Reconstruction of marine fisheries catches for Niue (1950–2010)[1]

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Abstract

Estimates for the subsistence, artisanal, and large-scale commercial sectors of Niue's fishery were obtained for the time period of 1950-2010. Throughout this time period we found that subsistence catches, as well as the large-scale commercial catches, were underestimated in the data reported to the FAO. Our reconstruction of Niue's total marine fisheries catches for 1950-2010 equalled 24,158 t, which was 4.9 times the FAO total catches. This translates to 19,231 tonnes of unreported catches. Subsistence estimates were obtained using *per capita* consumption rates and commercial fisheries estimates were based on catch information from independent reports. The combination of environmental pressures such as severe cyclones and anthropogenic pressures such as fishing, threaten the sustainable use of resources from the marine environment. This report illustrates the importance of collecting catch time series data for sustainable management of Niue's marine fisheries resources.

Introduction

Niue is a single, uplifted atoll island which, in 1974, became a self-governing nation in free association with New Zealand (Quentin-Baxter 2008). Being in free association means that Niue has the power to make its own laws and enter into agreements with other nations as if it was an independent nation, and New Zealand cannot interfere without Niue's consent (Quentin-Baxter 2008). However, Niue still receives essential financial aid, when needed, from New Zealand, and Niueans retain their New Zealand citizenship (Quentin-Baxter 2008). The island is located at 19°S and 169°W, with a land area of 259 km^2 (Figure 1). It has an Exclusive Economic Zone (EEZ) of 316,629 km^2 (www.seaaroundus.org), which borders the waters of American Samoa, Tonga, and the Cook Islands, while international waters lie directly south. Niue is surrounded by a narrow, wave-cut, shelf platform covered in coral, which drops off quickly to extreme depths within 3-5 km of shore (Dalzell *et al.* 1993; Kronen *et al.* 2008). Coral cliffs surround the island, which rise between 20 and 30 m above sea level (Kronen *et al.* 2008). Niue only possesses one wharf, located at Alofi Bay (Alofi being the capital). The wharf is only partially sheltered and is vulnerable to sea conditions, which requires that fishing boats be lifted in and out of the water each day (Gillett 2011). Although government agencies realize that a lack of marine infrastructure has severely hindered Niue's fishing opportunities, there is hesitation to invest due to the frequency of severe weather patterns (Gillett 2011). Over the years, Niue has suffered extensive reef damage, particularly from Cyclone Ofa (February 1990) and Cyclone Heta (January 2004; Kronen *et al.* 2008). Niue's economy is heavily dependent on aid it receives from New Zealand. The majority of Niueans work in the public sector, with their wages also provided by New Zealand (Kronen *et al.* 2008). Although local agricultural crops have failed to produce any profitable export opportunities (Bertram and Watters 1984) they are successful enough for subsistence purposes. Taro, tapioca, yams, kumara, bananas, breadfruit, papaya, watermelon, and citrus fruits are sold at the market twice a week along with coconut crabs, seafood, and imported products (Tuara 2000).

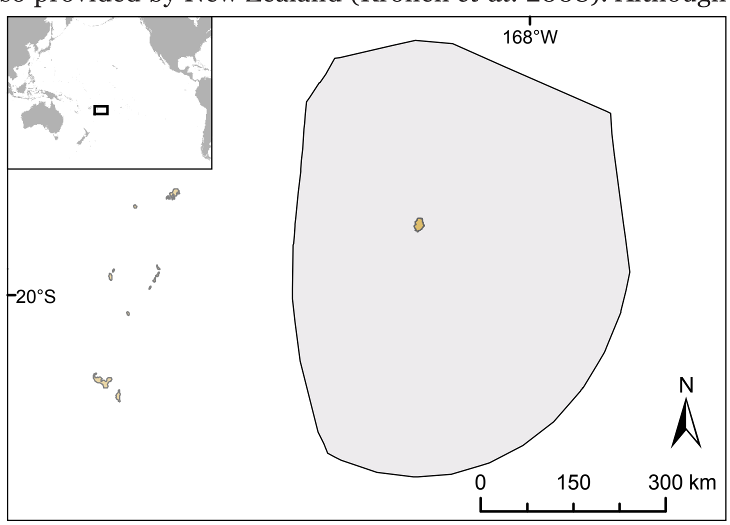

Figure 1. Map of Niue and its EEZ. Niue's closest neighbouring country, Tonga, which lies to the west of Niue, is also shown.

Fishing in Niue has very traditional roots, which are still present today. Niueans continue to use the one- or three-person wooden dug-out canoes that their ancestors have perfected, although these are used less frequently (Powell 1968; Kronen *et al.* 2008). In the late 1970s and early 1980s, several government funded programs were implemented to help increase fishing effort and productivity in Niue. Nick Dryden from the New Zealand Ministry of Agriculture and Fisheries, as well as South Pacific Commission[2] (SPC) "Master Fishermen" Tevita Fusimalohi and Paul Mead made visits to Niue and worked with local fishers to teach them more effective

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[2] Now the Secretariat of the Pacific Community.

fishing techniques (Crossland 1979; Mead 1980). In 1977, Nick Dryden brought with him new fishing gear as well as an 8.3 m diesel powered boat, *Nukulafalafa* (Crossland 1979). After surveying the area and finding that trolling was the most effective technique, he trained four local fishers in all aspects of trolling (including operation and maintenance of the vessel; Crossland 1979). In 1978, SPC "Master Fisherman", Tevita Fusimalohi of the SPC Deep Sea Fisheries Development Project (DSFDP) came to train the fishers in bottom fishing techniques as an alternative to trolling (Fusimalohi 1978; Crossland 1979). In 1979, SPC "Master Fisherman" Paul Mead took over operation of the DSFDP and continued working with the Niueans. Unfortunately, Niue was hit by a cyclone at the end of 1979 resulting in the loss of the boat and much of the fishing equipment (Mead 1980; Anon. 1981). However, fishing operations did resume in February 1980 with the arrival of an *alia* catamaran (Anon. 1981). In 1982, the SPC provided Niue with its first two fish aggregating devices (FADs; Farman and Dashwood 1989). That same year, "Master Fisherman" Paul Mead performed vertical longline trials in the vicinity of the FADs (Mead 1989). In the late 1980s, many organizations, including the United Nations Development Programme (UNDP), the Forum Fisheries Agency (FFA), and the U.S. Agency for International Development (USAID), provided the Niue fisheries sector with some support (Anon. 1990). This aid was used for improving infrastructure and obtaining equipment. Unfortunately, in January 2004, Niue was hit by Cyclone Heta, one of the most damaging cyclones to date. Although repaired, Niue's only wharf, as well as the infrastructure and machinery needed for fishing boats to access the water, remain vulnerable (Barnett and Ellemor 2007). The marine environment itself is vulnerable to the severe weather conditions it endures and proper analysis and management is needed to ensure the survival and sustainability of Niue's marine resources (Fisk 2007).

Currently, the FAO FishStatJ database, which provides time series data on marine fisheries landings from 1950 to present, is the only publicly available source of national fisheries catch data over time. FAO data are provided by its member countries. Therefore, the FAO relies on countries to report their figures accurately. The FAO data have been the basis of many influential global fisheries studies (i.e. Pauly *et al.* 1998) but they are known to be incomplete (Zeller *et al.* 2006; 2007).

The objective of this study is to provide a complete time series of estimated total marine fisheries catch of Niue from 1950-2010. Although there have been many studies which have estimated the impact of Niue's fisheries, there has been no comprehensive study showing catch trends over time.

Methods

Estimates of marine catches were made for three sectors: subsistence, artisanal, and large-scale commercial. The subsistence sector was estimated by combining available information on catches and human population data to estimate *per capita* consumption rates. For the artisanal and large-scale commercial sectors, several reports containing yearly catch data were used to make estimates. For the artisanal and subsistence sectors, interpolations between data anchor points were performed in order to obtain catch data for the entire study period of 1950-2010.

Large-scale commercial fisheries

Niue only recently developed a domestic, large-scale fishing operation. In 2005, Niue entered into a joint venture fishing agreement with a New Zealand company, Reef Group, to start a longline fishing sector in their EEZ (Tafatu 2006; Gillett 2011). Under this agreement, all fish caught in the Niue EEZ would be processed at the newly built fish processing facility, Niue Fish Processors Ltd. (Gillett 2011). Prior to 2005, there was no domestic large-scale commercial fishing in Niue's EEZ and therefore catches for this sector were set to zero from 1950-2004. Data from the FAO, Forum Fisheries Agency (FFA), and the Western and Central Pacific Fisheries Commission (WCPFC) all match in tonnage for the large-scale commercial species. FAO reported catches for albacore (*Thunnus alalunga*), bigeye tuna (*Thunnus obesus*), skipjack tuna (*Katsuwonus pelamis*), yellowfin tuna (*Thunnus albacares*), black marlin (*Makaira indica*), blue marlin (*Makaira mazara*), striped marlin (*Tetrapturus audax*), and swordfish (*Xiphias gladius*) are accepted as the reported data for the longline fishery with one exception. The FFA data reports small amounts of skipjack and yellowfin tuna as being caught by an "other gear type" in 2004-2006. The large-scale tuna fishery did not begin until 2005 and so these amounts are allocated as reported small-scale tuna catch. It was determined that a small amount of by-catch from wahoo (*Acanthocybium solandri*) and dolphinfish (*Coryphaena hippurus*) was missing from the data in some years. Tafatu (2006) gives a complete breakdown of the 2005 longline catch which includes tonnages for these two species. The ratio of the tonnages of wahoo and dolphinfish to the total reported longline catch was found for 2005 and then applied to 2006-2008 and 2010. For 2009, there was 6 t of reported "tuna-like fishes nei" and this was assigned proportionally to wahoo and dolphinfish. Although all reports provide consistent accounts of the tonnages caught by the longline fishery, Gillett (2009) notes that there may be some under-reporting occurring. Tafatu (2007) reported 320.3 tonnes of tuna and tuna-like fish caught in 2006 by the longline fleet in Niue's EEZ. However, Gillett (2009) points out that this was only the catch for six vessels, while Tafatu (2007) had stated that there were actually 12 vessels licensed to fish in Niue's EEZ. This led Gillett to double the figure resulting in an estimate of 640 t. Gillett (2009) backs up his assumption by stating that unpublished fishery export figures for 2007 equated to 602.2 t, and if local tuna consumption was added this would be close to 640 t. However, since we have estimated local consumption separately, we accept the export value of 600 t as the total catch (tuna plus by-catch) in the years 2006 and 2007. The FAO data for 2005 and 2008-2010 were accepted as correct. At the end of 2007, Niue Fish Processors Ltd. closed (Kronen *et al.* 2008), leaving Niue with fewer vessels fishing their waters in 2008 and resulting in decreased catches (Anon. 2010). This explains why catches drop down to 18.75 t in 2008. In 2009, Niue resumed its joint venture agreement causing catches to start rising again (Anon. 2010).

Large-scale tuna fishing operations can occur outside of a country's EEZ as tuna and other large pelagics are migratory species. The FFA data contained information on catches which could be utilized to determine how much of the catch is taken from inside the country's EEZ, in other countries' EEZs, and in the high seas. Therefore, these data were utilized directly to spatially allocate tonnages of tuna, and proportions were used to also allocate all of the associated by-catch species.

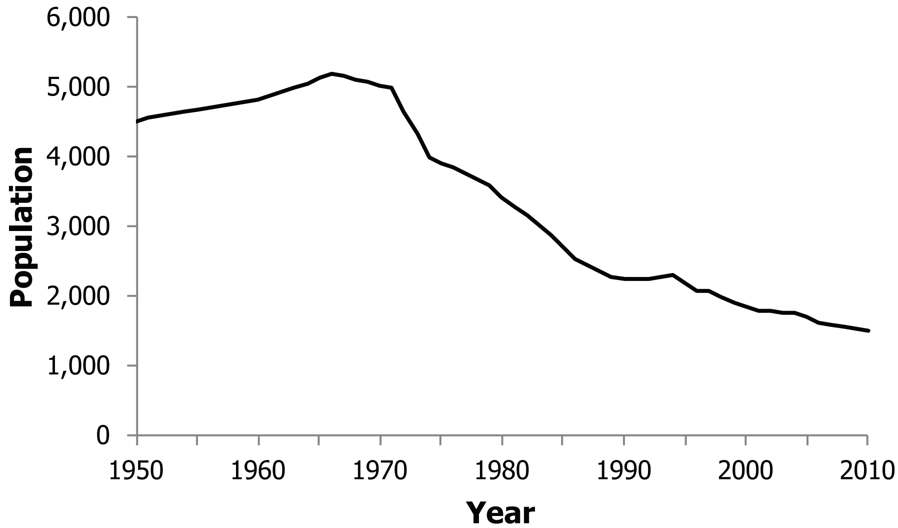

Figure 2. Estimated human population of Niue, 1950-2010.

Artisanal fisheries

Niue's artisanal sector is made up of 4-5 full-time and 2-3 part-time commercial fishers who sell their catch at the market (Dalzell *et al.* 1993). In the literature, this sector is referred to as either artisanal, small-scale commercial, or coastal commercial. Gillett (2009) estimated this sector at 10 tonnes per year and Dalzell (1993) also estimated 10-14 tonnes per year. To remain conservative, we accepted the estimate of 10 tonnes per year and assigned this as the artisanal catch starting in 1993 (as Dalzell was the first to report this estimate) and carried it forward until 2010. The earliest mention of the sale of fish in Niue is in a SPC report (Devambez 1962) and therefore we set artisanal catches at zero from 1950-1960. We then linearly interpolated from zero in 1960 to 10 tonnes in 1993.

Subsistence fisheries

Estimating subsistence catches required a complete time series of Niue human population data for 1950-2010. This was needed to convert *per capita* seafood consumption rates into an estimate of total demand, which was then used in calculating missing catch amounts. Population data for Niue were obtained from the Pacific Regional Information System (PRISM) website.[3] PRISM is a website produced by the Secretariat of the Pacific Community (SPC) to compile statistical data on all countries within the Pacific Community. Linear interpolations between known data points were employed to produce population data for the entire 1950-2010 time period (Figure 2).

Table 1. *Per capita* seafood consumption rates used to estimate total subsistence demand.

Years	Consumption rate (kg/person/year)	Source
1950	118.9	Gillett and Lightfoot (2001)[a]
1951-2006	-	Linear interpolation
2007	89.7	Gillett (2009)
2008-2010	89.7	Carried forward from 2007

[a] Gillett and Lightfoot's (2001) estimate of consumption was assumed to be representative for 1950.

Gillett (2009) estimated the total subsistence catch in 2007 to be 140 tonnes. This estimate was based on the compilation of several different sources, containing both consumption and catch data (Gillett 2009). Using this figure and the 2007 population estimate, a catch-derived subsistence consumption rate of 87.9 kg·person^{-1}·year^{-1} was obtained. This was used as the 2007 anchor point and was carried forward, unaltered, to 2010 (Table 1).

For the early time period, it was assumed that Niue was receiving less imported canned meats and fish than it is today. With fewer canned alternatives available, it was assumed that more fresh seafood was eaten. This trend can be observed by direct comparison of villages on the island in current times. Kronen *et al.* (2008) found that the amount of canned fish consumed is inversely related to the amount of fresh fish consumed. Therefore, in order to account for this increased consumption, Gillett and Lightfoot's (2001) estimate of 118.9 kg·person^{-1}·year^{-1} was used as an approximation for the consumption rate in 1950 (Table 1). We then linearly interpolated between the 1950 and 2007 consumption rates. These consumption rates, in combination with the population data gave a total subsistence demand for the 1950-2010 time period.

In Niue, subsistence fishing also consists of collecting fish to take overseas to friends and relatives living in New Zealand (Dalzell *et al.* 1993). These informal exports, estimated by Dalzell *et al.* (1993), depend on frequent and direct air service. There was direct air service between Auckland and Niue between 1982 and 1988, limited service for 1989 and 1990 (Dalzell *et al.* 1993), and an increase again in 1992 (Eur. 2002). Therefore, informal exports were set to zero from 1950 to 1981. We then linearly interpolated from zero in 1981 to 4.9 tonnes (Dalzell *et al.* 1993) in 1987 and carried this amount forward to 1988. In 1989 and 1990, exports decreased to 95 kg·year^{-1} (Dalzell *et al.* 1993). With air service increasing again in 1992, we assumed that exports reached their previous height by 1995 and thus set informal exports to 4.9 t·year^{-1} from 1995 onwards. A linear interpolation was performed between the

[3] http://www.spc.int/prism/country/nu/stats/Social/Population/Popstats.htm

anchor points of 95 kg in 1990 and 4.9 tonnes in 1995. Adding the informal exports to the calculated subsistence demand gave the total subsistence catch.

For the years 1999 to 2004, our estimated total reconstructed catch was slightly lower than the FAO data. It was therefore assumed that the FAO had additional information and we accepted their reported total catch for those years. In order to account for this discrepancy, we increased our estimated subsistence catch for those years, thus resulting in our total catch being equal to that of the FAO.

Table 2. Estimated catch composition for the large-scale commercial fisheries of Niue.

Species	Catch (%)					
	2005	2006	2007	2008	2009	2010
Acanthocybium solandri	3.13	3.13	3.13	3.13	2.23	3.13
Coryphaena hippurus	1.30	1.30	1.30	1.30	0.93	1.30
Katsuwonus pelamis	1.74	1.28	1.35	5.10	0.13	0.21
Makaira indica	2.61	0.96	2.70	1.27	0.13	0.21
Makaira mazara	3.48	2.56	3.16	5.10	3.16	0.85
Tetrapturus audax	0.87	1.60	4.06	1.27	0.13	0.85
Thunnus alalunga	47.78	68.08	61.76	35.68	77.37	82.40
Thunnus albacares	29.54	13.42	13.52	40.78	10.53	6.80
Thunnus obesus	8.69	7.03	8.11	5.10	5.26	3.40
Xiphias gladius	0.87	0.64	0.90	1.27	0.13	0.85

Source: FAO FishStatJ [accessed November 1, 2012] and Tafatu (2006).

Foreign vessels

Due to the development of the local joint venture fleet, no foreign vessels (with one exception) had authorized access to Niue's EEZ after 2002 (Tafatu 2006). US purse seiners have access under a multilateral treaty, however they have not fished Niue's EEZ for years (Gillett 2009). Japanese and Taiwanese longliners operated in Niue waters in the 1960s and 1970s (Dalzell *et al.* 1993). Dalzell (1993) and Klawe (1978) provide some limited data for these years. There are several reports (e.g. Pasisi 2003; Kronen *et al.* 2008) indicating that from about the mid-1990s to the early 2000s, there were Taiwanese and American Samoan vessels fishing in the Niue EEZ, operating under access agreements. However, these reports do not have enough information to determine the exact dates of these agreements or how much fish was caught.

Catch composition

The joint venture commercial longline fishery occurs offshore and targets large pelagic fish (i.e. tunas and tuna-like fish). The FAO data present landings for the four main species of tuna (albacore, bigeye, skipjack, and yellowfin tuna) and associated by-catch (black marlin, blue marlin, striped marlin, and swordfish). These reported values are accepted for 2005 and 2008-2010 with the aforementioned exemption of small amounts of skipjack and yellowfin tuna in 2005. An unreported component of wahoo amounting to 3.3% of the total reported large-scale catch and 1.4% of the catch for unreported dolphinfish were also added on in 2005-2008 and 2010. In 2009, the 6 t of reported "tuna-like fishes nei" was broken down into wahoo (71%) and dolphinfish (29%; Tafatu 2006). In 2006 and 2007, the proportions of the reported catches plus the unreported wahoo and dolphinfish, were used to determine the composition of the 600 t of longline catch. The complete percentage breakdown for the longline fishery is shown in Table 2.

The species compositions for both the subsistence and artisanal sectors were assumed to be the same. Kronen *et al.* (2008) assessed the status of Niue's fisheries using several different methods, which included a household survey (to gather information about seafood consumption), as well as a survey of fishers to collect data concerning the actual catch. At the broader level, these data provided total annual estimates by weight of catches from trolling and mid-water fishing (tuna and tuna-like species), reef and canoe fishery (reef finfish), and the invertebrate fishery. These data were

Table 3. Estimated species composition of both the subsistence and artisanal sector in Niue.

Taxa	Catch (%)	Taxa	Catch (%)
Acanthocybium solandri	27.90	*Parupeneus multifasciatus*	0.39
Turbo setosus	13.93	*Priacanthus hamrur*	0.31
Thunnus albacares	7.77	Bivalvia	0.28
Decapterus macarellus	4.49	*Chlorurus microrhinos*	0.28
Katsuwonus pelamis	3.75	*Octopus* spp.	0.26
Myripristis berndti	3.45	*Acanthurus guttatus*	0.25
Myripristis violacea	3.45	*Aphareus rutilans*	0.24
Other large pelagics	3.29	*Lutjanus bohar*	0.24
Kyphosus bigibbus	2.72	*Sargocentron cornutum*	0.23
Kyphosus cinerascens	2.72	*Epinephelus fasciatus*	0.23
Kyphosus vaigiensis	2.72	*Parribacus caledonicus*	0.19
Gastropoda	1.98	*Polymixia japonica*	0.18
Panulirus spp.	1.63	*Xiphias gladius*	0.14
Paracirrhites hemistictus	1.50	*Holothuria atra*	0.13
Cirrhitus pinnulatus	1.41	*Acanthurus achilles*	0.13
Istiophoridae	1.22	*Monotaxis grandoculis*	0.10
Thalassoma quinquevittatum	1.20	Misc. marine fishes	0.09
Seriola rivoliana	1.11	*Cephalopholis urodeta*	0.09
Caranx melampygus	1.10	*Variola louti*	0.07
Coryphaena hippurus	1.00	*Scomberoides lysan*	0.05
Epinephelus merra	0.95	*Cephalopholis aurantia*	0.05
Cephalopholis miniata	0.87	*Cephalopholis sonnerati*	0.05
Caranx lugubris	0.80	*Sphyraena barracuda*	0.04
Scylla serrata	0.76	Echinoidea	0.04
Crenimugil crenilabis	0.66	*Mulloidichthys flavolineatus*	0.03
Tridacna maxima	0.56	Misc. aquatic invertebrates	0.03
Tridacna squamosa	0.56	Belonidae	0.02
Decapoda	0.51	*Acanthurus triostegus*	0.02
Scarus spp.	0.51	*Sargocentron spiniferum*	0.01
Acanthurus xanthopterus	0.45	*Sphyraena forsteri*	0.01
Rhinecanthus rectangulus	0.43	*Sphyraena qenie*	0.01
Thalassoma purpureum	0.40	Exocoetidae	0.01

Source: Kronen *et al.* (2008).

used to calculate the proportions of the different sectors within the small-scale fishery. Each sector could then be broken down to individual species. Kronen *et al.* (2008) used the catch data to provide a complete species breakdown of reef finfish and invertebrates caught annually by weight. This was used as the basis for the reef fish and invertebrate species catch composition. As the survey did not include species information on the large pelagic fish caught by trolling and mid-water fishing, Dalzell's (1993) estimates were used for that sector. Dalzell (1993) provides catch data by weight for vessels targeting tuna and tuna-like species. The complete species breakdown for both the subsistence and artisanal sectors is provided in Table 3.

Women in fisheries

Fishing participation in Niue appears to be almost evenly split between men and women. According to the survey by Kronen *et al.* (2008), almost even numbers of males and females participate in both finfish and invertebrate fishing. In terms of fishers who only fish in one sector, there are more males who exclusively fish for finfish, and more females who are exclusive to invertebrate fishing (Kronen *et al.* 2008). Kronen *et al.* (2008) found that female fishers were responsible for 53% of the annual invertebrate catch. On average, per person, female fishers catch 75 kg·person^{-1}·year^{-1}, compared to the 133 kg·person^{-1}·year^{-1} that men catch on average (Kronen *et al.* 2008). Using the number of male and female fishers quoted by Kronen *et al.* (2008) who fish for finfish (either exclusive or in addition to invertebrates) and the annual catch rates, it can be estimated that female fishers are responsible for 24% of the finfish catch. This difference in contribution can be attributed to the types of fishing women generally participate in. One of the main fishing activities which women participate in is reef gleaning. They harvest invertebrates, using their hands and small tools, from the reef flat when the tide is low and collect octopus, sea urchins, sea cucumbers, shellfish, tube worms, snails, and clams (Tuara 2000). This is done during the day, and at night they go out with knives or long spears and hunt crabs, lobsters, and reef fish. They also use a simple wooden or bamboo rod and line with a small piece of bait to catch reef fish from rock pools and over cliff edges in both the day and night (Tuara 2000). While fishing out on a boat is no longer exclusive to men, there are still not many women found fishing on boats (Tuara 2000; Lambeth *et al.* 2002). Post-harvest duties of fish processing are completed by both men and women (Tuara 2000).

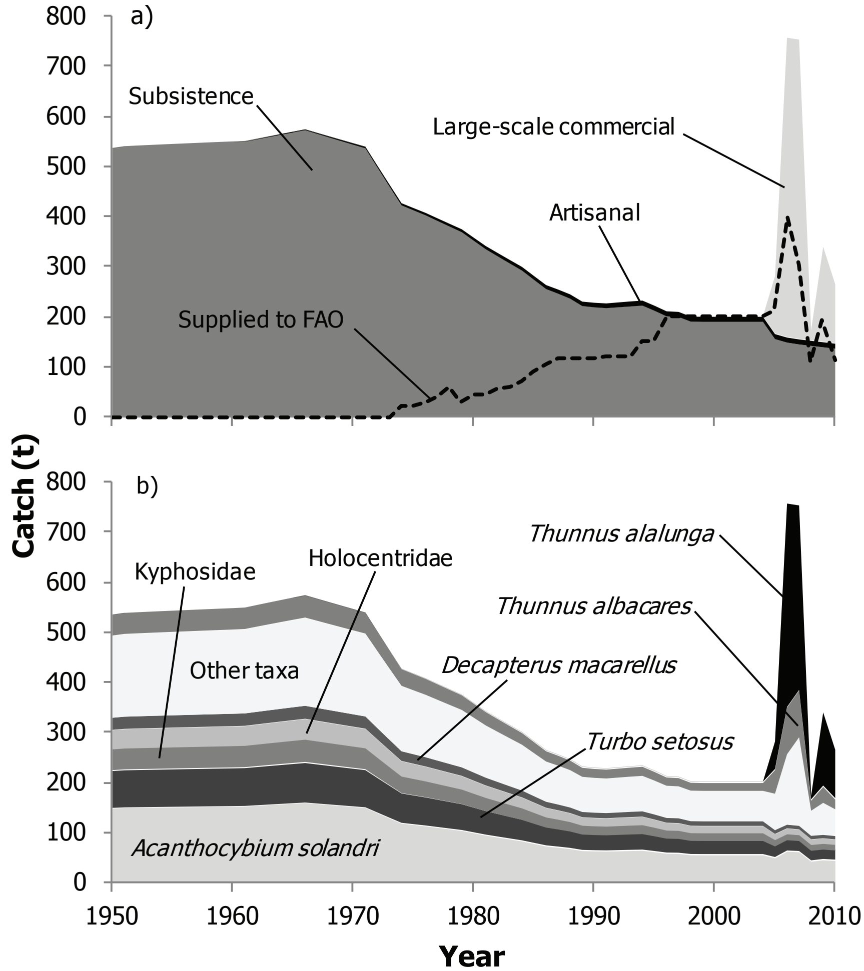

Figure 3. a) Total reconstructed fisheries catches for Niue, by sector, compared to the total catch data supplied to the FAO, 1950-2010; b) total reconstructed catch for Niue by major taxa. The grouping "other taxa" represents 52 taxa (as listed in Appendix Table A2). The families Kyphosidae and Holocentridae represent 3 and 4 species, respectively.

Results

For the period 1950-2010, the reconstructed total catch for Niue was estimated to be 24,158 t. This estimate is 4.9 times the total catch reported by the FAO on behalf of Niue over the same time period (Figure 3a). Overall, large-scale commercial catches represented 6.8% of the total catch, artisanal catches represented 1.4%, and subsistence catches made up the largest portion with 91.8% of the total catch (Figure 3a). Informal exports (which are included in the subsistence catch) are estimated at a total of 111 t, representing only 0.46% of the total catch but are unaccounted for in both the official catch and trade data. Annual catches have peaked in the last five years due to the joint venture agreement that Niue signed with Reef Group. The average annual catch for the recent time period (2005-2010) is estimated at 628 t·year^{-1}. However, there was an earlier peak in catch totals in the 1960s with average annual catches of 560 t·year^{-1}, which only consisted of small-scale catches. Small-scale catches then proceeded to decreased to a low of 175 t·year^{-1} in the 2000s.

The total reconstructed catch was dominated by wahoo (*Acanthocybium solandri*) with 6,329 t caught from 1950-2010. Other species representing large portions of the catch include *Turbo setosus*, *Thunnus albacares*, *T. alalunga*, and *Decapterus macarellus* with 3,436 t, 1,982 t, 1,085 t, and 1,011 t, respectively (Figure 3b). Two families also worth mentioning (which are not already represented) are Kyphosidae (three species) and Holocentridae (four species), with catches of 1,837 t and 1,609 t, respectively, over the 1950-2010 time period (Figure 3b). The remaining 52 taxa, which individually represent minor portions of the total catch, were grouped for presentation into the category "other taxa" (Figure 3b).

The large-scale commercial longline catch was dominated by albacore tuna (*Thunnus alalunga*) with an average of 180 t·year^{-1} caught from 2005-2010. The other species caught by the longliners were *Thunnus albacares*, *T. obesus*, *Acanthocybium solandri, Katsuwonus pelamis, Makaira mazara*, *Tetrapturus audax*, *Coryphaena hippurus, M. indica*, and *Xiphias gladius* with approximately 38.6 t·year^{-1}, 19.3 t·year^{-1}, 8.3 t·year^{-1}, 7.7 t·year^{-1}, 6.1 t·year^{-1}, 4.3 t·year^{-1}, 3.4 t·year^{-1}, 3.2 t·year^{-1}, and 2.0 t·year^{-1}, respectively, in the 2005-2010 time period.

The subsistence and artisanal sectors are dominated by almost the same species and families as the total catch with the exception of albacore tuna (*Thunnus alalunga*), not present in the small-scale sector catches. In the subsistence sector, *Acanthocybium solandri*, *Turbo setosus*, Kyphosidae, *Thunnus albacares*, Holocentridae, and *Decapterus macarellus* have average annual catches of approximately 101 t·year^{-1}, 51 t·year^{-1}, 30 t·year^{-1}, 28 t·year^{-1}, 26 t·year^{-1}, and 16 t·year^{-1}, respectively. Since the assumed start of the artisanal sector in 1961, the average annual catches for *A. solandri*, *T. setosus*, Kyphosidae, *T. albacares*, Holocentridae, and *D. macarellus* have been approximately 1.90 t·year^{-1}, 0.95 t·year^{-1}, 0.55 t·year^{-1}, 0.53 t·year^{-1}, 0.49 t·year^{-1}, and 0.31 t·year^{-1}, respectively.

As part of the allocation process, it was estimated that approximately 14% of the large-scale catches were taken from outside of the EEZ. These catches represent only 0.9% of the total reconstructed catch.

Discussion

The reconstructed total catch for Niue for 1950-2010 was estimated to be approximately five times the landings presented by the FAO on behalf of Niue. This discrepancy is the result of two main issues: a lack of documentation of subsistence catches and an underestimation of the longline catches of Niue's recent commercial joint venture operation. The subsistence sector was estimated to be over 90% of the entire reconstructed catch. Not only was there poor subsistence reporting in the early part of the time period, but it continues to be neglected in the recent period. Since 2005, the data reported to FAO have a greater species disaggregation. However, this disaggregation is a product of the start of the joint venture operation and the species only correspond to those caught by the industrial sector. Prior to 2005, only broad categories of "marine fishes not elsewhere included (nei)" and "tuna-like fishes nei" were used. Once the large-scale commercial longline tuna species began to be reported all other categories declined rapidly in amount, suggesting that large-scale commercial catches are the only catches being recorded. Although it is apparent that there has been an effort to report large-scale commercial catches, they are largely underestimated in some years (Gillett 2009). The total reconstructed large-scale commercial catch is almost 75% larger than the total industrial landings reported from 2005-2010.

From 1950-2004, the reconstructed catch is almost entirely dependent on the population size since the subsistence portion greatly overwhelms the very small artisanal and informal export portions. Therefore, the peak in this section of the timeline corresponds to the peak population in the 1960s (average population of 5,034). The Niuean population then decreases rapidly, with a large number of people migrating to New Zealand. Total fisheries catches decreased as demand declined. This is followed by a dramatic spike in 2006, which corresponds to the rapid increase in catch of the joint venture longline operation. There is another drop in 2008 which corresponds to the closure of the fish processing plant (Kronen *et al.* 2008). Catches begin to increase again in 2009 as Niue negotiated alternative arrangements for their joint venture agreement (Anon. 2010).

Overharvesting is a concern on the island of Niue. Invertebrates are particularly at risk, including lobsters, giant clams, turban shell molluscs, urchins, sea cucumbers, octopus, and some crabs (Tuara 2000). The stocks of giant clams have been decimated and Kronen *et al.* (2008) recommend a total ban. There has been some recognition of this decline by the Niueans. Nets were widely used in the past but are (for the most part) no longer used due to their effectiveness, and the subsequent depletion of associated resources (Tuara 2000). Past areas of concern include use of poisons and use of spear guns with the aid of scuba. In 1965, regulations were put in place to ban the use of poisons or stupefying agents (Wilson 1967). Unfortunately, due to the rugged topography of the coastline it is difficult to police the area (Wilson 1967). Poisons of known use have been the root of a New Guinea creeper *(Derris elliptica)*, the seeds of *kieto (Diospyrus samoenis)*, and the root of *Tephrosia purpurea*, locally known as *kohuhu* (Wilson 1967). Information was not available on whether the use of poisons has ceased or is at least less common. It is clear though, that there have been detrimental effects on the marine environment from the use of these poisons (Fisk 2007).

Niue's exposed coastline has been repeatedly damaged by cyclones, which have negatively affected the marine life. The added effects of a large subsistence sector, continued use of FADs, and increasing large-scale commercial longline effort, further threaten an already vulnerable resource. In an attempt to mitigate these pressures, the Government of Niue, in 1998, created the Namoui Fisheries Reserve (Labrosse *et al.* 1999). However, stronger measures are needed to manage the increasing strain of the more recently established large-scale commercial venture to ensure the sustainability of this fishery. This study highlights the need for and importance of comprehensive fisheries catch records, to monitor changes in fisheries resources caused by natural and anthropogenic stresses.

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References

Anon. (1981) Country Statement–Niue. South Pacific Commission, Nouméa (New Caledonia). 1 p.

Anon. (1990) Country statement–Niue: FADs in Niue. South Pacific Commission, Nouméa (New Caledonia). 3 p.

Anon. (2009) Annual report to the commission–Part 1, Information on fisheries, research and statistics: Niue. Western and Central Pacific Fisheries Commission, Port Vila (Vanuatu). 10 p.

Anon. (2010) Annual report to the commission–Part 1, Information on fisheries, research and statistics: Niue. Western and Central Pacific Fisheries Commission, Nuku'alofa (Tonga). 11 p.

Barnett J and Ellemor H (2007) Niue after Cyclone Heta. The Australian Journal of Emergency Management 22(1): 1324-1540.

Bertram IG and Watters RF (1984) New Zealand and its small island neighbours: A review of New Zealand policy toward the Cook Islands, Niue, Tokelau, Kiribati and Tuvalu. Institute of Policy Studies, Wellington (New Zealand). 574 p.

Crossland J (1979) Fisheries at Niue. South Pacific Commission, Nouméa (New Caledonia). 8-11 p.

Dalzell P, Lindsay SR and Patiale H (1993) Fishery resources survey of the island of Niue. South Pacific Commission, Nouméa (New Caledonia). 68 p.

Devambez LC (1962) Niue: Report on the organisation of fishing trials. South Pacific Commission, Nouméa (New Caledonia). 5 p.

Eur. (2002) Far East and Australasia 2003, 34 edition. Routeledge. 1538 p.

Farman R and Dashwood J (1989) Proposal for a regional small-scale purse seine test fishing project: Report of stage two study mission. South Pacific Commission, Nouméa (New Caledonia). 28 p.

Fisk D (2007) Niue sustainable coastal fisheries pilot project: Literature review and pilot baseline survey. Secretariat of the Pacific Regional Environment Programme, Apia (Samoa). 59 p.

Fusimalohi T (1978) Report on the South Pacific Commission Deep Sea Fisheries Development Project in Niue South Pacific Commission, Nouméa (New Caledonia). 8 p.

Gillett R (2009) Fisheries in the economies of the Pacific Island countries and territories. Asian Development Bank, Mandaluyong City (Philippines). 521 p.

Gillett R (2011) Fisheries of the Pacific Islands: Regional and national information. Food and Agriculture Organization of the United Nations, Bangkok. 279 p.

Gillett R and Lightfoot C (2001) The contributions of fisheries to the economies of the Pacific Island countries. Asian Development Bank, Manila (Philippines). 218 p.

Klawe WL (1978) Estimates of catches of tunas and billfishes by the Japanese, Korean and Taiwanese Longliners from within the 200 mile economic zone of the member countries of the South Pacific Commission. South Pacific Commission, Nouméa (New Caledonia). 43 p.

Kronen M, Fisk D, Pinca S, Magron F, Friedman K, Boblin P, Awira R and Chapman L (2008) Niue country report: Profile and results from in-country survey work (May to June 2005). Pacific Regional Oceanic and Coastal Fisheries Development Programme (PROCFish/C/Cofish), Secretariat of the Pacific Community, Nouméa (New Caledonia). 189 p.

Labrosse P, Yeeting B and Pasisi B (1999) Survey of the Namoui Fisheries Reserve in Niue. SPC Fisheries Newsletter 90(July/September): 29-36.

Lambeth L, Hanchard B, Aslin H, Fay-Sauni L, Tuara P, Rochers KD and Vunisea A (2002) An Overview of the involvement of women in fisheries activities in Oceania. pp. 127-142 *In* Williams MJ, Chao NH, Choo PS, Matics K, Nandeesha MC, Shariff M, Siason I, Tech E and Wong JMC (eds.), Global symposium on women in fisheries: Sixth Asian Fisheries Forum, 29 November 2001, Kaohsiung, Taiwan. The WorldFish Center.

Mead P (1980) Report on the second visit of the South Pacific Commission Deep Sea Fisheries Development Project to Niue. South Pacific Commission, Nouméa (New Caledonia). 28 p.

Mead P (1989) Vertical longlining: The concept, trials, and present state of development. South Pacific Commission, Nouméa (New Caledonia). 8 p.

Pasisi P (2003) National fisheries report for Niue. Secretariat of the Pacific Community, Nouméa (New Caledonia). 5 p.

Pauly D, Christensen V, Dalsgaard J, Froese R and Torres F (1998) Fishing down marine food webs. Science 279: 860-863.

Powell R (1968) Canoes of the Pacific Islands. South Pacific Commission, Koror (Palau). 7 p.

Quentin-Baxter A (2008) The New Zealand model of free association: What does it mean for New Zealand? Victoria University of Wellington Law Review 39: 607-634.

Tafatu J (2006) Country fisheries report–Niue. Western and Central Pacific Fisheries Commission, Manila (Philippines). 6 p.

Tafatu J (2007) Country fisheries report–Niue. Western and Central Pacific Fisheries Commission. 6 p.

Tuara P (2000) An assessment of the role of women in fisheries in Niue. Secretariat of the Pacific Community, Nouméa (New Caledonia). 37 p.

Wilson JW (1967) Faka kona ika: (a note on the use of fish poisons in Niue). South Pacific Bulletin 17(2): 35-36.
Zeller D, Booth S, Craig P and Pauly D (2006) Reconstruction of coral reef fisheries catches in American Samoa, 1950-2002. Coral Reefs 25: 144-152.
Zeller D, Booth S, Davis G and Pauly D (2007) Re-estimation of small-scale fishery catches for U.S. flag associated island areas in the Western Pacific: The last 50 years. Fishery Bulletin 105: 266-277.

Appendix Table A1. FAO landings vs. total reconstructed catch (in tonnes) for Niue, 1950-2010, as well as catch by sector.

Year	FAO landings	Total reconstructed catch	Subsistence	Artisanal	Large-scale commercial
1950	0.25	535	535	-	-
1951	0.25	539	539	-	-
1952	0.25	540	540	-	-
1953	0.25	541	541	-	-
1954	0.25	542	542	-	-
1955	0.25	543	543	-	-
1956	0.25	544	544	-	-
1957	0.25	545	545	-	-
1958	0.25	546	546	-	-
1959	0.25	547	547	-	-
1960	0.25	548	548	-	-
1961	0.25	550	549	0.30	-
1962	0.25	555	554	0.61	-
1963	0.25	560	559	0.91	-
1964	0.25	565	563	1.21	-
1965	0.25	569	568	1.52	-
1966	0.25	574	572	1.82	-
1967	0.25	567	565	2.12	-
1968	0.25	560	558	2.42	-
1969	0.25	553	551	2.73	-
1970	0.25	546	543	3.03	-
1971	0.25	540	536	3.33	-
1972	0.25	502	498	3.64	-
1973	0.25	464	460	3.94	-
1974	20.00	427	423	4.24	-
1975	20.00	417	413	4.55	-
1976	30.00	407	403	4.85	-
1977	40.00	396	391	5.15	-
1978	60.00	386	380	5.45	-
1979	30.00	375	369	5.76	-
1980	45.00	358	352	6.06	-
1981	45.00	341	335	6.36	-
1982	54.00	327	320	6.67	-
1983	60.00	313	306	6.97	-
1984	72.00	300	292	7.27	-
1985	90.00	281	274	7.58	-
1986	105.00	263	255	7.88	-
1987	115.00	254	246	8.18	-
1988	115.00	245	236	8.48	-
1989	115.00	230	222	8.79	-
1990	115.00	228	219	9.09	-
1991	120.00	227	217	9.39	-
1992	120.00	229	219	9.70	-
1993	120.00	231	221	10.00	-
1994	150.00	232	222	10.00	-
1995	150.00	222	212	10.00	-
1996	200.00	211	201	10.00	-
1997	200.00	210	200	10.00	-
1998	200.00	201	191	10.00	-
1999	200.00	200	190	10.00	-
2000	200.00	200	190	10.00	-
2001	200.00	200	190	10.00	-
2002	200.00	200	190	10.00	-
2003	200.00	200	190	10.00	-
2004	200.00	200	190	10.00	-
2005	212.00	281	156	10.00	115
2006	400.00	759	149	10.00	600
2007	302.00	755	145	10.00	600
2008	108.75	172	142	10.00	20
2009	193.00	339	139	10.00	190
2010	113.50	264	136	10.00	118

Appendix Table A2. Total reconstructed catch (in tonnes) for Niue by major taxa, 1950-2010.

Year	*Acanthocybium solandri*	*Turbo setosus*	*Thunnus albacares*	Kyphosidae	Holocentridae	*Thunnus alalunga*	*Decapterus macarellus*	Others[1]
1950	149	75	42	44	38	0	24.0	164
1951	150	75	42	44	39	0	24.2	165
1952	151	75	42	44	39	0	24.2	165
1953	151	75	42	44	39	0	24.3	166
1954	151	76	42	44	39	0	24.3	166
1955	152	76	42	44	39	0	24.4	166
1956	152	76	42	44	39	0	24.4	167
1957	152	76	42	44	39	0	24.5	167
1958	152	76	42	45	39	0	24.5	167
1959	153	76	43	45	39	0	24.6	168
1960	153	76	43	45	39	0	24.6	168
1961	153	77	43	45	39	0	24.7	168
1962	155	77	43	45	40	0	24.9	170
1963	156	78	43	46	40	0	25.1	171
1964	157	79	44	46	40	0	25.3	173
1965	159	79	44	46	41	0	25.6	174
1966	160	80	45	47	41	0	25.8	176
1967	158	79	44	46	41	0	25.5	174
1968	156	78	44	46	40	0	25.2	172
1969	154	77	43	45	40	0	24.8	169
1970	152	76	42	45	39	0	24.5	167
1971	151	75	42	44	39	0	24.2	165
1972	140	70	39	41	36	0	22.5	154
1973	129	65	36	38	33	0	20.8	142
1974	119	59	33	35	31	0	19.2	131
1975	116	58	32	34	30	0	18.7	128
1976	114	57	32	33	29	0	18.3	125
1977	111	55	31	32	28	0	17.8	121
1978	108	54	30	31	28	0	17.3	118
1979	105	52	29	31	27	0	16.8	115
1980	100	50	28	29	26	0	16.1	110
1981	95	48	27	28	24	0	15.3	104
1982	91	46	25	27	23	0	14.7	100
1983	87	44	24	26	22	0	14.1	96
1984	84	42	23	24	21	0	13.5	92
1985	78	39	22	23	20	0	12.6	86
1986	73	37	20	21	19	0	11.8	81
1987	71	35	20	21	18	0	11.4	78
1988	68	34	19	20	17	0	11.0	75
1989	64	32	18	19	16	0	10.3	71
1990	64	32	18	19	16	0	10.2	70
1991	63	32	18	18	16	0	10.2	69
1992	64	32	18	19	16	0	10.3	70
1993	64	32	18	19	16	0	10.4	71
1994	65	32	18	19	17	0	10.4	71
1995	62	31	17	18	16	0	10.0	68
1996	59	29	16	17	15	0	9.5	65
1997	59	29	16	17	15	0	9.4	64
1998	56	28	16	16	14	0	9.0	61
1999	56	28	16	16	14	0	9.0	61
2000	56	28	16	16	14	0	9.0	61
2001	56	28	16	16	14	0	9.0	61
2002	56	28	16	16	14	0	9.0	61
2003	56	28	16	16	14	0	9.0	61
2004	56	28	16	16	14	0	9.0	61
2005	50	23	47	14	12	55	7.4	73
2006	63	22	93	13	11	408	7.1	141
2007	62	22	93	13	11	371	7.0	177
2008	43	21	20	12	11	7	6.8	51
2009	46	21	32	12	11	147	6.7	64
2010	45	20	19	12	10	97	6.6	54

[1] Others category includes 52 additional taxonomic groups.