RECONSTRUCTION OF NAURU'S FISHERIES CATCHES: 1950-2008[1]

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ABSTRACT

Nauru is a small, single island country located in the western Pacific Ocean with a relatively large population. Historically, phosphate mining has destroyed much of the island's land surface. We reconstructed total fisheries catches for Nauru (1950-2008). The reconstructed catch consists of small-scale fisheries, including both commercial and subsistence components, as well as the offshore domestic catch. For 1950-2008, total reconstructed catches were 23,150 t, being 3.4 times higher than data supplied to FAO on behalf of Nauru. Of these catches, 9,000 t, 12,300 t and 1,850 t were small-scale commercial, small-scale subsistence and offshore catches, respectively.

INTRODUCTION

The Republic of Nauru is a small, single raised limestone island located at 0° 32' S latitude and 166° 55' E longitude, with a land area of approximately 21 km² (Figure 1) and an Exclusive Economic Zone (EEZ) of 308,000 km² (www.seaaroundus.org).

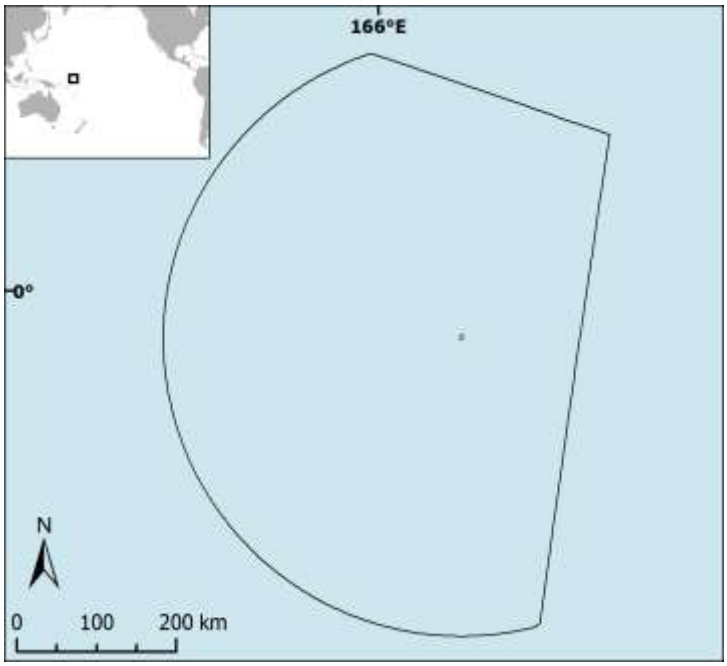

Figure 1. Map of Nauru and its Exclusive Economic Zone (solid line).

The island has an average height of 50 m above sea level, with an interior plateau that once held extensive deposits of phosphate bearing rock, resulting from the accumulation of seabird droppings over millenia. Phosphate mining was the island's largest source of revenue, but due to heavy mining the resource is now virtually depleted. This has left an estimated 80% of the land area uninhabitable, along with substantial environmental degradation from silt and phosphate runoff, which is believed to have impacted large parts of the island's marine life (Jacob, 1998). With an already degraded terrestrial environment and an eroding coastline, the impact of global sea level rise for a small island such as Nauru may be devastating (Stephen, 2011)

The original inhabitants of the island relied heavily on marine resources a source of animal protein. Nauru is surrounded by a coral belt that becomes exposed at low tide, ranging from 150 to 300 m in width, and the waters surrounding Nauru hold an abundance of both reef and pelagic fish species (Dalzell and Debao, 1994; Jacob, 1998).

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The colonial period

In 1888, Germany annexed the island as part of the *Marshall Islands Protectorate.* At the turn of the century, a British company discovered phosphate, and mining for the deposits began in 1906. Immigration to the island, starting with the European influx during the colonial period (between 1889 and 1913), followed by migrant workers to labour in the phosphate mining operation, changed the island's traditional make-up. These immigration patterns were linked to the mining developments of the Nauru Phosphate Corporation (NPC), yet were also relevant to the island's fishing capacity and history.

Initially, workers were brought to the island from other German-administered Micronesian islands, as well as New Guinea and China. Later, when Australia took control of the island in 1914, an increasing number of Chinese labourers were hired, and by 1939 their numbers (1,512) nearly equalled those of the native Nauruan population (1,733). This demographic make-up did not change until, during World War II, the Japanese occupiers of the island forcibly exiled Nauruans to Truk, where nearly 500 of them died (Underwood, 1989).

At the start of the 1950s, virtually every able-bodied Nauruan adult male was gainfully employed both and once again began to receive their respective phosphate mining royalty payments. This enabled the inhabitants to purchase imported foods as well as improving their living conditions (Viviani, 1970). This purchasing power brought on numerous changes in the structure of the island population, differentiating it from other Pacific islands.

Independence

At the time of its independence in 1966, Nauru had attained an economic status similar to that of rich oil-producing countries of the Middle East (Underwood, 1989; Vunisea *et al.*, 2008). This in turn increased the immigration of labourers to the island to compensate for the growing number of retiring Nauruan nationals (Figure 2). The population is largely concentrated along a narrow coastal strip. Most of the non-native Pacific islanders (largely from Kiribati and Tuvalu) that worked for the Nauru Phosphate Corporation (NPC) were also at least part-time fishers (Underwood, 1989; Dalzell and Debao, 1994).

Nauru's economic prosperity translated into profound cultural changes. This was also reflected in the diet, not only in terms of dietary preferences, but also in the means by which dietary goods were acquired. Until the mid 1980s, the majority of fishing was done by the non-Nauruan Pacific islanders. Nonetheless, the economic decline that occurred in the early 1990s, following the downscaling of phosphate production, reduced the population's ability to purchase high-valued fish, and contributed to the subsequent emigration of non native fishers from the island.

The development and management of the marine resources within the Republic of Nauru falls under the jurisdiction of the Nauru Fisheries and Marine Resources Authority (NFMRA). The NFMRA does not enforce the reporting of catches or issue any fishing quotas. Marine resources are open access, and records of catches are sparse (Dalzell and Debao, 1994). The NFMRA attempted to pursue industrial-scale fisheries by purchasing two purse-seine vessels. However, one ship was lost at sea, while the other was used sparsely due to inadequate fishing gear, and was subsequently sold.

The aim of the present study was to gather available information on fisheries catches and fishing practices to reconstruct Nauru's total fisheries catches for the period 1950-2008. The catch reconstruction approach used here is based on the approach developed by Zeller *et al.* (2006; 2007).

METHODS

At present, small scale marine fisheries in Nauru can be separated into two categories:

1) Subsistence fisheries, dominated by coastal reef fisheries, beach seining and reef gleaning (mainly by women [Chapman, 1987]), are known to be traditional fishing methods practiced throughout the

Pacific islands (Gillett, 2003). I-Kiribati, Tuvaluan and Nauruan fishers commonly operate outboard powered boats ranging from 3–7 m in size, using trolling and shallow-water bottom handlining as their main fishing methods. Some Nauruans carry out spear fishing equipped with scuba gear. This type of fishing may also be done at night, using battery powered flashlights (Chapman, 1998). These coastal fishing activities do overlap with commercial fisheries, if part of the catch is sold; and

2) Commercial fisheries, using fishing methods such as mid-water handlining and drop stone fishing, targeting offshore tunas and other pelagics (Gillett, 2003). The fishers involved in this type of fishery are generally Nauru Phosphate Corporation (NPC) workers from Tuvalu and Kiribati who fish whenoff from work. This fishing is often concentrated around the NPC's mooring buoys used for phosphate vessels that act as Fish Aggregation Devices (FADs) (Chapman, 1998).

Data sources

Human population

Human population numbers (1950-2008) were derived with assistance from G. Beccalossi; Programme Assistant at the Demography and Statistics division of the Secretariat of the Pacific Community (SPC), complemented with data from UN databases[2] and work by Underwood (1989). Every decade had at least one demographic composition anchor point, with linear interpolations performed between anchor points (Figure 2).

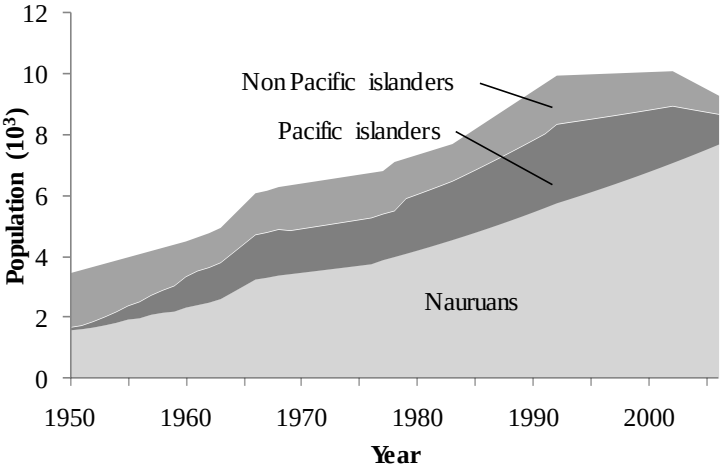

Figure 2. Population composition of Nauru, 1950-2008.

Catch data

Data estimates of fisheries catches, and used here as anchor points, were obtained from Dalzell and Debao (1994), Gillett and Lightfoot (2002), Vunisea *et al.* (2008), as well as Bell *et al.* (2009), for the period between 1991 and 2008. Linear interpolations were used for time periods between anchor points.

To reconstruct the 1950-1990 times series, we assumed that the *per capita* consumption rate for 1950 was twice the 1991 *per capita* catch rate of 45 kg·person^{-1}·year^{-1} for Nauru, taken from Dalzell and Debao (1994). Hence, we assumed a consumption rate of 90 kg·person^{-1}·year^{-1} for 1950. We also assumed negligible seafood imports for 1950. Nauruans, like most Pacific islanders, have traditionally relied on fish as a main protein source (Petit-Skinner, 1981; Sokimi and Chapman, 2001) and the assumed 1950 rate is in line with other data for Micronesia (Bell *et al.*, 2009). We linearly interpolated rates between 1950 and 1991 and derive total catch estimates in conjunction with population data (Figure 2).

Table 1. Fishing sector estimates for late 1990s, used as anchor points, from Gillett and Lightfoot (2002).

Fishing sector	Catch (t)
Coastal subsistence	110
Coastal commercial	315
Offshore locally based	50
Offshore foreign based	41,000
Total	41,475

For the 1990s, Gillett and Lightfoot (2002) estimated offshore and domestic commercial landings (accounting for approximately 77% of domestic supply) as well as subsistence catches (23%; Table 1). In addition, they documented offshore pelagic catches of around 41,000 t, taken by foreign vessels in the late 1990s. This breakdown by fishing sector provides a proxy for local *per capita* catch rates as well as domestically sourced consumption rates. Domestic fish landings were estimated based on coastal catch

[2] United Nations Department of Economic and Social Affairs Population Division: http://www.un.org/esa/population/ [Accessed: February 2010]

estimates by Gillett and Lightfoot (2002) (425 t) summed with domestic offshore catch (50 t) for a total of 475 t (Table 1).

The economic downturn of 1999 greatly diminished the population's purchasing power, decreasing their ability to pay for commercially sold fish. This is reflected in the increasing proportion of fish sourced via the subsistence sector which increased to 84% of the total domestic landings by 2004 (2008). In addition, a reduction in imported fish (22 t) was reported by Gillett and Lightfoot (2002) for 1999, which is considerably lower than the 55 t of imported canned and salted fish reported a few years earlier by Dalzell and Debao (1994). Nonetheless, a two month survey of the island's fishers and families in 2005 estimated that canned fish consumption had risen to an average of 16 kg·person^{-1}·year^{-1} (Vunisea *et al.*, 2008). Because Bell *et al.* (2009) report that Nauruan fish consumption rates range between 55.8 and 62.3 kg·person^{-1}·year^{-1} for the period between 2001 and 2006, we chose the latter rate to account for the canned fish consumption, along with the 425 t of small scale catch reported by Gillett and Lightfoot (2002), which translates into a demand of approximately 600 t of fish per year for Nauru in more recent years.

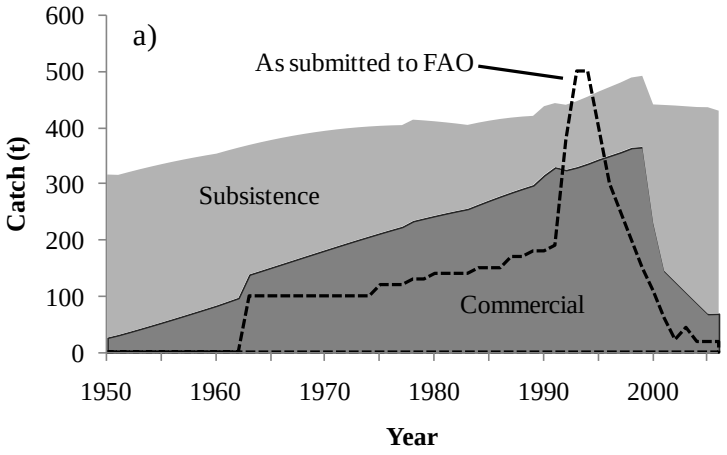

Figure 3a. Reconstructed catches breakdown for Nauru, compared with that reported to FAO from 1950 to 2008.

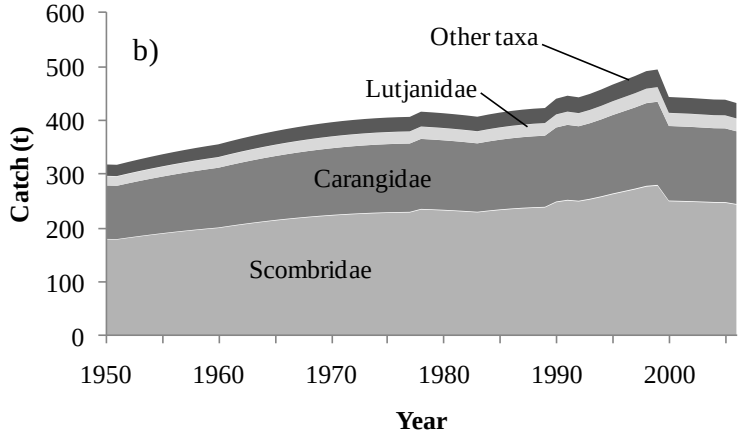

Figure 3b. Taxa layout for Nauru's landings for the period between 1950-2008. Scombridae species 56% of total catch by weight with substantial catches from the Carangidae (31%) and Lutjanidae (6%) families. Within the Scombridae family 90% of the catch were comprised of Skipjack (*katsuwonus pelamis*) and Yellowfin tuna (*Thunnus albacares*)

Catch composition

Dalzell and Debao (1994) list over 180 species of fish observed and reported in the waters of Nauru. They also report a catch breakdown by gear type collected over an eight month period between July 1992 and February 1993 where at the time, approximately 75% of the fishing was done by migrant workers and where approximately 70% of the total landings were commercially sold. Approximately 60% of the total landings were taken by trolling gear, highlighting a high prevalence of tunas (41% of total catch), mainly skipjack (*Katsuwonus pelamis*) and yellowfin (*Thunnus albacares*). Another 30% of the landings were caught using mid-water handlines, almost exclusively catching Carangidae such as rainbow runner (*Elagatis bipinnulata*) and using demersal handlines, that target various species such as squirrelfish (Holocentridae) and bluestripe snapper (*Lutjanus kasmira*). The Mid-water and demersal handline fisheries comprise 26% and 7% of the total landings, respectively. The remaining 7% corresponds to inshore reef fishing activities that are regarded as subsistence or semi-artisanal (Vunisea *et al.*, 2008), where catches were composed predominantly of surgeonfish (Acanthuridae, 38.5%), squirrelfish (Holocentridae, 12.1%), groupers (Serranidae, 7.7%) and rainbow runners (Carangidae, 5%). More recently, lesser valued reef fish such as surgeonfish and triggerfish as well as many invertebrates found during beach and reef gleaning (octopus, turban shell and sea cucumbers etc.), account for an increasing

proportion of inshore subsistence catches (Vunisea *et al.*, 2008). Those species were not necessarily favoured by the Nauruan locals a decade earlier (Dalzell and Debao, 1994; Gillett and Lightfoot, 2002). Presently, fishers indicated that most of their target species required further distances and hours at sea to catch, but regardless of where it came from, it was intended for their family consumption. Incidentally, all family members participated in one way or another in fishing activities (Vunisea *et al.*, 2008; Gillett, 2009) and the increasingly important reef gleaning activity is generally undertaken mainly by women (Chapman, 1987). Overall, the more detailed breakdown by Dalzell and Debao (1994) was applied to the total catch throughout the 1950-2008 time period.

RESULTS

Data supplied to FAO for Nauru would suggest incorrectly that essentially no fish were caught prior to the early 1960s (Figure 3a). Reported landings increased steadily from 100 t·year^{-1} in 1963 to around 190 t·year^{-1} in 1991, before increasing substantially to around 500 t·year^{-1} in 1993 and 1994 (Figure 3a). Thereafter, data supplied to FAO suggested a rapid decline throughout the 1990s to around 40 t·year^{-1} in the early 2000s.

Reconstructed catch estimates suggested a distinctly different picture (Figure 3a). Overall, the 1950-2008 total catches were estimated at 23,150 t, being 3.4 times greater than the data supplied to FAO on behalf of Nauru. Note the slightly lower total estimates for 1993 and 1994 compared to data supplied to FAO. Reconstructed commercial catches increased from around 30 t·year^{-1} in 1950 to around 360 t·year^{-1} in 1999, before declining rapidly to just under 70 t·year^{-1} by 2008 (Figure 3a). Conversely, reconstruction suggested a decline in subsistence catches from 290 t·year^{-1} in 1950 to a low of around 110 t·year^{-1} in 1991, before increasing rapidly to over 350 t·year^{-1} by 2008 (Figure 3a).

The taxonomic breakdown applied to Nauru's reconstructed fisheries catches (Figure 3b) is based on the reported catch composition given by Dalzell and Debao (1994) for the commercial catches, and on Vunisea *et al.* (2008) for the subsistence sector. Commercial catches were dominated by Scombridae (56%), composed of 80% skipjack (*Katsuwonus pelamis*) 10% yellowfin tuna (*Thunnus albacares*) and 10% other scombrids, followed by Carangidae (30%, mainly rainbow runner, *Elagatis bipinnulata*) as well as Lutjanidae (6%, mainly *Lutjanus kasmiri*), followed by coastal reef species such as surgeonfish (5%) and triggerfish (3%). Other taxa have been increasingly targeted more recently, due to ever more intensive fishing pressure. Overall, there is a predominance of pelagic species in local landings (Figure 3b). Nonetheless, far less of these landings are sold commercially; rather, they are intended for family consumption or sharing with other family members and neighbours. This shift to increasingly non-commercial basis was driven by the recent economical crisis and the weaker financial power of the Nauruan people (Vunisea *et al.*, 2008; Gillett, 2009).

DISCUSSION

Nauru's total domestic fisheries catches for the period 1950-2008 were estimated to be 23,150 t. This amount illustrates the historical importance fisheries have in meeting the island's dietary requirements, a fact which cannot be readily inferred from the data reported to FAO on behalf of Nauru. Small-scale fisheries are fundamental to many Pacific islands, nonetheless widespread lack of information on subsistence sector catches undervalues the social and economical importance of this sector (Zeller *et al.*, 2006; Gillett, 2009) and may impact any successful form of ecosystem-based fisheries management (Pauly *et al.*, 2002).

The landings reported to the global community on behalf of Nauru substantially underestimate total catches as estimated here for all but two years during the early 1990s. We assume that this peak in reported landings coincides with the publication of the seminal work by Dalzell and Debao (1994) and Dalzell *et al.* (1996), who presented estimates of *per capita* catch rates. These studies were likely used to estimate Nauru's 1993 and 1994 fisheries landings that were reported to FAO. However, the human population counts for that decade were overestimated (Underwood, 1989), likely resulting in the higher reported landings estimates as presented by FAO compared to our reconstructed estimates. We identified

that for the early 1950s, population statistics were underestimated by as much as 60% (Underwood, 1989) and in the most recent decade, the population was overestimated by 20% to 40%, due to the rapidly increasing emigration of foreign NPC workers (Vunisea *et al.*, 2008). Hence it is noteworthy to mention that the *per capita* fish consumption of 56 kg·person^{-1}·year^{-1} reported by Bell *et al.* (2009), which we used for recent time periods, is likely underestimated, due to it being based on inflated population estimates.

Despite the economic surge provided by the island's phosphate earnings during earlier decades, Nauru's fisheries did not develop in similar fashion, due in part to the absence of natural harbours to moor vessels. Three man-made channels and a small boat harbour have been excavated through the coral fringing reef, allowing only small outboard powered vessels to be launched. Industrial-scale fishing was attempted in the early 1980s involving two purse-seine vessels, but was not successful due to ineffective gear and through market loss which led to the sale of one vessel while the other was lost at sea (Chapman, 1998).

Nauru has been a party to the US Multilateral Fisheries Treaty since it came into effect in June 1988. In July of 1994, Nauru entered into a bilateral fishing access agreement with Japan, granting four Japanese fishing vessels access to Nauruan waters and in June 1997, the first fishing access agreement was signed with the Philippines (Chapman, 1998). It is estimated that Nauru received about US$3.4 million in access fees in 1999 (Gillett and Lightfoot, 2002) and US$5.4 million in access fees in 2008 (Gillett, 2009), with 131 foreign fishing vessels (10 countries), licensed to fish in Nauru's EEZ, catching approximately 66,000 t of tuna.

Attempts to farm milkfish (*Chanos chanos*) and tilapia (*Oreochromis mossambicus*) in the past had failed; these fish were introduced into the Baduan Lagoon. Milkfish, although part of the traditional Nauruan diet and culture, were used as bait for tuna fishing (Spennemann, 2002). Tilapia was introduced in the early 1960s but was not accepted as a staple food option and eventually infested all the milkfish ponds causing many farmers to abandon their traditional practice of raising milkfish (Gillett, 2009). Programs to eradicate the introduced fish from the island's lagoon have failed (Dalzell *et al.*, 1996). In 2000, 10,000 milkfish fry from Kiribati were introduced into Buada Lagoon, reaping 5,000 adult fish (Gillett, 2009). At present, several milkfish grow-out ponds exist; these are backyard and mostly subsistence operations. No accurate production estimates exist (Gillett, 2009).

Inshore fishing pressure appears to have increased dramatically since the late 1990s, with almost all households involved in fishing; women and children glean the beaches and reefs, collecting all invertebrate and finfish species they come across. Vunisea *et al.* (2008) surveyed invertebrate catches, estimating the total catch to be 23 t·year^{-1}, dominated by genera such as *Etisus, Octopus, Turbo, Thais, Tripneustes* and *Cardisoma* and to a lesser extent *Actinopyga, Panulirus, Grapsus*, and *Cypraea*. All species and types are targeted and consumed, with the exception of lobsters, which are destined for sale (Vunisea *et al.*, 2008). All sizes of fish are caught and consumed, however fishers have observed a decrease in size and volume of catches (Vunisea *et al.*, 2008), suggesting that overfishing is occurring. There has been a steady increase in the intensity and frequency of fishing since the economic crisis in 1999, driven mainly by increasing subsistence efforts. Presently, pelagic fishing is dominated by canoes operated by Tuvaluans and I-Kiribati (Vunisea *et al.*, 2008).

Fish continue to form a large part of the Nauruan diet, increasingly so with the island's recent economic downturn. Food security may be jeopardized, leading to substantial dietary changes. Imported produce such as meat and poultry have been replaced with canned sardines and mackerel from abroad, seafood provides the main source of protein for more than 98% of Nauruan households (Vunisea *et al.*, 2008). The Nauru Fisheries and Marine Resource Authority (NFMRA) have the responsibility of overseeing, managing and conserving the country's natural marine resources and environment. Yet, with fishing being the only major fallback option for the population, the task presents several challenges, especially when marine resources are vulnerable to overexploitation and the livelihoods of an entire nation are at risk.

ACKNOWLEDGEMENTS

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Appendix Table A1: Total FAO landings vs. total reconstructed catch for Nauru, 1950-2008, in metric tonnes.

Year	FAO landings	Total reconstructed
1950	0	296
1951	0	301
1952	0	306
1953	0	311
1954	0	315
1955	0	319
1956	0	323
1957	0	327
1958	0	331
1959	0	334
1960	0	337
1961	0	342
1962	0	347
1963	100	352
1964	100	356
1965	100	360
1966	100	364
1967	100	367
1968	100	370
1969	100	373
1970	100	375
1971	100	378
1972	100	380
1973	100	381
1974	100	382
1975	120	384
1976	120	384
1977	120	385
1978	130	394
1979	130	392
1980	140	391
1981	140	389
1982	140	387
1983	140	385
1984	150	388
1985	150	392
1986	150	394
1987	170	397
1988	170	398
1989	180	399
1990	180	452
1991	190	444
1992	377	441
1993	500	447
1994	500	455
1995	400	464
1996	300	472
1997	250	481
1998	200	490
1999	150	493
2000	109	443
2001	61	442
2002	22	440
2003	44	438
2004	19	437
2005	39	437
2006	39	447
2007	39	447
2008	39	447

Appendix Table A2: Total reconstructed catch (t) by major taxa for Nauru, 1950-2008. Others category contains 7 taxonomic groups including miscellaneous marine fishes.

Year	*Katsuwonus pelamis*	*Elagatis bipinnulata*	*Thunnus albacares*	Scombridae	Carangidae	*Lutjanus kasmiri*	Crustaceans nei	Others
1950	130	72	16	16	18	14	6	24
1951	132	73	17	17	18	14	6	25
1952	134	74	17	17	19	14	6	25
1953	136	75	17	17	19	15	6	25
1954	138	76	17	17	19	15	6	26
1955	140	77	17	17	19	15	6	26
1956	142	78	18	18	20	15	7	26
1957	143	79	18	18	20	15	7	27
1958	145	80	18	18	20	16	7	27
1959	146	81	18	18	20	16	7	27
1960	147	82	18	18	20	16	7	28
1961	150	83	19	19	21	16	8	28
1962	152	84	19	19	21	16	8	28
1963	171	73	21	21	18	14	8	25
1964	173	74	22	22	18	14	8	25
1965	175	75	22	22	19	14	8	25
1966	176	75	22	22	19	15	9	26
1967	178	76	22	22	19	15	9	26
1968	179	77	22	22	19	15	9	26
1969	180	78	23	23	19	15	9	26
1970	181	78	23	23	20	15	10	27
1971	182	79	23	23	20	15	10	27
1972	183	79	23	23	20	15	10	27
1973	183	79	23	23	20	15	10	27
1974	184	80	23	23	20	15	10	27
1975	184	80	23	23	20	15	11	27
1976	185	80	23	23	20	15	11	27
1977	185	80	23	23	20	15	11	27
1978	188	82	24	24	21	16	12	28
1979	188	82	23	23	20	16	12	28
1980	187	81	23	23	20	16	12	28
1981	186	81	23	23	20	16	12	28
1982	185	80	23	23	20	16	12	27
1983	184	80	23	23	20	15	13	27
1984	185	80	23	23	20	16	13	28
1985	187	81	23	23	20	16	13	28
1986	188	82	23	23	20	16	14	28
1987	188	82	24	24	21	16	14	28
1988	189	82	24	24	21	16	15	28
1989	189	83	24	24	21	16	15	28
1990	213	96	27	27	24	18	15	33
1991	209	93	26	26	23	18	16	32
1992	207	93	26	26	23	18	16	32
1993	210	94	26	26	24	18	16	32
1994	214	96	27	27	24	19	16	33
1995	218	98	27	27	25	19	16	34
1996	221	100	28	28	25	19	16	34
1997	225	102	28	28	26	20	16	35
1998	229	105	29	29	26	20	16	36
1999	230	105	29	29	26	20	16	36
2000	190	105	24	24	26	20	16	37
2001	190	105	24	24	26	20	16	37
2002	189	105	24	21	26	20	16	39
2003	189	104	24	12	26	20	16	48
2004	188	104	24	21	26	20	16	38
2005	188	104	24	21	26	20	15	39
2006	193	107	24	21	27	21	15	39
2007	193	107	24	21	27	21	15	39
2008	193	107	24	21	27	21	15	39