UPDATING TO 2018 THE CATCH RECONSTRUCTIONS FOR 14 COUNTRIES OF THE WEST AFRICAN MAINLAND*

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Abstract

This original catch reconstructions for 1950-2010 for Benin, Congo (Brazzaville), Congo (Ex-Zaïre), Equatorial Guinea, Gabon, Guinea, Guinea-Bissau, Liberia, Morocco (Atlantic) Namibia, Nigeria, Senegal, Sierra Leone and Togo are here updated to 2018. The major challenge in updating catch reconstructions for countries of the African mainland, besides comprehensively accounting for domestic small-scale fisheries, is in estimating the reported and unreported catches of foreign fleets fishing within their Exclusive Economic Zones (EEZ). Data reported by fishing countries by the FAO statistical areas are presented in broad ocean areas (Eastern Central Atlantic and Southeast Atlantic) and must be assigned to the different EEZs. To do this, we used the ratios of reported landings per taxon, per fishing country that was assumed to fish within each EEZ in 2010, based on the original detailed research, and maintained these ratios to 2018, under consideration of the *Sea Around Us* fishing access database that contains foreign fishing access information between countries. Detailed descriptions of the methods used to update the data for each of the EEZs are presented by country.

Introduction

This contribution updates to 2018 the original catch reconstructions, covering the years 1950 to 2010 that were performed and published for Benin, Congo (Brazzaville), Congo (Ex-Zaïre), Equatorial Guinea, Gabon, Guinea, Guinea-Bissau, Liberia, Morocco (Atlantic) Namibia, Nigeria, Senegal, Sierra Leone and Togo. The major challenge in updating the catch reconstruction of countries of the African mainland, besides comprehensively accounting for domestic small-scale fisheries, is in estimating the reported and unreported catches of foreign fleets fishing within each Exclusive Economic Zone (EEZ). To address this challenge for

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West Africa, in July 2016, the first author, then with the *Sea Around Us*, organized a workshop at the Institute for the Oceans and Fisheries in Vancouver with several of the co-authors. Many of the insights presented herein originated from this workshop.

Data reported by each West African country as well as by distant water fishing countries to the FAO are presented in broad FAO ocean areas (e.g., Eastern Central Atlantic, Southeast Atlantic) and must be assigned to the different EEZs. To do this, we have used the proportion of reported landings per taxon, per fishing country that was assumed fishing within each EEZ in 2010, based on the original detailed research, and maintained these ratios to 2018 with our database level application of fishing access information between fishing countries. Detailed descriptions of the methods used to update the data for each of 4 sectors for per EEZ are presented by country.

The uncertainty associated with the reconstructed catch data presented below was assessed using the method presented in Pauly and Zeller (2016) and Zeller *et al.* (2016) and presented in this report in Derrick and Pauly (2020), but is not presented here by country. However, all catch data (reported as well as unreported) in the database of the *Sea Around Us* and available through its website (www.seaaroundus.org) are associated with a reliability score based on these uncertainty assessments.

Benin

Reconstructions of Benin's marine fisheries catches were completed for 1950-2010 by Belhabib and Pauly (2015) and Belhabib *et al.* (2016). What follows are details of the update to 2015 and forward carry to 2018, by sector.

Subsistence and lagoon (acadja) fisheries

Here, the catch of subsistence fishers was updated for 2011-2015 using the methods described in the original reconstruction (Belhabib and Pauly 2015). The number of women fishers that glean was updated for 2011-2015 using the same ratio described in the original methods. The size of the household, CPUE, and consumption rate were all carried forward unaltered from 2010 to 2015 and used to calculate the subsistence catch. The taxonomic breakdown of subsistence catches was assumed the same as in 2010 for each fishing method.

Gangbazo (2016) estimated the number of marine small-scale vessels to be 728 in 2014. The number of marine artisanal vessels in 2010 was interpolated to 728 in 2014 and multiplied by the household size and catch per unit effort (CPUE) per year. The rate of decline in small-scale boats between 2010 and 2014 was extrapolated for 2015.The total number of lagoon fishers was carried forward for 2011-2015 by interpolating between the 2010 anchor point and an anchor point of 61,650 lagoon fishers in 2012 (Ahouandjogbe *et al.* 2013). To update to 2015, the percentage of lagoon fishers in the total population was calculated for 2012 and used to calculate lagoon fishers for 2013-2015 based on updated total population data from the World Bank. The total number of lagoon subsistence fishers was separated between fishers who used acadja and those that did not based on the levels described in the original reconstruction (Belhabib and Pauly 2015).

Artisanal and domestic industrial fishing

Reported landings by commercial fisheries were updated for 2011-2015 using the FAO 2015 dataset and then assigned to the artisanal and industrial sectors based on the totals reported in national statistics (INSAE 2016). Unreported artisanal landings were calculated for 2011-2015 using the methods described in Belhabib and Pauly (2015) for 2010 and the anchor points described above for small-scale fishing vessels. Because national reported landings for this sector outweighed reconstructed catch, artisanal landings were assumed to

be fully reported from 2013-2015. Similarly, total domestic industrial landings for 2011 were assumed to be the same in 2010 and unreported landings were determined as the difference between total landings and reported landings in 2011. Because reported landings for 2012-2015 were greater than the total catch estimated in 2010-2011, domestic industrial landings were assumed to be 100% reported for 2012-2015. Unreported landings from each sector were assigned to taxa for 2011-2015 based on the taxonomic breakdown in 2010. Because industrial landings in recent years are largely or perhaps entirely due to foreign fishing vessels (Ayoubi and Failler 2013; COMHAFAT/ATLAFCO 2014), domestic FAO reported landings in excess of nationally reported landings were assumed to have been due to foreign fishing in Nigeria and landed in Benin. Unless these vessels were registered as Benin vessels and thus flying the Benin flag while fishing, reporting such catches as Benin catches is flag-misreporting by Benin and is in contradiction to internationally agreed data reporting principles.

More on foreign fishing

Reported landings by foreign fishing entities were updated for 2011-2015 based on the percentages of reported taxa estimated to be caught in Benin's EEZ in 2010. The large increase in reported landings in 2012-2014 by China was assumed to be the result of improved reporting rather than increased landings. Therefore, total landings by China in Benin in 2011-2015 were assumed to have remained as in 2010; unreported landings were determined to be the difference between total landings and reported landings. Unreported landings by Nigeria were held constant at the 2010 level because updated information was not available at this time. Commercially valuable bonga shad (*Ethmalosa fimbriata*) and Madeiran sardinella (*Sardinella maderensis*) continue to attract interest by foreign fishing entities (Petrossian 2018).

Discards

Discards from all industrial fisheries were updated for each fishing entity based on the ratio of discards to landings in 2010. Discarded taxa were assumed to remain at the 2010 ratio for 2011-2015.

Transition from 2015 to 2018

The catch reconstructed to 2015 was carried forward to 2018 using the semi-automated procedures outlined in Noël (2020), based on FAO reported landings data available to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

Benin has an EEZ of 30,286 km² that was declared in 1976 (Belhabib and Pauly 2015), and 30 % of the terrestrial area is protected (UNEP-WCMC and IUCN 2020). However, efforts towards management of marine resources and marine conservation are not prominent in the government's agenda. The country is in the multilateral treaty of the Convention on Biological Diversity (Aichi), but currently there are no existing MPAs that protect Benin's waters (Marine Conservation Institute 2020).

Much of the coast of Benin is lined by seagrass beds, mangroves and saltmarshes, with seagrasses forming the predominant habitat (Bryan *et al.* 2020). Future MPAs would help preserve these rich ecosystems and their species from some of the current and potential threats, including concentration of population in coastal areas, offshore wind energy and climate change. Regarding the offshore wind energy viability in Benin, locations near the shore are the most suitable to offshore wind power generation (Aza-Gnandji *et al.* 2019).

Congo (Brazzaville)

The catch of the marine fisheries of the People's Republic of Congo, here: 'Congo (Brazzaville)', was originally reconstructed for the years 1950 to 2010 by Belhabib and Pauly (2015, 2016) and updated to 2014 by the *Sea Around Us* before being carried forward to 2018.

Reported landings from artisanal and industrial fisheries were updated for 2011-2014 using the 2010 ratios assigned to each sector. The 2010 ratios of gear-types for each sector were maintained for 2011-2014. The taxa determined to be caught by demersal trawl or purse seine were allocated between gears using the 2010 ratios. The 2010 taxonomic breakdown of the FAO category "Marine fishes nei" was maintained for 2011-2014. The newly reported category of "Deep-water rose shrimp" in 2011-2014 was assumed to be caught by the artisanal and industrial sectors and using the same gears as "*Penaeus* shrimps nei".

Note that Congo has now banned blast fishing and small-mesh nets explicitly (Anon. 2011). A survey of demographics and estimates of catch from marine fisheries in the districts of Pointe Noire and Kouilou are available for 2006-2010 from a national study (Anon. 2013); however, the catch estimates therein are lower than our update estimates.

Subsistence catches

Subsistence catch were carried forward for 2011-2014 using the same methods as in the original reconstruction (Belhabib and Pauly 2015). The 2010 ratio of rural coastal population was used to calculate rural coastal population from total population information for 2011-2014 using data obtained from the World Bank. For 2011-2014, the consumption rate and the percentage of consumption attributed to subsistence fishing were held constant at the 2010 levels. The taxonomic breakdown of subsistence catch was maintained at the 2010 proportions for 2011-2014.

Domestic industrial landings

Domestic unreported landings were updated for 2011-2014 based on the 2010 ratio of unreported industrial landings to reported industrial landings. The ratio of gear-types and taxa breakdown for each gear-type was carried forward to 2014 at the 2010 ratio. Discards from industrial fisheries were carried forward for 2011-2014 using the percentage discarded for each fishery as described in the original methods.

Foreign fishing

Because no updated information was found, landings and discards from China fishing in the Congo (Brazzaville) were carried forward at the 2010 amounts unchanged.

In 2011, Congo (Brazzaville) introduced a satellite surveillance system to monitor fishing vessels in national waters (Anon. 2011). To further dissuade illegal fishing in Congo's EEZ, Congolese coastal patrol forces received training from the US Navy (Clark and Decalo 2012). In future updates to these changes may be reflected in the data through decreased illegal catch estimates.

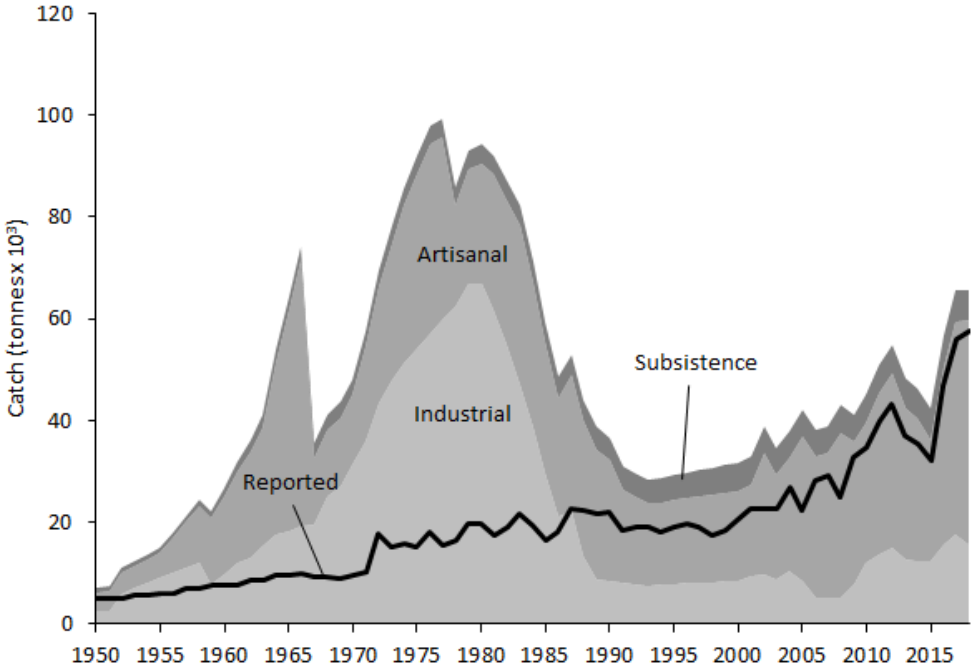

Figure 1. Reconstructed domestic catch in the EEZ of Congo (Brazzaville), by sector for 1950-2018.

Transiting from 2014 to 2018

The catch reconstructed to 2014 was carried forward to 2018 using the semi-automated procedures outlined in Noël (2020), based on FAO reported landings data available to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

Congo (Brazzaville) has agreed to protect its biological diversity through the international Convention on Biological Diversity (Aichi) (Marine Conservation Institute 2020).

Congo (Brazzaville) has one MPA and one marine managed area. The two areas' extent is 3,896 km², covering 10% of the entire EEZ (39,618 km²; Belhabib and Pauly 2016). The MPA is the Conkouati-Douli National Park (Parc National), which was designated in 1999 and covers 5049 km² of terrestrial and water territories. The National Park is home to species such as Atlantic humpback dolphins (*Sousa teuszii*), humpback whales (*Megaptera novaeangliae*), West African manatees, and sea turtles, all of which are threatened by illegal commercial fishing in the region (Hoyt 2012).

The marine managed area is called 'Congo-Brazzaville Shark Sanctuary'. It was designated in 2001 and protects 966 km² of water (Marine Conservation Institute 2020). The creation of this sanctuary was a response to an uncontrolled and illegal shark fishing industry that was very established along the country's coastline. Due to the high price of shark fins in Asian markets, Congolese trawlers and professional small-scale fishers focused their efforts on this unauthorized practice (Marine Conservation Institute 2020). Even after the designation of the sanctuary and the fact that shark fishing was completely banned by the government, 126 shark-fishing permits were issued to private fishers from Benin, Congo and Ghana (Mikangou 2001). A fisher from a Beninese fishing village affirmed that "[s]ome of us don't have shark-fishing permits. […] Shark fishing brings in real money. In three days spent fishing, you can earn between 35,000 and 50,000 CFA francs", i.e.,

50-75 USD at the time (Mikangou 2001). Moreover, enforcement of regulations is not remarkable prominent in the area (Marine Conservation Institute 2020).

Congo (Ex-Zaïre)

The reconstruction of marine fisheries catches in the Democratic Republic of Congo (DRC, Ex-Zaïre) was completed for 1950-2010 by Belhabib *et al.* (2015, 2016). Since this initial reconstruction, the FAO data have been retroactively changed. Thus, reported and unreported landings were corrected for the years 1987-1990 and 2000-2010, to consider the changes in the data reported by the FAO during the update to 2015 (Figure 1). Unreported landings were subsequently adjusted to maintain the total landings for the sector in years with retroactive changes; the most recent FAO statistics were used to carry forward the updated reconstruction to 2018.

Subsistence fishing

Catches by subsistence fishers were extrapolated for 2011-2015 based on the average decline in subsistence catch per year for 2000-2010. The earlier taxonomic breakdown of subsistence catches was maintained for the entire time series.

Artisanal fishing

Total artisanal landings were reconstructed for 2011-2015 using methods described in the original report. No recent estimates of the number of artisanal vessels were found at the time of update (Anon. 2012). An anchor point of 658 vessels was reported for 2009 in Anon. (2012), but this number was assumed an underestimate of the number of artisanal boats. As a result, the number of canoes in 2010 was assumed to remain the same for 2011-2015 and was multiplied by the catch per unit effort (CPUE) to estimate artisanal landings. The interpolated rate of decline in CPUE was determined for 1967-2010 and extrapolated to 2015. Unreported artisanal landings were determined to be the difference between total reconstructed artisanal catch and reported catch. Unreported artisanal landings were disaggregated with the same taxonomic breakdown throughout the time series.

Foreign fishing

Reported landings from China in DRC were updated for 2011-2015 based on the 2010 ratio of China's catch in the Eastern Central Atlantic attributed to the DRC EEZ. The 2010 unreported landings by China in the DRC EEZ were carried forward unaltered to 2015. Discards were calculated for China's total industrial landings in the DRC EEZ at the same ratio described in the original methods. The 2010 taxonomic breakdown of discards was used to disaggregate discards for 2011-2015.

Transition from 2015 to 2018

The catch reconstructed to 2015 was carried forward to 2018 using the semi-automated procedures outlined in Noël (2020), based on FAO reported landings data available to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

Congo (ex-Zaire) has agreed to protect its biological diversity through the international Convention on Biological Diversity (Aichi) and the Ramsar Convention on Wetlands of International Importance and the World Heritage Convention (Marine Conservation Institute 2020).
Congo (ex-Zaire) has one MPA and two marine managed areas. The three areas' extent is 32 km2, which equals less than 1% of the entire EEZ (13,140 km^2; Belhabib *et al.* 2016). The MPA is the 'Parc National Marin des Mangroves', designated in 1992 with 216 km^2 (Marine Conservation Institute 2020).

"The Mangrove Marine Park, like all the protected areas of the Democratic Republic of Congo, is under the responsibility of the Congolese Institute for the Conservation of Nature, abbreviated 'ICCN', a public establishment created by the Congolese State to monitor and protect the integrity of all these areas of high ecological value. […] Today, the Congolese Institute for the Conservation of Nature has more than 4,000 park wardens forming a veritable paramilitary troop, armed and dedicated, fully committed to monitoring protected areas. For the past thirty years, this troop has paid a heavy price to the cause of preservation through the supreme sacrifice of many of its members. The Democratic Republic of Congo is the country in the world where the largest number of Park rangers have been killed in the past three decades" (Le Parc Marin des Mangroves 2020).

The two marine managed areas are the Natural Reserve of the Mangrove designated in 1992 with a total area of 1000 km^2 and 12 km^2 of reported marine area, and the Ramsar site (also in the Parc National des Mangroves), which was designated in 1996 and has a surface area of 660 km^2. This Ramsar site "supports important fish and crustacean reserves for local fisheries. Nine species of rare or endangered mammals occur, including the manatee; six bird and eight reptile species, including marine turtles, are at risk from habitat destruction. Human activities include fishing, the gathering of medicinal plants, and subsistence cropping. Threats include extensive fuelwood cutting, refinery pollution, and uncontrolled urban development" (Ramsar sites information service, 2020).

Equatorial Guinea

The reconstruction of Equatorial Guinea's marine fisheries catches for 1950-2010 was performed by Belhabib *et al.* (2015, 2016a, 2016b), updated to 2014 by the *Sea Around Us*, and carried forward to 2018. Updated information regarding Equatorial Guinea's fisheries sectors was scarce, but Equatorial Guinea is currently ending a four-year project to improve its fisheries statistics and fisheries management (FAO 2015). When data from this project become available, they will be considered for the next reconstruction update.

Artisanal, subsistence and recreational sectors

Updated FAO data were used to update reported landings from artisanal fisheries for 2011-2014. Unreported landings from the artisanal and subsistence sectors were updated using the 2010 ratio of each sector to reported landings. The 2010 taxonomic breakdowns for unreported artisanal and subsistence catches were used unaltered for 2011-2014. Similarly, recreational landings were updated for 2011-2014 based on the ratio of recreational landings to reported landings in 2010. The 2010 ratios of taxa caught recreationally were held constant for 2011-2014.

Industrial fisheries and their discards

Unreported industrial landings were updated for each fishing entity based on the 2010 ratio of landings by that entity to reported domestic landings. The portion of a fishing entity's catch estimated to have been caught illegally was held constant at the 2010 ratio. Unreported landings from 2011-2014 were disaggregated into taxa using the 2010 ratios for each fishing entity. Reported landings by China were updated for 2011-2014 based on the 2010 ratio of reported landings in the Eastern Central Atlantic assumed to be from Equatorial Guinea's EEZ.

Discards were updated to 2014 using the ratios of industrial landings described in the original reconstruction. The 2010 proportion of discards that arose from illegal fishing was held constant and used to calculate discards from illegal landings for 2011-2014. The taxonomic breakdown of discards remained unaltered for 2010-2014.

Updates from 2014 to 2018
The catch reconstructed to 2014 was carried forward to 2018 using the semi-automated procedures outlined in Noël (2020), based on FAO reported landings data available to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection
Equatorial Guinea has agreed to protect its biological diversity through the international Convention on Biological Diversity (Aichi) and the Ramsar Convention on Wetlands of International Importance and the World Heritage Convention (Marine Conservation Institute 2020).

Equatorial Guinea has six marine managed areas and one MPA. Together, these areas cover 521 km² (Marine Conservation Institute 2020), which is tiny compared to the EEZ (308,275 km²; Belhabib *et al.* 2016b).

The four marine managed areas are Annobón (Natural Reserve designated in 2000 with a total area of 221 km²), Isla de Annobón (Ramsar Site designated in 2003 with a total area of 230 km²), Playa Nendyi (Scientific Reserve designated in 2000 with a total area of 5 km²), Reserva Natural del Estuario del Muni (Ramsar Site designated in 2003 with a total area of 800 km²), Rio Campo (Natural Reserve designated in 2000 with a total area of 330 km²) and Río Ntem o Campo (Ramsar Site designated in 2003 with a total area of 330 km²) (Marine Conservation Institute 2020). The Ramsar sites are considered internationally important because of their protection of vulnerable habitats and species. The major activities in these sites are traditional fishing, hunting and subsistence agriculture (Ramsar sites information service 2020).

The MPA of Corisco y Elobeyes is a Natural Reserve designated in 2000 with the intent to protect 462 km² of marine and coastal ecosystems (i.e., 89% of all protected areas in Equatorial Guinean waters; Marine Conservation Institute 2020). A study indicates that marine megafauna would benefit from an expansion of this MPA, by creating a transboundary marine park with a newly established marine park in northern Gabon. “The results, however, also show that high impact areas are pervasive on the continental shelf, particularly near populated areas, highlighting that increasing protection of marine megafauna in this region will require more than just the implementation of MPAs. Specifically, turtle species were found to be highly impacted by access to nesting beaches, so the expansion of terrestrial protected areas in coastal areas also warrants further exploration. MPAs, however, will only be effective if they are supported by the development of national standards, best practice guidelines and management strategies to reduce the impact of terrestrial and marine human activities mentioned herein. Our results may therefore help initiate discussions among national implementing agencies, different sectors (e.g., fishing and industry) and key stakeholders by increasing awareness of current pressures on marine biodiversity, as well as facilitating the identification of viable strategies to mitigate and reduce pressures in areas of high impact” (Trew *et al.* 2019).

Gabon

The reconstruction of Gabon’s marine fisheries catches was performed for 1950-2010 as described in Belhabib (2015, 2016), and this account presents the update to 2014, which was then carried forward to 2018. Retroactive changes in the FAO 2014 dataset were identified which justified correction of the data for 2007-2010 (Figure 2); in years with retroactive changes to reported landings, the unreported landings were adjusted so that the total catch per sector remained the same. The original reconstruction was also updated to include the FAO reported landings of ‘Tilapias nei’, a brackish water taxon that is landed by artisanal fisheries in Gabon (FAO 2007).

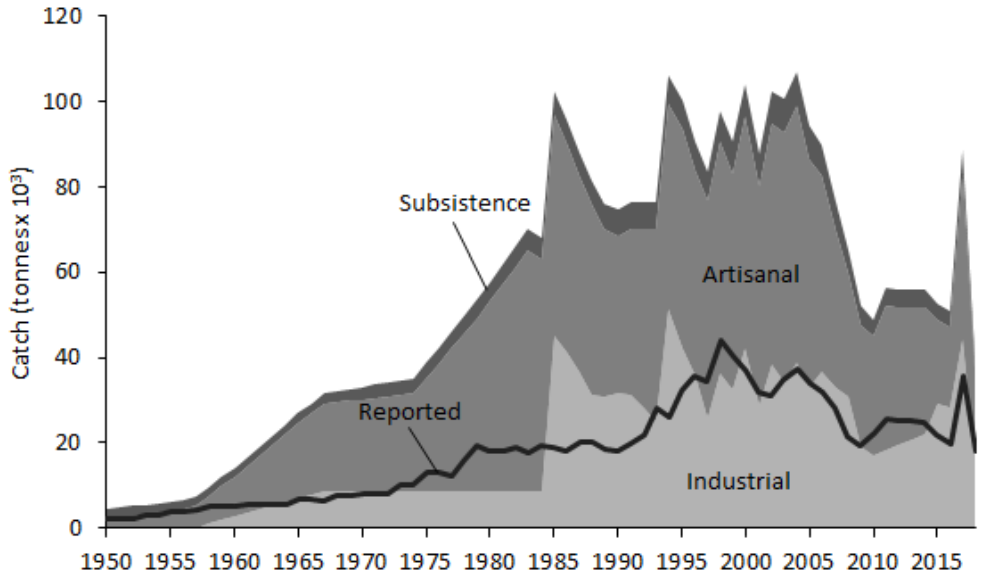

Figure 2. Reconstructed domestic catch in Gabon's EEZ by fishing sector (1950-2018).

Subsistence fishing

Subsistence catch was updated for 2011-2014 based on the 2010 ratio of subsistence catch to reported artisanal landings. The taxonomic breakdown of subsistence catch was carried forward unaltered at the 2010 proportions for 2011-2014.

Domestic commercial fisheries: artisanal and industrial

Reported landings for 2011-2014 were allocated to the artisanal and industrial sectors based on the 2010 ratios. Unreported artisanal landings were updated for 1996-2010 to account for the contribution of 'Tilapias nei' to the previously calculated total artisanal catch.

Similarly, unreported industrial landings were updated for 2009-2010 based on the remainder of total catch that was not reported to FAO. Unreported landings from commercial fisheries were updated for 2011-2014 based on the 2010 ratio of unreported to reported landings for each sector. The taxonomic breakdown of unreported landings was held constant at the 1996 proportions for artisanal fisheries and the 2008 ratios for industrial fisheries. Since this update was completed, recent estimates of the catch and discards of the domestic and foreign industrial fleets in 2017 have become available from Anon. (2017). This information will be reviewed and incorporated in future updates.

Discards from domestic fisheries were updated for 2011-2014 at the percentage of trawl landings described in the methods. The taxonomic breakdown of discards was held constant for 2011-2014.

Foreign industrial fishing

Landings by foreign fishing entities in Gabon for 2011-2014 were updated with FAO data using the 2010 ratios of catch allocated to Gabon's EEZ. Unreported landings by South Korea were updated for 2011-2014 by assuming that total landings remained constant at the 2010 amount and that the difference between total landings and reported landings was determined to be unreported. Total landings by China in Gabon were assumed to remain constant for 2010-2014 because we assumed that large increases in reported landings by China in 2011-2012 were due to better reporting in those years rather than an increase in catch. Unreported

landings by fleets from Cameroon, Republic of Congo, Madagascar, and Togo were updated for 2011-2014 using the 2010 ratio for each fishing entity to total reported domestic landings for Gabon.

Discards from foreign fishing entities were estimated using the 2010 ratios of discards to landings for each entity. The taxonomic breakdowns of discards and unreported landings by foreign fishing entities were held constant at the 2010 levels for 2011-2014.

Transiting from 2014 to 2018

The catch reconstructed to 2014 was carried forward to 2018 using the semi-automated procedures outlined in Noël (2020), based on FAO reported landings data available to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Recently, Gabon has taken steps to combat illegal fishing including signing the UN Port State Measures Agreement requiring vessels to request access to ports and to report their activities. In 2016, Gabon partnered with the Sea Shepherd organization to patrol Gabon's EEZ for fisheries monitoring and enforcement (Anon. 2016; FAO 2016; MarEx 2016).

Marine biodiversity protection

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

In 2014, Gabon announced plans to establish 23% of its EEZ as a no-take Marine Protected Area (Robinson 2014).

Gabon has 32 MPAs and 11 marine managed areas. The MPAs span 52,075 km^2 (Marine Conservation Institute 2020), which equals 27% of the entire EEZ (191,944 km^2; Belhabib 2015). In 2002, the government of Gabon committed to create a network of MPAs in Gabonese waters, which currently host one of the largest MPA networks in Africa.

The Reserve Aquatique du Grand Sud du Gabon, established in 2017, is one of the biggest MPAs, totalling 27,518 km^2, contributing 52.8% of the area of all MPAs (Marine Conservation Institute 2020). One of the most famous MPAs is the Mayumba National Park, which is a no-take MPA of 908 km^2 designated in 2003. It is well known because of the ecosystem services that it provides (from November to April) to the single largest population of nesting leatherback turtles, a critically endangered species and one of the main reasons for the creation of this MPA (Mayumba National Park 2011).

In 1960, offshore oil and gas exploration began in Gabon and today there are about 40 offshore oil platforms in Gabon. These platforms act as artificial reefs on continental shelves and provide hard substrate in an area of sandy seafloors. There are several disadvantages associated with these structures, such as oil spills, noise, invasive species and vessel traffic. However, they may provide a unique habitat for some marine communities (Friedlander *et al.* 2014). "These platforms increase local production through enhanced settlement, increased reproductive output, and likely through reduced natural and fishing mortality. […] because they exclude trawl fishing and their large internal spaces offer shelter to fishes and other organisms. Platforms are complex structures, involving numerous crossbeams and large interstitial spaces" (Friedlander *et al.* 2014).

Guinea

The reconstruction of Guinea's marine fisheries catches was completed for 1950-2010 by Belhabib *et al.* (2012, 2016); here, it was updated to 2015, then carried forward to 2018 using the semi-automation procedure of Noël (2020) and FAO landing data to 2018.

Reported catch baseline

The landings data reported to the FAO were compared to national industrial catch data reported by the Centre National des Sciences Halieutiques de Boussoura, provided by collaborators working specifically on the catch reconstruction for Guinea. Some inconsistencies in domestic industrial fisheries were noted during comparison between national and FAO datasets. These problems may result from the quality of industrial data. It may be that underestimation of industrial data has been reduced from 2011 to 2014, that an institutional change occurred, or that some foreign industrial landings were included. Due to inconsistencies in the national data, the FAO data was used to update reported landings.

Unreported landings from commercial fishing

Commercial fisheries in Guinea, as in all West African countries, includes a substantial artisanal sector deploying dugout canoes and a largely foreign industrial fishing sector deploying bottom trawlers. Unreported landings for commercial fisheries were estimated for 2011-2015 based on the 2010 ratio between unreported landings and reported landings. Discards were calculated for 2011-2015 using the original methods described for 2010 (Belhabib *et al.* 2012). The 2010 taxonomic composition was maintained to 2015 for unreported landings of each sector.

Subsistence fishing

Subsistence fisheries catches were reconstructed for 2011-2015 by multiplying updated population data available from the World Bank with the 2010 per capita consumption rate.

Transition from 2015 to 2018

The catch reconstructed to 2015 was carried forward to 2018 using the semi-automated procedures outlined in Noël (2020), based on FAO reported landings data available to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

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

Guinea has six marine managed areas and two MPAs[6]. Together, these areas cover 583 km² (UNEP-WCMC and IUCN 2020), which is very small relative to its EEZ (109,439 km²; Belhabib *et al.* 2016). The major listed MPA, Tristao Faunal Reserve, was implemented by presidential decree in 2013 with an area of 1090 km² but this information has gone largely unreported (Marine Conservation Institute 2020; UNEP-WCMC and IUCN 2020). Moreover, not much information is available about monitoring and enforcement of regulations governance type and management authority and the management plan from 2012 has not been updated until now. The marine managed areas are Ile Alcatraz (Ramsar Site with less than 1 km² and designated in 1992 and Integral Natural Reserve since 2013), Ile Blanche (Ramsar Site with less than 1 km² and designated in 1993), Iles Tristao (Ramsar Site with a total extent of 850 km² and designated in 1992), Konkouré Delta (Ramsar Site

[6] Natural Managed Reserve of the Tristao Islands and the Alcatraz Island Integral Reserve

with a total extent of 900 km² and designated in 1992), Rio Kapatchez (Ramsar Site with a total extent of 200 km² and designated in 1992) and Rio Pongo (Ramsar Site with a total extent of 300 km² and designated in 1992) (Marine Conservation Institute 2020).

The two smallest Ramsar sites are ecologically important and, for example, the Ile Alcatraz, which is covered by a thick layer of guano, also has the national, legal designation of "sanctuary" (Ramsar sites information service 2020a). The Ile Blanche is a rocky sand islet with coral. It provides refuge for the vulnerable olive ridley (*Lepidochelys olivacea*) turtle, which is threatened in the area by illegal activities, notably the collection of eggs (Ramsar sites information service 2020b).

Guinea-Bissau

The reconstruction of Guinea-Bissau's marine fisheries catches was completed for 2011-2010 by Belhabib and Pauly (2015, 2016), updated to 2015 by Intchama *et al.* (2018), and carried forward using the semi-automation procedure outlined in Noël (2020) and FAO landing data to 2018.

Illegal foreign fishing is rampant in Guinea-Bissau, including in its marine protected areas (Kaczynski and Djassi 2006), rendering all catch estimates from that country's EEZ very uncertain.

Subsistence and recreational fisheries

The catches of subsistence fisheries were updated based on updated population data for 2011-2015 available from the World Bank and the per capita consumption rate from 2010. The total number of recreational fishers was extrapolated to 2015 based on the original methods for 2010-2012 and multiplied by the 2010 CPUE and the estimate of days fishers spent angling. The taxonomic breakdown from 2010 was used to disaggregate landings for all unreported landings and discards

Artisanal and industrial fisheries

The catches of the artisanal fisheries were updated using the methods in Belhabib and Pauly (2015). The annual numbers of artisanal vessels were available to 2015 and were multiplied by a CPUE of 150 kg·vessel^{-1}·day^{-1} and by the number of days that each vessel was assumed to operate per season. It was assumed that artisanal vessels operate 80% of the days during the fishing season.

The Government of Guinea-Bissau reported industrial landings for 2011-2015. Reconstructed industrial landings were updated for 2011-2015 with a catch per unit effort (CPUE) of 14.8 kg·vessel^{-1}·GRT^{-1}·day^{-1} applied to national data on the number of vessels and days fished per year for the gear associated with the vessel. Discards were updated for 2011-2015 using the methods described for 2010 (Belhabib and Pauly 2015).

Transition from 2015 to 2018

The catch reconstructed to 2015 was carried forward to 2018 using the semi-automated procedures outlined in Noël (2020), based on FAO reported landings data available to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

Guinea Bissau has agreed to protect its biological diversity through the international Convention on Biological Diversity (Aichi) and the Ramsar Convention on Wetlands of International Importance. Its commitments extend to NGOs and/or public bodies like the West Africa MPA Network or RAMPAO (Marine Conservation Institute 2020).

Guinea Bissau has 12 MPAs and three marine managed areas. The MPAs' extent is 8942 km² (Marine Conservation Institute 2020), which represents 8.4 % of the entire EEZ (105,839 km²; Belhabib and Pauly 2015). The Bioguinea Foundation (a biodiversity conservation trust fund) supports protected area coverage and controls financial operations within Guinea-Bissau's National Parks (Cross 2016).

In some cases, like in the Urok Marine Protected Area (established in 2005 and occupying 618 km²), the zoning and the issuance of fishing licenses is a prerogative of the Ministry of Fisheries. Moreover, the Fisheries Monitoring Service (FISCAP) is in charge of the national regulations' enforcement and surveillance of the Urok MPA. The rest of the management duties are performed by the Institute of Biodiversity and Protected Areas (IBAP).

This may be an example of success where conservation and fisheries management are possible with a multi-stakeholder participatory approach at both the community and institutional level (Weigel *et al.* 2014). On the other hand, there is the case of the Orango National Park (designated in 2000 with 942 km² of marine area), whose designation produced a series of issues between different stakeholders after fishers lost access to Ancopado beach. Nowadays, fishing persists in this MPA, demonstrating how an initially weak management plan can have detrimental effects to compliance, especially by small-scale fishers (Cross 2016).

Liberia

The reconstruction of Liberia's marine fisheries catches was completed for 1950-2010 by Belhabib *et al.* (2016a, 2016b). Since the original reconstruction, updated FAO data became available and were used to update data for 2009-2015 (Figure 3), then the reconstructed data were carried forward to 2018, using the procedure in Noël (2020).

In 2014-2015, Liberia experienced an outbreak of the Ebola epidemic (FAO 2014; Anon. 2016b). Here, , the impact of the Ebola epidemic on domestic fisheries is not accounted for in Liberia's catch reconstruction due to a lack of available numerical estimates, but the likely change in seafood consumption during this period should be addressed in future updates.

Basic considerations

Reconstructed landings from small-scale and industrial fisheries were updated for 2011-2015 using the methods outlined in Belhabib *et al.* (2016a). Updated information on the number of artisanal and industrial vessels was available for 2015 (Kay 2016). Total number of vessels were interpolated between the 2010 and 2015 anchor for each vessel type. The catch per unit effort (CPUE) estimates for each vessel type were extrapolated to 2015 based on the 2009-2010 rate of decline. The number of artisanal *Popoh* fishers were estimated for 2011-2015 using the 2010 ratio between artisanal canoes and *Popoh* fishers. Updated population data were available from the World Bank and were multiplied by the percentage of the total population that was deemed rural coastal in 2010 in order to calculate subsistence catches from lagoon fishing. The taxonomic breakdown from 2010 for each sector was held constant for 2011-2015.

Figure 3. Comparison of retroactive changes to FAO data versions for Liberia within Eastern Central Atlantic for 2000-2018.

European vessels in Liberia

In 2015, Liberia signed a five-year fishing agreement with the European Union that permits European vessels to fish for tuna and other highly migratory taxa in Liberian waters (Anon. 2015). The funds from this agreement will be used to help Liberia to improve monitoring, control and surveillance of its waters to protect against illegal fishing (Anon. 2015). Ghana has also recently agreed to cooperate with Liberia in its fight against illegal fishing in its waters (Anon. 2016a).

Other foreign fishing

Estimates of landings and discards by foreign fishing entities fishing in Liberia were updated for 2011-2015. The ratio of landings by foreign fishing entities in the Eastern Central Atlantic taken from Liberia's EEZ was determined for 2010 and was assumed to remain constant for 2011-2015. Angola, Ghana, and Senegal did not report landings in Liberia in 2010, therefore, unreported landings by these entities were held constant at the 2010 amount for 2011-2015. The 2010 taxonomic ratios were carried forward unaltered for unreported landings for each fishing entity.

The discards of foreign fishing fleets were calculated for 2011-2015 based on the 2010 ratio of discards to landings for each fishing fleet. The ratio of discards attributed to illegal fishing was held constant at the 2010 levels. Discarded taxa were disaggregated using the 2010 ratios.

Transition from 2015 to 2018

The catch reconstructed to 2015 was carried forward to 2018 using the semi-automated procedures outlined in Noël (2020), based on FAO reported landings data available to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

Liberia has agreed to protect its biodiversity through the international Convention on Biological Diversity (Aichi) and the Ramsar Convention on Wetlands of International Importance and the World Heritage Convention (Marine Conservation Institute 2020).
Liberia has five marine managed areas and no MPAs. Together, these areas cover 256 km² (UNEP-WCMC and IUCN 2020), which equals less than 1% of the entire EEZ (246,093 km²; Belhabib *et al.* 2016b).

The five marine managed areas are Lake Piso Reserve (Multiple Sustainable Use Reserve designated in 2003 with a total area of 339 km^2), Lake Piso (Ramsar Site designated in 2003 with a total area of 760 km^2), Margibi Mangrove (National Park designated in 2003 with a total area of 238 km^2), Marshall Wetlands (Ramsar Site designated in 2006 with a reported marine area of 67 km^2) and Mesurado Wetlands (Ramsar Site designated in 2006 with a reported marine area of 22 km^2) (Marine Conservation Institute 2020).

The Ramsar site of Lake Piso, also called Fisherman's Lake (Marine Conservation Institute 2020), is the largest of these marine managed areas and has the national legal designation of 'Nature Conservation Unit'. "The site is important both as a nursery and spawning ground for fish and sea turtles and as feeding and roosting places for large numbers of shore and sea birds. Mammals such as antelopes, duikers, monkeys, bushbucks, and a few crocodiles are also found in the area" (Ramsar sites information service 2020).

Morocco (Atlantic)

The total fisheries catches for Morocco were reconstructed from 1950 to 2010 by Belhabib *et al.* (2012, 2016a, 2016b). Morocco was defined as comprising of three parts with respect to fisheries: (1) North, consisting of the Mediterranean coast of Morocco (FAO area 37), and updated in Khalfallah (2020; see also Derrick and Pauly 2020); (2) Central, consisting of the Atlantic coast of Morocco from the Strait of Gibraltar to the border of the former Spanish Sahara, and (3) South, consisting of the former Spanish Sahara, which Morocco claims as part of its territory. The catch reconstruction and updates of parts (1, North) is addressed in Khalfallah (2020), while parts (2, Central) and (3, South), representing 'Morocco (Atlantic)'in FAO area 34 is updated here to 2014, and then carried forward to 2018, based on the semi-automation procedure in Noël (2020) and the FAO landing data to 2018. The catch data that were carried forward will later be replaced by a more detailed update.

Reporting baseline

The data reported by the FAO for FAO areas 34 and 37 on behalf of Morocco was compared to national statistical reports from the Office National des Pêches (ONP 2012, 2013, 2014, 2015), as well as stock and fishery assessments from the Institut National de Recherche Halieutique (INRH 2014, 2015). The FAO data were accepted as the reported catch baseline for 2011 to 2014 for domestic industrial catches, split spatially and taxonomically according to 2010 proportions between the North, Central, and South parts of Morocco's Exclusive Economic Zone (EEZ). Reported catches in the Atlantic (i.e., Central and South) spiked considerably from 2012 to 2014. This increase may be due to improved reporting with the establishment of the Halieutis Strategy (MEF 2013) but may be a sign of catches by foreign ships flying Moroccan flags. No information on this latter re-flagging issue is currently available, though it is likely.

A reported baseline for foreign fishing in Morocco was established by allocating a portion of catches from countries other than Morocco operating in FAO area 34 (Eastern Central Atlantic) to the Moroccan Atlantic EEZs, following 2010 proportions. Reports by the INRH (2014, 2015) indicate that fishing vessels from Russia and the EU may be catching more than is estimated with this method, potentially requiring a re-evaluation of foreign fishing in Moroccan waters. This adds considerable uncertainty around foreign fisheries catches in Moroccan waters.

Artisanal fisheries

Artisanal fisheries catches operating from *barques* were reconstructed using artisanal fleet size data (DPM 2011; Anon. 2012) and estimated catch per unit effort (CPUE) carried forward from Belhabib *et al.* (2012). Catch per unit effort (CPUE) in the Atlantic EEZ of Morocco was extended forward following the declining

CPUE trend from 2008-2010. Unreported artisanal catches from *barques* were estimated by multiplying the CPUE with the number of vessels, and taxonomically allocated as in 2010. The illegal artisanal cephalopod fishery catches were carried forward unchanged.

Subsistence and recreational fisheries
The subsistence fishery of Atlantic Morocco, composed of artisanal catch retained for subsistence purposes and bivalve catches for subsistence and bait, was reconstructed following the method from Belhabib *et al.* (2012) for each sector. The unreported recreational fishery was carried forward from 2010 unchanged.

Industrial fisheries
The unreported industrial fisheries catches were examined for 3 different sectors: the offshore fishery within the Moroccan Atlantic EEZ, and the large-scale coastal pelagic and coastal demersal fisheries. The ratio of the unreported catch of each of these components to the reported industrial landings for 2010 was derived and maintained to 2014 to estimate their catches and split spatially and taxonomically according to 2010 ratios.

Foreign fisheries
The unreported catch of foreign vessels in the Moroccan Atlantic EEZs was carried forward to 2014 using the original method as an average of estimated catches using the ratio of unreported-to-reported foreign catches and the ratio of unreported foreign-to-reported domestic catches for 2010. This average was allocated to the Central and South parts of the EEZs and the same fishing entities following the original 2010 ratios. Given the large spike in reported domestic catches from 2012 to 2014, it is likely that foreign vessel catches (or reflagged catches) may be mixed in with truly domestic catches. This should be looked at more closely in future research-intensive updates.

Managing the Moroccan fisheries
Morocco's fisheries received close scrutiny from 2011 to 2014. Many projects assessed Morocco's fisheries sustainability and worked to improve the country's reporting infrastructure, which is currently fragmented between multiple departments (DPM 2011; Anon. 2012; MEF 2013). Morocco's partnerships with countries in the EU remained strong, with the renewal of fishing agreements between the EU and Morocco (Anon. 2011) and research initiatives between Spain and Morocco addressing the state of the Atlantic bluefin tuna (*Thunnus thynnus*) population in the Mediterranean (Malouli Idrissi *et al.* 2013). Scientific stock assessment reports for major fished stocks in Morocco for 2013 and 2014 provide more granularity in understanding the fisheries sector of Morocco (INRH 2014, 2015); however, these were not considered in the current update.

Transition from 2014 to 2018
The catch reconstructed to 2014 was carried forward to 2018 using the semi-automated procedures outlined in Noël (2020), based on FAO reported landings data available to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection
Morocco has agreed to protect its biological diversity through the international Convention on Biological Diversity (Aichi) (Marine Conservation Institute 2020).
The Moroccan Atlantic EEZ has one MPA that covers 129 km^2 (Marine Conservation Institute 2020), which is minuscule compared to the EEZ of Morocco in the Atlantic (558,766 km^2; Belhabib *et al.* 2016a, 2016b). This MPA is the National Park of Sous Massa and its marine area is a no-take reserve managed by the high Commission for Water and Forests and designated in 1991 (Marine Conservation Institute 2020).

"This park protects continental and marine environments. It is crossed by [the] Souss and Massa river estuaries. The park administratively is under three provinces: Aït Melloul Inezgane, Chtouka Aït Baha, and Tiznit (Harif *et al.* 2008). The park consists of four areas [(Conservation area of natural resources, Natural resource management areas, Traditional use areas and Special use areas)] that are subject to a 5-year development plan and management" (Hirich *et al.* 2016). Some of the threats in the marine ecosystems of the Natural Park originate from agricultural run-off and discharge of sewage.

"Nitrogen and phosphorus are the prime causative agents of eutrophication, the former tending to be more problematic in the marine environment, and the latter in freshwater systems. Adverse environmental impacts upon receiving waters, fresh and marine, are numerous. An extensive 4-year study found that most of the nitrogen entering the Bay stayed there and is assimilated there. Consequently, the report recommended a precautionary of at least a primary treatment, which allows a reduction of 50% nitrogen load" (Choukr-Allah *et al.* 2016).

Namibia

The original reconstruction of Namibia's fisheries catches for 1950-2010 is detailed in Belhabib *et al.* (2015, 2016a, 2016b); this report details how the catch reconstruction was updated to 2014, and then forward carried to 2018.

Subsistence and recreational fishing

Subsistence fishers were estimated for 2011-2014 as a ratio of the total population based on the 2006 percentage of subsistence fishers in the total population. For 2011-2014, the number of days spent subsistence fishing were assumed to be the same as in 2010. Subsistence catch per unit effort (CPUE) was assumed to have continued to decline at the same rate for 2011-2014 as derived for 1996-2010. The taxonomic breakdown for subsistence catches were assumed to be unchanged since 2010.

Recreational catches were updated for 2011-2014 using the 2010 ratio to reported catches. The 2010 taxonomic breakdown for recreational catches was carried forward unaltered to 2014.

Industrial domestic fisheries

The ratio of reported catch assigned to the industrial fishing sector was assumed to remain the same as in the original reconstruction. The 2010 ratio of unreported industrial landings to reported landings was used to update unreported catch for 2011-2014. The taxonomic breakdown of unreported industrial landings was assumed to be the same as the reported industrial landings for 2011-2014. Discards from the industrial fisheries were updated using the same discard rate and taxonomic ratios as in the original reconstruction.

Foreign industrial fishing

Reported landings by foreign fishing entities were determined for the Southeast Atlantic region (FAO area 47) using the FAO data. The 2010 taxa caught per fishing entity in Namibia's EEZ were assumed to have remained the same for 2011-2014. Unreported landings by foreign fishing entities were calculated using the 2010 ratio of reported landings for each fishing entity and were assigned to the category "marine fishes not identified" as in the original reconstruction.
However, it is known that foreign vessels heavily target European anchovy (*Engraulis encrasicolus*), South American pilchard (*Sardinops sagax*), Whitehead's round herring (*Etrumeus whiteheadi*), Cape horse mackerel (*Trachurus capensis*), deep-water cape hake (*Merluccius paradoxus*), and snoek (*Thyrsites atun*) (Petrossian 2018). This information will be used to improve the taxonomic resolution of foreign catches in future updates.

Transition from 2014 to 2018

The catch reconstructed to 2014 was carried forward to 2018 using the semi-automated procedures outlined in Noël (2020), based on FAO reported landings data available to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Recent literature presents both the successes and failures of Namibia's fisheries management. Hake stocks have failed to recover since the high pressure placed on them by distant water fleets prior to 1990 (Paterson *et al.* 2013; Paterson and Kainge 2014). Paterson and Kainge (2014) stated that the Total Allowable Catch assigned to this fishery is too high to allow the stock to recover. Management of illegal fishing has been successful in Namibia because of strong deterrents including high penalties, effective monitoring, and enforced restrictions to Namibia's EEZ (Sjöstedt and Sundström 2015).

Marine biodiversity protection

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

Namibia has two MPA and five marine managed areas. Together, the MPAs cover 9,423 km^2 (Marine Conservation Institute 2020), which equals 2% of the entire EEZ (560,101 km^2; Belhabib *et al.* 2016b). The five marine managed areas are Namib-Naukluft (a National Park designated in 1986 with a reported marine area of 18 km^2), Skeleton Coast Park (a National Park designated in 1973 with a marine reported area of 26 km^2), Orange River Mouth (a Ramsar Site designated in 1995 with a total area of 5 km^2), Sandwich Harbour (a Ramsar Site designated in 1995 with a total area of 165 km^2) and Walvis Bay (a Ramsar Site designated in 1995 with a total area of 126 km^2) (Marine Conservation Institute 2020).

Sandwich Harbour is the largest of those Ramsar sites with a wetland fed from an aquifer that is slowly disappearing. This wetland is inside the largest MPA of Namibia, the Namib-Naukluft Park (designated in 2009), which is under tidal influence and supports endangered species and human activities such as fishing, guano collection, tourism and recreation (Ramsar sites information service 2020).

The other MPA, Cape Cross Seal Reserve (designated in 1968; Marine Conservation Institute 2020, 60 km^2; Ministry of Environment and Tourism Namibia 2020), is a so-called sanctuary for the world's largest breeding colony of South African fur seals (*Arctocephalus pusillus)*, with up to 210,000 individuals present during the breeding season in November and December. However, "[s]ustainable seal harvesting takes place in the reserve annually under the auspices of the Ministry of Fisheries and Marine Resources, which also sets the quota of seals to be harvested" (Ministry of Environment and Tourism Namibia 2020).

Nigeria

Nigeria's marine fisheries catches were reconstructed for 1950-2010 by Etim *et al.* (2015, 2016). This section presents the details of an update to 2015 that was subsequently carried forward to 2018.

Artisanal and domestic catch

Increases in reported landings for 2011-2015 by Nigeria were assumed to be due to an improvement in reporting rather than actual catch increases. However, Nigerian marine resources are reportedly overexploited (Nsentip 1983, Moses 1989, Ajayi 1991, Ganapathiraju and Pitcher 2006 and Falaye 2008) and catches from several fisheries components continue to go unreported (Etim *et al.* 2015). Reported landings by industrial

and artisanal fisheries were updated with the FAO data for 2000-2015 (Figure 4) based on the data allocations to each sector in the national reports in Akintola and Fakoya (2017) and NBS (2017).

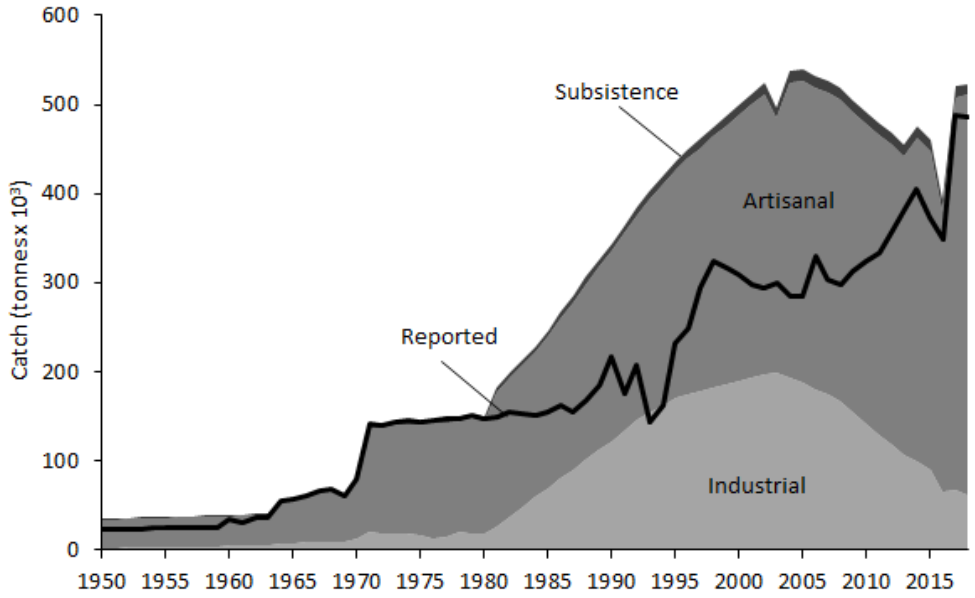

Figure 4. Reconstructed domestic catch within Nigeria's EEZ by fishing sector for 1950-2018.

Total unreported industrial landings were extrapolated for 2011-2015 based on the 2010 rate of decline in the ratio of unreported landings from 2009. Unreported subsistence catches were assumed constant for 2010-2015. The 2010 percentage of industrial unreported catch attributed to fish trawlers and shrimp trawlers was assumed to remain constant for 2011-2015.

Artisanal landings were held constant for 2011-2013 and fully reported from 2013 onward when reported landings were greater than reconstructed landings. Unreported landings were disaggregated to taxa for 2011-2015 based on the 2010 taxonomic breakdown for each sector. Discards were updated for 2011-2015 using the 2010 ratio of discards to total industrial landings.

Transition from 2015 to 2018

The catch reconstructed to 2015 was carried forward to 2018 using the semi-automated procedures outlined in Noël (2020), based on FAO reported landings data available to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

While an estimated 90% of Nigeria's coastal communities depend on fishing and fisheries for their livelihood, landings from fisheries in Nigeria have not been enough to keep up with the domestic demand for fish in recent years (Gbigbi and Enete 2014). Nigeria's per capita fish consumption rate has been estimated at 11 kg per year (Anon. 2016). In order to meet this demand, approximately 200 million USD worth of frozen fish are imported by Nigeria each year (Gbigbi and Enete 2014). In 2014, Nigeria introduced a structured embargo with the hope of becoming self-sufficient in fishery products, but that embargo appears to have been lifted in 2016 (Davies 2016). Nigeria's proximity to transshipment and ports of convenience locations puts it at high risk of illegal, unreported, and unregulated fishing (Petrossian 2018). Indeed, illegal foreign trawlers contribute to the problem, as they continue to fish in coastal areas in Nigeria with little threat from the over-stretched policing activities of the Nigerian Navy (Anon. 2016). A future update will have to concentrate on this issue.

Marine biodiversity protection

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

Currently, Nigeria has no MPAs. However, 128,070 km^2 are proposed to be protected in the future. This extent would occupy nearly 60% of the entire EEZ (216,325 km^2; Etim *et al.* 2015).

The terrestrial protected areas cover 15.2% of the total landmass of Nigeria, but these areas are so degraded that they are far from the target 4 of the National Biodiversity Strategy and Action Plan (2016 – 2020) (Olaniyi *et al.* 2019). "There were stark evidences that people enter the protected areas (PAs) with ease either for farming activities and/or collection of fuel wood. The cattle herdsmen equally lead their animals into the PAs without hindrances. It was equally observed that some residents of communities located near the PAs scavenge for dried twigs of trees for fuel wood while some engaged in direct cutting of these trees. To these people, there was nothing extraordinary in the rate at which they make use of resources within the PAs. In their opinion, resources within the protected areas were seen as God-given endowment that is freely available to the people. It was also confirmed that many people especially the poor wouldn't have survived the harsh economic reality in the society without these resources" (Olufemi and Kenneth 2019).

If marine protected areas were to be established in Nigerian waters, they should involve the different stakeholders within planning, managing and monitoring. Otherwise, they would likely turn into paper MPAs similar to the terrestrial areas that are supposedly protected.

Senegal

The original reconstruction of Senegal's marine fisheries catches was completed for 1950-2010 by Belhabib *et al.* (2013, 2014a, 2016b). It was updated to 2015 here and carried forward to 2018 using the semi-automation procedure of Noël (2020) and FAO landing statistics to 2018.

Reported baseline catch data

Data were gathered for artisanal and industrial landings for 2011-2015 for both domestic and foreign fleets operating in Senegalese waters. The number of industrial fishing vessels, vessel name, gear type, and GRT were collected from the Department of Surveillance and Protection of Fisheries (DPSP), and data on exports and imports were extracted from statistical reports of the Senegalese government.

Industrial landings

To reconstruct large-scale fisheries catches, we used the method developed by Belhabib *et al.* (2014). This allowed us to estimate the product of the daily catch per unit effort (CPUE) per unit of GRT (kg·GRT^{-1}·day^{-1}), the GRT for each vessel, the number of days of fishing operation of each vessel, we were then able to sum the result to obtain the total catch per year. The CPUE was estimated by Belhabib *et al.* (2014a) using the Monte-Carlo method (Pauly *et al.* 2013) as 14.8 kg·GRT^{-1}·day^{-1} for 2010. The average number of fishing days for the trawl fleet (coastal and offshore demersal) was estimated at 275 fishing days per year (11 trips per year, and 25 fishing days per trip).

Industrial discards

Discards were estimated based on the discard rates described by Belhabib *et al.* (2014) and ter Hofstede and Dickey-Collas (2006), who estimated the discard rates at 38% for the demersal and shrimp trawl fleet catches and 12% for the purse seine and pelagic trawl fleet catches, respectively.

Subsistence catches
Subsistence catches were extrapolated for 2011-2015 based on the last 5 years of the previous reconstruction. The taxonomic breakdown for each sector was maintained at the 2010 composition.

Recreational catches
Recreational catches were estimated as the product of the number of tourists fishing per year (4% of the tourist population; Belhabib *et al.* 2014a), the CPUE of 35 kg·tourist^{-1} day^{-1} (Belhabib *et al.* 2016a), and five fishing days·tourist^{-1} year^{-1} (Belhabib *et al.* 2014a; 2016a). The tourist population was updated for 2011-2015 from World Bank data.

Artisanal catches
Artisanal catches caught in Senegal's Exclusive Economic Zone (EEZ) can be difficult to distinguish from catches by the same fleet segments taken in neighboring countries' waters but reported as caught in Senegalese waters. It is though that Senegalese artisanal fishers typically catch over 40% of their catch outside of Senegal (Belhabib *et al.* 2014a). We estimated unreported artisanal catches iteratively following the formula: country population x consumption per person per year = artisanal catch + industrial catch - exports + imports + recreational catch + subsistence catch. Updated population data were available from the World Bank. Import and export data were available in wet weight or converted from product weight to wet weight where necessary. The per capita consumption rate, obtained from surveys, is estimated as 29 kg·person^{-1} year^{-1} (Agence Nationale des Statistiques et de la Démographie, unpublished data). Overall, we assumed that 40% of total estimated artisanal catches (reported + unreported) are caught outside Senegal for 2011-2015 as in previous years (Belhabib *et al.* 2014a).

The number of pirogues used in the original catch reconstruction was contested by Chaboud *et al.* (2015), but Belhabib *et al.* (2015) refuted their claims. However, it would be useful to revisit this issue, given the large role that artisanal fisheries play in Senegal. This research-intensive investigation should be done while also revising the semi-automatic carry forward to 2018.

Updates to select taxa

Bonga shad *(Ethmalosa fimbriata)*
Reconstructed catches of Bonga shad (*Ethmalosa fimbriata*) were lower than artisanal catches reported by expert working group (FAO 2020). Because artisanal fishing by Senegalese pirogues occurs in neighbouring countries (classified by *Sea Around Us* as industrial), missing species-level catches of *Ethmalosa fimbriata* present in FAO (2020) were disaggregated from Senegalese catches of 'Marine fishes not identified' by artisanal pirogues fishing outside of Senegal for 1990-2017.

Cunene horse mackerel (*Trachurus trecae*)
Comparison of reconstructed catches of Cunene horse mackerel (*Trachurus trecae)* with catches reported by expert working group (FAO 2020) alerted us to missing catches at species-level from the original reconstruction (Belhabib *et al.* 2014a; Palomares *et al.* 2020). Similar to the methods for Bonga shad described above, we disaggregated missing catches of *Trachurus trecae* present in FAO (2020) from reconstructed catches of 'Marine fishes not identified' for artisanal pirogues and unreported industrial domestic landings for 1990-2011.

Correction to original artisanal taxonomy 1950-1980
Following species level assessment using CMSY, the original use of Bergerard and Samba (1980) to taxonomically disaggregate artisanal unreported landings for 1950-1976 within the original reconstruction

(Belhabib *et al.* 2014a) was re-evaluated. Bergerard and Samba (1980) provided taxonomic information for average catch proportions per trip from two landing sites (Kayar and St Louis) and as a result, we deemed this information unlikely to be representative of unreported artisanal landings across Senegal's coastline during this time period. Instead, the taxonomic breakdown from 1981 by Samba (1994) was held constant for 1950-1981 as it was deemed more representative of artisanal unreported landings at the national level.

Transition from 2015 to 2018

The catch reconstructed to 2015 was carried forward to 2018 using the semi-automated procedures outlined in Noël (2020), based on FAO reported landings data available to 2018. The semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update, which will also have to account for the increasing, but unreported fraction of Senegal's artisanal and industrial catch of small pelagic fish that is diverted from local human consumption to fishmeal factories whose production is exported to East Asia (Pauly 2019a, 2019b).

Marine biodiversity protection

Senegal has agreed to protect its biological diversity through the international Convention on Biological Diversity (Aichi), the Ramsar Convention on Wetlands of International Importance and the World Heritage Convention and it is also part of the international network of UNESCO called Man and the Biosphere. Its commitments extend to NGOs and/or public bodies like the West Africa MPA Network (RAMPAO) (Marine Conservation Institute 2020).

Senegal has 16 MPA and four marine managed areas. Together, the MPAs cover 1,528 km² (Marine Conservation Institute 2020), which equals about 1% of its EEZ (157,709 km²; Belhabib *et al.* 2016b). The four marine managed areas are Delta du Saloum (a UNESCO-MAB Biosphere Reserve designated in 1980 with a reported marine area of 1,800 km²), Reserve ornithologique de Kalissaye (a Bird Reserve designated in 1978), Delta du Saloum (a Ramsar Site designated in 1984 with a total area of 730 km²) and Gueumbeul (a Ramsar Site designated in 1986 with a total area of 7 km²) (Marine Conservation Institute 2020). The Delta du Saloum is the largest of those Ramsar sites and "supports a varied fauna, including numerous species of notable mammals, four species of breeding turtles, and numerous species of nesting waterbirds and wintering Palearctic migrants. Human activities include nature conservation, tourism, and pastoralism. Management issues include illegal gathering of molluscs, and of bird and turtle eggs and unsustainable exploitation of plant products. Surrounding areas are used for agriculture, livestock rearing, fishing, and hunting" (Ramsar sites information service 2020).

"[T]he Saint Louis MPA, covering a total area of 496 km², is the largest in Senegal and responded to the need to repopulate the seabeds alongside one of the country's main fishing grounds and to keep foreign trawlers away. […] We applaud the avowed desire of the Government and its departments to involve the Guet Ndariens (locals from area in Saint Louis) in the various stages of the process, from choosing the MPA site to defining the management plans. However, significant challenges and problems specific to this complex region emerged when the initiative was implemented. […] The steady increase in the number of fishermen has led to a high building density (traditionally, there are no two-storey houses in this district) and put growing pressure on fish resources against a general background of fish depletion and competition for access both to fishing zones, especially between small-scale fishermen, trawlers and shrimpers […]" (Cormier-Salem 2014).

Sierra Leone

Sierra Leone's marine fisheries were described in Valily *et al.* (2012), and their catches were reconstructed for 1950-2010 by Seto *et al.* (2015, 2016) and updated to 2015 as described by Seto *et al.* (2017). Here, their catch

is carried forward from 2015 to 2018 using the semi-automated procedure in Noël (2020) and using FAO landings data to 2018.

Okeke-Ogbuafor *et al.* (2019) examined the various issues associated with the decline of fisheries resources in Sierra Leone. They noted a lack of political will to mitigate the damage caused by the most destructive foreign trawl fisheries and suggested that this issue could be addressed by a coalition of local fishers' associations and a strong focus on environmental education and fish processing.

Marine biodiversity protection

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

Sierra Leone has eight marine managed areas and no MPAs. Together, these areas cover 863 km² (UNEP-WCMC and IUCN 2020), which is less than 1% of the entire EEZ (159,300 km²; Seto *et al.* 2016).

The eight marine managed areas are Scarcies River Estuary (Marine Protected Area designated in 2012 with a total marine area of 102 km²), Sewa-Waanje (Game Reserve with a total area of 100 km²), Sherbro River Estuary (Marine Protected Area designated in 2012 with a total marine area of 283 km²), Sierra Leone River Estuary (Marine Protected Area designated in 2012 with a total area of 248 km²), Sierra Leone River Estuary (Ramsar site designated in 1999 with a total area of 2950 km²), Yawri Bay (Marine Protected Area designated in 2012 with a total marine area of 760 km²), Bonthe Mangrove Swamp (Strict Nature Reserve with a total area of 998 km²), and Sulima Mangrove Swamp (Strict Nature Reserve with a total area of 25 km²) (Marine Conservation Institute 2020). The Ramsar site of Sierra Leone River Estuary encompasses 19% of Sierra Leone's total mangrove. "The Estuary is threatened by vegetation clearance and unsustainable fishing, and efforts are being made strictly to conserve certain core areas within the site. Vast areas of untouched mangrove forest still exist, however, and traditional fishing and agro-forestry for fuelwood can be managed sustainably in collaboration with an existing EU-funded Artisanal Fishing Community Development Programme. Fine beaches in some areas provide hope for well-managed tourist development, especially in light of the presence of an historic slave castle on Bunce Island, and so ecotourism development is considered promising" (Ramsar sites information service 2020).

Togo

The original reconstruction of Togo's marine fisheries catches was completed for 1950-2010 by Belhabib *et al.* (2015, 2016). Here, data were updated for 2011-2015 using FAO data, then carried forward to 2018. Retroactive changes in reported data were assumed minor between the different versions of FAO datasets and were not addressed in the carry forward.

Artisanal fisheries

Artisanal fisheries catches from land-based gear and pirogues were updated for 2011-2015 based on the total artisanal marine catches reported by Anon. (2016). In 2015, the number of artisanal pirogues was estimated to be 370 and the artisanal catch by these pirogues was estimated at 7600 tonnes (Anon. 2016). Catch by land-based artisanal fishers was assumed equal to the total marine artisanal catch minus the pirogue catch in 2015. Reconstructed artisanal landings were allocated to land based or pirogue caught by interpolating between the percentage caught by each component in 2010 and in 2015. Unreported landings from each gear-type were estimated to be the remainder of total estimated catch after reported landings were accounted for. The 2010

taxonomic breakdown of unreported artisanal landings for each gear-type was carried forward unaltered for 2011-2015.

Subsistence and recreational catches
The catch from subsistence fisheries was updated for 2011-2014 based on the percentage of artisanal catch (see below) that is estimated to be taken home for family- or self-consumption. Approximately 10-13% of artisanal catch was estimated to be taken home by fishers in 2014 and, as a result, the subsistence catch was estimated for 2012-2015 as 11.5% of artisanal catch (Ali *et al.* 2016).

Recreational fisheries catches were updated using the approach of Belhabib *et al.* (2015). The percentage of recreational fishers in the total Togolese population for 2010 was used to estimate the number recreational fishers for 2011-2015. The number of recreational fishing trips per fisher, per year in 2010 and CPUE for 2010 was held constant for 2011-2015. The 2010 taxonomic breakdown of recreational landings and subsistence catches was assumed to remain constant for 2011-2015.

Domestic industrial landings and discards
Domestic industrial landings were estimated for the single domestic trawler that was reported by Anon. (2016) to have been operating in 2011-2015 and whose catch is assumed to have been reported to FAO in 2012-2015 but not 2011. Thus, we interpolated between 2010 and 2012 to estimate domestic catch by this trawler for 2011. Discards from domestic trawling were estimated for 2011-2015 using the method of Belhabib *et al.* (2015). The taxonomic breakdowns for 2010 was used to disaggregate landings and discards for 2011-2015.

Foreign industrial landings and discards
An estimated 14% of landings reported by Togo to the FAO are assumed to have been caught in Togo's EEZ by Spanish vessels and landed in Lomé in 2009-2010. Thus, this represents a flag-misreporting in the data reported by Togo to the FAO. China, Greece, Italy, and Spain also reported catches from the Eastern Central Atlantic and the percentage of reported landings that were estimated to have been taken from Togo's EEZ by these fleets in 2010 was used to estimate reported catch by each fishing entity in Togo for 2011-2015. Total catch by China, Greece and Italy was assumed to remain constant for 2011-2015. Unreported landings by Spain fishing in Togo's EEZ were calculated for 2011-2015 based on the 2010 percentage of unreported to reported landings. Unreported landings by Guinea and Ghana in Togo's EEZ were carried forward for 2011-2015 based on the 2010 ratio of unreported landings by each fishing entity to Togo's domestic reported landings. Discards from foreign fisheries in Togo were estimated for 2011-2015 as described by Belhabib *et al.* (2015). The 2010 taxonomic breakdowns of unreported landings and discards by foreign fishing entities were carried forward unaltered for 2011-2015.

Transition from 2015 to 2018
The catch reconstructed to 2015 was carried forward to 2018 using the semi-automated procedures outlined in Noël (2020), based on FAO reported landings data available to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

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

Togo has no MPAs (Marine Conservation Institute 2020) but WDPA indicates that there is 31 km² protected in its waters (UNEP-WCMC and IUCN 2020), which is only 0.2 % of the entire EEZ (15,442 km²; Belhabib *et al.* 2016).

There are four Ramsar sites in Togo but only one is especially close to the coast – Zone Humides du Littoral du Togo – which was designated in 2008 and has 5,910 km² (Ramsar sites information service 2020). "These different ecosystems of the littoral zone are of great natural biological, ecological and economic value and host a wide variety of bird, mammal, reptile, fish, mollusc and crustacean species. Endangered species found here include marine turtles (*Chelonia mydas*, *Eretmochelys imbricata, Lepidochelys olivacea* and *Dermochelys coriacea*), the African manatee (*Trichechus senegalensis*), hippopotami, etc. This zone contributes over 85 % of the total annual fish production in Togo and is also important for transportation of people and goods. The site is also exploited for construction and fuel wood, mollusks, crustaceans, bush meat and medicinal plants, both for subsistence and commercial purposes. There is presently no management plan for the site, but personnel from the Ministère de l'Environnement et des Ressources Forestières combat unsustainable logging and fishing and illegal hunting" (Ramsar sites information service 2020).

Discussion

The countries whose marine (and in some cases estuarine or lagoon) fisheries catch data were reconstructed here all suffer, if to a variable extent, from the fisheries in their EEZ being largely uncontrolled, whether they are small-scale and local or industrial and foreign. This leads to much uncertainty in the estimation of their catch, which may end up landed in the ports of the countries in question or elsewhere, or as discarded bycatch. It also substantially increases the uncertainty around any attempts to estimate the actual biomass status of the underlying fish stocks being exploited.

This uncertainty should not lead, however, to the acceptance of 'zero' as an estimate of these catches in lieu of 'no data', whether fished legally or not, because no operating fishery generates catches of zero. Rather, we present here our best estimates, and look forward to feedback and collaborations that would allow them to be corrected.

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