Reconstructed catches of Samoa 1950–2010[1]

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Abstract

Samoa has a long history of marine resource use, and today maintains a strong connection to the marine environment. Despite the acknowledged importance of marine resources for food security, Samoan fisheries landings have been under-reported since the FAO started reporting fisheries catch data on behalf of Samoa in 1950. Catches are particularly under-represented in the early years, but reporting has improved somewhat since the 1990s. Using a consumption-based approach, we linked historical information with current patterns of marine resource use to create a complete time series of total marine fisheries catches over the 1950 to 2010 time period. Estimated total marine fisheries catches were 627,700 t for the 1950-2010 period, which is 2.8 times the reported landings submitted to the FAO of almost 220,900 t. In recent years, total reconstructed catches included estimates of under-reported subsistence and artisanal catches, by-catch and discards. This study illustrates the importance of small-scale fishing in Samoa, as well as a need for better monitoring of all fisheries sub-sectors to prevent further declines in fisheries resources vital to food security.

Introduction

Samoa, a small Pacific island country, is comprised of two large islands (Savai'i and Upolu), and seven small islets (two of which, Manono and Apolima, are inhabited). Geographically, Samoa lies between 13° and 15° S, and 168° and 173° W, and is situated in the Western South Pacific. Samoa has a land area of 2,935 km² and an oceanic shelf of 4,500 km² (www.seaaroundus.org; Figure 1). Due to the close proximity of neighbouring countries (American Samoa, Tonga, and Wallis and Futuna), Samoa's Exclusive Economic Zone (EEZ) does not extend 200 nautical miles offshore, which results in Samoa having the smallest EEZ (131,812 km²) in the Pacific region. Barrier reefs encircle most of the islands except on the north coast of Upolu, the main inhabited island, where the shelf extends 14 miles offshore (Gillett 2002).

Samoa is thought to have first been settled by Polynesians 3,000 years ago (Meleisea 1987). In 1830, missionaries from the United Kingdom, the first in a series of three colonial powers, landed in Samoa (Thornton *et al.* 2010). The country was then turned over to Germany from 1914 to 1943 (Meleisea 1987). New Zealand took over as colonial ruler from 1944 until 1962, when Samoa, then known as Western Samoa, gained independence (Meleisea 1987). Western Samoa changed its name to Samoa in 1997. Today the country is one of the poorest in the Pacific region with a *per capita* GDP in 2009 of $2,926 USD.[2] For decades the economy of Samoa has relied on agricultural exports such as coconuts, cocoa and bananas (Beaglehole 1947; Zann *et al.* 1985). More recently, since the establishment of a locally based tuna fishery, marine exports have become a major commodity valued at 10.4 million USD, or 63% of the country's total exports in 2002 (Read 2006). Tourism has also become a major industry, and has expanded substantially since its infancy in the 1980s to over 100,000 visitors annually in 2009 (Tagomoa-Isara 2010).

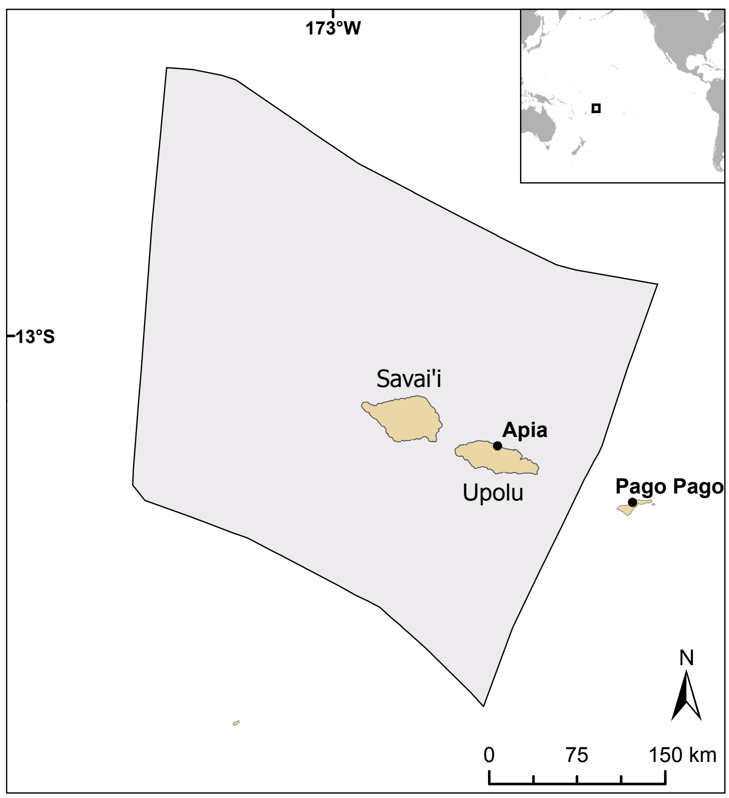

Figure 1. Map of the Samoan EEZ, showing the islands of Savai'i and Upolu as well as the capital city Apia. American Samoa with its capital, Pago Pago, is also shown.

[1] Cite as: Lingard, S., Harper, S., and Zeller, D. (2012) Reconstructed catches of Samoa 1950-2010. pp. 103-118. *In*: Harper, S., Zylich, K., Boonzaier, L., Le Manach, F., Pauly, D., and Zeller D. (eds.) Fisheries catch reconstructions: Islands, Part III. Fisheries Centre Research Reports 20(5). Fisheries Centre, University of British Columbia [ISSN 1198-6727].

[2] http://data.un.org/CountryProfile.aspx?crName=Samoa [accessed January 2012]

Samoa has maintained a strong link to its traditional way of life (termed *fa'asamoa*). *Fa'asamoa* encompasses the entire fabric of Samoan life, which has had major impacts on the economic and political development of the country (Lati 2000). Organizational aspects of *fa'asamoa* (which have resulted in sustainable marine resource use over millennia) include extended kinship groups (*agia*), as well as a chieftain system termed *fa'amatai*. Rather than an individual or nuclear family being the unit of social organization, the *agia* encompasses a large extended family group amongst which resources are shared. Land has customarily been distributed based on a tenure system given to *agias* rather than individuals. Similar to the tenured distribution of land, marine resources are tenured and under the jurisdiction of the village chiefs (Faasili and Kelekolio 1999; King and Faasili 1999; Mollica 1999; Zann 1999). The marine tenure system includes many management strategies to prevent overfishing. These strategies include restrictions or specifications on species and/or sizes of fish taken, gear types, harvest seasons, and fishing grounds (Johannes 1978; Mollica 1999). Any excess harvested resources are distributed within the wider community to prevent waste. Each *agia* is headed by a chief (*matai*) who grants permission for the harvesting of marine resources, and whose responsibility it is to distribute resources fairly amongst the community. The details of this system are described in Cahn (2006), Lati (2000), Macpherson (1999), and Meleisea (1987).

Although Samoa has retained a strong link to the *matai* system and other aspects of *fa'asamoa*, (Fitzgerald and Howard 1990), the *fa'amatai* system lost some of its power to sustainably manage marine resources due to pressures from western political systems (Macpherson 1999; Cahn 2006). Additionally, shifts in social organization and an increasing population have resulted in overfishing on Samoa's reefs since the 1960s (Van Pel 1960; Horsman and Mulipola 1995; Mulipola 1998; Faasili and Kelekolio 1999). An example of how the move to a westernized political system impacted the *fa'amatai* system's ability to manage marine resources is that although the *fa'amatai* system contained many village bylaws and customs to combat overfishing, federal legislation and regulations often made enforcement of village bylaws and penalties illegal (Faasili and Kelekolio 1999). Recognizing the opportunity for successful management at the village level, the Fisheries Division added provisions to the 1988 Fisheries Act giving village *fonos* (council of *matais*) the power to enact village by-laws that were legally binding (Faasili and Kelekolio 1999; Johannes 2002).

Traditionally, fish supplied the majority of protein to the Samoan diet (Van Pel 1960; Horsman and Mulipola 1995; Mulipola 1998; Zann 1999; Passfield 2001). Marine resources continue to be important to domestic food security, supplying approximately 74% of the animal protein to the Samoan diet (Bell *et al.* 2009). Two separate types of fishing activities occur in Samoa: fishing for the domestic market and tuna fishing for export markets. The export fishery targets tuna species almost exclusively, while the domestic fishery is for domestic consumption and includes inshore and offshore species (Horsman and Mulipola 1995; Passfield 2001). Although lagoon species provide the majority of food requirements (Horsman and Mulipola 1995; Passfield 2001), pelagic species are also targeted and consumed locally (Van Pel 1960; Anon. 1984). Lagoon fisheries employ a wide variety of gear types. While diving and spear fishing are most common, gillnets, hook and line, and gleaning activities are also important (Zann 1991, 1999; Passfield 2001). Women and children contribute significantly to the household protein supply through the gleaning of invertebrates and seaweeds, and the collection of nearshore fish (Horsman and Mulipola 1995; Passfield 2001; Lambeth *et al.* 2002).

Fisheries are important for both subsistence and economic purposes. Subsistence and artisanal catches were estimated to be 13,800 t with a value of 34.2 million USD over the 2006/2007 financial year (Samuelu and Sapatu 2007). An additional 6.6 million USD was generated from tuna exports for the same year (Hang 2008). Fisheries also employ a substantial portion of the Samoan population, often in an informal manner. Gillett (2009) estimated only 900 people (out of an employable population of nearly 200,000)[3] would be considered commercial fishers, which sell at least 50% of their catch, while 9,200 engage in fishing primarily for subsistence purposes.

The Fisheries Division, originally part of the Department of Economic Development and now part of the Ministry of Agriculture and Fisheries, was established in 1970 (Anon. 1984). In the late 1960s, prior to the establishment of the Fisheries Division, a fishery subsidy program began providing assistance for the mechanization of canoes (Philipp 1977). Mechanization of the fleet was rapid and by 1977 the majority of fishers were using outboard motors (Philipp 1977). In the late 1970s, shortly after mechanization and the development of the Fisheries Division, a formal offshore tuna fishery was established (Philipp 1977).

Fishing by foreign fleets (Japan, Taiwan and Korea) for tuna occurred in Samoan waters from the late 1940s to 1979 (Anon. 1984). Catches by these fleets, mainly longliners, were estimated to be 159.8 t in 1976 (Anon. 1984). While foreign access fishing for tuna is common in many Pacific Island countries, foreign catches in Samoan waters have remained minimal (25 t·year^{-1}) in the 2000s (Gillett 2009).

Development of a locally based offshore tuna fishery in Samoa commenced in 1975, using modified traditional catamarans called *alias* (Mulipola 1998). However, prior to the development of the formal offshore fishery, customary pole and line fishing for tuna and shark species had occurred for centuries, just outside the barrier reef when weather permitted (Anon. 1984). Reported tuna catches from the locally based offshore fishery in the early period were dominated by skipjack (*Katsuwonus pelamis*) and yellowfin tuna (*Thunnus albacares*; Mulipola 1998). Development of a small-scale longline fishery began in 1991 (Mulipola 1998); however, the commercial offshore longline fishery for tuna officially commenced in 1996 (Su'a *et al.* 2002). Since the start of the fishery in 1996, catches have grown from 2,092 t to 6,200 t in 2002 (Su'a *et al.* 2002), with the majority of fish caught by this sector being exported (Anon. 2007a). As there is no cannery in Samoa, a large portion of catches are exported to American Samoa for processing (Chapman 1998). *Alias* were the dominant fishing craft used by fishers of this sector (Faasili and Time 2006) until 2002, when large commercial vessels (greater than 15 m) came into service.

[3] http://www.sbs.gov.ws/Statistics/Social/DemographicIndicators/tabid/3345/language/en-US/Default.aspx [accessed January 2012]

Under-reporting of fisheries catches is a problem globally, which undermines the importance of fisheries in economics and food security (Zeller *et al.* 2007; Jacquet *et al.* 2010; Garibaldi 2012). Additionally, fisheries have not been acknowledged for their contributions to informal employment (Teh and Sumaila 2011), as well as indirect economic benefits (such as boat building, gear purchases, processing, shipping; Dyck and Sumaila 2010). In Samoa, fisheries are important for domestic food security, livelihoods, and export earnings. However, reporting of national fisheries landings to the Food and Agriculture Organization of the United Nation (FAO) does not adequately reflect their importance. The present study aims to improve the accounting of marine resource use by estimating all fisheries catch components and improving the taxonomic resolution of catches for the period 1950-2010.

Methods

For the 1950-2010 period, FAO landings data were obtained in addition to annual reports by the Fisheries Division of the Ministry of Agriculture, Fisheries and Forests for comparison. National reports divide fisheries into two sectors: inshore and pelagic resources destined for domestic sale, and tuna destined for export (Faasili *et al.* 1997; Faasili *et al.* 1999; Anon. 2000b, 2001, 2002, 2003). In the early period, FAO landings were approximately 300 t·year^{-1}. Fisheries Division data for the same period were not available to make a comparison. However, in recent years national reporting has included better estimates of subsistence and artisanal catches (Faasili *et al.* 1997; Faasili *et al.* 1999; Anon. 2000a, 2001, 2002). Due to a long history of reliance on marine resources in Samoa, we assumed *per capita* subsistence catch rates in the early period would be greater than those experienced today. To estimate unreported catch components, we used seafood consumption rates to estimate total domestic demand for seafood. We considered total domestic demand to represent the total domestic catch, only a portion of which is represented in the reported landings data. Additionally, a comparison between FAO tuna landings and national export records indicated that the majority of tuna were exported. However, some tuna is consumed domestically and this was accounted for in our domestic consumption estimate. The export oriented tuna were treated as a distinct category in our reconstruction, separate from the subsistence and artisanal catches for domestic consumption.

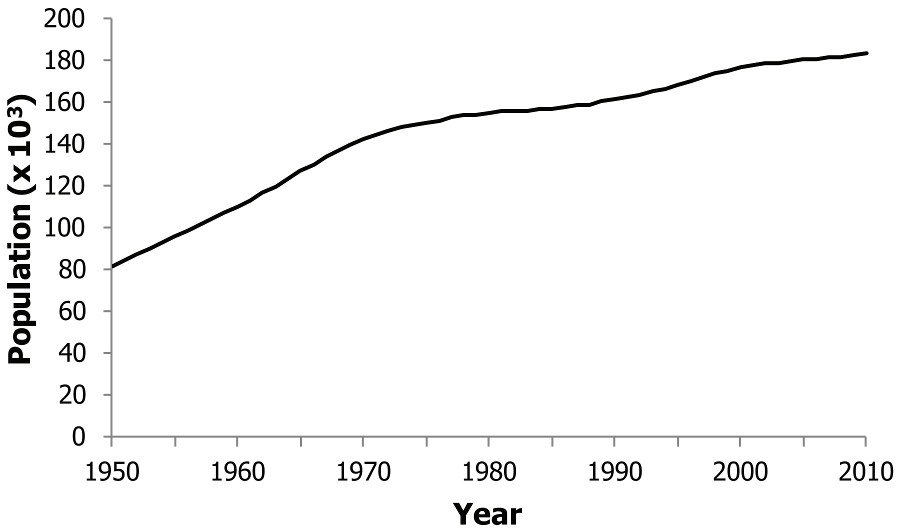

Figure 2. Population of Samoa 1950-2010.

Total domestic catch

Population

Human population data were obtained from the statistic division of the government of Samoa (www.sbs.gov.ws), the World Bank (data.worldbank.org) and The World Resource Institute.[4] World Bank data were available from 1960-2010, and national census data were available for 2001 and 2006 from the government of Samoa. World Bank data for both 2001 and 2006 were similar to national census estimates; therefore, we used the World Bank data for this study. The World Resource Institute estimated a population of 82,000 for the islands of Samoa in 1950. We interpolated between the 1950 estimate and the first year of World Bank data (1960), to derive a complete time series of population for Samoa from 1950 to 2010 (Figure 2).

Seafood consumption

In recent years, attempts have been made to estimate the magnitude of Samoan subsistence catches (Zann 1991; Passfield 2001; Samuelu and Sapatu 2007; Bell *et al.* 2009). Prior to the 1990s, there is little recorded information on subsistence consumption. Some recent information does exist on seafood consumption rates, which includes consumption of seafood derived from subsistence and artisanal fisheries as well as imported products. Passfield (2001) used village surveys on both Savai'i and Upolu to calculate *per capita* consumption rates of 57 kg·person^{-1}·year^{-1} for local seafood, and 14 kg·person^{-1}·year^{-1} for imported seafood (71 kg total).

Prior to 1975, estimates of *per capita* consumption, as well as import data were not available. Although there were reports of imports of milk, butter, and tinned meat into Samoa in the 1950s, these commodities were

[4] http://earthtrends.wri.org/pdf_library/country_profiles/pop_cou_882.pdf

mostly consumed by the small urban population of Apia, while rural areas had minimal access to imported goods (Johnston 1953). Additionally, the subsistence economies of Samoa in the late 1940s were reported to have met the dietary needs of the Samoan people (Beaglehole 1947), which suggests there was no need for imported fish in 1950. With negligible fish imports in the early period, we assumed a fish consumption rate in 1950 of 71 kg·person^{-1}·year^{-1} based on Passfield (2001), consisting entirely of domestically sourced fish. Between 1990 and 1991, two major cyclones (Ofa and Val) hit Samoa, reducing coral cover to nearly zero in many places, and causing major damage to the offshore *alia* fleet (Zann, 1991). Due to these events, fishing capacity was greatly reduced (Zann 1991; Anon. 2000b), thereby reducing consumption in these two years. A household survey between 1990 and 1991 revealed a national average consumption rate of 36 kg·person^{-1}·year^{-1} (Zann 1991). We interpolated linearly from the 71 kg·person^{-1}·year^{-1} in 1950 to 57 kg·person^{-1}·year^{-1} in 2000 (Passfield 2001); however, to reflect the decrease in consumption due to the cyclones, we replaced the interpolated rate in 1990 and 1991 with a rate of 36 kg·person^{-1}·year^{-1} (Zann 1991). From 1992 to 2000, we interpolated linearly between the 36 kg·person^{-1}·year^{-1} estimate and the 57 kg·person^{-1}·year^{-1}. In 2006, a survey undertaken by the fisheries division provided a consumption rate of 59.4 kg·person^{-1}·year^{-1}. We interpolated linearly from the 57 kg·person^{-1}·year^{-1} in 2000 to 59.4 kg·person^{-1}·year^{-1} in 2006 (Samuelu and Sapatu 2007), and carried the 2006 consumption rate forward, unaltered to 2010 (Table 1).

Table 1. Consumption rates used to estimate total domestic demand for seafood in Samoa.

Years	Consumption rate (kg/person/year)	Source
1950	71.0	Passfield (2001)
1951-1988	-	Interpolated[a]
1989	60.1	Interpolated[a]
1990-1991	36.0	Zann (1991)
1992-1999	-	Interpolated[b]
2000	57.0	Passfield (2001)
2000-2005	-	Interpolated[c]
2006	59.4	Samuelu & Sapatu (2007)
2007-2010	59.4	Carried forward[d]

[a] 1951-1989 consumption rate estimated using a linear interpolation from 71 kg·person^{-1}·year^{-1} in 1950 to 57 kg·person^{-1}·year^{-1} in 2000
[b] 1992-1999 consumption rates estimated using linear interpolation from 36 kg·person^{-1}·year^{-1} in 1991 to 57 kg·person^{-1}·year^{-1} in 2000
[c] 2000-2005 consumption rates estimated using linear interpolation from 57 kg·person^{-1}·year^{-1} in 2000 to 59.4 kg·person^{-1}·year^{-1} in 2006
[d] 2007-2010 consumption rates estimated by carrying forward the 2006 estimate unaltered

Total demand for seafood

The time series of *per capita* consumption rates was combined with annual population estimates to give total domestic demand for seafood from 1950 to 2010. Previous studies in other Pacific island countries have, in the absence of catch data, utilized seafood consumption as a proxy for estimating annual catches (Leopold *et al.* 2004). This total domestic demand is considered to be the total domestically retained catch (hereafter referred to as domestic catch) from the artisanal and subsistence sectors. This estimate includes both reported and unreported components.

Artisanal vs. subsistence sectors

Our estimated total domestic demand was used to determine the magnitude of Samoa's domestic catch. This was disaggregated into catches taken by the subsistence and artisanal sectors. In the early period, officially reported landings were considered an under-representation of the true catch and no information was available to disaggregate non-export catches into subsistence and artisanal components. Utilizing national data for the mid to late 1990s (Faasili *et al.* 1997; Faasili *et al.* 1999), we estimated 93% of domestic catches were from the subsistence sector, and 7% from the artisanal sector. We used this breakdown to assign sectors for the reported and unreported components of the domestic catch for the entire time period (Figure 3). In 2008, reported domestic landings were higher than our estimated domestic catch by 260 t. We assumed the FAO estimate was correct and set unreported catches to zero in that year.

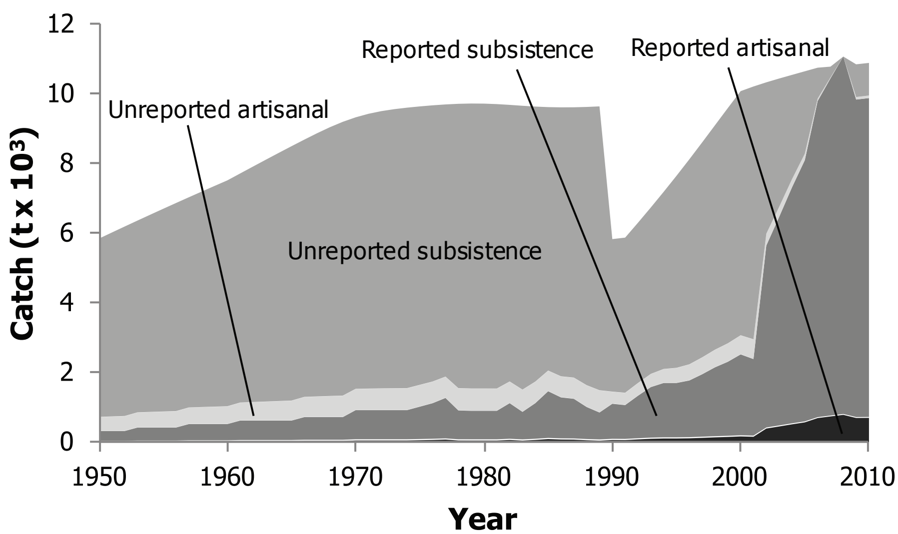

Figure 3. Total domestic demand (tuna and pelagics excluded) for Samoa, 1950-2010, divided into reported and unreported components of the subsistence and artisanal sectors. The catch decline in 1990/91 was due to cyclones (see text).

Export Fishery

Tuna landings

We compared national tuna data (Su'a *et al.* 2002; Imo *et al.* 2005; Faasili and Time 2006; Anon. 2010a) with FAO landings for targeted tuna export species and found these data to be similar. Therefore, we accepted FAO landings data as the best representation of the tuna species (albacore [*Thunnus alalunga*], yellowfin [*T. albacares*], skipjack [*Katsuwonus pelamis*] and bigeye tuna [*T. obesus*]) caught for the export market. Tunas appear in the FAO data beginning in 1978, and in the national data in 1994. From 2002-2010 Samoa's tuna fishery has been well documented, but the data reported to FAO have had poor taxonomic resolution, and were considered slightly underestimated for several years. FAO landings of billfish (black marlin, blue marlin, striped marlin, and swordfish) and the non-specific categories, "tuna-like fishes nei" and "sharks, rays, skates, etc. nei", only appear in some years. National reports (Imo *et al.* 2005; Faasili and Time 2006; Anon. 2007a, 2010a) present landings of billfish, sharks and other pelagic species as by-catch. We assumed the FAO categories "tuna-like fishes nei" and "sharks, rays, skates, etc. nei" also represented by-catch for Samoa. Additionally, due to the use of longliners and the export nature of the fishery, which requires high quality products, the discarding of undersized or low-quality tuna is likely (Kelleher 2005). Using detailed data from national reports, we have improved/estimated by-catch and discards associated with the tuna fishery.

<u>By-catch</u>

The Samoan tuna fishery, between 1975 and 1996, utilized small-scale trolling gear, which incurs minimal by-catch (Bailey *et al.* 1996). However, we assumed that some by-catch occurred during this time and was reported as "tuna like nei" or "sharks, rays, skates, etc. nei" in the FAO data. Longliners came into widespread use in 1996 in Samoa (Su'a *et al.* 2002), and are reported to have significant by-catch rates (13.05% of total catch in the Western South Pacific; Bailey *et al.* 1996). However, Samoa's average by-catch of non-target species from 2002-2009 was 7% (Anon. 2009). Species specific information on longline by-catch was available for the period of 2002-2009 from Western and Central Pacific Fisheries Commission (WCPFC) reports (Anon. 2007a, 2010a). These data were compared to FAO data and it was determined that only part of the data from the WCFPC report was reported in the FAO data. Therefore, unreported by-catch amounts were calculated for the period of 2002-2009. Average proportions from the data were also used to disaggregate the "tuna-like fishes nei" and "sharks, rays, skates, etc. nei" categories in the FAO data. No additional unreported amount of by-catch was calculated for 1978-2001. However, the ratio of unreported by-catch to reported landings of the export fishery for 2009 was used to estimate an unreported amount of by-catch in 2010, with the 2009 species composition being applied as well.

<u>Discards</u>

Longline fishing for tuna and highly migratory species is non-selective and known to incur by-catch of non-targeted species and discards both of targeted and non-targeted species (Bailey *et al.* 1996; Kelleher 2005). Targeted species of inferior quality or individuals caught once quotas have been filled are frequently discarded (Alverson *et al.* 1994; Kelleher 2005). Early on, Samoan tuna fishing was carried out by the domestic *alias* fleet using pole and line, which incurred minimal by-catch and discards (Kelleher 2005). Prior to 1996, we did not apply a discard rate to the pole and line fishery catches. From 1996 onwards, when use of longlines became the dominant gear type, we applied distinct discard rates for catches of bigeye tuna (9.8%), yellowfin tuna (3.6%) and albacore tuna (4.6%) (Anon. 2007b). Globally, (Kelleher 2005) advises a discard rate of 15% for longliners, but Samoa has been reputed to have negligible discard rates (Kelleher 2005; Gillett 2011). Therefore, we applied the lower individual discard rates to estimate discards of the three main target species from 1996-2010.

<u>Baitfish</u>

Baitfish is required to catch tuna using pole and line, however due to limited baitfish supplies in Samoa's EEZ (Anon. 1984), baitfish is imported (Trade and Investment Promotion Unit 2000, in Fitzgerald 2004). Therefore, estimates of baitfish were excluded from this reconstruction.

<u>Spatial allocation</u>

Although it is reported that all catches by the Samoan fishing fleet are taking within the EEZ boundaries (Anon. 2009), data from the Forum Fisheries Agency (FFA) report a small amount of catch in the years 2002 and 2010 being taken from outside of Samoa's EEZ. In 2002 these catches were reported as being taken from another country's EEZ and in 2010 part of the catches come from another EEZ and part from the high seas. The catches within another country's EEZ were assigned as being taken from within American Samoa's EEZ due to the close proximity, the historical relationship between the two countries, and the fact that American Samoa is home to a processing facility which Samoa frequently exports to. Associated by-catch and discards were also proportionally assigned to American Samoa's EEZ and the high seas according to the average proportion of the tuna species in these areas for the years 2002 and 2010. Catches for all other years are taken completely within Samoa's EEZ.

Taxonomic breakdown

Reported domestic catch

Taxonomic detail in the FAO landings is limited, especially for the early period. FAO data are presented in highly aggregated categories such as "marine fishes nei", "echinoderms", "aquatic invertebrates nei", "marine molluscs nei", and "marine crustaceans nei".

To improve the taxonomic resolution of the "marine fishes nei" category, we utilized species compositions of inshore, deepwater, and pelagic catches available from market surveys (Faasili *et al.* 1997; Faasili *et al.* 1999; Anon. 1995, 2000a, 2001, 2002). For inshore species, we combined market survey information from 1986-2002 (Anon. 1995; Faasili *et al.* 1997; Faasili *et al.* 1999; Anon. 2001, 2002). We used an average of the first and last 3 years of data and carried these estimates backward to 1950, and forward to 2010, respectively. For deepwater species, we used a four year average from the time period 1996-2001 (Faasili *et al.* 1997; Faasili *et al.* 1999; Anon. 2001). These averages were then carried back unaltered to 1950 and forward to 2010. For pelagic species there was a clear declining trend in some species of tuna from 1996-2002. To capture this trend, we have carried the species composition of market landings in 1996 back to 1950, and the estimates for 2002 forward to 2010. To combine these categories into a single species composition, we calculated the contribution each of the three sectors made to total domestic finfish catches. Market data from 1978 (Anon. 1995) and 1996-2001 (Faasili *et al.* 1997; Faasili *et al.* 1999; Anon. 2001), which provide total market landings by category (inshore, deepwater, and pelagic), were used to weight each category. Although pelagic species only occur until 2001, these species are known to be consumed domestically (Passfield 2001). To account for pelagic species caught for domestic consumption, we set pelagic catches to 10% of total finfish catches in 2010 and interpolated back to the last pelagic species estimate in 2001. The ratio of deepwater species to inshore species was kept constant from 2001 to 2010. The estimate for all categories from 1978 was carried back to 1950 unaltered. The species in each category were then weighted by the contribution of each category in total domestic finfish catches and combined into a single species composition (Appendix Table A1). This breakdown was applied to both the subsistence and artisanal components of the "marine fishes nei" category.

Market survey data also included information regarding invertebrate catches. Three categories (shellfish, crustaceans, and molluscs) are presented in the market data from 1996-2000 (Faasili *et al.* 1997; Faasili *et al.* 1999; Anon. 2000a). As there was no visible trend, we applied a 3 year average to the "crustacean" category, which was applied to the "marine crustaceans nei" of FAO data for the time series of 1995-2010 (Appendix Table A2).

The shellfish and mollusc categories in national market surveys are both in the phylum Mollusca, therefore, they had to be combined for application to the FAO category "marine molluscs nei". "Molluscs" showed no trend in the national market surveys from 1996 to 1998, therefore we used a 3 year average species composition for this category. "Shellfish" data suggested a decrease in *Tridacna squamosa* and *T. maxima* consistent with reports of overfishing of these resources in Samoa (Helm 1988; Mulipola 1993; Zann 1999). Catches of *T. squamosa* have always been small, but decreased to zero in 2000 as the resource has become functionally extinct (Anon. 2001). Reporting of giant clams ceased in national reports in the early 2000s, but collecting of *T. maxima* continues (Passfield 2001); therefore, it was necessary to allocate a small portion of our reconstructed catch to *T. maxima*. Catches of *T. maxima* were set to 10% of total shellfish catches in 2010. Between 2001 and 2010, a linear interpolation was done. Proportions of the remaining species in this family were adjusted accordingly. Estimates for all species were carried back from 1995 to 1950 unaltered. We used ratios of the categories of "molluscs" and "shellfish" in national survey data to weight the species in these two categories and combine them into a single "mollusc" category. The time series of species estimates from this single "mollusc" category was then applied to the FAO category 'marine molluscs nei' 1950 to 2010 (Appendix Table A2).

Similarly to the "mollusc" category, all three categories "crustaceans", "molluscs" and "shellfish" in national data needed to be combined into a single estimate for application to the FAO category "aquatic invertebrates nei", and unreported invertebrate catches. Using the ratio of landings of these three categories in national market data (Faasili *et al.* 1997; Faasili *et al.* 1999) we derived a single species composition by weighting individual taxa (Appendix Table A2).

Unreported catches

Passfield (2001) separated seafood consumption into two components, seaweed and invertebrates (23%), and finfish (77%). Unreported subsistence and artisanal catches were disaggregated into these two categories for the entire time period assuming the ratio of these two components have remained stable in the Samoan diet over the time period considered. We assumed invertebrates represented the majority of the non-finfish consumption and considered the entire 23% to be invertebrates. For the finfish component, we modified the inshore species composition used to disaggregate the "marine fishes nei" category of the reported landings by excluding the pelagic species and applied this new breakdown to the unreported finfish catches (Appendix Table A3). We assumed unreported catches would consist predominately of species from the inshore regions as pelagic species are often better accounted for in the reported data, and Samoans mainly target inshore species for domestic consumption (Zann *et al.* 1985; Passfield 2001). To the invertebrate portion of unreported catches we applied the same taxonomic composition that was applied to the "aquatic invertebrate nei" category of the reported landings (Appendix Table A2).

By-catch

Reported amounts of by-catch (black marlin, blue marlin, striped marlin, and swordfish) were accepted as is. The "tuna-like fishes nei" category for 1978-1992 and 2001 was disaggregated using the 3-year average (2002-2004) of the proportions all non-shark species within the WCPFC by-catch data. The "tuna-like fishes nei" category in 2006 and 2007 was broken down using the same proportions of the 2006 and 2007 unreported tuna-like by-catch in those respective years. The species breakdown of the unreported tuna-like by-catch from 2002-2009 was determined directly from catch amounts of the determined unreported by-catch. Proportions from 2009 were utilized for 2010. The "sharks, rays, skates, etc. nei" category was disaggregated using the average proportions of shark species from the 2002-2009 WCPFC data. Note, however, that due to the large percentage of a miscellaneous shark category in this breakdown, half of the amount of miscellaneous shark was redistributed proportionally to the other categories. For 2002-2007, the respective yearly proportions from the WCPFC data were applied. In 2008-2009, unreported amounts were used directly and the 2009 proportions were used for 2010.

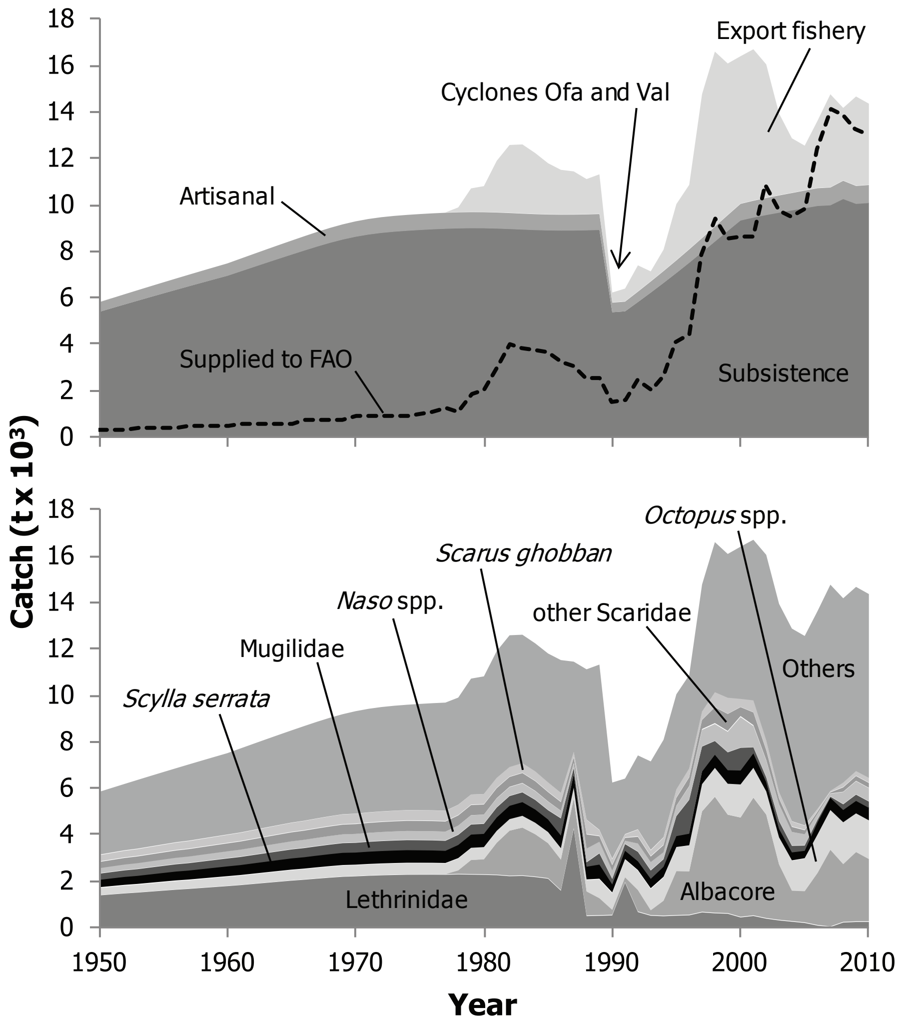

Figure 4. a) Total reconstructed catches for Samoa (by sector), 1950-2010, compared to the total reported landings. Export fishery refers to the tuna and other large pelagic catch that is destined for export and includes by-catch and discard estimates as well. This is part of the artisanal sector but has been separated to distinguish it from domestic catches. The sudden decrease in catches in 1990 was due to two successive cyclones. b) Total reconstructed catches for Samoa, 1950-2010, by major taxa.

Results

Total reconstructed catches were estimated to be 627,694 t over the 1950-2010 time period, which was 2.8 times the total reported landings (220,896 t) presented by the FAO on behalf of Samoa (Figure 4a, Appendix Table A4). The most important taxa in terms of overall tonnage were: Lethrinidae, *Thunnus alalunga*, *Octopus* spp., *Scylla serrata* (mud crab), Mugilidae (mullets), *Naso* spp., *Scarus ghobban* (blue-barred parrotfish), and other Scaridae (parrotfishes), with respective tonnages of: 89,800 t; 66,600 t; 43,700 t; 32,200 t; 24,900 t; 24,900 t; 21,300 t; and 21,300 t (Figure 4b). Between 1950 and 2010, *Thunnus alalunga* contributions increased from 0.03% of the total catch to 18.6% of total catch, while Lethrinidae decreased substantially from 24.2% to 1.9% (Figure 4b, Table A5).

The total small-scale catch for the domestic market was estimated to be 533,000 t over the 1950 to 2010 time period (Figure 3). This consisted of 402,600 t of unreported catches and 130,200 t of reported catches. Artisanal and subsistence sectors contributed 7% and 93%, respectively. Total domestic artisanal catches were estimated to be 38,100 t (Figure 4a). The domestic artisanal fishery catch was dominated taxonomically by Lethrinidae (6,400 t), *Octopus* spp. (3,100 t), *Scylla serrata* (2,300 t), Mugilidae (1,800 t), *Naso* spp. (1,800 t), *Scarus ghobban* (1,500 t) and other Scaridae (1,500 t). Total subsistence catches, over the 1950 to 2010 time period, were approximately 494,750 t (Figure 4a). Lethrinidae represented the largest individual contribution with catches of 83,300 t (Figure 4b). Other important taxa in this sector were *Octopus* spp. (40,600 t), *Scylla serrata* (29,900 t), Mugilidae (23,200 t), *Naso* spp. (23,200 t), *Scarus ghobban* (19,800 t), other Scaridae (19,800 t), *Tridacna maxima* (giant clam; 18,600 t), Labridae (sweetlips; 17,000 t), Carangidae (jacks and trevallies; 14,400 t), and Holocentridae (soildierfishes and squirrelfishes; 13,800 t; Figure 4b). Lethrinid catches decreased from 24.0% of total subsistence catches in 1950 to 2.5% in 2010. A decreasing trend was also seen in Holocentridae (from 4.0% in 1950 to 0.4% in 2010) and Labridae (from 5.3% in 1950 to 0.7% in 2010). In contrast, there was an increasing trend in the catches of *Octopus* spp. from 5% in 1950 to 15% in 2010.

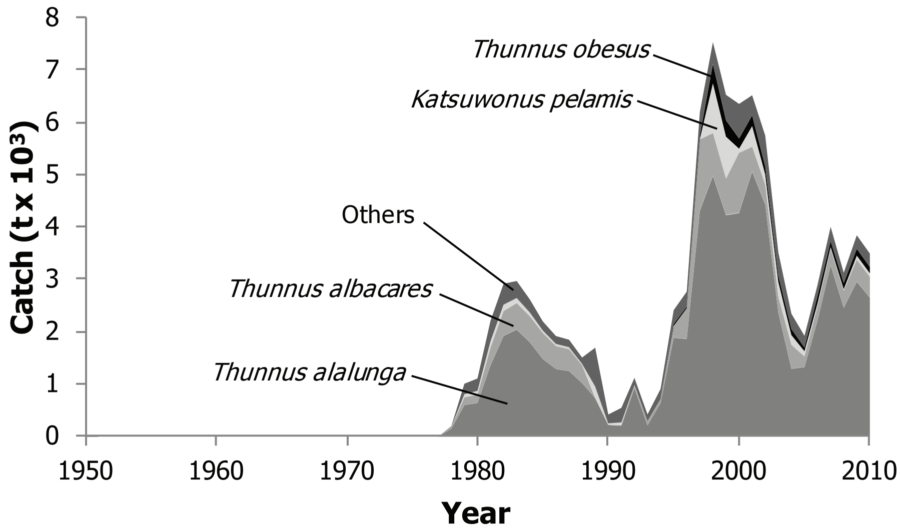

Figure 5. Total reconstructed catches of the export fishery in Samoa, 1950-2010. By-catch and discards are included.

Total reconstructed catch of the tuna and other large pelagic export fishery, from 1978–2010, was estimated to be 94,800 t (Figure 5). Catches were dominated by *Thunnus alalunga* (66,000 t). *Thunnus albacares*, *Katsuwonus pelamis,* and *T. obesus* were also substantial contributors to the catch, contributing 12,600 t, 4,300 t, and 2,300 t, respectively (Figure 5). Total catches of the export fishery included 90,700 t of reported landings. Total by-catch was estimated to be 10,750 t over the 1978–2010 period. This included 9,280 t reported by-catch which consisted of billfishes and miscellaneous tuna-like and shark categories which were further disaggregated in this study. Unreported by-catch in Samoa's tuna fishery was estimated at 1,470 t. The most abundant species caught as by-catch were unidentified sharks (1,730 t), *Acanthocybium solandri* (wahoo; 1,550 t), *Coryphaena hippurus* (dolphinfish; 1,360 t), *Katsuwonus pelamis* (1,100 t), and *Makaira mazara* (blue marlin; 840 t). Total discards of target species by the longline fishery from 1996-2010 were estimated at 2,700 t. This included 2,190 t of *Thunnus alalunga,* 300 t of *T. albacares* and 220 t of *T. obesus*.

As part of the allocation process, it was estimated that approximately 0.3% of the large-scale catches were taken from outside of the EEZ. These catches represent less than 0.05% of the total reconstructed catch.

Discussion

Our reconstructed total catch (1950–2010) for Samoa was 627,700 t, which is 2.8 times the reported landings of 220,900 t presented by the FAO on behalf of Samoa for the same time period. Reconstructed catches in 1950 were 20 times the reported amount, whereas in 2010, reconstructed catches are only 10% higher than the reported data. Importantly, while reported data suggest that Samoa's landings have been increasing since 2001, when we consider total catches (subsistence, artisanal, by-catch and discards) there is an overall declining trend since the peak of 16,700 t in 2001.

Although Samoa's reported landings showed an increasing trend in the early 2000s, reported landings of tuna species have been decreasing since 2001. Reported tuna landings decreased substantially in 2002, likely due to localized excessive effort by *alia* craft in areas of Samoa's EEZ accessible to these vessels (Imo *et al*. 2004; Barclay 2010). Since the mid 2000s, larger vessels have been in operation (Imo *et al*. 2004; Barclay 2010), and although small increases in catches have been achieved, catches have not again reached 2001 levels (Imo *et al*. 2004). The declines in tuna catches are concurrent with reports of declining CPUE, overall tuna catches (Mulipola 1998), and overfishing of bigeye and yellowfin stocks in the Western South Pacific area (Anon. 2010a). In response to these issues, Samoa has adopted the FFA policies for the conservation of tuna stocks, which includes a reduction in longline fishing by 10%, and temporal closures of FAD fishing in member country EEZs (Anon. 2010b). Samoa has also limited foreign participation in tuna fisheries which has resulted in the fishery remaining small in scale due to limited local capital (Read 2006).

In contrast to declining tuna resources, reported landings for the domestic market have been increasing since 2001, suggesting increasing pressure on these resources. During the 1990s, in response to the depletion of inshore resources from natural and anthropogenic disturbances, Samoa turned to small-scale aquaculture of nile tilapia (*Oreochromis niloticus*) as a way to increase domestic seafood production (Ponia 2004). Other conservation efforts have included giant clam nurseries in many villages (Anon. 2010b) and the translocation of other bivalve species to areas where they have been locally depleted (Anon. 2001). An additional factor which has helped to reduce pressure on species targeted for domestic consumption, was the sale of by-catch from the longline fishery at local markets in the mid 1990s (Chapman 1998; Passfield 2001).

Samoa's vulnerability to severe weather events and natural disasters is illustrated by the 1990 and 1991 cyclones which significantly damaged inshore reefs and incapacitated the offshore tuna fleet (Zann 1991). Samoa's islands were again affected by cyclone Heta in 2004, which severely damaged reefs in several villages (Samuelu and Sapatu 2007), and a major tsunami in 2010, which reduced catches in the short term (McAdoo *et al*. 2011). Following the tsunami, acute reductions (as much as 30%) in fish consumption was observed as affected villages were forced to find alternative food sources (McAdoo *et al*. 2011).

In addition to natural disruptions in resource use, human caused depletion of marine resources is a major concern to Samoa's food security. Compounding the effects of overfishing is pollution from sewage and other land-based activities which have caused the degradation of marine resources, particularly in the Apia area (Zann 1991; Samuelu and Sapatu 2007). Due to the volcanic geological origins of Samoa, there is limited arable land on either Savai'i or Upolu (Zann 1999). As a consequence, marine resources are the primary source of protein. Bell (2009) estimated that Samoa's marine resources are inadequate to ensure good health for the population into the future. Imports, if the population can afford to purchase them, could supplement the fish shortages forecasted by Bell (2009). However, the combination of Samoa's low *per capita* GDP and rising oil prices, suggests that the purchase of imports may not be a feasible long-term solution for Samoans. Furthermore, many of the countries in the Pacific region have experienced increased health problems associated with an increasingly westernized diet (Hawkes *et al.* 2010). In response to this and as a means of preserving the *fa'asamoa* culture, Samoa has deterred imports of unhealthy foods by imposing taxes on these items (Hawkes *et al.* 2010).

In recent years, there has been a renewed interest in community-based marine resources management in the Pacific region (Johannes 2002). Samoa, in particular, has moved to re-instate the *fa'amatai* system (King and Faasili 1999) for the management of inshore resources. In the 2009/2010 financial year, a total of 87 villages were implementing community-based management plans through village *fonos* and *matais* (Anon. 2010b). Strong local governance and recognition of community leadership by higher levels of government have been acknowledged as factors in the success of community-based management programs in other marine settings (Bueno-Cudney and Basurto 2009). In Samoa, the retained link to the *fa'asamoa* culture and *fa'amatai* system as well as the recognition of the *fa'amatai*, system by higher levels of government (King and Faasili 1999), likely contributed to the success of these programs in Samoa.

In this study of Samoan fisheries, we have linked historical and cultural aspects of Samoan fishing activities to reconstruct total marine fisheries catches over the last 60 years. Our reconstructed catches suggested a declining trend in overall tuna catches, and an increase in catches for domestic consumption. Despite an increasing trend in inshore catches, overall total fisheries catches show a declining trend, and are forecasted to be inadequate in meeting the future needs of the country in terms of food supply (Bell *et al.* 2009). Ensuring sustainable use of all marine resources, inshore and offshore, is imperative to both domestic food security and the economy of Samoa into the future.

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Appendix Table A1. Taxonomic composition (%) applied to the "marine fishes nei" FAO category for reported subsistence and artisanal catches.

Taxon	1950-1978	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001-2010
Acanthocybium solandri	0.14	0.45	0.49	0.53	0.57	0.58	0.59	0.60	0.61	0.62	0.56	0.49	0.46	0.41	0.47	0.15	0.31
Acanthurus lineatus	1.99	0.96	0.46	0.73	0.42	1.12	0.25	0.42	0.35	0.30	0.44	0.47	0.65	0.69	0.70	0.94	0.83
Ctenochaetus striatus	1.99	0.96	0.46	0.73	0.42	1.12	0.25	0.42	0.35	0.30	0.44	0.47	0.65	0.69	0.70	0.94	0.83
Naso unicornis	1.00	0.38	0.19	0.48	0.30	0.38	0.13	0.29	0.25	0.17	0.42	0.76	0.85	0.76	1.05	1.78	1.38
Naso spp.	3.01	1.14	0.56	1.43	0.91	1.14	0.38	0.86	0.76	0.51	1.26	2.29	2.55	2.28	3.16	5.33	4.13
other Acanthuridae	1.70	0.82	0.40	0.62	0.36	0.96	0.21	0.36	0.30	0.25	0.38	0.41	0.56	0.59	0.60	0.81	0.72
Coryphaena hippurus	0.35	1.16	1.26	1.36	1.46	1.49	1.51	1.54	1.56	1.59	1.43	1.27	0.98	0.67	1.15	0.41	0.69
Gymnosarda unicolor	0.12	0.41	0.45	0.49	0.52	0.53	0.54	0.55	0.56	0.57	0.51	0.45	0.23	0.00	0.06	0.03	0.11
Holocentridae	3.05	0.28	0.31	2.24	0.12	<0.01	<0.01	0.32	0.39	0.37	0.45	0.31	0.29	0.58	0.89	0.07	0.42
Istiophoridae	0.02	0.06	0.06	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.07	0.06	0.63	1.22	4.14	1.63	0.45
Katsuwonus pelamis	14.41	47.85	52.03	56.21	60.39	61.43	62.48	63.53	64.58	65.63	59.02	52.40	53.67	54.95	25.46	4.33	4.23
Kyphosus cinerascens	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.08	0.24	0.13	0.12	0.17	0.00	3.53
Labridae	3.96	0.20	0.07	3.29	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.14	0.13	0.21	0.10	1.65	0.44
Elagatis bipinulatus	0.03	0.11	0.12	0.13	0.14	0.14	0.15	0.15	0.15	0.15	0.14	0.12	0.11	0.09	0.06	0.01	0.00
Selar crumenophthalmus	0.99	1.26	0.03	0.00	0.09	0.00	0.32	0.05	0.01	0.63	0.65	0.18	0.32	0.19	0.23	0.49	0.12
other Carangidae	3.34	2.54	0.67	0.62	2.20	0.53	0.45	0.65	0.49	0.43	0.80	1.15	1.20	0.88	2.52	3.67	4.93
Lethrinus olivaceus	4.13	1.72	1.41	1.11	0.81	0.74	0.68	0.61	0.54	0.47	0.95	1.42	1.36	1.29	6.62	11.94	11.58
other Lethrinidae	18.21	5.96	13.27	1.29	1.00	1.75	5.57	1.72	1.14	0.90	1.61	2.27	2.46	2.04	2.27	1.90	2.11
Aphareus rutilans	1.04	0.43	0.35	0.28	0.20	0.19	0.17	0.15	0.14	0.12	0.24	0.36	0.34	0.32	1.66	2.99	2.91
Aprion virescens	1.02	0.42	0.35	0.27	0.20	0.18	0.17	0.15	0.13	0.12	0.23	0.35	0.34	0.32	1.63	2.95	2.86
Etelis spp.	3.38	1.41	1.16	0.91	0.66	0.61	0.55	0.50	0.44	0.39	0.78	1.16	1.11	1.06	5.42	9.78	9.49
Lutjanus gibbus	5.45	2.26	1.87	1.47	1.07	0.98	0.89	0.80	0.72	0.63	1.25	1.87	1.79	1.71	8.73	15.75	15.29
Lutjanus kasmira	0.31	0.13	0.11	0.08	0.06	0.06	0.05	0.05	0.04	0.04	0.07	0.11	0.10	0.10	0.50	0.90	0.87
Pristipomoides spp.	3.38	1.41	1.16	0.91	0.66	0.61	0.55	0.50	0.44	0.39	0.78	1.16	1.11	1.06	5.42	9.78	9.49
other Lutjanidae	0.55	0.53	0.16	0.00	0.37	0.00	0.00	0.39	0.47	0.29	0.40	0.36	0.28	0.24	0.27	0.09	0.68
Mugilidae	3.43	2.74	0.87	0.46	0.90	0.76	0.82	1.01	0.76	0.57	2.56	5.95	3.88	1.88	2.80	3.98	1.79
Mullidae	2.27	1.82	0.78	0.14	0.83	0.00	0.15	0.69	0.67	0.47	0.62	0.53	0.45	0.50	0.32	0.40	0.42
Gymnothorax spp.	1.13	0.42	0.11	0.62	0.17	0.20	0.04	0.11	0.16	0.19	0.37	0.57	0.48	0.35	0.34	0.53	0.76
other Muraenidae	1.13	0.42	0.11	0.62	0.17	0.20	0.04	0.11	0.16	0.19	0.37	0.57	0.48	0.35	0.34	0.53	0.76
Scarus ghobban	3.41	1.37	0.73	1.48	0.44	0.72	0.35	0.70	0.50	0.52	1.00	1.52	1.39	2.14	2.62	1.55	1.75
other Scaridae	3.41	1.37	0.73	1.48	0.44	0.72	0.35	0.70	0.50	0.52	1.00	1.52	1.39	2.14	2.62	1.55	1.75
Variola louti	0.15	0.06	0.05	0.04	0.03	0.03	0.03	0.02	0.02	0.02	0.04	0.05	0.05	0.05	0.25	0.44	0.43
other Serranidae	1.87	0.91	0.73	0.42	0.40	0.27	0.24	0.49	0.57	0.36	0.57	0.66	0.66	0.82	1.56	2.26	2.62
Sharks	1.47	0.61	0.50	0.39	0.29	0.26	0.24	0.22	0.19	0.17	0.34	0.50	0.48	0.46	2.59	4.34	4.32
Siganidae	0.28	0.25	0.10	0.00	1.19	0.00	0.00	0.16	0.22	0.19	0.25	0.20	0.23	0.17	0.27	0.82	0.47
Sphyraena fosteri	0.76	0.32	0.26	0.20	0.15	0.14	0.12	0.11	0.10	0.09	0.17	0.26	0.25	0.24	1.75	2.42	2.46
Thunnus alalunga	0.61	2.02	2.20	2.38	2.56	2.60	2.64	2.69	2.73	2.78	2.50	2.22	1.95	1.68	1.30	0.36	0.45
Thunnus albacares	3.36	11.17	12.15	13.12	14.10	14.34	14.59	14.83	15.08	15.32	13.78	12.23	14.12	16.08	8.29	1.63	1.54
Thunnus obesus	0.50	1.65	1.79	1.93	2.08	2.11	2.15	2.18	2.22	2.26	2.03	1.80	0.99	0.14	0.29	0.11	0.22
Xiphias gladius	0.17	0.55	0.60	0.65	0.70	0.71	0.72	0.73	0.75	0.76	0.68	0.61	0.31	0.00	0.02	0.01	0.36
Miscellaneous marine fish	2.49	1.49	0.92	0.81	2.51	2.29	1.57	0.56	0.87	0.66	0.73	0.50	0.61	0.53	0.63	0.73	1.51

Sources: Anon. (1995); Faasili et al. (1997); Faasili et al. (1999); Anon. (2000a); Anon. (2001); Anon. (2003). 1979-1985 was estimated from linear interpolation between 1978 and 1986 catch compositions. Data for 2001-2010 is displayed as the average composition of each species in that time period, as values did not change significantly.

Appendix Table A2. Species compositions of Samoa's invertebrate catches 1950-2010. Derived from Faasili *et al.* (1997, 1999) and Anon. (2001).

Crustaceans[a]				
Common name	**Samoan name**	**Scientific name**	**1950-2010**	
Lobster	–	*Panilurus penicillatus*	21.21	
Lobster	–	*Panilurus versicolor*	21.21	
Mud crabs	Paalimago	*Scylla serrata*	53.01	
Reef crabs	Paa aau	*Etisus spendidus*	2.72	
Slipper lobster	Papata,	*Parribacus calendonicus*	1.70	
other crabs	Isi paa	Other crabs	0.14	
Molluscs[b]				
Common name	**Samoan name**	**Scientific name**	**1950-1996**[c]	**2010**
Octopus	Fee	*Octopus* spp.	62.43	62.43
Topshells	Pu, alili	*Turbo mammorata*	2.34	2.34
Other molluscs	–	–	0.30	0.30
Giant clam	Faisua	*Tridacna maxima*	32.13	3.49
Giant clam	–	*Tridacna squamosa*	2.79	0.00
Cockle	–	–	0.00	30.79
Other bivalves	–	–	0.00	0.64
All invertebrates[d]				
Common name	**Samoan name**	**Scientific name**	**1996**[e]	**1997**[f]
Octopus	Fee	*Octopus* spp.	23.77	23.77
Topshells	Pu, Alili	*Turbo mammorata*	0.89	0.89
Other molluscs	–	–	0.12	0.12
Giant clam	Faisua	*Tridacna maxima*	16.80	18.23
Giant clam	–	*Tridacna squamosa*	1.46	0.00
Cockle	–	–	0.25	0.26
Other bivalves	–	–	0.29	0.30
Lobster	–	*Panilurus penicillatus*	11.97	11.97
Lobster	–	*Panilurus versicolor*	11.97	11.97
Mud crabs	Paalimago	*Scylla serrata*	29.91	29.91
Reef crabs	Pa aau	*Etisus spendidus*	1.54	1.54
Slipper lobster	Papata	*Parribacus calendonicus*	0.96	0.96
Other crabs	Isi paa	–	0.08	0.08

[a] Applied to the "marine crustacean nei" category of FAO data
[b] Applied to the "marine molluscs nei' category of FAO data
[c] Between 1996 and 2010 linear interpolation was applied
[d] Applied to "aquatic invertebrates nei" category of FAO data, as well as unreported invertebrate catches
[e] From 1950 to 1996 the proportions of *Tridacna maxima*, *Tridacna squamosa*, cockle and other bivalves changed relative to each other as linear interpolation was done to account for the appearance of cockle and other bivalves in 1997 market survey data
[f] From 1997 to 2010 the proportions of *Tridacna maxima*, *Tridacna squamosa,* cockle and other bivalves changed relative to each other as linear interpolation was done to account for the disappearance of *T. squamosa* after 1997, and decrease of *T. maxima* to 10% of mollusc landings in 2010

Appendix Table A3. Taxonomic composition (%) applied to the finfish component of unreported subsistence and artisanal catches.

Taxon name	1950-1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003-2010
Acanthurus lineatus	3.47	3.85	2.22	4.33	3.30	9.62	2.32	4.39	4.19	4.01	3.18	2.34	3.46	3.98	3.35	3.86	3.62	3.62	2.98
Ctenochaetus striatus	3.47	3.85	2.22	4.33	3.30	9.62	2.32	4.39	4.19	4.01	3.18	2.34	3.46	3.98	3.35	3.86	3.62	3.62	2.98
Naso unicornis	1.75	1.52	0.89	2.85	2.39	3.27	1.18	3.01	2.99	2.32	3.04	3.77	4.52	4.39	5.06	7.28	4.76	4.76	5.40
Naso spp.	5.26	4.57	2.67	8.54	7.17	9.80	3.54	9.04	8.97	6.95	9.13	11.31	13.55	13.17	15.17	21.85	14.27	14.27	16.20
other Acanthuridae	2.97	3.30	1.91	3.71	2.83	8.25	1.99	3.76	3.59	3.44	2.72	2.01	2.96	3.41	2.87	3.31	3.10	3.10	2.55
Selar crumenophthalmus	1.74	5.08	0.13	0.00	0.69	0.00	3.05	0.48	0.08	8.48	4.69	0.90	1.70	1.10	1.12	2.03	0.00	0.00	0.62
other Carangidae	3.61	8.08	1.11	1.63	15.37	2.60	2.27	4.82	3.84	3.85	3.68	3.50	4.19	2.79	2.34	0.00	7.63	7.63	4.19
Chanos chanos	0.00	0.00	0.00	0.00	10.79	0.00	0.00	0.00	1.52	0.73	0.36	0.00	0.30	0.20	0.00	0.00	0.00	0.00	0.00
Gerridae	1.51	0.81	0.09	3.62	0.00	0.00	0.23	0.48	2.71	2.55	1.27	0.00	0.30	0.20	0.00	0.00	0.00	0.00	0.00
Holocentridae	5.28	1.10	1.44	13.31	0.90	0.00	0.00	3.37	4.55	4.97	3.23	1.50	1.50	3.29	4.08	0.00	1.48	1.48	1.28
Kyphosus cinerascens	0.00	0.00	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.60	1.20	0.70	0.70	0.84	0.00	1.96	1.96	17.89
Labridae	6.92	0.81	0.33	19.60	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.70	0.70	1.20	0.47	6.76	0.00	0.00	2.32
Leiognathidae	0.00	0.00	0.00	0.00	7.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lethrinidae	31.81	23.96	63.77	7.68	7.88	15.04	52.62	18.07	13.43	12.14	11.67	11.19	13.07	11.78	10.88	7.76	8.36	8.36	7.83
Lutjanidae	0.96	2.11	0.76	0.00	2.91	0.00	0.00	4.10	5.53	3.94	2.87	1.80	1.50	1.40	1.28	0.35	4.66	4.66	1.77
Mugilidae	5.99	11.01	4.20	2.77	7.07	6.49	7.78	10.60	8.99	7.66	18.52	29.37	20.66	10.88	13.42	16.30	4.15	4.15	7.82
Mullidae	3.96	7.31	3.73	0.84	6.52	0.00	1.38	7.23	7.88	6.31	4.46	2.60	2.40	2.89	1.55	1.62	2.11	2.11	1.37
Gymnothorax spp.	1.98	1.71	0.51	3.71	1.33	1.76	0.36	1.20	1.84	2.60	2.70	2.80	2.54	2.00	1.63	2.18	4.09	4.09	2.38
other Muraenidae	1.98	1.71	0.51	3.71	1.33	1.76	0.36	1.20	1.84	2.60	2.70	2.80	2.54	2.00	1.63	2.18	4.09	4.09	2.38
Scarus ghobban	5.95	5.50	3.50	8.85	3.46	6.21	3.27	7.35	5.87	7.02	7.26	7.49	7.39	12.38	12.58	6.34	8.58	8.58	5.88
other Scaridae	5.95	5.50	3.50	8.85	3.46	6.21	3.27	7.35	5.87	7.02	7.26	7.49	7.39	12.38	12.58	6.34	8.58	8.58	5.88
Serranidae	2.38	2.80	2.67	1.66	2.32	1.51	1.47	4.34	5.95	4.09	3.24	2.40	2.59	3.79	3.53	3.19	6.82	6.82	3.57
Siganidae	0.49	1.02	0.47	0.00	9.39	0.00	0.00	1.69	2.66	2.60	1.80	1.00	1.20	1.00	1.29	3.35	1.80	1.80	1.80
Miscellaneous marine fish	2.58	4.39	3.36	0.00	0.27	17.86	12.59	3.13	3.50	2.70	2.10	1.50	1.40	1.10	0.98	1.45	6.32	6.32	2.92

Sources: 1986-1994 (Anon., 1995); 1996 (Faasili et al., 1997); 1998 (Faasili et al., 1999); 1999 (Anon., 2000a); 2000 and 2001 (Anon., 2001); 2002 (Anon., 2003). In intervening years linear interpolation was used. For years 1950-1985 the average of 1986-1988 was used, and for 2003-2010 the average of 2000-2002 was used.

Appendix Table A4. FAO landings vs. total reconstructed catch, as well as catch by sector, for Samoa, 1950-2010, in tonnes.

Year	FAO Landings	Total reconstructed catch	Subsistence	Artisanal	Export fishery
1950	300	5,822	5,406	416	0
1951	300	5,996	5,568	429	0
1952	300	6,169	5,728	441	0
1953	400	6,341	5,887	453	0
1954	400	6,510	6,045	466	0
1955	400	6,679	6,201	478	0
1956	400	6,845	6,356	489	0
1957	500	7,010	6,509	501	0
1958	500	7,174	6,661	513	0
1959	500	7,336	6,811	525	0
1960	500	7,496	6,960	536	0
1961	600	7,695	7,145	550	0
1962	600	7,894	7,329	564	0
1963	600	8,091	7,512	579	0
1964	600	8,286	7,694	592	0
1965	600	8,479	7,873	606	0
1966	700	8,669	8,049	620	0
1967	700	8,854	8,221	633	0
1968	700	9,027	8,382	645	0
1969	700	9,181	8,525	656	0
1970	900	9,310	8,644	666	0
1971	900	9,412	8,739	673	0
1972	900	9,488	8,810	678	0
1973	900	9,544	8,862	682	0
1974	900	9,588	8,902	686	0
1975	1,000	9,624	8,936	688	0
1976	1,100	9,655	8,965	690	0
1977	1,250	9,680	8,988	692	0
1978	1,090	9,897	9,005	693	198
1979	1,890	10,717	9,013	694	1,010
1980	1,990	10,814	9,010	694	1,110
1981	3,095	11,905	8,997	693	2,215
1982	4,020	12,588	8,977	691	2,920
1983	3,820	12,612	8,953	689	2,970
1984	3,720	12,239	8,931	688	2,620
1985	3,641	11,801	8,917	687	2,198
1986	3,186	11,517	8,911	686	1,920
1987	3,076	11,449	8,912	686	1,850
1988	2,500	11,119	8,922	687	1,510
1989	2,530	11,323	8,937	688	1,698
1990	1,505	6,229	5,392	415	422
1991	1,595	6,400	5,432	418	550
1992	2,436	7,401	5,830	449	1,122
1993	1,986	7,141	6,237	480	424
1994	2,591	8,077	6,654	512	911
1995	4,094	10,042	7,082	545	2,414
1996	4,410	10,870	7,523	579	2,768
1997	7,867	14,780	7,974	614	6,192
1998	9,364	16,611	8,433	649	7,529
1999	8,562	16,099	8,891	685	6,523
2000	8,594	16,413	9,344	720	6,350
2001	8,612	16,712	9,468	729	6,515
2002	10,880	16,062	9,579	738	5,746
2003	9,702	13,945	9,681	745	3,519
2004	9,455	12,877	9,777	753	2,347
2005	9,835	12,558	9,874	760	1,924
2006	12,434	13,635	9,970	768	2,897
2007	14,090	14,773	9,998	770	4,005
2008	13,898	14,186	10,267	791	3,128
2009	13,278	14,678	10,060	775	3,843
2010	12,999	14,368	10,097	778	3,493

Appendix Table A5. Total reconstructed catch (in tonnes) by major taxa for Samoa, 1950-2010.

Year	Lethrinidae	*Thunnus alalunga*	*Octopus* spp.	*Scylla serrata*	Mugilidae	*Naso* spp.	Other Scaridae	*Scarus ghobban*	Others
1950	1,410	2	299	377	266	233	264	264	2,707
1951	1,453	2	309	389	274	240	272	272	2,786
1952	1,496	2	318	400	282	247	280	280	2,864
1953	1,531	2	322	405	289	253	287	287	2,965
1954	1,573	2	331	417	296	260	294	294	3,042
1955	1,614	2	340	428	304	267	302	302	3,118
1956	1,655	2	349	440	312	274	310	310	3,193
1957	1,690	3	353	444	318	279	316	316	3,291
1958	1,730	3	362	455	326	286	324	324	3,365
1959	1,769	3	371	466	333	293	331	331	3,438
1960	1,809	3	379	477	341	299	338	338	3,511
1961	1,851	4	385	484	349	306	346	346	3,624
1962	1,900	4	395	498	358	314	355	355	3,714
1963	1,948	4	406	511	367	322	365	365	3,803
1964	1,996	4	417	524	376	330	374	374	3,892
1965	2,044	4	427	538	385	338	382	382	3,979
1966	2,084	4	432	544	393	345	390	390	4,088
1967	2,129	4	442	556	401	352	398	398	4,172
1968	2,172	4	451	568	409	359	406	406	4,250
1969	2,210	4	460	579	416	365	413	413	4,320
1970	2,229	5	456	574	420	369	417	417	4,424
1971	2,254	5	461	581	425	373	422	422	4,470
1972	2,272	5	466	586	428	376	425	425	4,504
1973	2,286	5	469	590	431	378	428	428	4,530
1974	2,297	5	471	593	433	380	430	430	4,549
1975	2,299	6	468	588	433	380	430	430	4,588
1976	2,301	7	464	584	433	380	430	430	4,625
1977	2,297	8	457	575	433	380	430	430	4,671
1978	2,310	155	509	616	435	382	432	432	4,625
1979	2,303	606	510	618	434	381	431	431	5,004
1980	2,292	648	510	618	432	379	429	429	5,079
1981	2,278	1,369	509	617	429	377	426	426	5,474
1982	2,234	1,933	496	611	421	369	418	418	5,687
1983	2,247	2,051	508	626	423	372	420	420	5,544
1984	2,196	1,817	493	608	414	363	411	411	5,526
1985	2,127	1,503	472	582	401	352	398	398	5,568
1986	1,612	1,314	477	590	740	307	370	370	5,737
1987	4,274	1,275	479	592	281	179	235	235	3,899
1988	523	1,042	486	604	189	581	603	603	6,488
1989	537	740	804	666	482	488	236	236	7,135
1990	552	228	705	406	238	360	228	228	3,283
1991	1,957	213	762	408	289	132	122	122	2,396
1992	697	928	833	429	409	348	283	283	3,190
1993	538	222	910	461	360	360	235	235	3,819
1994	517	651	997	486	326	296	299	299	4,206
1995	541	1,892	1,022	517	859	424	337	337	4,114
1996	556	1,868	1,106	545	1,459	562	372	372	4,031
1997	682	4,314	1,185	566	1,077	707	385	385	5,480
1998	642	4,979	1,263	586	593	718	675	675	6,480
1999	624	4,228	1,344	608	771	871	722	722	6,207
2000	465	4,265	1,436	626	977	1,310	380	380	6,572
2001	528	5,056	1,305	642	262	902	542	542	6,934
2002	413	4,445	1,008	428	205	705	423	423	8,012
2003	337	2,383	1,152	404	337	697	253	253	8,129
2004	282	1,316	1,279	394	282	584	212	212	8,315
2005	228	1,349	1,393	367	228	471	171	171	8,180
2006	114	2,243	1,641	566	114	237	86	86	8,548
2007	55	3,293	1,710	557	55	114	41	41	8,908
2008	247	2,486	1,794	566	247	511	186	186	7,963
2009	271	2,980	1,661	572	271	561	204	204	7,954
2010	272	2,679	1,659	576	272	563	204	204	7,938