Updated catch reconstructions for U.S.-flag associated Pacific island areas to 2018

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Abstract
The initial reconstructions of the catch of marine fisheries catches for U.S.-flag associated island areas in the Pacific was commissioned by the US Western Pacific Regional Fishery Management Council and covered the years 1950 to 2002 for American Samoa, Guam, the State of Hawaii, the Commonwealth of the Northern Mariana Islands, and the minor islands of Howland and Baker, Jarvis, Wake, Johnston Atoll, Palmyra Atoll, and Kingman Reef. Subsequently, these were collectively updated to 2010 and further updated to 2016 (Hawaii), 2017 (American Samoa, Guam, Commonwealth of Northern Mariana Islands, Wake Island), and carried forward to 2018 as documented in this contribution. For those islands that are inhabited, fisheries are vital to the societal and food security welfare from coastal fisheries, as well as economically important through large pelagic fisheries. We have conservatively accounted for local fishing through reported FAO data, national statistics, and estimates of unreported catches from secondary data and information sources. Descriptions of the methods used to reconstruct catches are presented in EEZ-specific sections.

Introduction
The initial reconstruction of the catches of marine fisheries for U.S.-flag associated island areas in the Pacific were commissioned and funded by the US Western Pacific Regional Fishery Management Council for the years 1950 to 2002, and were documented in Zeller et al. (2005, 2006, 2007a, 2007b, 2008), and were updated to 2010 (Gibson et al. 2015; Zeller et al. 2015), and with contributions in Pauly and Zeller (2016). Here, they were updated to 2016 (Hawaii), 2017 (American Samoa, Guam, Commonwealth of Northern Mariana Islands, Wake Island), and carried forward to 2018. The industrial fisheries for large pelagic species occurring in the EEZ waters of the uninhabited Howland and Baker Islands, Wake Island, Jarvis Island, Johnston Atoll, and Palmyra Atoll and Kingman reef were covered in Coulter et al. (2020).

For those islands that are inhabited, fisheries are vital to the societal and food security welfare from near-shore fisheries, as well as economically important large pelagic fisheries. We have attempted to conservatively account for local fisheries catches through reported FAO data, U.S. Western Pacific Fisheries Information Network data (WPacFIN), and independent literature sources. Large pelagic fisheries were covered in a separate study on global tuna fisheries by Coulter et al. (2020). Descriptions of the methods used to reconstruct catches are presented in country-specific sections.

Materials and Methods
American Samoa
The original reconstruction to 2002 by Zeller et al. (2005, 2006) was updated to 2010 by Zeller et al. (2015, 2016), and were subsequently updated to 2017 and carried forward to 2018. In this update, reported data from the FAO were used as the reported baseline for the entire time series. Following the original methods by Zeller et al. (2005, 2006, 2007, 2015), all catches as reported by the FAO were assigned as artisanal, except for wahoo (*Acanthocybium solandri*) and dolphinfish (*Coryphaena hippurus*). Wahoo and dolphinfish catches were assigned as industrial catch and were addressed separately in Coulter et al. (2020).

Unreported catches from Zeller et al. (2005, 2006) were updated to 2017 by applying the existing per capita catch rate from 2002 to updated population data from the American Samoa Department of Commerce and the Statistics for Development Division of the Secretariat of the Pacific Community (SPC). These non-artisanal catches were assigned as 20% subsistence and 80% recreational (Figure 1). The reconstruction resulted in catch amounts comparable to those estimated by Gillett (2016), specifically, subsistence and recreational catches were equivalent to Gillett (2016) estimated coastal subsistence catches.

Transition from 2017 to 2018
The catch reconstructed to 2017 was carried forward to 2018 using the semi-automated procedure 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
American Samoa has agreed to protect its biodiversity through the international agreements of the United Nation 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. American Samoa is a signatory to regional treaties and agreements such as the Regional Seas Convention (Marine Conservation Institute 2020).

“Traditional management of marine resources in American Samoa through the Community-based Fishery Management Program (CFMP) has proven to be an effective tool in implementing conservation measures to facilitate the sustainable management of the local subsistence and recreational fishery, and increase the abundance of marine resources” (Oram et al. 2016). However, more collaboration between federal and territorial agencies is needed in order to improve public support, enhance coordination of science and enforcement, and maintain long-term political support (Oram et al. 2016).

American Samoa has three MPAs: The Ross Atoll Marine National Monument (designated in 2009 with 34,838 km²), the Rose Atoll National Wildlife Refuge (designated in 1973 with 158 km²) and the Fagatele Bay Unit National Marine Sanctuary of American Samoa (designated in 1986 with a total of 0.65 km²; U.S. Department of Commerce 2012). These areas jointly cover 34,997 km² (Marine Conservation Institute 2020), i.e., 8.6% of the EEZ of 404,370 km² (Zeller et al. 2016).

The Fagatele Bay Sanctuary is the smallest and most remote of the 13 sanctuaries managed by NOAA’s Office of National Marine Sanctuaries (ONMS). “Fagatele Bay’s coral reefs provide habitat for at least 271 species of fishes, 168 species of coral and at least 1,400 species of algae and invertebrates other than coral. Marine mammals and sea turtles may also be found in or near the sanctuary and surrounding environments. In addition, Fagatele Bay’s shoreline bears witness to the rich Samoan maritime culture as the site of a pre-historic village [...]” (U.S. Department of Commerce 2012).
The Ross Atoll Marine National Monument is a no-take area on paper. “[However,] poaching of fish and marine invertebrates (primarily giant clams) is a realistic threat to Rose Atoll’s marine ecosystem. As with terrestrial trespass, marine poaching is difficult to detect yet has the potential to cause serious damage to Rose’s reef communities, especially if the poaching is driven by socio-economic factors” (Swenson et al. 2006).

**Figure 1.** Domestic marine catches for American Samoa from 1950-2018 by fishing sector.

**Guam**

Guam’s marine fisheries catches for 1950 to 2002 were first reconstructed by Zeller et al. (2005, 2007), and updated to 2010 by Zeller et al. (2015); see also Zeller and Pauly (2016). Due to the overlap of sectors making them difficult to distinguish and following the method of Zeller et al. (2005, 2007, 2015), in the update here to 2017, all catch was first assigned as artisanal (36%) or subsistence (64%). Subsistence catch was then further broken down into true subsistence (20%) and recreational (80%). Large pelagic taxa were not included in Guam’s catch reconstruction (i.e., blue marlin, common dolphinfish, Indo-Pacific sailfish, skipjack tuna, tuna-like fishes nei, wahoo, yellowfin tuna) because these were covered in Coulter et al. (2020).

Discrepancies between the reconstructed catches (for 1965-2002) and the reported statistics over the time period mentioned were discussed in the original reconstruction paper by Zeller et al. (2005), which included a two-fold adjustment factor suggested in numerous earlier DAWR (Guam Division of Aquatic and Wildlife Resources) reports up to 1985 (Zeller et al. 2007). National data were utilized as the reported baseline until 1999, after which data from the FAO were used as the reported component for 2000-2017 (Figure 2). There have been no unreported catches since 1985; this took into account supply and demand comparisons and the slightly increasing population (Bureau of Statistics and Plans 2018). The catch reconstruction showed a general decline in reported catches in all sectors from the early 2000s. The 2017 Western Pacific Regional Fishery Management Council annual report (WPRFMC 2018b) also noted a decline in catch in bottom fish and boat-based fisheries, and Weijerman et al. (2016), focusing on the Guam shore-based fishery, also showed a general decrease in biomass from 1985 to 2012.

There was also a shift in catch composition, where the majority of the landings since 1999 were comprised of lower-valued species such as the bigeye scad (*Seler crumenophthalmus*) (Zeller et al. 2005; Weijerman et al. 2016). This downward trend is cause for concern, since fishing for coral reef fishes is vital not only for contributing to the subsistence and home consumption needs of the indigenous Chamorros, other fishers and their families, but also for preserving their histories and identities (Weijerman et al. 2016; WPRFMC 2018a).
Since reef habitats are popular dive sites, they are often adversely impacted when large numbers of inexperienced divers visit the site within a short period of time (Burdwick et al. 2008). The overuse and misuse of certain high-profile reef areas, e.g., Piti Bomb Holes Marine Preserve for recreational activities) has also raised concern.

**Transition from 2017 to 2018**

The catch reconstructed to 2017 was carried forward to 2018 using the semi-automated procedure 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.

![Figure 2. Domestic marine catches for Guam from 1950-2018 by the 5 main taxa caught, plus 'others' contributing 123 additional taxa.](image)

**Marine biodiversity protection**

Guam is a signatory to regional treaties and agreements such as the Regional Seas Convention (Marine Conservation Institute 2020). “Both local and U.S. laws, including the Endangered Species Act (1973), the Marine Mammal Protection Act (1972), and the Shark Conservation Act (2011) afford protection to marine species on Guam” (Martin et al. 2016).

There are two MPAs in Guam’s waters: the Guam NWR (National Wildlife Refuge, designated in 1978 with 93 km² and 1 km² of reported marine area, which is a no-take area) and the Guam Territorial Sea Shore (designated in 1978 with 61 km² and 25 km² of reported marine area) (Marine Conservation Institute 2020). These areas jointly cover 154 km² (Marine Conservation Institute 2020), i.e., 0.07% of the EEZ of 221,899 km² (Zeller and Pauly 2016).

“The Guam NWR is comprised of three units: the Andersen Air Force Base Overlay Unit, the Navy Overlay Unit, and the Ritidian Unit. The Ritidian Unit, known to the Native Chamorro (Chamoru) people as Puntan Litekyan, is located on the northern tip of Guam and encompasses approximately 5 km², including 3.5 km² of submerged areas offshore” (U.S Fish & Wildlife Service 2019).

“In Guam, MPAs typically prohibit all fishing and other resource extraction (analogous to IUCN protected area categories I–II), although there are some exceptions. Military lands include U.S. military bases and airstrips, where both military and non-military fishing is limited; in these areas, access to adjacent waters may be limited for those without a boat. Public and private lands contain shorelines that are legally accessible to the
public (and as defined here, with no MPA restrictions on resource extraction), although cliffs may prevent convenient access in some places” (Martin et al. 2016).

State of Hawaii: Main and Northwestern Islands
The reconstruction of Hawai’i’s fisheries catches were originally completed for 1950–2002 by Zeller et al. (2005, 2007, 2008) and updated to 2010 by Gibson et al. (2015); see also Zeller and Pauly (2016). Since the update by Gibson et al. (2015), new Western Pacific Fisheries Information Network (WPacFIN) data became available up to 2016 and were used to update the reconstruction. Algae, freshwater fishes, sea turtles, freshwater shrimps, and tilapia were excluded from updated WPacFIN data. In this update, reported landings were assigned between the Main and Northwestern Hawaiian Islands EEZs. Based on a review of available literature, the split was independently determined for lobsters, bottom fish, and large pelagic taxa.

Lobster
Lobsters were assigned to the EEZ areas based on the ratio in the original reconstruction by Zeller et al. (2007) from 1950 to 2000. In 2000, the lobster fishery was closed in the Northwestern Hawaiian Islands, and from then onwards, all lobster catches were attributed to the Main Hawaiian Islands. All lobster catches were designated as artisanal catch.

Bottom fish
Ratios of bottom fish landings from the Main and Northwestern Hawaiian Islands were determined from information available for 1950-2006 (Zeller et al. 2007; Gibson et al. 2015). In 2010, the bottom fish fishery in the Northwestern Hawaiian Islands closed due to the establishment of the Papahānaumokuākea Marine National Monument. Thus, there was reduced fishing in the Northwestern Hawaiian Islands in 2010, followed by no catch from 2011 onwards. Interpolation was used to determine ratios of bottom fish caught in each EEZ area from 2007 to 2010. Bottomfish landings in the Main Hawaiian Islands were associated with small-scale commercial catch and were designated as artisanal catch. Bottom fish landings attributed to the Northwestern Hawaiian Islands were assumed to be industrial due to the increased vessel size required to travel the greater distance. Bottom fish discard rates and taxonomic breakdown of discards were maintained from the original reconstructions (Zeller et al. 2007; Gibson et al. 2015). Gear types were assigned using the taxonomic gear breakdown available in the WPacFIN reported data.

Recreational
All recreational catches were assumed to originate from the Main Hawaiian Islands because the Northwestern Hawaiian Islands are uninhabited. Recreational catch data from the Marine Recreational Information Program (MRIP) was converted from number of fish caught to catch tonnage based on length-weight conversion factors from FishBase from 2010-2016. A 1991 anchor point from Hamm and Lum (1992) was used to taxonomically disaggregate the catches from 1950 to 1991. This disaggregation was then interpolated from 1991-2002 when the MRIP data with taxonomic resolution became available. An adjustment factor of 0.82 was applied for 2004-2010 to account for reporting errors noted by Williams and Ma (2013).

Pelagic fish
All large pelagic species catches were designated as industrial large-scale commercial catch (Kittinger et al. 2010), and are addressed separately in Coulter et al. (2020).

**Transition from 2016 to 2018**

The catch reconstructed to 2016 (Figure 4) was carried forward to 2018 using the semi-automated procedure outlined in Noël (2020), based on WPacFIN landings data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.

**Figure 4.** Domestic marine catches for the State of Hawaii from 1950-2018 by the 5 main taxa caught and ‘others’ representing 192 additional taxa.

**Marine biodiversity protection**

The United States of America has agreed to protect the biodiversity of the State of Hawaii 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 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 (CaMPAM) and the North American MPA Network (NAMPAN) (Marine Conservation Institute 2020).

There are two major MPAs in the northwestern part of Hawaii: the Papahānaumokuākea Marine National Monument (PMNM) (designated in 2006) and the Papahānaumokuākea 2016 Expansion Marine National Monument (designated in 2016) (Marine Conservation Institute 2020). These areas cover 1,508,736 km² (Marine Conservation Institute 2020), contributing to 96% of the Northwestern Islands EEZ of 1,578,680 km² (Zeller and Pauly 2016). Previous to these designations, the Northwestern Hawaiian Islands Coral Reef Ecosystem Reserve was recognized as a mixed cultural site (Claudino-Sales 2019); in 2010, the Marine National Monument was designated as a natural World Heritage site. After the establishment of the MPAs, the two areas jointly formed one of the largest and most strictly protected marine reserves in the world.

“The laws that established PMNM as well as the current management practices emphasize the integration of Western and Native Hawaiian values and practices. This framework provides opportunities for cultural perspectives to be integrated into all management decisions. Foundational elements of integration include formal co-management agreements for governance, and structured opportunities for Native Hawaiian
community involvement. PMNM is cooperatively managed by the National Oceanic and Atmospheric Administration (NOAA), the U.S. Fish and Wildlife Service (FWS), the State of Hawaii, and the Office of Hawaiian Affairs (OHA). Although OHA has acted as a co-manager since PMNM’s inception, a crucial milestone was a 2017 Memorandum of Agreement, which elevated OHA to Co-Trustee status” (Clark and Miller 2019.).

In the Main Islands of the Hawaiian waters, there are more than 90 unique marine managed areas that regulate fishing and other marine-related activities (Friedlander et al. 2019). These areas cover 872 km² (Friedlander et al. 2019), i.e., 0.1% of the Main Islands EEZ (896,002 km²; Zeller and Pauly 2016).

“These areas include MLCDs (Marine Life Conservation Districts designed primarily for conservation), fisheries management areas (designed to resolve conflicts among users), and fish replenishment areas (aquarium fish protected areas), along with various areas with other designations, such as military exclusion zones, national parks, and community-based management areas” (Friedlander et al. 2019). The median area of these marine managed areas is 1.2 km². The largest is the Kaho‘olawe Island Reserve, with a total extent of 202 km² and with 42 km² of highly protected nearshore waters. The mean age of these managed areas is 29 years (±13 years SD), with the oldest being the Moku o Lo‘e Marine Laboratory Reserve, which was established in 1953 (Friedlander et al. 2019).

**Commonwealth of the Northern Mariana Islands (CNMI)**
The Commonwealth of the Northern Mariana Islands (CNMI) is a self-governing territory of the United States. It is volcanic in origin and lies north of Guam and roughly 2,500 km east of the Philippines. Marine fisheries catches for the CNMI were initially reconstructed for the 1950 to 2002 by Zeller et al. (2005, 2007a) and updated by Zeller et al. (2015); see also Zeller and Pauly (2016). In this update to 2017, data were retroactively corrected from the 1980s to the late 2000s to match more recent estimates of CNMI catch in the secondary literature, including Cuentos-Bueno and Houk (2015) and Gillett (2016).

**Commercial fisheries**
National data based on a commercial dealer purchase receipt collection system provided by the Western Pacific Fisheries Information Network (WPacFIN) of the National Oceanographic and Oceanic Administration, Pacific Islands Fisheries Science Center (NOAA - PIFSC) were accepted as the reported commercial landings baseline for 1981-2017[56]. The initial reconstruction by Zeller et al. (2005, 2007a, 2007b) interpolated between zero commercial catch in 1960 and the value as reported by WPacFIN in 1983, and these earlier values were retained. Cuentos-Bueno and Houk (2015) found some underreporting within the WPacFIN data. Thus, WPacFIN catches were adjusted upwards by 10% to better reflect likely true commercial landings. For all years, catches of large pelagic fishes (tunas, billfishes) were assumed to be industrially-caught; they were excluded from consideration here, as they were addressed separately by Coulter et al. (2020). All other taxa were considered to be local artisanal catches.

**Non-commercial fisheries**
In line with the initial reconstruction by Zeller et al. (2005, 2007a, 2007b), non-commercial catches were considered entirely unreported, and they encompassed subsistence and recreational sectors. These non-commercial sectors were calculated as a ratio of WPacFIN total commercial landings (both reported plus unreported). A 1:7:1 ratio of non-commercial landings to commercial landings, originally estimated by Graham (1994), was applied to the adjusted WPacFIN dataset for 1983-1993. For the period 1994-2000, a 1:1 ratio was

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[56] https://www.pifsc.noaa.gov/wpacfin/home.php
applied based on the suggestion in Graham (1994) that the ratio of non-commercial landings may have decreased. However, in the initial reconstruction by Zeller et al. (2005, 2007a, 2007b), these ratios were applied only to non-pelagic catches. Cuentos-Bueno and Houk (2015) suggested that to more accurately estimate unreported non-commercial landings, this ratio should have been applied to all commercial catch, including large pelagic fishes. As such the ratio (1.7:1 and 1:1) were applied to total commercial catch in order to estimate 1983-2000 non-commercial catch in the present update. For the period between 1980 and 1983, the downward trend in catch between 1979 and 1980 was continued for two years.

Following the year 2000, three anchor points summarized by Gillett (2016) were used to estimate rates of underreporting in the CNMI. The first anchor point, calculated by Cuentos-Bueno and Houk (2015) for the mid-2000s and applied here to 2005, was the average (i.e., 385.5 tonnes) between their non-conservative (514 tonnes) and their conservative (257 tonnes) estimate of total reef fish landings per year. This anchor point does not include non-commercial pelagic species landings. Cuentos-Bueno and Houk (2015) also estimated a conservative total catch (including commercial and non-commercial both reported and unreported landings) of non-pelagic fish of 385.5 tonnes, resulting in 292 tonnes of unreported non-commercial catch in 2005.

Gillett (2016) presented commercial and non-commercial landings for 2007 and 2014, which were used as anchor points in this update. Linear interpolation was applied for the years between 2000, 2005, 2007, and 2014 to derive a complete time series estimate of unreported non-commercial landings. The rate of unreported landings in 2014 was held constant to 2017.

Most fishers engage in approximately equal amounts of subsistence and recreational fishing (Hospital and Beavers 2014). As a result, the non-commercial catches were interpolated from 59.9% subsistence and 40.1% recreational in 1980 to 50% each in 2000. After 2000, the subsistence-recreational split was maintained at 50-50 for the remaining years in the reconstruction.

**Taxonomic composition**

According to the surveys conducted by Hospital and Beavers (2014), CNMI fishers target pelagic fish, bottom fish, and reef fish in roughly equal quantities, with 25-45% of respondents claiming they had no primary target (depending on the sector). Thus, in all unreported catches of commercial and non-commercial sectors, catch composition was conserved from the reported landings.

**Transition from 2017 to 2018**

The catch reconstructed to 2017 (Figure 5) was carried forward to 2018 using the semi-automated procedure outlined in Noël (2020), based on WPacFIN landings data to 2018. Semi-automated reconstructed catch data will later be replaced by a more detailed, research-intensive update.
Marine biodiversity protection

The Marianas Trench Marine National Monument surrounds the US Territories of the Commonwealth of the Northern Mariana Islands (CNMI) and occupies approximately 246,608 km², i.e., 33% of the EEZ of 748,870 km² (Zeller et al. 2016). The monument was established by President George W. Bush in 2009 and expanded by President Barack Obama between 2014-2016. The monument is divided in three units: the Monument's Trench Unit, which occupies only the submerged lands along the length of the archipelago; the Volcanic Unit, which extends in the submerged mud volcanoes and thermal vents along the Mariana Arc; and the Islands Unit with protected waters and submerged lands. This is the only unit that has fishing restrictions (Kotowicz et al. 2017).

“Within the Islands Unit of the monument, the Secretary of Commerce shall prohibit commercial fishing. Subject to such terms and conditions as the Secretary of Commerce deems necessary for the care and management of the objects of the Islands Unit, the Secretary ... shall ensure that sustenance, recreational, and traditional indigenous fishing shall be managed as a sustainable activity consistent with other applicable law and after due consideration with respect to traditional indigenous fishing of any determination by the Government of the Commonwealth of the Northern Mariana Islands (Presidential Documents 2009)” (Richmond and Kotowicz 2015).

“A recent assessment of human use in the Islands Unit of the Monument revealed that trips to the waters of the LMPA are rare but culturally important events, with an average of four trips per year by residents [...]” (Kotowicz et al. 2017). “Access and exchange of goods between Marianas residents and the Islands Unit have served as a significant link to this historically and culturally important place. The importance of this area should be considered when regulating access and traditional indigenous fishing in the Islands Unit of the monument and the aim of management plans should be to facilitate continued connection to the waters surrounding Uracas, Maug, and Asuncion” (Kotowicz and Richmond 2013).

A qualitative study exploring perceptions and attitudes about the Monument “found that many CNMI locals who were closely connected to the Monument were against or had strong reservations about the LMPA [(Large
Marine Protected Area). However, the survey showed overall high levels of support for the Monument among the general public. The survey also indicated that respondents, even those who had heard of the Monument, had low overall knowledge about it. Perhaps stakeholders' greater awareness of the Monument and the process through which it was designated caused them to uncover aspects about the Monument that led them to exhibit lower support compared to the public” (Kotowicz et al. 2017). In another study, “not all respondents agreed on the designation and regulation of the Monument or the best strategies to protect this cultural resource. Several commercial fishermen described the importance of commercial ventures to their cultural experience of the islands and expressed a lamentation over the loss of commercial access from Monument designation [Others] felt that at least some forms of commercial fishing should be prohibited in order to continue to conserve these valuable places (Four CNMI Residents, personal communication, 2011)” (Richmond and Kotowicz 2015).

**Howland and Baker Islands**
Reconstruction of the marine fisheries catch of Howland and Baker Islands was completed for 1950-2002 by Zeller et al. (2005), and was updated to 2010 by Zeller et al. (2015); see also Zeller and Pauly (2016). Howland and Baker Islands have been uninhabited since World War II, and are contained within the Pacific Remote Islands Marine National Monument, which bans commercial fishing within 370 km (200 nautical miles) from shore. Therefore, catches associated with the industrial large pelagic fisheries are documented in Coulter et al. (2020). Illegal foreign fishing is a possibility, as the remoteness of these islands make regular monitoring difficult.

**Jarvis Island**
The fisheries catch from around Jarvis Island was reconstructed in Zeller et al. (2005, 2015), see also Zeller and Pauly (2016), and was assumed to include no small-scale catch, as the island is uninhabited. Jarvis Island is now contained within the Pacific Remote Islands Marine National Monument, which bans commercial fishing within 370 km (200 nautical miles) of the island. However, any large pelagic catches continue to be documented as in Coulter et al. (2020). Illegal foreign fishing is a possibility, as the remoteness of this island makes regular monitoring difficult.

**Johnston Atoll**
Johnston Atoll was formerly a US Air Force base and had some limited domestic recreational fishing by resident US military personnel and civilian contractors. A reconstruction of the fisheries catch of Johnston Atoll was completed for 1950-2002 by Zeller et al. (2005), and was updated by Zeller et al. (2015); see also Zeller and Pauly (2016). However, the atoll was evacuated in 2007 due a hurricane which struck the island. Since then, the island has been largely abandoned except for small teams of researchers and staff of the US Fish and Wildlife Service, and thus domestic marine fisheries catches are assumed to be null since 2007. Commercial fishing is banned for 200 nautical miles (370 km) around the atoll however, some industrial catches for large pelagic species do still occur in this EEZ; these catches are included in Coulter et al. (2020).

**Palmyra Atoll and Kingman Reef**
Reconstruction of the marine fisheries catches of Palmyra Atoll and Kingman Reef were completed for 1950-2002 by Zeller et al. (2005, 2007) and updated to 2010 by Zeller et al. (2015); see also Zeller and Pauly (2016).

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Currently, Palmyra Atoll has a small resident population because the island is a nature reserve of the Nature Conservancy and has some US Fish and Wildlife Staff\(^6\). Palmyra Atoll and Kingman Reef are within the Pacific Remote Islands Marine National Monument, which bans commercial fishing within 50 nautical miles (93 km) from shore\(^6\). Therefore, domestic fisheries catches were assumed to be zero as of 2009.

Wake Island

Wake Island’s reconstructed catch was updated to 2017, after initial reconstructions by Zeller et al. (2005, 2007, 2015); see also Zeller and Pauly (2016). While this area is now contained within the Pacific Remote Island Marine National Monument\(^6\), recreational fishing likely continues to occur at a very small scale by the resident military personnel and contractors. Recent estimates of the population are around 150 military personnel and civilian contractors, and this was kept constant from 2011\(^6\). The recreational fishing rate was assumed to remain constant at 9.9 kg-fisher\(^{-1}\)-year\(^{-1}\), and the original taxonomic disaggregation was carried forward as 60% jacks (Carangidae) and 10% for each of soldierfish (Holocentridae), mullet (Mullidae), parrotfish (Scaridae), and surgeonfishes (Acanthuridae).

Transition from 2017 to 2018

The catch reconstructed to 2017 (Figure 6) was carried forward to 2018 using the semi-automated procedure outlined in Noël (2020), based on the pre-2018 reconstructed data. The catch data thus generated will be later replaced by a more detailed update.

Marine biodiversity protection

The ‘Howland and Baker Islands’, ‘Jarvis Island’, ‘Johnston Atoll’, ‘Palmyra Atoll and Kingman Reef’ and ‘Wake Island’ are the five regions that together form the Pacific Remote Islands Marine National Monument (PRIMNM). The monument was designated in 2009 by President George W. Bush and in 2014 was expanded by President Barack Obama (Raineault et al. 2018). The President is the only decision maker with the ability and authority to use the Antiquities Act to act swiftly and decisively to protect these national treasures (Sala et al. 2014). The monument is one of the largest marine and terrestrial protected areas on the planet, covering 1,269,000 km\(^2\) (Raineault et al. 2018), i.e., 79% of the EEZ of the monument region of 1,601,344 km\(^2\) (Zeller and Pauly 2016).

Moreover, the monument is characterized by having one of the most pristine tropical marine environments, and it includes 165 known seamounts, which are biodiversity hotspots. These ecosystems are very vulnerable to the increasingly, high water temperatures and lower pH. The fisheries that exist around these islands target deep-bottom fish, crustaceans and coral reef fishes, notably surgeonfish (Acanthuridae), goatfish (Mullidae), rudderfish (Kyphosidae), wrasses (Labridae), parrotfish (Scaridae) and soldierfish (Holocentridae) (Marine Conservation Institute 2020).

However, “[i]t is prohibited for foreign vessels to fish in the entirety of the EEZs of the islands. Infrequent Coast Guard patrols and the lag time between spotting and apprehending a violator before the boat exits US waters means few illegal entrants are caught and prosecuted. The Coast Guard patrols Kingman, Palmyra and Johnston Island EEZs using direct flights from Honolulu. Regular aerial patrols of the other EEZs do not happen unless there is an extended deployment of a Coast Guard aircraft. As a result, even if an aircraft from Hawaii is deployed to American Samoa or Guam, only one to two hours of active patrol time per dispatch

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\(^6\) [https://www.fws.gov/refuge/pacific_remote_islands_marine_national_monument/](https://www.fws.gov/refuge/pacific_remote_islands_marine_national_monument/)

could be dedicated to patrol the most remote EEZs, such as those of Howland, Baker, Jarvis or Wake Island. These factors, combined with an aging air fleet in need of modernization, challenge the Coast Guard’s ability to protect US living marine resources in the assessment areas. Despite these limitations, the Coast Guard has observed the presence in the islands’ EEZs of an average of 15 illegal fishing vessels per year for the last 4 years. In 2007, there were 11 illegal fishing vessels detected in the islands’ EEZs compared to nine illegal vessels in 2006 (Balazs 1982)” (Sala et al. 2014).

Figure 6. Reconstructed domestic recreational catches for Wake Island from 1950-2018 by taxonomic grouping.

**Results and Discussion**

The data of the reconstructions presented above for the U.S.-flag associated island areas in the Pacific Ocean are available on the website of the *Sea Around Us* (www.seaaroundus.org).

The inhabited U.S.-flag associated islands in the Pacific have small domestic catches which are largely unreported and are dominated by recreational catches largely due to large recreational fisheries in Hawaii (Figure 7).
Figure 7. Catches for Hawaii and the other U.S.-flag associated islands in the Pacific from 1950-2018 by fishing sector. Reported landings are overlaid by the black line.

Catches for Hawaii and Wake Island increased over time, while catches for American Samoa, Guam and Northern Mariana all decreased. Howland and Baker Island, Jarvis Islands, Johnston Atoll, and Palmyra Atoll and Kingman Reef catches consist entirely of industrial large pelagic fisheries catches addressed separately by Coulter et al. (2020).

The creation and usefulness of large marine protected areas, like the Pacific Remote Islands Marine National Monument65, which covers the marine waters around Howland and Baker Island, Jarvis Islands, Johnston Atoll, Palmyra Atoll and Kingman Reef, and Wake Island, has been contested by some (Jones and De Santo 2016). However, such protected areas are crucial to ensure biodiversity protection and resilience in a changing ocean.

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References (for US-Flag Islands, then by EEZ)

US-Flag Islands


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American Samoa


Guam


Hawaii


### Howland and Baker Islands


### Jarvis Island


**Johnston Atoll**


**Commonwealth of Northern Mariana Islands (CNMI)**


Palmyra Atoll and Kingman Reef

Wake Island