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UPDATED RECONSTRUCTION OF HAWAIIAN FISHERIES 1950-2010

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ABSTRACT

This is an update of the reconstruction of the State of Hawaii, including the Northwestern Hawaiian Islands, which was previously done from 1950-2002 (Zeller *et al.* 2005, 2007; Zeller *et al.* 2008). The total reconstructed Hawaiian catch is 31% higher than the reporting baseline from the Western Pacific Fisheries Information Network (WPacFIN). Recreational catch represents 17% of the reconstruction over time which demonstrates its importance to Hawaii. Bigeye scad is the most commonly caught species in the recreational fishery in Hawaii, comprising 13% of the total recreational catch. Industrial large-scale catch represents 74% of the total reconstructed catch which is largely the result of a prominent fishery for large pelagic species. Skipjack tuna (*Katsuwonus pelamis*), bigeye tuna (*Thunnus obesus*), yellowfin tuna (*Thunnus albacares*) and swordfish (*Xiphias gladius*) comprise 58% of the total reconstructed catch. The State of Hawaii collects landings statistics through the Department of Land and Natural Resources (DLNR) Division of Aquatic Resources (DAR) which is reported to WPacFIN, a branch of the National Oceanic and Atmospheric Administration (NOAA). There are many tiers to the fisheries management in the State of Hawaii which collect large amounts of data which are then made publically available. There is however shortcomings in the collection of discarded catch data.

INTRODUCTION

The Hawaiian Islands are located in the middle of the Pacific Ocean and became the 50th State of the United States of America in 1959 (Figure 1). These islands are generally divided into the inhabited Main Hawaiian Islands (MHI) and the uninhabited North Western Hawaiian Islands (NWHI). The MHI are popular tourist destinations, attracting people with plentiful beaches and coral reef systems. In the post World War II environment, tourism in the MHI has become substantially more important (Laney 2009); it has been estimated to contribute over 25% to the Hawaii Gross Domestic Product (GDP) while creating 33% of the job opportunities (Laney 2009). As a result of the growing tourism, there is a large dependency on marine ecosystems to meet demands for seafood, sport fisheries and other marine-based recreational activities such as diving, snorkeling and surfing (Smith 1993).

The NWHI are not part of the tourism hub in Hawaii and have been used as grounds for industrial large-scale fisheries in the 20th century. The NWHI have some of the most intact coral reefs and pristine waters in the world (Heinemann *et al.* 2005). These islands were established as the Northwestern Hawaiian Islands Marine National Monument by George W. Bush in 2006 and renamed the Papahānaumokuākea Marine National Monument (PMNM) in 2007 (Selkoe *et al.* 2008). The PMNM extends 50 nautical miles, surrounding the islands (Selkoe *et al.* 2008) but is not exclusive of commercial fishing practices.[1] Parts of the PMNM have been extended by President Barack Obama as of 2014. Recreational, Native Hawaiian

[1] Papahānaumokuākea Marine National Monument http://www.papahanaumokuakea.gov/about/faq.html#1 (Accessed 19 January 2015)

and commercial fishing practices are allowed within the PMNM with the appropriate fishing permit.[1] The PMNM is managed in the spirit of cooperative conservation between the National Oceanic and Atmospheric Administration (NOAA), the US Fish and Wildlife Service (FWS) and the State of Hawaii's Department of Land and Natural Resources (DLNR).[1]

While there are millions of tourists visiting Hawaii every year, the islands are home to the Polynesian people who have their own strong cultural connection to marine ecosystems with their own traditional fisheries management practices which are increasingly being incorporated into fisheries management (Jokiel *et al.* 2011). The People of Hawaii use marine resources for personal consumption as well as means for an income through fisheries and tourism.

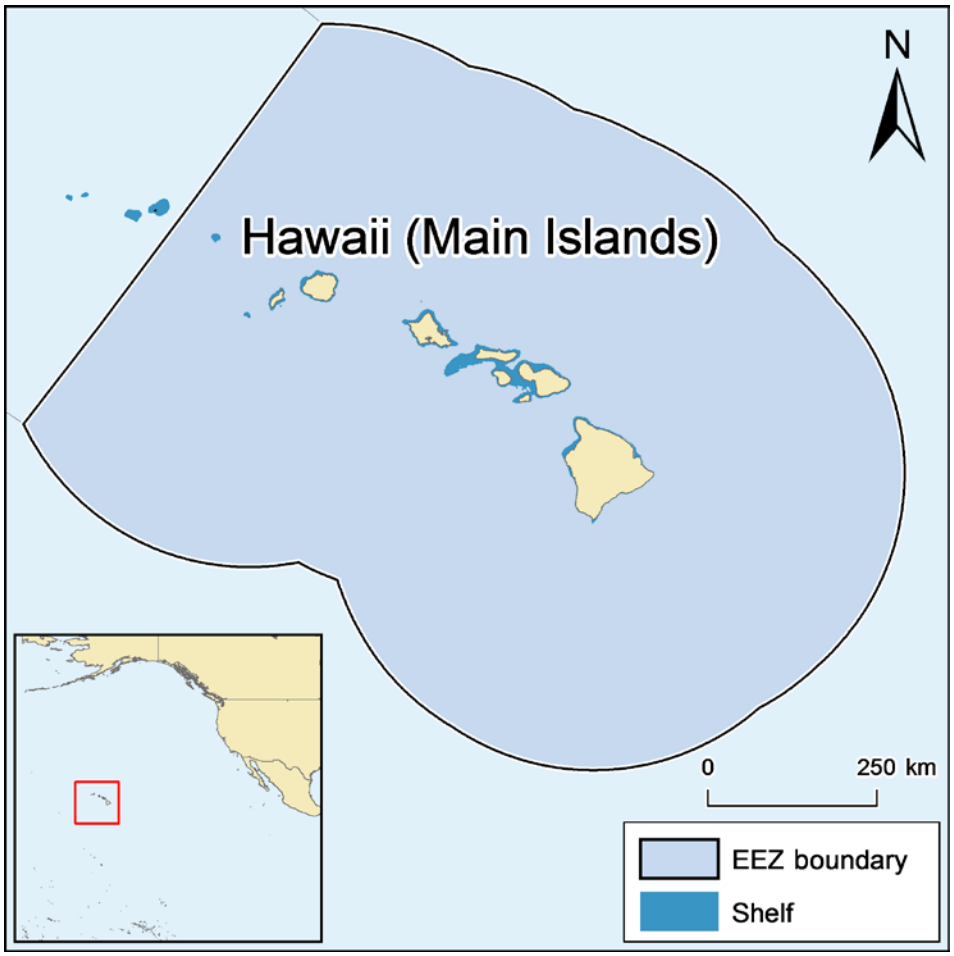

Figure 1: Map of Hawaii (Main Islands) with its Exclusive Economic Zone.

METHODS

Commercial landings

Commercial landings data from the Western Pacific Fisheries Information Network (WPacFIN) is considered the most reliable source of reported landings data from 1950-2010. The online version of these data are not separated by the North West Hawaiian Islands (NWHI) and the Main Hawaiian Islands (MHI). The reported commercial landings data are provided by species and year with totals corresponding weigh in pounds (lbs). Here, these values are converted to metric tonnes (t). The previous

report by Zeller *et al.* (2005) makes the distinction between NWHI and MHI, which was important, as there was an average of 88.3% of the commercial catch in MHI from 1950-2002. All corals, algae and tilapia are excluded from our estimates. Large pelagics however, are included as they were not included in Zeller *et al.* (2005).

The total reported commercial landings are then split into a proportion of industrial (large-scale commercial) and artisanal (small-scale commercial) landings. We assume that all landings of large pelagic species come from industrial large-scale fisheries. All other catches are designated as artisanal small-scale fisheries.

Recreational catch

The Marine Recreational Information Program (MRIP) data are used for the recreational catch of the Hawaiian Islands from 2003-2010. These data include a detailed species composition for this time. Total estimated annual recreational catch from 1950-2002 is used from Zeller *et al.* (2007). The proportion of taxa in the MRIP for each year are averaged and applied to annual totals from Zeller *et al.* (2007).

Discarded catch

Commercial discards were calculated for the full time series using methods found in Harrington *et al.* (2005). A bottomfish fishery discard rate of 19% was applied to annual reported landings of bottomfishes (26 taxa). The annual calculated discards were split with taxonomic proportions of bottomfish fishery discards from Harrington *et al.* (2005). An estimate of pelagic discards was calculated from Harrington *et al.* (2005) as well. Discards were determined for 16 pelagic taxa using discard to landing ratios from Harrington *et al.* (2005). These discard estimates cover the more important Hawaiian fisheries, however, they do not include all Hawaiian fisheries and may be considered conservative estimates.

RESULTS

Commercial landings

Total reported landings in Hawaii increase over time from 3,800 tonnes in 1950 to 14,000 tonnes in 2010 (Figure 2a). There is an initial increase in catch in 1953 and the catch remains relatively stable at an average reported landing of 6,200 $t \cdot year^{-1}$ until 1976. There is a slight decline in landings in the 1980s and a dramatic increase in 1991 to an average of 12,900 $tonnes \cdot year^{-1}$ until 2010 (Figure 2a). The total reported landings consist of a majority of large pelagic species (88%) such as skipjack tuna (*Katsuwonus pelamis*) and yellowfin tuna (*Thunnus obesus*).

For the bottomfish fisheries in Hawaii, there was initially a decline from 1,000 tonnes in 1950 to 600 $t \cdot year^{-1}$ in the early 1960s, before increasing to a peak of almost 1,600 t in 1989. Catches then declined gradually to 880 t in 2010 (Figure 2b). These trends are similar to those found in (Zeller *et al.* 2005). These landings consist mostly of bigeye scad, snappers and other scads comprising 27%, 17% and 14% of the catch respectively (Figure 2b). The bottomfish fishery contributes approximately 12% to the total reported landed catch in Hawaii over this time series.

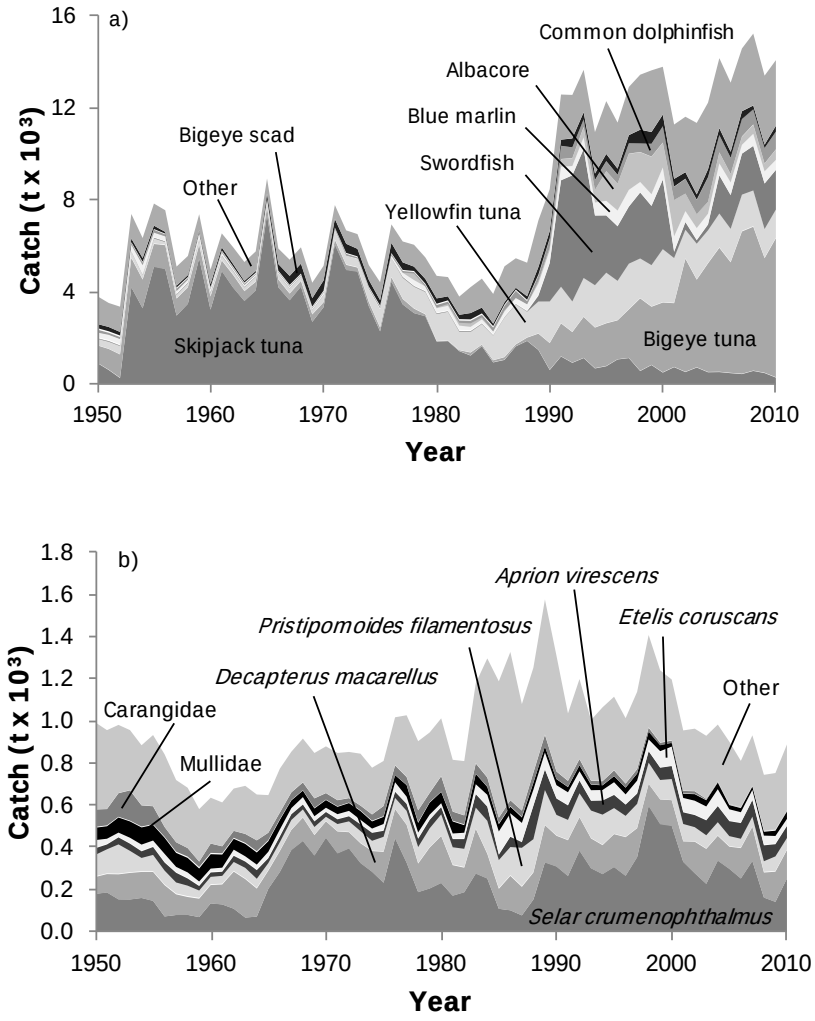

Figure 2. Reported commercial landings by taxa from 1950-2010 with a) large pelagic taxa included, and b) large pelagic taxa not included.

Recreational catch

Recreational catch in the Hawaiian Islands consists of a variety of taxa, with bigeye scad (*Selar crumenophthalmus*) making up the largest single species component, 13% of the catch (Figure 3). Yellowstripe goatfish (*Mulloidichthys flavolineatus*), skipjack tuna, bluestripe herring (*Herklotsichthys quadrimaculatus*), convict surgeonfish (*Acanthurus triostegus*), yellowfin tuna and flagtails (Kuhliidae) represent 40% collectively. This estimate is different from that of Zeller *et al.* (2005) mostly due to the inclusion of large pelagic species i.e., yellowfin tuna.

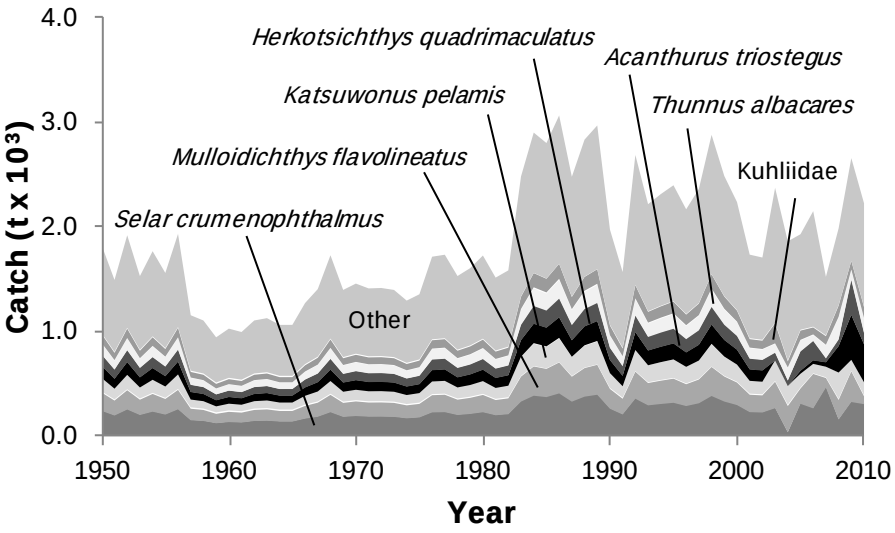

Figure 3. Reconstructed total recreational catch for the Hawaiian Islands 1950-2010.

Discarded catch

Discarded catch in Hawaii is estimated from bottomfish fisheries as well as pelagic fisheries according to Harrington *et al.* (2005). Discards of large pelagic species account for 91% of the estimated discards over the time series, while those of bottomfish fisheries comprise 9%. Skipjack tuna, swordfish, bigeye tuna (*Thunnus obesus*) and yellowfin tuna are discarded in the pelagic targeted fisheries and comprise 87% of discards overall from 1950-2010 (Figure 4).

Discarded by-catch has increased over the time series from 250 tonnes in 1950 to 760 tonnes in 2010. The discarded by-catch is quite steady from the early 1950s to the late 1970s (Figure 4). Discarded by-catch peaked at 1,700 tonnes in 1993 and have been steadily declining since then.

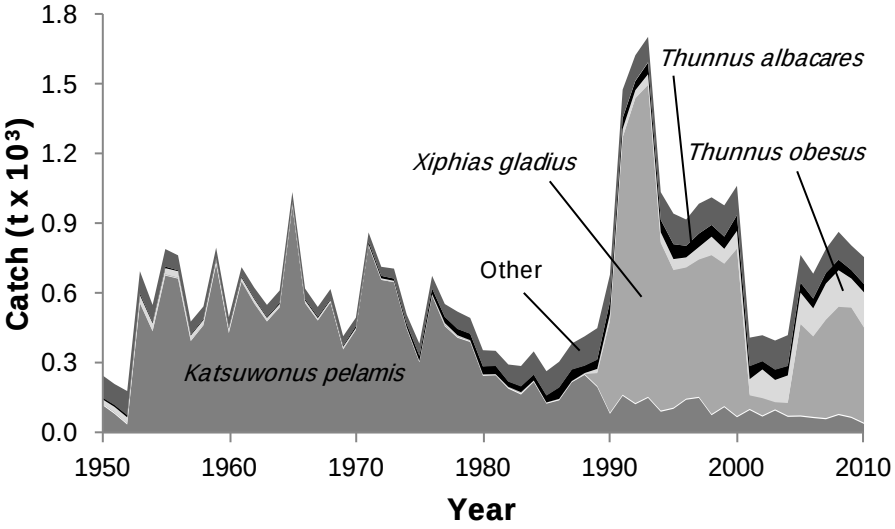

Figure 4. Reconstructed total discarded catch from the Hawaiian Islands 1950-2010.

Reconstructed total catch

The majority of Hawaiian catch is considered 'industrial' or 'large-scale commercial' (74%; landed industrial catch is 69% of the total) and reflects the large proportion of pelagic fisheries (Figure 5a). Pelagic fisheries were not estimated in the previous reconstruction of Hawaiian catch, which would explain the discrepancy with the previous results (Zeller *et al.* 2005). Artisanal catch (small-scale commercial catch) contributes 8%.

Recreational catch represents 17% of the overall reconstructed catch (Figure 5a) which is very large for recreational catch. This is likely due to the high levels of marine tourism in the state. Discarded catch represents 6% overall (Figure 5a), most of which is a result of discarding in pelagic fisheries (91%).

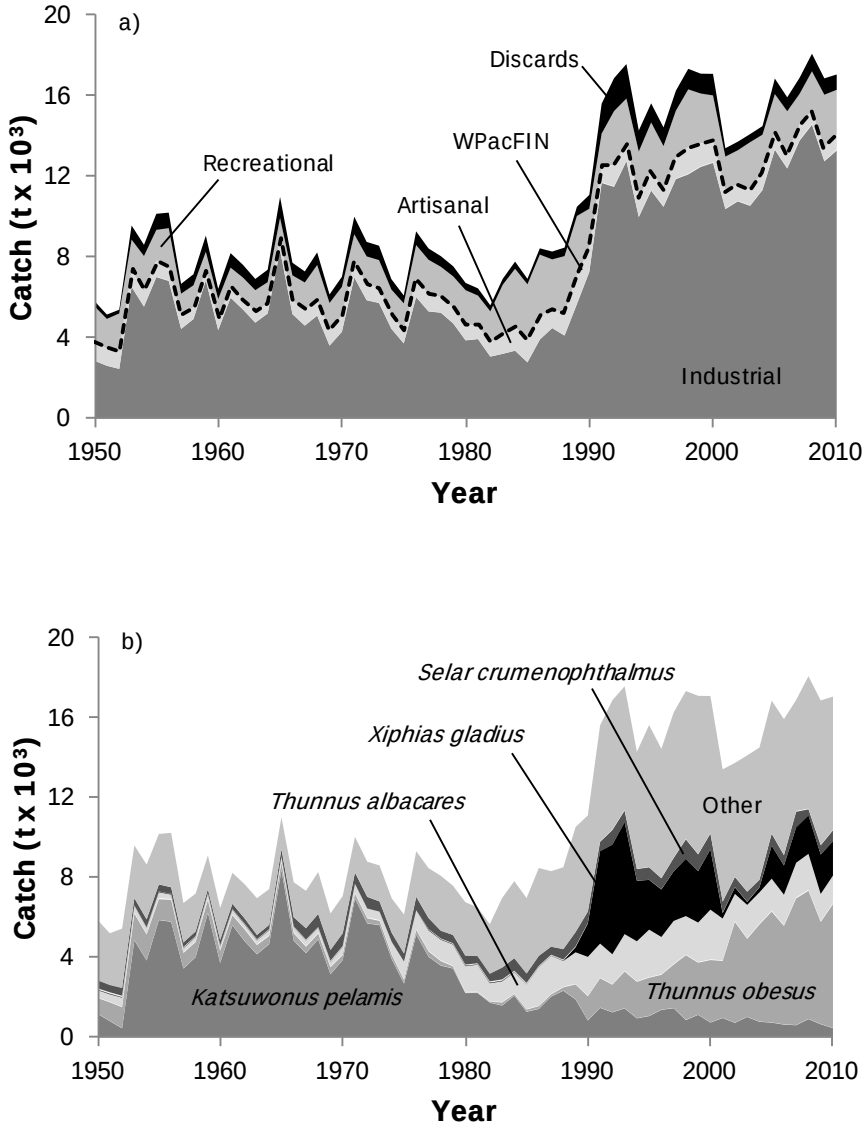

Figure 5. Reconstructed total catch for the Hawaiian Islands from 1950-2010 by a) sector, with reported WPacFIN landings overlaid as a dashed line graph, and b) major taxonomic groups. "Other" represents 171 additional taxonomic categories.

DISCUSSION

Our reconstruction of the total catch from the Hawaiian Islands from 1950-2010 is 31% higher than the reported landings from WPacFIN. This updated reconstruction demonstrates a small increase in catch between 2002, the last reconstruction (Zeller *et al.* 2005, 2007; Zeller *et al.* 2008), and 2010.

Recreational catch makes up 17% of the reconstructed catch, which seems substantial. There seems to be little true subsistence fishing in the MHI, as most non-commercial fishing can be viewed as recreational (Smith 1993). The number of tourists to the MHI has increased from 2002 to 2010 (HTA 2013), which could also have contributed to the increase in catches after 2002.

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