flyingfishes were destined for DHC.

The difference between national statistics and those reported by FAO was used to estimate the unreported catches for these species between 1950 and 1970. For searobin species, we assumed a 20% rate of underreporting with industrial bottom trawlers. For small-scale trawlers, we assumed a 30% rate of underreporting. For flyingfishes, we assumed a 25% rate of underreporting. Some exceptions to these rules were implemented in years when the national statistics exceeded FAO reported catch by

more than the assigned rates. In those years, the differences between the two datasets was used as the unreported catch. Alternatively, no underreporting was considered when FAO statistics exceeded those appearing on national reports.

Palm ruff (*Seriolella violacea*)

This species is reported by FAO under 'Warehou nei' (FAO 2019). The catch was split between the industrial and artisanal sector as indicated by Mendo and Wosnitza-Mendo (2014). This species was caught by industrial bottom trawlers and small-scale vessels using gillnets, handlines and purse seines (Marín *et al.* 2017; Mendo and Wosnitza-Mendo 2014; Sueiro and De la Puente 2015). All catches of this species were used for DHC. We assumed that the reported industrial catch represented 82% of the total catch, but for small-scale fishing methods we applied different rates depending on the gear and year and reflecting changes in small-scale fisheries monitoring systems. For small-scale gillnets and purse seiners, we assumed that the catch was underreported by a factor of 25% between 1950 and 1984, by a factor of 20% between 1985 and 1996, and by a factor of 15% between 1997 and 2018. For handlines, we assumed higher rates of underreporting (i.e., 30% between 1950 and 1984, 25% between 1985 and 1996 and 20% between 1997 and 2018).

Drums or croakers

FAO reported these species under 7 different taxonomic categories: 'Corvina drum', 'croakers nei', 'croakers, drums nei', 'Peruvian banded croaker', 'Peruvian weakfish', 'Sciaenas nei' and 'Marine fishes nei' (FAO 2019). Based on multiple sources of data (Appendix table 1) we were able to extract time series for six species: Corvina drum (*Cilus gilberti*), Lorna drum (*Sciaena deliciosa*), Minor stardrum (*Stellifer minor*), Pacific drum (*Larimus pacificus*), Peruvian banded croaker (*Paralonchurus peruanus*) and Peruvian weakfish (*Cynoscion analis*). The catches of other species of the Sciaenidae family were included within the 'Other marine fishes' category in this reconstruction.

Catches of these species were split between DHC and FIFO using data from PRODUCE. All of these species, except for the Lorna drum, are exclusively used for DHC. The Lorna drum is sometimes caught as bycatch in industrial anchoveta fishery, and thus a small component of its catch was used for FIFO.

The split between industrial and artisanal sectors differed among species. The corvina drum and the minor stardrum were caught only by the artisanal sector. The four remaining species were caught by both artisanal and industrial sectors, but the latter never amounted to more than 19% (Lorna 14%, Minor stardrum 8%, Peruvian banded croaker 19% and Peruvian weakfish 10%). The distribution of the industrial-artisanal catch was split based on rates available in Mendo and Wosnitza-Mendo (2014) and adjusted proportionally to changes in the industrial fishing effort.

The minor stardrum was fully underreported by FAO statistics. Yet, for the rest of the species, underreporting varied depending on the year and the gear. Generally, we assumed that underreporting was higher in small-scale handlines (30%) and trawl nets (35%) in comparison to small-scale gillnets, longlines and purse seines (within the 20%-25% range).

Chilean silverside (*Odontesthes regia*)

All catches of this species belonged to the artisanal sector. The catch was split among small-scale fishing gears. FAO data were assumed to cover 80% of the total catch, except for 1994 and 1996. In these two years, PRODUCE reported much higher values than those reported by FAO. Thus, the

difference between the two was used as the unreported catch. All catches were fully retained and exclusively used for DHC (Christensen *et al.* 2014; PRODUCE 2018).

Tunas

Multiple tuna species are regularly caught in Peru; however, the two most common are yellowfin tuna (*Thunnus albacares*) and skipjack tuna (*Katsuwonus pelamis*) (Marín *et al.* 2017; PRODUCE 2018). These correspond with the categories used by FAO. However, in 2017 two additional categories for tuna were included in FAO statistics: ‘Tuna-like fishes nei’ and ‘Albacore’ (FAO 2019). We were not able to reconstruct the time series for these two new categories. Thus, we decided to add their catches to the ‘Marine fishes nei’ category in 2017.

For yellowfin and skipjack tunas we assumed the FAO data represented 75% of the total catch of these species. However, we assumed 24% of the unreported catch corresponded to yellowfin tuna and 20% of the unreported catch of the skipjack tuna to be discards, because these species are regularly bled and gutted at sea (JC Sueiro, pers. comm.). We used data from PRODUCE to split the catch between artisanal and industrial sectors.

The industrial catch of tuna, swordfish and billfishes were not included here because they are estimated by a separate *Sea Around Us* study (Coulter *et al.* 2020).

Peruvian rock seabass (*Paralabrax humeralis*)

The catch of this species was split between industrial and artisanal sectors using data provided by PRODUCE. We assumed that industrial catches were underreported by a factor of 20%. For small-scale fishing gears, we assumed that reported catches using hands or tools, handlines and trawl nets corresponded to 70% of the total catch, while those using gillnets, longlines, or purse seiners corresponded to 80% of the total catch. Finally, we assumed that 1% of the unreported catch was discarded at sea.

Cabinza grunt (*Isacia conceptionis*)

Only 2% of the catch of this species was assigned to industrial purse seiners. FAO data were assumed to cover 75% of the reported catch caught by small scale gillnets, purse seiners and trawlers. FAO data was assumed to cover 70% of the catch caught by small scale handlines. The only exceptions were 1954 and 1994, when IMARPE reported data exceeded the reconstructed value; we used the difference between the value reported by IMARPE and FAO as a proxy for the unreported catch. This was proportionally distributed among the gears. Finally, 1% of the unreported catch was assumed to be discarded for small-scale gillnets and purse seines.

Punctuated snake-eel (*Ophichthus remiger*)

This species is listed in FAO statistics under the category ‘Snake eels nei’; however, catches for it were only reported in 2017 (FAO 2019). We were able to extract this species out of the ‘Marine fishes nei’ category for the 1950-2016 period using multiple sources of information (Appendix table 1) and 2000-2018 data provided by PRODUCE (PRODUCE 2011, 2012, 2013, 2015a, 2015b, 2016, 2017, 2018). The catch of this species was entirely attributed to small-scale traps (Marín *et al.* 2017) fully retained and destined for DHC.

Tilefish (*Caulolatilus* spp.)

Two species of tilefish are reported to be landed in Peru: Bighead tilefish (*Caulolatilus affinis*) and the Ocean whitefish (*C. princeps*). Most catches appear to belong to the bighead tilefish (Sueiro and De la Puente 2015). No additional catch was reconstructed between 1950 and 1961, because catches reported by FAO were roughly 1.4 times those reported by PRODUCE. The FAO has reported almost no catches of this species since 2004. We used the difference between IMARPE and PRODUCE data and FAO data to reconstruct the catch from 1999 to 2018. Using the estimated bycatch rate of this species by industrial trawlers targeting hake (2008-2018), we were able to estimate the unreported catch of this species by trawlers back to 1967. For the period between 1962 and 1998, we estimated that small-scale gillnets, handlines, longlines, purse seiners and trawlers capturing these species reported only 75% of the catch. No discards were considered for these species.

Cusk-eels (Ophidiidae)

Cusk-eels are mainly composed of two species; the most abundant species is the Pacific bearded brotula (*Brotula clarkae*), and the less abundant (by far) is the black cusk-eel (*Genypterus maculatus*) (Sueiro and De la Puente 2015). The catch was divided by fishing gears using the same methods as for the other species. We used the difference between data provided by PRODUCE, data extracted from Caillaux (2011), and data reported by FAO to estimate the unreported catch before 1970, allocating it proportionally to the fishing gears active at the time. Since 1970, we assumed the reported catch represented 75% of the total catch. Only 1989, 1990, and 1999 were exceptions because the difference between the reported catches by FAO and PRODUCE exceeded the 75% rule. Thus, we used the difference between the two statistics as the unreported catch. Discards, amounting to 1% of the unreported catch, were assigned only to small-scale trawlers and gillnets.

Swordfish (*Xiphias gladius*)

In years during which FAO data exceeded PRODUCE estimates of the catch of swordfish, and PRODUCE was less than 80% of the catch reported by FAO, we did not add unreported catches. For all other years, we assumed FAO data covered only 80% of the reported catch. Discards were assumed to represent 10% of the unreported catch. Catches were split among small-scale fishing gears (mainly small-scale gillnets and longlines, Marín *et al.* 2017). The industrial catch of tuna, swordfish and billfishes were not included here as they are estimated by a separate *Sea Around Us* study (Coulter *et al.* 2020).

Peruvian moonfish (*Selene peruviana*)

This species only appeared in FAO statistics in 2017 (FAO, 2019). However, using data reported by Peruvian institutions and research groups, we were able produce a time series for this species. The catches were distributed among gears as for other species. This species was assumed to be fully retained and used exclusively for DHC.

Pacific sierra (*Scomberomorus sierra*)

As in previous cases, Pacific sierra catches were split between small-scale gears. Reported FAO data were assumed to cover 75% of the total catch of the species. Discards, amounting to 1% of the unreported catch, were allocated only to small-scale gillnets and purse seines.

Flatfishes (Pleuronectiformes)

Based on Marín *et al.* (2017), flatfishes are almost exclusively caught using gillnets. FAO catches were, for the most part, larger than PRODUCE data. For years when the difference between the two data

sets made PRODUCE values 75% or more of FAO catch, we added unreported landings. If PRODUCE catches were less than 75% of FAO data, we did not add unreported catches.

Paloma pompano (*Trachinotus paitensis*)

Catches of this species are included under the ‘Pompanos nei’ category in FAO statistics (FAO 2019). The difference between the reported landings by FAO and those available from other sources of information (Appendix table 1) was used to estimate unreported catches. This species was exclusively caught by gillnets (Marín *et al.* 2017), fully retained and exclusively used for DHC (Sueiro and De la Puente 2015).

Basses, groupers, hinds (Serranidae)

These species are listed in two different categories in FAO statistics: ‘Groupers nei’ and ‘Groupers, seabasses nei’ (FAO 2019). We used these and local sources of data to reconstruct the catches of these species. Catches reported by FAO generally exceeded those reported locally. For years where the difference between the two data sets made PRODUCE values 75% or more of FAO catch, we added unreported landings. If PRODUCE catches were less than 75% of FAO data, we did not add unreported catches. We assumed that all catches were fully retained, exclusively used for DHC, and caught by the artisanal sector using hands or tools, and small-scale gillnets, handlines and longlines (Marín *et al.* 2017; Sueiro and De la Puente 2015).

Peruvian grunt (*Anisotremus scapularis*)

We obtained data from local sources (Appendix table 1) to reconstruct the catches of this species labeled in the FAO statistics as ‘Grunts, sweetlips nei’ (FAO 2019) and in the *Sea Around Us* database as ‘Grunts, sweetlips, bonnetmouths’. Since this species is so severely underreported, we used the difference between FAO catches and other sources of reported catch as the unreported catch. We split the catch between fishing fleets as in the previous cases. We assumed that all catches were fully retained and that they were exclusively used for DHC.

Peruvian morwong (*Cheilodactylus variegatus*)

We assumed that all catches were fully retained, used exclusively for DHC and caught by the artisanal sector (Marín *et al.* 2017; Sueiro and De la Puente 2015). The difference between data reported by FAO and data reported by local sources was used to determine the level of unreported catches between 1950 and 1965. For all other years, we assumed that the reported landings by FAO represented 70% of the total catch. We split the catch between fishing fleets as in the previous cases. We assumed that all catches were fully retained and used exclusively for DHC.

Fully unreported taxa

Time series for five species were reconstructed using local data (Appendix table 1). Black snook (*Centropomus nigrescens*), Californian needlefish (*Strongylura exilis*), chalapo clinid (*Labrisomus philippii*), fortune jack (*Seriola peruana*), and grape-eye seabass (*Hemilutjanus macrophthalmos*), were caught using exclusively small-scale fishing gear and were fully retained and used for DHC.

Other marine fishes

Catches for the remaining groups reported by FAO were added to the ‘Marine fishes nei’, which we describe in this reconstruction as ‘other marine fishes’ (FAO 2019). We subtracted the catches from the new groups reported as part of this category. We assumed that the reported catches corresponded to 80% of the total catch

and that the catch was fully retained (i.e., no discards). We split the catch proportionally by fishing methods to represent the distribution of fishes caught for direct human consumption.

Results and Discussion

FAO fishery statistics included catch estimates for 98 taxonomic groups (species or groups of species) caught within the Peruvian EEZ between 1950 and 2018 (FAO 2019). The taxonomic resolution of this database shows important improvement over time, particularly in 2017. However, since 1990 information has been consistently displayed for 57 (± 3) groups.

For this iteration of the catch reconstruction, we produced time series data for 71 taxonomic groups extending from 1950 to 2018, including: 42 taxa of teleost fishes, 11 taxa of molluscs, 10 taxa of cartilaginous fishes, 3 taxa of crustaceans, 3 taxa of macroalgae, and 2 taxa of echinoderms. This represents a 29% increase in the taxonomic resolution of the Peruvian catch reconstruction with respect to its previous version (Mendo and Wosnitza-Mendo 2014).

Reported vs reconstructed catch

The reported catch of Peru amounted to 381.84 million tonnes between 1950 and 2018 (Figure 1). This country's catch is equivalent to 9% of the total global fisheries production reported by FAO during this period (FAO 2019). Marine living resources were caught by Peruvian fishing fleets at an average rate of 5.53 (± 0.77) million tonnes per year. Nonetheless, since 1995 the total reported catch has been decreasing at a rate of over 186,000 tonnes per year.

After accounting for discards and unreported landings, the total reconstructed catch of Peru totaled 471.20 (± 9.37) million tonnes (Figure 1). In other words, reported catches by FAO represented only 81% of the reconstructed (total) catch. These findings are similar to those reported in the previous iteration of the Peruvian catch reconstruction (Mendo and Wosnitza-Mendo 2014).

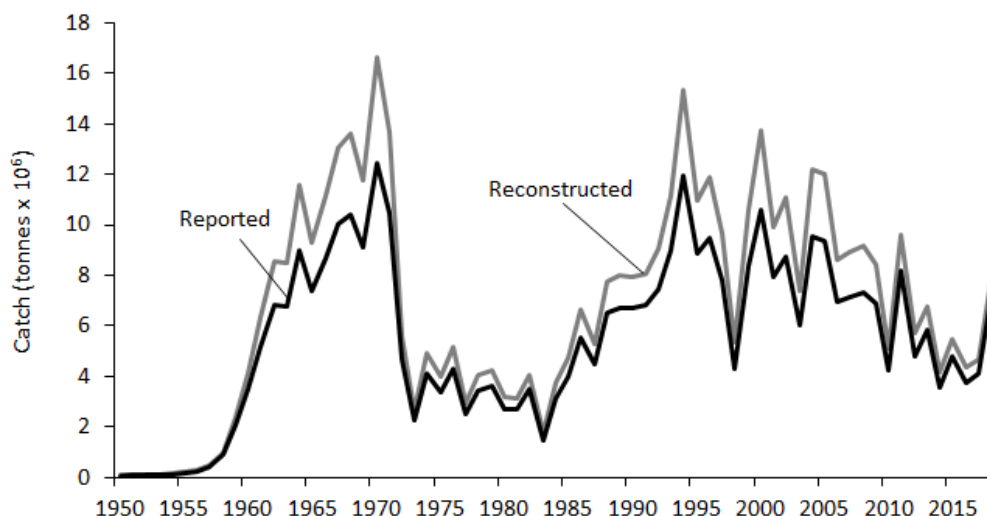


Figure 1. Reported and reconstructed domestic catch within Peru's EEZ for 1950-2018.

Underreporting rates have not been constant over time (Figure 2) and are heavily influenced by the changes in the strength of government systems monitoring the industrial anchoveta fishery (Mendo and Castillo 1987). Thus, it is not surprising that the implementation of the 3rd party observer program, which started in 2004 and has inspectors stationed year-round on 100% of the industrial landing sites (De la Puente *et al.* 2011;

SPDA 2019), has led to an important reduction in the total unreported catch of Peru. However, it is worth noting that artisanal vessels targeting anchoveta for illegal fishmeal and fish oil production are a current problem for Peru (Grillo *et al.* 2018) and continue to be a major source of unreported catches since 2007.

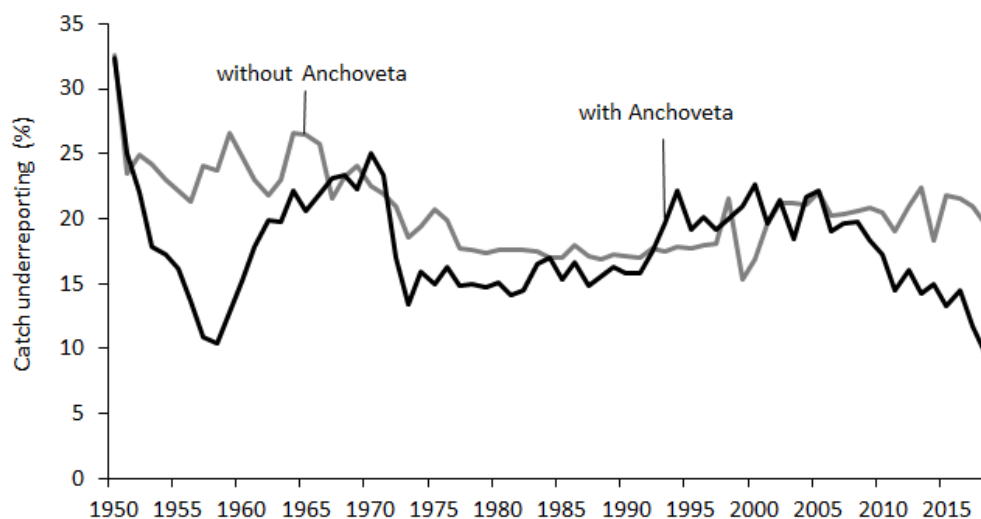


Figure 2. Catch underreporting within Peru's EEZ, expressed as a percentage of the reconstructed domestic catch, with and without anchoveta.

If anchoveta catches are removed from the equation, reporting seemed to improve during the second half of the 20th century. However, underreporting in the 21st century has been well above the average rate estimated for the time series (Figure 2). The main sources of unreported catches between 2000 and 2018 were: the small-scale fleet targeting jumbo flying squids with manual jigs (38%); the industrial purse seine fishery landing Chilean jack mackerel (13%) and Pacific chub mackerel (7%) for fishmeal production; the small-scale longline fleet targeting common dolphinfish (6%); the industrial bottom trawl fleet fishing for Peruvian hake (4%); small-scale purse seiners targeting Eastern Pacific bonito (3%); small-scale vessels using traps targeting punctuated snake-eels (3%); and small-scale fishers targeting flathead grey mullets (2%). Together, these fisheries represent 76% of the unreported catch of Peru without anchoveta over the last two decades.

Systems monitoring artisanal/small-scale fisheries landings have improved since 1996 (Estrella and Swartzman 2010; Marín *et al.* 2017). However, they continue to be underfunded (Pajuelo and Sueiro 2019; Sueiro and De la Puente 2015), and their task keeps getting more difficult with the ever-growing artisanal fleet (De la Puente *et al.* 2020). Nonetheless, a big segment of the jumbo flying squid and common dolphinfish unreported catch corresponds to discards. These species are commonly cleaned and gutted at sea (Palacios-Abrantes *et al.* 2018). However, the discarded weight is not accounted for in Peruvian statistics which reflect landings (i.e., retained catch) rather than the total catch (i.e., retained and discarded catch) (Palacios-Abrantes *et al.* 2018; Sueiro and De la Puente 2015). Additionally, the industrial catch of mackerel species for the reduction industry (i.e., FIFO production) was reported by PRODUCE but not included in FAO statistics.

Reconstructed catch by fishing sector

The industrial sector was responsible for 94% of the reconstructed catch of Peru during the time series. However, catches by the small-scale fleet increased after the 1997/1998 El Niño event and averaged at 1.23 (± 0.08) million tonnes per year between 2007–2018, while industrial. Industrial catches averaged at 5.47 (± 1.15) million tonnes per year during that time. These results show that the relative importance of the Peruvian industrial fleet has declined over the last 12 years (Figure 3). Subsistence and recreational fisheries are

negligible in Peru. During the whole time series, catches corresponding to recreational fisheries amounted to 17,000 tonnes (average: 241 ± 50 tonnes per year), while the subsistence catch reached 450,000 tonnes (average: $6,525 \pm 393$ tonnes per year).

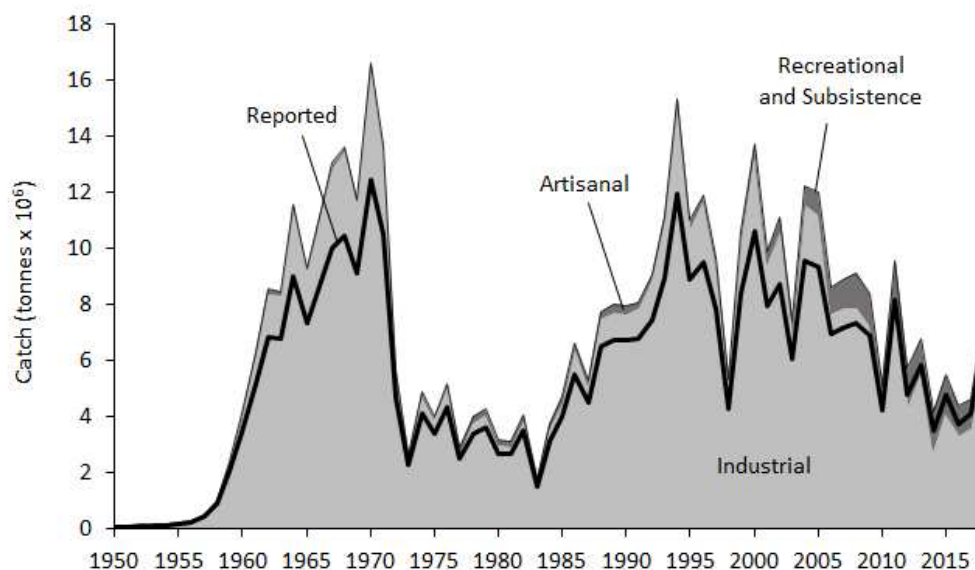


Figure 3. Reconstructed domestic catch within Peru's EEZ, by fishing sector for 1950-2018.

Regarding fishing methods, most of the catch across the time series was caught by industrial purse seiners (92.5%). Industrial bottom trawlers and small-scale trawlers contributed with 1.2%, and 0.1% of the reconstructed catch, respectively. The main contributors to the catch in Peru pertaining to the artisanal sector were vessels equipped with purse seine nets (2.2%), manual squid jiggers (1.8%), gillnets (1%), hands or tools (0.5%), longliners (0.3%), handlines (0.3%) and traps (<0.1%).

Finally, most of the Peruvian catch has been historically used in FIFO production (86%), and virtually all of it (99%) was captured by industrial vessels using purse seine nets. Nonetheless, illegal production of FIFO using artisanal catches is an ongoing problem in Peru (Grillo *et al.* 2018; Sueiro and De la Puente 2015). The estimated illegal catch of anchoveta for FIFO represented 14% of the artisanal catch reconstructed for the 2007-2018 period (Fig. 4).

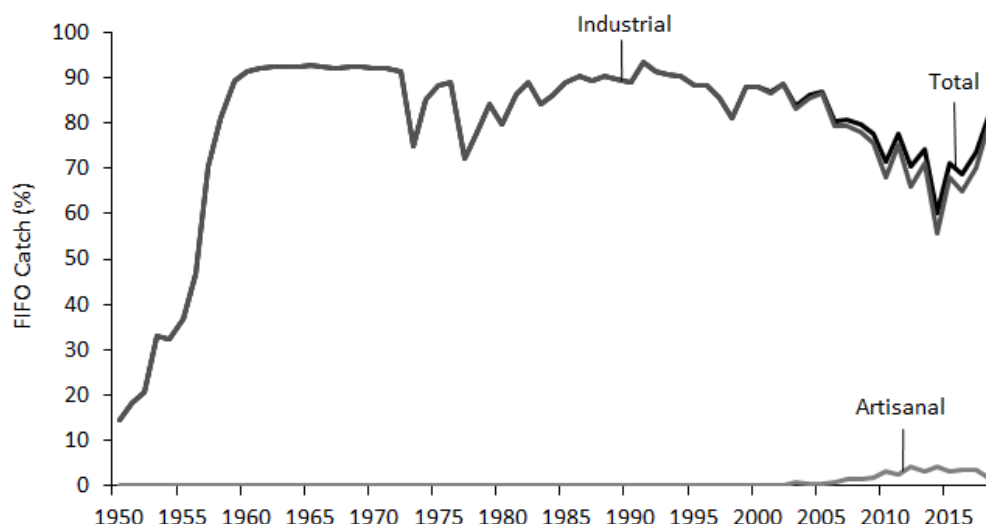


Figure 4. Domestic catch used for fishmeal and fish oil production (FIFO catch) within Peru's EEZ, expressed as a percentage of the reconstructed catch and segregated by fishing sector.

Reliance on traditional target species

Only ten species (of the 71 taxa included here) were responsible for 97% of the reconstructed catch between 1950 and 2018. These were: Anchoveta (*Engraulis ringens*, 79.1%), Pacific sardine (*Sardinops sagax*, 10.7%), Chilean jack mackerel (*Trachurus murphyi*, 2%), jumbo flying squid (*Dosidicus gigas*, 1.9%), Peruvian hake (*Merluccius gayi peruanus*, 0.9%), Pacific chub mackerel (*Scomber japonicus*, 0.9%), Eastern Pacific bonito (*Sarda chiliensis*, 0.7%), longnose anchovy (*Anchoa nasus*, 0.3%), common dolphinfish (*Coryphaena hippurus*, 0.2%) and the flathead grey mullet (*Mugil cephalus*, 0.2%).

Three of these species were exclusively captured by the artisanal sector (i.e., jumbo flying squid, common dolphinfish and flathead grey mullet), while the others were caught by both the artisanal and industrial sectors. Catches of sardines have been almost negligible since 2002 (on average: $1,800 \pm 1,500$ tonnes per year). The species virtually disappeared of the Peruvian seas as a result of overexploitation (Cárdenas-Quintana 2009; Cárdenas-Quintana *et al.* 2015) and multifarious regime shifts (Bertrand *et al.* 2011; Salvatelli *et al.* 2018).

As reported by Mendo and Wosnitza-Mendo (2014), the relative importance of traditionally targeted coastal species is declining in Peruvian catch statistics. This pattern corresponds to the growing catch of oceanic taxa (e.g., jumbo flying squid, common dolphinfish, blue shark, shortfin mako and common thresher) and macroalgae by the artisanal fleet (Fig. 5). This hints to the potential decline in abundance of coastal species valued locally because of increasing fishing effort (De la Puente *et al.* 2020; Pauly 2009) and increasing global demand of seafood products (Christensen *et al.* 2014; Crona *et al.* 2016).

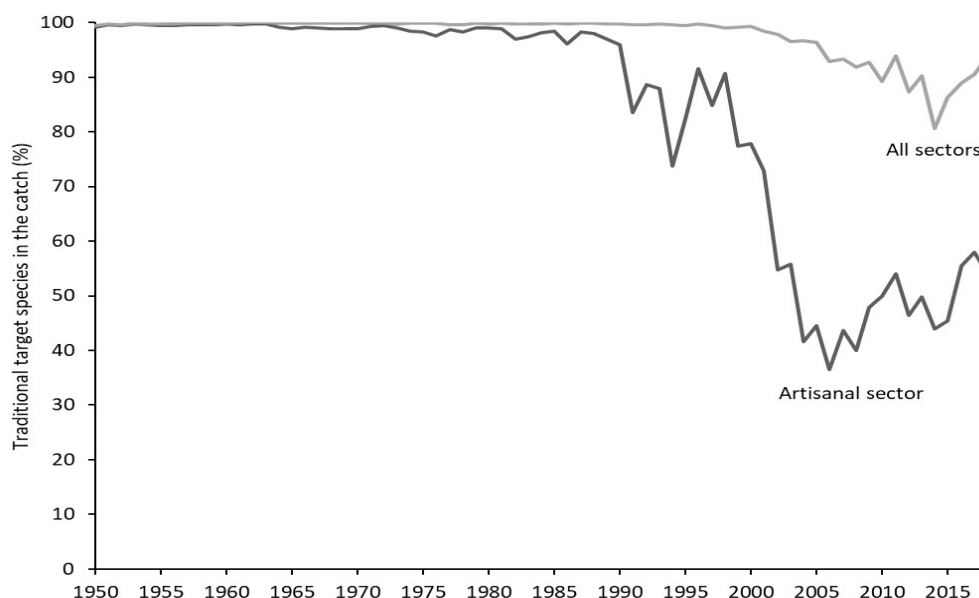


Figure 5. Domestic catch of traditional target species within Peru’s EEZ, expressed as a percentage of the reconstructed catch, highlighting the artisanal sector.

Marine biodiversity protection

Peru has agreed to protect its biological diversity through the international agreements of the Convention on Biological Diversity (Aichi) and Ramsar Convention on Wetlands of International Importance (Marine Conservation Institute 2020).

Peru has eight MPAs and four marine managed areas. Together, these areas cover 4,030 km² (Marine Conservation Institute 2020), which equals 0.47% of the EEZ of 857,000 km² (Mendo and Wosnitza-Mendo 2016). The many smallish islands off Peru are important for the wildlife they support, notably South American sea lion (*Otaria flavescens*) and South American fur seals (*Arctocephalus australis*) (Majluf and Reyes 1989), and especially seabirds, i.e., Peruvian booby (*Sula variegata*), Guanay cormorant (*Phalacrocorax bougainvilli*) and Peruvian pelican (*Pelecanus thagus*) (Tovar *et al.* 1987), which is why, before and during the Incas’ reign, they have been protected through a kind of community-based system. The Spanish invasion and the mining of guano during the late 19th and early 20th centuries are an exception to this (Láinez del Pozo and Jones 2020).

“‘Isla Lobos de Tierra’ and ‘Isla Lobos de Afuera’ are two MPAs that show the importance of history in governance. In 2009 they were designated among the Guano Islands, Islets and Capes Reserve System for wildlife conservation and sustainability, after being protected for hundreds of years to manage guano. Since their designation, governance changed on paper, but not de facto. The major driver undermining conservation is fishing, which is enhanced by pressures of the global seafood market and informality (the predominant way of thinking and acting in Peru, transgressive of order and disrespectful of values, norms and institutions). [...]. An obstacle is that the Parks Service has no authority to manage marine species. Management effectiveness requires improving cross-jurisdictional coordination with the Vice-Ministry of Fisheries, the Maritime Authority and other relevant entities to develop an integral plan where they all convene on working towards conserving these MPAs. Success will rely on an improved and diligent state participation that deeply understands the social complexities of these environments in order to address informality and potential equity issues. Despite the minimal intervention, the land ecosystem and its species remain relatively protected due to

a governance legacy of strict enforcement and fraternal relationships between guardians and artisanal fishers, which highlights the importance of recognising history in conservation” (Laínez del Pozo and Jones 2020).

Final remarks

Peru continues to have one of the highest fish catches in the world (FAO 2018). Overall reporting of Peruvian catches is improving, because of significant improvements in monitoring systems for the industrial fleet (De la Puente and López de la Lama 2019). Artisanal fisheries, however, remain marginalized by management institutions and endure the consequences of ineffective regulations, environmental uncertainty, social traps and market inequity (De la Puente *et al.* 2020; Marín *et al.* 2018; SPDA 2019; Sueiro and De la Puente 2015; Vélez-Zuazo *et al.* 2020). These are common challenges for small-scale fisheries around the world (Chuenpagdee and Jentoft 2019; Finkbeiner *et al.* 2017; Pauly 2006; Salas *et al.* 2007). However, in Peru artisanal fisheries are major contributors to employment, gross domestic product and food security (Christensen *et al.* 2014; Palacios-Abrantes *et al.* 2018) and make only minor contributions to total landings. Artisanal fisheries need improved management plans and would benefit from reliable catch statistics, that pay greater attention to threatened taxa (Alfaro-Córdova *et al.* 2017; Velez-Zuazo *et al.* 2015). Improving catch statistics and fisheries management would benefit from bottom-up approaches and listening to fishers’ creative solutions to increase reporting (López de la Lama *et al.* 2018b; Mason *et al.* 2020; Nakandakari *et al.* 2017). However, these initiatives need to be paired with heightened financial support for monitoring agencies and cross-agency collaboration (SPDA 2019; Sueiro and De la Puente 2015).

Acknowledgements

The authors would like to acknowledge the support of B. Derrick, R. López de la Lama, M. Kisner, J. Mendo, M. Pajuelo, D. Pauly, J.C. Riveros and J.C. Sueiro, who supplied data and provided feedback to strengthen the current catch reconstruction.

References

- Alfaro-Córdova, E., A. Del Solar, J. Alfaro-Shigueto, J.C. Mangel, B. Diaz, O. Carrillo and D. Sarmiento. 2017. Captures of manta and devil rays by small-scale gillnet fisheries in northern Peru. *Fisheries Research*, 195: 28–36. doi.org/10.1016/j.fishres.2017.06.012
- Alfaro-Shigueto, J., J.C. Mangel, M. Pajuelo, P.H. Dutton, J.A. Seminoff and B.J. Godley. 2010. Where small can have a large impact: Structure and characterization of small-scale fisheries in Peru. *Fisheries Research*, 106: 8–17. doi.org/10.1016/j.fishres.2010.06.004
- Bertrand, A., A. Chaigneau, S. Peraltila, J. Ledesma, M. Graco, F. Monetti and F.P. Chavez. 2011. Oxygen: A Fundamental Property Regulating Pelagic Ecosystem Structure in the Coastal Southeastern Tropical Pacific. *PLoS ONE*, 6: e29558–8. doi.org/10.1371/journal.pone.0029558
- Borgo Derpich, J.L., I. Vásquez Aguirre and A. Paz Torres. 1967. La pesquería marítima peruana durante 1966. Informe Instituto del Mar del Perú No.19. 118 p.
- Borgo Derpich, J.L., I. Vásquez Aguirre and A. Paz Torres. 1969. La pesquería marítima peruana durante 1967. Informe Instituto del Mar del Perú No.26. 46 p.
- Bouchon, M., M. Niquen, M. Franco and H. Tito. 2018. Estadísticas de la pesquería pelágica en la costa peruana (1959-2015). *Informe Instituto del Mar del Perú*, 45(4): 397-562.
- Bouyer, T. 2009. Les quotas individuels: Outils de Gestion des Pêcheries. École nationale du génie rural, des eaux et des forêts (ENGREF), Paris.
- Caillaux, M. 2011. Efecto de la pesquería en la estructura del ecosistema de afloramiento peruano. Universidad Nacional Agraria La Molina, Lima, Peru.
- Cárdenas-Quintana, G., M. Franco-Meléndez, J. Salcedo-Rodríguez, D. Ulloa-Espejo and J. Pellón-Farfán. 2015. The Peruvian sardine, *Sardinops sagax*: Historical analysis of the fishery (1978–2005). *Ciencias Marinas*, 41: 203–216. dx.doi.org/10.7773/cm.v41i3.2466
- Cárdenas-Quintana, G. 2009. Análisis de series de tiempo de los indicadores biológicos, pesqueros y poblacionales de la sardina, *Sardinops sagax sagax* (Jenyns, 1842), en función de la variabilidad ambiental y la pesca. Universidad Nacional Mayor de San Marcos, Lima, Peru.

- Cashion, T., D. Al-Abdulrazzak, L. van der Meer, B. Derrick, E. Divovich, D.K. Moutopoulos, S.-L. Noël, M.L.D. Palomares, L.C.L. Teh, D.C. Zeller and D. Pauly. 2018. Reconstructing global marine fishing gear use: Catches and landed values by gear type and sector. *Fisheries Research*, 206, 57–64. doi.org/10.1016/j.fishres.2018.04.010
- Cashion, T., F. Le Manach, D.C. Zeller and D. Pauly. 2017. Most fish destined for fishmeal production are food-grade fish. *Fish and Fisheries*, 18: 837–844.
- Castillo, G., J. Fernández, A. Medina and R. Guevara-Carrasco. 2018. Tercera encuesta estructural de la pesquería artesanal en el litoral peruano. Resultados generales. *Informe Instituto del Mar del Perú*, 45(3): 299–388.
- Christensen, V., S. De la Puente, J.C. Sueiro, J. Steenbeek and P.Y. Majluf. 2014. Valuing seafood: The Peruvian fisheries sector. *Marine Policy*, 44: 302–311. doi.org/10.1016/j.marpol.2013.09.022
- Chuenpagdee, R. and S. Jentoft. 2019. Small-Scale Fisheries: Too Important to Fail, p. 349-353. In: International Ocean Institute - Canada (ed). *The Future of Ocean Governance and Capacity Development, Essays in Honor of Elisabeth Mann Borgese (1918-2002)*. Leiden, the Netherlands.
- Coulter, A., T. Cashion, A. Cisneros-Montemayor, S. Popov, G. Tsui, F. Le Manach, L. Schiller, M. Palomares, D. Zeller and D. Pauly. 2020. Using harmonized historical catch data to infer the expansion of global tuna fisheries. *Fisheries Research*, 221:105379. doi.org/10.1016/j.fishres.2019.105379
- Crona, B.I., T.M. Daw, W. Swartz, A.V. Norström, M. Nyström, M. Thyresson, C. Folke, J. Hentati-Sundberg, H. Österblom, L. Deutsch and M. Troell. 2016. Masked, diluted and drowned out: how global seafood trade weakens signals from marine ecosystems. *Fish and Fisheries*, 17: 1175–1182. doi.org/10.1111/faf.12109
- Csirke, J., J. Argüelles, A. Alegre, P. Ayón, M. Bouchon, G. Castillo, R. Castillo, R. Cisneros, R. Guevara-Carrasco, L. Lau, L. Mariátegui, C. Salazar, R. Tafur, J. Torrejón-Magallanes and C. Yamashiro. 2018. Biología, estructura poblacional y pesquería de pota o calamar gigante (*Dosidicus gigas*) en el Perú. *Boletín Instituto del Mar del Perú*, 33(2): 302–364.
- De la Puente, S., D. Flores D., J. Grillo and C. Paredes. 2015. Caracterización y análisis de la cadena productiva de perico (*Coryphaena hippurus*) desembarcado en las principales regiones de la costa peruana. Consultoría elaborada para WWF-Perú por Inteligencia Financiera SAC, Lima. 119 p.
- De la Puente, O., J.C. Sueiro, C. Heck, G. Soldi and S. De la Puente. 2011. La pesquería peruana de anchoveta. Universidad Peruana Cayetano Heredia, Lima, Perú. 160 p.
- De la Puente, S. 2014. El Decreto Legislativo No. 1084 y su impacto en el comportamiento de la flota industrial de cerco que captura anchoveta en la Zona Norte-Centro del litoral Peruano. Universidad Peruana Cayetano Heredia, Lima, Perú.
- De la Puente, S. 2017. Characterizing the knowledge and attitudes towards sharks and the domestic use of shark meat and fins in Peru. Master's thesis, University of British Columbia, Vancouver. 101 p.
- De la Puente, S. and R. López de la Lama. 2019. Industrial fisheries in Latin America: Challenges and lessons from Chile, Mexico and Peru, p. 15-32. In: M. Ruiz Muller, R. Oyanedel, B. Monteferrri (eds). *Marine and Fisheries Policies in Latin America: A Comparison of Selected Countries*. Routledge, London.
- De la Puente, S., R. López de la Lama, S. Benavente, J.C. Sueiro and D. Pauly. (2020). Growing into poverty: reconstructing Peruvian small-scale fishing effort between 1950 and 2018. *Frontiers in Marine Science*, 7: 681. doi: 10.3389/fmars.2020.00681
- Escobedo Oblitas, R.M.D.C. 2018. Índice de abundancia para múnida (*Pleuroncodes monodon*) a partir de datos de su captura incidental en la pesca industrial de la anchoveta peruana (*Engraulis ringens*) desde 1997 a 2014. Universidad Peruana Cayetano Heredia, Lima, Peru.
- Espino, M. 1990. Análisis de las poblaciones de los principales recursos demersales del Perú. *Boletín Instituto del Mar del Perú*, 14(1): 1–26.
- Espino, M., C. Wosnitza-Mendo and R. Castillo. 1984. La pesca de arrastre de la flota costera de Paita entre 1970-1982. *Boletín Instituto del Mar del Perú*, 8(5): 163–178.
- Estrella, C. and R. Guevara-Carrasco. 1998. Informe estadístico anual de los recursos hidrobiológicos de la pesca artesanal por especies, artes, caletas y meses durante 1996. Informe Instituto del Mar del Perú No.131. 215 p.
- Estrella, C., R. Guevara-Carrasco, W. Avila, J. Palacios and A. Medina. 2000a. Informe estadístico de los recursos hidrobiológicos de la pesca artesanal por especies, artes, meses y caletas durante el segundo semestre de 1999. Informe Instituto del Mar del Perú No.151. 194 p.
- Estrella, C., R. Guevara-Carrasco, A. Medina, J. Palacios and W. Avila. 1999a. Informe estadístico de los recursos hidrobiológicos de la pesca artesanal por especies, artes, caletas y meses durante el segundo semestre de 1998. Informe Instituto del Mar del Perú No.143. 226 p.

- Estrella, C., R. Guevara-Carrasco and J. Palacios. 1998. Informe estadístico de los recursos hidrobiológicos de la pesca artesanal por especies, artes, caletas y meses durante el primer semestre de 1998. Informe Instituto del Mar del Perú No. 139. 229 p.
- Estrella, C., R. Guevara-Carrasco, J. Palacios, W. Avila and A. Medina. 1999b. Informe estadístico de los recursos hidrobiológicos de la pesca artesanal por especie, artes, caletas y meses durante el primer semestre de 1999. Informe Instituto del Mar del Perú No.148. 214 p.
- Estrella, C., J. Palacios, W. Avila and A. Medina. 2001. Informe estadístico de los recursos hidrobiológicos de la pesca artesanal marina por especies, artes, meses y lugares de desembarque durante el segundo semestre del 2000. Informe Instituto del Mar del Perú No.164. 163 p.
- Estrella, C., J. Palacios, W. Avila, A. Medina and R. Guevara-Carrasco. 2000b. Informe estadístico de los recursos hidrobiológicos de la pesca artesanal marina por especies, artes, meses y lugares de desembarque durante el primer semestre del 2000. Informe Instituto del Mar del Perú No.158. 157 p.
- Estrella, C. and G. Swartzman. 2010. The Peruvian artisanal fishery: Changes in patterns and distribution over time. *Fisheries Research*, 101: 133–145. doi.org/10.1016/j.fishres.2009.08.007
- FAO. 2018. The state of world fisheries and aquaculture 2018: Meeting the sustainable development goals. Food and Agriculture Organization of the United Nations (FAO), Rome. 227 p.
- FAO. 2019. Fishery and Aquaculture Statistics: Global production by production source 1950–2017. Food and Agriculture Organization of the United Nations (FAO), Rome.
- Fernández, F., S. Vera, R. Marcelo and E. Chirinos. 2000. Estadísticas de los desembarques de la pesquería marina peruana 1999. Informe Instituto del Mar del Perú No.155. 41 p.
- Finkbeiner, E.M., N.J. Bennett, T.H. Frawley, J.G. Mason, K. Briscoe, C.M. Brooks, C. A. Ng, R. Ourens, K. Seto, S. Switzer Swanson, J. Urteaga and L.B. Crowder. 2017. Reconstructing overfishing: Moving beyond Malthus for effective and equitable solutions. *Fish and Fisheries*, 18:1180–1191. doi.org/10.1111/faf.12245
- Flores, M., S. Vera and E. Chirinos.1996. Estadísticas de los desembarques de la pesquería marina peruana durante 1995. Informe Progresivo Instituto del Mar del Perú No.45. 35 p.
- Flores, M., S. Vera, R. Marcelo and E. Chirinos. 1994. Estadísticas de los desembarques de la pesquería marina peruana 1983–1992. Informe Instituto del Mar del Perú No.105. 202 p.
- Flores, M., S. Vera, R. Marcelo and E. Chirinos. 1997. Estadísticas de los desembarques de la pesquería marina peruana 1995–1996. Informe Instituto del Mar del Perú No.129. 64 p.
- Flores, M., S. Vera, R. Marcelo and E. Chirinos. 1998a. Estadísticas de los desembarques de la pesquería marítima peruana 1970–1982. Informe Instituto del Mar del Perú No.134. 256 p.
- Flores, M., S. Vera, R. Marcelo and E. Chirinos. 1998b. Estadísticas de los desembarques de la pesquería marina peruana 1996–1997. Informe Instituto del Mar del Perú No.140. 63 p.
- Froese, R., N. Demirel, G. Coro, K.M. Kleisner and H. Winker. 2017. Estimating fisheries reference points from catch and resilience. *Fish and Fisheries*, 18:506–526. doi.org/10.1111/faf.12190
- Froese, R., D.C. Zeller, K. Kleisner and D. Pauly. 2012. What catch data can tell us about the status of global fisheries. *Marine Biology*, 159: 1283–1292. doi.org/10.1007/s00227-012-1909-6
- Greer, K., D.C. Zeller, J. Woroniak, A. Coulter, M. Winchester, M.L.D. Palomares and D. Pauly. 2019. Global trends in carbon dioxide (CO₂) emissions from fuel combustion in marine fisheries from 1950 to 2016. *Marine Policy*, 107: 103382. doi.org/10.1016/j.marpol.2018.12.001
- Grillo, J., R. Gozzer, J.C. Sueiro and J.C. Riveros. 2018. Producción ilegal de harina de pescado en Perú a partir de anchoveta extraída por la flota artesanal y de menor escala. Oceana, Lima, Perú.
- Guevara-Carrasco, R. and J. Leonart. 2008. Dynamics and fishery of the Peruvian hake: Between nature and man. *Journal of Marine Systems*, 71(3–4): 249–259. doi.org/10.1016/j.jmarsys.2007.02.030
- Gutiérrez, D., M. Akester and L. Naranjo. 2016. Productivity and Sustainable Management of the Humboldt Current Large Marine Ecosystem under climate change. *Environmental Development*, 17: 126–144. doi.org/10.1016/j.envdev.2015.11.004
- Gutiérrez, M., J. Castillo, L. Naranjo and M.J. Akester. 2017. Current state of goods, services and governance of the Humboldt Current Large Marine Ecosystem in the context of climate change. *Environmental Development*, 22: 175–190. doi.org/10.1016/j.envdev.2017.02.006
- Gutiérrez, M., A. Ramirez, S. Bertrand, O. Móron and A. Bertrand. 2008. Ecological niches and areas of overlap of the squat lobster “munida” (*Pleuroncodes monodon*) and anchoveta (*Engraulis ringens*) off Peru. *Progress in Oceanography*, 79: 256–263. doi.org/10.1016/j.pocean.2008.10.019
- INEI. 2018. Peru resultados definitivos de los censos nacionales 2017. Insituto Nacional de Estadística e Informática, Lima, Perú.
- Laínez del Pozo, D. and P.J. Jones. 2020. Governance analysis of two historical MPAs in northern Peru: Isla Lobos de Tierra and Isla Lobos de Afuera. *Marine policy*, 104096.

- López de la Lama, R., S. de la Puente and A. Valdés-Velasquez. 2018a. Bringing sustainable seafood back to the table: exploring chefs' knowledge, attitudes and practices in Peru. *Oryx*, 11: 1–9. doi.org/10.1017/S0030605318000273
- López de la Lama, R., A. Valdés-Velasquez, L. Huicho, E. Morales and M. Rivera-Ch. 2018b. Exploring the building blocks of social capital in the Sechura Bay (Peru): Insights from Peruvian scallop (*Argopecten purpuratus*) aquaculture. *Ocean & Coastal Management*, 165: 235–243. doi.org/10.1016/j.ocecoaman.2018.08.030
- Majluf, P. and J. Reyes. 1989. The marine mammals of Peru: a review, p. 344–363. In: D. Pauly, P. Muck, J. Mendo and I. Tsukayama (eds). *The Peruvian Upwelling Ecosystem: Dynamics and Interactions. ICLARM Conference Proceedings 18*. International Center for Living Aquatic Resource Management (ICLARM), Philippines.
- Marcelo, R., S. Vera and E. Chirinos. 2001. Estadística de los desembarques de la pesquería marina 1964–1969. Informe Progresivo Instituto del Mar del Perú No.141. 67 p.
- Marín, A., J. Serna, C. Robles, B. Ramírez, L.E. Reyes-Flores, E. Zelada-Mázmela, G. Sotil and R. Alfaro. 2018. A glimpse into the genetic diversity of the Peruvian seafood sector: Unveiling species substitution, mislabeling and trade of threatened species. *PLoS ONE*, 13: e0206596. doi.org/10.1371/journal.pone.0206596
- Marín, W., A. Medina, G. Castillo, C. Estrella, A. Guardia, R. Guevara-Carrasco, G. Domalain, M. Wach and A. Bertrand. 2017. Atlas de la pesca artesanal del mar del Perú. IMARPE-IRD, Lima, Peru.
- Marine Conservation Institute. 2020. MPAtlas [Online]. Seattle, WA. Available at: www.mpatlas.org
- Martell, S.J.D. and R. Froese. 2013. A simple method for estimating MSY from catch and resilience. *Fish and Fisheries*, 14: 504–514. doi.org/10.1111/j.1467-2979.2012.00485.x
- Martín, J.I. 2012. The small-scale coastal fleet in the reform of the common fisheries policy. IP/B/PECH/NT/2012_08. Directorate-General for internal policies of the Union. Policy Department B: Structural and Cohesion Policies. European Parliament. 44 p.
- Mason, J.G., J. Alfaro-Shigueto, J.C. Mangel, L.B. Crowder and N.M. Ardoin. 2020. Fishers' solutions for hammerhead shark conservation in Peru. *Biological Conservation*, 243: 108460. doi.org/10.1016/j.biocon.2020.108460
- Mendo, J. 2018. Electrophoretic studies of Peruvian anchoveta *Engraulis ringens* confirm the existence of distinct North/Central and Southern Stocks, p. 16–26. In: D. Pauly and V. Ruiz-Leotaud (eds). *Marine and Freshwater Miscellanea*. Fisheries Centre research report 26(2).
- Mendo, J. and S. Castillo. 1987. Estimation of unregistered Peruvian anchoveta (*Engraulis ringens*) in official catch statistics, 1951 to 1982, p.109–116. In: D. Pauly and I. Tsukayama (eds). *The Peruvian Anchoveta and Its Upwelling Ecosystem: Three Decades of Changes*. ICLARM Studies and Reviews, Callao, Peru.
- Mendo, J. and C. Wosnitza-Mendo. 2014. Reconstruction of total marine fisheries catch for Peru: 1950–2010. Fisheries Centre Working Paper #2014–21. 23 p.
- Mendo, J. and C. Wosnitza-Mendo. 2016. Peru, p. 366. In: D. Pauly and D. Zeller (eds). *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Island Press, Washington, D.C.
- Nakandakari, A., M. Caillaux, J. Zavala, S. Gelcich and F. Gherzi. 2017. The importance of understanding self-governance efforts in coastal fisheries in Peru: insights from La Isilla and Ilo. *Bulletin of Marine Science*, 93: 199–216. doi.org/10.5343/bms.2015.1087
- Ñiquen, M., M. Bouchon, D. Ulloa and A. Medina. 2013. Análisis de la pesquería del jurel *Trachurus murphyi* en el Perú. *Revista Peruana de Biología*, 20: 97–105.
- Pajuelo, M. and J.C. Sueiro. 2019. Los gobiernos regionales y la gestión pesquera: Planes, competencias y presupuestos. Oceana, Lima, Perú. 22 p.
- Palacios-Abrantes, J., C. Vargas, D. Viana, M.I. Rivera, R. Gozzer, S. De la Puente and A.M. Cisneros-Montemayor. 2018. Contributions of marine capture fisheries to the domestic livelihoods and seafood consumption of Brazil, Chile, and Peru. Oceana, Washington, D.C.
- Paredes, C.E. 2014. La anchoveta: pesca y descarte de juveniles, Cuaderno de Investigación. Instituto del Perú, Universidad de San Martín de Porres, WWF, Lima, Perú. 47 p.
- Paredes, C.E. and S. De la Puente. 2014. Situación actual de la pesquería de la pota (*Dosidicus gigas*) en el Perú y recomendaciones para su mejora. Consorcio de Investigación Económica y Social, Lima, Perú. 112 p.
- Pauly, D. 2006. Major trends in small-scale marine fisheries, with emphasis on developing countries, and some implications for the social sciences. *Maritime Studies*, 4: 7–22.

- Pauly, D., 2009. Beyond duplicity and ignorance in global fisheries. *Scientia Marina*, 73(2): 215–224. doi.org/10.3989/scimar.2009.73n2215
- Pauly, D. and D. Zeller. 2016. Catch reconstructions reveal that global marine fisheries catches are higher than reported and declining. *Nature Communications*, 7(1): 10244. doi.org/10.1038/ncomms10244
- Pauly, D. and D. Zeller. 2019. Agreeing with FAO: Comments on SOFIA 2018. *Marine Policy*, 100: 332–333. doi.org/10.1016/j.marpol.2018.12.009
- PRODUCE. 2011. Anuario estadístico 2010. Oficina General de Tecnología de la Información y Estadística. Ministerio de la Producción (PRODUCE), Lima, Perú.
- PRODUCE. 2012. Anuario estadístico pesquero y acuícola 2011. Ministerio de la Producción (PRODUCE), Lima, Perú.
- PRODUCE. 2013. Anuario estadístico pesquero y acuícola 2012. Ministerio de la Producción (PRODUCE), Lima, Perú.
- PRODUCE. 2015a. Anuario estadístico pesquero y acuícola 2013. Despacho Viceministerial de Pesquería. Ministerio de la Producción (PRODUCE), Lima, Perú.
- PRODUCE. 2015b. Anuario estadístico pesquero y acuícola 2014. Ministerio de la Producción (PRODUCE), Lima, Perú.
- PRODUCE. 2016. Anuario estadístico pesquero y acuícola 2015. Ministerio de la Producción (PRODUCE), Lima, Perú.
- PRODUCE. 2017. Anuario Estadístico Pesquero y Acuícola 2016. Ministerio de la Producción (PRODUCE), Lima, Perú.
- PRODUCE. 2018. Anuario estadístico pesquero y acuícola 2017. Ministerio de la Producción (PRODUCE), Lima, Perú.
- Salas, S., R. Chuenpagdee, J.C. Seijo and A. Charles. 2007. Challenges in the assessment and management of small-scale fisheries in Latin America and the Caribbean. *Fisheries Research*, 87(1): 5–16. doi.org/10.1016/j.fishres.2007.06.015
- Salgado, H., C. González, J.C. Sueiro and S. De la Puente. 2015. Estimación del Valor Económico Total (VET) de los bienes y servicios ecosistémicos del Gran Ecosistema Marino de la Corriente de Humboldt (GEMCH), Proyecto GEF-PNUD Hacia un manejo con enfoque ecosistémico de Gran Ecosistema Marino de la Corriente de Humboldt. Programa de las Naciones Unidas para el Desarrollo & Fondo Mundial para el Medio Ambiente, Lima, Perú.
- Salvatteci, R., D. Field, D. Gutiérrez, T. Baumgartner, V. Ferreira, L. Ortlieb, A. Sifeddine, D. Grados and A. Bertrand. 2018. Multifarious anchovy and sardine regimes in the Humboldt Current System during the last 150 years. *Global Change Biology*, 24: 1055–1068. doi.org/10.1111/gcb.13991
- Sanjinez, M.N., E. Espinoza, L. Mariátegui, A. Taipe, J. Argüelles, R. Tafur, A. Gamarra, G. Castillo and R. Cisneros. 2019. Pesquería de los principales invertebrados marinos en la costa peruana, 2016. *Informe Instituto del Mar del Perú*, 46(3): 462–483.
- Sanjinez, M.N., C. Yamashiro, E. Espinoza, A. Taipe, R. Tafur, L. Mariátegui, R. Cisneros, L. Pizarro and J. Argüelles. 2018. Seguimiento de la pesquería de los principales invertebrados marinos en la costa peruana durante 2015. *Informe Instituto del Mar del Perú*, 45(2): 139–165.
- SPDA. 2019. Guía legal para la defensa de los ecosistemas y especies del mar peruano. Sociedad Peruana de Derecho Ambiental (SPDA), Lima, Perú.
- Sueiro, J.C. and S. De la Puente. 2015. La pesca artesanal en el Perú: Diagnóstico de la actividad pesquera artesanal peruana. PRODUCE, FAO, UPCH, Lima, Perú.
- Torrejón-Magallanes, J., E. Solana-Arellano and M. Dreyfus-León. 2016. Estimación del descarte por exceso de captura en la pesquería industrial de cerco del stock Norte-Centro de la anchoveta peruana *Engraulis ringens* a partir de un programa de observación a bordo. *Revista Peruana de Biología*, 23: 183–194. doi.org/10.15381/rpb.v23i2.12435
- Tovar, H., V. Guillen and M.A. Nakama. 1987. Monthly population size of 3 guano bird species off Peru, 1953 to 1982, p. 208–218. In: D. Pauly and I. Tsukayama (eds). *The Peruvian anchoveta and its upwelling ecosystem: three decades of change. ICLARM Studies and Reviews 15*. International Center for Living Aquatic Resource Management (ICLARM), Philippines.
- Torrejón-Magallanes, J., E. Solana-Arellano, and M. Dreyfus-León. Estimación del descarte por exceso de captura en la pesquería industrial de cerco del stock Norte-Centro de la anchoveta peruana *Engraulis ringens* a partir de un programa de observación a bordo. *Revista Peruana de Biología*, 23(2): 183 – 194. doi.org/10.15381/rpb.v23i2.12435
- Treviño, H., W. Condori, M. Zambrano and M. Quiroz. 2000. Estadísticas de desembarque de la flota artesanal en la zona sur del litoral peruano (enero 1996 - diciembre 1999). Informe Progresivo Instituto del Mar del Perú No.122. 32 p.

- Vásquez Aguirre, I. and A. Paz Torres. 1969. La pesquería marítima peruana durante 1968. Informe Instituto del Mar del Perú No.30. 93 p.
- Vásquez Aguirre, I., Paz Torres, A., Hidalgo Reyes, R., 1970. La pesquería marítima peruana durante 1969. Informe Instituto del Mar del Perú No.32. 85 p.
- Vélez-Zuazo, X., J. Alfaro-Shigueto, F. Castagnino and F. Córdova. 2020. Evaluación anual de la comercialización de peces bajo la talla mínima legal en terminales pesqueros y puntos de desembarque (2018-2019). Sociedad Peruana de Derecho Ambiental (SPDA), Lima, Perú.
- Velez-Zuazo, X., J. Alfaro-Shigueto, J. Mangel, R. Papa and I. Agnarsson. 2015. What barcode sequencing reveals about the shark fishery in Peru. *Fisheries Research*, 161: 34–41.
doi.org/10.1016/j.fishres.2014.06.005
- Wosnitza-Mendo, C., M. Espino and M. Veliz. 1988. Anexo al informe de la pesquería artesanal en el Perú durante junio de 1986 a junio de 1988. Informe Instituto del Mar del Perú No.93. 64 p.
- Zeller, D.C., S. Booth, G. Davis and D. Pauly. 2007. Re-estimation of small-scale fishery catches for U.S. flag-associated island areas in the western Pacific: the last 50 years. *Fishery Bulletin*, 105: 266–277.
- Zeller, D., M. L. D. Palomares, A. Tavakolie, M. Ang, D. Belhabib, W. W. L. Cheung, V. W. Y. Lam, E. Sy, G. Tsui, K. Zylich and D. Pauly. 2016. Still catching attention: Sea Around Us reconstructed global catch data, their spatial expression and public accessibility. *Marine Policy*, 70: 145-152.
- Zeller, D.C. and D. Pauly. 2016. Catch reconstruction: concepts, methods, and data sources, p.12-33. In: D. Pauly and D. Zeller (eds) *Global Atlas of Marine Fisheries: A Critical Appraisal of Catches and Ecosystem Impacts*. Island Press, Washington, D.C.

Appendix 1

Table 1: Main sources of data used to reconstruct the domestic catch within Peru's EEZ

Coverage		Catch					Publication type	Notes	Reference
Spatial ⁶⁹	Temporal	Fishing sector	Fishing method	End use	Target species	Bycatch species			
National	1966	Yes	No	Yes	Yes	No	Report*	-	Borgo Derpich <i>et al.</i> (1967)
National	1967	Yes	No	Yes	Yes	No	Report*	-	Borgo Derpich <i>et al.</i> (1969)
National	1968	Yes	No	Yes	Yes	No	Report*	-	Vásquez Aguirre <i>et al.</i> (1969)
National	1969	Yes	No	Yes	Yes	No	Report*	-	Vásquez Aguirre <i>et al.</i> (1970)
Local	1970-1982	Yes	Yes	No	Yes	Yes	Peer-reviewed report*	Data only for the coastal trawl fleet	Espino <i>et al.</i> (1984)
Local	1951-1982	Yes	Yes	Yes	Yes	No	Peer-reviewed report*	Unreported catch estimates for the industrial purse seine fleet	Mendo and Castillo (1987)
Local	1986-1988	Yes	Yes	No	Yes	No	Peer-reviewed report*	Catches for the artisanal sector only	Wosnitza-Mendo <i>et al.</i> (1988)
National	1965-1988	Yes	Yes	No	Yes	No	Peer-reviewed report*	Data only for the coastal trawl fleet	Espino (1990)
National	1983-1992	No	No	No	Yes	No	Peer-reviewed report*	-	Flores <i>et al.</i> (1994)
National	1995	No	No	No	Yes	No	Peer-reviewed report*	-	Flores <i>et al.</i> (1996)
National	1995-1996	No	No	No	Yes	No	Peer-reviewed report*	-	Flores <i>et al.</i> (1997)
National	1996	Yes	Yes	No	Yes	No	Peer-reviewed report*	Data only for small-scale fisheries	Estrella and Guevara-Carrasco (1998)
National	1970-1982	No	No	No	Yes	No	Peer-reviewed report*	-	Flores <i>et al.</i> (1998a)
National	1998-I	Yes	Yes	No	Yes	No	Peer-reviewed report*	Data only for small-scale fisheries, data for January to June	Estrella <i>et al.</i> (1998)
National	1996-1997	No	No	No	Yes	No	Peer-reviewed report*	-	Flores <i>et al.</i> (1998b)
National	1998-II	Yes	Yes	No	Yes	No	Peer-reviewed report*	Data only for small-scale fisheries, data for July to December	Estrella <i>et al.</i> (1999a)
National	1999-I	Yes	Yes	No	Yes	No	Peer-reviewed report*	Data only for small-scale fisheries, data for January to June	Estrella <i>et al.</i> (1999b)
National	1999-II	Yes	Yes	No	Yes	No	Peer-reviewed report*	Data only for small-scale fisheries, data for July to December	Estrella <i>et al.</i> (2000a)
Local	1996-1999	Yes	No	No	Yes	Yes	Peer-reviewed report*	Data only for small-scale fisheries in southern Peru	Treviño <i>et al.</i> (2000)
National	1999	No	No	No	Yes	No	Peer-reviewed report*	-	Fernández <i>et al.</i> (2000)
National	2000-I	Yes	Yes	No	Yes	No	Peer-reviewed report*	Data only for small-scale fisheries, data for January to June	Estrella <i>et al.</i> (2000b)
National	1964-1969	No	No	No	Yes	No	Peer-reviewed report*	-	Marcelo <i>et al.</i> (2001)
National	2000-II	Yes	Yes	No	Yes	No	Peer-reviewed report*	Data only for small-scale fisheries, data for July to December	Estrella <i>et al.</i> (2001)
National	1967-2005	Yes	Yes	Yes	Yes	No	Peer-reviewed scientific publication	Data only for hake fishery	Guevara-Carrasco and Leonart (2008)
National	1950-2005	Yes	Yes	No	Yes	No	Doctoral thesis	Data only for the sardine fishery	Cárdenas-Quintana (2009)
National	2007-2009	Yes	Yes	Yes	Yes	No	Professional thesis	Data only for hake fishery	Bouyer (2009)
National	1950-2008	No	No	No	Yes	No	Undergraduate thesis	Unreported catch estimates for the main coastal target fishes	Caillaux (2011)
National	2001-2010	No	No	Yes	Yes	No	Report	Official landing statistics for Peru	PRODUCE (2011)
National	2002-2011	No	No	Yes	Yes	No	Report	Official landing statistics for Peru	PRODUCE (2012)
National	2003-2012	No	No	Yes	Yes	No	Report	Official landing statistics for Peru	PRODUCE (2013)

⁶⁹ The spatial coverage of the defined as local (valid for parts of the country), national (valid for the whole country), regional (extracted from data repositories for South American countries), global (extracted from data repositories of global scope)

National	1950-2012	Yes	Yes	No	Yes	No	Peer-reviewed scientific publication	Data only for Chilean jack mackerel fishery	Ñiquen <i>et al.</i> (2013)
National	1950-2010	Yes	Yes	Yes	Yes	No	Peer-reviewed report	Reconstruction of total marine fisheries catches for Peru	Mendo and Wosnitza-Mendo (2014)
National	1990-2013	Yes	Yes	Yes	Yes	No	Report	Data only for jumbo flying squid fishery	Paredes and De la Puente (2014)
National	1996-2012	Yes	Yes	Yes	Yes	No	Report	Uses detailed unpublished data on small-scale fisheries supplied by IMARPE	Sueiro and De la Puente (2015)
National	1950-2005	Yes	Yes	Yes	Yes	Yes	Peer-reviewed scientific publication	Data only for the sardine fishery	Cárdenas-Quintana <i>et al.</i> (2015)
National	2004-2013	No	No	Yes	Yes	No	Report	Official landing statistics for Peru	PRODUCE (2015a)
National	2005-2014	No	No	Yes	Yes	No	Report	Official landing statistics for Peru	PRODUCE (2015b)
Local	2005-2014	Yes	Yes	Yes	Yes	No	Peer-reviewed scientific publication	Discard estimates for the industrial anchoveta fleet	Torrejón-Magallanes <i>et al.</i> (2016)
National	2006-2015	No	No	Yes	Yes	No	Report	Official landing statistics for Peru	PRODUCE (2016)
Global	1950-2010	Yes	Yes	Yes	Yes	No	Peer-reviewed scientific publication	Global estimates of FIFO catches by country and species	Cashion <i>et al.</i> (2017)
National	1996-2012	Yes	Yes	No	Yes	No	Peer-reviewed report*	Data only for small-scale fisheries	Marín <i>et al.</i> (2017)
Local	2015-2016	Yes	Yes	No	Yes	Yes	Peer-reviewed scientific publication	Data only for ray species caught by the small-scale gillnet fishery in northern Peru	Alfaro-Córdova <i>et al.</i> (2017)
National	1996-2015	Yes	Yes	Yes	Yes	No	Masters thesis	Reconstruction of total catch for shark species in Peru	De la Puente (2017)
National	2007-2016	No	No	Yes	Yes	No	Report	Official landing statistics for Peru	PRODUCE (2017)
Global	1950-2014	Yes	Yes	No	Yes	No	Peer-reviewed scientific publication	Global estimates of marine catch by fishing gear and sector	Cashion <i>et al.</i> (2018)
National	1985-2017	Yes	Yes	No	Yes	No	Peer-reviewed report*	Data only for jumbo flying squid fishery	Csirke <i>et al.</i> (2018)
National	2017	Yes	Yes	Yes	Yes	No	Report	Estimates illegal small-scale anchoveta FIFO catch	Grillo <i>et al.</i> (2018)
National	1997-2014	Yes	Yes	No	Yes	Yes	Masters thesis	Data on bycatch of squat lobster by the industrial anchoveta fleet	Escobedo Oblitas (2018)
Global	1950-2016	No	No	Yes	Yes	No	Report	Global estimates of marine catch by country and species	FAO (2018)
National	1996-2015	Yes	Yes	Yes	Yes	No	Peer-reviewed report*	National catch estimates for the main targeted species of invertebrates	Sanjinez <i>et al.</i> (2018)
National	1959-2015	No	No	No	Yes	No	Peer-reviewed report*	National catch estimates for the main targeted pelagic fish species	Bouchon <i>et al.</i> (2018)
National	2008-2017	No	No	Yes	Yes	No	Report	Official landing statistics for Peru	PRODUCE (2018)
Regional	2010-2016	Yes	Yes	Yes	Yes	No	Report	Estimates of DHC catch data for Brazil, Chile and Peru, including discards	Palacios-Abrantes <i>et al.</i> (2018)
National	1996-2015	Yes	Yes	Yes	Yes	No	Peer-reviewed report*	National catch estimates for the main targeted species of invertebrates	Sanjinez <i>et al.</i> (2019)
National	1950-2018	Yes	Yes	No	Yes	Yes	IMARPE online data repositories	Multiple types of information available online or upon request	see text for specifics ⁷⁰
National	1950-2018	Yes	Yes	Yes	Yes	No	PRODUCE online data repositories	Multiple types of information available online or upon request	see text for specifics ⁷¹

⁷⁰For general searches start at: <<http://www.imarpe.gob.pe/imarpe/>>

⁷¹Data for 2018 should be considered 'preliminary' until officially published in a report by PRODUCE (e.g., PRODUCE, 2018). For general searches start at: <<https://www.gob.pe/produce>>.