Fisheries in the Caribbean Islands: Updating catch reconstructions to 2018*

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Abstract

Updates to 2018 of fisheries catch reconstructions for the island states and territories in the Caribbean originally covering the year 1950 to 2010 or about are presented. The updates were completed for Anguilla, Antigua and Barbuda, Aruba, Bahamas, Barbados, British Virgin Islands, Cayman Island, Cuba, Dominica, Dominican Republic, Grenada (and the Grenadines), Guadeloupe, Haiti and Navassa, Jamaica, Martinique, Montserrat, the ex-Netherlands Antilles (Bonaire, Curaçao, Saba & Sint Eustatius and Sint Maarten), Puerto Rico, Saint Barthélémy, Saint Kitts and Nevis, Saint Lucia, Saint Martin, Saint Vincent and the Grenadines, Trinidad and Tobago, Turks and Caicos Islands, and the US Virgin Islands.

The impact of the tourism industry on the amount of fish caught and locally sold to hotels and restaurants and the number of recreational fishers continues to be an important component to consider for reconstructions. Information on the number of stop-over tourists and their per capita consumption, the recreational fishing participation rate and their catch rate were used to update catch form recreational and artisanal subsectors. Therefore, a detailed description of the methods used to update Caribbean catch reconstructions is presented.

Introduction

Updates to 2018 of fisheries catch reconstructions for Caribbean states and territories originally covering the year 1950 to 2010 or about are presented here. These include Anguilla, Antigua and Barbuda, Aruba, Bahamas, Barbados, British Virgin Islands, Cayman Island, Cuba, Dominica, Dominican Republic, Grenada (and the Grenadines), Guadeloupe, Haiti and Navassa, Jamaica, Martinique, Montserrat, ex-Netherlands Antilles (Bonaire, Curaçao, Saba & Sint Eustatius and Sint Maarten), Puerto Rico, Saint Barthélémy, Saint Kitts and Nevis, Saint Lucia, Saint Martin, Saint Vincent and the Grenadines, Trinidad and Tobago, Turks and Caicos Islands, and the US Virgin Islands. A description of the methods used to update catch reconstructions for these states and territories is presented in the following sections.

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Methods

Anguilla (United Kingdom)

The reconstruction of Anguilla's marine fisheries catches was completed for 1950-2010 by Ramdeen *et al.* (2014, 2016). Here, we present an update of this reconstruction to 2014, which was then carried forward to 2018.

Reported landings data of the FAO taxonomic category 'Marine fishes nei' were disaggregated by sector and taxa using the original 2010 reconstruction breakdowns. According to Gumbs *et al.* (2015), Anguilla's fisheries remain dependent on demand by local citizenry and tourists.

To update landings from small-scale and recreational fishing, updated estimates of Anguilla's population and the number of stop-over tourists[4] were derived for 2011-2014. The total population of Anguilla was extrapolated to 2014 based on the rates of increase in previous years. The total demand for seafood was determined for 2011-2014 by multiplying estimates of the local population and stop-over tourists by the 2010 consumption rates for fish, conch (*Lobatus gigas*), and lobsters by locals and tourists. The 2010 breakdown of unreported small-scale landings by sector and taxa was maintained for 2011-2014.

Recreational landings were updated for 2011-2014 by multiplying the number of stop-over tourists by the recreational fishing participation rate and the recreational catch rate from 2010. The 2010 taxonomic breakdown of recreational landings was held constant for 2011-2014. Currently, Anguilla's fisheries are focused on near-shore reefs, and some fisheries, such as conch, are showing signs of unsustainable catch levels (Wynne *et al.* 2016). To improve sustainability, Anguilla is currently evaluating the best methods to manage fisheries within its Marine Park System (Anon. 2016; Wynne 2016).

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 landings data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine protection

Anguilla (UK) has agreed to protect biodiversity through the international agreements of the Convention on Biological Diversity (Aichi) (Marine Conservation Institute 2020).

Anguilla has eight MPAs (Gore *et al.* 2019), which cover 32 km^2 (UNEP-WCMC and IUCN 2020), i.e., 0.035% of the EEZ of 92,178 km^2 (Ramdeen *et al.* 2016). Five marine parks are part of Anguilla's Marine Park System under the 2007 amendments in the Marine Parks Act and from those Marine Parks, three are located around the offshore cays of Dog Island, Prickly Pear Cay, and Sandy Island (Gore *et al.* 2019).

"In general, coral coverage in Anguilla has declined from an average of 14% in the 1990s (Oxenford and Hunte 1990) to 5% in 2016, with macroalgal coverage showing a gradual increase over time, reaching a mean of 15% in 2016 (Wynne 2017)" (Gore *et al.* 2019).

The level of fishing activity and associated seabird by-catch in Important Bird Areas (IBAs) of Anguilla seems to overlap with the core foraging areas of breeding seabirds. These areas are also known for high fishing activity. "These findings highlight the need to work both nationally and across territorial boundaries to

[4] www.onecaribbean.org.

implement appropriate marine spatial planning" (Soanes *et al.* 2016). "Prior to the 2017 hurricane season, tourism and travel in Anguilla generated 56.6% of the island's gross domestic product (GDP) and employment opportunities (WTTC 2017)" (Gore *et al.* 2019).

Antigua and Barbuda

The catch reconstruction for Antigua and Barbuda from 1950 to 2010 was completed by Georges *et al.* (2015, 2016); it is here extended to 2014, then carried forward to 2018.

Population data from the World Bank, along with tourism data from the Ministry of Tourism, Economic Development, Investment, and Energy of Antigua and Barbuda (2014), and the International Monetary Fund (2015) were used to calculate local demand for fish from 2011-2014 using the original method.
When local and tourist fish demand was greater than the artisanal catches reported to the FAO, the excess demand was assumed to be met by unreported subsistence catches. In 2013, subsistence catches appeared to be zero. This is unlikely to be the case in reality, and future updates need to undertake careful revisions to more accurately examine sectoral assignment and estimation of sectoral catches. The ratio of subsistence catches to FAO reported catches was interpolated from surrounding years and used to calculate the ratio of total to subsistence catches.

Catches of common dolphinfish (*Coryphaena hippurus*) were subtracted from total finfish catches when calculating artisanal and subsistence catches, because fishers in Antigua and Barbuda do not usually target dolphinfish. The 'missing' amount was redistributed to other finfish taxa as reported subsistence catches.

Reported catches of conch (*Lobatus gigas)* in 2010 were considered to represent total conch landings, and were split into 50% artisanal, 40% subsistence and 10% recreational catches. In the absence of additional information, these assumptions were carried forward to 2014.

Artisanal finfish and total conch catch equaled 90% of landings, while lobster catches made up the last 10%. The lobster catch was allocated to different sectors; 90% to the artisanal, 7% to subsistence, and 3% to recreational fisheries. The 2010 assumption made for total lobster catches by Georges *et al.* (2015) was carried forward.

Fisheries grew and became strongly motorized from 1970 to 2000, though multiple hurricanes have tended to reduce fishing (Horsford 2004).

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 landings data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

The government of Antigua and Barbuda has agreed to protect biodiversity through the international agreements of the Convention on Biological Diversity (Aichi) and the Ramsar Convention on Wetlands of International Importance (Marine Conservation Institute 2020).

There are 40 MPAs in Antigua and Barbuda, and one marine managed area. Together, these areas cover 491 km^2 (Marine Conservation Institute 2020), which is less than 0.5% of the EEZ of 107,939 km^2 (Georges *et al.* 2016).

The Barbuda Council has the authority to regulate fishing and other marine uses within the nearshore waters from the shore out to three nautical miles, including the inland lagoon, i.e., a total area of 456 km^2 (Johnson *et al.* 2020). The government of Antigua and Barbuda recognizes that to improve the health of the marine ecosystems, marine data collection is necessary (Camacho *et al.* 2020).

"Many activities in Antigua and Barbuda are currently being conducted unsustainably, with negative impacts on the coastal environment. The current sectorial-based management approach is disjointed, top-down, involves inadequate stakeholder participation, and is poorly enforced" (Ruttenberg *et al.* 2018). "[However,] many of the regional threats observed on other Caribbean islands are present on Barbuda, but some resources—particularly lobster and conch—may be less overexploited than on other Caribbean islands. Local management has the potential to provide sustainability for at least some of the island's marine resources" (Ruttenberg *et al.* 2018). In a previous study, different stakeholders affirmed that they were willing to participate in coastal resources management in a more inclusive and holistic way, using, for example, an approach such as Integrated Coastal Zone Management (Ramsey *et al.* 2015).

"According to Barbuda Fisheries officers, some enforcement action has taken place, though the extent of enforcement has not been researched. Despite substantial efforts, a new law that would increase enforcement penalties and create a special fund for coastal management has yet to be enacted. The Council continues to struggle with enforcement and compliance, though prior to Hurricane Irma, the Barbuda Fisheries Division and police had an effective enforcement collaboration. Anecdotal evidence indicates that illegal fishing increased post-hurricane, though these claims have not been researched. Another major challenge has been standing up the advisory committees as laid out in the regulations" (Johnson *et al.* 2020).

Aruba (Netherlands)

The reconstruction of Aruba's marine fisheries catches was completed for 1950-2010 by Pauly *et al.* (2015, 2016); here, they are updated to 2014, then carried forward to 2018.

The taxonomic breakdown of the FAO taxonomic category "Marine fishes nei" for 2010 was maintained for 2011-2014. The 2010 ratio of unreported artisanal landings to reported artisanal landings was used to calculate unreported artisanal landings for 2011-2014. Discards from artisanal fisheries were carried forward to 2014 at the 2010 rate. The increase in subsistence catches from 2009-2010 was extrapolated to 2014. Recreational landings were updated for 2011-2014 using the original methods.

Updated stop-over tourist arrivals were obtained for 2011-2014 from the Central Bureau Statistics Aruba[5] and Aruba Tourism Authority[6] and multiplied by the 2010 recreational fishing participation rate, the number of days spent fishing and catch rate per fishing day from 2010 (Pauly *et al.* 2015) to estimate recreational landings for 2011-2014. Landings by Taiwanese and Venezuelan fishing vessels in Aruba were updated for 2011-2014 by carrying forward the 2008 amount. As a result, discards by foreign fishing entities were maintained at the 2008 level for 2011-2014. All landings and discards for 2011-2014 were disaggregated by taxa using the taxonomic breakdown from 2010 for each sector.

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 landings data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

[5] http://cbs.aw/wp/
[6] https://www.aruba.com/us/organization/aruba-tourism-authority

Marine protection

The Government of the Netherlands and the local government of Aruba have agreed to protect biodiversity mainly through the Convention on Biological Diversity (Aichi) (Marine Conservation Institute 2020).

Aruba has four MPAs with an extent of 60 km² (Parke Marino Aruba 2019), which protect 0.24% of the EEZ of 25,199 km² (Pauly *et al.* 2016). The Parke Marino Aruba is formed by four MPAs: Arikok, Sero Colorado (biggest MPA with 19 km²), Mangel Halto and Oranjestad Reef Islands (smallest MPA with 9 km²), which are managed as multi-use MPAs and contain one or more Key Biodiversity areas (Parke Marino Aruba 2019).

"As of 16 April 2019, Fundacion Parke Nacional Aruba (FPNA) will not only be the managing organization of Arikok National Park and the connecting National Park/RAMSAR site, but will also be the managing organization of the new 'Parke Marino Aruba' or the Aruba National Marine Park" (Parke Marino Aruba 2019). Together with the local community and other stakeholders, FPNA's objectives are: Nature Conservation, Conservation Education, Sustainable Recreation and Science & Research (Parke Marino Aruba 2019).

A study focused on marine mammals' injuries indicated that fishing gear and propeller hits threaten small and medium-sized cetaceans in Aruban waters (Luksenburg 2014). Moreover, the Aruban tourism industry, which is valued at over 1 million USD per annum, contributes nearly 90% to the gross domestic product (Parke Marino Aruba 2019).

Bahamas

Marine fisheries catches in The Bahamas were reconstructed for 1950-2010 by Smith and Zeller (2013, 2016a, 2016b) and updated to 2017. Data provided by the FAO were used as the baseline for 2011-2017 to account for reported catches from the industrial and artisanal sectors. Due to changes detected between different annual releases of the FAO data, the reported and unreported catches of conch (*Lobatus gigas*) i.e., 'Stromboid conchs nei' were retroactively increased to match these changes (Figure 1).

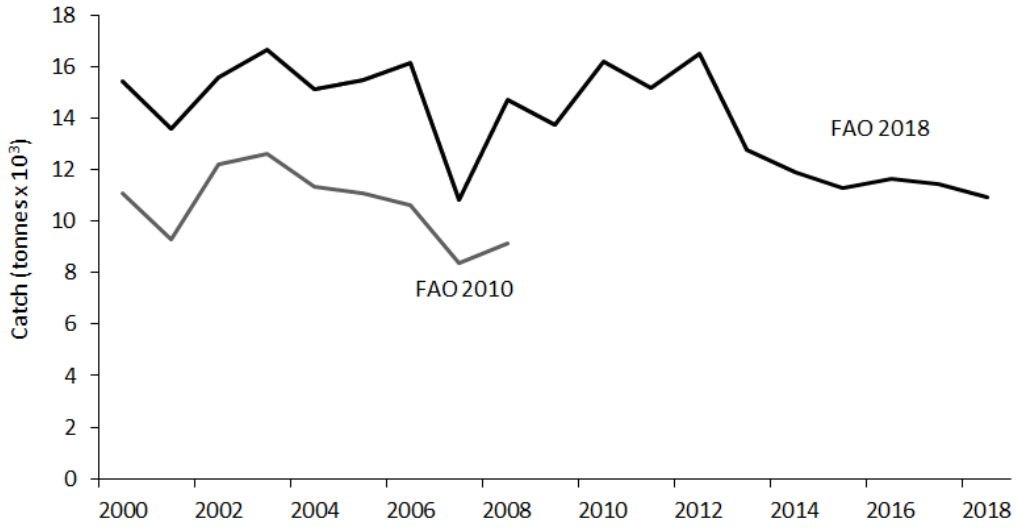

Figure 1. Comparison of reported catch between the FAO data releases of 2010 and 2018 for the Bahamas in the Western Central Atlantic FAO area for 2000-2018.

Due to systematic under-reporting of commercial catches, the fraction of commercial catch per taxon thought to be under-reported was carried forward from 2010 to 2017. Gear type disaggregation for the artisanal sector

was carried forward from 2010 to 2017. The subsistence sector was calculated for 2011-2017 based on national population data from the World Bank and the Bahamas Department of Statistics (2012). The local subsistence catch rate was derived from expert opinion and the taxonomic disaggregation of 2010.

Because no new catch was reported, tournament recreational catches remained at 2010 levels. Non-tournament recreational catches were estimated using updated national population data (World Bank), updated stopover visitor data (Bahamas Ministry of Tourism 2019), and the taxonomic disaggregation of 2010. Finally, the invasive lionfish (*Pterois volitans*) catches were assumed fully reported in 2015.

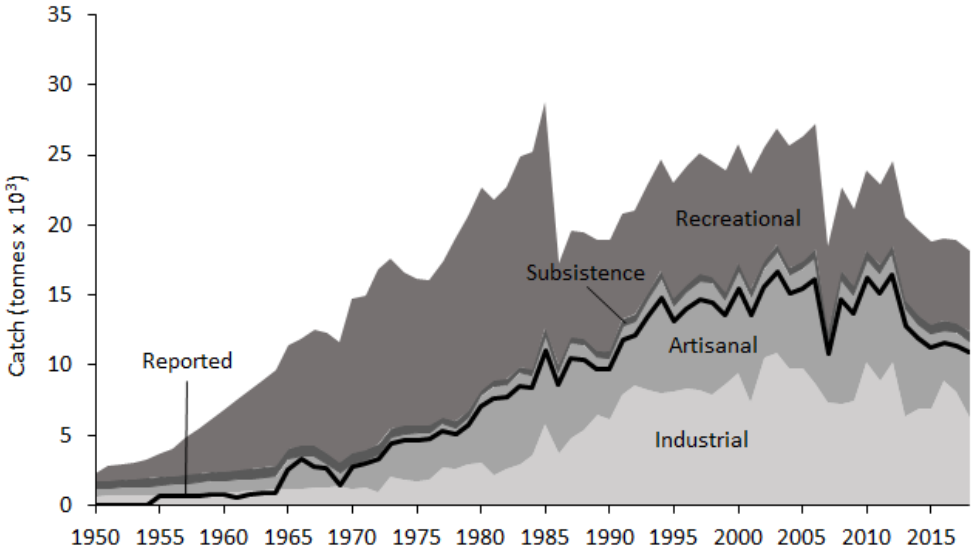

Figure 2. Reconstructed domestic catch within Bahamas' EEZ by fishing sector for 1950-2018.

Transition from 2017 to 2018

The catch reconstructed to 2017 (Figure 2) was carried forward to 2018 using the semi-automated procedures outlined in Noël (2020), based on FAO landings data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

The Bahamas have agreed to protect biodiversity through the international agreements of the Convention on Biological Diversity (Aichi) and the Ramsar Convention on Wetlands of International Importance (Marine Conservation Institute 2020). However, diametrically opposed to what is laid out in the United Nations Ramsar treaty signed by the commonwealth of the Bahamas in 1997, 50% of North Bimini has been experiencing coastal development such as a new port, wharf and golf courses (Fuentes 2019).

The Bahamas have 76 MPAs and two marine managed areas, which jointly cover 47,140 km² (Marine Conservation Institute 2020); this represents 7.5% of the EEZ of 628,026 km² (Smith and Zeller 2016a, 2016b).

"In the Bahamas, managers claim to employ community-based conservation techniques when implementing MPAs. In practice, these techniques vary and can range from some type of outreach or town meetings to participation in mapping areas, or employing local residents to survey, monitor, or enforce the MPA. Generally, participation focuses heavily on the inclusion of interested and affected parties such as resource

users. Just how relevant users are identified and integrated into the planning system remains a challenge and often open to much critique" (Wise 2014).

Bimini is an example of this challenge: "In 2000, the Bahamian Minister of Agriculture and Fisheries, recognizing the ecological and economic value of marine life, declared Bimini one of five highest-priority sites in the Bahamas for proposed Marine Protected Areas (MPA), with the goal of implementation by June 2001 (Gruber and Parks 2002; Wise 2014). However, at the time of this announcement no management plans were outlined or boundaries defined (Dahlgren 2002). A series of community meetings followed to discuss MPA boundaries, restrictions and management. Potential sites within Bimini were proposed based on a set of socioeconomic and ecological factors, including impact from displacement of fishing activities, community support in management and potential economic benefits (Dahlgren 2002). Ecological parameters included habitat diversity and the importance of the area for supporting local fisheries (Dahlgren 2002). In 2009, the North Bimini Marine Reserve was declared, however not gazetted by the government. In 2012, The Master Plan for the Bahamas Protected Area System assessed the network of MPAs in the Bahamas and determined that the country was drastically behind schedule on its commitment to protect 20% of biodiversity targets by 2020. Currently, less than 5% of marine turtle habitat is being protected (Dahlgren 2002; Wise 2014)" (Fuentes 2019).

Barbados

The first reconstruction of Barbados' marine fisheries catches for the years 1940 to 2000 was performed by Mohammed *et al.* (2003), and updated to 2010 by Mohammed *et al.* (2015, 2016). Here, we document an update to 2014, followed by a carry-forward to 2018. Minor retroactive changes were made to account for small differences between the FAO dataset released in 2014 and those of previous years (Figure 3).

Industrial landings of tunas and other highly migratory large pelagic species were not considered here because they are estimated in a separate study (Coulter *et al.* 2020). The percentage breakdowns by sector, gear type, and taxa were held constant at their 2010 levels. Similarly, unreported artisanal landings were calculated based on the average ratio of unreported artisanal landings to FAO 2014 data for 2006-2010. The taxonomic breakdown for unreported artisanal landings remained at 2010 ratios.

World Bank population data were used to update subsistence catches using the original methods (Mohammed *et al.* 2003). The per capita subsistence rate and ratio of the population participating in subsistence fishing were held constant at the 2010 level to calculate subsistence catches for 2011-2014.

Because of a calculation error in the earlier reconstruction, recreational landings for 1950-2014 were recalculated and updated. The number of international arrivals of tourists per year was obtained from the World Bank. To obtain the total recreational catch for 2011-2014, participation and catch rates were held constant at the 2010 level and multiplied by tourists arriving per year. The taxonomic breakdown of recreational taxa was held constant throughout the time series.

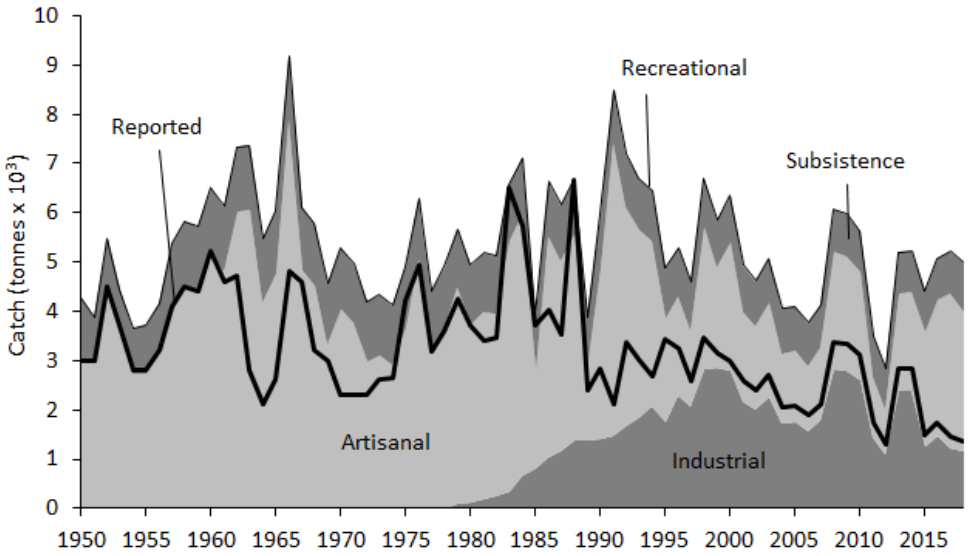

Figure 3. Reconstructed domestic catch within Barbados' EEZ by fishing sector for 1950-2018.

Since the previous reconstructions (Mohammed *et al.* 2003, 2015), the legally binding international accord to stop illegal fishing that Barbados signed in 2009 has come into effect (Anon. 2016). Under the Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (FAO 2016), Barbados will implement port state measures including requirements for vessels to provide information on catch and identification before requesting permission to access ports.

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 landings data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

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

Barbados has two MPAs and one marine managed area, which jointly cover 83 km² (Marine Conservation Institute 2020), i.e., 0.045% of and EEZ of 183,773 km² (Mohammed *et al.* 2016).

These two MPAs are the Carslisle Bay Marine Reserve and the Folkstone Marine Reserve. The bay is popular for activities such as diving, sailing and fishing. It is in an area whose protection was first proposed in 1993, when the dive operators' association started to experience degradation of the marine ecosystem. They counted with the support of the Coastal Zone Management Unit (Marine Conservation Institute 2020). The Folkstone Marine Reserve was designated in 1981 with 2 km² (Marine Conservation Institute 2020) and is currently managed by the National Conservation Commission (Coastal Zone Management Unit of Barbados 2020). It has four different zones: a Scientific Zone designated for marine research, a Northern and a Southern Water Sports Zone designated for fast speed watercraft use, as well as a Recreational Zone, including swimming, snorkeling and fishing (Coastal Zone Management Unit of Barbados 2020).

Economically speaking, tourism is a very important activity in Barbados with potential synergies for conservation efforts. For example, a study carried out in the Folkstone Marine Reserve, where visiting the park is free of charge, "demonstrate[d] that almost all (97%) visitors would be willing to pay a Folkestone Marine Reserve user fee. By combining data of the artificial and natural reef models, our results indicate overseas tourists would be prepared to pay an average of US$18 as a fee per visit, which could supplement reef conservation finance" (Smith *et al.* 2016).

The establishment of an environmental fund for marine and costal conservation for the entire island was also studied. Half of the tourists visiting Barbados expected to view underwater marine life during their visit, and most are willing to pay a fee to conserve these ecosystems. The mean willingness to pay ranged from US$36 to US$52 per visit (Schuhmann *et al.* 2019b). Again, this fee might provide benefits for conservation management, the benefits of which will eventually also spill over to broader local communities and the broader economy, as more tourists would decide to return to Barbados. "[These] decisions are sensitive to changes in all aspects of coastal and marine quality. A reduction in seawater quality discourages tourists' intention to return more than other environmental factors. These results are of paramount interest to destination managers, marketers and policymakers who rely on repeat visitation data to develop marketing strategies and infer future direction" (Schuhmann *et al.* 2019a).

British Virgin Islands (United Kingdom)

The marine fisheries of the British Virgin Islands (BVI) were originally reconstructed for 1950-2010 by Ramdeen *et al.* (2014, 2016); here, we detail an update to 2014, followed by a carry-forward to 2018. FAO data were used to update reported landings. Retroactive changes between different releases of the FAO data were assumed minor and not considered.

Although the British Virgin Islands have recently created many marine protected areas (MPAs), most allow fisheries to operate within them; therefore, local fisheries are not likely to have been greatly affected (Pascoe *et al.* 2013) nor will fishers benefit from stock rebuilding and increased resilience that no-take zones support. Small-scale artisanal fisheries are gaining increasing importance, and there is greater control over fisheries through the new Fisheries Advisory Committee[7].

FAO reported data for the longline fishery for the following taxa: common dolphinfish (*Coryphaena* spp.), swordfish (*Xiphias gladius*), tunas (Scombridae), wahoo (*Acanthocybium solandri*), yellowfin tuna (*Thunnus albacares*), marlins and sailfishes (Istiophoridae), and seerfishes (*Scomberomorus* spp.). Industrial landings of tunas and other billfishes were addressed separately in Coulter *et al.* (2020).

Discards were calculated as 10% of landings of the offshore longline fishery. The recreational fishery was reconstructed based on the 2010 catch rate by tourists and updated information on the number of tourists obtained from Caribbean tourism statistics[8]. Improved population data were used to update landings from the near shore fishery sector throughout the time series[9]. The number of fishers was recalculated with updated population information using the original methods. The sectoral split for the near-shore fishery in 2010 was carried forward to 2014. Landings for each sector were disaggregated for 2011-2014 using the taxonomic breakdown from 2010.

[7] http://bvinews.com/new/gray-traditional-fishermen-must-be-protected/
[8] http://www.onecaribbean.org/statistics/
[9] http://data.worldbank.org

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 landings data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine protection

The United Kingdom's government and the government of the British Virgin Islands have agreed to protect biodiversity through the international agreements of the Convention on Biological Diversity (Aichi) and the Ramsar Convention on Wetlands of International Importance. The territory is also a signatory to Natura 2000 (Marine Conservation Institute 2020). "The complexity of protected areas management has increased significantly in the past decade. This is particularly true of small Caribbean economies where development activities are either directly dependent on the natural resource base, or where those activities have significant long-term impact on environmental resources" (Gardner 2007).

In the British Virgin Islands' EEZ of 80,111 km^2 (Ramdeen *et al.* 2016), there are 14 MPAs, jointly covering 3 km^2 (UNEP-WCMC and IUCN 2020), i.e., less than 0.004% of the EEZ. All but one of these areas are fisheries protected areas (FPAs) managed by the Conservation and Fisheries Department. One area is designated as a marine park and managed by the National Parks Trust of the Virgin Islands (Gore *et al.* 2019). The levels of protection of these MPAs are divided into nine categories recognized by the National Parks Act (2006) and other categories that include Bird Sanctuaries (under the Wild Birds Protection Ordinance, Cap. 98), Forestry Areas and Water Areas (under the Protection of Trees and Conservation of Soil and Water Ordinance, Cap. 86) and Fisheries Protected Areas (under the Fisheries Act, 1997)" (Gardner 2007).

"The BVI's commitment in the Caribbean Challenge Initiative, a group of nine Caribbean Governments and Territories committed to designating at least 20% of their respective marine environment as protected by 2020 has yet to happen. The lapse of time since the System's Plan was approved to the current unknown state of the marine environment based on the lack of monitoring data now questions the validity of such protected areas to ensure reef resiliency, to climate change especially" (Gore *et al.* 2019). However, at least until 2007, the involvement of local communities in MPA management was limited and sporadic. "Yet, several institutions indicated (during the consultation process for the System Plan) a willingness and ability to participate more consistently and meaningfully" (Gardner 2007).

"The Beach Protection Ordinance (1985) protects beaches from dumping or removing any material from the foreshore, and the Virgin Islands Fisheries Regulations, 2003, protects nesting sea turtles, no other legislation fully protects coastal habitats. The provision to declare an area as "protected" exists through the Virgin Islands Planning Act of 2004 and the National Parks Act of 2017, but this has never been utilized, and critical habitats such as wetlands, mangroves, and beaches continue to remain unprotected" (Gore *et al.* 2019).

Cayman Island (United Kingdom)

The reconstruction of fisheries catches for the Cayman Islands was performed for 1950-2007 by Harper *et al.* (2009) and to 2010 by Harper *et al.* (2016). This original reconstruction was updated to 2014 using the unchanged FAO reported catches for 2000-2014; this was then carried forward to 2018.
Percentage breakdowns between sectors, catch types, and taxa from the original reconstruction have been maintained. A correction was made to the original data, whereby the catch of groupers (Serranidae) and snappers (Lutjanidae) taxa were recalculated to reflect the percent breakdown stated in the methods.

Recreational fishing continues to be a popular activity for tourists in the Cayman Islands, notably the annual April Cayman Islands International Fishing Tournament. One tourist sport fisher estimated more than 30 sport fishing boats during one day of the tournament. Their targets included dolphinfish (*Coryphaena hippurus*), wahoo (*Acanthocybium solandri*), blue marlin, (*Makaira nigricans*), swordfish (*Xiphias gladius*), and various tunas, and they reported a catch of 7 dolphinfish for one vessel in one day (Hendricks 2016).

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 landings data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

The United Kingdom and the Cayman Islands authorities have agreed to protect the biodiversity of the Cayman Islands through the international agreements of the Convention on Biological Diversity (Aichi) (Marine Conservation Institute 2020).

The Cayman Islands, which has an EEZ of 119,134 km² (Harper *et al.* 2016), has six MPAs, of which one is a shark sanctuary of 120,000 km² shared with adjacent Sint Marteen, and which is fully closed to commercial shark fishing (EnezGreen 2016; Marine Conservation Institute 2020). The Cayman island MPAs have the support of local fishers who reported that the areas closed to fishing improved catches in neighboring fishing grounds by up to 65% (Heney, 2018).

"In 1984, the comprehensive set of 'Marine Park Regulations and Marine Conservation Laws' (MPRMCL) were introduced to the Islands', which have since been efficiently enforced, prohibiting the majority of exploitive uses of marine resources. This has served to protect and manage the marine environment; thus, the Cayman Islands are seen to be some of the most pristine waters in the Caribbean. The lack of commercial fishing and the successful development of the MPRMCL's provide a unique opportunity to study the conservation potentials of MPA's for fishery and habitat management, as well as the effects of recreational and artisanal fishing on the marine environment. […] The five DOE [(Department of the Environment)] Enforcement Officers based on Grand Cayman appear to effectively enforce the MPRMCL's of the Cayman Islands. In comparison with the majority of MPA's worldwide, Caymanian waters benefit from some of the most effectively managed and enforced marine regulations. Patrols are conducted on a regular basis on both land and sea; officers all have their own boat which can access the marine environment at any of the slipways available around the Island, and each officer has access to a truck for land patrols" (Henshall 2009).

One of the main goals of the National Conservation Council Plan for Sea Turtles Long is to recover the sea turtles' populations had crashed by the early 1800s (Cayman Islands 2019). In contradiction with the plan's last paragraph, which mentions that Grand Cayman prohibits the majority of exploitive uses of marine resources, the council may grant licenses for traditional, legal fishing of sea turtles for consumption within the islands (Cayman Islands 2019).

Cuba

Cuba signed the legally binding UN Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (FAO 2016) to combat Illegal, Unreported, and Unregulated fishing (Anon. 2016). This agreement came into effect in June 2016 and will make it more difficult for IUU vessels to enter ports because of the requirements to request, permission for entry in advance and to provide information on catch and activities (FAO 2016).

The original reconstruction of Cuba's fisheries catches for 1950-1999 was performed by Baisre *et al.* (2003) and updated to 2010 by Au *et al.* (2014, 2016). Here, it is further updated to 2014, then carried forward to 2018.

Reported landings of *Coryphaena hippurus* were not estimated separately as stated in Au *et al.* (2014); therefore, these landings were added to the dataset for 1996-2012. Retroactive changes to reported landings of conch in 2007-2008 were detected between successive releases of the FAO data and were updated in the current dataset (Figure 4).

The ratio of offshore and inshore catches was determined for species with offshore catch components in 1999, and was held constant to 2014. The tonnage of discards and bycatch in 2011-2014 was calculated for shrimp landings as described in the initial reconstruction (Baisre *et al.* 2003). The 2010 taxonomic breakdown for bycatch was maintained for 2011-2014 and subtracted from reported landings of 'Marine fishes nei'. The remaining landings of 'Marine fishes nei' were disaggregated using the taxonomic breakdown of reported landings for 2011-2014. New information estimating pink shrimp (*Farfantepenaeus duorarum*) landings, provided by Garcés *et al.* (2012), supported this reconstruction's estimated catch of pink shrimp for 2003-2005.

To obtain estimates of the coastal population to 2014, updated World Bank estimates of the Cuban population were combined with the 2010 ratio of the total population assumed to be coastal. The decline in per capita consumption rate was extrapolated to 2014 and used to calculate subsistence catches for 2011-2014.

Updated information on tourist arrivals was obtained from the Cuban National Statistics Office for 2008-2014 (ONEI 2015). The recreational fishing participation rate of tourists and the recreational catch rate were assumed to remain constant at the 2010 levels for 2011-2014. The original taxonomic breakdowns for recreational and subsistence catches were maintained for 2011-2014.

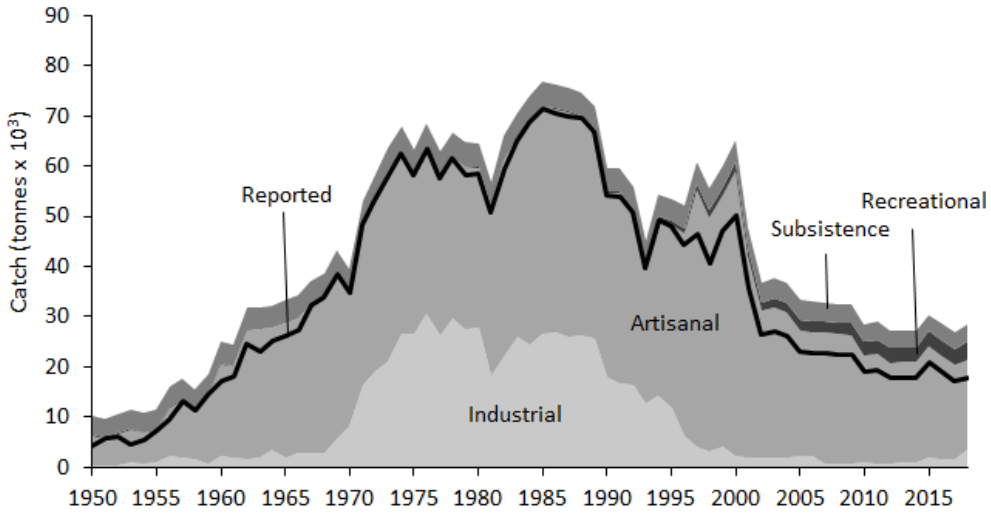

Figure 4. Reconstructed domestic Cuban catches in the Cuban EEZ by fishing sector for 1950-2018.

Cuba is working to find ways to provide better estimates of shark catches. In October 2015, Cuba and the United States agreed to collaborate on research and development of regulations to manage shark populations (Tollefson 2015). For example, a study by Aguilar *et al.* (2014) estimated that between 0.4 and 4.4 sharks were caught per ten artisanal fishing trips.

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 landings data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection
Cuba has agreed to protect its biodiversity through the international agreements of the Convention on Biological Diversity (Aichi), the United Nations Convention on the Law of the Sea, the Ramsar Convention on Wetlands of International Importance, the International Coral Reef Initiative and the World Heritage Convention. Cuba is a signatory to regional treaties and agreements such as the Regional Seas Convention. It is also part of the international network of UNESCO Man and the Biosphere (Marine Conservation Institute 2020).

Cuba has 110 MPAs and 12 marine managed areas, which jointly cover 13,521 km² (Marine Conservation Institute 2020), and protect 3.71% of the EEZ of 364,511 km² (Au *et al.* 2016). "In Cuba, marine protected areas (MPAs) are those protected areas that have a marine or coastal component; this includes coastal wetlands, the submerged coastal zone (mean high water line to a depth of 200 m), and offshore keys" (Estrada-Estrada *et al.* 2004).

"During the First National Protected Areas Workshop, held in 1989, a SNAP proposal was developed in a multiorganizational manner for the first time among experts from various national and provincial institutions. Initial discussions of marine areas occurred at this meeting [...]. The first group of MPAs was formally declared through Agreement 4262 in 2001 by the Executive Committee of the Council of Ministers (CECM)" (Estrada-Estrada *et al.* 2004).

"The Environment Defense Fund (EDF) has worked with the National System of Protected Areas of Cuba (SNAP) to strengthen the design and management of marine reserves. EDF supported SNAP and others in establishing two new marine reserves through a community-based project called SOS Pesca. This project brought together park rangers, scientists, fishermen and community members to collect baseline data and develop management plans for Ojo de Agua and Macurije-Santa María Wildlife Refuges" (Environment Defense Fund 2020).

The National Park of Jardines de la Reina was designated in 2010 with 2,000 km² of marine area and is now considered one of the treasures of the Caribbean. This Park has some 'Zones Under Special Regime of Use and Protection' located where tourism and conservation activities take place under strict regulations. However, in the south of the park, 'bonito" and lobster fishing with artisanal gear is still allowed (Marine Conservation Institute 2020), and illegal fishing and conflicts related to resource access are still a threat (Environment Defense Fund 2020). "In the Gardens of the Queen and other marine reserves, enforcement and compliance are important issues. For many countries, including Cuba, patrol boats are prohibitively expensive. But, with the right incentives, fishermen can help conserve the resource, and enforce the rules while improving their livelihoods at the same time" (Environment Defense Fund 2020).

Dominica
The original reconstruction of Dominica's marine fisheries catches was completed for 1950-2010 by Ramdeen *et al.* (2014, 2016); here, we update these data to 2014 based on FAO data and available national data (see Masters 2014), followed by a carry-forward to 2018 (Figure 5).

The calculated demand for seafood was updated for 2008-2014 using updated population information from the World Bank and updated numbers of stopover tourists[10]. The percentage of the total population that participated in fishing was assumed to have remained constant at the 2000 level. The average length of stay for tourists and the per capita consumption rate were assumed to have remained at the 2010 level, which permitted an approximate estimate of the tourist demand for seafood. Imported, exported, or locally produced aquaculture seafood for Dominica were not considered substantial and not included in the estimation of the seafood demand in 2011-2014.

The percentages of total demand for seafood attributed to artisanal and subsistence sectors were extrapolated forward to 2014. Landings of all taxa reported to FAO (except for the category 'Marine fishes nei') were assumed to originate with the artisanal fisheries. The 2010 taxonomic breakdown was used to disaggregate unreported landings of artisanal and subsistence fisheries and the reported landings of marine fishes not identified by artisanal and subsistence fisheries.

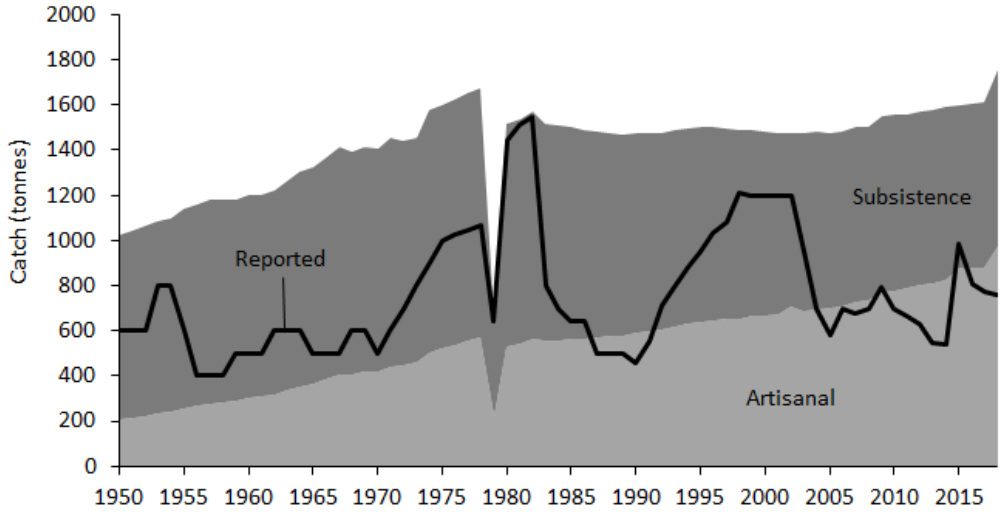

Figure 5. Reconstructed domestic catches within Dominica's EEZ by fishing sector for 1950-2018; the drop of catches in was due to Hurricane David (August/September 1979).

In recent years, Dominica signed the legally binding UN Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (FAO 2016). The agreement came into effect in June 2016 and requires vessels to request permission for entry into ports and to provide information to authorities on their catch and other activities (Anon. 2016).

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 landings data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

Dominica has agreed to protect its biodiversity through the international agreements of the Convention on Biological Diversity (Aichi) (Marine Conservation Institute 2020).

[10] www.onecaribbean.org/statistics/

Dominica has no marine managed areas but has three MPAs which jointly cover 35 km² (Marine Conservation Institute 2020), thus protecting about 0.1% of its EEZ of 28,593 km² (Ramdeen *et al.* 2016). These MPAs are the Cabrits National Park (designated in 1987), the Indian River National Park (designated in 1995) and the Soufrière/Scott's Head Marine Reserve (designated in 1998).

Dominica, the "Nature Island of the Caribbean", generates most of its foreign exchange through tourism (Patterson *et al.* 2004). "Due to geographical challenges and a desire for greater foreign investment, Dominica developed a strategy to increase cruise ship visitor numbers and ideally, their national economy. The cruise industry, however, has various detrimental impacts on the environment it depends on. It could be that these islands are cruising to destruction" (Moscovici 2017).

One of the most popular destinations for tourist is the Cabrits National Park, which suffers well-documented disturbances by visitors. One of the solutions to this is increasing funding for protected areas management through fees for visitors. However, the country needs to adjust these fees such as not to discourage the cruise lines from visiting Dominica (Moscovici 2017).

"[M]any social, economic, governance, and ecological results related to issues of limited access and Dominica's "Nature Island" brand. Community member access to the benefits of tourism was hindered by chiefly physical access issues on the island and enabled chiefly by interactive sectors and industries. Key factors identified that affect resilience positively include access to multiple sources of income and social structures that are independent of economic factors (e.g., income source) and support social equality. Factors identified that inhibit resilient systems include a 'hustle mindset', grant dependency, and long feedback loops" (Weis 2018).

Dominican Republic

The original reconstruction of the Dominican Republic's marine fisheries catches was completed for 1950-2010 by van der Meer *et al.* (2014, 2016); here, we briefly document an update to 2014, followed by a carry-forward to 2018, both relying heavily on FAO data. Retroactive changes between different releases of the FAO data were minor and were not considered in this update.

The landings reported by FAO for 2011-2014 were assigned to artisanal and industrial sectors based on the 2010 ratios by taxon. Reported artisanal landings were assumed to represent 60% of total artisanal landings for 2011-2014 as estimated by the original reconstruction (van der Meer *et al.* 2014).

Artisanal catches to meet the demand for seafood by tourists were updated to 2014 using the original methods (van der Meer *et al.* 2014). The number of stop-over tourists was updated for 2011-2014 with data from the Caribbean Tourism Organization[11]. The consumption rate of tourists and average length of stay per tourist were assumed to remain at the 2010 level for 2011-2014. The participation rate of tourists in recreational fishing and the recreational catch rate were assumed to remain constant for 2010-2014, which enabled the estimation of recreational catches. The catches of subsistence fisheries were updated for 2011-2014 using the same methods described for 2010.

Updated population data were obtained from the World Bank, and the percentage of population determined to be urban and coastal in 2010 was held constant for 2011-2014. The decline in rural and urban consumption rates was extrapolated to 2014 to calculate the total subsistence catch. The taxonomic breakdowns for each sector were maintained at the 2010 level for 2011-2014.

[11] www.onecaribbean.org

Qualitative data from fishers in Buen Hombre indicates a decline in the number and size of fish caught from the Dominican Republic's coral reefs (Wilson *et al.* 2016). Meanwhile, the number of fishers in Buen Hombre increased from 47 in 1985 to 90 in 2014 along with fishers' level of dependency on the reef to provide income and food (Wilson *et al.* 2016).

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 landings data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

The Dominican Republic has agreed to protect its biodiversity through the international agreements of the Convention on Biological Diversity (Aichi), the United Nations Convention on the Law of the Sea, the Ramsar Convention on Wetlands of International Importance, the International Coral Reef Initiative and the World Heritage Convention. The Dominican Republic is a signatory to regional treaties and agreements such as the Regional Seas Convention. It is also part of the international network of UNESCO Man and the Biosphere (Marine Conservation Institute 2020). It is a national priority to ensure a 'reasonable exploitation' and conservation of both living and non-living resources within marine areas (Constitute 2015).

Towards the conservation of marine areas, "notable success has been made through the establishment of the Ministry of Environment in 2000 under law 64-00 where dozens of other environmental rights and articles of legislation related to coastal and marine areas have been enacted. More specifically, Sectoral law 202-04 on protected areas, and Decree No. 571-09, strengthened protections and led to the creation of 34 new protected areas (including marine areas, wetlands, mangroves, dry forest, coastal lagoons) which were then added to the National System of Protected Areas (SINAP) (Reynoso 2011). These initiatives were followed by additional legal and institutional mechanisms for environmental protection, and environmental advocacy and consciousness began to grow throughout the country (USAID 2005)" (Eger and Doberstein 2019).

The Dominican Republic has 75 MPAs and three marine managed areas, which jointly cover 13,172 km^2 (Marine Conservation Institute 2020), i.e., almost 5% of the EEZ of 269,489 km^2 (van der Meer *et al.* 2016). However, the effectiveness of this protection is uncertain (Eger and Doberstein 2019). These MPAs are national parks, marine sanctuaries, and natural monuments, among others. Deficiencies in funding and resources affect management plans and ultimately effectiveness of MPAs. "In May of 2008, the government of The Dominican Republic, alongside leaders from other Caribbean nations committed to protecting nearly 20 percent of their marine and coastal habitat by 2020. With support from the Nature Conservancy the Caribbean Challenge was launched, a region-wide campaign to protect the health of the Caribbean's lands and waters" (Marine Conservation Institute 2020).

"[Various] part[s] of the MPA network in the SE Dominican Republic, have high coral cover, and favourable coral reef condition indicators. This study emphasizes on hot spots, promoting effective local management tools, preserving untouched and isolated reefs (Cayo Ratón), protecting exposed reefs (La Pared y Atlantic Princess), and reducing reef threats (Dominicus Reef, Peñón and Punta Cacón). Some of the Dominican Republic's SE MPAs have been established since 1975 and are enforced by local participation, through fishermen, divers, NGOs, businessmen and committed government authorities that have supported the resource management process for several years, exerting control and permanent surveillance in the area. Our findings indicate that local reef management should continue because the benefits of MPAs may increase with

efficient management" (Cortés-Useche *et al.* 2019). Nevertheless, some other studies stated that there is no proper integration of local communities in the management plans and that poverty among these communities remains despite tourism (Navarro 2019). "Lower to moderate levels of tourism development appeared beneficial, but as tourism development increased, perceptions of the community worsened. The results also confirmed that tourism contributes to environmental degradation, mainly due to contamination of rivers and coastlines, accumulation of waste, and over-exploitation of natural resources" (Navarro 2019).

A study assessing the turtle nesting stock in the Dominican Republic, found that the "two main nesting sites are within protected areas: the Jaragua National Park in the south-west, important for leatherback turtles (*Dermochelys coriacea*, mean of 126 nests per season), and Del Este National Park on Saona Island in the south-east, principally for hawksbill turtles (*Eretmochelys imbricate*, mean of 100 nests per season)" (Revuelta *et al.* 2012). However, even though this nesting activity occurs within MPAs, illegal activities such as theft of eggs, turtle poaching and meat consumption are still happening in those areas and in the rest of the country. Therefore, it is necessary that proper management of MPAs, together with efficient law enforcement, takes place to avoid further loss of marine turtles (Revuelta *et al.* 2012).

Grenada (and the Grenadines)

The reconstruction of marine fisheries catches for Grenada between 1950 and 2010 was completed by Mohammed and Lindop (2015, 2016); this account details how this reconstruction was updated to 2014, then carried forward to 2018, based mainly on FAO data.

The baseline of reported catches by Grenada within its Exclusive Economic Zone (EEZ) and around the Grenadines, was taken from the FAO's data reported on behalf of Grenada. These catches were split between the Grenada and the Grenadines according to the 2010 ratios per taxon. Reported catches were assigned to sectors and gear following the 2010 ratios for 2011-2014. Because the Grenadines extends outside Grenada's EEZ, all catch was categorized as part of the industrial sector, following the *Sea Around Us* convention for catch outside of a country's home EEZ. In reality, this fleet could be considered as semi-industrial.

The unreported artisanal and industrial catch within and outside Grenada's EEZ was calculated as a ratio of reported catch using the average ratio between 2006-2010 and applied to reported catch for 2011-2014. Recreational and subsistence catch for Grenada and the Grenadines were calculated from the 2010-2012 average percentage of reported catch and split between Grenada and the Grenadines and between taxa according to 2010 ratios.

Gear assignment

The assignment of catches to fishing gear types was based on Table 1 in Mohammed and Lindop (2015). Reef-associated fishes were considered caught using gillnets and driftnets. 'Miscellaneous marine fishes' were split 50/50 between gillnets/driftnets and purse seines.

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 landings data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

Grenada (and the Grenadines) has agreed to protect its biodiversity through the international agreements of the Convention on Biological Diversity (Aichi), the United Nations Convention on the Law of the Sea, the

Ramsar Convention on Wetlands of International Importance, the International Coral Reef Initiative and the World Heritage Convention. Grenada (and the Grenadines) is a signatory to regional treaties and agreements such as the Regional Seas Convention. Its commitments extend to NGOs and/or public bodies like the Caribbean MPA Network (Marine Conservation Institute 2020).

Grenada (and the Grenadines) has 37 MPAs and one marine managed area, which jointly cover 23,2 km^2 (Marine Conservation Institute 2020), i.e., less than 0.1% of the EEZ of 26,133 km^2 (Mohammed and Lindop 2016).

Multiple environmental threats occur in the waters in Grenada (and the Grenadines), including in its MPAs. In 2001, legislation for the Moliniere-Beausejour MPA was passed to protect threatened coral reefs. In 2009, permanent mooring buoys were deployed and fishing restrictions were enforced. Nonetheless, after implementation (2011-2012), a study showed "that algal cover on the reef had increased significantly both inside and outside the MPA. This algal increase along with some reduction in live hard coral cover suggests that protection measures have not yet impacted the benthic reef community. To date, no significant changes in the benthic or fish community have been recorded in the MPA" (Anderson *et al.* 2014).

Another example is the MPA of the Woburn Clarks Court Bay Marine Protected Area (WCCB, designated in 1999; Marine Conservation Institute 2020) in which levels of fecal coliforms exceeded the EPA level (Farmer *et al.* 2016). "[Moreover,] the watershed, discharge from the Clarke's Court Rum distillery and mangrove runoff were identified as the major sources of organic pollution in the WCCB MPA in accordance with correlation analysis of such parameters as Biochemical Oxygen Demand and most probable viable numbers of heterotrophic bacteria" (Farmer *et al.* 2016).

In a more recent study "conducted to assess knowledge and attitudes to climate change and coastal and marine ecosystems of residents in the westerly parishes of St. Mark and St. John in Grenada. The participants discussed their observations of major changes in the coastal and marine environments including considerable build-up of sediments along the shoreline due to the erosion of soil from inland, smaller volume of rivers, increased severity and frequency of flooding, larger deposition of sand in reefs, decline in the stock and variety of fishes, and erosion of coastal lands. The fishers were more knowledgeable about changes in the environment and advocated for the designation of marine protected areas (MPAs) to protect their trade" (Glasgow *et al.* 2018).

Guadeloupe (France)

The reconstruction of marine fisheries catches in the Exclusive Economic Zone (EEZ) of the French island of Guadeloupe was completed for 1950 to 2007 by Frotté *et al.* (2009), and updated to 2010 by Frotté *et al.* (2016). This account briefly documents how this initial reconstruction was updated to 2014, then carried forward to 2018, based mainly on FAO data.

Retroactive changes were detected between releases of the FAO data. Therefore, reported landings data were corrected from 2003-2014. Subsistence and recreational landings were updated for 1990-2010 (Figure 6) using population data from the French Statistics Institute (INSEE 2016). The per capita fishing rates of subsistence and recreational fishers were maintained from 2008 to 2014 and multiplied by annual population data from INSEE (2016).

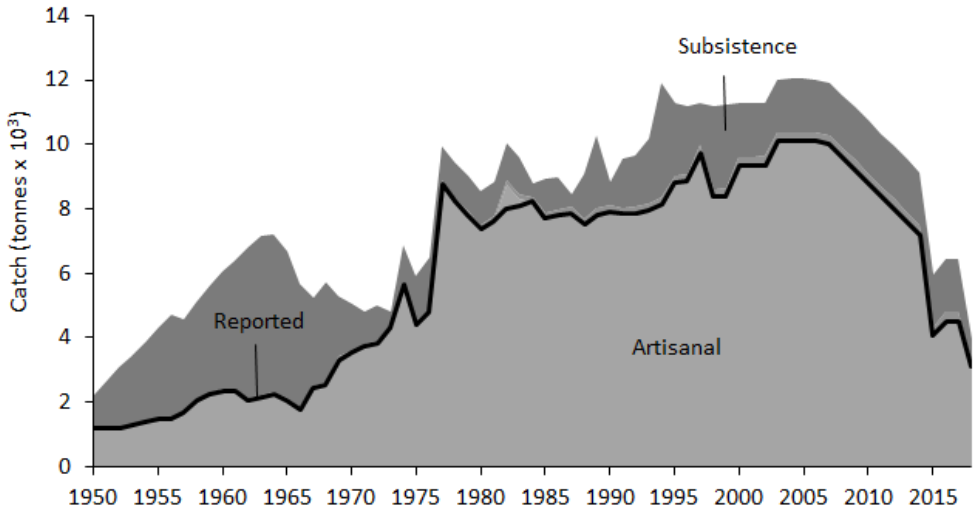

Figure 6. Reconstructed domestic catches within Guadeloupe by fishing sector for 1950-2018.

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 landings data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

France has agreed to protect the biodiversity of Guadeloupe, one of its overseas territories, through international agreements, i.e., the Convention on Biological Diversity (Aichi) and the Ramsar Convention on Wetlands of International Importance; it is also part of the international network of UNESCO Man and the Biosphere (Marine Conservation Institute 2020).

Guadeloupe has five MPAs (Marine Conservation Institute 2020) that jointly cover the entire EEZ (UNEP-WCMC and IUCN 2020) of 90,570 km² (Frotté *et al.* 2016). These MPAs include the UNESCO MAB Reserve of Archipel de la Guadeloupe designated in 1992 (Marine Conservation Institute 2020), which comprises the grand-Cul-de-Sac Marin, "a vast bay of 15,000 hectares between Basse-Terre and Grande-Terre. It includes coral reefs, mud flats, sea-grass bed and mangrove forests, freshwater swamps forests and marshes. In the lagoon, sea-floor 'meadows' provide habitat to turtles and teem with fish. Giant sponges and soft corals, urchins and fish are abundant. The mangroves host many sedentary and migratory birds (pelicans, terns, moorhens, ducks, herons and kingfishers). Parts of the biosphere reserve also comprise a Ramsar site, designated in 1993. The transition areas of the biosphere reserve include numerous small towns and villages with many tourist facilities" (UNESCO 2015).

Haiti and Navassa Island

The reconstruction of marine fisheries catches for Haiti's EEZ (including Navassa Island) from 1950-2010 was carried out by Ramdeen *et al.* (2012, 2016). This account documents the update of the original reconstruction to 2015 and its carry-forward to 2018, both based on data that FAO reported on behalf of Haiti.
According to the Ministry of Agriculture, Natural Resources and Rural Development (MARNDR), the 2010 earthquake damaged much of the agricultural infrastructure. Fisheries were not affected as much, with only a few ships being cut from their moorings or anchors (MARNDR 2010a). Thus, most of the assumptions by Ramdeen *et al.* (2012) were retained to update the reconstruction of the marine fisheries catches in Haiti's EEZ.

Catches assigned to the taxon "Marine fishes nei" in 2011-2015 were disaggregated following the 2010 ratios. All catches were considered part of the artisanal sector. Unreported artisanal catches were calculated for 2011-2015 by multiplying the 2010 catch-per-unit-effort (CPUE) of artisanal fishers by the number of fishers from 2011-2015 to estimate total artisanal catch, then subtracting the reported catch from this amount. The number of fishers for 2011-2014 was estimated using various sources (MARNDR 2010b; Felix 2012; Ramdeen *et al.* 2012; Anon. 2015). The number of fishers in 2015 was estimated by multiplying the percentage of the total population of fishers from 2014 by the total population in 2015 based on World Bank data. Unreported artisanal landings were disaggregated according to 2010 ratios.

The unreported subsistence catch was calculated for 2011-2015 by multiplying the per capita consumption rate of fish consumption with updated population information provided by the World Bank. The per capita consumption rate was extrapolated from 2011-2015 based on the 1950-2010 trend. Subsistence catch was disaggregated taxonomically for 2011-2015 as in 2010.

Finally, in the absence of updated information, catches from Navassa were held constant at the 2010 level for 2011-2015; see Miller *et al.* (2007) for what appears to be the latest account of the Haitian fishery around this island, which is firmly inside Haiti's EEZ but which the U.S. claims to control.

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 landings data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

Haiti has agreed to protect biodiversity through the international agreements of the Convention on Biological Diversity (Aichi) (Marine Conservation Institute 2020).

Haiti has 16 MPAs and eight marine managed areas. These areas jointly cover 2,379 km^2 (Marine Conservation Institute 2020), i.e., almost 2% of the EEZ of 123,525 km^2 (Ramdeen *et al.* 2016). Some of the first MPAs in these waters were the Trois Baies and Port Salut-Aquin, which were designated in 2013 and together equal approximately half of the total extent of MPAs in this country (Marine Conservation Institute 2020).

"Haiti is home to an incredibly diverse array of marine life, housed in mangrove forests and coastal reefs. It is also the poorest country in the Western Hemisphere, with 80 percent of the population living in poverty. Natural disasters, [humanitarian crises] and political instability have further hampered the nation's ability to create meaningful economic opportunities for its citizens. […] Driven by extreme poverty, many Haitians have resorted to overfishing. Others have turned to harvesting coral reefs, which also provide protection and shelter for fish, for construction material such as rocks and lime" (The Goldman Environmental Prize 2020).

Sustainable management and protection of marine resources is key for a country like Haiti, which has high levels of poverty and political instability. "Coastal children have a reduced likelihood of severe stunting in Haiti but have increased likelihoods of [general] stunting and reduced dietary diversity in the Dominican Republic. […] Proximity to fertile plains and marine resources could also explain better dietary diversity among children living in coastal areas in Haiti" (Temsah *et al.* 2018).

The uninhabited Navassa Island is located firmly within the Haitian territory and is claimed by the US, which administers it as a marine reserve through its Fish and Wildlife Service (see https://en.wikipedia.org/wiki/Navassa_Island). Haitian fishers operate around Navassa Island, and hence this account: "[u]nmanaged and unquantified artisanal fishing is ongoing at Navassa Island, a small oceanic island about 70 km west of Haiti that is part of the U.S. Caribbean Islands National Wildlife Refuge. Concern has been expressed regarding the possible impact of these fishing activities on reef resources, and no quantitative catch or effort data are available. However, informal qualitative observations made during a cruise in November 2002 suggest that escalation in fishing activity (and impact) has occurred since previous observations made in April 2000. Namely, size structure of fish was markedly reduced and the adoption of net fishing has allowed the exploitation of queen conch, *Strombus gigas*, and hawksbill turtles, *Eretmochelys imbricata*" (Miller *et al.* 2003).

Jamaica

The reconstruction of Jamaica's marine fisheries catches was completed for 1950-2010 by Lingard *et al.* (2012, 2016). This account details how this reconstruction was updated to 2017, then carried forward to 2018, based mainly on FAO data.

Retroactive data changes were detected between different releases of the FAO data, and reported landings were updated to match the 2017 FAO data release. The proportions of the FAO category 'Marine fishes nei' caught by Jamaican fisheries in each subregion were assigned based on the 2010 ratios and each area's taxonomic breakdown was carried forward unaltered for 2011-2017.

Landings of shrimp were reconstructed for 2010-2017 with anchor points in 2009 and 2011. An estimated 111 tonnes of shrimp were reported landed in Jamaica in 2009 by Waite *et al.* (2011) based on national data. An estimated 45 tonnes of shrimp were reported in national data in 2011 (Masters 2014). Landings for unreported shrimp was interpolated for 2009-2011 using these 2 reported data anchor points; the subsequent catch was held constant at 2011 levels until 2017.

Discards from artisanal fisheries were updated to 2017 using the original methods. The ratio of artisanal landings attributed to each gear type, and the discard rate of each gear type was held constant at 2010 ratios and rates.

No updated information was found for Jamaica's recreational fisheries. Therefore, the tonnage estimates for 2010 was held constant for 2011-2017. The taxonomic breakdown was held constant at 2010 levels.

Subsistence fishing

The catches of subsistence fisheries were updated for 2011-2017 using the original methods (Lingard *et al.* 2012). Updated import, export, and aquaculture data were available from FAO for 2011-2016, but not for 2017; therefore, it was assumed to have remained at 2016 levels. The rate of consumption was reported at 15.7 kg per capita per year in 2013, and 14.8 kg per capita per year for 2014 and 2015 (MOAF 2014, 2015a, 2015b). Using these anchor points, per capita consumption rate was interpolated for 2008-2013 and held constant at the 2015 level to 2017.

Human population estimates were updated from the World Bank to 2017. Using all the updated data, the total demand for fish and subsequently the total subsistence catches were estimated for 2010-2017 using the original methods. The taxonomic breakdown of subsistence catch was held constant for 2010-2017.

Transition from 2017 to 2018

The catch reconstructed to 2017 was carried forward to 2018 using the semi-automated procedures outlined in Noël (2020), based on FAO landings data to 2018. The catches estimated from this procedure will eventually be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

Jamaica has agreed to protect its biodiversity through the international agreements of the Convention on Biological Diversity (Aichi), the United Nations Convention on the Law of the Sea, the Ramsar Convention on Wetlands of International Importance, the International Coral Reef Initiative and the World Heritage Convention. Grenada (and the Grenadines) is a signatory to regional treaties and agreements such as the Regional Seas Convention. Its commitments extend to NGOs and/or public bodies such as the Caribbean MPA Network (Marine Conservation Institute 2020).

Jamaica has 44 MPAs and one marine managed area, which jointly cover 1,834 km^2 (Marine Conservation Institute 2020), i.e., 0.7% of the EEZ of 263,284 km^2 (Lingard *et al.* 2016). "There are no 'pristine spaces' in Jamaica (i.e., spaces devoid of anthropogenic forces). As such, 87% of protected areas on the island have become a conservation tool to encourage sustainable use (i.e., IUCN Category VI) (UNEP 2015)" (Chan 2017).

"In Jamaica, there are 19 types of protected areas (PAs), administered by five government agencies and three ministries. This system of PAs was first introduced by the National Environment & Planning Agency (NEPA) and the National Environmental Societies Trust in 1992 (NEPA 2004). [...] Despite arguments that the Jamaican protected area system may be too "peculiar" for adoption of international classifications (e.g., there are no baseline pristine habitats, precluding human use is rarely an option), NEPA recognizes that formally adopting the IUCN system could facilitate international support and funding (NEPA, 2004, p. 9)" (Chan 2017).

The challenges related with MPAs management in Jamaica are threefold: insufficient governance capacity, continuous, unresolved conflicts between actors as well as a lack of locals' compliance due to limited economic alternatives (Chan 2017). "User-supported funding policies, such as taxes and fees, which might sustain the operations of MPAs in Jamaica and the broader Caribbean region [are advised]" (Reid-Grant and Bhat 2009).

Martinique (France)

The catch data reconstruction of fisheries in Martinique from 1950 to 2007 was completed by Frotté *et al.* (2009) and updated to 2010 by Frotté *et al.* (2016). This account documents the update of the original reconstruction to 2014, and is then carried forward to 2018 based mainly on data that FAO made available on behalf of Martinique (Figure 7).

The reconstruction update from 2008-2010 (Frotté *et al.* 2016) was done using trend ratios from previous years. This was improved by taking FAO data and applying the methods from Frotté *et al.* (2009), as well as a broader taxonomic disaggregation from IFREMER data available for 2009 and 2010 (Reynal *et al.* 2011). The taxonomic disaggregation was done by distributing the catches reported as FAO "Marine fishes nei" category among IFREMER taxa that were not already represented in the FAO data. For 2008, 2011 and 2012, an average of the 2009 and 2010 ratios was used. For 2013 and 2014, taxonomic disaggregation of "Marine fishes nei" reported by the FAO data was done using more recent reports (Reynal *et al.* 2015; Reynal *et al.* 2016). The taxonomic breakdown of "Marine fishes nei" for 2012 was maintained for 2015-2018.

Unreported subsistence and recreational fisheries landings were estimated with the same method as in Frotté *et al.* (2009) and carried forward to 2014.

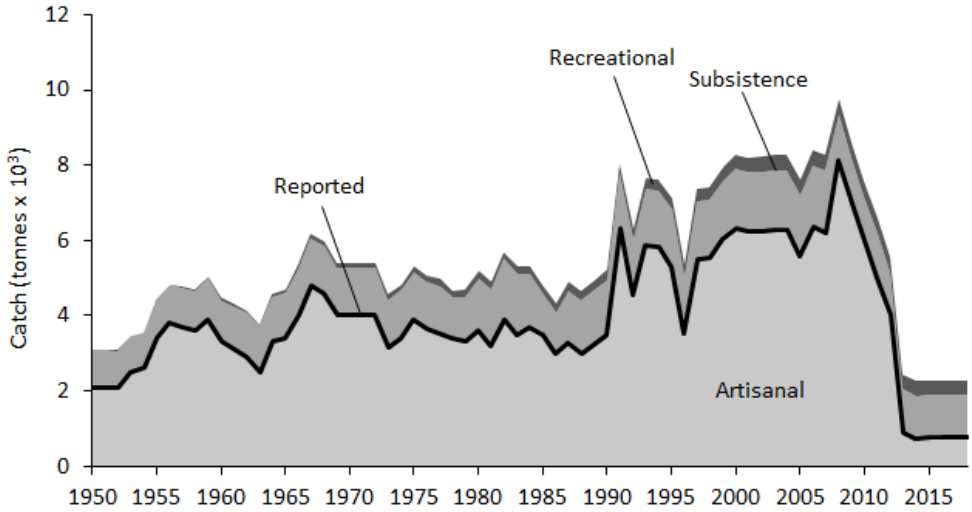

Figure 7. Reconstructed domestic catch for Martinique by fishing sector for 1950-2018.

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 landings data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

France and the local authorities have agreed to protect the biodiversity of Martinique, a French overseas territory, through the international agreements of the Convention on Biological Diversity (Aichi) (Marine Conservation Institute 2020). The island of Martinique has an important biological wealth, which contains, mangrove, seagrass, coral communities, rocky cliffs (resting and nesting seabirds) and beaches (nesting sea turtles) (Marine Conservation Institute 2020).

Martinique has four MPAs, including a Marine Natural Park designated in 2007 (Marine Conservation Institute 2020) covering the entire EEZ of 47,372 km² (Frotté *et al.* 2016; UNEP-WCMC and IUCN 2020).

The waters of Martinique and its neighboring areas suffer from the impact of invasive species such as the lion fish (*Pterois volitans* and *P. miles*). In the last years, "Martinique developed a strategy to control the population and launched numerous actions for controlling and fighting it: observation network, capture campaigns, promoting its consumption including the publishing of a recipe book. […] The 15 years of monitoring show a regressive evolution of the [local fish] populations which translated into a loss of diversity and coral cover in favor of algae" (IFRECOR 2017).

Montserrat (United Kingdom)

The original reconstruction of Montserrat's marine fisheries catches was completed for 1950-2010 by Ramdeen *et al.* (2012, 2016). This account documents the update of the original reconstruction to 2015 and its carry-forward to 2018, both based on FAO data. Retroactive data changes were detected between subsequent releases of the FAO data; thus, reported landings were updated for 1983-2003 with data from the FAO 2014 dataset (Figure 8). The FAO reported landings were compared with nationally reported landings from Masters (2014) for 2011-2014; this showed that it was reasonable to continue with the FAO data as baseline.

Total landings for local consumption were carried forward for 2011-2014 by assuming that the percentage of landings not reported remained at the 2010 level. Total landings for local consumption were disaggregated by sector based on the 2010 ratios. All artisanal landings for local consumption were assumed reported and the remaining reported landings were assigned to subsistence fisheries. The 2010 taxonomic breakdown for each sector was maintained for 2011-2014.

The number of stop-over tourists[12] was updated for 2011-2014 and used to calculate the demand for seafood by tourists based on the average serving size per day and average stay per tourist as estimated for 2010. The taxonomic breakdown of unreported artisanal landings caught for tourist consumption was held constant at the 2010 ratios for 2011-2014.

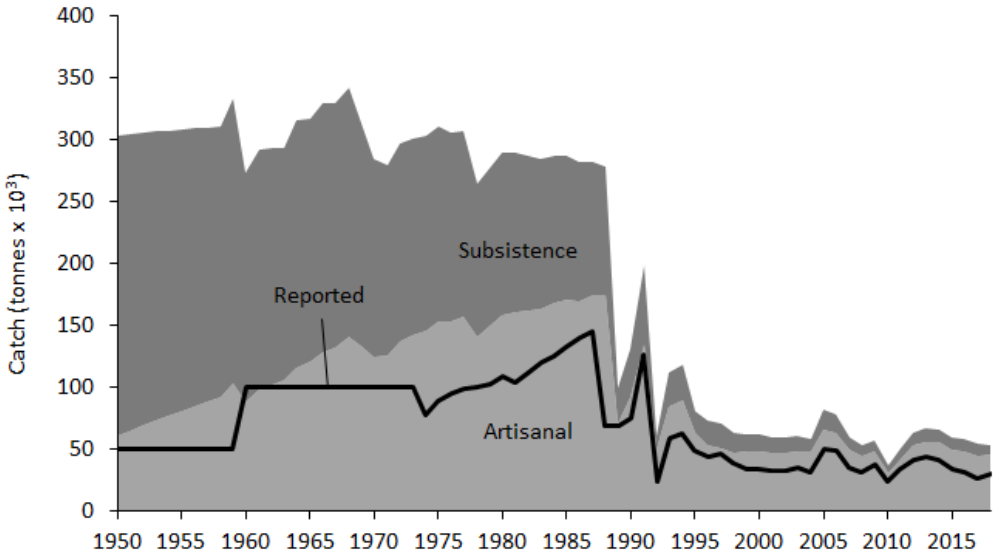

Figure 8. Reconstructed domestic catch by Montserrat by fishing sector for 1950-2018. The catch declined abruptly in 1989 due to Hurricane Hugo (Ramdeen *et al.* 2016).

Montserrat has made efforts to improve the management of its fisheries by adopting marine vessel monitoring systems (VMS) technology (Anon. 2014).

Transition from 2014 to 2018

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

Marine biodiversity protection

Montserrat has no MPAs (UNEP-WCMC and IUCN 2020) in its EEZ of 7,586 km² (Ramdeen *et al.* 2016), though efforts have been undertaken to protect some areas. As in many other islands of the Caribbean, small-scale fisheries and tourism are very common. The marine environment of Montserrat has been heavily impacted due to volcanic activity (Flower *et al.* 2020).

[12] http://www.onecaribbean.org/

Scientific review and analysis of data undertaken in 2015 lead to a Marine spatial Planning process in 2017 (Flower *et al.* 2020). "The Montserrat Reef Project, Coral Cay Conservation, the Waitt Institute, and the Blue Halo Initiative have all provided extensive data for baseline benthic habitat conditions, reef and commercial fisheries assessments, and community consultations. Support to the Montserrat government from these efforts point Montserrat in the right direction toward sustainable management of their marine resources" (Gore *et al.* 2019).

"Montserrat enacted the Conservation and Environmental Management Act (CEMA) of 2014 to address a wide range of environmental issues. The Act requires development of a national environmental management strategy and sets out a uniform enforcement and penalty structure for environmental offenses. The Act also provides substantive law governing biodiversity conservation and trade, protected areas, and pollution control. Additionally, CEMA recognizes close linkages between development, land use planning, and the environment, and it contains provisions to encourage collaboration between the Environment Department and the Physical Planning Unit for which the Physical Planning Act provides specific provisions for environmental protection. While the Beach Protection Act primarily provides protection against pollution along coastlines, the Montserrat National Trust manages protected lands such as the Woodlands Beach" (Gore *et al.* 2019).

Ex-Netherlands Antilles (Sint Maarten, Bonaire, Curaçao, Saba and Sint Eustacius)

Fisheries catch reconstructions for the various territories of the ex-Netherlands Antilles (see Wikipedia for its present composition) were completed from 1950-2010 by Lindop *et al.* (2015, 2016a, 2016b, 2016c, 2016d). This account documents the update of the original reconstructions to 2014, which was then carried forward to 2018, both based mainly on FAO data. Note, however, that this does not include Aruba, which was treated separately above.

The reconstructions of the ex-Netherlands Antilles consist of multiple, separate Exclusive Economic Zones (EEZ), including Bonaire, Curaçao, Saba & Sint Eustatius and Sint Maarten. For 1950 to 2010, FAO reported the 'Netherlands Antilles' as a single fishing entity and thus as a single record. After 2010, FAO began reporting for Bonaire and Saba & Sint Eustatius as one fishing entity, and Curaçao and Sint Maarten as separate entities. The disaggregation of landings reported as Bonaire, Saba and Sint Eustatius for the 2011-2014 period followed the original methods, using 2011 population data to disaggregate catch by EEZ. FAO's unspecified fish category (Marine fishes nei) comprised most of the reported landings from the ex-Netherlands Antilles.

Retroactive data changes were detected between different releases of FAO data, and landings were updated throughout the time series to match data in the most recent FAO data release. Unreported landings were updated to ensure that the total reconstructed landings for each sector remained unchanged. In this iteration of the data, landings of conch (*Lobatus gigas*) have been reconstructed separately for 1950-2014. Conch landings were estimated for Curaçao based on the demand for domestic consumption.

Bonaire's portion of FAO reported data for 'Marine fishes nei' was allocated 100% to the artisanal sector and was disaggregated into reef, pelagic, baitfish and lobster fisheries, with 19 separate taxa using the 2010 ratios for 2011-2014. The unreported subsistence catch for Bonaire was calculated based on the portion of fish taken home by artisanal fishers in 2010 (Lindop *et al.* 2015). The recreational catch was reconstructed based on

updated population[13] and tourist[14] numbers for 2011-2014. The catch was disaggregated equally across 11 different taxa using the 2010 catch composition.

The reported category of 'Marine fishes nei' for Curaçao was allocated to artisanal and subsistence catches by calculating the subsistence catch using the same methods as Lindop *et al.* (2015), then subtracting subsistence from the total reported catch to get the artisanal amount. Note that all artisanal and subsistence catches were reported from 2010-2014. The only unreported catch in Curaçao was the recreational sector, which was calculated for 2011-2014 using the same methods as Lindop *et al.* (2015).

Since this update was completed, a study by Vermeij (2019) was released that compiled information on artisanal fishing practices and the effect on species composition and catch size for Curaçao between 1905-2016. This information will be reviewed and included in future updates.

For Saba, Sint Eustatius and Sint Maarten, the FAO reported catch of 'Marine fishes nei' was split into three fisheries: 'Lobster', 'Lobster bycatch,' and 'Redfish'. Saba's portion of the reported 'Marine fishes nei' category catch was assigned to the artisanal sector and disaggregated into 13 different taxa following the same ratios as in 2010. The total reconstructed catch for 'Lobster', 'Lobster bycatch,' and 'Redfish' fisheries remained constant from 2007; this amount was extended to 2014. The reported amount was subtracted from the total reconstructed amount for each fishery; the remainder was considered unreported and disaggregated by fishing sector and taxa using the same ratios as for 2010. Updated population numbers[15] for Saba were multiplied by the 2010 catch rate to update the recreational catch to 2014, which was then disaggregated into taxa using the same ratios as in 2010.

The reconstructed amount of lobster and redfish caught in Sint Eustatius was slightly higher than the total FAO reported landings in 2011 and 2012; in these cases, the excess catch was considered unreported. In 2013 and 2014, the reported landings were higher than the estimated amount so we accepted FAO's total unaltered.

Sint Maarten's reconstructed catch in 2011-2014 was much lower than FAO's reported landings of 'Marine fishes nei'. As a result, the excess catch reported to the FAO for Sint Maarten's was allocated in part to Saba's EEZ, and the remainder outside of the EEZ was reported as industrial catch following *Sea Around Us* convention (Zeller *et al.* 2016). FAO retroactively changed the amount of 'Marine fishes nei' from 180 tonnes to 240 tonnes for the years 2011-2014, and this has been corrected in this 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 landings data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

The Ex-Netherland Antilles (Sint Maarten, Bonaire, Curaçao, Saba and Sint Eustacius) have agreed to protect their biodiversity mainly through the Convention on Biological Diversity (Aichi) (Marine Conservation Institute 2020). In 2005, the Dutch Caribbean Nature Alliance (DCNA, a regional network of protected areas)

[13] http://statline.cbs.nl/Statweb/publication/?DM=SLEN&PA=80539eng&D1=0-1,9-11&D2=1&D3=0-1,3-4,7-8&LA=EN&VW=T
[14] https://www.cbs.nl/en-gb/background/2015/14/tourism-in-the-caribbean-netherlands-in-2014
[15] https://www.cbs.nl/en-gb/news/2016/29/population-caribbean-netherlands-stable

was established on St Maarten, aiming to safeguard nature in the Dutch Caribbean and ensure sustainable management of natural resources (MacRae and De Meyer 2020).

The Ex-Netherland Antilles have six MPAs, where activities such as fishing, snorkeling and diving are restricted (MacRae and De Meyer 2020). Together, these areas cover 25,167 km² (UNEP-WCMC and IUCN 2020a, 2020b, 2020c), which represents 45% of their collective EEZ of 55,792 km² (Lindop *et al.* 2016a, 2016b, 2016c, 2016d). "[However,] the lack of reliable and adequate structural funding to support conservation management is one of the main challenges facing conservation managers in the Dutch Caribbean. This is compounded by the fact that the Dutch Caribbean islands are part of the Kingdom of the Netherlands and are therefore ineligible for grants from donors such as the World Bank, USAid and other bilateral funding organizations, whilst within The Netherlands many conservation funds are only available to organizations based in the European part of the Kingdom" (MacRae and De Meyer 2020). Coral reefs can generate high economic returns from recreational activities like in Bonaire. User fee systems could generate income but must be properly established (Alban *et al.* 2006).

"The islands are a hotspot for biodiversity, which includes globally threatened and endangered ecosystems and species from primary rainforest and dry forests to coral reefs, seagrass beds and mangrove forests. [...] The first protected area in the Dutch Caribbean, the Washington-Slagbaai National Park, was established on Bonaire on 9th May 1969. This was followed by the creation of the Christoffel Park on Curaçao in 1978 and the first Marine Protected Area (MPA) in the Dutch Caribbean, the Bonaire National Marine Park in 1979. [...] In 2010 St Maarten designated the Man of War Shoals Marine Park at the same time as the establishment of the Saba Bank National Marine Park" (MacRae and De Meyer 2020).

Puerto Rico (USA)

The original reconstruction of domestic marine fisheries catches in Puerto Rican waters was completed for 1950 to 2010 by Appeldoorn *et al.* (2015, 2016). This account documents the updating of the original reconstruction to 2014, and the carry forward to 2018, both based mainly on data FAO made available on behalf of Puerto Rico.

Appeldoorn *et al.* (2015) initially assigned a set portion of the catch reported by the FAO to the artisanal sector, while the remaining portion of FAO catches was 'filled out' by accounting for a reported part of the reconstructed recreational and subsistence catch calculated for Puerto Rico. For 2011-2013, the component of reported data assigned to the recreational catch data was calculated as the remainder after accounting for reported artisanal and baitfish landings, assuming 1,125 tonnes of artisanal catch for 2011-2013.

For 2014, the total catch reported by the FAO is less than the 1,125 tonnes of catch assigned to the reported artisanal sector for 2010-2013. Thus, all FAO reported catch was assigned to the artisanal sector and taxonomically split according to the 2010 taxon composition. Commercial catches and baitfish catch by Puerto Rico within its domestic waters are assigned 100% to the artisanal sector for 2014.

Reconstructed subsistence catches were calculated as 4% of reported commercial catches for 2011-2014. The 2010 subsistence taxonomic breakdown was maintained for 2011-2014.

Data for total recreational catches in Puerto Rico were obtained from the Marine Recreational Information Program (MRIP) of the US National Oceanic and Atmospheric Administration (NOAA) for 2011-2014. Because of improved sampling methods, NOAA replaced The US Marine Recreational Fisheries Statistics Survey (MRFSS) with MRIP in 2013; therefore, MRIP data was used for 2011 onward. Unreported

recreational catch was calculated by subtracting the portion assigned to reported landings from the total reconstructed recreational catch per year.

Baitfish catches were estimated at a rate of 5.65% of commercial catch, excluding discarded bycatch, for 2011-2014. Unreported baitfish was equal to the remaining reconstructed baitfish catch after accounting for the reported baitfish catch.

Discards were calculated as 0.7% of reported commercial catches for 2011-2014, based on the 2010 ratio. All these reconstructed data were taxonomically assigned as in 2011-2014 for their respective sectors.

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 landings data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

As an unincorporated territory of United States of America, Puerto Rico has agreed to protect its biodiversity through the international agreements of the Ramsar Convention on Wetlands of International Importance, the International Coral Reef Initiative, the World Heritage Convention. It is also part of the international network of UNESCO Man and the Biosphere. The United States of America are a signatory to regional treaties and agreements, such as the Regional Seas Convention. Its commitments extend to NGOs and/or public bodies like the Caribbean MPA Network and the North American MPA Network (Marine Conservation Institute 2020).

Puerto Rico's MPAs and marine managed areas (such as the three areas in the Red Hind Spawning Aggregation Areas West of Puerto Rico, which protects *Epinephelus guttatus*) jointly cover 3,195 km^2 (UNEP-WCMC and IUCN 2020), i.e., 1.8% of the EEZ of 177,327 km^2 (Appeldoorn *et al.* 2016).

Some of the threats to MPAs are urbanization and coastal developments. Other threats are due to terrigenous pollution affecting the health of coral reefs. In the bay of Guanica (Southwestern of Puerto Rico), "unusually high concentrations of total chlordane, total PCBs, nickel and chromium [have been found]. A variety of other contaminants (total DDT, total PAHs, As, Cu, Hg, and Zn) were also at levels which may indicate sediment toxicity" (Whitall *et al.* 2014).

One might think that this would benefit MPAs in Puerto Rico, a country where the population has been decreasing since the beginning of the 21st century. However, a recent study revealed "that the number of houses around protected areas continued to increase, while population declined both around protected areas and island-wide. A total of 32,300 new houses were constructed within only 1 km from protected areas, while population declined by 28,868 within the same area. At the same time, 90% of protected areas showed increases in housing in the surrounding lands, 47% showed population declines, and 40% showed population increases, revealing strong spatial variations. Our results highlight that residential development remains an important component of lands surrounding protected areas in Puerto Rico, but the spatial variations in population and housing changes indicate that management actions in response to housing effects may need to be individually targeted" (Castro-Prieto *et al.* 2017).

Saint Barthélémy (France)

A tentative reconstruction of the marine fisheries catches of Saint Barthélémy for 1950-2010 was presented by Bultel *et al.* (2015, 2016). This account documents the update of the original reconstruction to 2014, which is then carried forward to 2018.

As noted in Bultel *et al.* (2015), consistent statistics on the fisheries of Saint Barthélémy are missing. However, for Saint Barthélémy, the FAO reported data in 2007-2014, which increased from 50 tonnes per year until 2010 in previous FAO versions to 100 tonnes per year in 2007 and beyond in recent FAO statistics. In the absence of data to evaluate this change, this was tentatively accepted as the new baseline to 2014, including for the calculation of discards by the artisanal fishery. We have thus recalculated artisanal and subsistence catches from 1950-2010 to reflect the updated proportion of Guadeloupe's reported catch that is likely attributed to Saint Barthélémy using the original methods of Bultel *et al.* (2015) with updated FAO statistics (Figure 9).

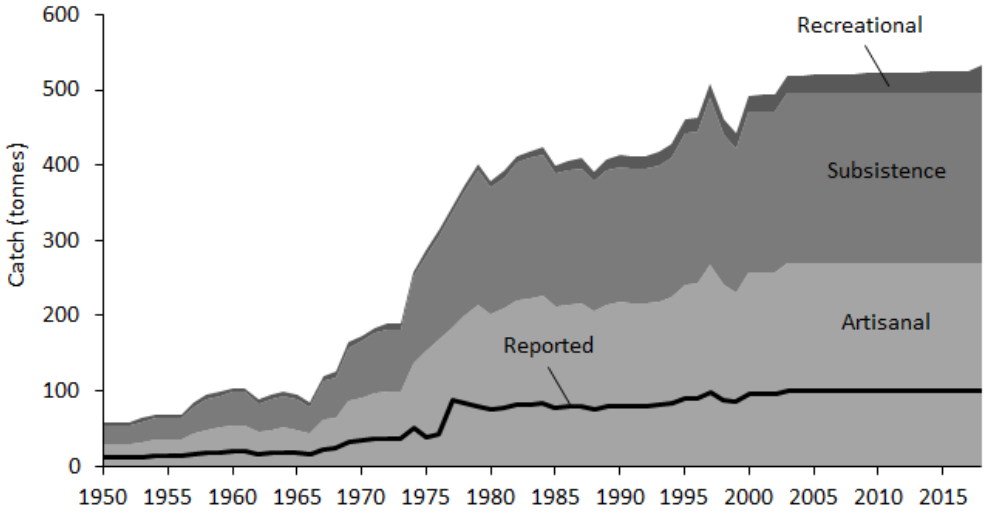

Figure 9. Reconstructed domestic catch for Saint Barthélémy by fishing sector for 1950-2018.

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 landings data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

France and the local authorities of Saint Barthélémy have agreed to protect the biodiversity of this French overseas territory through of the Convention on Biological Diversity (Aichi) (Marine Conservation Institute 2020).

Saint Barthélémy has five implemented MPAs, which jointly cover 16 km² (Marine Conservation Institute 2020), i.e., about 0.5% of the EEZ of 4,295 km² (Bultel *et al.* 2016). However, all these MPAs have a low protection status (Marine Conservation Institute 2020).

The largest MPA in these waters is the Saint-Barthélemy nature reserve, which was created in 1996 and currently covers 11 km² (Marine Conservation Institute 2020). It is divided into five zones: Colombier – Petite

Anse, Ilet Tortue-Les trois anses (Marigot, Grand et Petit Cul-de-Sac), Gros Ilets-Pain de sucre, Ilet Fourchue and Ilets Frégate et Toc-Vers (Journal Officiel de la République Française 1996). "The Nature Reserve of Saint-Barthélemy is exclusively marine and includes two major types of ecosystems: seagrass beds of marine phanerogams and coral formations. These coastal ecosystems constitute privileged habitats for many marine species; they are, moreover, at the base of many ecosystem services, and many economic and social activities" (Vaslet and ATE 2018).

"To understand the functioning and evolution of sensitive ecosystems but also to assess the effectiveness of the measures taken [within Saint-Barthélémy nature reserve], data is collected and analyzed each year. The ATE [Agence Territoriale de l'Environnement)] works in collaboration with recognized scientists and consultancies to monitor changes in the health of ecosystems" (Agence Territoriale de l'Environnement 2018).

"The Territorial Environment Agency is a public industrial and commercial establishment. Created in 2013, it notably takes over all the missions of the GRENAT association, including the management of the Nature Reserve. It is administered by a Board of Directors of twelve members comprising: six representatives of the Territorial Council appointed from among its members, two representatives of environmental protection associations, a staff representative, three qualified individuals appointed by deliberation of the Territorial Council" (Agence Territoriale de l'Environnement 2018).

Saint Kitts & Nevis

The reconstruction of Saint Kitts and Nevis' marine fisheries catches was completed for 1950-2010 by Ramdeen *et al.* (2013, 2016). This account documents the updating of the original reconstruction to 2014, which is then carried forward to 2018. Both based mainly on data FAO made available on behalf of Saint Kitts & Nevis (Figure 10).

In the most recent FAO dataset, the category 'Stromboid conchs nei' was retroactively changed so that landings accounted for the conch shell as part of live weight tonnage as opposed to conch meat, as previously reported (FAO 2016b). Because Ramdeen *et al.* (2013) calculated landings based on the demand for conch meat, their catch was not expressed in live weight. Here, catches of conch meat were corrected to live weight using a conversion factor of 7.5 (FAO 2016b).

The demand for fish, lobsters, and conch by the local population was updated for 2011-2014 using the original methods. It was assumed that the consumption rate did not change from 2010-2014 and that the percentages of the calculated total demand attributed to subsistence and artisanal fishing remained the same as in 2010. The calculated demand from the artisanal sector was first compared to reported landings. If reported landings were greater than the calculated artisanal demand, the remaining reported landings were assumed to originate from the subsistence sector. If reported landings were less than the calculated demand, the remaining catch was considered unreported. Unreported fish landings from artisanal and subsistence fisheries were disaggregated into taxa based on the 2010 ratio for each sector.

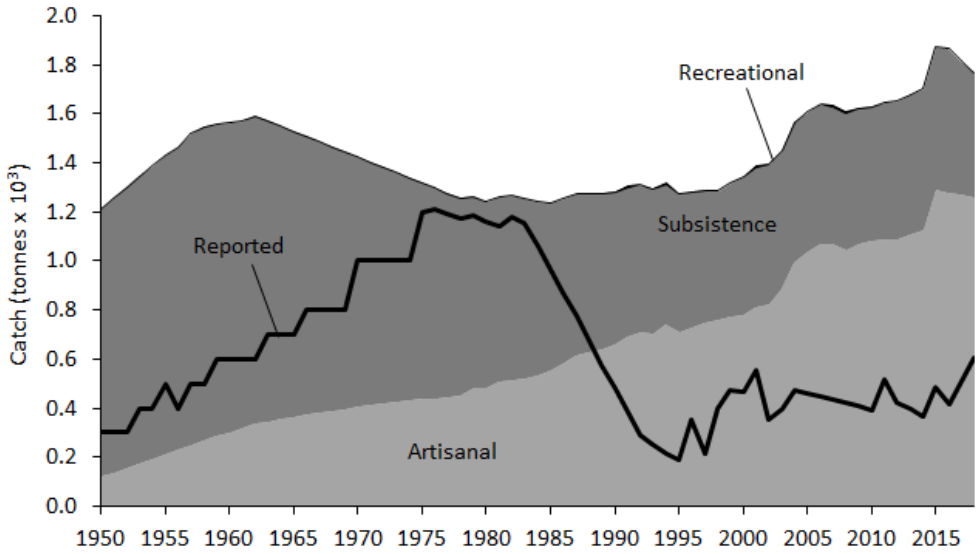

Figure 10. Reconstructed domestic catch within Saint Kitts and Nevis' EEZ by fishing sector for 1950-2018.

The demand for fish from tourists and the recreational catch by tourists fishing in Saint Kitts and Nevis were updated for 2011-2014 using the same methods as described in the original report. The number of tourists was updated for 2012-2014 using updated data from the Caribbean Tourism Organization[16] and interpolated for 2011. The catch rate and participation rate of tourists recreational fishing, the length of visit, and serving size consumed by each tourist per day were assumed to be the same as in 2010 for 2011-2014. The 2010 taxonomic breakdowns for recreational landings and artisanal landings taken to meet tourist demand were used for 2011-2014.

In response to the European Union assigning it a 'yellow card' in 2014 because of IUU activities by distant water fleets flying the Saint Kitts and Nevis flag (a flag of convenience), Saint Kitts and Nevis has taken measures against illegal fishing by becoming a party to the Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (PSMA) which came into effect in June 2016 (Anon. 2015, 2016). Under this agreement, Saint Kitts and Nevis will implement measures that require foreign fishing vessels to request advance permission to enter ports and report on their activities (FAO 2016a). The distant water activities of vessels from Saint Kitts and Nevis' are not addressed in this reconstruction.

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 landings data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

Saint Kitts & Nevis has agreed to protect its biodiversity through the international agreements of the Convention on Biological Diversity (Aichi) (Marine Conservation Institute 2020).

[16] http://www.onecaribbean.org/statistics/2003-july-2015-tourism-stats/ [Accessed: August 2016]

Saint Kitts & Nevis has 12 MPAs and one marine managed area, which jointly cover 6 km² (Marine Conservation Institute 2020), i.e., 0.06% of the EEZ of 10,210 km² (Ramdeen *et al.* 2016).

"Historically, sea turtles in St. Kitts have been perceived as an agricultural resource available for consumption. A sea turtle harvest still exists in St. Kitts during which sea turtles can be legally captured and consumed, as long as the capture falls within the outlined harvest season (Fisheries Regulations 2002). This perception is not unique to St. Kitts, as 21% (9/43) of Caribbean nations still have a legal harvest" (Stewart *et al.* 2018). "In St. Kitts, three different sea turtle species are found year-round, either as residents of the marine environment (hawksbill, *Eretmochelys imbricata* and green turtles, *Chelonia mydas*), or as seasonal nesters (leatherback, *Dermochelys coriacea*), hawksbill and greens. Because of these increasing interactions, there is budding research interest in the zoonotic pathogens associated with turtles that utilize the near-shore waters and beaches of St. Kitts" (Ives *et al.* 2017).

"The St. Kitts Sea Turtle Monitoring Network has implemented a number of conservation education programs. The primary conservation education program has been an annual Sea Turtle Camp Program that was developed and initiated in 2007 with the goal of engaging and educating youth in the conservation of sea turtle species" (Stewart *et al.* 2018). An interview assessment of the performance of these programs showed that participants increased their knowledge in certain aspects of turtle conservation biology and history. Some of the comments and conclusions by the participants were: "I now pick up trash off the beach"; "I am eager to tell others about turtles"; "I am now aware of the importance of the living creatures that live in the sea and the coral reefs"; "When I go to the beach I don't litter anymore and I tell people don't litter too"; "It had a huge effect on the way I saw the marine world"; "Yes, because now I know that I should be cautious of how and where to walk when I'm on the beach because there can be nest"; "I know what can happen to sea turtles"; and "I know the different types of sea turtles" (Stewart *et al.* 2018).

Saint Lucia

The reconstruction of marine fisheries catches in Saint Lucia was completed for 1950 to 2010 by Mohammed and Lindop (2015, 2016). This account documents the update of the original reconstructions to 2014, which is then carried forward to 2018.

FAO's 'Marine fishes nei' taxonomic category catches were disaggregated according to the taxonomic breakdown in 2010, and catches of each taxon were assigned to artisanal, industrial, and subsistence sectors according to 2010 ratio.

Recreational landings were reconstructed for 2011-2014 using the rate of recreational catch per fisher in 2010 multiplied by the number of tourist fishers for 2011-2014. The number of tourists fishing was determined by multiplying the total tourist arrivals from the World Bank by the participation rate determined by Mohammed and Lindop (2015).

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 landings data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

Saint Lucia has agreed to protect its biodiversity through the international agreements of the Convention on Biological Diversity (Aichi), the Ramsar Convention on Wetlands of International Importance and the World Heritage Convention (Marine Conservation Institute 2020).

Saint Lucia has 39 MPAs and two marine managed areas, which jointly cover 37 km² (Marine Conservation Institute 2020); this is equal to about 0.2% of the EEZ of 15,472 km² (Mohammed and Lindop 2016).

The Pitons Management Area is the only World Heritage Site in Saint Lucia's waters. It was designated in 2004 (Marine Conservation Institute 2020) with a total extent of 29 km² from which only 0.8 km² are in the sea (Claudino-Sales 2019). "In 1986, most of the reef system fringing Gros Piton was declared a marine reserve. In 1994, the Soufriere Marine Management Area was established. In 2002, the Pitons Management Area was created. [...] Terrestrial Conservation Areas are administered by the Ministry of Physical Development and Housing with the Forestry Department, and Marine Areas are administered by the Soufriere Marine Management Area under the Department of Fisheries (UNEP/WCMC 2011). [...] A large part of the site is in private hands and risks being approved for luxury development. Despite the Integrated Development Plan and specific guidelines, the designation seems to have accelerated the sale of plots for resorts and multiple homes on the almost pristine and visually sensitive land between the Pitons (UNESCO WHC 2017)" (Claudino-Sales 2019).

A survey carried out in different MPAs of Saint Lucia 10 to 16 years after the MPAs were created revealed that terrestrial sediment is a real threat because it accelerates the degradation of coral reefs. The study suggests that the MPA network existing in the country should be complemented by measures to reduce terrestrial runoff (Bégin *et al.* 2016). "Reducing sediment loads on the coral reefs of Saint Lucia will require the co-operation of agencies responsible for land and marine jurisdictions. Such initiatives towards integrated planning were recently outlined by the government of Saint Lucia, but the project did not proceed due to a lack of political will, financial support, and backing from key institutions (Tulsie, 2006)" (Bégin *et al.* 2016).

Saint Martin (France)

The catch reconstruction of fisheries in Saint Martin from 1950 to 2010 was performed by Bultel *et al.* (2015, 2016). This brief account documents the update of the original reconstructions to 2014, which is then carried forward to 2018.

As noted in Bultel *et al.* (2015), statistics on the fisheries of Saint Martin are lacking, and no new information appears to have been generated about this fishery.

However, the FAO catch data for the neighboring French entity Saint Barthélémy from 2007 to 2010 suggested there was a steady 200 tonnes per year in earlier versions of FAO data, but that number dropped to 90 tonnes per year from 2007 onwards in more recent FAO statistics. In the absence of any other information, 90 tonnes was also accepted as the new baseline for Saint Martin. We have thus recalculated artisanal and subsistence catches from 1950-2010 to reflect the updated proportion of Guadeloupe's reported catch that is likely attributed to Saint Martin using the original methods of Bultel *et al.* (2015) with updated FAO statistics (Figure 11). The methods and assumption of Bultel *et al.* (2015) were applied unaltered to that baseline for the years 2011 to 2014, including for the estimation of discards from the artisanal fishery.

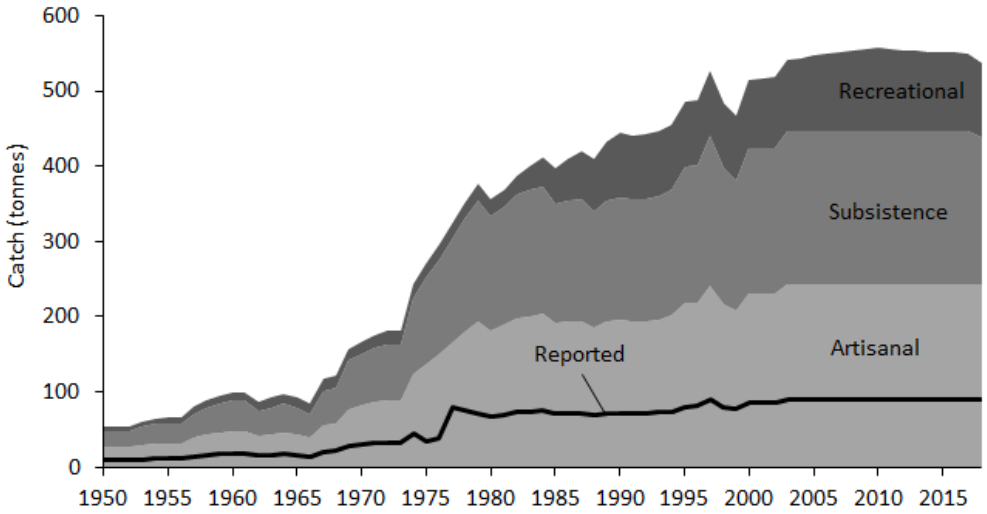

Figure 11. Reconstructed domestic catch for Saint Martin by fishing sector for 1950-2018.

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 landings data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

France and the local authorities of Saint Martin have agreed to protect the biodiversity of the French overseas territories through two international agreements, the Convention on Biological Diversity (Aichi) and the Ramsar Convention on Wetlands of International Importance (Marine Conservation Institute 2020).

Saint Martin has four MPAs (Marine Conservation Institute 2020), Étangs lagunaires de Saint-Martin Specially Protected Area (designated in 2012), Saint-Martin Specially Protected Area (designated in 2012), Saint-Martin Ramsar Site (designated in 2012) and Saint-Martin National Nature Reserve (designated in 2012), which jointly cover 98 km^2. However, UNEP-WCMC and IUCN (2020) states that the marine protected areas in this island cover 1,031 km^2, i.e., 97% of the EEZ of 1,066 km^2 (Bultel *et al.* 2016).

One of the largest MPA in these waters is the Ramsar site of Saint-Martin 'Zones humides et marines de Saint-Martin', which contains a network of 14 ponds, sea grass beds, coral reefs, mangroves and lagoons (Ramsar sites information service 2020). "The ponds are influenced by the sea and serve as feeding, breeding and wintering areas for as many as 85 bird species, many of them threatened and some endemic. The marine part of the site harbours most of the coral reef areas surrounding the island and is habitat to several endangered and critically endangered sea turtles such as leatherback (*Dermochelys coriacea*). It constitutes a feeding and spawning area for more than 100 species of fish and is also important as shelter, nursery and migration path. The site fulfills a diverse set of ecological functions like water flow regulation, oxygenation of water, stabilization and storm protection as well as the reduction of pollutant loads entering the Sea. The marine part of the site is used for recreational activities such as diving, sailing, kayaking and surfing. Threats include poaching, water pollution from sewage, and extreme weather events as well as increasing water temperatures" (Ramsar sites information service 2020).

Saint Vincent and the Grenadines

The reconstruction of marine fisheries catches of Saint Vincent and the Grenadines was completed from 1950 to 2010 by Mohammed and Lindop (2015, 2016). This account documents the update of the original reconstruction to 2014, which is then carried forward to 2018.

Retroactive changes in reported landings data were detected between different releases of the FAO data. As a result, reported landings were updated for 1990, 1993, 1997, 2001, and 2007-2010 to match the updated baseline. Unreported landings were updated for those years assuming that total reconstructed catch remained the same (Figure 12). While industrial catches of large pelagic taxa were included in the FAO's reported data, they were excluded from consideration in the reconstruction as documented here and in Mohammed and Lindop (2015) because such catches are addressed elsewhere using data provided by ICCAT, as described by Coulter *et al.* (2020).

The reconstruction was updated for 2011-2014 using the ratio of total reconstructed catch to reported landings in 2010 to estimate total catch for 2011-2014. Total reconstructed landings were disaggregated by sector and taxa for 2011-2014 using the 2010 breakdowns.

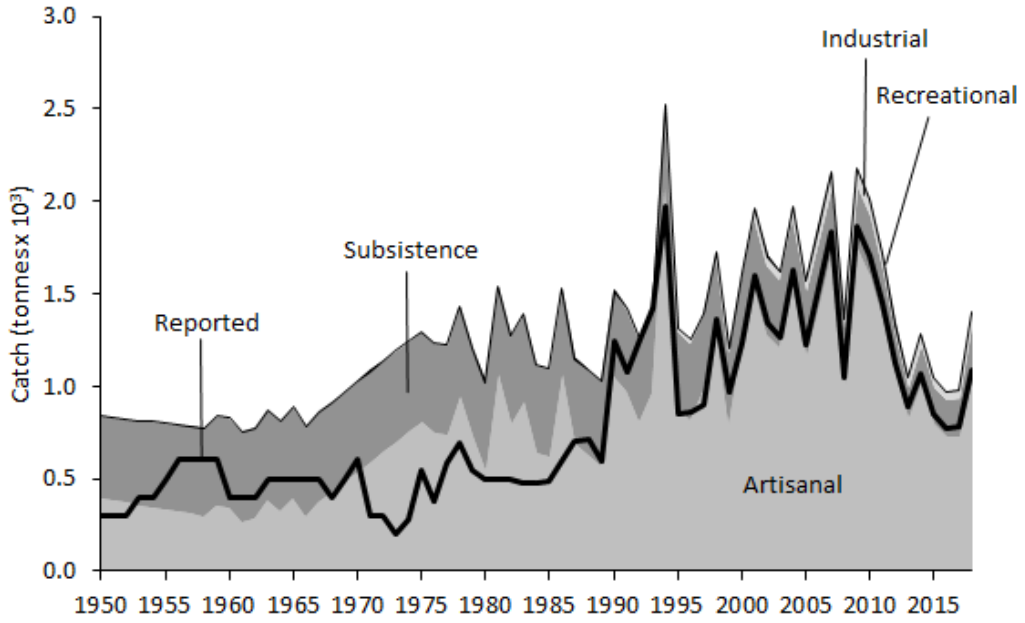

Figure 12. Reconstructed domestic catch within Saint Vincent and the Grenadines' EEZ by fishing sector for 1950-2018.

Industrial discards were calculated as 10% of the reported industrial landings for 2014. Subsistence catches in 2014 were estimated by multiplying total population data obtained from the World Bank for Saint Vincent and the Grenadines by the average per-capita subsistence rate from 2011. Unreported recreational catches were updated to 2014 by assuming the same participation rate in recreational fishing by tourists as suggested by Mohammed and Lindop (2015) and deriving the 2014 fishing rate of those recreational fishers as the average of the 2011-2013 rates.

Since the last update, Connell (2018) has released a study of Saint Vincent and the Grenadines which highlighted the need for annual data from the Saint Vincent and the Grenadines Fisheries Division to produce a database to facilitate analysis of patterns. Cornell (2018) also lauded the initiation of a program to register fishing vessels across the nation.

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 landings data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

Saint Vincent and the Grenadines has agreed to protect biodiversity through the international agreements of the Convention on Biological Diversity (Aichi) (Marine Conservation Institute 2020).

Saint Vincent and the Grenadines has 40 MPAs and no marine managed area, which jointly cover 82 km^2 (Marine Conservation Institute 2020), i.e., 0.2% of the EEZ of 36,304 km^2 (Mohammed and Lindop 2016). The Tobago Cays-Mayreau Marine Park (TCMP) was established in 1987 (Marine Conservation Institute 2020), with 52 km^2 (Garcia Rodriguez *et al.* 2017) and was initially designated to increase tourism on the island. "The enforcement capacity of the TCMP should improve, as currently its staff does not have the authority to fine infractions occurring in the area, such as anchoring in restricted areas. Finally, the enforcement capacity of the TCMP should cover all regulations and monitoring of activities that are necessary to focus on the achievement of their goals. Meeting current management, conservation, and socioeconomic needs of the MPA, investing in research activities, using available data to improve management, and conducting performance evaluations are the only way in which the TCMP will be able to become a successful and fully operational MPA at a time when effective marine management and protection are urgently required" (Garcia Rodriguez *et al.* 2017).

A study that assessed the ecosystem service benefits from extending the current network of MPAs showed that "stopping pollution from agriculture run-off and sewage was found to generate the highest ecosystem service benefits, restricting over-fishing and bad fishing practices. We demonstrate how economic valuation of marine ecosystem service might be used to design and target marine conservation policies that maximize welfare benefits" (Christie *et al.* 2015).

Trinidad and Tobago

The reconstruction of Trinidad and Tobago's marine fisheries catches was completed from 1950 to 2010 by Mohammed and Lindop (2015, 2016). This account documents the update of the original reconstructions to 2014, which is carried forward to 2018.

Industrial landings of large pelagic taxa were not considered in the reconstruction as they are addressed in a separate study (Coulter *et al.* 2020). As a result, total catches were modified for 2011-2014 to exclude industrial catches of large pelagic taxa using the average ratio of reported artisanal catches in the reconstruction to catches reported by FAO for 2006-2010.

Reported landings for 2011-2014 were allocated between the Exclusive Economic Zones (EEZ) of Trinidad and Tobago and Venezuela. Within Trinidad and Tobago, reported catches were assigned between the artisanal, industrial, and subsistence fishing sectors, according to the average ratio from 2006-2010. Total catches were disaggregated for each sector according to Mohammed and Lindop (2015).

Subsistence catches were calculated separately using the methods of Mohammed and Lindop (2015) and by extrapolating the 1950-2010 trend of the annual per-capita subsistence catch rate to 2014 and multiplying this rate by the coastal population of Trinidad and Tobago as obtained from the World Bank.

The 2006-2010 average ratio of total reconstructed catches to reported catches was used to estimate the unreported catches for 2011-2014 for the artisanal, industrial, and recreational fishing sectors. Unreported industrial catches were allocated between the EEZs of Trinidad and Tobago and Venezuela and between landings and discards according to the average ratio of unreported catches assigned to each between 2006 and 2010. The 2006-2010 average ratio of unreported catches assigned to artisanal, industrial and recreational sectors within Trinidad and Tobago was used to assign domestic unreported catch to sector for 2011-2014.

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 landings data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

Trinidad and Tobago have agreed to protect its biodiversity through the international agreements of the Convention on Biological Diversity (Aichi) and the Ramsar Convention on Wetlands of International Importance (Marine Conservation Institute 2020).

Trinidad and Tobago have 10 MPAs and four marine managed area, which jointly cover 124 km^2 (Marine Conservation Institute 2020), i.e., 0.16% of the EEZ of 79,798 km^2 (Mohammed and Lindop 2016).

"The NE Tobago area is fragile and sensitive and is increasingly threatened by activities, such as overfishing, deforestation as well as climate change which [jeopardizes] the overall ecosystem of the area and the ecosystem services provided (EDG and Kairi Consultants Ltd. 2003). […] To reduce local stress factors on corals in NE Tobago the following is recommended: strict enforcement of existing water pollution rules, support of organic agriculture initiatives in the related watershed areas, minimization of construction related sedimentation through strict enforcement of requirements outlined in EIAs for non-residential projects, establishment and enforcement of visitor regulations at reefs. In the medium-term sustainable solutions for domestic grey and black-water disposal must be found for Speyside, Charlotteville and Parlatuvier" (Wothke 2013).

"In Trinidad and Tobago, shark consumption is prevalent but not frequent, and consumers generally knew very little about sharks even though they had good attitudes towards sustainable shark use and the public health implications of shark consumption. Tobagonians knew more about sharks, but Trinidadians had attitudes more open to safe and sustainable shark consumption. Tertiary education was a good predictor of knowledge about sharks but failed to predict attitudes or practices. Both the attitudes and practices of women were more inclined towards safe and sustainable shark consumption than those of men" (Ali *et al.* 2020). "Community surveys indicate that community participation in any management is a priority but that co-management must be supported with capacity building and ongoing education of the wider community" (Wothke 2013).

Turks and Caicos Island (United Kingdom)

The marine fisheries catches of the Turks and Caicos Islands (TCI) were originally reconstructed for 1950-2010 by Ulman *et al.* (2015, 2016a, 2016b). This account documents the update of the original reconstruction to 2016, which is then carried forward to 2018. Turks and Caicos do not have a domestic industrial fishery, but its small-scale fisheries play an important role for subsistence, export, and support of the tourism industry.

Updated population data were obtained from the World Bank and used to calculate subsistence and artisanal catches for 2011-2016 based on adult fish and invertebrate consumption rates estimated for 2010 in the original reconstruction (Ulman *et al.* 2015)[17]. Foreign fishing by Haiti and the Dominican Republic was assumed to continue at the same percentage of Haiti's and the Dominican Republic's reconstructed catch for 2012-2016, although total removals by these foreign fleets are relatively small. Updated data on the number of stopover tourists and cruise ship tourists were obtained from several tourism statistics sources[18]. The 2010 recreational fishing participation rate of 4% of stopover tourists and cruise ship tourists were held constant to 2016 in order to estimate the number of tourists participating in recreational fishing. The recreational catch rate was assumed to remain at the 2010 rate of 10 $kg \cdot visit^{-1}$ kg (6-day average visit; Ulman *et al.* 2016a) for 2011-2016.

Taxonomic breakdowns were maintained at the 2010 ratio for domestic and tourist consumption of reef-fish and game fish (Ulman *et al.* 2016a). While reconstructed catch increased for most sub-sectors for the TCI, the amount reported to the FAO has declined, which signals a decline in exports because all reported catch is considered commercial catch destined for export (Ulman *et al.* 2016a). Currently, catch quotas are calculated based on exported amounts and do not consider domestic consumption, which likely has accelerated the depletion of local fish and invertebrate populations including Queen conch *Lobatus gigas* (Ulman *et al.* 2016a).

Transition from 2016 to 2018

The catch reconstructed to 2016 was carried forward to 2018 using the semi-automated procedures outlined in Noël (2020), based on FAO landings data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

The United Kingdom and the local government of the Turks and Caicos Islands have agreed to protect the biodiversity of the Turks and Caicos through the international agreements of the Convention on Biological Diversity (Aichi) and the Ramsar Convention on Wetlands of International Importance (Marine Conservation Institute 2020).

Together, the MPAs of Turks and Caicos Islands cover 150 km^2 (UNEP-WCMC and IUCN 2020), which amounts to 0.1% of the EEZ of 153,533 km^2 (Ulman *et al.* 2016a, 2016b). "The Department of Environment and Coastal Resources (DECR) is mandated to ensure the sustainable use of natural resources as well as to protect and promote biodiversity and economic prosperity through a sustainable fisheries industry, environmentally sustainable development, and a Protected Areas system. The Turks and Caicos National Trust manages a small number of terrestrial and coastal protected areas, which are held in a public trust" (Sealey *et al.* 2019).

[17] http://data.worldbank.org/indicator/SP.POP.TOTL?end=2015&locations=TC&start=1960&view=chart&year_low_desc=true

[18] http://turksandcaicostourism.com/wp-content/uploads/2015/03/Turks-Caicos-Tourism-Statistics-2014.pdf ; http://turksandcaicostourism.com/turks-and-caicos-islands-tourism-statistics-2013/ ; http://www.tcinewsnow.com/headline-Tourist-Board-announces-visitor-arrival-numbers-for-2012-5712.html; http://www.caribbeanhotelandtourism.com/wp-content/uploads/2017/03/Turks-Caicos-Final-2016-Tourism-Statistics.pdf; http://turksandcaicostourism.com/wp-content/uploads/2016/03/Turks-Caicos-Tourism-Statistics-2015.pdf

"Valleys between ridges are typically low-lying areas where palustrine wetlands form and collect floodwaters. In recent years, however, due to escalating real estate values, low-lying areas are being filled and developed, leading to widespread flooding during periods of high rainfall. This ill-advised practice may be addressed in proposed legislation to amend the National Parks Ordinance to include all wetlands as protected areas. At the time of this writing, the legislation is still pending Cabinet approval" (Sealey *et al.* 2019).

Some of these MPAs are not large enough to protect fish population such as groupers, which are not only valuable from an ecological point of view, but also for the local economy. For example, in the South Caicos Island, "the Admiral Cockburn Land and Sea National Park (ACLSNP) may not be large enough to protect effectively large reef fishes such as the Nassau grouper [(*Epinephelus striatus*)], which have large home ranges and/or undergo seasonal spawning migrations" (Tupper and Rudd 2002). Having smaller and generally fewer individuals of groupers in these MPAs may affect the tourism industry negatively. It has been calculated that "increasing grouper abundance adds value to the dive experience. Dive operators could charge higher prices and increase revenue by taking clients to sites with higher grouper abundance. Alternatively, MPA entrance fees could be used to capture consumer surplus resulting from increased grouper abundance. […] The income generated through premium pricing for access to MPA dive sites might be sufficient to compensate fishers for losses of fishing opportunities due to MPA implementation, as well as cover the marginal costs of expanded park operations necessary for the protection for the ecological services crucial to the competitiveness of the dive industry" (Rudd *et al.* 2001).

Other activities that threaten marine ecosystems in these waters include "illegal, unreported, and unregulated (IUU) fishing, [which] is an on-going and serious problem [and] especially poaching from foreign fishers from Hispaniola. Remote islands are also experiencing significant deforestation from an illegal charcoal trade. [MPAs] require boats or complicated logistics to manage. DECR has one ocean-going vessel that requires costly maintenance and staff for operations. In addition, there are five smaller vessels that also require maintenance for patrolling […]" (Sealey *et al.* 2019).

US Virgin Islands

The US Virgin Islands' marine fisheries catch was reconstructed for the period of 1950-2010 (Ramdeen *et al.* 2015, 2016). This account documents the update of the original reconstructions to 2014, which is carried forward to 2018 (Figure 13).

Previously, catches by the small-scale sector were reconstructed based on the number of fishers and catch-per-unit-effort per fisher (Table 1). The taxonomic breakdown of the artisanal and subsistence catches was based on the original reconstruction and applied to catches reported as 'Marine fishes nei' in the FAO data (Table 2; Ramdeen *et al.* 2015).

Due to changes in the 2014 FAO data version, the previously reconstructed data were retroactively modified. These changes suggest that from 1990 onwards the subsistence sector was considered in the reported data. Therefore, from 2003 onwards, when our reconstructed small-scale catches became less than the total reported by the FAO, a new protocol was followed. From 2003-2010, the difference between the FAO 2014 data and 2010 data was assigned to subsistence fishing. From 2011-2014, the ratio of subsistence to artisanal fishing in reported FAO data was carried forward. All taxa were assigned to subsistence and artisanal sectors in the ratio established above (Table 2).

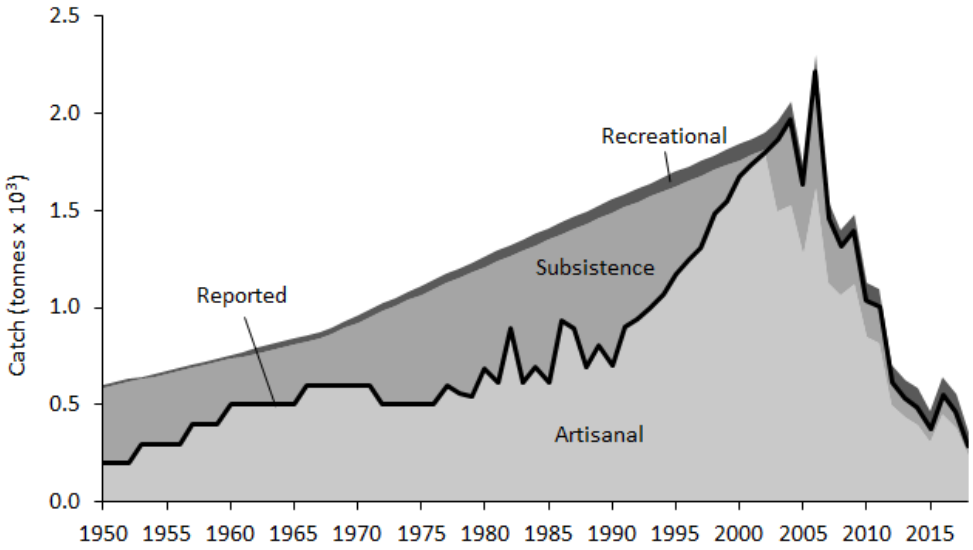

Figure 13. Reconstructed domestic catch within US Virgin Islands' EEZ by fishing sector for 1950-2018.

The recreational fishery was reconstructed for both the tourists and resident populations. Current population data were sourced from the World Bank[19] for residents, and from OneCaribbean[20] for stop-over tourists. The recreational fishing catch-per-unit-effort rates were kept constant for residents and tourists at 24 kg·fisher^{-1}·year^{-1} and 0.1 kg·tourist^{-1}·year^{-1}, respectively.

Since the original reconstruction, the US Virgin Islands have been the subject of conservation efforts and monitoring for both their coral reefs and their local fish populations[21]. Recent research has identified an important shark nursery habitat which may be important to future considerations of fisheries (Legare *et al.* 2015). This increased interest in fisheries and biodiversity conservation may be reflected in the updated statistics, as the ratio of unreported catch has shrunk substantially in recent years. Finally, accounting for the recreational sector, which is currently unreported, could be important as other sectors of fishing diminish and as the recreational catch comprises a more substantial portion of total marine catches (see also Smith and Zeller 2013).

Table 1. Number of fishers and their catch rate for the small-scale (subsistence and artisanal) sectors 1950-2003 (updated 2003 from Ramdeen *et al.* 2015)

Year	No. of fishers	CPUE (t·fisher^{-1}·year^{-1})
1932	405	0.69
1967	400	2.1
2003	383	4.8

[19] http://data.worldbank.org/indicator/SP.POP.TOTL?locations=VI
[20] www.onecaribbean.org
[21] http://cubajournal.co/noaa-launches-long-term-fisheries-study-involving-cuba ; http://www.noaanews.noaa.gov/stories2015/121015-noaa-awards-more-than-8-million-for-coral-reef-conservation.html

Table 2. Taxonomic composition (in %) of small-scale reconstructed catches, used to taxonomically disaggregate the officially reported "Marine fishes nei" data as well as the reconstructed unreported catches.

Taxon	%
Scaridae	25
Balistidae	15
Lutjanidae	13
Acanthurus spp.	12
Haemulidae	12
Epinephelus spp.	7
Panulirus argus	6
Misc. marine fishes	5
Diplodus spp.	4
Conch	1

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 landings data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

Marine biodiversity protection

The US and the local Virgin Islands governments have agreed to protect the biodiversity of the Virgin Islands through the international agreements of the Convention on Biological Diversity (Aichi) and the Ramsar Convention on Wetlands of International Importance (Marine Conservation Institute 2020).

The US Virgin Islands have 33 MPAs (Pittman *et al.* 2014), which jointly cover 896 km² (UNEP-WCMC and IUCN 2020), i.e., 2.6% of the EEZ of 33,748 km² (Ramdeen *et al.* 2016).

"Following the establishment of the land portion of the Virgin Islands National Park in 1956, the Virgin Islands government and St. Thomas and St. Croix Chambers of Commerce, jointly with the U.S. Department of the Interior, conducted a survey of recreational needs, sites, and services in the USVI. This study identified areas of high ecological significance to support the development of a Territorial Park System. In the early 1960s, Buck Island Reef National Monument and Virgin Islands National Park were designated, becoming some of the world's first coral reef MPAs" (Pittman *et al.* 2014).

Even though the rangers of the Department of the Interior National Park Service have increased their effort to enforce regulations and increase public awareness, illegal fishing inside no-take MPAs still occurs. "Outreach campaigns to improve voluntary compliance in the fishing community and evaluation of existing enforcement effort, techniques, and tactics could help address illegal fishing inside MPAs. On St. Croix, Buck Island Reef National Monument and East End Marine Park could create joint outreach, management and monitoring initiatives that would share resources and reach a broader section of the community" (Pittman *et al.* 2014).

Discussion

The island countries and territories covered here share several features, one of which is the impact of the tourism industry on their fisheries. Tourism impacts the number of fish caught in Caribbean countries and territories both as part of catch caught and sold locally to hotels and restaurants, as well as tourists directly participating in recreational fishing. To estimate the impact of tourists on domestic Caribbean fisheries, we reconstructed the number of stop-over tourists and their per capita consumption and the recreational fishing participation and catch rates.

The resulting estimates are tentative, and readers are encouraged to send us corrections and/or publication providing numbers that would replace the numerous assumption we have made.

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