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Reconstruction of coral reef fisheries catches in American Samoa, 1950–2002

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Abstract Fisheries catches from Pacific Island coral reefs are rarely recorded in official statistics. Reconstruction of catch estimates with limited hard data requires interpolation and assumptions, justifiable only by the unsatisfactory alternative of continued substitution of zero catches, a common policy interpretation for ‘no data’. Uncertainties associated with reconstructions are high, requiring conservative estimation. American Samoan domestic fisheries consist of an artisanal, small-boat sector, whose commercial catches are reported, and a shore-based subsistence sector, with no regular reporting. Our catch reconstruction (with large pelagic species removed) suggested a 79% decrease in catches between 1950 (752 t) and 2002 (155 t). Accounting for rapid human population growth on the main island, the *per capita* catch rate may have declined from 36.3 kg-person⁻¹ year⁻¹ in 1950 to 1.3 kg-person⁻¹ year⁻¹ by 2002, while the catch rate for the inhabited outer islands has been independently reported as 58.6 kg-person⁻¹ year⁻¹. Catch per area of coral reef (to 50-m depth) may have declined from 5.5 to 0.7 t km⁻² year⁻¹ for the main island, and from 9.1 to 4.9 t km⁻² year⁻¹ for the outer islands, for 1950 and 2002, respectively. Summed for 1950–2002, our reconstruction suggested a 17-fold difference between reconstructed estimates and reported statistics.

Keywords Artisanal fisheries · Coral reef fisheries · Data reconstruction · Fisheries catches · Small-scale fisheries · Subsistence fisheries

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Introduction

While pelagic fisheries are the commercially most significant fisheries in many areas of the tropical Pacific (despite most commercial catches being taken by Pacific Rim nations, Dalzell et al. 1996), near-shore fisheries, particularly coral reef fisheries, are of more fundamental subsistence, social and cultural importance for many Pacific Island communities, providing more than just food, trade and recreation (Boehlert 1993; Dalzell 1996; Dalzell et al. 1996; Dalzell and Adams 1997). However, while catches of commercial large pelagic fisheries appear to be reasonably well documented (at least for recent periods), catches of small-scale, artisanal and subsistence fisheries are, despite their fundamental importance, often not recorded or under-reported by local fisheries agencies (but see Rawlinson et al. 1996). Reasons for this are numerous, and range from limited resources to comprehensively account for these spatially dispersed fisheries, to the simple fact that these fisheries are often not mandated for reporting by fisheries agencies traditionally focused on commercial sectors. Hence, extractions of these resources usually remain under-represented in official statistics and national economic accounts (Gillett and Lightfoot 2002). However, incomplete accounting or estimation of catches for all sectors, and the resulting limited understanding of historical trends are a concern, given recent illustrations of the historical impacts of fishing and other human activities on marine resources and ecosystems (Jackson et al. 2001; Christensen et al. 2003; Rosenberg et al. 2005).

The reconstruction of catch time series in cases where ‘hard’ time series data are lacking or incomplete requires interpolation and bold assumptions, justifiable only by the unsatisfactory alternative of continuing to report nothing for fisheries sectors that are not covered by existing reporting systems, which inadvertently may end up being interpreted as catches of zero in the senior policy- and decision-making arena (Pauly 1998). Given

the highly scattered nature of many coral reef fisheries, especially subsistence fisheries, accounting of their catches can usually not be accomplished with traditional reporting mechanisms devised for commercial sectors that generally rely on a limited number of relatively centralized landing or marketing points. However, in many instances, small-scale studies have been undertaken, reporting local catches or catch rates for specific periods, locations and/or gear types (e.g., Craig et al. 1993), often relying on creel survey techniques that seem ideally suited for these types of fisheries (e.g., Rawlinson et al. 1996). Information is also often hidden in unpublished, gray literature reports (e.g., Saucerman 1994), or form part of published studies with a primary focus other than catch reporting (e.g., Craig et al. 1997; Léopold et al. 2004). Such diverse sources can form the foundation for deriving estimates of catch, catch rates per unit area, or *per capita* catch rates during a given time interval. These ‘reference data points’ provide time point estimates around which total catch estimates can be formed. Once all quantitative data have been extracted from the diverse information sources, interpolations (e.g., via *per capita* catch rates) between reference data points, and expansions (e.g., via human population census data) to island-wide or country-wide estimates can be employed to fill in the periods for which hard time-series data are missing. While, at first sight, interpolated periods may seem unsupported by data, the common alternative is to leave years blank (no hard data), which later may inadvertently be interpreted as catches of zero by senior decision makers, generally removed from the detailed scientific knowledge of the fisheries. However, such ‘zero’ interpretations in cases of missing data are generally more incorrect than any interpolated estimate. Thus, the key aspect of the approach used here is psychological, as one has to overcome the notion that “no information is available”, which is not necessarily an incorrect assumption when dealing with fisheries, but a profoundly misleading one (Pauly 1998).

Without better attempts at accounting for historic extractions of living marine resources for all fisheries sectors, we cannot begin to fully understand the direct and indirect economic and cultural value of these resources, or the risks and foregone benefits associated with overfishing or ecosystem degradation in American Samoa. This is of concern, given that human growth rates in American Samoa are high (e.g., 2.1% per year, Craig 2002; Green 2002). Furthermore, natural resources have been reported as declining in American Samoa (Craig 1995; Tulagi and Green 1995), leading to concerns of overfishing on the main island of Tutuila (Craig et al. 1999; Craig 2002; Green 2002). Significantly, by estimating historic baselines and time-series of catches (even if estimated with high uncertainty) we can establish historic perspectives that may contribute to improved management, leading to sustainability (Pauly et al. 2002; Rosenberg et al. 2005).

The purpose of the present study was to assemble available information and data on catches for the coral reef fisheries of American Samoa, and to derive estimates of total removal of coral reef fisheries resources for 1950–2002. Our starting points were the official catch statistics for American Samoa as published by Western Pacific Fishery Information Network (WPacFIN), NOAA, www.pifsc.noaa.gov/wpacfin, based on data collected and reported by the American Samoan Department of Marine and Wildlife Resources (DMWR). These official statistics were supplemented by data for fisheries sectors not covered by the DMWR data collection scheme, sourced from peer reviewed and gray literature sources, and amended by local expert knowledge. The aim was to derive estimates of likely historic total catches of all coral reef fisheries for American Samoa covering the full time period, and to illustrate, by example, an approach suited for deriving best estimates of total catches for countries with missing fisheries data. The present reconstruction estimates excluded large pelagic species (i.e., tuna and billfishes) and associated fisheries, and the remainder was treated as the target groups: reef fisheries, including the so-called ‘bottom-fishery’ (Anonymous 2004), as well as catches of coastal, reef-associated small pelagic species such as carangids, e.g., the culturally important big-eye scad (*Selar crumenophthalmus*). We compared these reconstructed total estimates to the official globally reported statistics for American Samoa as presented by FAO based on member country reports.

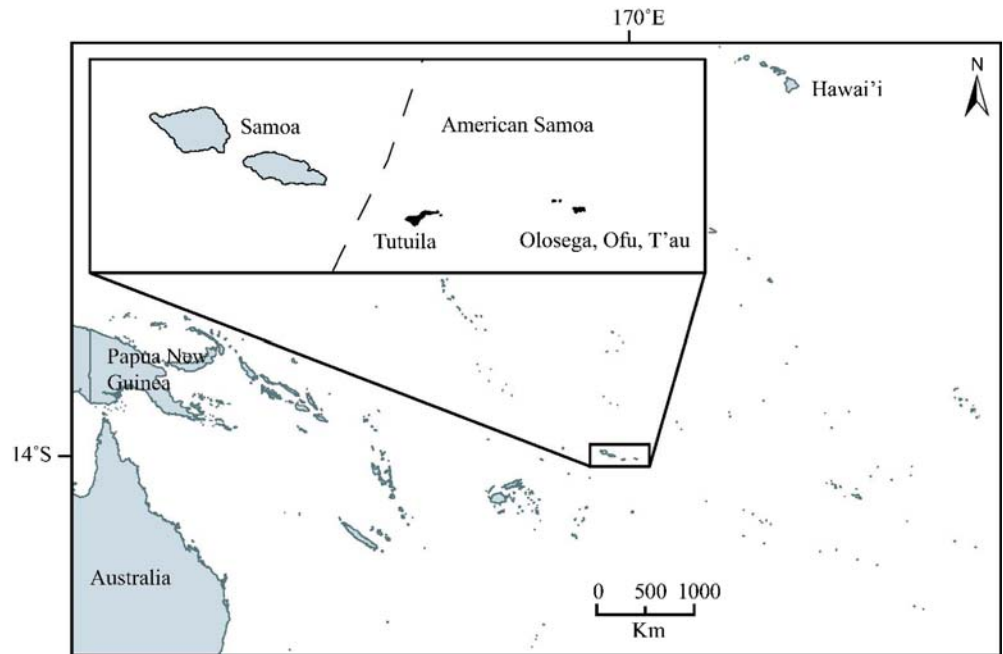
Methods

Data sources and approach

While Craig et al. (1993) differentiated four types of domestic fisheries in American Samoa (central South Pacific, 14°S, 168–173°W, Fig. 1), we excluded those targeting large pelagic species (i.e., tuna and billfishes) from consideration, and focused on the artisanal, small-boat fishery for bottom- and reef-species, and the shoreline subsistence fishery.

Western Pacific Fishery Information Network (NOAA, www.pifsc.noaa.gov/wpacfin) presents the data collected by the DMWR going back to the early-1980s. Examination of the WPacFIN data and associated information (Aitaoto 1985; Craig et al. 1993; Hamm et al. 2003) indicated that these data pertained to the artisanal, small-boat fleet, and provided the best estimates for catches of this sector back to the early-1980s. The second sector considered here, the shoreline subsistence fishery, was first examined by Hill (1978) and Wass (1980). During the first half of the 1990s, an inshore creel survey estimated shoreline catches for the main Island Tutuila, but was discontinued (Ponwith 1991; Craig et al. 1993; Saucerman 1994, 1996). Between 1991 and 1995, WPacFIN reported shoreline subsistence catch estimates based on this survey. However, differences in the catch estimates between

Fig. 1 Location of American Samoa (14°S, 168–173°W) in the western South Pacific, with the expanded insert showing the main island of Tutuila, the ‘outer islands’ of Olosega, Ofu and T’au, as well as neighboring Samoa (formerly Western Samoa) with the associated border (dotted line)



WPacFIN records and original sources (Ponwith 1991; Craig et al. 1993; Saucerman 1994), combined with uncertainties about the procedure used to derive the expanded WPacFIN estimates from the creel surveys suggested that the original sources were more reliable (D. Hamm, WPacFIN personal communication). Thus, the procedure for reconstructing likely total catches was based on a suite of ‘hard data point’ estimates, augmented by local expert knowledge, and connected by interpolations as set out below:

Artisanal fisheries

- (1) 1950–1979: As no published information was available, we relied on local expert opinion (P. Craig), and assumed that the primarily commercial, artisanal fisheries developed during or after WWII (Table 1). To remain conservative, we set artisanal catches to zero in 1950 and interpolated *per capita* catch rates between 1950 and 1980 (see below), and expanded to catch estimates using human population statistics interpolated linearly between the decadal census years (www.census.gov/ipc/www/idbprint.html);
- (2) 1980–1981: We used total catches reported in the American Samoa Statistical Digest (Anonymous 1988). These data were based on the same creel survey as used in (3) below, but pre-dated WPacFIN database reporting. As no taxonomic breakdown was reported by Anonymous (1988), we accounted for catches of pelagic species for 1980–1981 by removing the 1982–1984 average percentage for pelagic species (40.8%) as per WPacFIN data, resulting in non-pelagic catch estimates of 41 and 51 t for 1980 and 1981, respectively;
- (3) 1982–2002: The data reported by WPacFIN, and based on the DMWR surveys, were taken as artisanal, small-boat catches (www.pifsc.noaa.gov/wpacfin, data extracted May 26, 2004). We removed the catches of pelagic species by taxon, thus retaining only bottom-fish and reef-associated species, with catches fluctuating from 60 t in 1982 to 34 t in 2002.

Subsistence fisheries

The shore-based subsistence fisheries were separated into two geographic components, the main island (Tutuila) and the inhabited ‘outer islands’ (Ofu, Olosega, T’au and minor islands) (Table 1). This was done for two reasons: (a) the studies undertaken in the past (Wass 1980; Ponwith 1991; Craig et al. 1993; Saucerman 1994, 1996) restricted their sampling to the main island, and (b) the ‘outer islands’ have not experienced the increasing human population pressure of the main island, are deemed to have remained more stable in their near-shore fisheries pattern over the last decades, and are thought to be more representative of baseline subsistence fisheries conditions (Green 2002; P. Craig, personal observation). Data sources for the main island were extensively literature based, as the only available electronic time-series (WPacFIN 1991–1995) was considered less reliable than the original sources (D. Hamm, WPacFIN personal communication). The sources used consisted of the best studies available to us, containing island-wide expansions, or clear descriptions of data to permit expansion.

The procedure for subsistence catch reconstruction was as follows:

Table 1 Sources, values and applicable time periods of data point estimates used for the reconstruction of American Samoan non-pelagic fisheries catches for the artisanal and subsistence fisheries

Year	Source		Comment	Catch estimate (t)
	Reference	Data		
Artisanal: American Samoa				
1950	P. Craig (see methods)	0	Assumed started after WWII	0
1980	Anonymous (1988)	69,624 kg	1982–1984 pelagic percentage removed	41
1981	Anonymous (1988)	86,510 kg	1982–1984 pelagic percentage removed	51
1982–2002	WPacFIN	70,738–7.16×10 ⁶ kg	Pelagic spp. removed	60–34
Subsistence: main island (Tutuila)				
1950	P. Craig (see methods)	36.3 kg·person ⁻¹ year ⁻¹	60% of 2002 outer island catch rate	598
1980	Wass (1980)	266,196 kg (8.7 kg·person ⁻¹ year ⁻¹)	Main island estimate	266
1991	Craig et al. (1993)	199,129 kg (4.3 kg·person ⁻¹ year ⁻¹)	Main island estimate	199
1992	Saucerman (1994)	43% decline from 1991	Main island estimate	113
1993	Saucerman (1994)	45% decline from 1992	Main island estimate	62
1994	Saucerman (1996)	89,000 kg	Main island estimate	89
1995	Saucerman (1996)	136,000 kg (2.6 kg·person ⁻¹ year ⁻¹)	Main island estimate	136
2002	Coutures (2003)	39,429 kg (0.7 kg·person ⁻¹ year ⁻¹)	Main island estimate	39
Subsistence: outer islands (Ofu, Olosega, T'au)				
2002	P. Craig (unpublished data)	82,000 kg (58.6 kg·person ⁻¹ year ⁻¹)	Ongoing investigation	82

(1) Hard data time point estimates (Table 1):

- (a) Main island Tutuila: For 1950 we assumed a *per capita* catch rate of 36.3 kg·person⁻¹ year⁻¹, based on a 40% lower subsistence catch rate than that observed for ‘outer islands’ in 2002 (see below). We applied this reduced catch rate to Tutuila in 1950 despite the likely high reliance on subsistence fishing by the majority of the human population of the main island at that time, as more opportunities for alternative livelihoods and cash employment were available on Tutuila compared to the outer islands in 1950. While we considered this a conservative estimate, it is subject to high levels of uncertainty, and may need to be viewed with caution. For 1980, we relied on the study by Wass (1980) for main island catches of 266 t, while for 1991 we utilized the estimate from Craig et al. (1993) of 199 t for the main island (Table 1). For 1992–1995, we used Saucerman’s (1994, 1996) data and reported percentage decline of catches relative to the 1991 estimate by Craig et al. (1993), resulting in 113, 62, 89 and 136 t for 1992, 1993, 1994 and 1995, respectively. Finally, for the year 2002, we used the maximum estimate by Coutures (2003) of 39 t (Table 1). The maximum, rather than the average estimate was used here, to account for the suggested underestimation of effort (p. 15 Coutures 2003; F. Aitaoto, NOAA WPRFMC, personal communication).
- (b) Outer islands: No published data were available for these islands. However, recent work by one of us (P. Craig) indicated that a previous catch estimate for these islands of approximately 7.7 t for 1991

(Craig et al. 1993) was a substantial underestimate. Instead, a total catch estimate of 82 t for 2002 was used, derived as part of an ongoing investigation into subsistence fisheries in American Samoa (P. Craig, unpublished data). This was converted into a *per capita* catch rate of 58.6 kg·person⁻¹ year⁻¹ (Table 1) for the ‘outer islands’ using population statistics. We considered this a representative baseline subsistence catch rate for American Samoa under minimal influence of urbanization, development and pollution.

(2) Time-series interpolation:

- (a) Main island Tutuila: For 1950–1980, we interpolated between the *per capita* catch rates of 36.3 kg·person⁻¹ year⁻¹ for 1950 and 8.7 kg·person⁻¹ year⁻¹ for 1980 (Table 1), and expanded to total catches using human population data;
- (b) For the period 1981–1990, we interpolated via *per capita* catch rates based on the 1980 and 1991 hard data point estimates (Table 1), and expanded catches for the human population sizes on Tutuila from 1981 to 1990;
- (c) For the period 1996–2002, we interpolated catches via *per capita* catch rates based on the 1995 and 2002 hard data points (Table 1) and expanded using human population size.
- (d) Outer islands: We carried the *per capita* catch rate of 58.6 kg·person⁻¹ year⁻¹ recorded for 2002 (P. Craig, unpublished data) back to 1950, and expanded catches using human population data for these

islands. Thus, we assumed that, given the low human population density and the ongoing reliance on subsistence fishing on the outer islands, this catch rate reflected long-term average conditions.

Catch rates

To enable comparisons with other studies, we converted reconstructed total catch estimates (artisanal plus subsistence) into catch per km² of coral reef (to 50-m depth, including all substrates) and into *per capita* catch of seafood (excluding pelagics) using human population data (U.S. Census Bureau data www.census.gov/ipc/www/idbprint.html). American Samoa has 479 km² of coral reefs to a depth of 50 m, with 108.2 and 16.9 km² associated with the main Island Tutuila and the outer inhabited islands, respectively (A. Graves, National Park of American Samoa, unpublished data).

Results

Examination of globally reported fisheries catch statistics, as reported by FAO based on American Samoan reporting, with large pelagic species (i.e., tuna and billfishes) removed, but with ‘miscellaneous’ groups retained in full, indicated that prior to 1970, no data appear to have been reported by American Samoa to FAO (Fig. 2a). The ‘miscellaneous marine fishes’ category made up approximately 99% of the reported taxa in the data reported by FAO up to 1993, and likely contained pelagic species. The data reported by WPacFIN for non-pelagic species, representing the local (American Samoa) official statistics for the small-boat based artisanal fisheries since 1980, matched the FAO (non-pelagic) pattern relatively well, at least for the latter years (Fig. 2a). While this reflected a well established reporting mechanism from the local (American Samoa) to the international level (FAO), it also illustrated that the artisanal, small-boat catches appear to be the only non-pelagic catches reported by the government of American Samoa to the global community via FAO.

The catch reconstruction as undertaken here for the shore-based, subsistence fisheries, whose catches were not represented in the officially reported statistics, displayed two distinct trends (Fig. 2b). Based on the reconstruction approach for the main island, Tutuila, the catch estimates suggested a decline in subsistence catches from 598 t in 1950 to 39 t in 2002, with a distinct, short-term drop in the early 1990s. In contrast, and driven by the data-limited nature of our approach, reconstructed catches for the ‘outer islands’ simply reflected the decrease in population levels on the islands, and reconstructed catch estimates ranged from 154 to 82 t between 1950 and 2002 (Fig. 2b). The artisanal catches, as reported by American Samoa and WPacFIN since 1980, and reconstructed back to 1950, contributed the smallest component of total

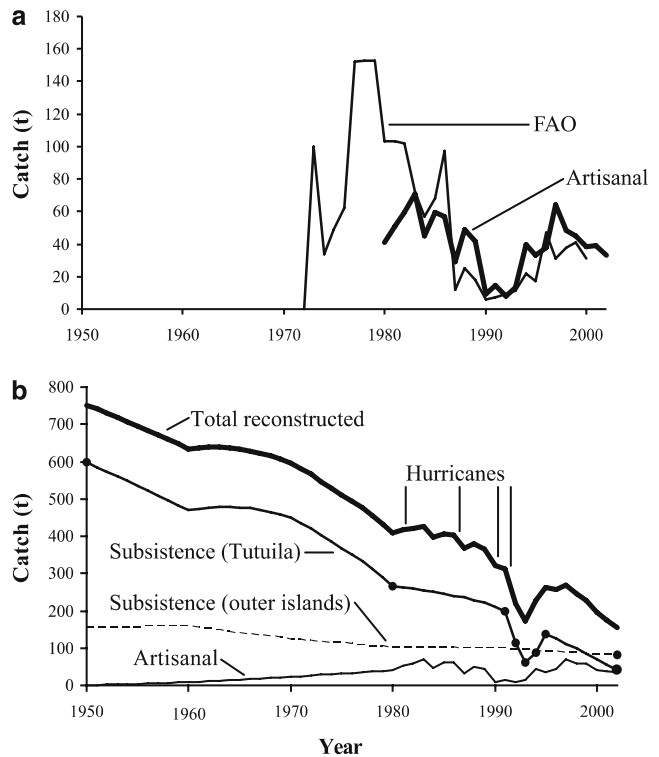


Fig. 2 Catch time series for non-pelagic fisheries in American Samoa, with (a) Officially reported catch time series for non-pelagic species as presented by two sources: FAO (FISHSTAT 2001 data) and NOAA WPacFIN (representing artisanal, boat-based fisheries). Until 1993, ‘miscellaneous marine fishes’ made up approximately 99% of the FAO reported catches, and therefore likely contained pelagic species, possibly explaining some of the discrepancy in catches between the two sources for the early period; and (b) Reconstructed (1950–1979) as well as reported catches (1980–2002) of the boat-based, artisanal fisheries, and reconstructed catches for the shore-based, subsistence fisheries of American Samoa as estimated by the present study. Subsistence catches were estimated separately for the main island Tutuila, and the outer islands (Ofu, Olosega, T’au and minor islands), with hard data points (Table 1) indicated (filled black circle). The time periods of major hurricanes in the last 20 years are indicated. Total reconstructed coral reef fisheries catches for American Samoa (boat-based, artisanal and shore-based, subsistence fisheries combined) are also shown

reconstructed catches (Fig. 2b). Based on our reconstruction, the picture for the whole of American Samoa may be one of distinctly declining total catches, from an estimated peak of 752 t in 1950 to a low of 155 t in 2002 (Fig. 2b), driven by a likely decline of 84% in the subsistence sector of the fisheries.

Based on our reconstruction approach, and summed over the time period considered here (1950–2002), the officially reported data (artisanal sector) may have underestimated the likely total historic catches for both sectors combined (artisanal and subsistence) by a factor of 17.3. Our reconstruction also suggested that the officially reported data failed to give any indication of the likely decline in coral reef fisheries resources of 79.3% (artisanal and subsistence combined) experienced by the local population (Fig. 2b).

Catch rates

Estimated catch per area of coral reef (to 50-m depth), based on the reconstructed catch estimates for the entire American Samoan territory, ranged from about $1.6 \text{ t km}^{-2} \text{ year}^{-1}$ at the start of the time series to $0.4 \text{ t km}^{-2} \text{ year}^{-1}$ in 2000 (Table 2). This estimated decline in area catch rates was driven by the reconstructed data for the main island, Tutuila, where estimated rates may have declined from $5.5 \text{ t km}^{-2} \text{ year}^{-1}$ to approximately $1.03 \text{ t km}^{-2} \text{ year}^{-1}$ between 1950 and 2000 (Table 2). Estimated catch rates for the outer islands declined less, from about $9 \text{ t km}^{-2} \text{ year}^{-1}$ in 1950 to approximately $5 \text{ t km}^{-2} \text{ year}^{-1}$ by 2000 (Table 2).

The human population of American Samoa has grown rapidly in the last few decades. However, this growth occurred only on the main island of Tutuila, while the outer islands experienced a steady decline in resident population (Table 2). Taking into account these population changes, the estimated *per capita* catch rate appeared to have declined considerably on Tutuila, from about $36 \text{ kg-person}^{-1} \text{ year}^{-1}$ to $1.3 \text{ kg-person}^{-1} \text{ year}^{-1}$ over the time period considered here. The *per capita* catch rate for ‘outer islands’ has remained constant in our reconstructed data ($58.6 \text{ kg-person}^{-1} \text{ year}^{-1}$, Table 2) due to the nature of our reconstruction in this data-poor context.

Table 2 Summary information for reconstructed coral reef fisheries catches for American Samoa

Year	Estimated catch (t)	Catch/area ($\text{t km}^{-2} \text{ year}^{-1}$)	Population	<i>Per capita</i> catch ($\text{kg-person}^{-1} \text{ year}^{-1}$)
American Samoa (479 km ²)				
1950	752	1.57	19,100	39.4
1960	635	1.35	20,000	31.8
1970	596	1.25	27,267	21.9
1980	409	0.85	32,418	12.6
1990	322	0.67	47,199	6.8
2000	195	0.41	57,301	3.4
Main island (Tutuila; 108.2 km ²)				
1950	598	5.52	16,468	36.3
1960	477	4.41	17,305	27.6
1970	473	4.37	25,155	18.8
1980	307	2.84	30,686	10.0
1990	221	2.05	45,485	4.9
2000	112	1.03	55,886	2.0
Outer islands (Ofu, Olosega, T’au; 16.9 km ²)				
1950	154	9.12	2,632	58.6
1960	158	9.34	2,695	58.6
1970	124	7.32	2,112	58.6
1980	101	6.00	1,732	58.6
1990	100	5.94	1,714	58.6
2000	83	4.90	1,415	58.6

Estimated catches are presented also as catch per surface area of coral reefs including all substrates to a depth of 50 m, and as *per capita* catch of reef species, for American Samoa in total (including offshore banks where bottom-fishing occurs), and for the ‘main’ and ‘outer’ islands separately

Discussion

The historic catch reconstruction attempt as undertaken here suggested a 79.3% decline in likely total catches of coral reef- and bottom-species, as well as reef-associated pelagics around American Samoa, from an estimated total fisheries catch of 752 t in 1950 to an estimated 155 t in 2002. Interesting was the large discrepancy (17.3-fold difference) between the reconstructed scenario and official reported statistics consisting of small-boat based artisanal catches only. The historic focus of many national fisheries data, and therefore FAO statistics dependent on national reports, were on reporting commercial landings data for economic development purposes (Ward 2004). Thus, it was not surprising that the official FAO statistics for American Samoa reflected only the (predominantly commercial) small-boat artisanal bottom fish catches reported by American Samoa through WPacFIN (as well as the large pelagic species excluded here). Nevertheless, officially reported statistics of a country are generally used as indicators of the economic benefits derived from fisheries as part of national accounting, without fully accounting for those fisheries sectors and catches not considered by official records (but see Gillett and Lightfoot 2002). If our reconstruction was indeed ‘closer to the truth’ with regards to total catches than the currently used official data, then the latter may have substantially under-represented the true nature of and economic benefits derived from fisheries for American Samoa over the last 50 years.

In contrast to the predominantly commercial, artisanal boat-based fisheries, the historically large shore-based subsistence fisheries and its catches have not been estimated or reported on an equal and regular basis (although several studies were made over the last 20+ years), despite being known to be culturally and socially important (Craig et al. 1993; Dalzell et al. 1996). While commercial fisheries components undoubtedly make direct economic contributions to the American Samoan economy, subsistence fisheries play a potentially highly significant role in island culture, and make important food security and indirect economic contributions to households (Gillett and Lightfoot 2002), given the generally low levels of wage-income by islanders (Craig et al. 1993; Green 1997).

The shore-based catches on the main island Tutuila have been reported as declining at least since the 1970s (Ponwith 1991; Craig et al. 1993). The 79.3% decline in overall American Samoa coral reef catches since the 1950s, as suggested here supported the argument of overfishing. In the past, many Pacific Islanders have relied heavily on coral reef resources, often as their primary source of protein (Dalzell et al. 1996). While economic and social changes over the last 50–100 years have resulted in islanders’ diet becoming more variable and often increasingly reliant on imported foods, coral reef resources remain a major element in food security (Dalzell et al. 1996). For American Samoa, the apparent increases in reef fish imports from Samoa (formerly

Western Samoa) in recent years also indicated that local catches did not meet the demand (Craig et al. 1993). Furthermore, the small size of fish observed in catches and surveys (Craig et al. 1993; Green 1997) also supported concerns about overfishing. Interestingly, the annual *per capita* catch, as estimated here for the main island Tutuila, may have declined from about 36 to 2 kg-person⁻¹ year⁻¹ between 1950 and 2000. In contrast, Samoa has a reported *per capita* fish supply of between 32.0 and 61.5 kg-person⁻¹ year⁻¹ (Spalding et al. 2001; Gillett and Lightfoot 2002). Given the proximity and historic cultural affinity between the two Samoas, one could assume that American Samoa would have a similar or slightly lower consumption pattern (due to increased westernization), hence the high and growing rates of imports of reef fishes into Tutuila (Craig et al. 1993). Similarly, *per capita* catch for the 'outer islands' was recently estimated at approximately 58 kg-person⁻¹ year⁻¹ (P. Craig, unpublished data). This compared favorably with estimates of 61 kg-person⁻¹ year⁻¹ as the average *per capita* catch in the Polynesian Islands in the mid 1990s (Dalzell et al. 1996), yet was considerably below rates reported for other islands, e.g., 183 kg-person⁻¹ year⁻¹ for Kiribati or 124 kg-person⁻¹ year⁻¹ for Palau (Gillett 2002).

Clearly, high and often unknown levels of uncertainty are associated with reconstructions such as ours. This applied particularly to the first few decades of the time period considered here, due to our reliance on assumed subsistence catch rates for Tutuila in 1950 (36.3 kg-person⁻¹ year⁻¹), based on 60% of the catch rates reported for the outer islands in 2002 (P. Craig, unpublished data). While this information did not relate directly to the time period in question, we considered this reduced catch rate a likely conservative estimate of potential historic rates of subsistence catch for post-war Tutuila, and it compared well with other reported rates, e.g., consumption rates of locally caught fish of 32.5–41.2 kg-person⁻¹ year⁻¹ in Fiji (Rawlinson et al. 1996).

Dalzell and Adams (1997) suggested a maximum sustainable yield for reef fisheries for American Samoa of about 20 t km⁻² year⁻¹ (Pacific Island range: 0.3–64 t km⁻² year⁻¹), making the historic maximum estimate of 1.6 t km⁻² year⁻¹ presented here (range 0.3–1.6 t km⁻² year⁻¹) for the whole of American Samoa fit within the lower range of these limits. Dalzell and Adams (1997) also presented catch rates for the main island of Tutuila of 7.04 and 17.03 t km⁻² year⁻¹ for the mid 1990s and early 1980s, respectively, higher than those calculated from our reconstructed estimates (0.7–5.5 t km⁻² year⁻¹). Dalzell and Adams (1997) based their results on the inshore creel survey study area along Tutuila's south coast, which is the most densely populated area of Tutuila, while our estimates were based on island-wide catch expansions. Similarly, our estimated catch rates for 'outer islands' (4.9–9.3 t km⁻² year⁻¹), while being higher than for Tutuila, also fitted well within the lower range of Dalzell and Adams' (1997) estimates. However, area catch rates can be influenced

by the depth ranges used for coral reef area estimation, making comparisons between sources difficult if depths are not defined clearly. Although our data for surface area of coral reefs (to 50-m depth) underestimated the actual area from which fish were caught (as our reconstructed catch data included deeper-water bottom fish catches), our area catch rates were within the lower bounds of published information (e.g., Dalzell and Adams 1997), and therefore one may consider the catch rates estimated here to be conservative. Furthermore, as Fig. 2b indicates, the majority of catches were taken by subsistence fishing, which is associated with shallow, inshore reef areas, thus validating our choice of the 50-m depth contour for area estimation.

We suggest that the reconstructed catch estimates presented here may be more 'accurate' (i.e., closer to the unknown true value) than the official reported statistics. Furthermore, we propose that no matter how uncertain their accuracy, conservative approaches to catch reconstruction, such as presented here, may contribute significantly to our understanding of small-scale, coastal fisheries. While accounting procedures for future 'hard' data collection need to be implemented, it is also important that we obtain a better understanding and appreciation of likely historic trends, as they provide baselines for comparison to present and future trends and developments. The need for this has also recently been demonstrated for non-tropical fisheries species (e.g., Rosenberg et al. 2005). While most experts in coral reef fisheries may freely acknowledge that past catches for American Samoa were likely higher than officially reported catches, descriptive accounts, however eloquent, cannot replace the visualization of time series of assumption-based reconstructed estimates such as the ones shown here, even at the risk of such historic estimates eventually being viewed as 'real'.

In order to validate if the estimates presented here are representative, and to ensure more complete accounting of benefits derived from fisheries to the American Samoan economy and society, American Samoa should re-establish and maintain country-wide estimations of their non-commercial fisheries sector. Given the likely high monetary and human resource costs of the required surveys, consideration could be given to undertaking these surveys on a regular, even if non-annual basis, and applying interpolations such as those used here for the intervening periods. This approach is commonly used in human population censuses.

The present study documented a procedure and conceptual approach that can be used to derive 'best estimates' of unreported historic fisheries catches. While we acknowledge that American Samoa may be data-rich (at least after 1980) compared to many other countries, we feel that similar approaches may be used to obtain better (often the first) representations of likely small-scale and/or non-commercial fisheries catch time series for which at least some information is usually available. As shown elsewhere (Zeller et al. 2005), recovering 'lost' data or otherwise 'forgotten' information is a worthwhile

scientific exercise that can provide historic baselines of knowledge for comparison with current and future trends, and thus provide a valuable service to science and society. We hope the present study will encourage colleagues to engage in, and agencies to allocate resources to catch reconstruction efforts to provide the scientific, management and policy community with a more realistic picture of likely total fisheries extractions over the last 50+ years in the tropical Pacific and elsewhere.

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