

Decadal changes in subsistence fishing and seafood consumption patterns on Rarotonga, Cook Islands

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Introduction

Cook Islands is located east of Samoa and west of French Polynesia. It lies between latitudes 8 to 23 degrees south and longitudes 156 to 167 degrees west. The northern Cook Islands are mainly atolls formed from tips of submerged, coral-encrusted mountains. These include Manihiki, Rakahanga, Pukapuka, Nassau, Penrhyn and Suvarrow. The southern Cook Islands include Aitutaki, Atiu, Mangaia, Manuae, Mauke, Mitiaro, Palmerston, Rarotonga and Takutea (What's on in the Cook Islands 2001). Manuae, Suvarrow and Takutea are the only uninhabited islands. The Southern Cook Islands are volcanic in origin with elevated encircling reef platforms adjacent to the coast (Tatuava 2001; Chapman and Cusack 1997).

The 15 islands of Cook Islands have a total land area of 237 square kilometres that is encompassed by a sea area of 200 nautical miles known as the exclusive economic zone (EEZ). The reefs and lagoons support a wide range of demersal fish, corals, molluscs, crustaceans, echinoderms and other marine organisms. Beyond the reefs, tuna (albacore, yellowfin and skipjack) form part of the Western and Central Pacific tuna stocks, which are the basis of the world's tuna fishery (MMR 1998).

Tourism is the major foreign exchange earner apart from offshore banking and the black pearl industry. Agricultural products (including pawpaw, taro, oranges, maire [*Alyxia stellata*], black pearls and pearl shells, live fish and fresh or chilled fish) are the main exports. The pearl industry alone accounts for 60 per cent of total exports. Imported goods consist of food and live animals, minerals, fuels, transportation equipment, manufactured goods, chemicals and crude materials, beverages and tobacco. More than 56 per cent of total imports are from New Zealand (MMR 1998; Cook Islands Statistics Office 2001; Cook Islands Tourism Corporation 2001).

Fishing activities in Cook Islands are classified into three main categories. Subsistence fishing com-

prises 55 per cent of the fishing activity in terms of the number of people involved. Artisanal fishing (whereby the harvest is sold for income at local markets, restaurants and hotels) makes up 35 per cent of the total fishery sector. Commercial and industrial fishing make up the remaining 10 per cent. This operation requires more gear and capital and is aimed at export markets. However, gathering of sedentary products relies on simple techniques and low technology.

The main focus of the fisheries sector has been on commercial fishing, which includes tuna fishing by foreign fleets with access licenses from countries and territories such as Korea, Taiwan, French Polynesia and American Samoa (Tatuava 2001; Chapman and Cusack 1997).

The common fishing methods used in Cook Islands are hook-and-line, net fishing, spear fishing and gleaning. Other fishing methods include traps using coral fencing and plaited baskets to catch schools of lagoon fish and fresh water eels, jabbing methods used to catch mantis shrimp, freshwater fishing using gillnets and hook-and-line to catch tilapia, eels and snake mackerel (MMR 1998).

Destructive fishing methods, e.g. the use of the poisonous vine *Derris* sp., have been prohibited. The fruit of the barringtonia tree (*Barringtonia asiatica*) and dynamite have been banned because these methods are destructive. They kill all types of fish, shellfish and corals, harming larvae and juvenile marine organism (MMR 1998).

This paper documents subsistence fishing activities and fishing efforts over a twelve-year period in Rarotonga. It also assesses the importance of seafood in household diets and investigates seafood consumption trends from 1989 to 2001. Seafood consumption in the context of this research includes the consumption of imported canned fish, frozen fresh fish fillets sent from the outer islands to Rarotonga and other imported processed seafood, e.g. chilled and marinated mussels, oysters and prawns.

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Methods

Study site

Rarotonga is the largest island in Cook Islands, with an estimated area of 67 km², and is oval in shape (MMR 1998; What's on in the Cook Islands 2001). According to census counts, the population of Rarotonga was 10,337 in 1996 compared to 9,678 in 1986 (Cook Islands Statistics Office 1997). Avarua is the main township and the centre for administration and shopping.

Rarotonga's fringing reef (2.6 km²) is close to the shore, while the shallow lagoon covers eight square kilometres. Several interior freshwater streams around the Ngatangia, Avatiu and Avarua have inhibited coral growth, causing reef passages to form. Avatiu harbour is used by local fishing boats and dive operators, both private and commercial, and is the main port of entry for large ships and cruising yachts.

The surrounding coral reefs and lagoons have provided sufficient fishery resources to the population of Rarotonga for many generations. However, over the years, increases in fishing activities for subsistence consumption and for the cash economy have caused heavy fishing pressure on the marine environment on Rarotonga. In recent years, there has been resurgence in the *rau'i* (traditional management of the marine environment). Harvesting of marine resources is banned from these areas until the *rau'i* is lifted.



Figure 1. Satellite map of Rarotonga island, Cook Islands, showing coral reefs and coastal villages (Source: <http://earth.google.com>)

Subsistence fishery survey

Surveys were undertaken of the fishery between December and February of 1989 and 2001. The survey consisted of a combination of household and seafood consumption surveys as per methods described in Zann and Aleta (1984), Zann et al. (1984), Vuki (1991), and Kuster et al. (2005).

Households were selected at random and a senior member was interviewed. Interviews were conducted in the Cook Islands Maori language. A total of 100 households were surveyed each year in 1989 and 2001.

The questionnaire consisted of three main sections. The first section asked about the socio-economic status of each household. Another section had details of the subsistence fishing activities, time and area of fishing, fishing craft and gear used, fishing effort and species caught. The third section consisted of an estimate of the quantity (kg) and identity of fish, shellfish and invertebrates consumed the day before the survey. This also included imported canned fish and meat consumed. In the seafood consumption section of the questionnaire, bivalves and gastropods were classified as shellfish. This included meat of black pearl oyster, giant clams, mussels, trochus and snails. Crustaceans, sea cucumbers, sea urchins and octopus were grouped as other invertebrates. Captured fish included those that were harvested from the sea and those received locally from friends and family.

Results and discussion

Socio-economics

The average number of people per household was 4 in 2001, while in 1989 it was 5. This may indicate that Cook Islanders are moving away from living

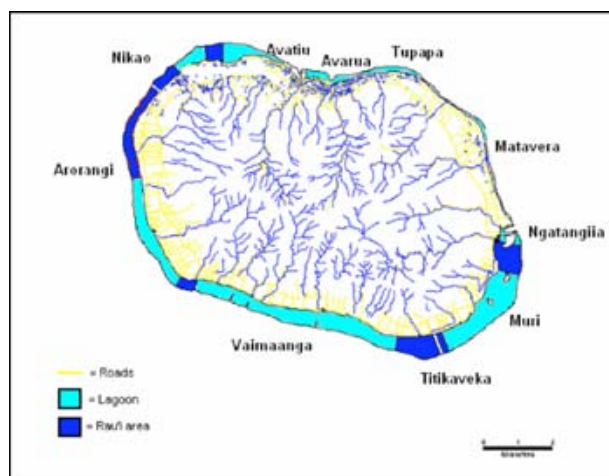


Figure 2. Map of Rarotonga showing districts

in extended households and toward a nuclear type family (Cook Islands Statistics Office 1997).

The average weekly income per household has increased from NZD 232 in 1989 to NZD 327 in 2001. This is an increase of NZD 7 per year over the twelve-year period. The increase in income could be due to inflation and also to increases in the minimum wage.

Salaried workers from the public and private sectors made up the majority of workers per household during the twelve-year period (Figs 3 and 4). Retired workers received regular fortnightly or monthly income from superannuation and pensions. Other contributions to the household income were made by those who were unemployed but on welfare benefits such as child benefits (mainly mothers).

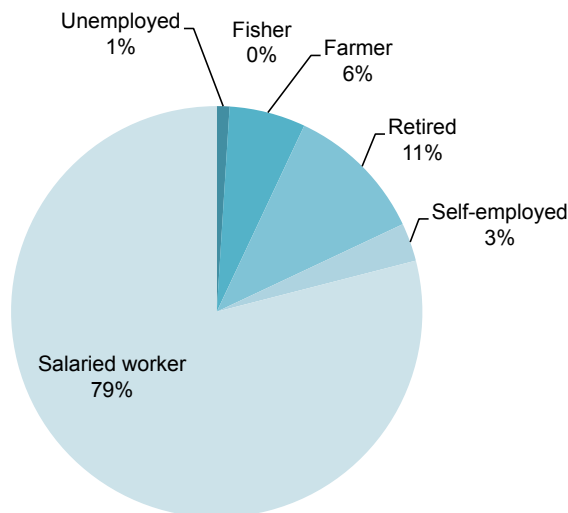


Figure 3. Occupation in 1989

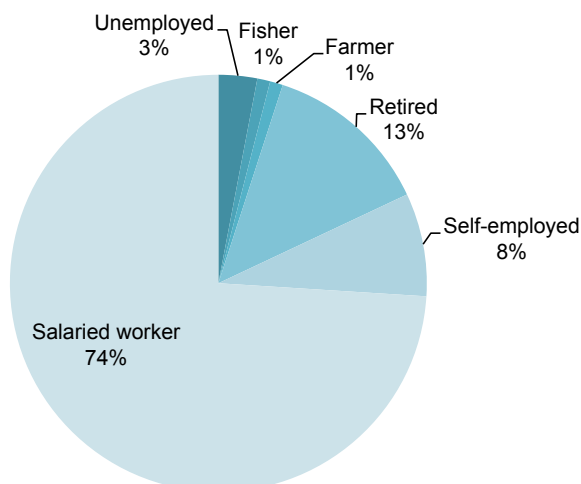


Figure 4. Occupation in 2001

Subsistence fishing

Subsistence fishing activities

Our surveys indicated that 14 households took part in fishing activities in 2001 compared to 17 households in 1989. Each household spent 3.4 days and 2.2 days fishing per week in 1989 and 2001 respectively. Therefore, time per week spent on fishing has decreased even though our surveys indicated that the number of household members who go fishing and the hours spent on each fishing trip have remained the same. The increase in the average salary and wages earned per week in the private and public employment sectors may have contributed to more than 55 per cent of the households spending less time taking part in some form of fishing activity. This has resulted in the frequency of seafood meals (mainly fish) declining from 2.8 times per week in 1989 to 1.8 times per week in 2001.

Studies undertaken in Penrhyn in the outer islands of Cook Islands showed that over 90 per cent of households took part in fishing activities (Passfield 1998). The lower income earned per week in Penrhyn may have contributed to the high percentage of fishing activities performed by household members. Fish meals were more frequent, averaging six times per week (Passfield 1998).

The fishing activities were mainly carried out in the lagoon and inshore reef areas of Rarotonga (Fig. 5). Spear guns, fishing nets and fishing handlines were the main gear used. There were some variations in the times of fishing between the surveys in 1989 and in 2001. An average of two individuals went on each fishing trip. Each trip took about two hours on average.

Spear fishing was the most popular fishing method; 50 per cent and 29 per cent of households surveyed used this method in 1989 and 2001 respectively (Fig. 5). Gleaning decreased while net fishing increased. Net fishing included set gillnet fishing and drive gillnet fishing. Handline fishing increased over the period (see Fig. 5).

In stationary or passive gillnet fishing, gillnets are anchored in the lagoon along the reef slope and usually left overnight. This method is non-selective and destructive as it catches many kinds and sizes of fish which could be wasted because they may not be eaten.

Drive or active gillnet fishing is carried out by a large group of fishers (normally five or more) who sight and stalk a school of fish and then place a net across a reef channel to trap the school. In another method, fishers use a long net to surround the school and then beat the water and chase the school toward the half-encircling net.

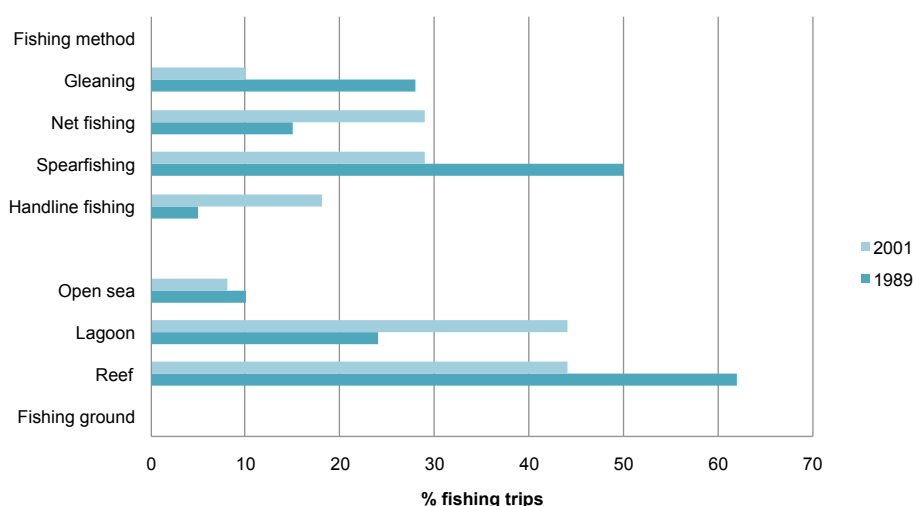


Figure 5. Percentage of fishing trips using different methods and fishing grounds

The reef was the most popular fishing ground (62%) in 1989 (Fig. 5). In 2001, both the reef and lagoon were commonly used fishing grounds. The open sea was not fished as often as the lagoon and reef (Fig. 5).

There were no fishing crafts used in 1989; however, 12 per cent of the households surveyed in 2001 used motorized boats during fishing trips. In both years, there were no traditional canoes used for fishing.

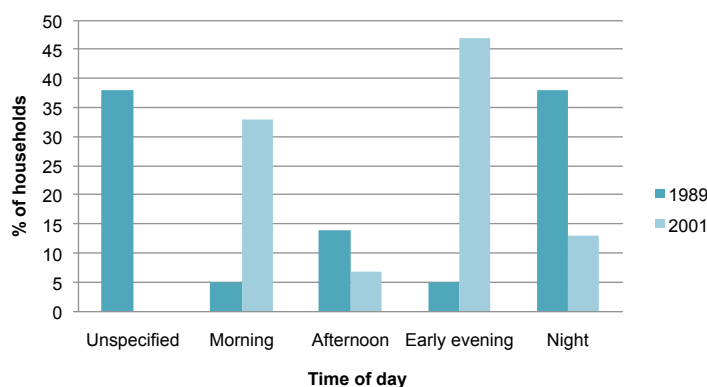


Figure 6. Time of the day fishing occurred

Time of fishing and fishing effort

In 1989, most households preferred to fish at night (38%), while only a few fished in the morning (5%), afternoon (14%) and evening (5%) (Fig. 6). However, a different trend was observed in 2001: the morning (33%) and evening (47%) hours were the times fishers were most likely to go fishing. Only a few fished late at night (13%) and in the afternoon (7%). Thirty eight per cent of the fishing households in 1989 did not state the time they went fishing (Fig. 6).

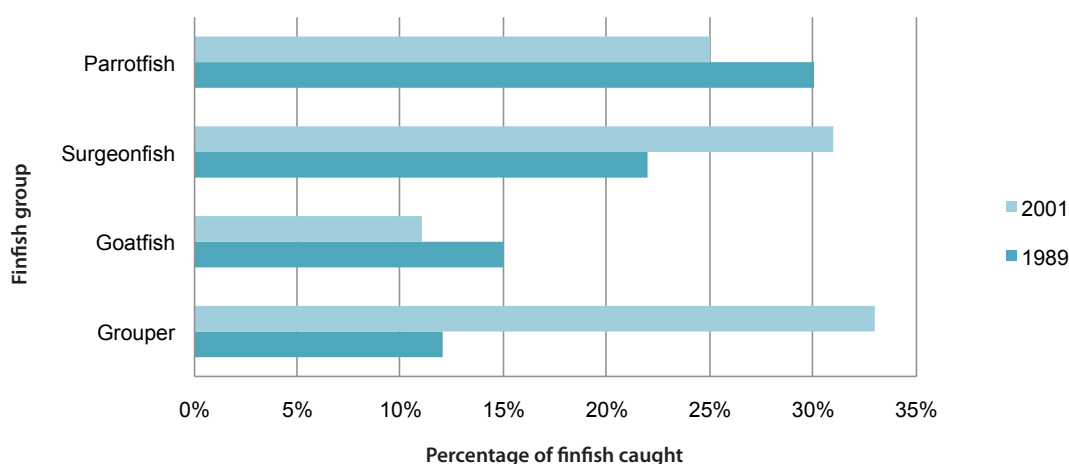
An average of two hours were spent fishing. An average catch per unit effort of approximately 0.61 kg per person per hour was recorded in 2001, which is almost the same as that in 1989. Spear guns have remained the popular choice of gear amongst the fishing households. Most spear fishing activities took place in the lagoon at night in 1989. Households using spear guns in 2001 fished equally in the lagoon, the reef and the open sea in the evenings and at night. This gear type landed 1.3 kg and 1.2 kg of finfish per person per hour in 1989 and 2001 respectively (Table 1). The catch

per unit effort of household surveys in Rarotonga was higher than those from household surveys on Ono-i-Lau, Fiji Islands.

The catch per unit effort for gleaning activities and the use of fishing handlines could not be calculated for 2001 because most households could not estimate the total weight of fish and shellfish landed. Thus, comparisons could not be made with catch per unit effort in 1989 for these two fishing activities (Table 1). The household surveys showed that catch per unit effort on Ono-i-Lau were higher than those on Rarotonga for handline (Table 1). Handline fishing is a more popular method of fishing on Ono-i-Lau than on Rarotonga. Ono-i-Lau has larger areas of reef and lagoon and is an isolated island with a very small population. It was noted however that the number of households taking part in gleaning activities on Rarotonga has decreased, while use of the handline method has increased (Fig. 5). The catch per unit effort in gleaning and net fishing was

Table 1. Summary of catch per unit effort (kg person⁻¹ hour⁻¹) from household surveys on Rarotonga (Cook Islands) and Ono-i-Lau (Fiji Islands) by gear used.

Fishing method	Catch per unit effort 1989 (Rarotonga)	Catch per unit effort 2001 (Rarotonga)	Catch per unit effort (Ono-i-Lau, Fiji Islands) (Kuster et al. 2006)
Handline	1.00	Unavailable	1.78
Spear	1.30	1.20	0.88
Net	0.05	0.02	0.37
Gleaning	0.02	Unavailable	0.32

**Figure 7.** Importance of the major finfish groups caught

higher on Ono-i-Lau than on Rarotonga (Table 1). The use of gillnets on Rarotonga produced similar catch per unit effort in 1989 and 2001: 0.05 kg and 0.02 kg per person per hour, respectively (Table 1). The set gillnet fishing method was common in 1989, but this was replaced by the drive gillnet fishing method in 2001.

Major composition of catches

As shown in Figure 7, in 1989 the largest part of the finfish catch (30%) for surveyed households consisted of parrotfish (*pakati*, *u'u*). Twenty two per cent of the catch consisted of surgeonfish of the species *Naso unicornis* (*ume*), *Acanthurus triostegus* (*manini*) and *Ctenochaetus striatus* (*maito*). The goatfish *Mulloidops vanicolensis* (*koma* and *takua*) made up 15 per cent of the catch. The finfish caught least often (12%) was the grouper, *Epinephelus tauvina* (*patuki*).

In contrast, the catch in 2001 consisted of 33 per cent grouper. The second major finfish caught (31%) were the three species of surgeonfish. Twenty five per cent of the catch was made up of parrotfish. The finfish caught the least often (11%) was the goatfish.

In 1989, the shellfish caught most often by surveyed households (71%) was the large worm snail (*Dendropoma maxima*) (*ungakao*). Mussels (*Asaphis virescens*) (*ka'i*) made up 28 per cent of the shellfish collected. The giant clam of the species *Tridacna maxima* (*pau'a*) made up only 1 per cent of the catch.

In 2001, the shellfish collected in largest quantity (77%) was the rough turbo snail (*Turbo setosus*) (*ariri*). Fifteen per cent of shellfish collected were trochus (*Trochus niloticus*) (*torokati*). The shellfish collected in smallest quantity (8%) was the giant clam (*Tridacna maxima*) (*pau'a*). There were no *ungakao* and *ka'i* collected in 2001. *Ka'i* is often harvested seasonally and our ad hoc surveys between November 1998 and 2000 of *rau'i* reef areas show low abundances (1–12 *pau'a* 100 m⁻²) of *pau'a*. This could indicate over-harvesting of *ungakao* and *ka'i*.

In the category of other invertebrates, 63 per cent of the catch was crayfish (*koura*), caught mainly by spearfishing at night. Sea cucumber gonads (*Holothuria atra*) (*matu ori*) made up 37 per cent of the catch. There were no other invertebrates recorded during the 2001 survey.

Table 2. Finfish sold, given away or received each week

	1989			2001		
	Household %	Weight (kg)		Household %	Weight (kg)	
		Total	Mean		Total	Mean
Sell	3	123.5	41.2	10	25.5	12.8
Give away	35	129.0	3.4	55	12.0	1.7
Receive	62	252.2	4.3	35	24.0	4.8

Finfish sold, given away or received

The majority of the households (62%) in 1989 received finfish and the average quantity was 4.3 kg each week. In 2001, 35 per cent received finfish and the amount rose slightly to 4.8 kg of fish per week on average (Table 2). The percentages of households selling and giving away fish increased. However, the mean weights of fish sold and given away in 2001 were less than in 1989 (Table 2).

Seafood consumption***Frequency of fish meals in household diets and finfish consumption***

On average, fish was consumed 1.8 times per week in 2001 as opposed to 2.8 times per week in 1989. Our surveys showed that at mealtimes, households most frequently consumed one fish type. Consumption of two to three fish types was occasional, while consumption of more than three fish types was rare.

A total of 74 and 43 households were recorded to have consumed fish in the week prior to the survey in 1989 and 2001, respectively. The weight of fish consumed per household was divided by the number of people per household to give a per capita estimate (Zann et al. 1984). The average consumption of fish per capita on a daily basis was 148.9 g in 1989 and 167.1 g in 2001.

There were 30 households in 1989 and 13 households in 2001 that captured their finfish. An estimated 8 households in 1989 and 12 households in 2001 purchased fish from fish markets, stores and restaurants. Thus, 38 households in 1989 compared to 25 households in 2001 consumed captured and purchased finfish.

The majority of the households in 1989 and 2001 were fishing households and captured fish from the sea. Commonly consumed fish in 1989 were lagoon and reef species such as parrotfishes (29%) (Table 3). The pelagic fish tuna was consumed by 21 per cent

of the households. Surgeonfish was consumed by 12 per cent of the households. A range of 3–7 per cent of the households consumed trevallies, moray eels, flying fish, drummerfish, groupers and snake mackerel. Less than 1 per cent of households consumed goatfish, mahi-mahi, emperor, porcupine fish and wahoo. No mullet and rabbit fish were consumed in 1989 or 2001.

The pelagic fishes flying fish, mahi-mahi and tuna dominated fish consumed by households in 2001 (17–26%) (Table 3). Therefore, there was a shift in fish consumption from reef fishes to pelagic fishes. This could be due to ciguatera poisoning, which was a major problem at that time. A further 8 per cent of households consumed marlin, parrotfish and snake mackerel. A range of 2–4 per cent of households consumed other reef fishes such as surgeonfish, trevally, goatfish, emperor and snapper. Drummerfish was consumed by 1 per cent of the households in 2001. As for purchased fish, most were bought from the fish markets. Pelagic fish such as flying fish and tuna made up the bulk of commonly purchased fish species.

Table 3. Percentages of major finfish consumed

1989		2001	
Parrotfish	29	Flying fish	26
Tuna	21	Mahi-mahi	19
Surgeonfish	12	Tuna	17
Trevally	7	Marlin	8
Moray eel	7	Parrotfish	8
Flying fish	6	Snake mackerel	8
Grouper/cod	6	Others	14
Others	2		

Shellfish consumption

A total of ten households in 1989 and five households in 2001 consumed captured and purchased shellfish, namely giant clams and mussels. A wider variety of shellfish was consumed in 1989 than in 2001 (Table 4). The majority of the households in

2001 purchased shellfish from stores instead of harvesting it from the sea. Three households in 1989 consumed shellfish harvested from the sea compared to no households in 2001. However, the overall shellfish consumption on average rose to 50 g per capita per day in 2001 from 32 g in 1989.

Table 4. Frequency of shellfish consumption (% of households)

1989		2001	
Mussels	54%	Mussels	93%
Pearl oysters	27%	Giant clams	7%
Giant clams	13%		
Large worm snail	5%		
Rough turban snail	1%		
Total	100%	Total	100%

Other invertebrate consumption and sea grape consumption

No invertebrates other than shellfish were captured in 2001. Prawns were the only type of invertebrate consumed in 2001 that were bought from the store (one household). In 1989, crayfish/lobster and coconut crabs were consumed by 68 per cent and 20 per cent of households respectively (Fig. 8). Octopus, sea cucumber gonads and sea urchins gonads were also consumed in 1989 as delicacies (Fig. 8). An average of 88 per cent of invertebrates consumed were captured and 12 per cent were purchased from the fish market. Our results showed a higher household capture and consumption of invertebrates in 1989 (118.4 g per capita per day) than in 2001 (35.7 g).

Only one household in 2001 consumed sea grapes (*Caulerpa racemosa*), which could not be categorized

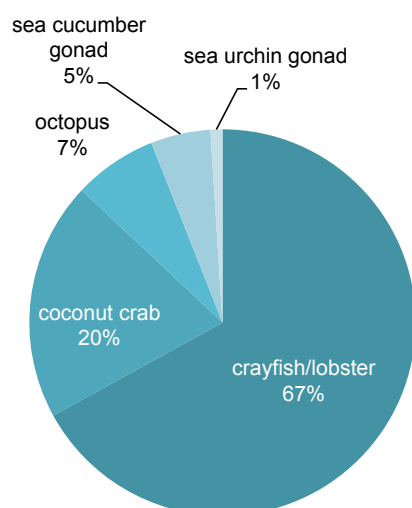


Figure 8. Other invertebrates consumed in 1989

into any of the above sections because it is not an invertebrate or an animal but rather is a plant. Thus it is classified as other seafood. The weight of the consumed sea grapes was not taken into account. These sea grapes could have been sent from Aitutaki. Sea grapes found in Rarotonga are restricted to Ngatangia and women do not harvest them because they are more calcified in nature and therefore inedible. There were no households in 1989 that consumed sea grapes.

Imported canned fish and meat consumption

A decline in household consumption of imported canned fish the day before the survey was found in 2001. There were 17 households in 2001 consuming canned mackerel with different brand names, and they ate 20 cans of fish, while in 1989 there were 27 households and they consumed 41 cans of fish. The most popular canned fish consumed was the Japanese-made brand Wonderful. These cans came in 425 g sizes at NZD 4.40 for dark coloured cans and NZD 2.50 for light coloured cans. Average canned fish consumption was 18.4 g and 17.9 g per capita per day for 1989 and 2001, respectively.

The ratio of households consuming meat increased from 36.4 per cent in 1989 to 48.8 per cent in 2001 (Fig. 9). Meat consumed was mostly imported and included chicken, mince, lamb chops, beef, bacon and other forms of pork, and sausages. Based on the number of households surveyed, chicken was consumed in larger quantities than finfish, shellfish, invertebrates or imported canned fish.

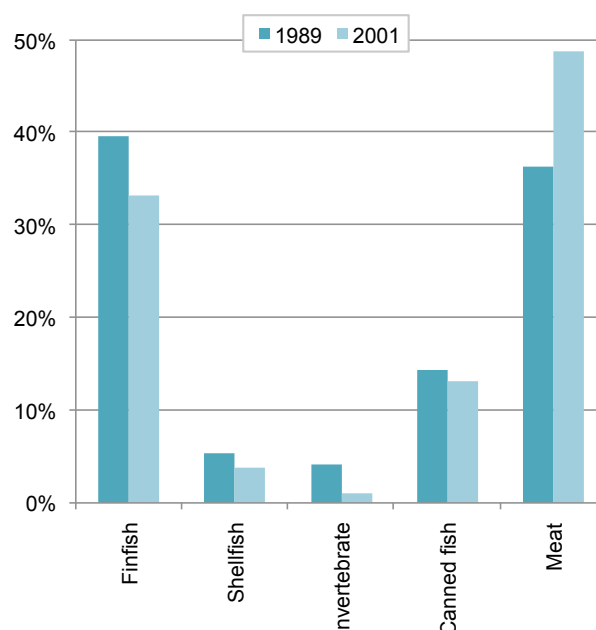


Figure 9. Percentage consumption of five different food groups

Table 5. Average amount of finfish, shellfish, other invertebrates and canned fish consumed daily

	Per capita (g) ¹		Per household (g)	
	1989	2001	1989	2001
Finfish	148.9	167.1	744.6	668.6
Shellfish	32.0	50.0	160.0	200.0
Other invertebrates	118.4	35.7	591.3	142.9
Imported canned fish	18.4	17.9	92.2	71.4
Total seafood consumption	317.7	270.7	1588.1	1082.9

¹ The weight of fish consumed per fish consuming household was divided by the number of people per household to give a per capita estimate (Zann et al. 1984)

Total seafood consumption, meat and trends

A summary of the average amount of finfish, shellfish, other invertebrates and canned fish consumed is presented in Table 5. The most consumed seafood per capita per household is finfish while the least consumed is imported canned fish.

Our surveys showed that the total seafood consumption has decreased over a twelve-year period. The average daily consumption of seafood per capita was 317.7 g in 1989 compared to 270.7 g in 2001 (Table 5).

The major factor contributing to this decline is the fear of ciguatera poisoning that was prevalent during that period. The establishment of marine protected areas (closed areas and permanent), or *rau'i*, also contributed to this decline. This customary community based management system (MMR 1998) was implemented due to heavy fishing pressure in most lagoon and reef areas caused by coastal activities, gleaning and over-fishing. There was also an increase in the use of monofilament gillnets and scuba spear fishing. These activities led to further decline of living marine resources such as giant clams, mussels and certain fish species (Ponia et al. 1999; MMR 1998). Marine protected areas were implemented around Rarotonga's reefs and lagoons as a fisheries management tool.

There was higher (36.4–48.8%) meat consumption in 2001 when compared to 1989. Meat is readily available in stores and is much cheaper than most seafood sold, especially finfish. The purchase of finfish would cost the consumer about NZD 19 per kg of fresh fish sent in from Palmerston (an island in the southern Cook Islands), NZD 22–25 per kg of fresh fish imported from New Zealand or NZD 20 per string with 10 fish per string, or NZD 20–30 per whole tuna fish depending on the size. On the other hand, meat costs about NZD 9–15 per packet or just over NZD 5 per kg.

Importance of seafood in household diets on Rarotonga and other Pacific Islands

In relation to the average consumption of seafood per capita per day, studies conducted by Zann and Aleta (1984) and Zann et al. (1984) in Tokelau and Samoa showed that each household member consumed an average of 481 g and 420 g respectively. Similarly, studies carried out by Vuki (1991) on Dravuni Island (Fiji Islands) revealed that the average daily seafood consumption per capita was 355.7 g. This included imported canned fish, finfish, shellfish and other invertebrates. Thus, the average amount of seafood consumed on Rarotonga is lower (317.7 g in 1989 and 270.7 g in 2001). However, as we have seen, seafood still plays a major role in most household diets on Rarotonga.

Conclusions

Between 1989 and 2001, there were considerable changes in patterns of fishing and seafood consumption on Rarotonga. Though the average amount of finfish consumed increased by 18 g per capita per day from 1989 to 2001, invertebrate consumption decreased by 82.7 g per capita per day. Therefore, total seafood consumption decreased over the twelve-year period from 317.7 g to 270.7 g per capita per day.

The fishing spots visited most often over the twelve-year period were the lagoon and inshore areas. The fish catch was dominated by parrotfish in 1989, while in 2001 grouper was the major fish caught.

The changes in lifestyle in Rarotonga may have been caused partly by the increase in wages earned, which reduced the need for families to fish in order to put food on the table. There were 55 per cent of households spending less time in 2001 than in 1989 in any form of fishing activity, and the frequency of seafood meals declined from three times per week

in 1989 to two times per week in 2001. In addition, the establishment of marine protected areas and the increase in ciguatera poisoning may have contributed to the change in the trend of seafood consumption on Rarotonga.

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