A REPORT OF A SURVEY OF THE MARINE RESOURCES OF FAKAOFO ATOLL, TOKELAU.

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1 INTRODUCTION

1.1 Background

In late 1997, Tokelau requested assistance from the Secretariat for the Pacific Community (SPC) to conduct a stock assessment of marine resources in Fakaofo as a first step towards producing a management plan for the lagoon. SPC recruited a consultant to conduct the survey in conjunction with local staff early in 1998. However, the shipping service to Tokelau was having problems during this time, and was in NZ for maintenance. The timing of subsequent sailings clashed with other work commitments by the consultant, and the survey was not carried out until July/August 1998. The terms of reference for the work are contained in Appendix 1.

The consultant travelled on the Forum Tokelau, departing Apia on 27 July, arriving at Fakaofo on 29 July. The total duration of stay on Fakaofo was 21 days. The other two atolls (Nukunono and Atafu) were not visited. A daily diary is attached as Appendix 2.

1.2 Geography

Tokelau consists of three atolls stretching in a north-westerly direction from 9° 23" S, 171° 14"W for a distance of 170 km to 8° 30"S, 172° 30"W. The southern most atoll of Fakaofo is 65 km from Nukunono, with a further 105km to Atafu, the northern most atoll. The total land area for the 3 atolls is only 10 sq. km., in an EEZ of 290,000 sq. km. None of the 3 lagoons have deep-water entrances, and access for the artisanal fleet of small aluminium skiffs and traditional canoes is through shallow passages in the reef, often inaccessible at low tides. Figure 1 shows the map of Tokelau and Fakaofo.

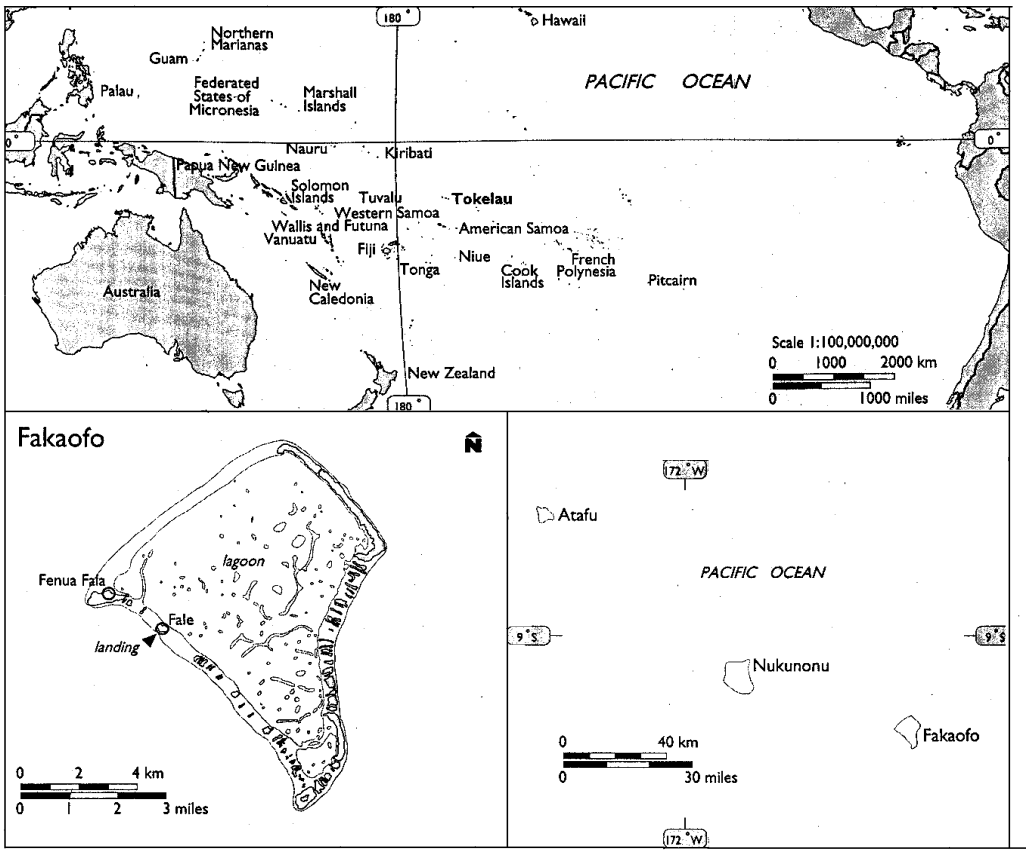

Figure 1. Map showing the location of Tokelau and Fakaofo**.**

1.3 Demography

The population of Tokelau consists of approximately 1500 people, with between 400 and 600 people on each of the three atolls. A further 5000 Tokelauans live in New Zealand (SPC , 1998), with an unknown number living in Australia and Samoa. In 1996, Fakaofo, the location for this study, had a population of 564, living in 87 households, on two islands (SPC 1998). The island of Fale currently has a population of around 340 living in 51 households, with approximately 220 people in 33 households living on the other inhabited island of Fenua Fala (M. Pelasio, pers com).

Livestock

As in most Pacific Island countries, pigs are the most important terrestrial animals to the people of Tokelau. Because of a shortage of land on Fale, each family keeps their pigs in a fenced off area on the elevated reef flat on the west and north west of the island, where they are free to roam and search for food in the shallow water. On much larger Fenua Fala, where more land is available, pigs are kept out of the village in pens. However, a number of escaped pigs roam freely around the village, and also wade in shallow lagoon water in search of food. Chickens are also abundant, especially on Fenua Fala, where they are left to roam freely around the village in search of food.

2 SURVEY METHODOLOGY

Questionnaire surveys were conducted of 20 households in the two villages, covering approximately 25% of the population. Topics covered included food consumption, fishing activity, and perceptions of problems in the fishery sector. This questionnaire is attached as Appendix 4. A school questionnaire was also prepared regarding fish consumption and fishing activity in their home, and was given to form five students (15 to 18 yrs). This is attached as Appendix 5.

Ten areas around the lagoon perimeter were surveyed for marine resources. Observations were made of fish life, and transects were undertaken in areas where there were sedentary resources of interest, e.g. trochus, clams, sea cucumbers and sea urchins. Clams (*Tridacna. maxima*) were measured in situ at several locations. In addition, the shells from harvested clams were measured. An intensive search for trochus was conducted in one area where they were known to be abundant. Snorkeling over the reef was undertaken where conditions permitted.

Two SCUBA dives were completed inside the lagoon. These were to observe fish and other marine life, and to look for species of interest such as pearl oysters and giant clams (*T. squamosa*), as well as note the general condition of coral. An additional two SCUBA dives were conducted outside the reef, again for general observations as well as looking for high value aquarium species.

Two meetings were held, one with the men of Fenua Fala, and the other with the Council of Elders. At these meetings the men were asked about their perceptions of the issues confronting their marine resources. Notes on these meeting are attached as appendix 5 and appendix 6. No collective meetings with women were held, though many of the household surveys were conducted with women. The consultant's wife also conducted interviews with several women on women's fishing activities, and accompanied one on an octopus fishing expedition.

The consultant talked to Form 5 students about their questionnaire survey. He also covered the topics of marine resource management and conservation issues in their lagoon. The tag/recapture technique of determining stock abundance was explained, and students were encouraged to join the fisheries officer in field trips on the reef, in particular to assist in trochus survey work in future.

A visual boat census was conducted to determine the approximate number and type of boats in use for each island.

Following the field work, visits were made to the SPREP library and the Tokelau Apia Liaison Office in Samoa, as well as the University of Auckland Library in NZ to look for additional information on Tokelau of relevance to the Marine Resources sector.

3 RESULTS

Information from the household survey is presented below. Other results are then presented under the headings for the various resources surveyed or methods used. Information from the household surveys, field work, and other informal interviews and observations is combined in to determine which resources may be in need of management.

3.1 Household questionnaire

3.1.1 Household size and income

A total of 20 questionnaires were completed, 13 for Fale and seven for Fenua Fale. This corresponded with the total population distribution for the atoll, as approximately 65% of the population resided in Fale. The surveyed covered 23% of the total households and 25% of the total population recorded in the SPC (1996) demographic survey.

The average household size was seven, and the average weekly income was $173.73[1] per household, or $28.87 per head of population. The major source of income was from the Taupulega (Council) work force wages, with public servants the next largest source of income in the community. Allowances paid to the male elders attending the Council meeting and old age pensions comprised the other regular sources of income. All these funds come from the Government's NZ assisted budget. Other sources of income were minimal, though some families sometimes receive remittances from family members overseas. These sometimes amount to $2,000 or more in a year. Handicrafts also supplied a minor portion of some households' income, though the lack of an organised marketing effort reduces potential income from this activity.

3.1.2 Fishing activity and gender balance

The average household spent 14 person hours per week fishing, with women spending an average of two hours, and men 12 hours. Several of the households commented that the men do not fish as much as in previous times, as they are all required to work for the Taupulega (Council) work force if they are not otherwise employed[2]. In 90% of households interviewed, men spent some time fishing every week. In 60% of households, women also spent some time fishing.

3.1.3 Seafood consumption

Seafood is eaten on average 12.6 times per week, or at 73% of all meals consisting of some animal protein content. Fresh frozen meat or chicken, tinned meat, and tinned fish are consumed in 13%, 9% and 5% respectively of other meals. Approximately four meals per week contain no animal protein, and these are usually breakfasts where rice or biscuits are eaten.

The most commonly eaten fish were flying fish (hahave, *Cypselurus* spp), consumed by 80% of the surveyed households. This could be expected to be lower at other times of the year, as the survey work corresponded with the main flying fish season. Although available throughout the year, they are reported to be more abundant from July to October. Yellowfin (kakahi, *Thunnus albacares*) (40%) and skipjack (atu, *Katsuwonus pelamis*) (35%) were the next most commonly eaten species. Atule (*Selar crumenopthalmus*) was noted in 20% of households, but could be expected to be more commonly eaten during periods of seasonal abundance, when they are caught in large numbers in the fish traps (fota). The highest ranked reef fish was kamutu, a green parrotfish species, (possibly *Scarus frontalis, S. altipinnis* or *S. microrhinus*), noted in 20% of questionnaires. These are commonly netted on the reef crest and reef flat using monofilament gillnets.

Other commonly eaten fish, mentioned by at least 10% of households, included ono (*Sphyraena barracuda*), kanae (*Crenimugil crenilabus*), aheu (small *Caranx melampygus*), and *ume (Naso literatus*).

Table **1** presents these results in tabular form.

In contrast to the commonly eaten fish, the favourite fish of most households were atule, kakahi, malau (*Myripistis spp*), tafauli (*Caranx lugubris*), and atu, all of which were mentioned in more than 25% of questionnaires. Other fish mentioned by more than 10% of households were fapuku (*Epinephelus microdon*), pone (*Acanthurus achilles*), and laulaufau (either *Zanclus cornettus* or *Heniochus sp*). The fact that some of these favourite fish are not among the most commonly eaten is probably a reflection on their relative abundance compared with the commonly eaten fish, or the fact that they are more difficult to catch. Table 2 shows these results in tabular form.

[1] Tokelau uses New Zealand currency. Figures are given in $NZ, equivalent to $US0.53 at the time of the survey.

[2] All able bodied men who are not formally employed, usually as public servants, are expected to do community work for 4 mornings per week. For this they receive around $60 from Council funds for approximately 20 hours work. Women may also do community work one day per week, for which they receive approximately $12.

Table 1. Most commonly eaten species of fish (% of households reporting this fish as being commonly eaten).

Tokelauan name[3]	% of h/holds
Hahave	80
Kakahi	40
Atu	35
atule, kamutu	20
ono, aheu, kanae, ume	10
paara, atule, komulo, papo, taiva, ulafi, laulaufau, patpatupo, tifitifi, patuki, gatala	5

Table 2. Favourite fish (% of households reporting these fish as being their favourite)[4]

Tokelauan name	% of h/holds
Atule	30
kakahi, malau, tafauli, atu	25
Pone	20
fapuku, laulaufau	15
ono, kamutu, gatala	10
maeva, kanae, aheu, paala, palupo, malau, papo, ume, ufu, feke, fahua, patuki, patupatupo, manini, taiva,	5

Other seafood items commonly eaten included ugauga (*Birgus latro*), ura (*Penicillatus spp*), feke (O*ctopus sp*) fahua (*T. maxima*), tupa (*Cardisoma carnifex*), paikea (*Cardisoma sp*.) and kamakama (*Grapsus sp*). The sea urchins kamutoa (*Heterocentrotus sp*,) and tuitui (*Tripneustes sp*.) are occasionally eaten by people accustomed to eating similar species while living in Samoa and New Zealand. Spondylids (pipi = generic name) are commonly consumed in Tuvalu, and some of the Tuvaluans living on Fakaofo occasionally eat them.

Fahua are eaten on average 1.4 times per month per household. Most people interviewed estimated they ate around 50 clams per meal, per household, with leftovers being eaten at the next meal. From this information, a total consumption of around 6,000 clams per month in Fakaofo, or 72,000 per year, equivalent to 2880 kg, was calculated (see 3.1.4. below for conversion factor).

The actual portion size (equivalent whole fish) eaten per meal was not determined. To do so would require a set of accurate weighing scales located in a number of representative households, as well as the keeping of an accurate diary by the household for a predetermined period of a week or more. Flying fish were the most common fish eaten during the time of the study, and several people were asked how many they eat. Most responses indicated that two flying fish per adult per meal are eaten, and each fish is around 300g.

3.1.4 Exports

The widespread availability of freezers allows people to store seafood for sending to friends and relatives abroad. Of the 20 households interviewed, 85% had working freezers, and one family had two freezers. Ninety percent of the households interviewed exported some seafood every year. Some people send seafood out on every boat (i.e. approximately monthly), while others send it only once or twice per year. The questionnaire indicated that the average household exports fish 5.8 times per year.

Sixty five percent of the households sometimes export clams (*T. maxima*). An average of 325 kg of clams is estimated to be exported per year for the 20 families surveyed. This can be extrapolated

[3] See **Appendix 3** for common and Latin names

[4] Each household was asked to name their 3 favourite fish.

to about 1400 kg for the entire population of Fakaofo, or around 140 kg per voyage of the Forum Tokelau. Data collected in Tongareva, Cook Islands, found the average weight of 1 piece of cleaned clam meat to be 54g (Passfield, 1997). The average size of Tokelau clams is probably smaller than Tongareva due to the comparatively high exploitation rate combined within the smaller lagoon. Therefore, assuming an average weight per piece of 40g, or around 25 clams per kg of meat, there are about 35,000 clams exported per year.

Exports of seafood on the ship departing Fakaofo on 5 August were weighed as they were loaded onto the barge. The major export was hahave, with 297kg of frozen flying fish being exported. Next were fahua, with 52 kg frozen clams being shipped out. Together with dried clam exports, this is about half of the average monthly export suggested by the household questionnaire. Other exports were ugauga (*Birgus latro*) (26kg), komulo (*Caranx sexfasciatus*) 30 kg, and ono (*Sphyraena barracuda*) (32 kg). Mu (*Monotaxis grandoculis*) (4 kg) and moray eel (family Muraenidae) (4.5 kg) were the only other frozen exports recorded on this voyage.

The MV Tutolu, the inter-island catamaran, also transports some frozen seafood to Apia when it does trips to collect fuel for Tokelau. With very limited freezer space available, it is usually the more compact and sought after commodities such as frozen clam meat that is taken. The MV Tutolu does approximately 10 trips per year, and account for at least some of clam exports, though no quantities could be established.

Limited quantities of dried seafood are also exported. This is difficult to monitor at the point of departure, as it is usually contained in passengers' luggage. However, most exporters apparently get a quarantine certificate to allow for easier importing into New Zealand and Australia. On this voyage of August 5, the quarantine records showed 5 cartons of dried fish and 1 carton of dried clams. The weights and species are not recorded, so it is not possible to accurately estimate the quantity of these dried exports.

3.1.5 Total Production

The total catch of seafood in Fakaofo could be approximated from the above consumption data, combined with information from exports (see 3.1.4). The population of Fakaofo eats seafood at 12.6 meals per week, and consume an estimated average of 380g of seafood per person[5]. This equates to a subsistence consumption of around 140 tons per year. Exports on August 5 were approximately 450 kg for the monthly trip, which can be extrapolated to a further 5.4 tons of seafood which is exported. Further monitoring of exports would be required to determine if this was an average monthly export. Total production is therefore estimated at 150 tons per year. A significant percentage of this is likely to be flying fish, though without catch data for a full 12 month period, it is not possible to determine the proportion accurately. During the period of this survey, an estimated average catch per vessel was 200 flying fish, with three to ten boats out fishing on suitable nights. An educated guess would put the weekly catch of flying fish at 1.5 to 2 tons during this period.

Combining clam exports (see 3.1.4) are with those eaten for subsistence (see 3.1.3), gives an approximate annual production of 107,000 clams, equivalent to 4.3 tons, per year.

SPC (1995) provided an estimate of total annual production for Tokelau of 191 tons. Though no work was done on Nukunono or Atafu during the current study, information collected from Fakaofo, which is inhabited by about 35% of the total population, suggests a National production in the vicinity of 400 tons.

3.1.6 Seasonal species

Question 7 related to seasonal seafood species. Responses provided the following information.

Atule were mentioned by 50% of informants as a seasonal fish, though few people were able or willing to state the season. Answers ranged through every new moon, every full moon, every quarter moon, May to October, November to March, and February. Other species mentioned by more than 25% of informants were fapuku, hahave, ufu (probably *Scarus sordidus*, initial phase), pone, and laulaufau. Some consistency in answers on season was evident for flying fish (around July/August to October) and fapuku (April/May inside lagoon, moving outside in June/July). This season is consistent with known spawning migrations of the same species, *Epinephelus*

[5] Passfield (1998) calculated an average daily per capita consumption of 380g of seafood for Tongareva (Penrhyn), an atoll in the northern Cook Islands. Observations in Tokelau suggest similar portion sizes, though when smaller whole fish such as hahave are eaten, the average is more likely to be around 500g.

polyphekadion, in the northern Cook Islands. Mentioned by more than 15% of informants were atu (skipjack), kakahi (yellowfin), and aheu. The responses to the seasonality question received such varied answers that few conclusions could be drawn.

3.2 Form 5 school questionnaire

A total of 24 questionnaires were distributed through the principal to form 5. Insufficient time was available to translate this questionnaire into Tokelauan, and still collect the required information before having to depart the island. Fifteen questionnaires were returned after the six-day period covered by the questionnaire. As several of the students resided in the same household, a total of nine households were covered. These questionnaires were not particularly well completed, most probably due to the fact that they were in English, with no Tokelauan translation. Some of the answers to questions had obviously been fabricated (e.g. in some households extensive fishing was apparently conducted on Sunday, though this is a definite violation of local laws). It was suggested that the survey be repeated, after translation into Tokelauan.

Despite these difficulties, some useful information was obtained. In particular, in answer to question 4, four out of nine households identified over harvesting of clams as a problem, corroborating the results of the household questionnaire. In addition, seven out of nine households listed flying fish as a regular part of the diet, also corroborating the household questionnaire results.

3.3 Reef perimeter study areas

Figure 2 shows the location of the survey sites around Fakaofo, and Table 3 summarises the results obtained at the 10 sites. Each site was first assessed visually. This was to determine whether a 100m by 2m strip transect on the reef crest/reef flat, a shorter 12m by 2m strip transect, a 100 sq. m. quadrant, or a combination of two or three of these methods was the most appropriate method to determine density of species present.

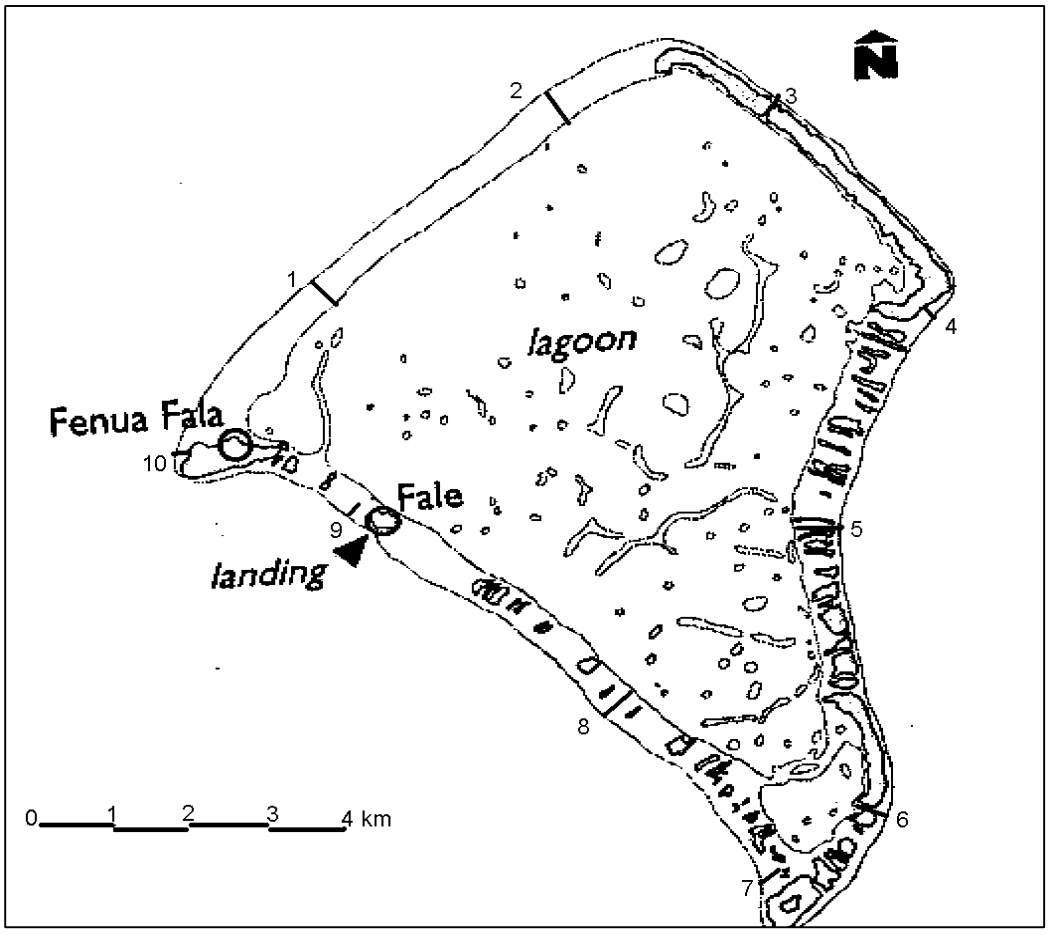

Figure 2. The 10 survey sites around Fakaofo

Table 3. The 10 areas surveyed

Site	Name	Location	Comments
0	Triangulation mark	9° 22.447' S, 171°,15.785' W	RNZN Hydrographic Survey Triangulation Station no. 19, School Jetty, Fenua Fala, included for reference.
1	Moeni	9° 21.872' S, 171°,15.590' W.	Scarids, Acanthurids, Naso, abundant in surge zone. *H. atra* abundant 75m in from surge zone to within 50m of inner reef edge (4,500/ha). *Echinothrix diadema*, *T. maxima*, present but not common (200 to 500 per ha). Small stromb, probably *S. luhuanus*, very common close to inner reef edge (4,400/ha.)
2	Tulua fatu	Two rocks, middle of N.W. reef	Pencil spine sea urchins, Mullidae, Scaridae, Acanthuridae, Balistidae common in surf zone. Urchins at around 500/ha in surge zone, H. atra around 1500/ha 70m to 100m in from surge zone, and also within 50m of the inner reef edge.
3	Talapeka	2 km east of wreck	Surge zone too rough for transects. Visual survey revealed nothing of interest. Also nothing of interest noted lagoon adjacent to inner reef. Quite sandy.
4	Fenuatapu	Eastern extremity of atoll	A lot of rubbish, fishing floats, bottles, etc, washed up on the island here. Good source of floats for pearl farming trials. Nothing of interest in surge zone; again too rough for transect. Lagoon edge coral heads had around 2500 *T. maxima* per hectare.
5	Nukuheheke	9° 23.476' S, 171°12.108' W	Abundant juvenile urchins on outer reef flat. *B. argus* common in inner reef area, around 1000/ha.
6	Reserve 1	9° 25.760' S, 171°11.856' W	Scarid schools common on reef flat. Acanthurids also common. Sedentary animals rare on outer reef. Clams more common on inner reef, as well as *Echinothrix diadema*
7	Reserve 2	9° 25.796' S, 171°12.418' W	Again nothing of interest on reef flat. Fish life abundant over reef, especially small trevally *(C. sexfasciatus*). *T. maxima* abudant on inner reef flat and adjacent coral heads, around 40,000/ha.
8	Te tafa	9° 24.970' S, 171°13.024' W	Reef flat lacking significant sedentary species. Clams approx. 5,000/ha. around inner reef edge,
9	Ava Ulafi	9° 23.335' S, 171°14.853' W	Trochus abundant in this small area, from adjacent to power house to Catholic Island. 162 trochus were tagged with pencil mark on inner shell. Reef topography appears to favour trochus and *Echinothrix diadema* which had localised abundance of up to 7500 per ha. *A. mauritiana* also common, average 1000/ha. Pencil spine urchins extremely common (up to 10/sq.m) in narrow 10m surge zone.
10	Vai afua	Reef flat sth of Fenua Fala	Abundant pencil spine urchins. Few *A. mauritiana*, but not abundant, around 50 per ha.

3.3.1 Trochus

Trochus are not native to Tokelau, and were transplanted to Fakaofo in 1986 (586 and 283 trochus on 2 separate occasions) and again in 1988 (578 trochus) (Gillett, 1994). Several subsequent trochus surveys have been carried out, the last in June 1994.

Although extensive surveys for Trochus were not conducted all around the atoll, the fact that they were not observed at any sites other than from south east of Fale to Fenua Fala suggests that they are still not wide spread. The reef crest and inner reef flat were searched. Juveniles were searched for under rocks. A total of 162 trochus were measured and tagged. All trochus were found in the area from Fale to the Catholic island. Most were found in a 400-metre stretch from the powerhouse towards the Catholic Island. Sea conditions did not permit searching over the reef in this area, where Gillett (1994) found more trochus of an average larger size than those on the reef flat. Figure 3 shows the size distribution for the trochus. Most were in the 9 to 10 cm size range. During the 1994 survey by Gillett, trochus were most abundant in the 6 to 7cm category on the reef flat. This large cohort is unlikely to be the same one four years later, as growth would be expected to be around 2cm per year at the 6 to 7cm age class, decreasing to about 1cm per year at the 10cm age class (Nash, 1985). Gillett's 6 and 7 cm trochus would now be around 12 cm. It is possible these have moved over the reef flat into deeper water, as Gillett's survey found trochus of an average larger size over the reef.

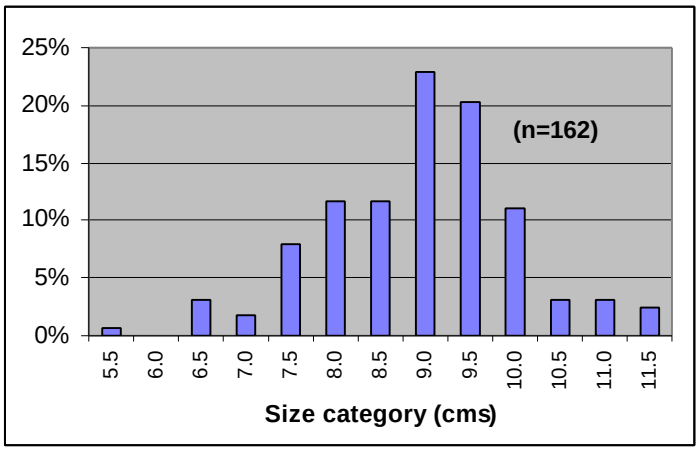

Figure 3. Trochus size frequency data for Fakaofo

3.3.2 Giant clams.

Giant clam harvesting is the only commercial fishery known to operate in Fakaofo. Although clams are not actually harvested for sale as such, some people, particularly public servants with disposable income, pay unemployed men to harvest clams on their behalf. This is most often just before the monthly boat is due, so that they can be sent to family and friends in Samoa, Australia and New Zealand. The price paid is around $NZ10.00 to $12.50 per kg, based on $25.00 for a 2 litre oil bottle full of clam meat, or $100 for a plastic biscuit barrel full (about 10 kg).

Clams were counted during reef flat 100m transects. Shorter 12m transects were also carried out on several patch reefs around the lagoon side of the reef flat. Fifty clams were measured in situ at each of two sites, all in shallow water (<2m). Figure 4 and show the size frequency at these sites. The most frequently occurring size classes were between 4 and 7cm. Though one of these sites was in the reserve, there was no obvious difference in size composition. This probably reflects the fact that the reserve is sometimes opened to harvesting, and therefore does not truly represent an unexploited stock. The most recent harvest inside the reserve was reported to have occurred several months prior to this survey.

Braley (1989) found the most abundant cohorts to be in the 7 to 10 cm size range. However, it is not possible to directly compare the surveys, as the 1989 survey was conducted using SCUBA, and therefore sampled deeper clams. Shallow clams can be expected to have smaller average size due to a higher level of exploitation. Difficulties in obtaining suitable diving gear locally limited the number of SCUBA dives conducted during this survey, and no clam measurements were made below two metres in depth.

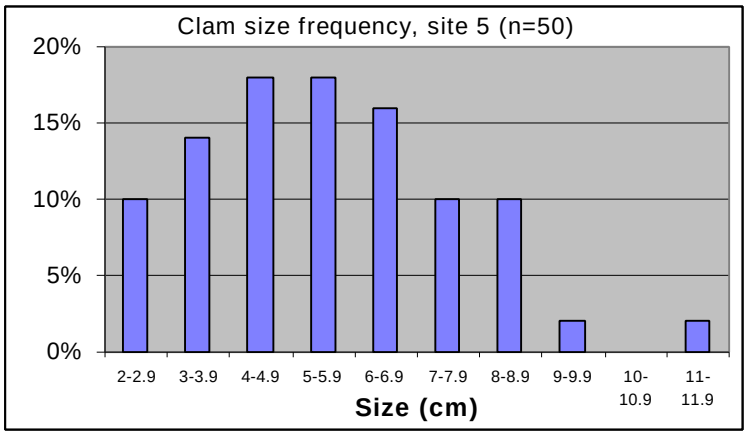

Figure 4. In situ clam measurements, site 5

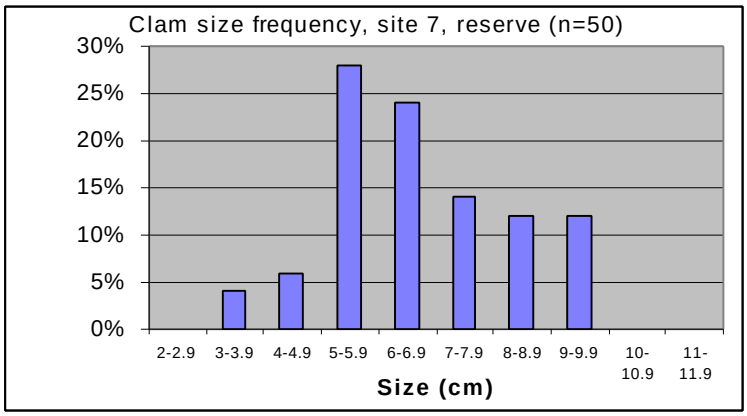

Figure 5. In situ clam measurements, site 7

A total of 40 harvested clam shells were also measured on 2 occasions, to determine the size of commonly harvested clams. Figure 6 shows the size frequency of these consumed clams. 68% of harvested clams were in the 7 to 10 cm classes, though clams as small as 6 cm are also harvested.

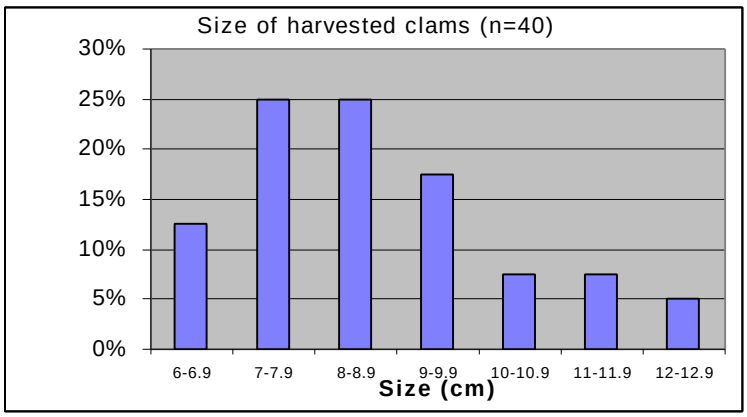

Figure 6. Size frequency of harvested clams

3.3.3 Sea cucumbers.

The sea cucumber resource is not large, but could support limited exploitation. Table 1 gives approximate densities obtained during the reef flat survey. Sites 9 and 10 had high densities *of Actinopyga mauritiana*, and *Bohadaschia argus* were moderately abundant in a number of locations around site 5. Information obtained from an importer indicates the fishermen in Tokelau could expect at least NZ$7.00/kg at present for *A. mauritiana*, and $3.50/kg for *B. argus*. Although high value species such as *H. nobilis* are present, they are not abundant. Only 7 individuals were sighted during the surveys. Any exploitation of this species could possibly lead to localised extinction.

Holothuria atra are extremely common, particularly in the shallow areas on the lagoon side of Fenua Fala, as well as on the inner reef flat at many other sites surveyed. This species is usually small, and has a low commercial value. It is unlikely Tokelauans would consider it a worthwhile use of their time to harvest and process them. They are however useful as pig food, and several wandering pigs were observed eating them in the shallows. One person claimed they also occasionally collected this species to feed to their pigs. There are no reports of any ill effects on the pigs from this unusual diet.

3.3.4 Seaweeds

Two species of seaweed were common on the reef flat. Samples were taken and sent to the University of the South Pacific in Suva for identification. They were identified as *Caulerpa serrulata* and *Caulerpa cupressoides var. mamillosa*. Seaweeds are not eaten in Tokelau as they are in many other Pacific island countries. It is not clear whether this is because of a lack of edible species, or for other reasons.

3.4 Other resources

3.4.1 Reef fish

Questionnaire data revealed no particular concern for reef fish stocks. Although some species were noted as being less abundant than in previous years, there was little evidence of intensive reef fish fishing obtained during the 3 weeks on Fakaofo. Netting is the most common form of reef fish exploitation. The 20 households interviewed owned a total of 29 nets. Although 35% of the households interviewed owned no nets, all had access to a net, and some households owned up to 4 nets. It is thus likely that there are in excess of 120 nets available in Fakaofo, or slightly more than one net per 5 people. The most common mesh size was 2 inch, with the largest being a 4 inch, and the smallest being a single 0.5 inch mesh. The only regulation covering nets is that no net can be set and left overnight.

Net making is a common past time among the men. Many nets are locally made from monofilament of approximately 30 kg breaking strain. The local style of net fishing, often over coral rocks and reef, is extremely damaging to the lighter commercially available nets, while the locally made nets prove more resilient. Most netting is done on the reef flat, catching fish as they move in and out of the lagoon over the reef. Species caught include surgeonfish, parrotfish, and trevally.

Other common forms of reef fish fishing includes rod fishing from the reef and coral heads, and spearing and hand netting of fish caught in the fish traps (fota) located on the reef flat.

A list of Tokelauan fish species with local names is given in Appendix 3

3.4.2 Flying fish

Flying fish are abundant around Fakaofo, and were the most common species consumed and exported at the time of the survey. Flying fish are a pelagic species, living to about 2 years of age and maturing after 10 to 14 months (Gillett and Ianelli, 1993). In Tokelau they are caught close to the reef on the leeward side of the atoll from aluminium skiffs, using locally made scoop nets and a battery powered light mounted on a wooden pole about 3 metres high. Catches of 200 to 300 fish per night are common. Flying fish are commonly consumed locally, as well as exported overseas to friends and family (see 3.1.3 and 3.1.4). As a resource difficult to overfish, especially at the artisanal level in Tokelau, they may offer potential for commercial export, after investigation of appropriate processing and markets.

3.4.3 Octopus

Octopus (feke) is a popular component of the Tokelauan diet. Eighty percent of the households interviewed stated that they sometimes eat octopus. Some informants stated they eat it only once per year, while others consumed it weekly or monthly. Octopuses observed during this study were small, with most weighing between 0.5 and 1 kg. A household commonly consumes between two and six of these in a meal. It is one of the few fisheries in which women are engaged. Octopus are gleaned from the reef flat, where experienced octopus fishers identify holes that contain octopus by the small rocks that are gathered around the entrance to the hole. Although octopuses are known to be seasonally more abundant in some countries, e.g. Fiji, people in Fakaofo did not identify a distinct season. There was no concern expressed for stocks.

3.5 SCUBA dives

Difficulties in locating enough diving equipment early in the survey period resulted in only four dives being completed. These were used for general observations. Insufficient dives were made to effectively utilise underwater visual census (UVC) techniques of surveying fish.

Two dives were completed inside the lagoon. The coral observed was for the most part dead, and covered in algae. No *T. squamosa* were found, though one empty shell from a recently alive specimen was found. *Spondylus* sp. (probably *S. squamosus*) are very common, with densities of 50,000 per hectare common on coral heads, especially below the 10m depth range. *T. maxima* were very rare at depth, and only one was seen during the two dives. However, two snorkelers above collected about 15 in 20 minutes from shallow reef patches.

No pearl oysters of any species were found during the SCUBA dives. At the meeting with the men of Fenua Fala, it was stated that they knew of only one pearl oyster being found in the previous year. Tifa (*Pinctada margaritifera*) can be considered to be extremely rare in the lagoon.

The two dives outside the reef found nothing of commercial interest, considering the limitations placed on commercial activities by virtue of the islands isolation and limited access to markets. Though aquarium species such as *C. flavisimus* (lemon peel angel) are common in shallow water, they are not of sufficient value to support the operation of a profitable aquarium fish export business from a location as isolated from international air transport as Tokelau.

The coral was colourful, and generally appeared healthy. Larger predatory species such as *Epinephelus spp* of up to 50 cm in size were not uncommon. No signs of recent coral bleaching were noticed inside or outside the lagoon, though the significant amount of dead coral inside the lagoon may have been caused by earlier bleaching events.

3.6 Lagoon depth

Soundings were taken using hand held sonar while traversing the lagoon. A short distance away from coral heads, the depth increases rapidly, with much of the north and east of the lagoon exceeding 60 metres. Along the east lagoon edge there are numerous coral heads with adjacent shallow water, around 7 to 15 metres. Table 4 gives the GPS coordinates and spot depths for 12 locations in the lagoon.

Table 4. Spot soundings inside lagoon

Location no.	GPS coordinates	depth, m	Location no.	GPS coordinates	depth, m
1	9° 21.515'S	75	**7**	9° 24.794'S	69
	171° 13.978'W			171° 12.797'W	
2	9° 21.515'W	79	**8**	9° 22.723"S	47
	171° 13.743'S			171° 12.123"W	
3	9° 21.278'S	78	**9**	9° 22.949'S	19
	171° 13.477'W			171° 12.450'W	
4	9° 20.965'S	78	**10**	9° 20.597'S	34
	171° 13.983'W			171° 11.93'W	
5	9° 24.173'S	75	**11**	9° 20.962'S	49
	171° 12.425'W			171° 11.797'W	
6	9° 24.5'S	60	**12**	9° 21.377'S	10
	171° 12.560"W			171° 11.553'W	

3.7 Boat Census

Visual surveys were undertaken during Sunday afternoons, when most boats were assumed to be on the beach or at anchor, rather than out fishing or picnicking.

The SPC demographic survey (SPC 1998) recorded 58 aluminium boats during their survey in 1996. The present census recorded 47 boats with engines in Fale, and 30 in Fenua Fala. In addition there were 70 aluminium boats that were not in service, whether in need of repairs, in storage as they were not needed, or their owners were overseas. Mose Pelasio also did a mental assessment of aluminium boats and with engines, and arrived at very close to the same figures achieved in the visual census (48 boats for Fale, and 34 for Fenua Fala). Thus there are around 80 boats with outboards available for fishing in Fakaofo. More aluminium boats could be brought into service if aluminium welding equipment was available for minor repairs on the island. However, the current number of vessels being utilised appears to satisfy demand.

A number of households surveyed in the questionnaire had boats with no engines, while others had more than one operational engine. Most outboards were Yamaha or Mariner, with nine 15 horsepower, seven 25 horsepower, one 10 horsepower, and one 20 horsepower included in the household survey.

Only one traditional canoe appeared to be currently in use (on the beach, with outboard attached). Three other canoes appeared to be sound, and probably seaworthy. Disassembled canoes cosisting of parts of main hulls were scattered around both Fale and Fenua Fala. Atafu Atoll is reported to be the only atoll in Tokelau where use of traditional canoes is still widespread.

4 CURRENT MANAGEMENT METHODS

4.1 Regulations

In 1988, each Tapuelega or Council of Elders in the Tokelau group exercised their legislative authority under the Tokelau Village Incorporation Regulations 1986 to establish village rules. In the village rules set down for Fakaofo, rule 2 deals with fisheries matters (Angelo, 1993). Marine resources covered under this rule included turtles, marlin, and dolphins. The rule states that if any of these resources are caught, they must be shared throughout the village using the Inati system (see 4.2). In addition, if more than 50 atu (skipjack tuna) are caught by one vessel, they too must be shared according to the Inati system.

Other fisheries regulations can be made by the Tapuelega at their meetings, and people are informed of these regulations by word of mouth. Apparently all regulations are not written down, though the Secretary for the Tapuelaga keeps minutes of the proceedings of the meetings. There are few regulations currently operating for marine resources. These include a ban on taking of turtles while nesting, and the ban on taking resources from the ha (reserve), except when this is opened to harvesting for brief periods. There may be other regulations, but as they are not written down, it was difficult to document them. Although the Tapuelega agreed to provide a list of all regulations, this was not received before the end of the field work. Despite a further request, the information has still not been received for inclusion in this report.

People who break the regulations are called before the Tapuelega to be chastised, and if the infringement warrants further punishment, a fine may be imposed. While the system generally appears to work, it was observed that some of the men in the 16 to 40 age group treat some of the regulations with minimal respect, providing they think that they can get away with it.

4.2 The Inati system

The Inati system is a traditional Tokelauan system used to share resources in the name of the village, as well as to levy resources on behalf of the village. The inati is a group of people related as kin in different ways, and sometimes not at all, but self or parent assigned to a particular inati for a variety of reasons (J. Huntsman, pers comm). Examples of the system include the sharing of food and other aid received after a cylcone, or the contribution by inati of handicrafts for the raising of funds for a community project.

With particular respect to marine resources, when sufficient fish is caught in the fota (fish trap), it is shared among the Inati. Turtles are also shared, though obviously there would not be sufficient to

be shared among everybody. In this case, it is the very old people who get to share in the turtle meat.

This sharing of surplus resources removes some of the motive to overharvest the resources for personal gain. However, if strictly enforced, it may also be considered as a constraint to economic self sufficiency, as there is little incentive for individuals to work hard at fishing for personal gain or for the benefit of their families. Thus any entrepreneurial traits in the people are likely to be suppressed by this system. In the past, men who have started to sell fish have been censured. Tokelauans consider the institution a very distinctive hallmark of their culture (J. Huntsman, pers. comm.).

5 ISSUES

The small population and lack of export oriented harvesting of most of the marine resources means that there are few anthropogenic threats to the marine resources of Fakaofo at present. Some issues that were noted during the survey work are listed below.

a. Clam stocks diminishing in population and size. The one resource which appears to be decreasing in abundance and size is giant clams. *T. squamosa* would appear to now be extremely rare in the lagoon, while anecdotal information indicates that *T. maxima* are becoming depleted in many areas of the lagoon, especially at shallower depths more accessible to divers. The present survey was inadequate for useful comparison with the earlier work by Braley (1989). However, anecdotal information reveals a decrease in size and abundance. Clam harvesting now requires diving to a greater depth than in the past, and this has reduced the involvement of women in clam harvesting.

The problem can probably be adequately addressed by banning exports and strictly enforcing a total ban on harvesting in the reserve.

b. Ciguaterra poisoning around the wreck. Some species from this area are now not eaten because of their toxic effects, particularly the uluafi (white parrot fish), *Hipposcarus longiceps*. Other fish reported to be poisonous include api (*Acanthurus guttatus*), nanue (*Kyphosus cinerascens*), mamanu (*Scarus altipinnis*), laea, kamutu, (possibly two phases of *S. microrhinos*), aloga (*Acanthurus striatus*), munua (large *Epinephelus sp*) and fagamea (*Lutjanus bohar*). The poisoning now appears to be moving down the reef towards Fenua Fala (Ahagaloa).

c. Trochus not widely distributed around the atoll. Trochus appears to be largely limited to the areas from Fale to Fenua Fala. If harvesting of trochus is to provide significant income to the island in future, more wide spread distribution would be required.

d. Reliance on aid as the major source of income. If the New Zealand budgetary aid was significantly decreased, as has happened for example in the Cook Islands recently, there is limited scope at present for economic activity to bring more revenue into the country. Unlike a number of other Pacific Island countries, mass tourism is unlikely to be an option given no air links.

Without proper management, marine resources could be in danger of over-exploitation if the population relied heavily on them for income. The current share of the U.S. Multi Lateral treaty provides ample opportunity to invest in income generating projects, if viable ones can be identified[6]. Attempts to marry the modern ideas of sound business practice with the traditional Inati system of sharing are likely to prove problematic.

[6] There is presently a proposal to utilise U.S. Treaty funds for an aluminium alia vessel longline fishery for the 3 atolls of Tokelau. To date, it is understood that 3 alias have been purchased in Apia, and are ready for delivery. Nine fishermen were undergoing training in Samoa in appropriate fishing techniques to target albacore tuna and other pelagic species. Further development of this project, for example appropriate shore based infrastructure to freeze the catch, is dependent on the catch rates achieved over the next 12 months.

6 RECOMMENDATIONS

1. The Ministry of Natural Resources and the Environment of Tokelau have made an official request to the South Pacific Aquaculture Development Project (SPADP) in Suva for assistance in obtaining *P. margaritifera* for transplanting to a lagoon in Tokelau. It is understood that SPADP are endeavoring to assist with this request. Tokelau should also request the SPADP to follow up with a request to the Cook Is. Ministry of Marine Resources, for the purchase of 500 *P. margaritifera* spat from the Tongareva Marine Research Centre. This could be transported to Fakaofo in November/December, when the Forum Tokelau is undertaking several trips to Manihiki for the Island Reconstruction (following Cyclone Martin devastation). Sufficient floats are already present in Fakaofo to support the spat, though main lines and chaplet ropes would need to be procured. The hatchery reared spat will have the benefit of coming from a quarantine facility, and thus limit the possibility of introducing harmul organisms which could occur if the introduced pearl oysters were obtained from wild stock.
2. The harvesting of *T. squamosa* should be totally banned. Any reported sightings should be reported to the Fisheries Officer, who will place them in the reserve.
3. The export of clams from Fakaofo should be banned. The harvesting of *T. maxima* should be restricted for local consumption only. Although they are still abundant, a cautious approach to their exploitation will help guarantee they persist for future generations.
4. A campaign should be initiated to increase harvesting of *Spondylus sp*. The exported component of the *T. maxima* catch could be conceivably replaced by exports of the extremely abundant Spondylid oysters.
5. Trochus should be collected from the area where they are abundant, and transplanted to other areas around the island containing suitable habitat, in an effort to increase overall abundance.
6. The current practice of periodically opening the ha (reserve) for resource harvesting should be discontinued. The ha should be made a permanent marine protected area, with no exemptions for any purpose or any person.
7. The quarantine records for exports of produce should include information on species, approximate weight, and whether the produce is frozen or dried. The monitoring of frozen exports initiated for this survey should also be continued, and expanded to include monitoring of exports on the MV Tutolu.
8. The regulations made by the Council of elders should be written down and well publicised so that all residents know them. There appears to be some confusion and ignorance over certain regulations.
9. Investigations should be made to determine whether there is a market for seasonally abundant Tokelauan flying fish in Samoa,. Frozen, dried or smoked flying fish could be exported. Potential as a suitable baitfish for the recently expanded Samoan long line fishery should also be investigated.

7 ACKNOWLEDGMENTS

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Thank you all very much for your assistance.

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Appendix 1. Terms of reference

- Liaise and plan detailed activities with the local project leader, Mose Pelasio
- Carry out a survey of a reasonable sample of households at Fakaofo, to establish the pattern of subsistence and artisanal fishing, and providing additional fisheries detail to the previous general household survey by the SPC Demography Programme;
- Carry out a creel survey, of landings by fishers, or by accompanying fishers on their activities, to establish the species composition of the catch, gear types, frequency of fishing, social organisation and other standard fishery indicators;
- Carry out direct rapid appraisal of reef and lagoon fishery resource status as appropriate, using underwater visual census;
- Estimate what volume and type of fishery resources/products are exported from the island, to whatever destinations, and what proportion of fishery production is commercial;
- Provide an idea of the relative contribution of men and women to fisheries production;
- Summarise and provide references to the available literature and reports relevant to Fakaofo reef and lagoon fisheries;
- Maintain dialogue during the fieldwork with fishers and community leaders responsible for fisheries, as appropriate;
- As a result of the above, roughly estimate the current composition and total production of Fakaofo coastal fisheries;
- As a result of the above provide an opinion on the main problems currently facing Fakaofo fisheries, taking into account both biological and social factors.

Appendix 2. Daily Diary

23 July. Depart Rarotonga Thursday 2 AM. Arrive Nadi 4AM, 24 july. Raffles Hotel, Thurs, Friday.

25 July depart Nadi arrive Samoa, midnight. Stay Friday, Sat 26, Sunday 27 July.

27 July 9pm depart Apia, Forum Tokelau, 9pm.

28 July, en route. Stop at Swain's Island, but do not go ashore.

29 July, AM arrive Fakaofo, Tokelau. Establish accomodation arrangements.

30 July, meet with Mose and discuss survey required. Review TOR with Mose.

31 July. Prepare survey gear, start survey with site no. 1, 2 transects, 1 quadrant, and training in standardised method. NW reef, about 2 km from Fenua fale. Laoon reef flat edge GPS position: 9^{o} 21' 52.3" South, 171^{o}, 15'35.4" west.

Agree on 10 reef flat areas as sites 1 to 10 for transects. Sites are approximately 4 km apart.

August 1. Saturday. No permission at this stage for field work on Saturday Data entry,begin report.

August 2, Sunday. No formal work permitted today. Talked to several people about fisheries. Reviewed available literature.

August 3. Site 2. Tu lua fatu. 2 transects. Free dive over ocean side of reef.

August 4. Site 3 and site 4. Visual surveyfound nothing of interest on reef flat. No transects done. Clams not abundant. SCUBA dive on coral head, 9^{o}22'36.7"S, 171^{o} 13'35.7"W. Did some lagoon soundings.

August 5. Wasted a lot of time, as boat day. Managed to weigh seafood being exported.

August 6. Tokelau Public Service meeting delays our start. Transect at Fale reef flat. Then intensive search for trochus, as they are known to exist here. Found and tagged 11 trochus.

August 7. Site 5. 1 transect on reef flat. Abundant juvenile urchins (*Diadema sp*).

Site 8. Nothing on reef flat. Did clam counts and measurements on inner reef flat.

August 8. Saturday. Mose's family island. Similar to site 5, but no obvious juvenile urchins here. Leopard fish common, and 1 black teat fish in lagoon, 20 ft depth. Did some lagoon depths.

August 9. Sunday. Lunch with Peter and Fuafua McQuarrie.

August 10. Public Holiday. Did a visual boat census on fale and Fenua fala. Heavy rain all day. Prepare school questionnaire.

August 11. Site 6, inside reserve area. Did 1 transect. Reef flat . Site 7, also reserve area. Clam counts and measurements.

August 12. Trochus search, from Fale wharf to Catholic mission island. Tagged 63 trochus, found 10 dead. Snorkel survey on coral head out from Fale late afternoon.

August 13. Meeting with the men from Fenua fale. Afternoon repeat trochus search at low tide. Recovered 5 tags, and measured/ tagged 81 new trochus. Urchin and *A. mauritiana* survey.

August 14. Meeting with Council of elders, Fale. Waited all day, finall had meeting at 3.30 pm. Meanwhile continued household questionnaires on Fale.

August 15, Saturday. Suia's family motu. Saw 3 black teat fish, plus the longest H. atra I have seen (50cm). Few clams, not scarce.

August 16. Sunday. Church and family day.

August 17. Trochus search and A. mauritiana, urchin survey, Fenua fala back to Catholic island, then resurvey area to Fale for trochus and tag recoveries.

August 18. School presentation to Form 5. Discuss school questionnaire, trochus, marine resource management and conservation. SCUBA dive outside reef, Tu lua fatu. Observe fishing in fish trap.

August 19. Collect information on dried marine resource exports. Depart for Apia, 12.40pm.

August 20. Arrive Apia. Overnight Apia.

August 21. Visit Tokelau Liaison Office and SPREP library, looking for any relevant Tokelau documents. Depart Apia for Nadi. Overnight Nadi.

August. 23. (Lost 1 day over date line). Depart Nadi for Auckland. Overnight Auckland.

August 24. Overnight Auckland. Transit.

August 25. Depart Auckland, arrive Rarotonga (24 August, gained 1 day over dateline).

Appendix 3. Species list

Tokelauan name	Scientific name	Common English name
Ika		**Fish**[7]
aua	Neomyxus chaptali	silver mullet
afulu	Parupeneus bifasciatus	two barred goatfish
aheu	Caranx sp.	small trevally
aku	Strongylura sp	long tom
alaala	Carangoides orthogrammus	thicklip trevally
alaalafutu	Gnathodon speciosus	golden trevally
ali	Bothus mancus	left eye flounder
alogo	Ctenochaetus striatus	surgeon fish
amafua	Caranx melampygus	bluefin trevally
anaoho	Flammeo opercularis	branded soldierfish
apalani	Acanthurus xanthopterus	yellowfin surgeon fish
api	Acanthurus guttatus	whitespotted surgeonfish
atu	Katsuwonus pelamis	skipjacktuna
atualo	?	jack family
atule	Selar crumenopthalmus	purse-eyed scad
atutaoa	Thunus alalunga	albacore tuna
ava	Chanos chanos	milk fish
eve	Epinephelus hexagonatus	hexagon grouper
ihe	Hemiramphus sp.	garfish
ikutea	Melichthys vidua	triggerfish
o	Lepidozygus tapeinosoma	damselfish
ono	Sphyraena barracuda	barracuda
ufu	Scarus sordidus	initial phase bullethead parrot
ulafi	Scarus longiceps	longnose parrotfish
uli	Decapturus sp.	mackerel scad
ulihega	Pterocaesio tile	blue streak fuselier
uloulo	Thalassoma trilobatum	christmas wrasse
ulua	Caranx sp	trevally
uluakata	Caranx ignobilis	giant trevally
ume	Naso unicornis	unicorn fish
umu	Balistoides viridescens	triggerfish
umufatu	?	triggerfish
umutea	?	triggerfish
utu	Aprion virescens	job fish
fai	Himantura sp	stingray
faikili	Himantura sp.	stingray
fafalua	Aetbatis nari nari	stingray
fagamea	Lutjanus bohar	red bass
faloa	Epinephelus tauvina	greasy rock cod
fapuku	Epinephelus polyphekadion	camouflage rock cod
filoa	Lethrinus elongatus	long nose emperor
fuafuaika	Generic, tiny fish	bait fish
galio	Tylosorus crocodilus	long tom
gagale	?	parrotfish

[7] Most of these names were obtained from the Tokelau Dictionary (Office of Tokelau Affairs, 1986). They were compiled by Tokelauan fishers with assistance from Antony Hooper during his visits to Tokelau between 1967 and 1981. They used several fish identification books for common and Latin names (A. Hooper, pers comm). Some additions have been made during the current study, while some other Latin names have been corrected, but identifications should still be considered preliminary.

galo	Scarus globiceps	brown parrot
gatala	Epinephelus merra	honeycomb grouper
gutuloa	Epibulus insidiator	slingjaw wrasse
kakahi	Thunnus albacares	yellowfin tuna (smaller)
kamai	Elegatis bipinnulatus	rainbow runner
kamutu	Scarus sp.	green parrotfish
kanae	Crenimugil crenilabis	warty-lipped mullet
kapoa	P. prometheus	snake mackerel
kata	Caranx ignobilis	giant trevally (large)
kiokio	Albula vulpa	bone fish
komulo	Caranx sexfasciatus	big eye trevally
koti	Scaridae	cut parrot
laea	Sacrus frontalis	small size
laeafatu	Scarus festivus ?	festive parrotfish
lai	Scomberoides lysan	queenfish
laeamea	Scarus sp	parrotfish
loi	Cephalopolis argus	peacock cod
laulaufau	Zanclus cornutus	moorish idol
lupolupo	Carangidae	small carangid
maeva	Siganidae	rabbitfish
mago	Carcharinidae	shark, general
malau	Myripristis sp	soldierfish
malaufagamea	Myripristis amaena	soldierfish
malauloa	Myripristis sp.	soldierfish
malaunaunefe	Myripristis sp.	soldierfish
malautea	Myripristis sp.	soldierfish
malatea	Cheilinus undulatus	napoleon wrasse
malili	Mulloidicthys vanicolensis ?	goatfish
malolo	Cypselurus spp.	flying fish
mamanu	Scarus sp. (altipinnis?)	parrotfish
manini	Acanyhurus triostregus	convict tang
mahi mahi	Coryphraena hippurus	dolphin fish
matapula	Heteropriacanthus cruentatus	glasseye
matu	Gerres sp	silver biddy
memea	Mulloidicthys vanicolensis ?	goatfish
moaga	Mulloidithys sp	goatfish
moamoa	Parupaneus bifasciatus	double-bar goatfish
molali	Cheilinus trilobatus	triple-tail wrasse
mu	Monotaxis grandoculis	big eye bream
munua	Epinephelus sp.	large grouper (around 1m)
mutu	Abudefduf sp	seargent
nanue	Kyphosus cinerascens	topsail drummer
nofu	Sycanceia verrucosa	stone fish
pakeva	Carangoides ferdau	blue trevally
pala	Acanthocybium solandri	wahoo
paluutu	Pristipommoides sp.	flower snapper
Palugatae		
paluloa	Etelis carbunculus	red snapper
palumalau	Pristipomoides sp.	flower snapper
palupo	Ruvettus pretiosus	castor oil fish
paluhega	Priistipomoides zonatus	flower snapper
palutupua	Ruvettus pretiosus	castor oil fish

paluvakaalo	Aphareus furcatus	job fish
pananua	Syphyraena sp	barracuda
papo	Cheilinus fasciatus	red breasted maori wrasse
patuki	Cirrhitus pinnulatus	stocky hawkfish
pone	Acanthurus achilles	achilles tang
ponelolo	Ctenochaetus striatus	striped surgeon fish (during spawning aggregations)
puhi	Muraenidae	moray and related eels
putalaloa	Neoniphon sammara	spotfin squirrelfish
haohao	Sphyraena forsteri	forster's sea pike
hafole	Kuhlia mugil, K. marginata	flagtail
hakula	Istiophoridae (billfish)	marlin, swordfish
hakuhakuele	Pterois antennata	ragged-finned firefish
haputu	Lutjanus rivulatus	maori seaperch
hahave	Cypselurus spp.	flying fish
havane	Lutjanus kasmira	bluestripe seaperch
hipa	Cypseluris sp.	juvenile flying fish
hoaote puhi	Novaculichtys taeniourus	rock mover wrasse
hoke	Trachinotus bailloni	black-spotted dart
hugale	Thalassoma hardwicki	sixbar wrasse
humu	Balistidae	triggerfish
ta	Sargocenton spiniferum	sabre squirrelfish
taea	Lutjanus gibbus	paddle-tail snapper
taiva	Lutjanus monostigma	onespot seaperch
tautao	Fistularia commersoni	smooth flutemouth
tautu	Diadon hystrix	porcupine fish
tafauli	Caranx lugubris	black trevally
tagau	Lutjanus fulvus	yellow-margined sea perch
takuo	Thunnus albacares	larger yellowfin
talatala	Myripristis violacea	lattice soldierfish
talitaliuli	Naucrates ductor	pilot fish
talitaliuli	Labroides dimidiatus	cleaner wrasse
tamalau	Sargocentron caudimaculatum	tailspot soldierfish
tapatu	Sphyraena forsteri	juvenile forster's sea pike
tatifi	Naso spp	unicorn fish
tavatava	Gymnosardar unicolor	small dogtooth tuna
teletelevakaniu	Echeneis naucrates	remora
tete	Arothron meleagris	puffer fish
tifitifi	Chaetadontidae	butterfly fish
tonu	Plectropomus spp.	coral trout
tuita	Parapaneus barberinsus	goatfish
tupoutupou	Aulostomus chinensis	trumpetfish
vete	Mulloides flavolineatus	yellowstripe goatfish
valu	Gymnosardar unicolor	large dog tooth tuna

Figota		**Shells**[8]
	Arca sp	
	Anadara sp.	
	Chama sp.	
	Conus sp.	
	Cypraea tigris	
pule	Cypraea spp.	cowry
	Drupa grossularia	
	D. morum	
	Drupella cornus	
fao	?	conch shell
	D. fenestrata	
	Glycodonta marica	
	Isognomon acutirostris	
	I. perna	
	Laevicardium sp.	
	Lima sp.	
	Pinctada maculata	
tifa	P. margaritifera	
	Streptospinna saccata	
	Strombus gibbosus	
	Terebra crenulata	
fahua	T. maxima	giant clam
fahuataka	T. squamosa	
Kalea?	Strombus luhuanus	blood mouthed stromb
mimiha	?	type of snail
makulu	?	small snails used for necklaces
alili	Turbo setosus	turban snail
Others		
ura	Penicillatius spp	tropical rock lobsters
feke	Octopus sp	octopus
tupa	Cardisoma carnifex	land crab
ugauga	Birgus latro	coconut crab
paikea	Cardisoma sp	land crab
kamakama	Grapsus sp	rock crab
kamutoa	Heterocentrotus sp	pencil spine sea urchins
tio	Vermetidae	vermetid gastropod
vana	Echinothrix diadema	long spined sea urchin
tuitui	Tripneustes sp	sea urchins
pipi	Spondylus squamosus	thorny oyster
mamao	Actinopyga mauritiana	red surf fish
funa funa?	Bohadaschia argus	leopard fish
funa funa?	Holothuria atra	lolly fish
funa funa?	Microthele nobilis	black teat fish

[8] Most of these shell identifications are from Mildner (1988), and have not been verified in this study. Where local names are given, these were obtained from the Tokelau Dictionary.

Appendix 4. Questionnaire for Fakaofo, Tokelau

Date: Household: Village: Questionnaire no.---

1. Household economic survey. Complete for all members of household, including children.

Name	sex	Age	Rel to head of house	Job	Est. incm from job	Hours fished per week	Est fish incm	Est. other incm	Est. total week incm

2. Household boat? Type? Engine?

3. Which types of seafood do you normally eat? How often? How much?

- fish (which ones, 3 most common)
- turtles
- sea urchins
- giant clams
- lobsters
- coconut crabs
- sea cucumbers
- octopus
- others eg.

4. Are their some fish, or other seafood that you never eat?
Why?

5. Do you process some seafood, eg smoke, dry, fillet?

6. Do you ever fish at night? Which nights (moon phase)?

What do you catch? (lobsters, fish, others?).

7. Are there some seafoods that you get alot more of at certain times of the year?

Which ones? Time of year? Indicators (flowers, etc)

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8. Can you name at least 3 seafoods harder to get now? Why?

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Are there any you used to get, but never get now?

9. How many meals do you normally eat per day?

What do you normally have for breakfast?

Lunch?

Dinner?

10. How many meals per week do you eat fresh/frozen seafood?

more than once per day?
Once per day
Several times per week (how many)
Once per week?
Something else?

Do you catch your own, or get it from somebody else?

11. At how many meals do you eat tinned fish?

more than once per day?

Once per day

Several times per week (how many)

Once per week?

Something else?

How many tins per meal? How much do you spend?

12. At how many meals do you eat tinned meat?

more than once per day?

Once per day

Several times per week (how many)

Once per week?

Something else?

How many tins per meal? How much do you spend?

13. At how many meals do you eat fresh/frozen meat or chicken?

more than once per day?
Once per day
Several times per week (how many)
Once per week?
Something else?

How much do you spend per meal?

14. What vegetables do you eat? How often?

15 How much rice do you eat per meal (or buy per month)

16. Do you ever send seafood on the boat to Apia? What do you send? How much? Who to? Is it sold?

17. Do you own a freezer? Size? (large, medium, small)

18. What are your 3 favourite fish?

19. Are there some fisheries in which women are involved? (Information also from q.1)

20. What fishing gear belongs to the household?

Nets, number, size.
Spears and spear guns
Trolling lines
Rods, local and imported
Scoop nets

Appendix 5. Questionnaire for form 5 students, Fakaofo Tialeniu School.

Name of head of house?_____ No. Of people living in house. _____

1. Did any one in your house go fishing today? Yes/no

If yes, who (father, mother, brother, sister, grandfather, grandmother, aunt, uncle, cousin, you).

2. If yes, what did they catch?

   Fish? What type? How many?
   Fahua? How many?
   Feke? How many?
   Ura? How many?
   Unga unga? How many?
   Others? What? How many?

3. In your house, did you have any seafood (ika, fahua, feke, unga unga,, others) for:

   Breakfast? What? How many?
   Lunch? What? How many?
   Evening meal? What? How many?

Table for answering questions 1, 2, and 3

Day	What was eaten in your house (ika, fahua, feke, others, what type and how many	Who went fishing, what, and how many did they catch?
Tuesday, b'kfast		
lunch		
dinner		
Wednesday, b'fast		
lunch		
dinner		
Thursday, b'fast		
lunch		
dinner		
Friday, b,fast		
lunch		
dinner		
Saturday, b'fast		
lunch		
dinner		
Sunday, b'fast		
lunch		
dinner		

4. Ask the people who fish in your household if hey think there are any problems with the marine resources (fish, fahua, feke, unga unga, ura, etc) in Fakaofo. Are some of them getting less in number? Which ones? Why? Write answer on back if you need more room.

Appendix 6. Notes on meeting with the men from Fenua Fala, 13 August, 1998.

All discussions were translated by Mose Pelasio. Attended by 16 men.

I first introduced myself, and explained the background of what I was doing there in Fakaofo. I then asked them if they had any concerns regarding their fisheries or lagoon.

Lomi said that the coral in the lagoon is largely dead now. I asked him if he had any idea why, and he told a story of a US Navy ship with a name something like "Hitihiti) which poured some white powder at several locations around the reef on an incoming tide. Fish and eels died, and the coral died shortly after this. He was not sure of the date, but probably in the 1970s. Mose said he had heard this same story once before from somebody else.

When I asked them whether they complained about it at the time, he said they did not make an issue of it. The ship had asked permission to do some research, and they just accepted what happened. Apparently the same ship also visited Atafu and perhaps Nukunono.

Vaipapa said that clams (*T. maxima*) used to be more abundant, and now even new recruits appear to be decreasing in number.

Lomi said that the gatala fish (*Epinephelus sp*. probably *merra*) used to be abundant, and were caught with local rods on the reef and coral heads. Now there are not so many. He also said that tonu (*Plectropomus sp*.) up to 18 inches in length, used to be caught in the fish traps, but not any more.

Vaipapa and Hulo spoke of the shipwreck, and how the coral has been killed around the wreck, and and also the fish poisoning which the wreck appears to be responsible for. He asked whether the wreck could be removed. The ciguaterra started with Uluafi, and later moved in to api, nanue, mamanu, laea, kamutu, aloga, and ono. Also munua and fagamea. The poisoning now appears to be moving down the reef towards Fenua Fala (Ahagaloa).

I asked them their opinion on the reserve which has been established, i.e. is it working well, are people respecting the ban on taking the resources from the area.

Lomi said that it was a good idea, especially for the reef fish, as when the elders opened the Ha for harvesting for special occasions, the catches were always very good. Vaipapa said it also worked well for the clams for the same reason. However, he also said that the reserve should be for everyone, i.e. there should not be special exemptions given to some people to harvest resources[9]. Lomi also stated that the reserve works well for coconut crabs and paikea crabs. People appear to respect the reserve, and there is a fine of $10 imposed on any one breaching the ban. Few cases of fines were reported.

Several men then went on to talk about a hook or grab device which was used in the past to harvest *T. squamosa*. Apparently it was a simple device to make, and could be lowered by a diver from the water surface and used to harvest the clams. They said this might be the reason for the very low numbers of *T. squamosa* present today. This device, constructed from ½ inch steel rod, was apparently common about 50 years ago. The meat was sometimes exported, or the clams were kept alive in the lagoon near a persons home as a source of fresh clam meat for the family meal when required. This was before the days of freezers.

I asked them if there was any history of exploitation of the funafuna (sea cucumbers). One man remembered in 1985 there was a brief period of exporting one species, apparently leopard fish (*Bohadaschia argus*), to Samoa. Nothing else was mentioned.

Asked whether they exploit any urchins, Vaipapa and Hulo said that there was a belief in Fakaofo that if you take the kamutoa (pencil spine sea urchin from the reef, the weather will become rough. Vaipapa also mentioned that they used to sometimes find pearls in *T. squamosa* clams.

Asked if they would be interested in fishing for and processing red surf fish if they were present in sufficient numbers, 1 man expressed interest. They also say that this is the species they can use to stun fish by rubbing the animal on a rock near a fish hole. (author's note: other places they use *H. atra*). However, the elders ban the practice.

They said that they had a crown of thorns (alamea) outbreak around 1988/89. They collected a lot of them and burnt them.

[9] For example, apparently church ministers have been known to gain an exemption to permit them to harvest clams from the reserve to take with them on trips to Samoa.

The men then asked me my opinion on whether the wreck should be removed. I explained that an EIA would need to be done for such an undertaking, but it is possible that you could cause more damage by trying to remove the wreck than by leaving it where it is. I also told them, for future reference, if another wreck should occur in the future, that the owner should be responsible for removal, or pay compensation. However, this may involve expensive legal fees for Tokelau.

Another man questioned me about processing and marketing sea cucumbers. I explained that the resource is small, and only viable for perhaps 1 or 2 people, i.e. not a big industry. I lent the man my SPC handbook on sea cucumbers.

They also asked about farming sea cucumbers. I explained the Japanese and some other Asians are trying it, but the process is not widely known at present.

Lomi mentioned the mussel (Arca ventricosa?) became much more abundant after the extreme low tides of 1983. (Note that McLean (1993) reports that the extreme low tides of 1982/83 were reported to have a devastating effect on the on corals, fish, and other life in the lagoon).

The men asked then if I had identified any commercial opportunity from the marine resources. I answered that there was nothing to get excited about, though limited exports of some sea cucumbers may be possible.

I asked when the last time a pearl shell was found, and apparently there was one found last year.

In response to questions, the men said that as well as Samoa, clam meat is exported to Australia and New Zealand to family and friends.

They asked me at what size do clams start to reproduce, and I replied around 8 cm for *T. maxima*. I did not know about *T. squamosa*.

I then offered my final comments, i.e. that although there were no significant commercial prospects at present, the people were extremely well off to have such resources in and around their lagoon. They have access to an excellent source of food which has the potential to feed them well and keep them healthy, much more so than if they relied more on the imported diet of meat, tinned meat, and tinned fish. If they continue to look after it, their children and grandchildren will be the ones to benefit by having continued access to the same rich resources they themselves are enjoying today.

Appendix 7. Meeting with elders, Fale, 14 August.
Mose Pelasio translating.

.After the introductions, I explained why I was there, though they should have all been aware already (i.e. SPC received an official request from Tokelau to assist with a stock assessment survey with a view to preparing a management plan).

I then asked them what concerns they had regarding their marine resources. They raised the issue of the wreck on the reef flat, and asked me whether the corals will recover. I answered that if no more significant stress is added to the corals in the area, there is a good chance that the reef will recover over time. However, water temperature increases, storm damage, etc., could continue to hamper recovery of the reef. I also repeated the message about seeking compensation for future events from the vessel owners, and that it should be the responsibility of the owners to remove the wreck.

They then asked what opportunities in the marine resource sector I had identified. Based on the survey work completed so far, I repeated what I had said to the men in Fenua Fala, i.e. limited potential for sea cucumber harvesting. Also that trochus were doing well, and in another 10 years a harvest may be possible.

A question was asked whether, as it was the trochus shell that was worth the money, the meat could be harvested now, and leave the shell on the reef for harvesting later. I explained why this would not work.

They then asked how long the reserve area should be closed before opening the area to periodic harvesting. I said my opinion is that the reserve should be a permanent reserve, as stocks would build up in there and overflow into the rest of the reef and lagoon, from where they can be harvested.

They asked about the clams, and why their numbers were decreasing. I explained about the Aitutaki experience, and how the island council there were asking similar questions 10years ago. The answer in that case could be found on the planes and boats leaving the island, taking clam meat with them. I believe that the export of clam meat to Samoa as well as to NZ and Australia may be leading to the decrease. While clams (*T. maxima*) could still be considered abundant in the lagoon, it is wise to be careful so that they continue to be abundant.

They asked how to replenish clams in areas of low abundance. I said they may restrict fishing for clams in these areas, and perhaps transplant some larger individuals form the reserve area to these areas in the hope that any recruitment resulting from these animals spawning will remain in the depleted area.

They also asked whether outboard engine emissions might be causing mortality in clams and coral. I said I did not know, but would make some inquiries.

They asked whether the spawn from clams near the passages would be sucked out of the lagoon and lost. I said this may be the case, but recruitment to these areas would then probably occur from somewhere else in the lagoon.

They stated the belief that by harvesting the clams in the sea, the eggs and sperm released would result in recruitment. I said that the animals spawned naturally, in cycles, and that when the clams are harvested, they are not necessarily in spawning condition. It is better to leave them to spawn naturally.

They asked about whether a transfer of *T. derasa* would be useful. I said my opinion is to stick with the species they already have, but if you asked 10 clam biologists the same question, you would probably get five yes and five no answers.

I concluded with a request for a list of their current regulations concerning marine resources. I also left them with similar comments as the concluding remarks to the Fenua Fala men's meeting, regarding the fortunate situation the were in with their resources, and the need for wise utilisaton if these resources are to be available for future generations.