RECONSTRUCTION OF TOTAL MARINE FISHERIES CATCHES FOR FRENCH POLYNESIA (1950-2007)[1]

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ABSTRACT

French Polynesia's total marine fisheries catches were estimated for the 1950-2007 time period. The 'catch reconstruction' method used to estimate total catches includes all fisheries sectors (i.e., commercial, artisanal and subsistence catches). Separate approaches were used for each of the major island groups, reflecting differences in fishing activities between the islands. Overall, our estimated catch for French Polynesia's fisheries from 1950 to 2007 was approximately 600,000 t. This total was twice the amount reported by the FAO on behalf of French Polynesia. The data supplied to the FAO reflect only commercial landings, while our reconstructed catch estimate was more comprehensive, combining small-scale fisheries catches with commercial sector catches. This method of accounting for all fisheries components is essential to improving the management of fisheries resources and reducing threats to food security in French Polynesia.

INTRODUCTION

Over 100 islands make up the French Pacific Territory of French Polynesia, with an Exclusive Economic Zone (EEZ) of nearly 5 million km² (www.seaaroundus.org), located between 13° and 22° S and 25° and 148° W (Figure 1). The islands are divided into 5 main groups: the Society Islands, the Austral Islands, the Gambier Islands, the Marquesas Islands, and the Tuamotu Islands (Figure 1). The Society Islands are the best known, with the popular tourist destinations of Bora Bora, Moorea and Tahiti (Figure 1). The island of Tahiti is host to the capital city of Papeete, where the main fish market is located. The human population of French Polynesia reached approximately 160,000 in 2007. Since 1992, more than 70% of the total population of French Polynesia has resided on the island of Tahiti, being mostly concentrated around the capital city of Papeete (Walker and Robinson, 2009). In 2004, French Polynesia acquired a status as part of France which made it responsible for all regulation and management regarding fisheries resources within its own EEZ.

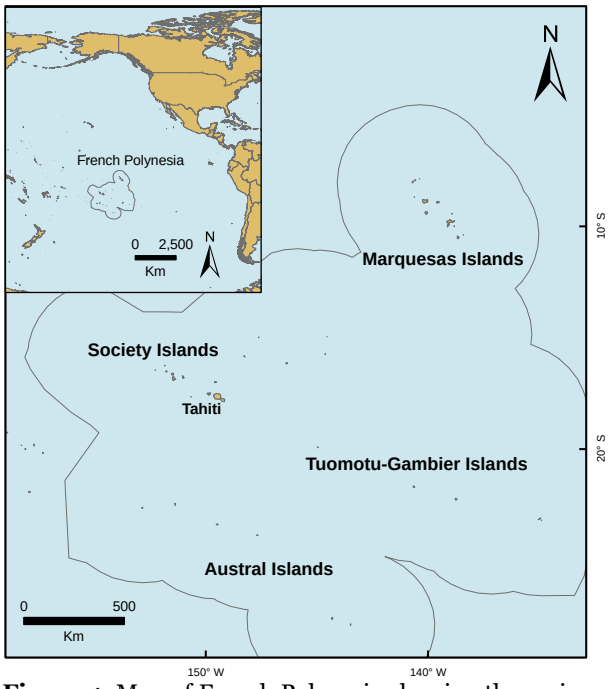

Figure 1. Map of French Polynesia showing the major island groups, the country's EEZ and an inset map showing the location within the Pacific Ocean.

Fishing has always been an important source of protein in French Polynesia, especially for populations living greater distances from the main island of Tahiti (Salvat, n.d.). Many of the islands are host to diverse reef and lagoon systems; the Tuamotu and Society Islands have moderately high coral diversity, with large

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coral reefs and a variety of reef types, and approximately 800 species in 90 families of fish have been recorded. Overall, approximately 84 of the islands of French Polynesia are coral atolls and are considered vulnerable to human pressures (Salvat, n.d.). Because of the rich diversity surrounding the Society and Tuamotu Island groups, and concentration of human populations, these coral reefs have been subjected to varying degrees of exploitation for centuries. Some areas of the Society Islands show signs of extensive overfishing with noticeable declines in mature-sized fish due to the use of destructive gear types including fine meshed nets and spears (Payri and Bourdelin, 1986). However, fishing apparently has never comprised a significant portion of the economy. Prior to the 1960s, exports of copra, vanilla, coffee, and phosphate dominated the economy, while fishing was largely conducted for subsistence purposes. In the early 1960s, France began nuclear testing in French Polynesia. The nuclear testing program had significant impacts on the development of the Polynesian economy, as many military personnel were sent to the islands to work (Anon., 2008). As a result, a major airport and shipping port were built near the capital city of Papeete. These developments greatly facilitated economic activities with other countries (Walker and Robinson, 2009). The nuclear program was conducted mainly between 1966 and 1974 (Danielsson, 1990), but was not completely concluded until 1996. The French government then enacted 'Le Pacte de Progrès', to facilitate growth in tourism, agriculture and fisheries (Walker and Robinson, 2009).

Currently, the economy is dominated by copra, fishing, pearl farming and tourism (Anon., 2002). The majority of domestic fishing in French Polynesia has always been for subsistence and artisanal purposes. Small-scale fishing on the coast is conducted in boats called *'poti marara'* (flyfishing boats), while the *'bonitier'* fleets operate a little further offshore. The catches of the coastal *poti marara* boats consist mainly of albacore (*Thunnus alalunga*), yellowfin (*Thunnus albacores*) and dolphinfish (*Coryphaena hippurus*; Bard *et al.,* 1998). Historically, these fishers used canoes with hand-lines made of vegetable fibers, hooks made of wood and mother-of-pearl, and chunks of live fish for bait. The *bonitier* vessels target mainly skipjack (*Katsuwonus pelamis*) and some yellowfin (Bard *et al.*, 1998). Catches from small-scale fisheries are consumed for subsistence, bartered or traded locally, or taken to market.

Fishers also obtain catches from lagoons; consisting mainly of parrotfish (Scaridae), surgeonfish (Acanthuridae) and trevally (Carangidae). The main gears used for lagoon fishing include nets, lines, spearguns, cages, traps, and traditional Polynesian fish ponds (latticed networks of stones built to trap fish; Anon., 2002). While many subsistence fishers fish for themselves and their families, it is also common to give or trade fish with other individuals (Yonger, 2002). There are also a significant number of fish sold at the roadside, including the majority of lagoon fish caught on the island of Moorea (Walker and Robinson, 2009). Fishers who ship their catch to markets in Tahiti do so by plane or boat (Payri and Bourdelin, 1986).

In the early 1990s, financial incentives were given to develop an offshore industrial tuna fishing fleet as part of 'Le Pacte de Progrès' (Walker and Robinson, 2009). The Polynesian long-liner fleet targets deep swimming tunas with bigeye tuna (*Thunnus obesus*) heavily exploited, and some billfish in the north-east portion of the EEZ, north of the Marquesas Island group. This north-eastern portion of the EEZ where Polynesian long-liners have operated since the early 1990s, has traditionally been targeted by international distant-water long-liners. Korea, Japan and Taiwan have operated such fleets historically, while currently, only Korean boats possess licenses (Bard *et al.*, 1998). While Bard *et al.* (1998) stated that the majority of long-liner catches were sold locally, with some exports to Japan, Hawaii and France, Walker and Robinson (2009) state the majority of long-liner catches are in fact exported. It is likely that the exported portion of these catches has increased over time. French Polynesia also imports several varieties of fish not available in local waters (e.g., Atlantic salmon), as well as a variety of processed fish products due to the absence of any domestic processing or canning facilities (Anon., 2002).

FAO FishStat (www.fao.org) is the only publically accessible database for global fisheries catches. The catches presented in this database are known to represent primarily commercial landings. In the case of French Polynesia, the data presented by FAO on behalf of French Polynesia are thought to account for all catches landed for the markets in Papeete and possibly Pirae, as well as the commercially exported tunas from offshore long-liners.

The purpose of this study was to estimate the total fisheries catches for French Polynesia from 1950-2007, including all fisheries sectors (i.e., subsistence, artisanal and commercial catches). As described above, the majority of catches in French Polynesia have historically been subsistence in nature. The resources available to provide estimates of subsistence catches are limited, and our approach uses an assumption

based approach using information found in the academic and grey literature, with interpolations between anchor points to estimate unknown catches (Zeller *et al.*, 2006, 2007; Zeller and Pauly, 2007).The report herein presents the best estimate of all small-scale catches and commercial landings for French Polynesia from 1950-2007.

MATERIALS AND METHODS

Human population data

Human population data were derived from the Populations Statistics database (www.populstat.info) and the Institut Statistique de Polynésie Française (ISPF; www.ispf.pf). Population data were acquired for each of the 5 island groups between 1950 and 2007 whenever census data were available. The Island of Tahiti (part of the Society Islands) was treated separately due to the large urban population which resides there. Specific population data for the island of Tahiti (total population) and its urban municipal jurisdictions (communes) were used to disaggregate rural and urban populations (see below). The urban population of the capital city of Papeete was taken to include the following 7 communes: Papeete; Faaa; Punaauia; Pirae; Mahina; Paea; and Arue. These urban population data were taken from the Population Statistics database (www.populstat.info). Data for all populations on all islands were typically acquired from the Population Statistics database prior to 2002, and from the ISPF (www.ispf.pf) from 2002-2007. Years between census points were interpolated linearly to estimate population time series (Figure 2).

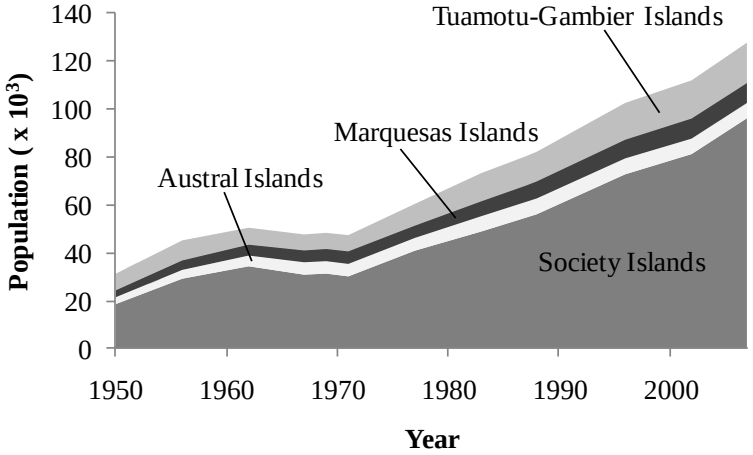

Figure 2. Human population for the major Island groups of French Polynesia, 1950-2007

Subsistence fisheries

Both the academic and grey literature were thoroughly reviewed for data pertaining to subsistence fisheries in each of the five island groups of French Polynesia. *Per capita* catch data referring to subsistence and artisanal fishing were found for the island of Moorea (Society Island), and the Tikehau atoll (Tuamotu Islands). The island of Moorea is adjacent to the island of Tahiti, which is visited frequently by tourists. An estimate of 519 t·year^{-1}, or 43.7 kg·person^{-1}·year^{-1} was reported to be caught and consumed for subsistence by fishers on Moorea (Yonger, 2002).

Subsistence catch data for the Tikehau atoll reflect a more remote population on healthy, productive atolls (Schultz, 1999). Subsistence catches were reported at approximately 150 kg·person^{-1}·year^{-1} (Caillart *et al.*, 1994). Using human population data for each island group, we expanded these *per capita* catch data to represent subsistence catches on all island groups from 1950-2007. Once the total subsistence catch for each island group was derived, we estimated the taxonomic composition with data from Caillart *et al.* (1994), Schultz (1999), Yonger (2002), Aswani and Allen (2009), Suggs (n.d.). Caillart *et al.* (1994) and Yonger (2002) present catches of the most frequently caught species on the Tikehau atoll (Table 1), and the island of Moorea (Table 2), respectively. Aswani and Allen (2009) present counts of individual taxa on the inner, mid, and outer portions of a reef in the Marquesas Island group, Suggs (n.d.) provides general information pertaining to subsistence fishing which aided formulation of our assumptions, and Schultz (1999) provides detailed information on taxa found in and around the Marquesas Islands. These data were used to appropriate the taxonomic composition of reconstructed subsistence catches.

Society Islands (except Tahiti): The Society Islands are frequently visited by tourists. The subsistence catch data found in the literature for the island of Moorea represents fishers who reside within a reasonable distance of the market in Papeete, as well as those who are influenced by the tourist industry (which provides alternative sources of income). We applied the subsistence catch rate found for the island of Moorea in 2001 of 43.7 kg·person^{-1}·year^{-1} (Yonger, 2002), to all island populations found within the Society Island group for 2001 (Table 1), excluding the population of the island of Tahiti (see below). This rate was held constant from 2002-2007 (Table 1). For 1950, we assumed a rate twice that of 2001 (i.e., 87.4 kg·person^{-1}·year^{-1}), and interpolated linearly from 1950-2001 (Table 1). This decreasing trend in *per capita* subsistence consumption since 1950 is assumed to account for the growth of Papeete as an urban centre, the growth of the tourism industry, and increased availability of imported goods. Taxonomic breakdowns of estimated catches were based on data from Table 2.

Table 1. Annual *per capita* catch rates (kg·person^{-1}·year^{-1}), applied to the resident populations of the five island groups of French Polynesia to estimate subsistence catches from 1950-2007, values in *italics* denote anchor points, (-) denotes linear interpolation in years between anchor points. Sources: Caillart *et al.* (1994); Yonger (2002); see text for details.

Year	Society Islands	Rural Tahiti	Austral Islands	Marquesas Islands	Tuamotu-Gambier Islands
1950	*87.4*	*43.7*	*43.7*	*43.7*	150
1951-2000	-	-	-	-	150
2001	*43.7*	*21.9*	*43.7*	*21.9*	150
2002	43.7	21.5	43.7	21.9	150
2003	43.7	21.0	43.7	21.9	150
2004	43.7	20.6	43.7	21.9	150
2005	43.7	20.2	43.7	21.9	150
2006	43.7	19.8	43.7	21.9	150
2007	43.7	19.3	43.7	21.9	150

Society Island (rural Tahiti only): Under the assumption that the urban population of Tahiti does not engage in subsistence fishing, we provide estimates of subsistence catches for the rural population of Tahiti only. The rural population was derived by subtracting the urban population of Papeete from the total population of Tahiti for 1950-2007. In 2001, we applied half the rate found for the island of Moorea from Yonger (2002) to represent subsistence catch rates (i.e. 21.9 kg·person^{-1}·year^{-1}) in rural Tahiti. Thus, we assumed lower due to relative proximity to an urban centre (Table 1). This is supported by Salvat (n.d.) who noted a relatively lesser amount of fishing for subsistence purposes on the island of Tahiti. In 1950 we assigned the original 2001 *per capita* catch rate found for Moorea, representative of the year 2001. We interpolated linearly between 1950 and 2001, then applied the average decrease in *per capita* catch rates from 1950-2001, for the years 2002-2007 (Table 1). This methodology represents a conservative estimate for a population in close proximity to the main Polynesian fish market and largest urban centre.

Table 2. Lagoon and reef fish (kg) taken from the lagoon of Moorea in 2001 (Society Islands), French Polynesia (Yonger, 2002).

Taxon name	Common name	Catch (kg)	%
Selar crumenophthalmus	Bigeye scad	26,762	40.6
Myripristis sp.	Soldierfish	6,056	9.2
Naso unicornis	Bluespine unicornfish	3,700	5.6
Scarus oviceps	Dark capped parrotfish	3,246	4.9
Epinephelus merra	Honeycomb grouper	2,508	3.8
Ctenochaetus striatus	Striated surgeonfish	1,848	2.8
Caranx melampygus	Bluefin trevally	1,613	2.3
Misc. marine fishes	Other	20,115	30.8

Austral Islands: The Austral islands are located in the southwest portion of the French Polynesian EEZ (Figure 1). The northern Austral islands include the rocky Bass Islands, while the southern Austral islands, the Rapa islands, are volcanic in origin. These most southerly islands are surrounded by relatively low sea temperatures, and have no fringing reefs. The Bass islands in the north, however, have well developed fringe, and barrier reefs (Spalding *et al.*, 2001). These aspects of geography contribute significantly to the diversity of species available for inshore fishing.

Very little information pertaining to fishing in the Austral Islands was found. However, Spalding *et al.* (2001) refer to the critical role fishing plays in all Polynesian populations, and particularly those of more remote islands. Larrue (2006) states that the majority of Tubuai's population (one of the more populated northern, Austral Islands) are dual fisher/farmers. The author describes a wild harvest for Giant Clam (*Tridacna maxima)* as being an important subsistence fishery. On land, the dietary stables are taro, breadfruit, coconut, sweet potato, yams, and chestnuts, which are grown on the Island (Larrue, 2006). The

population also relies on introduced species of pig and chicken (Bolt, 2008). Given the relative lack of reef and lagoon habitat, we assumed a lower rate of fisheries productivity and thus, lower *per capita* subsistence catch rates. These assumptions were made despite the relative isolation of the Austral Islands, which would normally contribute to increased *per capita* catch rates. This lead to the application of the more conservative rate for the island of Moorea (i.e. 43.7 kg·person^{-1}·year^{-1}; Yonger, 2002), held constant for the 1950-2007 time period (Table 1). Using the population data for the Austral Islands, we applied the *per capita* catch rate reported for the island of Moorea in 2001. Taxonomic breakdowns of catches were estimated using the information presented for Moorea (Table 2), although the more marginal nature of coral reef habitats may cast some doubts on this.

Marquesas Islands: The Marquesas group is located in the most northerly region of the French Polynesian EEZ. These islands are somewhat similar to the Austral Islands, being steep, rugged, and volcanic in origin. Due to the cool Humboldt currents from Peru, the islands are too cool to support extensive growth of coral reefs (Suggs, n.d.) and lack the enclosed lagoon environments characteristic of the Society and Tuamotu Islands. Anaho Bay has a small inshore reef, but ciguatera has greatly reduced the Marquesan population who traditionally fished in this bay (Aswani and Allen, 2009). In the 1950s, when populations still fished in the bay (before ciguaterabecame widespread), commonly caught taxa included parrot fish, jacks (Carangidae), squirrel fish (Holocentridae), grouper (Serranidae), mullets, triggerfish, wrasse, sharks, manta rays and two species of sardines. However, a lack of reef and lagoon environments forced many Marquesans to focus on pelagic fishing as a source of sustenance. Fishing was done with hook and line as well as with nets and included catches of tuna and bonito (Scombridae), mahi-mahi *(Coryphaena hippurus)* and wahoo (*Acanthocybium solandri*). Today, local crops as well as pigs, cattle and imported foods have an impact on the necessities of fishing for subsistence (R. Suggs, pers. comm.)[2].

Table 3. Taxonomic composition applied to subsistence catches for the Marquesas Islands from 1950-2007. Percentage data derived through assumption-based consideration of source material.

Taxon name	Common name	Proportion of total subsistence catch (%)
Scombridae	Mackerels, tunas and bonitos	30
Acanthocybium solandri	Wahoo	20
Lutjanidae	Snappers	20
Serranidae	Sea basses: groupers and fairy basslets	10
Misc. marine fishes	Others	20

Table 4. Lagoon and reef fish taken from Tikehau atoll of the Tuamotu Islands, French Polynesia (Caillart *et al.*, 1994)

		Catch (kg)				
Taxon name	**Common name**	**1983-1984**	**1984-1985**	**1985-1986**	**1986-1987**	**%**
Lethrinus miniatus	trumpet emperor	34,812	29,923	13,961	50,983	19.6
Lutjanus gibbus	humpback red snapper	8,152	11,371	24,374	24,354	10.3
Caranx melampygus	bluefin trevally	24,357	21,332	10,213	11,214	10.1
Selar crumenophthalmus	bigeye scad	8,337	14,201	17,133	16,063	8.4
Epinephelus microdon	camouflage grouper	180	810	5,183	48,902	8.3
Lutjanus fulvus	blacktail snapper	11,226	15,962	13,050	7,694	7.2
Naso brevirostris	spotted unicornfish	3,036	15,299	19,374	2,293	6.0
Mulloides sp.	Goatfish	9,593	8,506	11,066	5,359	5.2
Albula vulpes	Bonefish	12,292	7,889	6,391	5,099	4.8
Upeneus vittatus	yellowstriped goatfish	9,454	882	6,206	1,085	2.7
Sphyraena forsteri	bigeye baracuda	2,835	2,835	5,085	1,954	1.9
Acanthurus xanthopterus	yellowfin surgeonfish	2,085	6,229	307	1,661	1.6
Myripristis sp.	Soldierfish	2,475	1,559	2,931	1,851	1.3
Decapterus pinnulatus	mackerel scad	2,195	1,424	3,580	1,582	1.3
Misc. Marine Fishes	Other	15,848	15,974	16,152	26,348	11.2

As a result of the ciguatera concerns in inshore waters, the subsistence fishing that still occurs is even more focused offshore. Furthermore, high abundances of deeper water snapper on the outer portion of the

[2] R. Suggs, personal communication, archaeologist, author, interpreter and lecturer of the Marquesas Islands and the Pacific, mongonui@msn.com, ph: (208) 429-1619, [*Date of communication*: December 30, 2009].

narrow and steep shelf surrounding the islands are also targeted (Aswani and Allen, 2009). Sport fishers have reported nearshore catches of Pacific little tunny (*Euthynnus affinis*), skipjack (*Katsuwonus pelamis*), yellowfin (*Thunnus albacores*), bigeye tuna (*Thunnus obesus*), blue marlin (*Makaira mazara*), sailfish (*Istiophorus platypterus*), wahoo (*Acanthocybium solandri*), giant trevally (*Caranx ignobilis*), jacks (Carangidae), queenfish (*Scomberoides* sp.), job fish (*Aprion virescens*), red snapper (*Lutjanus bohar*), emperors (Lethrinidae) and groupers (Serranidae), including white-margined groupers (*Gracila albomarginata*) and occasionally Giant groupers (*Epinephelus lanceolatus*; Schultz, 1999).

Thus, we felt a conservative estimate of subsistence catches on the Marquesas Islands would be accomplished by applying the 2001 Morea catch rate of 43.7 kg·person^{-1}·year^{-1} to 1950 Marquesas. For 2001, we assumed half this rate (21.9 kg·person^{-1}·year^{-1}). Linear interpolation was used to estimate catches from 1950-2001, and the 2001 rate was held constant for the period from 2002-2007 (Table 1). Species compositions of catches were broken down for all years in the period from 1950-2007 (Table 3).

Tuamotu-Gambier Islands: The information derived from Caillart *et al.* (1994) for the Tikehau atoll (Tuamotu Island) was used to represent *per capita* subsistence catch rates of 150 kg·person^{-1}·year^{-1} throughout the Tuamotu and Gambier Islands. The rate of 150 kg·person^{-1}·year^{-1} was applied in all years (1950-2007) to the combined population of the Tuamotu-Gambier Islands to estimate subsistence catches (Table 1).

Artisanal and commercial fisheries

Most information from the literature pertaining to commercial or artisanal fisheries catches document those sold at the market in Papeete, or tunas caught by offshore long-liners which are both sold locally and exported. The majority (about 72%) of fish sold in the market in Papeete are from local lagoons and reefs, while the other 28% are caught offshore. Approximately 23% of marketed lagoon and reef fish are caught in waters surrounding the Society Islands, while approximately 64% are from the atolls surrounding the Tuamotu Islands, and 13% are from reefs and lagoons elsewhere in the French Polynesian EEZ (Payri and Bourdelin, 1986). Many artisanal fishers also sell catches by the roadside or directly to restaurants. These catches likely remain unaccounted for in data supplied to the FAO. Chauvet and Galzin (1996) report that approximately 15% of catches of reef and lagoon fish by artisanal fishers in the Tuamotus are represented by 'unauthorized sales'. This value was used in our reconstruction to augment annual catches of lagoon and reef fish in all Islands to fully account for all likely catches from 1950-2007. This rate was not applied to any other species (tunas, or other pelagics) due to a lack of disaggregation between commercial and artisanal origins of these landings in the data presented by the FAO on behalf of French Polynesia.

From 1950-1970, landings, as supplied to FAO, describe only two taxonomic entities, miscellaneous marine fishes and Skipjack tuna. After 1970, FAO presents additional landings of some invertebrates (crustaceans, spiny lobsters, echinoderms) and dolphinfish, and in the late 1980s and early 1990s, landings of bigeye tuna, albacore tuna, and minor quantities of other taxa are documented. It seems that the majority of fish from reefs and lagoons are lumped into the miscellaneous marine fish category. Taxonomic data derived from Caillart *et al.* (1994) and Yonger (2002) provide a breakdown of the most commonly fished taxa from reefs and lagoons (previous section, Tables 2 & 4) around the Society and Tuamotu Islands.

Since the majority (64%) of lagoon and reef fish marketed in Papeete come from the Tuamotus, we applied the taxonomic breakdown from Caillart *et al.* (1994) to 64% of the catch of miscellaneous marine fishes as presented by FAO in each year from 1950-2007. Similarly, since 23% of marketed lagoon and reef fish are caught in the Society Islands, we applied the taxonomic breakdown from Yonger (2002) to 23% of the miscellaneous marine fishes presented by FAO in each year during the period from 1950-2007. We retained the remaining (13%) of miscellaneous catches from FAO as such. Therefore, the new adjusted miscellaneous marine fishes (MMF) category accounts for the cumulative sum of 'others' from Caillart *et al.* (1994), Yonger (2002), and the remaining 13% from MMF category as presented by FAO.

Bard *et al.* (1998) provide data for skipjack and yellowfin tuna sold in the Papeete market, Polynesia-wide catch estimates of skipkack and yellowfin, and Bigeye catches by both domestic and foreign long-liners (Table 5). The authors also provide an estimate of catches of tuna made by coastal *poti marara* boats for all years during the period from 1954-1996 (200-500 t·year^{-1}) consisting mainly of albacore, yellowfin and dolphinfish (Bard *et al.*, 1998; Table 5). Catches by coastal fleets are not required to be reported (Bard *et*

Table 5. Data reported by FAO and Bard *et al.* (1998) for skipjack and yellowfin tuna (1950-2007) as well as catches reported by Bard *et al.* (1998) for catches of albacore, yellowfin and dolphinfish from the coastal *bonitier* fleet for all of French Polynesia for the period 1954-1996, (n/a) denotes years for which no data were reported by a source.

	FAO	Bard *et al.* (1998)	
Year	Skipjack + Yellowfin	Skipjack + Yellowfin	Albacore, yellowfin + dolphinfish
1950	500	n/a	n/a
1951	500	n/a	n/a
1952	500	n/a	n/a
1953	800	n/a	n/a
1954	1,000	n/a	350
1955	800	n/a	350
1956	1,000	n/a	350
1957	700	n/a	350
1958	600	n/a	350
1959	700	n/a	350
1960	1,000	n/a	350
1961	1,000	n/a	350
1962	1,500	n/a	350
1963	1,000	n/a	350
1964	1,000	n/a	350
1965	700	n/a	350
1966	900	n/a	350
1967	700	n/a	350
1968	800	n/a	350
1969	1,000	n/a	350
1970	900	n/a	350
1971	600	n/a	350
1972	700	n/a	350
1973	700	n/a	350
1974	713	n/a	350
1975	721	n/a	350
1976	749	1,711	350
1977	263	1,996	350
1978	1,037	2,981	350
1979	696	n/a	350
1980	936	1,312	350
1981	1,001	1,468	350
1982	1,034	1,557	350
1983	836	1,491	350
1984	1,250	2,344	350
1985	836	1,623	350
1986	961	1,356	350
1987	878	1,536	350
1988	715	1,314	350
1989	754	1,370	350
1990	1,567	1,400	350
1991	1,623	1,472	350
1992	1,520	1,406	350
1993	1,727	n/a	350
1994	1,440	n/a	350
1995	2,220	n/a	350
1996	2,211	n/a	350
1997	1,986	n/a	n/a
1998	2,403	n/a	n/a
1999	2,611	n/a	n/a
2000	2,951	n/a	n/a
2001	3,071	n/a	n/a
2002	2,633	n/a	n/a
2003	2,600	n/a	n/a
2004	2,644	n/a	n/a
2005	2,510	n/a	n/a
2006	2,963	n/a	n/a
2007	1,984	n/a	n/a

al., 1998), so it is unlikely that these catches are included in data supplied to FAO. Though the report by Bard *et al.* (1998) refers to their particular period of study (1954-1996), we augmented landings supplied to FAO with an addition 350 t (the median of the given range) each year by assigning 1/3 of this tonnage to each of the three species cited by the authors (albacore, yellowfin tuna & dolphinfish).

For the years Bard *et al.* (1998) provide total landings of skipjack and yellowfin for all of French Polynesia (1976-1992), totals exceed those of all skipjack and yellowfin landings presented by FAO (often being 1.5-2 times as much) for the years 1976-1978 and 1980-1989 (Table 5). Thus, we replaced FAO landings for these years with the data provided by Bard *et al.* (1998). The skipjack and yellowfin totals given by Bard *et al.* (1998) were split into two taxonomic groupings (skipjack and yellowfin), by using the ratio of reported skipjack to yellowfin landings from FAO statistics in each year.

Bigeye tuna catches from Polynesian long-liners reported by Bard *et al.* (1998) from 1990-1995, match those presented by FAO during this time, and thus, it was assumed that data supplied to FAO after this time (1996-2007) are likely to be correct.

Therefore, we used data presented by the FAO to represent artisanal and commercial fisheries catches in French Polynesia between 1950 and 2007, except for the period 1976-1992 when data from Bard *et al.* (1998) was used in place of data as supplied to FAO.

Thus, our reconstruction of commercial/ artisanal catches entailed: 1) disaggregating the miscellaneous marine fishes category with data from Caillart *et al.* (1994) and Yonger (2002) for all years, 1950-2007; 2) improving the accuracy of commercial skipjack and yellowfin landings in the years listed above, 3) adding additional albacore, yellowfin and dolphinfish catches from the *poti marara* fishery in all years (1950-2007); and 4) augmenting commercial/artisanal catches of lagoon and reef fish by 15% to appropriately represent unauthorized sales for the period from 1950-2007. We also present landings from distant water fleets as reported from Japan, Korea and Taiwan. However, these landings are not included in our reconstruction totals.

RESULTS

Subsistence catches

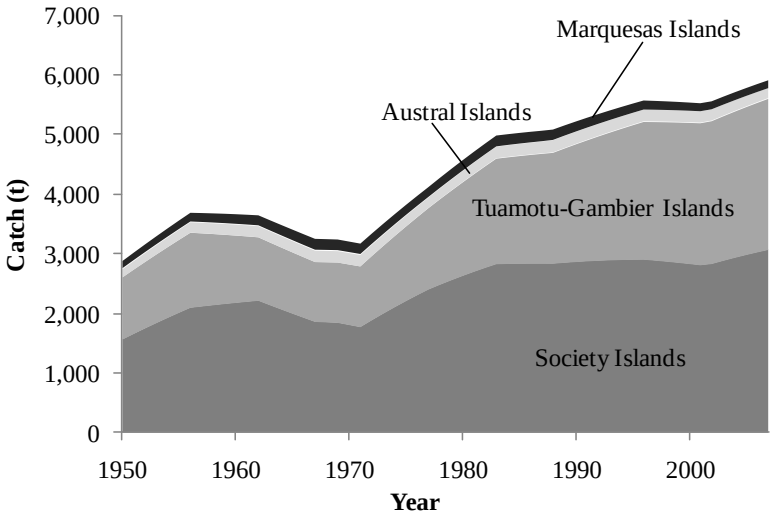

Figure 3. Subsistence catches for French Polynesia, 1950-2007, by island group.

Society Islands: Subsistence catches for the Society Islands including rural Tahiti totaled approximately 146,500 t for the period 1950-2007 (Figure 3). For the most recent years, annual subsistence catches in these islands appeared to account for around 3,000 t·year^{-1}. Overall, subsistence catches for the Society Islands were the greatest of all the island groups considered in this study due to the large proportion of the total population residing in this group. Bigeye scad (*Selar crumenophthalmus*) was the largest individual taxon of the catch, with approximately 57,000 t for the period (1950-2007), and around 1,200 t·year^{-1} for recent years. Soldierfish and Bluespine unicornfish were the next largest individual taxon, with catches of approximately 250 t·year^{-1} in the recent time period (2000-2007).

Tuamotu-Gambier Islands: Our estimate of subsistence catches for the Tuamotu-Gambier Island group for the period 1950-2007 totaled approximately 94,000 t (Figure 3). For recent years, catches were around 2,400 t·year^{-1}.Catches of trumpet emperor (*Lethrinus miniatus*) were the dominant individual taxon component, totalling approximately 18,400 t (480 t·year^{-1} for recent years). Bluefin trevally and Bigeye scad also had substantial catches, with totals of approximately 9,460 t and 7,900 t, respectively over the 1950-2007 time period (250 t·year^{-1} and 205 t·year^{-1}, respectively, for the recent period).

Austral Islands: Our estimate of subsistence catches totaled approximately 13,500 t for the period 1950-2007 for the Austral Island group (Figure 3). In the recent period (2000-2007), catches were estimated to be around 280 t·year^{-1}. Bigeye scad comprised the largest individual taxon component of subsistence catches with totals of approximately 5,500 t for the period 1950-2007. Other major taxa included Soldierfish, Bluespine unicornfish, and Darkcapped parrotfish, each representing between 5-10% of total the Austral Island subsistence catch over the 1950-2007 time period.

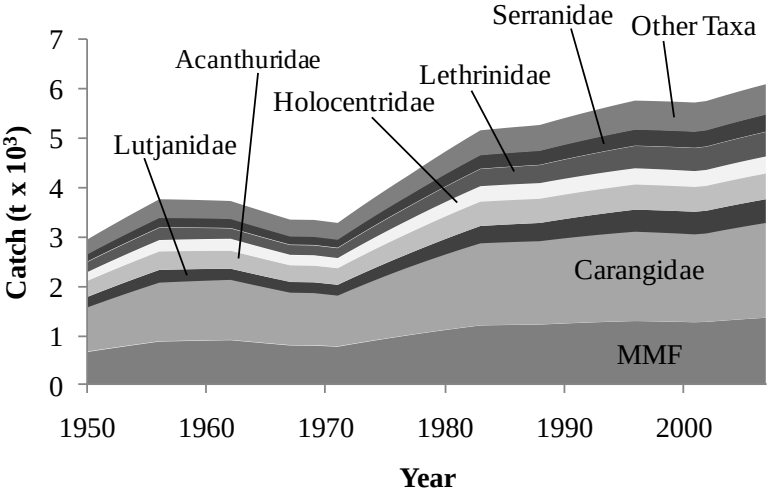

Figure 4. Subsistence catches by taxa for all Island groups combined. The category 'other taxa' includes Albulidae, Mullidae, Scaridae, Scombridae and Sphyraenidae.

Marquesas Islands: Our estimate of subsistence catches for the Marquesas Islands totaled approximately 10,700 t for the period from 1950 to 2007 (Figure 3). Annual catch for the recent period was 180 t·year^{-1}. Family Scombridae (Mackerels, tunas and bonitos) contributed the greatest component of the overall subsistence catches. Catches of fish in the Scombridae family totaled over 5,000 t for the period 1950-2007 (approximately 90 t·year^{-1} ·for the recent period, 2000-2007), while catches of wahoo and snapper (Lutjanidae) were approximately 2,000 t each for the period 1950- 2007 (around 36 t·year^{-1} for the recent period, 2000-2007).

Total subsistence reconstruction: Overall, subsistence catches totaled approximately 259,200 t for the period 1950-2007 (Figure 3). The majority of catches were taken in the Society Islands, followed by the Tuamotu-Gambier Island group, the Austral Islands, and the Marquesas Islands (Figure 3). Subsistence catches increased throughout the 1950s, and initially peaked at approximately 3,686 t·year^{-1} in 1956. During the 1950s the average catch was approximately 3,400 t·year^{-1}. Subsistence catches were estimated to have declined through the 1960s hitting a low of approximately 3,207 t·year^{-1} in 1971. Subsistence catches in French Polynesia have generally increased since this time, averaging 3,800 t·year^{-1} in the 1970s, approximately 5,000 t·year^{-1} in the 1980s, 5,600 t·year^{-1} in the 1990s, and approximately 5,800 t·year^{-1} from 2000-2007. While subsistence catches of some island groups maybe declining (i.e., Austral and Marquesas Islands), it appears that overall subsistence catches in French Polynesia are still increasing (Figure 3). While the taxonomic breakdown of subsistence catches included species level, we grouped the catches by family for the purposes of this report. Subsistence catches were dominated by fish in the Carangidae family (Figure 4). The Acanthuridae, Lutjanidae and Lethrinidae also provided substantial amounts of catch (Figure 4).

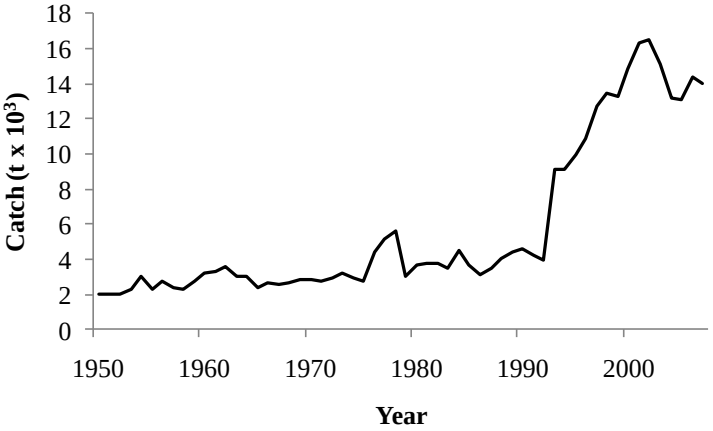

Figure 5. Estimated commercial catch for French Polynesia, 1950-2007.

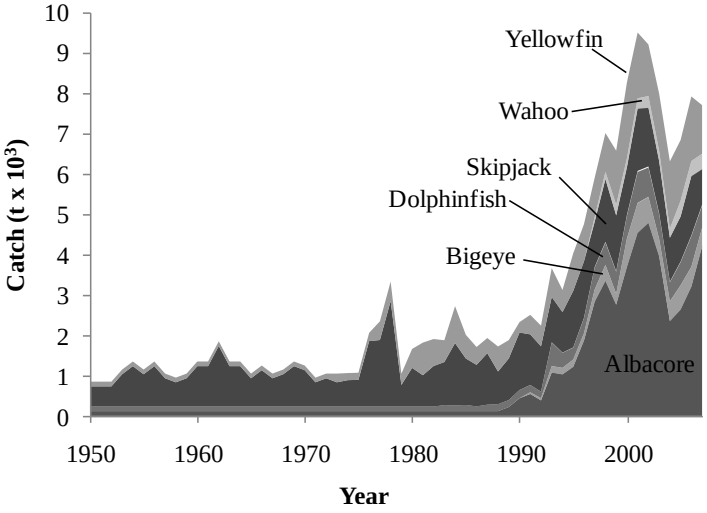

Figure 6. Commercial landings of main pelagic species caught by French Polynesia, 1950-2007.

Artisanal and commercial catches

Our estimates of commercial catches for the period 1950-2007 totaled approximately 336,000 t (Figure 5). Commercial catches initially averaged approximately 2,300 t·year^{-1} in the 1950s, and increased gradually to an average of between 3,000-4,000 t·year^{-1} in the 1980s. Starting in the early 1990s, a dramatic increase from approximately 4,000 t·year^{-1} to a peak of 16,500 t·year^{-1} by 2002 was reported (Figure 5). Since this time, commercial catches appear to have declined slightly to an average annual catch of 14,600 t·year^{-1}.

Our estimates of commercial catches were comprised mostly of data as supplied to FAO, however, some additions of skipjack and yellowfin tuna were made to commercial landings in the 1970-1980s, and to artisanal landings of albacore, yellowfin and dolphinfish throughout the time period (1950-2007). Additions for the artisanal *poti marara* fleet added approximately 7,000 t to the commercial catch totals of each of the respective species (1950-2007), while approximately 8,300 t of skipjack, and 4,000 t of yellowfin tuna landings were added to data presented by FAO (1950-2007).

Of the commercial pelagic catches (excluding reef and lagoon fishes), the main catches were those of skipjack, albacore, yellowfin, and dolphinfish, which comprised approximately 60,800 t (18%); 49,685 t (15%), 30,464 t (9%); and 13,792 t (4%) of the reconstructed total commercial catch, respectively (1950-2007; Figure 6). For the period 1950-1990, the main species appears to have been skipjack (Figure 6). In the 1950s, skipjack catches averaged approximately 700 t·year^{-1}, increasing to 1,050 t·year^{-1} by the 1980s. Only minor quantities of albacore, yellowfin tuna, and dolphinfish appear to have been caught during this period (1950-1990; Figure 6). In the early 1990s, catches of albacore tuna increased dramatically from approximately 400 t·year^{-1}, to more than 4000 t·year^{-1} in 2007, in line with the offshore expansion encouraged by 'Le Paste de Progrès'. Catches of yellowfin tuna increased throughout the time period, from those representative only of the coastal *poti marara* fishery (~120 t·year^{-1}) from 1950-1979, to averages of approximately 1,500 t·year^{-1} from 2000-2007. Catches of other large pelagics and tunas (i.e., dolphinfish, bigeye tuna, and wahoo) increased slightly in the early 1990s, averaging 490 t·year^{-1}, 375 t·year^{-1} and 275 t·year$^{-1,}$ respectively, for the period 1990-2007 (Figure 6).

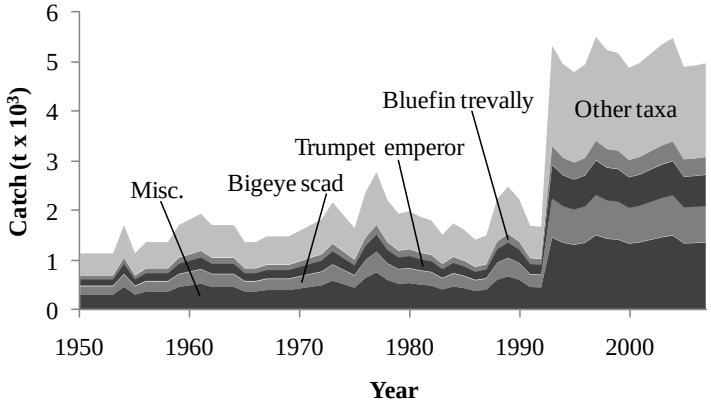

Figure 7. Improved FAO category for miscellaneous marine fishes (MMF) in terms of a) 15% addition of unauthorized sales, b) taxonomic breakdown from Caillart *et al.* (1994) to 64% of MMF category and Yonger (2002) to remaining 23%. The category 'other taxa' includes 15 individual species.

Data from Caillart *et al.* (1994) and Yonger (2002) were used to dissagregate the 'marine fishes nei' or 'miscellaneous marine fishes' category from FAO FishStat, where 18 taxa replaced most of the original miscellaneous marine fishes category. Approximately 35,800 t (10%) of total commercial catches remained as miscellaneous marine fishes. This was a substantial reduction from the original FAO data, in which approximately 40% of the commercial catch was represented as uninformative 'miscellaneous marine fishes'.

Thus, we improved the data taxonomically by about 30%. Bigeye scad (15%), trumpet emperor (13%) and bluefin trevally (7%) comprised the largest components of the disaggregated miscellaneous marine fishes category (Figure 7). Included in these estimates of commercial taxa were the 15% of unauthorized sales of reef and lagoon fish (1950-2007), attributed to artisanal fishers selling catches at the roadside or directly to restaurants. The addition of unauthorized sales added approximately 3% to the overall reconstruction (1950-2007).

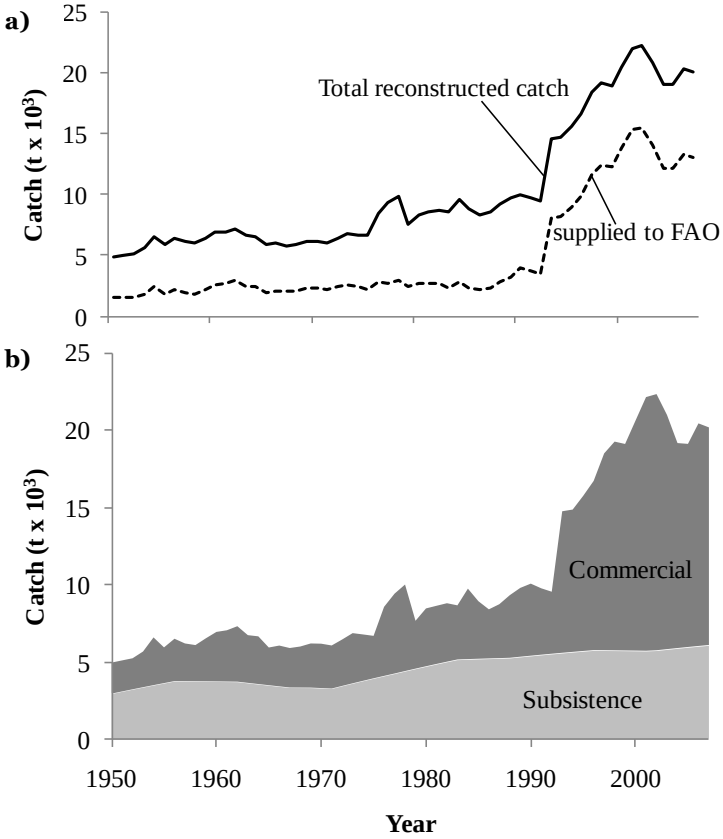

Figure 8. Total reconstructed catch for French Polynesia, 1950-2007, a) comparing reconstructed catches with landings as supplied to FAO; and b) showing reconstructed catch by fisheries sector: commercial and subsistence.

Overall reconstruction of catches for French Polynesia, including subsistence and commercial sector catches totaled approximately 595,500 t for the period 1950-2007 (Figure 8a). This catch total was twice the amount presented by FAO on behalf of French Polynesia for the same time period. Commercial and subsistence components were fairly similar in magnitude overall, representing approximately 56% and 44% (respectively) of the total reconstructed catch from 1950-2007 (Figure 8b). Subsistence catches appear to have been more prevalent than commercial catches between 1950 and the early 1990s, comprising between 44% and 62% of the total reconstructed catch. After this time, subsistence catches comprised approximately 30% of the total reconstructed catch (1992-2007), due to the offshore expansion of commercial fisheries under 'Le Pacte de Progrès'.

Table 6. Landings (t) of various taxa reported by Taiwan from the French Polynesian EEZ.

Year	Yellowfin	Albacore	Bigeye	Other
1972	402	2,192	544	272
1973	263	3,756	634	329
1974	252	2,568	377	236
1975	442	1,751	391	150

Table 7. Landings of various taxa reported by Japan from the French Polynesian EEZ, (n/a) denotes years in which no data were reported.

Year	Albacore tuna	Yellowfin tuna	Bigeye tuna	Marlins	Skipjack	Other
1972	7	154	358	n/a	6	89
1973	12	104	476	n/a	4	79
1974	33	236	1,307	n/a	7	249
1975	26	394	1,221	n/a	8	182
1979	90	807	819	n/a	n/a	229
1980	161	908	1,618	n/a	n/a	635
1981	89	370	763	n/a	n/a	196
1982	140	126	305	1	n/a	94
1984	26	221	464	n/a	n/a	158
1985	22	507	1,105	n/a	n/a	152
1986	32	n/a	n/a	n/a	n/a	n/a
1987	57	n/a	826	3	n/a	189.8
1988	142	n/a	n/a	n/a	n/a	n/a
1989	72	n/a	n/a	n/a	n/a	n/a
1990	49	n/a	n/a	n/a	n/a	n/a
1991	19	n/a	n/a	n/a	n/a	n/a
1992	3	n/a	n/a	n/a	n/a	n/a

Foreign fleets in the Polynesian EEZ:

Several foreign fleets were given access to fish in French Polynesia's EEZ during different time periods. Thus, Taiwan (1972-1975), Japan (1972-1992) and Korea (1975-1996) reported pelagic catches for the EEZ waters (Table 6, 7 and 8). After 1977, no legally permitted access has been granted to any foreign fleet, except for a non-executed access agreement with Korea in 2004 (www.seaaroundus.org).

Table 8. Landings of various taxa reported reported by Korea from the French Polynesian EEZ, (n/a) denotes years in which no data were reported.

Year	Albacore tuna	Yellowfin tuna	Bigeye tuna	Skipjack tuna	Marlins	Other
1975	85	555	1,778	6	n/a	116
1980	n/a	n/a	n/a	320	n/a	n/a
1981	n/a	466	491	n/a	n/a	596
1982	n/a	385	358	n/a	n/a	387
1983	685	314	291	n/a	n/a	338
1984	522	513	358	n/a	n/a	197
1985	1,176	737	826	n/a	n/a	357
1986	739	908	1,089	n/a	33	294
1987	935	n/a	n/a	n/a	n/a	n/a
1988	730	n/a	2,790	n/a	n/a	n/a
1989	627	n/a	1,004	n/a	n/a	n/a
1990	817	n/a	1,825	n/a	n/a	n/a
1991	515	n/a	3,213	n/a	n/a	n/a
1992	227	n/a	1,110	n/a	n/a	n/a
1993	n/a	n/a	750	n/a	n/a	645
1994	n/a	n/a	1,231	n/a	n/a	899
1995	n/a	n/a	1,321	n/a	n/a	702
1996	n/a	n/a	1,842	n/a	n/a	1,190

DISCUSSION

Our catch reconstruction totaled approximately 595,500 t for the period from 1950-2007, which is two times larger than total reported landings of approximately 286,000 t as

supplied to FAO. In our reconstruction, approximately 259,000 t of subsistence catches and approximately 51,000 t of commercial catches were added to the commercial landings presented by FAO. Additions of commercial catches were sourced from the literature. Reporting only commercial catches will have consequences for the management of fisheries resources. In the case of French Polynesia, a group of remote and isolated islands, the consequences are significant. The importance of subsistence fishing to remote populations is substantial and presents a likely food security issue. Dependence on such resources for sustenance has obviously decreased throughout the years, with increased transport of goods and pre-processed food between areas, however, subsistence fishing is still evident on the islands immediately surrounding the capital city, Papeete, and thus, must still be quite prevalent on the more remote islands (as was evident in catch rates described by Caillart *et al.* [1994]). As shown by estimates in this study, subsistence fishing can account for at least half of the total fisheries catches for a country, and thus, can comprise significant tonnage. Thus, marine resources are far more important for fundamental food security purposes in French Polynesia than the official data would suggest.

Many places in French Polynesia have already been observed to be showing signs of heavy exploitation (Yonger, 2002), and different environments likely warrant different management strategies. The subsistence catch reconstruction in this report was a first attempt to identify catches from particular island groups in French Polynesia. In addition, factoring in some estimate of unauthorized sales for populations living on remote islands would likely be very appropriate, since only one major fish market exists. Such sales are likely to be occurring on all islands in French Polynesia, and the estimate of 15% by Chauvet and Galzin (1996) may be an underestimate.

ACKNOWLEDGMENTS

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