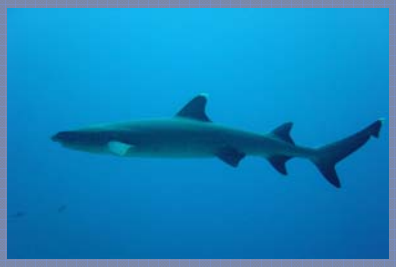
Marine Resources of Tokelau Atolls

FAKAOFO

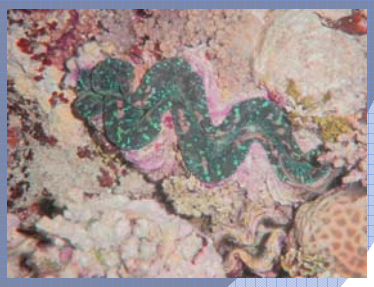
Marine Resource Management Plan

Background Report

December 2004





Prepared for:
Government of Tokelau

Authors: Dr David Fisk, Joanna Axford, Mary Power

for

South Pacific Regional Environment Programme

Table of Contents

Acknowledgements

SPREP gratefully acknowledges the assistance and support given to this survey by a range of people:

In Apia, many thanks to Falani Aukuso and his staff at the Apia Tokelau Liaison Office for their support and advice.

On Fakaofo, to the Council of Elders of Fakaofo, for their wonderful hospitality and also for making available the Tupuelega to assist in the survey work. Thanks also to Keli Neemia, Afega Gaualofa, Katieli Peleti, Tulafono Penehe, Telefoni Peliata and Tu Matini for assistance and guidance. To the school principal for allowing us to talk to the students and distribute environmental awareness materials. And finally, to Mose Pelasio for assisting with logistics and to Suia Pelasio looking for after us on the island.

And finally, the team who took part in the various components of the survey

Mary Power (SPREP), Project Development and Coordination
Foua Toloa, Tokelau Liaison and Finfish Surveys
Dr David Fisk, Marine Resource Survey Team Leader
Joanna Axford – Community Surveys
Caroline Vieux – Resource Assessment
Gordon LaPraik – Dive Coordinator and Resource Assessment
Seema Deo (SPREP) – Education Activities
Miriam Philips (SPREP) – community and education activities

And finally to Steve and the crew of the good ship 'Evohe' for their splendid support.

Authors:
Dr David Fisk, Oceania Consulting – davefisk@lagoon.nc
Joanna Axford, University of Queensland – jaxford@uq.edu.au
Mary Power, SPREP (now SPC) – maryp@spc.int

Executive Summary & Recommendations

Background to this Survey

In 2002, the Tokelau government approached SPREP for assistance with marine resource management of their atolls. A scoping study was undertaken in Tokelau over two separate visits in 2002 and 2003 to assess the level of community and leadership interest in revitalizing the proposed marine resource management project. The scoping study found that the communities and their traditional leaders of all atolls were very supportive of the government proposal and that all three atoll communities were keen to be involved.

SPREP put together a multi-disciplinary team (including scientists, educators, managers, and community specialists) to visit each of the Tokelau Atolls to undertake an assessment of the status and use patterns of the inshore and lagoon resources of the atolls as first step towards establishing a marine conservation program in Tokelau. The team also worked with the community on each atoll to establish an overview of community perceptions of atoll resource status, general concerns, as well as their attitudes towards conservation approaches to marine resources.

The project did not focus on assessing the biodiversity of Tokaleau's marine resources. Instead, it was designed to address issues raised by the community in particular, and to assess the general state of the marine environment and the status of harvested resources. In addition, the project was designed to assess the effectiveness of any management measures in place and the level of community support for management. The surveys aimed to:

- Undertake a rapid assessment of the status of significant marine resources and ecosystems;
- Undertake a series of surveys to gauge types and intensity of fishing activity;
- Conduct a series of workshops and interviews to engage all sectors of the community and traditional leaders, enabling the community of each atoll to identify their aspirations for their marine environment and identify actions that need to be undertaken to ensure sustainable use of their marine resources; and,
- Recommend actions / measures that should be incorporated into Marine Resource Management Plans for each Atoll, or portions of each Atoll as appropriate, for the establishment of Marine Protected Areas.

Ecological Condition

The survey results show that there are specific characteristics of the habitats and biotic communities on Fakaofo atoll that should be taken into account when considering sustainable management of marine resources.

The relative geographical isolation of Fakaofo atoll from other Tokelau atolls, and from other regional reef systems means that marine resources on Fakaofo are effectively isolated from all other sources of marine species replenishment, and is in effect a "closed" biological system. As a consequence, replenishment of reef fish, corals, clams and other stocks of marine species must occur from within the atoll's marine ecosystem. For this to happen there must be viable (or reproductively successful) populations of adults of each species of interest present within Fakaofo Atoll.

Fakaofo lagoon is a partially open lagoon system with small steep sided patch reefs scattered throughout the western lagoon which are surrounded by deep water. The lagoon does not have any deep water passages to the open ocean. Multiple shallow passageways between motus allow the transfer of water between the lagoon and the open ocean, but none are deeper than approximately a meter at low tide and are most are no wider than approximately 50 m. The central and southern sectors of the lagoon are subdivided into a series of wall reefs that run approximately east to west, and in the northern section the walls are aligned more south to north. These walls create enclosed or semi enclosed cells which significantly restrict water movement within the lagoon.

The status of marine resources on Fakaofo is one of general depletion of most traditionally harvested species. Some species are severely depleted to the point that they may never recover. The reasons for these depletions are not always easy to determine but they no doubt include natural fluctuations and natural disturbance events as well as human harvesting factors. Modern technologies introduced to the atolls that are leading to increased harvest pressure include food preserving fridges and freezers and highly efficient fishing tools like monofilament nets and non-traditional fishing gear. In addition, the dominance of a cash society and the availability of externally processed food items encourages more harvesting than might have been done in the past as a way of improving living standards.

The fish communities are generally low in diversity and in many areas are also low in abundance but there is a representative suite of species present from the major fish feeding groups. For example, there are reasonable representations of herbivores (plant eating fish), planktivores (plankton eating fish), detritivores (fish that eat detritus or waste particles) and predators (fish that eat other fish and reef animals). Nonetheless, there appears to have been major reductions in some of the more desirable predator fish species such as hump headed wrass, black trevally, and coral trout, that were apparently once quite abundant in preceding decades. There also is a noticeable low representation of some major reef invertebrate species groups, such as the Echinoderms (starfish, holothurians, etc) and Crustaceans (crabs, crayfish, etc). Among the non-harvested animals, there is the likelihood that a small number of coral species are present that have not previously been recorded from the Central Pacific and there may be one or two species that will be new to science.

There is clear evidence that significant impacts have occurred from recent bleaching events (in 2002-3) that have affected major components of the reef on the outer slope and also in the lagoon, where it would be expected that species in the lagoon were relatively adapted to high temperature fluctuations. The bleaching events correlate with observations of low sea levels within the lagoon and prolonged periods of dry still weather. Similar periods of low sea levels in the lagoon have been reported from1983.

A partially broken down ship wreck is located on the northern tip reef flat at Te Tafatafa. The ship ran aground in 1989 and has been partially dismantled, though multiple pieces of the ship structure is spread over the reef flat (and possibly onto the slope though this was not surveyed). A very large area of crest and reef flat habitat in both west and east directions has been impacted by the wreck. The wreck has caused the mortality of most commonly occurring reef organisms on the crest and reef flat and this effect was still present during the current survey.

Fakaofo Community Resource and Conservation Perceptions

The community investigations demonstrated that there are specific community perceptions, concerns and issues that should be taken into account when developing a resource management

plan and in implementing management prescriptions. Some of the issues and perceptions are outlined below (note that sections written in italics are taken directly from interviews with community members and community meetings).

The greatest change noted by respondents and by participants in the community workshops, was the declining populations of reef fish and giant clams (faisua) found within the lagoon. There are some species of fish that once came in large schools that are rarely or not ever seen now. Fish populations and species diversity are perceived as declining, and other traditionally harvested species are either not seen or are rarely seen (compared to before).

These changes have occurred along with other changes in the way in which things in Fakaofo are done. Previously the community fished together and shared the catch equally amongst the village members (through the system of *inati*). Now however, they often fish alone, "*more individual fishing and less sharing, village members rely more heavily on nets now*", including those with fine mesh. The different mesh sizes of the nets means that a variety of species and sizes can be caught and some fear if this continues there will be nothing left in the future.

People expressed a lack of knowledge about *fakahao* (conservation) and what it really meant. The following opinions and perceptions were expressed about *fakahao*, and what it means to them:

- Perceptions vary as to what reef and land area is included within the *fakahao* boundaries;
- There is lack of awareness of the *fakahao* amongst the community and especially the fishers;
- *Fakahao* is considered the sole responsibility of the Taupulega;
- Some respondents felt however that the *fakahao* was not actively managed and the area was regularly accessed and fished;
- Generally the rules of the MPA were thought to be not complied with; and,
- Punishment for non-compliance is rarely implemented.

There were varying opinions amongst respondents regarding the success of the area as a *fakahao*. Most however, felt it is not a success which was perceived to be because:

- the area is considered to be accessed too frequently and is too disturbed;
- there has been no increase in resources; and,
- the elders allow people to fish in there to provide products for people overseas.

The year 2003 had been a year of high impact according to respondents, "*there has been many visitors this year so the fakahao has been used a lot because that's the main area the elders use*". Others feel the area is not a success because people do not obey the rules and there is no one responsible to watch over it and ensure people respect the rules: "*No it is not successful because there are still people going there without permission for their personal needs…*".

The shipwreck and the fish poisoning perceived to be associated with it, are the dominant concerns for the community. A large variety of fish are now poisonous because of the wreck, according to respondents and workshop participants.

People expressed a lack of knowledge about *fakahao* (conservation) and what it really meant. There were varying perceptions as to what reef and land area is included within the *fakahao* boundaries. There is lack of awareness of the *fakahao* area (also referred to as a Conservation Area) amongst the community and especially the fishers. Community members generally

considered the conservation area as the responsibility of the *taupulega*. Some respondents however felt that the Conservation Area was not actively managed and was regularly accessed and fished. Most community members shared the view that in general, the rules of the conservation area were not complied with and that punishment for non-compliance is rarely implemented.

Perceptions of current and future success in the conservation area were explored. While there were varying opinions amongst respondents regarding the success of the conservation area, most felt it is not currently a success. Reasons for this perception include :

- Feelings that the area is accessed too frequently and is highly disturbed;
- There has been no increase in resources since establishment; and,
- The elders allow people to fish in there to provide for people living overseas.

According to respondents, 2003 was when there was high impact in the Conservation Area, "*there has been many visitors this year so the fakahao has been used a lot because that's the main area the elders use*". Others feel the area is not a success because people do not obey the rules and there is no one responsible to watch over it and ensure rule compliance : "*No it is not successful because there are still people going there without permission for their personal needs…*"

People felt that success will require active management of the *fakahao* by the *taupulega*. There was a need to have people working there, monitoring and patrolling the area frequently to ensure no one breaks the rules.

Recommendations

Considering the findings of the resource surveys and the interaction with the all groups of the community a number of recommendations are suggested as a way to improve resource management on Fakaofo. The recommendations are directed towards management actions that will contribute to the conservation and preservation of the atoll, by providing a framework for achieving sustainable resource management of human activities. The recommendations address the major management issues raised by the community and encompass the following principles:

1. ***Conservation***
   - Conserve the integrity of the natural and cultural values of Fakaofo Atoll; and
   - Restore, where possible, the natural biodiversity and cultural values of the atoll.
2. ***Community involvement and support***
   - Enhance community awareness, understanding and appreciation of the biological and physical diversity of the atoll, and promote community involvement in, and support for, its protection, conservation, and restoration; and
   - Incorporate traditional and modern resource management practices to form a comprehensive and integrated community-based Resource Management Plan.
3. ***Commercial and other uses***
   - Manage commercial and other uses in an ecologically sustainable way.
4. ***Research and Monitoring***
   - Implement a data collection and analysis program that provides for a much greater understanding of the impacts of use and management activities within the atoll To better understand the potential and real impacts resulting from resource use; and
   - Encourage and support community-based participatory research and monitoring.

Fish Aggregation Sites

It is apparent that some aggregation sites are mostly used by specific species or a small group of specific species, and that the aggregation sites are spread around most of the lagoon. Seasonal protection for these aggregations, especially from the very effective netting practices currently being used, would be a very significant step forward for long term sustainable management of finfish stocks of importance to subsistence livelihoods. It is also wise to nominate for protection more than one such species-related aggregation site for each species, so that annual variations in the degree of use of these sites is taken into account by protecting more than one of each of the species-specific sites.

RECOMMENDATION 1
It is highly recommended that more than one species-specific site known for their seasonal fish aggregations be protected from harvest activities during these critical phases and that this be applied to sufficient sites so that all the major fish target species are represented under this management goal.

Giant Clams

The status of giant clams is restricted to the species *Tridacna maxima* as only one individual of another species (*T.squamoasa*) was observed during the whole period of the survey. The densest aggregations of clams were observed in very small areas within the Fenua Loa Conservation Area. In all other locations densities were low or clams were not present at all. If clam densities are to be improved, strict restrictions on their harvesting will have to be enforced.

RECOMMENDATION 2
It is recommended that a relatively large total area (on the scale of 500m - 1 km) of reef flat and adjacent shallow lagoon area be considered as long term refuges for giant clams, which will act as sources of clam larvae for other parts of the atoll.

Conservation Areas

The current southern Conservation Area includes a totally enclosed lagoon cell within the main lagoon and the surrounding reef flat. The reef flat is periodically opened for harvesting of some resources when required. The enclosed lagoon cell has very low productivity potential[1] so the greatest value for the CA is in the outer reef flat and the adjacent slope habitat which is a highly productive area.

RECOMMENDATION 3

[1] **Productivity potential** refers to the ability of a particular habitat and its environment to support high biomass or numbers of fishery species and individuals. Low nutrient and energy regimes are typical of a low productivity environment and this is the situation in the enclosed lagoon cells.

The reef slope habitat that is currently not within the Fenua Loa Conservation Area should be included to exclude the harvesting of any species. The highest value of this conservation area to sustainable fisheries lies in the exclusion of harvest activities on the outer reef flat and crest. An effective long term sustainable fishery management option would be greatly enhanced by extending the exclusion zone to the slope which will greatly improve the potential for an increase in biomass of fish for the whole atoll as numbers move outside the reserve area.

Temporary vs permanent closures

Modern fisheries knowledge recognizes that the periodic opening and closing of specific areas for harvest activities is not very effective in the long term for maintaining sustainable fisheries. While there is a role for traditional temporary closures of areas it must be recognised that it will be limited in its ability to sustain long term fisheries if that is the only management technique that is adopted. The choice of areas for periodic closure should be targeted towards the most productive areas and should be rotated around a number of similar areas that are important for the aims of the resource conservation measure or species of concern.

RECOMMENDATION 4
Where harvesting is to be periodically allowed following temporary closures, there should be a systematic rotation of open and closed areas that are easily applied and the boundaries readily understood with reference to reef features. This will allow regular replenishment of species that can rapidly re-establish their numbers if left sufficient time to do so.

RECOMMENDATION 5
It is recommended that both temporary and permanent closure systems be employed to enhance overall fisheries yields for Fakaofo. Also, a clear distinction should be made between areas that are intended to be permanently closed to harvest activities and those that are to be more temporary (in terms of a number of years or on a seasonal basis).

Control on Harvesting

Current harvest activities on Fakaofo have several characteristics that are significantly contributing to the over harvesting of resources. These include the widespread use of fish gill nets in the shallow and narrow channels that dissect the reef flat. The targeting of fish aggregation areas is also a significant contribution to over fishing, including the permanent location of a major fish trap in one of a significant fish aggregation area (in terms of the diversity of fish that are known to aggregate there) on the reef flat east of Fenua Fala. The practice of taking all fish of any size is a further damaging factor that should be controlled if sustainable fisheries are to be maintained.

RECOMMENDATION 6
Good practice fisheries regulations need to be adopted that address the common causes of over fishing like small mesh net sizes, the targeting of most fish aggregation sites in any one

year, and the taking of small fish sizes. These regulations have to be understood by all members of the community and have to be adequately enforced if they are not automatically adopted by all fishers.

Export

The practice of exporting marine products for either family reasons or for income needs to be carefully managed so that over exploitation of limited resources does not occur. A number of management arrangements that will help include obtaining a more accurate estimate of the current export level to families overseas. A careful policy in relation to commercial export industries will have to be developed before any scheme is approved.

RECOMMENDATION 7
It is recommended that the export of marine resources be significantly controlled or preferably be stopped as an essential measure to manage resources more effectively.

Removal of Wrecks

It may be possible with a small grant and a high contribution of work effort from locals to effectively removal the bulk of the wreck in the NE corner of the atoll. This is a desirable outcome as the wreck is breaking up slowly and is impacting on a large area of the atoll and probably is causing. Fortunately, there are experienced people in the region that can be approached to give some initial advice and perhaps be available to undertake the task.

RECOMMENDATION 8
It is recommended that funds be accessed to undertake the removal of the ship wreck including the removal of metal fragments that are scattered over the reef flat. The removal should be done under experienced supervision with the fragments disposed in very deep water off the reef edge.

Waste Management

There is obviously an issue on Fakaofo relating to the treatment of solid rubbish and this includes the issue of the importation of plastics. Waste management plans should also address the potential important issues of effluent and chemical use. This is because there is very poor circulation in the lagoon which means that any introduction of nutrients or chemicals can be very damaging due to the time that these chemicals can spend in the lagoon system.

RECOMMENDATION 9

It is recommended that a wide ranging management plan for waste in all its forms be developed as a matter of urgency and that it be implemented as soon as is practical.

Atoll Wide Bans

There are certain resource issues that should be approached on an atoll wide basis and this usually means that an atoll wide exclusion from harvesting will be required. Specifically the low numbers of turtles and sea birds that were apparently once abundant. Islands that supported large colonies of seabirds no longer do so and no substantial colonies of sea birds were observed on any motu. A combination of natural disturbances (direct and indirect cyclone effects), and changes to the vegetation structure of the motus due to the expansion of coconut plantations, has probably contributed to the reduction in sea bird numbers. Sea birds are important to the ecology of the motu vegetation, providing nutrients to poor soils. While sea birds can provide food for the community, it is recommended that they be used for this purpose only during food emergency situations.

RECOMMENDATION 10:
It is strongly recommended that an atoll wide ban on the harvesting of turtles and sea birds be put in place.

Monitoring

Biological Monitoring provides ongoing data on the health and status of resource stocks. This data is essential for re-assessing and reviewing management issues with regards to specific animals and resources. This information is essential to provide the community with regular status reports of the marine environment (in particular specific resources of concern), and to highlight management actions that may need to be taken to ensure sustainable management of these resources.

RECOMMENDATION 11

It is strongly recommended that a Biological Monitoring Program be established once the final decisions are made on a sustainable management approach, so that information can be provided to the decision makers on the effectiveness of their decisions. Alterations and improvements to the rules governing the management of resources can also be made using the information obtained from monitoring efforts.

1 INTRODUCTION

1.1 Background

The Tokelau Government prepared a State of Environment Report in 1994[2] (SOE) and an Environmental Management Strategy[3] in 1995. An Environmental Legislation Review[4] has also been undertaken which gives an overview of existing legislation that impacts on the environment and proposes recommendations for improved environmental planning and management. In all of these reports priority was given to the development of a conservation strategy to address protecting lagoon and reef fisheries from the effects of pollution, siltation, sand and coral extraction and over-fishing. Recommendations include the establishment of an ecosystem profile, protected areas, regulation of fishing, resource monitoring, as well as monitoring the effects of land-based pollution.

In 1995 the Tokelau Government submitted a proposal to the South Pacific Regional Environment Programme's (SPREP) South Pacific Biodiversity Conservation Program (SPBCP) for assistance to establish a marine protected area program[5]. However, as the SPBCP was a GEF-UNDP funded program Tokelau was deemed ineligible for assistance under the Program and no action eventuated.

In 2002, the Tokelau government again approached SPREP for assistance with marine resource management in the Atolls. A scoping study was undertaken in Tokelau by Mr Foua Toloa over two separate visits in 2002 / 2003 to assess the level of community and leadership interest in revitalizing the proposed marine resource management project. The scoping study found that the communities and their traditional leaders were very supportive of the government proposal and that all three atoll communities were keen to be involved.

SPREP put together a multi-disciplinary team of scientists and managers to undertake an assessment of the status and use patterns of the inshore and lagoon resources of all three atolls as a first step towards establishing a marine conservation program in Tokelau. The team also worked with the communities to establish a picture of community perceptions of the status of marine resources and community attitudes towards conservation of these resources.

A combination of activities and methods were used to assess the status and health of major ecological zones and habitats on each atoll and to quantify the relative abundance and diversity of target species, invertebrates and finfish. Observations of seabird populations and turtles were also made and incidental observations of marine mammals were also recorded.

This report and the management recommendations developed from this process, provides the essential information and direction to empower the communities and their leaders to sustainably manage their environment and resources within the atoll. The survey aims are outlined below.

[2] Ioane M K 1994 Tokelau State of the Environment Report, SPREP, Apia Samoa.
[3] Toloa F. 1994 Tokelau Environment Managemental Strategy: Action Strategy for strengthening environmental management and sustainable development (Tokelau 2000). SPREP, Apia, Samoa
[4] Angelo A. H. 1993 Environmental Legislation Review –Tokelau Report for SPREP and the Tokelau Affairs Office.
[5] Environment Unit, DNRE 1995 Tokelau Marine Conservation Area Proejct – Concept Proposal. A submission to the South Pacific Marine Biodiversity Conservation Programme.

The surveys aimed to:

- **Undertake a rapid assessment of the status of significant marine resources and ecosystems;**
- **Undertake a series of surveys to gauge types and intensity of fishing activity.**
- **Conduct a series of workshops to engage all sectors of the community and traditional leaders to enable community to identify their aspirations for their marine environment and identify actions that need to be undertaken to ensure sustainable use of their marine resources;**
- **Recommend actions / measures that should be incorporated into Marine Resource Management Plans for each Atoll or portions of each Atoll as appropriate for the establishment of Marine Protected Areas**

The management strategies and goals of this project reinforce and support the Tokelau Environmental Management Strategy (TEMS). The strategies of the TEMS Action Plan that are directly relevant to management and utilization of the Tokelau's natural resources are:

Strategies of the TEM Strategy and Action Plan

1. ***Conservation of biodiversity and biological resources***
   - Blend new and traditional conservation and management .
2. ***Protection of the marine environment***
   - Training and capacity building towards conserving our resources.
   - Sustainable fishing practices.
3. ***Traditional culture and practices***
   - Apply traditional skills and knowledge.
   - Institute learning of the culture through the traditional way of passing knowledge from elders to the young, through schools, community meetings and workshops.
4. ***People and Biodiversity***
   - Self-reliance through traditional values and cultures.
   - Community wareness.
   - Working cooperatively and.
   - Clean up the environment.

1.2 Methodology

Consultations and Community Surveys

The development and sustainable management of Fakaofo's resources requires active involvement from all sectors of the community. Meetings were held with all stakeholder groups to document their concerns and perceptions of atoll resources and current and historic resource use. These were further supplemented by semi-structured interviews conducted at random with individuals from all community groups to obtain more details perceptions on the status and use of resources and also on management systems and their success or otherwise. Household surveys were also conducted.

Key stakeholders include:

- **Local Community –** recognising that all sectors of the community who live on the atoll and are an integral part of both the problems and solutions of environmental resource management:
  - ***Fatupaepae* –** womens (mothers) group
  - *Taulelea* - married men and *Taumalo* - unmarried men
  - ***Toeinga*** – elders
  - ***Kau talavou*** – youth and school children
- **General Community Meeting –** A full community meeting was held at the end of the surveys to provide immediate preliminary feedback on the findings of the surveys, to reconfirm the issues and concerns raised and to provide a brief overview of the resource status. Broad concepts for the Management Initiatives proposed here were presented. These meeting were well attended and also broadcast by radio throughout the community.
- **Local Government -Atoll Council – the *Taupulega* -** This group is required to take a lead role in establishing atoll ordinances, enforcing protocols and increasing public awareness.
- **National (*Fono)* and Regional Government -** Government agencies that provide advice and support to the atolls. National government agencies need to actively assist the Council and the community in managing natural resources by providing advice and expertise on a wide range of legislative and environmental resource management issues. Leading roles will need to be taken by Secretariat of the Pacific Community and SPREP to assist.

Community Consultations

Issues raised

- Depletion of marine resource stocks.
- Recent depletion of resource stocks.
- Poor enforcement of traditional management system.
- Concern with commercial harvesting.
- Lack of general knowledge of reef biology and life histories.
- Lack of legislative support
- The need for ordinances to support and 'back-up' traditional law.

Government Consultation

Issues raised

- *Role of government agencies in the resource management.*
- *Depletion of marine resource stocks.*
- *Balance between commercial activities and resource depletion*.
- *Need for development opportunities*

All efforts were taken to ensure widespread consultation with all these groups to make sure that all concerns and issues were considered and ensure there was widespread ownership of the process and thereby hopefully the proposed management initiatives.

Ecological Surveys

Ecological surveys of Fakaofo Atoll were conducted using both quantitative (standardised sampling techniques) and qualitative (descriptive) approaches. Significant and valuable use was made of the local information and knowledge offered to the team during initial consultations.

Sampling techniques were mainly confined to broad scale surveys using the manta tow technique, and also smaller scale timed surveys (by either swims in the lagoon or slope, or walks on the reef flat). Standard sampling techniques were used so that meaningful comparisons could be made about the presence and abundance of indicator species of the reef system. The types of data included: density estimates of specific reef species; distribution patterns of relative presence / absence or broad relative abundance category estimates; and the presence and distribution of health and disturbance indicators.

This methodology does not allow for the establishment of fishery stock calculations (standing stock or biomass) though the methodology does lend itself to the broad assessment of the status of resource stocks. The assessment focus adopted in this project was thought to yield a holistic assessment of the general health of the ecosystem and major reef populations, which would be more important if recommendations were to be made on future best management options. This also included extensive use of interpretations of prior disturbances (both natural and human) so that recommendations on fisheries management options are made with the specific characteristics, functions, and processes of the atoll are taken into consideration. Of particular importance was the interpretation of the likelihood of a repeat of certain disturbance factors or broad variations in abundance of specific species in the future. Finally, it was also imperative that the cultural setting and contemporary outlook for the atoll be taken into consideration when making recommendations on the management of natural resources.

Extensive use of photographic and video records was made so that permanent records were obtained of the major habitat features and major species present. Many of the photos will appear in this report and in the companion report with the combined technical information for all three atolls.

Two sites were established using rigorous quantitative assessment methods that are intended to be permanent monitoring sites for the slope habitat. One site was established in the western slope of the Fenua Loa Conservation Area, and a comparative site was established some 500 m north of this site which was outside the Conservation Area and south of the harbour entrance to Fale motu (or the original Fakaofo Village). The permanent monitoring sites were also digitally photographed along each of the transect tapes as a permanent record of the current status of the benthic communities.

1.3 Previous Studies

Prior to the 2003 rapid marine assessment no thorough inventory of Tokelau's marine resources had been conducted. The only know previous inventory of inshore resource in Tokelau was a limited survey undertaken in 1998 by Kelvin Passfield. This inventory however is limited in that it only focused on Fakaofo. A more general report on the effects of cyclone Tusi (1987) for all three atolls was conducted in 1987 by **Pierre Laboute** .

Laboute, P (1987). Mission to the Tokelau Islands to evaluate cyclone damage to coral reefs. SPREP Topic Review 31, South Pacific Commission, Noumea, New Caledonia.

Passfield, K. 1998 Report of a survey of Marine Resources of Fakaofo Atoll Tokelau, South Pacific Commission, Noumea, New Caledonia

The following compilation of studies, reports and papers on Tokelau are also relevant and were closely consulted during the development of the project.

Anon. (1991) Matagi Tokelau: history and traditions of Tokelau. Apia, Samoa, Office for Tokelau Affairs & Institute of Pacific Studies, University of the South Pacific. Gillet R. 1985 Traditional Tuna Fishing in Tokelau: Topic Review Number 7: South Pacific Regional Environment Programme

Gillet R. 1985 Traditional Tuna Fishing in Tokelau: Topic Review Number 7: South Pacific Regional Environment Programme

Hooper, A. (1983). 'Tokelau Fishing in Traditional and Modern contexts'. The Traditional Knowledge and Management of Coastal Systems in Asia and the Pacific: Papers presented at a UNESCO-ROSTSEA Regional Seminar held at the UNESCO Regional Office for Science and Technology for Southeast Asia 5-9 December 1983. K. Ruddle and B. Johannes. Jakarta, Indonesia, UNESCO. **1**.

Huntsman, J. & A. Hooper (1996) Tokelau: A Historical Ethnography, Auckland University Press, Auckland.

Ioane M K 1994 Tokelau State of the Environment Report, SPREP, Apia Samoa.

Martin S, Allan M. & Yska G. Tokelau 1006 Women's Craft Project – Feasibility Study and Project Design, Ministry Foreign Affairs and Trade.

MacGregor, G. (1937) Ethnology of Tokelau Islands, Bernice P. Bishop Museum, Honolulu, Hawaii.

SPREP 1994 A Waste Management Study for Tokelau Government.

Tokelau Government 1995 Tokelau marine Conservation Area Project: Concept Proposal – A submission to the South Pacific Biodiversity Conservation Program. Environment Unit, Division of Natural Resources and Environment, Government of Tokelau.

Toloa, F., R. Gillett &M, Pelasio. (1993). 'Traditional Marine Conservation in Tokelau. Can it be adapted to meet today's situation?' Inshore Fisheries Research Project Technical Document No. 5. Workshop on People, Society and Pacific Islands Fisheries Development and Management: Selected Papers. SPC, Noumea, New Caledonia.

2 ECOLOGY AND MARINE RESOURCE STATUS OF FAKAOFO ATOLL

2.1 Geography

Tokelau consists of three relatively small atolls that cover a total land area of approximately 12.25 sq km in an EEZ of 290,000 sq. km. The three atolls, Fakaofo, Nukunonu, and Atafu are located at between 9^0 20'S, $171^0$15'W (Fakaofo) and $8^0$20'S, $172^0$30'W (Atafu), with Nukunonu approximately midway between the other two atolls. Fakaofo, the southernmost atoll is 65 km from Nukunonu, with a further 105km to Atafu, the northern most atoll. The country lies approximately 500km to the north of Samoa, 600km west of Pukapuka in the Cook Islands and about 100km north east of Tuvalu. The three atolls are orientated along a south east to north east axis. The absence of an airport or airstrip on any of the atolls makes Tokelau one of the most remote countries in the South Pacific.

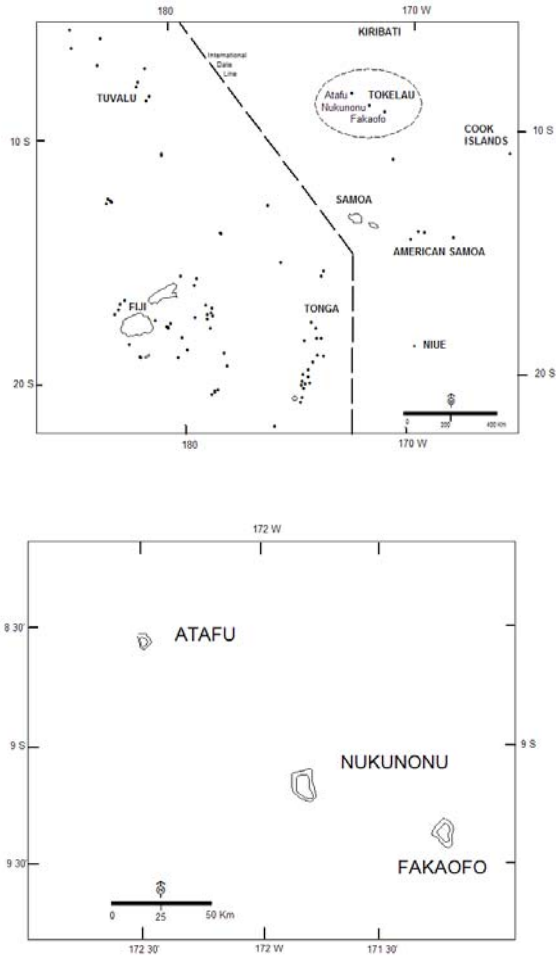


Figure 1. Location of Tokelau in the Pacific (Top) and relative location of the three atolls to each other (Bottom).

2.2. Environmental Conditions and Biogeography

Tokelau is situated in the oceanic realm of the slow moving easterly flowing Southern Equatorial Current and is therefore most likely to have a general flow of ocean currents carrying potential reef larvae from the east to the west. The predominant winds for most of the year are the NE Trade Winds with SE Trade Winds common in July (SPREP 1994). The NE Trade winds tend to drive the westerly flowing equatorial currents more to the west-southwest. The strength of the ocean currents vary from 0.75 – 1.0 knots for most of the year but are relatively slower in November – December at an average of 0.5 – 0.75 knots. These currents can vary substantially within any given month and can increase up to 2 – 3 knots Mean sea surface temperatures are between 28^0 C and 29^0 C throughout the year.

The three atolls of Tokelau are 65 to 95 km apart (Fakaofo to Nukunonu, and Nukunonu to Atafu, respectively), making them relatively isolated from each other. This geographical isolation, both from a regional perspective and relative to the other atolls of Tokelau is of major significance for the maintenance of ecological systems in Atafu as discussed in this section.

Motu or Islets

Fakaofo atoll is relatively small in total area compared to many other inhabited Pacific Ocean atolls (Figure 2). The land area of Fakaofo consists of about 60 small islets surrounding a rectangular reef approximately 13.5 km in its longest axis (approximately south to north) and 10 km wide (approximately west to east). The total land area is only about 4 sq km, which with their linking reef system encircle a lagoon of about 59 sq km[6]. Individual motus vary greatly in size (from 6 km to less than 100m in length, measuring parallel to the outer reef edge) and none are higher than 5 m above mean sea level (Photo 1). Most motus have extensive accumulation of shifting coral sand around the intertidal shoreline and more permanent sand deposits above high tide levels. The inter tidal and littoral sand beaches are a veneer on top of solid beach rock which is periodically exposed and buried according to the seasonal shifts in sea conditions. The permanently exposed portions of motus are heavily vegetated by coconut trees in addition to small pockets of natural vegetation, but soils are poorly developed and highly porous. Storm surges during cyclones frequently result in waves sweeping across the motus and into the lagoon.

Fakaofo has a population of 564, living in 87 households on 2 islands[7].. Due to necessity Fakaofo's village is divided between two islets : Fale, the traditional Fakaofo village and Fenuafala, which was settled in the late 1960's (Tokelau Government, 1995). However, it operates as one village socio-politically, cultural and economically. The majority of the population (approximately 340 people in 51 households) resides on the tiny motu of Fale, on the mid-southwest side of the atoll. The nearby motu, Fenua Fale, on the north west corner of the atoll now houses the school, hospital and other communal enterprises and families have been moving there in recent years due to crowding on Fale. The population on Fenua Fale is now approximately 230 people in 33 households.

[6] Compared to Jaluit Atoll in the Marshall Islands with a similar small land area (7 sq km) but with a lagoon area of 690 sq km.

[7] SPC 1998 Tokelau Population profile – Based on 1996 Census: A Guide for Planners and Policy Makers. Secretariat of the Pacific: Community, Noumea.

Photo 1. Small uninhabited motu on the atoll rim with the typical wall reef formation in the southern Conservation Area that reaches to the surface in the foreground. Shallow channels run between the lagoon and the open ocean on either side of the islet.

(Photo Gordon Lapraik)

The islet of Fale is fully utilized for housing and associated village infrastructure. The lack of available land space on the islet has resulted in the communal piggery being located to the beach rock platform and reef flat on the northern flank of the islet. Here the pigs are exposed to all elements and confined to foraging on the adjacent reef flat at low tide. A significant portion of the northern side of the Fakaofo Village was eroded away during the large cyclone Ofa in 1990. Very little damage by cyclone Ofa was reported in the lagoon (Laboute, 1987) though there was apparently substantial deposition of village infrastructure material there due to the storm surge associated with the cyclone. This apparently included chemicals stored on Fenua Fala that may have included drums of DDT and other herbicides and poisons (i.e rat poison).

Photo 2. Community pigs forage on the reef flat on Fale at low tide in an area that formerly was part of the island but was eroded away by cyclone Ofa in 1990.

(Photo Gordon Lapraik)

A small islet, Te Afua Tau Tahi, located between Fenua Fale and Fale (Fakaofo Village) has been used in the past as the village cemetery. However, there is now insufficient land area available for the continuation of this use. In fact, the whole island is showing significant reduction in size due to erosion, with some of the graves now resting in the inter tidal zone.

Lagoon

Fakaofo lagoon does not have any deep water passages to the open ocean. The only water exchange between the lagoon and the open sea occurs through tidal inundation of the reef flat and from water pushed over the crest by oceanic waves and swells. Multiple shallow passageways between motus transfer water between the lagoon and the open ocean, but none are deeper than approximately a meter at low tide and most are no wider than approximately 50 metres. Fakaofo lagoon is effectively subdivided internally into a number of separate cells by the presence of continuous coral walls (Photo 1) that are only a few centimetres below the surface at low tide with shallow, variable width passageways between adjacent cells. Figure 2 .highlights the most pronounced lagoon cells present within Fakaofo lagoon. Other natural structures in the lagoon are a combination of steep sided patch reefs and extended walls of variable shallow depths that result in many semi enclosed portions of the lagoon and also serve to restrict internal water flow. The most open and well flushed section of the lagoon is located along the northern atoll margin (Ahaga Loa) where there are no permanently exposed land areas or islets.

Figure 2. Fakaofo Atoll place names and major reef structures.

Photo 3. Continuous wall reef in the southern sector of Fakaofo lagoon. These reef structures extend to the level of mean low tide and effectively separate large portions of lagoon waters at low tide and significantly reduce water circulation.

(Photo David Fisk)

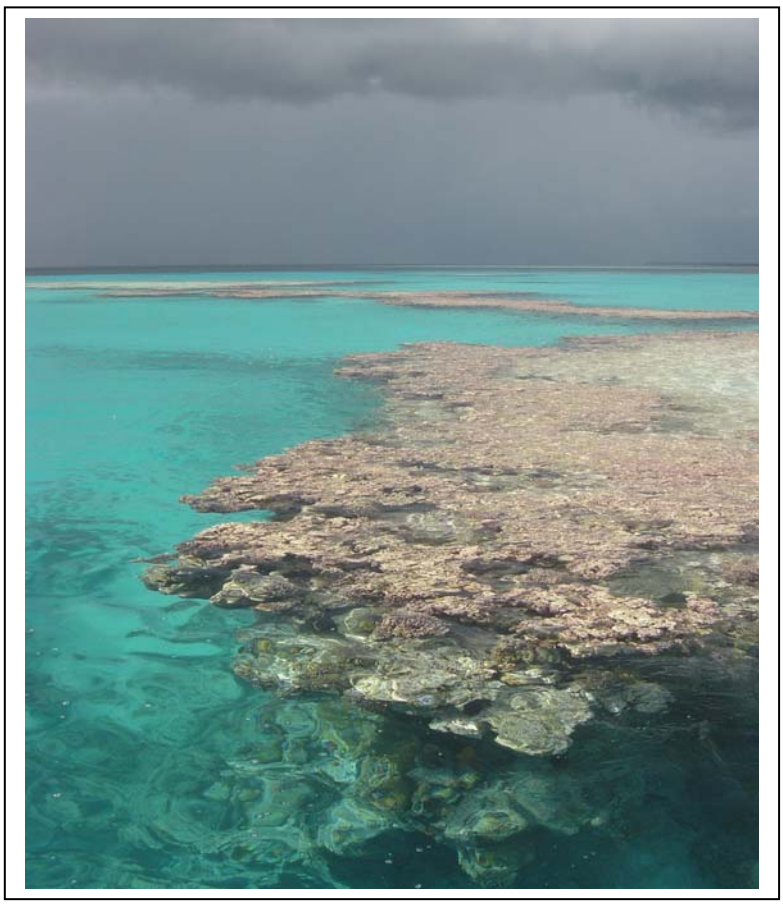


Photo 4. View of a wall reef in the southern lagoon which shows the tendency of these structures to extend out near the surface to create overhangs from the reef edge wall, effectively shading much of the side of the reef. A heavy rain squall approaches in the distance.

(Photo Gordon Lapraik)

Patch reefs and extended walls in the southern lagoon sectors are dominated on the surface by profuse growth of coralline algae[8]. The upper portions of the patch reefs frequently extend horizontally near the surface, giving a profile that typically shades the patch reef flanks. These flat tops and the common crevices and holes that are frequently formed under the surface growth offer refuge for many reef organisms. Eventually these unbalanced upper portions collapse under their own weight or are dislodged during storms to fall to the base of the reef or are thrown up on top of the reef.

The closed lagoon means that the removal from the lagoon of unwanted human derived waste and toxic substances will be very slow and these will possibly remain in the deeper parts of the lagoon for a considerable time. Naturally formed water conditions such as elevated sea temperatures during prolonged dry and calm weather also will remain inside the lagoon for longer than normal periods. Therefore the lagoon is highly susceptible to natural disturbances as well as to human induced ones, such as toxic substances from ship groundings, and land based sources of pollution. The potential for overheating of lagoon waters that can result in coral and other organisms becoming bleached and possibly dying is very high because of this lack of exchange of water with the open ocean. Bleaching and heating events will be a frequent occurrence if the conditions for bleaching become more common due to global warming. Another effect of global warming is that sea levels may rise and produce a greater degree of lagoon flushing, but this also means that less land space will be available and that there could be greater vulnerability to storm surge and cyclonic events. However, in the short term, bleaching will most likely become more prevalent prior to a marked increase in sea level, and the impact of bleaching has been noted in the status summaries below.

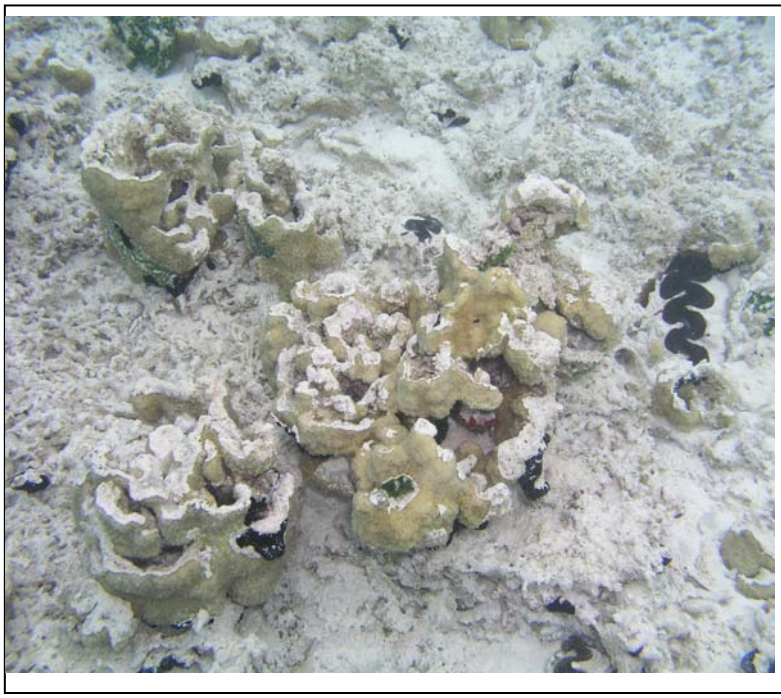


Photo 5. Fine sediment is present on all substrate surfaces within the southern CA which indicates very low water movement which has consequences for retention of warm water or pollutants, and subsequently for healthy growing rates of many reef animals.

(Photo David Fisk)

[8] **Coralline algae** refers to a type of hard algae that produces a skeleton of calcium carbonate or similar permanent skeleton. Coralline algae is very important to the maintenance and **growth** of reefs as it cements together other hard skeleton remains from corals and other reef organisms, ensuring that there is a net accumulation of the reef to counteracts the erosional forces that are common on a typical reef.

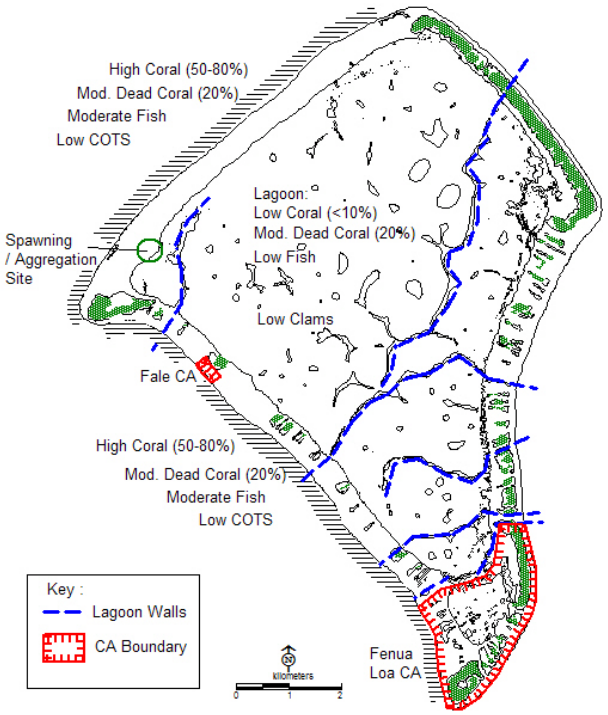


Figure 3. Fakaofo Atoll map showing the existing Conservation Areas, current status summary and major lagoon reef walls that are creating low circulation 'cells' within the lagoon.

The main area for water exchange between the lagoon and the open ocean is over the reef flat on the northern-north westerns side of the lagoon (the Ahaga Loa margin) though this area is still very shallow and limits the flow rate across the flat. Also, the channels adjacent to Fenua Fala islet in the region known as Fatu o Te Tuga are relative major water exchange areas. As well, water outflow is likely to move in and out through channels on the eastern margin (particularly through Motu Pelu and Ava Oto, the more northern islets), and through shallow channels in the western margin close to Fakaofo Village and Fenua Loa.

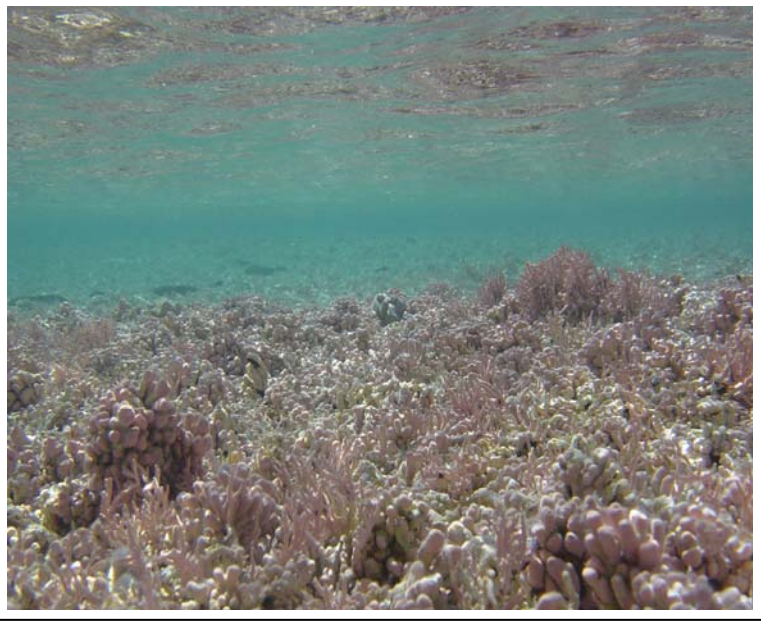


Photo 6. Close up photo of the main forms of coralline algae that dominate the shallow near surface portions of patch and wall reefs in the southern sector of the lagoon.

(Photo Gordon Lapraik)

Photo 7. Rapid growth of the surface coralline algae produces many crevices and holes in the patch reefs that are a feature of the southern sectors of the lagoon. These crevices offer refuge for animals such as crabs and crayfish as well as fish, but these species were not common in these areas.

(Photo David Fisk)

The lagoon has steep edges along the inner perimeter that drop away from the inner reef flat. The inner reef flat is either composed of conglomerate coral rock or loose rubble and is dominated by coralline algae. The lagoon is quite deep in places (40-50 m depth), with a general transition of relatively deeper to shallower depths along an axis from the south east to the north west corner.

The potential for introduced fishery species for mariculture is also an important issue for consideration in relation to the low water exchanges from the lagoon. High density mariculture of molluscs (pearl shell, clams) produce high nutrient loads in the surrounding water that can kill the animals if water exchange is not sufficiently high to remove these potential toxic substances. Trochus (*Trochus niloticus*) culture is different in that animals require the reef flat and crest habitat to live where there is very high water flush rates. The success of previous attempts with trochus introductions is discussed below in the status section.

Fish abundances were generally very low in the lagoon, with the exception of areas along the lagoon edge which were adjacent to the shallow channels that allow movement between the lagoon and the open ocean. The higher fish aggregation areas adjacent to the channels (see technical report) may represent accumulation areas for fish intending to move through the channels out to the open ocean. The survey period (October – November) coincided with the time of year when many reef fish commonly undertake mass spawning (usually in areas adjacent to deep water and with access to the open ocean). Most fish observed in the lagoon were either the common herbivorous fish families of Acanthuridae or Scaridae along with typical site attached families[9] of butterfly fish, damsel fish and wrass species.

[9] **Site attached fish** refer to those fish groups that do not roam or move around the reef but remain within a small area for all or most of their lives.

Reef Flat

The reef flat is generally smooth with shallow pools and very little heterogeneity or places for animals that could utilise these for shelter. The reason for the generally low relief on the reef flat is probably due to the high wave action and lack of water inundation to allow for reef growth (particularly through coral and coralline algae growth). The average height of the reef flat around the whole perimeter of the atoll is slightly above the normal minimum low sea level. The reef flat habitat typically shows a narrow set of zones commencing with the solid and pink coloured encrusting coralline algae zone on the crest and the outer flat area where the wave break occurs.

A zone of encrusting turf and macro algae and some wave adapted coral growth forms is present adjacent to the coralline algae zone towards the lagoon. Some shallow depressions also occur in this zone but few are deeper than 20 cm depth. In places, these depressions also have short overhangs which extend up to 30 cm, offering some shelter for animals, including some invertebrates (like octopus, crabs, and crayfish and fish). On the sections of the reef flat (Figure 2), there are relatively high sections of carbonate rock that are rapidly eroding, and possibly represent relic reef flat levels that were present prior to recent uplift. There are a number of thin fracture lines that typically extend across the reef flats at various points around the island that were a cause for minor concern to some locals. These are probably normal features of the reef and do not necessarily indicate that the atoll is unstable.

Photo 8. Photo of the inner reef flat and lagoon edge on the southern lagoon margin with shallow pools along this back edge. This can be good giant clam habitat but on Fakaofo clams were not often observed here. The reef flat typically shows zones that are dominated by different communities of plants and animals and are a response to wave intensity and depth of water at low tide.

(Photo Gordon LaPraik)

The reef flat is frequently visited by schools of herbivorous fish groups and some sharks at high tide. The herbivorous fish exploit the abundant algal growth that is present on the usual bare reef surface. Usually, these fish retreat to the slope or lagoon edge during the low tide periods because of insufficient water depth.

Reef Slope

The reef slope varies in steepness and hence in the expanse of shallow (<40 m depth) reef structures. Spur and groove formations are common in the upper 10 m depth range. The grooves are smooth and devoid of reef organisms except for turf algae. The upper surfaces of the grooves are well covered with robust coral colonies in particular. The highest fish densities are usually observed in the spur and groove zone where herbivorous fish are commonly feeding (especially at low tide). Strong wave action is common on the outer edge of the reef on all sides of the atoll. The dominant reef benthos on the slopes is very similar to what was described by Laboute in 1987. That is, there is a dominance of branching *Pocillopora* spp and *Porites* spp with relatively less cover of encrusting and foliaceous *Montipora* spp and low cover of *Acropora* spp, *Hydnophora* spp, *Pavona* spp, and *Millepora* spp. All species present are resistant to strong wave action even though they represent very different growth forms.

Photo 9. Typical spur and groove formation on the upper slope that leads up towards the crest zone where the wave breaks occur. The grooves are used by many fish as feeding locations as well as refuges, and entrances to the reef flat. The grooves are where large boulders and broken coral move out to deeper water in high wave conditions, making the walls of the grooves smooth from constant erosion, which in turn creates good habitat for turf algae on which the herbivorous fish feed. (Photo David Fisk)

The general profile of the reef slope is a smooth undulating shape with frequent depression running perpendicular to the reef edge. The calcareous macro algae *Halimeda* spp is common in crevices and cracks on the shallower slope areas. Fish densities varied greatly in the mid slope zone but commonly the site attached fish groups are present such as butterfly fish, damsel fish, angel fish, wrass, and (fewer) grouper species. Large schools of predators were occasionally encountered, particularly on the acute angles or corners of the atoll perimeter. This location is where many sharks and large predators like barracuda can be located. The corners of the atoll are probably attracting these predators because these are zones of tidal convergence and hence places where food is more sources meet, setting up a food chain that

attracts the predators in high numbers. The timing of the survey teams visit also coincided with the annual early summer fish spawning period, and aggregations of spawning fish species were sometimes observed at these corner location, e.g., on the corner opposite Fenua Fale Island.

The outer slope tends to drop away very steeply to deep water at approximately the 30-40 m depth. At the edge of the drop off in 30-40 m, the dominant coral form was plate forming massive *Porites* spp that normally grows as large hemispherical colonies in other habitats.

2.3. Resource and Habitat Accessibility

The relationship between the coral reef and the people who depend on its resources is complex and is highly dependent on safe weather conditions, the level of technology available to the people, and the knowledge of the community of the cycle of resources. For example, access to outer reef resources is weather dependent as reef attached species can only be harvested close to reef edge due to deep water near shore where strong oceanic swells impact on the reef edge. In contrast, offshore pelagic[10] fishing can also be weather dependent but this restriction can be partially overcome if relatively large seaworthy boats can be used. There is a limitation to the use of modern, ocean worthy boats in Fakaofo, because they cannot be safely moored or launched from shore due to the exposed position of the nearby outer slope and to a lack of access to a safe lagoon anchorage.

In contrast, lagoon resources are accessible all year round due to the extreme calm conditions present. However, distant locations in the lagoon from the centralised village residences still require special effort and / or mechanized boats which increase costs of accessing the resources. The effect is evident in the distribution and abundance of many fishery species within the Fakaofo lagoon (see Ecosystems and Resources below).

Walking around the exposed reef flat at low tide can be an alternative way of accessing distant locations, but this will mean that the tidal cycle will restrict the distance that can be travelled in a single low tide period or that temporary stays on distant island are required. Reef flat resources can be readily accessible at low tides (with the limitation of tidal periods mentioned above) but the presence of resources is also limited due to degree of tidal exposure to air and the shallow characteristics of most of the depressions in the reef flat.

Mobile species move in and out of the lagoon and on and off the reef flat through shallow channels but this concentration of mobile species to well defined and accessible areas make them extremely vulnerable to harvesting. Obviously the people of Fakaofo have a wealth of knowledge of the seasonal movements of fish in particular and also where the different species tend to be most prevalent when utilizing the channels. The movement of species through these channels is related to both tidal and seasonal biology rhythms particularly to spawning and reproduction. Many of the known aggregations of species may be due to the need to access the outer slope habitat to undertake the spawning aggregations that are typical of many reef

[10] **Pelagic** fishing targets fish species that live in the mid water away from the shallow reef areas, though the presence of a reef often provides a reference point and water movements that create food chains that are attracted to the food that is brought to the surface from these currents.

species.[11] This is backed up by the observation of local people that fish usually are full of eggs when moving to the outer slope, and the same species lack eggs when returning to the lagoon.

The degree of separation of the lagoon from the outer reef habitats means that juveniles of species adapted to lagoon conditions can be retained in greater numbers than in more open lagoon systems. For example, this characteristic is probably why there is a potential for high giant clam stocks in the lagoon, and for other sedentary organisms[12] that cannot move to the outer slope habitat.

2.4 Resource Management

The limited land availability and impoverished soil of Fakaofo has meant the community is highly dependent on the marine resources of their lagoon and the surrounding ocean. Despite Tokelau being an associated territory of New Zealand[13] and having regular transport to Samoa, Fakaofoans remain highly dependent on their marine resources for subsistence. Marine resources in Fakaofo are open access to the village level. Traditionally the management of atoll resources lies in the hands of the *taupulega*.

Resource management in Fakaofo has occurred in the past through a number of methods. For example at certain times the *taupulega* would temporarily restrict resource harvesting from family owned land (times of drought or after cyclone). During these times, resources are harvested and distributed communally on the *taupulega's* command. The people of Fakaofo also have a variety of traditional resource management practices. Restrictions on resource harvesting exist at certain times depending on the ruling of the *taupulega* (usually related to drought, bad weather and special occasions) and post-harvest rules exist for sacred species (i.e. turtles must be shared with the whole village), permanent harvesting rules however did not traditionally exist.

Traditionally the isolated conditions of the Tokelauan society, limited land for population growth and warfare may have meant there was no need for marine resource restrictions due to functionally unlimited marine fisheries (Johannes 2002). It appears traditional fishing gear, lack of freezers, no regular transport to Samoa along with the *inati*[14] system and the *taupulegas*' rule, enabled to a certain degree the sustainable use and management of each of the atolls limited resources. Growing individual expectations are increasing the pressure on Fakaofoans to accumulate possessions and therefore cash, the introduction of freezers, regular transport to Samoa and modern fishing gear, have meant that the pressure on fisheries resources has greatly increased. Motorised water vessels have enabled villagers to fish when it is convenient (not dependent on wind or weather factors) and more frequently thereby increasing fishing pressure. Local opinion in the status of marine species indicates that the impact of the motorised boat to Tokelau has had a large socio-economic, cultural and environmental impact.

[11] **Spawning aggregations** are a mechanism that is commonly adopted by reef species so as to maximize their collective reproductive output in the presence of high predation of the reproductive adults and spawned products by other organisms.
[12] **Sedentary organisms** are species that attach to the substrate and remain in that place for their full life cycle.
[13] Tokelau became a British protectorate is 1877 when Britain included Tokelau in the boundaries of the Gillbert and Ellice Island colony. In 1925 the British government transferred administrative control of Tokelau to New Zealand. Formal sovereignty was transferred to New Zealand under the 1948 Tokelau Act. (Statistics NZ 1993).
[14] Traditional institutionalised sharing, where every member of the village (infant, child, adult and elder) receives and equal portion of harvested resource i.e. fish, coconut etc.

Current and historical resource management practices based on (traditional/living) ecological knowledge

- *Lafu:* a temporal restriction on harvesting, according to respondents it was mainly a terrestrial-based management strategy, imposed by the *taupulega* and something, according to respondents, generally participants felt that this system has not been practiced for some time;
- *Fakahao* (no-take area): this interpretation of the 'western' conservation area concept represents a modern approach to resource management. Site selection is not necessarily aimed at protecting specific habitats or species, but at increasing resources for future harvest;
- Targeting older species and leaving the young: according to community members this is not a rule but a general practice, however it depends on the individual and is often not followed;
- Protection of vulnerable life history stages: no respondents mentioned this as a currently practiced management system;
- Territoriality[15]: marine ownership and resource (offshore and lagoon) rights are restricted to Fakaofoans, outsiders must gain permission from the *taupulega* to harvest resources;
- Traditional knowledge and expertise: Master fishermen (*tautai*) and *toeigas* once possessed in-depth detail knowledge of the relationship between specific marine species (their lifecycle and behaviour) and the lunar cycle. This knowledge was essential to successful fishing. These days however this knowledge is not as vital due to new fishing technology, cash economy and improved transportation; and
- Communal ownership of land: a few pieces of land are set aside as communal land. This land is used as a reserve area and probably formed an important component of the atolls resource management.

The main form of 'conservation' referred to in text and by practitioners is the 'lafu' system. This is a restriction imposed by the *taupulega* over a particular spatial area for a short-time period (i.e. 4-6 months). All resource harvesting is prohibited within the lafu area unless otherwise specified by the *taupulega*. Toloa, Gillet et al (1993) describe the lafu system as a management prescription that bans all types of fishing in a specific area of the reef. However, in our recent investigation participants felt that *lafu* was something only ever applied to the terrestrial environment[16]. *Lafu* was imposed on land when resources were scarce such as post-cyclone, in preparation for a special occasion when bulk resources will be needed (therefore the *lafu* acts as a larder) and at other times when there was a reduced abundance in a particular resource. In the past it appears this system was extremely important, now however according to Fakaofoan respondents it is something that is considered an 'old way', recalled from childhood and something that was land-based.

It has been asserted in the past that offshore fishing is encouraged in Tokelau, subsequently protecting inshore (lagoon) fisheries (Toloa, Gillet *et al* 1993). We found lagoon fisheries were preferred by community members in Fakaofo, and fishing effort was relatively even (between offshore and the lagoon) according to workshop participants and respondents. This could

[15] The traditional community-based fisheries management system in Tokelau is similar to other parts of the pacific, defined by common property regimes where access to a particular territory is limited to a defined user-group and control of resource use and access resides in traditional local authorities (Ruddle 1998).

[16] i.e. "just on the land not sure about the sea… I remember in the old days the toeiga put a stop to going to that area for a period of time, just like conserving for sometimes… " (FI12).

however reflect the time of year in which the investigation was conducted. It may also however be the result of a change in practices and new technology. For example, according to participants there is a reduced reliance on fisheries resources due to the availability of imported goods. It may also reflect the reduced emphasis on the '*tautai*' and the previously elevated status in tuna fishing. In Tokelau social status was gained through the possession of this knowledge as well as through demonstrated skill in utilising this knowledge. In a traditional Tokelauan society, a tautai was highly respected and needed[17].

Conservation Areas
Currently there are two "no-take" or '*fakahao'* (conservation) areas in Fakaofo. One is close to the village and is specifically for giant clams, all other activities and resource harvesting are allowed within the *fakahao*. The other *fakahao* is situated in the southern corner of the atoll and encompasses lagoon and land area. All resource harvesting activities are prohibited in this area unless otherwise directed by the taupulega.

Based on data from interviews and meetings, the main purpose of the conservation areas from the community's perspective, is to improve the marine resources of each atolls lagoon as opposed to (a western protected area aim of) improving biodiversity and ecosystem function. This does not necessarily inhibit the effectiveness of the conservation areas. A no-take conservation area of the right design and management can achieve both sustainable fisheries of the greater area and also protect the areas biodiversity and ecosystem function. However the Fakaofo conservation areas lack clear vision, appropriate design and position, management, community commitment and a concerted attempt at compliance and enforcement, and therefore all currently lack effective management. It appears the general community has not been able to conceptualise the conservation area ideal beyond a communal fish larder.

2.5 Ecosystem and Resource Status

2.5.1 Habitat Characteristics

Visibility of underwater conditions can be an indicator of relative turbidity or the amount of material that is suspended in the water. At Fakaofo, manta tows recorded very good visibility in nearly all the outer slope sites (defined as greater than 18m of vertical clarity), compared to the lagoon sites where low or medium visibility (less than 6m to less than 12m vertical clarity) was generally noted. In some sections of the lagoon, water clarity was much less than 6 m visibility. For example, in the southern conservation area (Te Atu Hakea) which is a very enclosed section of the lagoon, the turbidity levels were very high with a dense suspension of fine mud or clay occurring naturally in the water. The conditions in these areas are such that light penetration to the lagoon floor is very low and the level of suspended sediment is very high which will interfere with the ability of many filter feeding organisms to live. The relative visibility of areas within the lagoon is indicative of the relative level of water flushing, as clarity decreases from the northern end of the lagoon to the southern end. Some of the central isolated patch reefs and shorter wall reefs are surrounded by very clear water as little resuspension of sediment from the lagoon floor occurs due to the depth of surrounding water and the distance from the more turbid perimeter of the lagoon.

[17] The deterioration of traditional fishing skills and the lack of emphasis placed on the development of a fisherman into a tautai has had a negative impact on marine conservation in Tokelau according to Toloa, Gillet et al. (1993).

The broad assessment of the type of live organisms (Table 1) that were present in the lagoon and outer slope showed that 71% of tows in the lagoon and 100% of tows on the outer slope were dominated by live coral. The lagoon habitat also recorded a low number of tows where the benthos was dominated by filter feeding invertebrates like ascidians and sponges[18] though they were never dominant relative to other organisms. The presence of certain filter feeding animals are a significant characteristic of the lagoon and although the data from the tows does not really demonstrate this fact (due to the method of assessment), there is a dominance in terms of biomass, of filter feeding organisms on the patch reefs. Significant filter feeding organisms include the spiny oyster (*Spondylus* spp) and other bivalves (especially the boring date mussel, *Lithophaga* spp).

Habitat	Benthos					# Tows
	ASC	CA	LC	MA	SP	
Lagoon	14.3	0.0	71.4	0.0	14.3	7
Slope	0.0	0.0	100.0	0.0	0.0	12
All Habitats	5.3	0.0	89.5	0.0	5.3	19

Table 1. Summary of habitat dominance in terms of percentage of tows for broad scale tows in the lagoon and outer slope habitats of Fakaofo Atoll. ASC = Ascidian, CA= Coralline algae, LC = Live Coral, MA – Macro algae, SP = Sponge.

2.5.2 Biotic Characteristics

Hard Coral

A preliminary checklist of hard coral species present on Nukunonu shows that there are approximately 70 to 80 species present. Within this suite of species there is a clear dominance of a small number of species. That is, a few species of *Pocillopora* spp are dominant on the outer slope along with *Montipora* spp, along with 2 to 3 species of *Porites* spp. In the lagoon, where coral diversity is higher than the outer slope and reef flat, similar species of *Porites* spp to those present on the slope are also dominant, along with a few *Acropora* spp, *Echinopora pacificus*, and *Cyphastrea* spp. There is also the likelihood that a number of rare species are present that have not previously been recorded from the Pacific Ocean or from the Central Pacific Ocean, and that there may be one or two coral species new to science. These records are awaiting confirmation of their identities from experts in coral taxonomy and so these conclusions should be treated as preliminary findings at this time.

The composition of dominant coral species observed during this survey is consistent with descriptions of dominant species by Laboute (1987) from surveys that were carried out after the passing of cyclone Tusi in early 1987.

[18] **Filter feeding invertebrates** are animals that attach to the substrate and feed exclusively by drawing water through their gills and filtering out edible particles that are floating in the water. Live corals can also utilize this food source though most energy requirements are obtained by the corals living in association with microscopic algae.

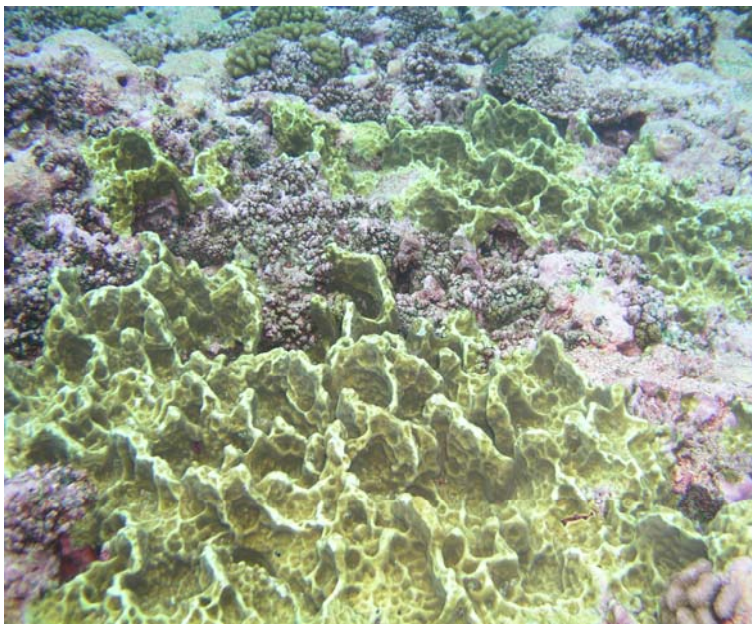


Photo 10. An uncommon live colony of the yellow stinging coral *Millepora* spp on the shallow reef slope on the western margin of the atoll. The genus is very susceptible to bleaching and has been significantly reduced in abundance in the lagoon and on the slope.

(Photo David Fisk)

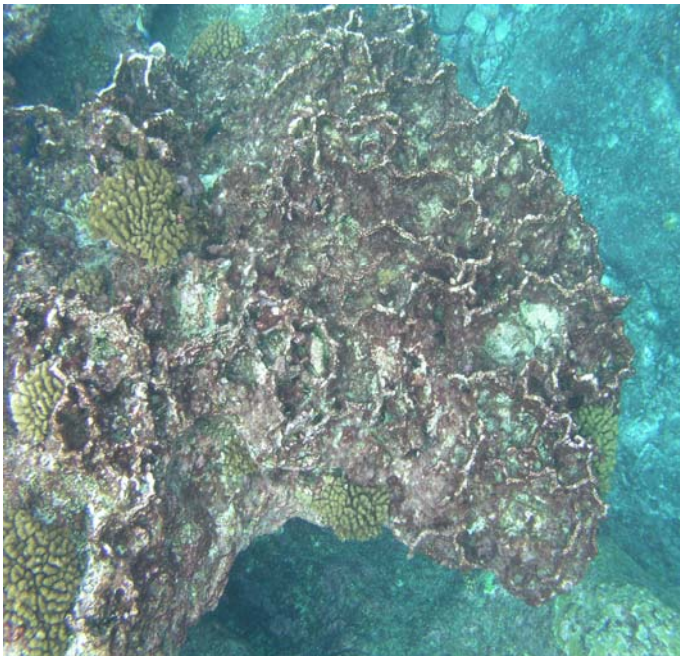


Photo 11.

The obvious remains of a stinging coral colony (*Millepora* spp) in the shallow upper slope which has probably been killed by recent bleaching events.

(Photo David Fisk)

Dominant live coral growth form was assessed as an indicator of the type of habitat that was present for other reef organisms that associate with different coral forms (Table 2). Growth form is also an indicator of natural environmental conditions that occur in a particular area[19]. The results indicate that in the lagoon habitat, encrusting and massive coral growth forms are clearly dominant, whereas on the outer slope, foliose and massive forms dominate

[19] Different **coral growth types** can indicate the degree of turbidity (therefore light conditions) or sedimentation, wave action, and water flow as their growth rates and ability to survive in varying conditions are influenced by the natural environmental conditions.

Photo 12. Mid to lower slope scene showing the typical foliose *Montipora* spp and flat plate-like *Porites* spp that is typical of this habitat. The *Porites* spp normally forms massive hemispherical colonies but in this habitat it changes form as a result of the exposed weather conditions. These two genera appear to have survived the recent bleaching events unlike other typical slope species.

(Photo David Fisk)

The dominance of massive and encrusting forms on the lagoon indicate that relatively high sedimentation (or turbidity) is present compared to the outside slope where strong wave action and water flows are the normal condition. This is a predictable result, but there are some noticeable omissions of typical dominant growth forms for these types of habitats and these are described in the Disturbance and Health sections below.

Habitat	Coral Form								
	ACB	ACC	BRA	ENC	FOL	MAS	POR FLAT	SUB	Total
Lagoon	0.0	0.0	0.0	71.4	0.0	28.6	0.0	0.0	7
Slope	0.0	0.0	0.0	0.0	33.3	66.7	0.0	0.0	12
All Habitats	0.0	0.0	0.0	26.3	21.1	52.6	0.0	0.0	19

Table 2. Summary of dominant growth forms from manta tows conducted in the lagoon and outer slope habitat. ACB = *Acropora* branching; ACC =*Acropora* corymbose (thick pillow shape); BRA = Other branching corals; ENC = Encrusting; FOL = Foliose; POR FLAT = Flat plate *Porites*; SUB = Submassive.

Estimates of cover of live, dead, and mortality index (or health index) from manta tows (Table 3) shows low live coral cover in the lagoon (7.1%) compared to the slope (61.7%), and dead coral cover of 20% in the lagoon and 27% on the slope. The mortality index was higher in the lagoon than on the slope (0.8 compared to 0.3, respectively) reflecting the much higher recent death of corals that has occurred in the lagoon. The number of completed tows was relatively low overall, but this pattern was also verified by timed swims conducted in other parts of the same habitats. Soft coral was extremely rare and was not recorded from any of the survey sites, though incidental observations were made of the presence of small colonies in a few slope sites.

TOWS		%LC	%DC	%SC	MI
LAGOON	Mean (sd) =	7.1 (5.7)	20.0 (0.0)	0.0 (0)	0.8 (0.1)
SLOPE	Mean (sd) =	61.7 (22.3)	27.1 (16.5)	0.0 (0)	0.3 (0.2)
TOTAL	Mean (sd) =	41.6 (32.3)	24.5 (13.4)	0.0 (0)	0.5 (0.3)
SWIMS					
LAGOON	Mean (sd) =	33.1 (24.6)	7.3 (6.4)	0.0 (0)	0.3 (0.3)
SLOPE	Mean (sd) =	39.7 (16)	34.3 (16)	0.0 (0)	0.5 (0.2)
TOTAL	Mean (sd) =	34.6 (21.3)	20.0 (18.4)	0.0 (0)	0.4 (0.2)

Table 3. Summary of manta tow and timed swim mean (and standard deviation) estimates of live coral (LC) cover, dead coral (DC) cover, soft coral (SC) cover, and a calculated mortality index (MI) based on the dead to live coral cover ratio. Number of lagoon manta tows = 7 and slope tows = 12. Number of lagoon swims = 15 and slope swims = 16.

The additional visual estimates of coral cover from the timed swims (20 mins per swim) in both lagoon and slope habitats are also included in Table 3. Mean estimates for the lagoon sites differ between tow and swim methods, but are similar for the slope estimates. This difference for the lagoon sites is probably due to the fact that the swim surveys resulted in a better view of the sides of the patch reefs and wall reefs that were not as visible from the surface during tows (where the tows are usually viewed from). Towing with a boat also required that the boat avoid very shallow areas so the tows tended to be undertaken in relatively deeper water than for the swims and as there was a rapid diminution of coral cover with depth in the lagoon, the two methods might be expected to differ. Many of the southern sites characteristically have the upper portions of the reefs extending vertically to create overhangs, thereby shielding visibility of the sides of the patches from above. Also, the majority of dead coral cover is mostly visible from above in contrast to the live coral cover that is largely on the sides of patch reefs. This would explain the discrepancy between the estimates from the two methods. For Fakaofo atoll, the mortality index ranged between 0.4 and 0.5 which corresponds to approximately 40 -50 % decrease in overall coral cover in the recent past and results in a current live coral estimate of approximately 40% cover with approximately twice as high cover on the slope compared to the lagoon.

Macro Invertebrates

Macro invertebrate distributions showed a relatively low presence of clams, holothurians, and selected filter feeding invertebrates (restricted in this survey to obviously abundant filter feeding bivalves (eg, *Spondylus* spp, spiny oyster), sponges and ascidians, Table 4). Clams are discussed in more detail below but as was the case from the manta tows, most clams were observed inside the lagoon with 40 % of timed swims (total of 15) where few or many clams were observed. Sea urchins were not recorded in either the lagoon or slope tows. Other invertebrates, especially Asteroids (starfish), were extremely rare in the lagoon and on the outer slope. Very low densities of crinoid starfish were observed on overhangs of lagoon patch reefs while none were observed on outer slope sites.

Holothurians were observed in 20 % of lagoon swims (Table 4), and were always in low abundance. Holothurian species present were mostly *Holothuria atra*, with also an occasional *Bohadaschia argus*, or *Actinophryga mauritiana*. Filter feeding macro invertebrates (sponges

and colonial or solitary ascidians) were present in 47% of swims in the lagoon, particularly in the southern section of the lagoon where the semi enclosed cells or sections of the lagoon were located.

Photo 13. The outer flat zone on the NW margin of the atoll south of Fenua Fala island. Two holothurian species are shown : the very uncommon *Actinophyga mauritiana* (foreground) and the common *Holothuria atra*. The substrate is typically covered with turf and low growing macro algae.

(Photo David Fisk)

The slope habitats surveyed by timed swims (Table 4) confirmed the general pattern from the more broad scale manta tows with no clams or large visible sponges or ascidians present and very few holothurians. The holothurians observed in swims on the slope were relatively uncommon and in very low densities and were different species to those observed in the lagoon, namely, *Holothuria scabra* and *Actinopyga mauritiana*.

HABITAT		
LAGOON	Sites with CLAMS (% swims)	6 (40 %)
	Sites with HOLOTHURIANS (% swims)	3 (20 %)
	Sites with OTHER (% swims)	7 (47 %)
SLOPE	Sites with CLAMS (% swims)	0
	Sites with HOLOTHURIANS (% swims)	1 (6 %)
	Sites with OTHER (% swims)	0
Total Sites with CLAMS (% swims)		6 (18 %)
Total Sites with HOLOTHURIANS (% swims)		4 (13 %)
Total Sites with INVERTEBRATES (% swims)		9 (27 %)

Table 4. Summary of timed swim data recording the presence of selected macro invertebrates. OTHER refers to the obvious abundance of large filter feeding sponges or ascidians. Number of lagoon swims = 15 and slope swims = 16.

Photo 14. The large orange sponge (F. Axinellidae) is a very common and conspicuous representative of the sponges in the lagoon. Also, there are abundant large bivalves (particularly, *Spondylus* spp shown here). The encrusting coral *Echinopora pacificus* is a very common coral found on the sides of patch reefs in the lagoon.

(Photo David Fisk)

Giant clams (manily *Tridacna maxima*) were generally in low numbers and were mainly observed in the lagoon of Fakaofo during manta tow surveys (Table 5). Caution should be taken when interpreting these results for fishery potential as there is a very high standard deviation associated with the mean value, which means that the distribution of clams is highly variable over the whole lagoon. Clam densities per hectare are highly dependent on the proportion of suitable hard substrate within the area of concern.

Within the lagoon, densities of clams tended to increase the further away from the principal settlements of the two islands on the NW side of the atoll. Table 5 shows the clam density estimates from manta tows which averaged 140 individuals per tow with each tow covering approximately 2000m^2.

The conversions of these densities to numbers of individuals per hectare are also presented in the table. It was estimated that the lagoon has overall densities of 350 clams per hectare. Almost all clams were of the one species, *Tridacna maxima*, with only a single individual of *Tridacna squamosa* observed in the southern Conservation Area.

Lagoon	
Mean Clams / Tow (SD)	140 (60)
Mean No./Ha (SD)	1166 (497)
Slope	
Mean Clams / Tow (SD)	0.1 (0.3)
Mean No./Ha (SD)	0.7 (2.4)
Overall	
Mean Clams / Tow (SD)	52 (77)
Mean No./Ha (SD)	430 (645)

Table 5. The mean numbers of clams per manta tow and per hectare for the lagoon and slope habitats on Fakaofo Atoll. Number of lagoon manta tows = 7 and slope tows = 12.

Photo 15. Giant clams (*Tridacna maxima*) among a massive *Porites* spp coral colony in the northern sector of the lagoon. Most observations of clams were in densities lower than those shown here.

(Photo David Fisk)

Trochus shell species were introduced to Fakaofo in the 1980's at two sites on the south reef flat (in the current Conservation Area) and the west reef flat adjacent to Fakaofo Village. Extensive surveys of these two sites at very low tide revealed no individuals at the southern site and a reasonable population at the Fakaofo Village site.

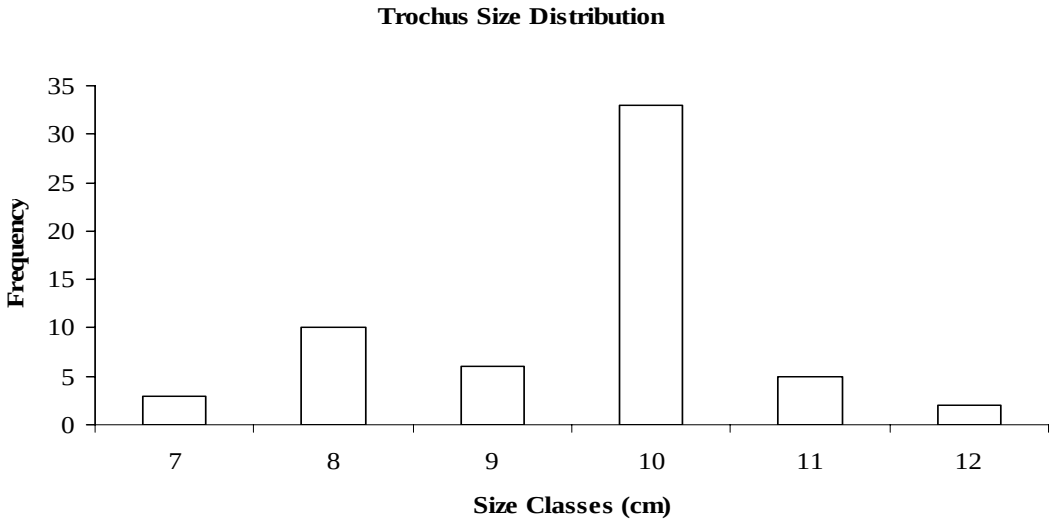


Figure 2. Size distribution of trochus from the outer reef flat and crest north of of Fale Island. The median size of 10 cm is only slightly larger than the median size of this population which was also surveyed in 1998 (Passfield, 1998).

Fish Communities

The status of fish from manta tow surveys (Table 6) showed that low numbers (less than a total of 100 fish per 3 min tow) were recorded from all lagoon sites. In contrast, 7 tows on the slope recorded high fish numbers (greater than 500 fish per 3 min tow) and the other 5 tows recorded medium numbers (100-500 fish per 3 min tow).

	Lagoon	Slope	Total
Butterfly fish	14.3	0.0	5.3
Damsel fish	14.3	0.0	5.3
Grouper	0.0	0.0	0.0
Snapper	0.0	0.0	0.0
Mixed	0.0	0.0	0.0
Paddletail	0.0	0.0	0.0
Parrot fish	57.1	58.3	57.9
Rabbit fish	0.0	8.3	5.3
Snapper	14.3	0.0	5.3
Surgeon fish	0.0	16.7	10.5
Trevally	0.0	8.3	5.3
Trigger fish	0.0	8.3	5.3
Wrass	0.0	0.0	0.0
Number of Tows	7	12	19

Table 6. The dominance of fish families recorded in manta tows from lagoon and slope habitats.

Parrot fish (F. Scaridae) are the most dominant family in both the lagoon and slope habitats, and surgeon fish (F. Acanthuridae) were the second most abundant fish family. The slope and lagoon habitats showed a different range of family dominance outside the top few dominant family groups. Butterfly fish, damsel fish, and snapper families were recorded as dominant in some lagoon habitats in contrast to the slope where rabbit fish, trevally and trigger fish were sometimes dominant.

The fish species list (Annex 1) indicates the relative paucity of predator fish species and the dominance of herbivorous fish, particularly, surgeon and parrot fish. There are representatives of many major reef fish groups in the overall fish populations of Fakaofo but often only a few species from that family are present. This characteristic demonstrates the relative isolation of Fakaofo and its vulnerability to over harvesting pressure. There are also very few species present in the lagoon along with the relative low abundance of all fish species. This also is a characteristic of remote atolls, with the majority of fish species and biomass mainly confined to the slope.

Photo 16. A rare observation of coral trout *Plectropomus areolatus* on the deep drop off at approximately 40m depth.

(Photo Gordon LaPraik)

Specific fish species that were once abundant but are no longer commonly seen are the coral trout (*Plectropomus areolatus*) and the black trevally (*Caranx lugubris*). Both species were rarely seen during the surveys though no surveys specifically targeted these species in particular. The few observations of these species were confined to isolated reports of a few individuals in deep water on the lower slope (in >30m depths).

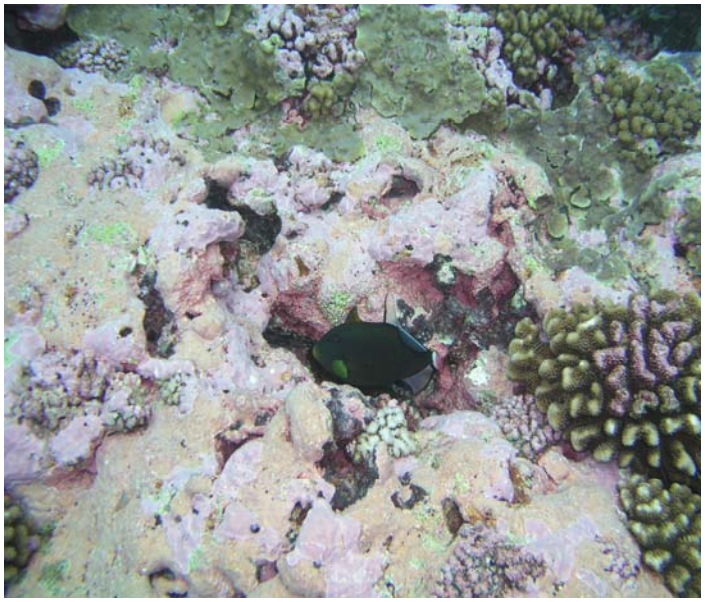


Photo 17. Holes and crevices are used by a variety of fish as refuge from predators. Here a trigger fish is on the entrance of a hole in the shallow slope habitat.

(Photo David Fisk)

Photo 18. School of parrot fish feeding along the upper slope and crest zone in the vicinity of the spur and groove zone.

(Photo Gordon LaPraik)

Specific fish species that were once abundant but are no longer commonly seen are the coral trout (*Plectropomus areolatus*) and the black trevally (*Caranx lugubris*). Both species were rarely seen during the surveys and the few observations were confined to isolated individuals in deep water on the lower slope (in >30m depths).

A checklist of fish species that were observed during all field work was compiled for Fakaofo Atoll and is presented in Annex 1. Some general information is included on habitats where each species were observed, their relative abundance, and their behaviour with respect to groupings.

Photo 19. Schools of convict surgeon fish here on the shallow outer slope are typical herbivors that utilize the reef flat and slope according to tidal conditions.

(Photo David Fisk)

2.5.3. Disturbance and Health Indices

Mortality indices from the manta tow data strongly show that there is a higher than normal proportion of dead coral in both lagoon and slope habitats (Table 3). Much of the dead coral in the lagoon were either from the genus *Acropora* spp (corymbose or think 'pillow' forms), *Stylophora* spp, or *Millepora* spp (branching forms). All of these genera were relatively common in the lagoon so the high reduction in abundance of these species has resulted in a shift in coral dominance in the lagoon. The selective mortality in these species is consistent with mortality due to bleaching, and this correlates with facts given to the survey team by villagers. Similarly, higher than normal ratios of dead coral on the slope is most likely due to bleaching in the recent past. In contrast to the lagoon, mortality on the outer slope was most pronounced in the dominant *Pocillopora* spp (particularly *Pocillopora eydouxi* and *P. cf indiana* or *P. cf zelli*), and has been very severe on *Acropora* spp plate colonies which are not present in the lagoon. Massive colonies of *Millepora* spp also were severely affected by the bleaching event and this species, along with *Acropora* spp, has been almost totally eliminated from the slope.

Photo 19. Following recent bleaching events there has been selective death of coral species which is being exploited by species with growth forms that can rapidly grow and occupy the space. Here a foliose *Montipora* spp colony is overgrowing a recently dead Pocillopora spp.

(Photo David Fisk)

Photo 20. White feeding scars from the gastropod *Drupella* spp is evident on a *Montipora* spp plate on the southern mid slope adjecent to the Conservation Area. Recently dead colonies from bleaching events of *Pocillopora* and *Acropora* spp are also shown.

(Photo David Fisk)

Natural disturbances to the coral reef of Fakaofo are also occurring from other factors in addition to bleaching, and include coral disease, feeding scars from a gastropod (*Drupella* spp) and from crown of thorns starfish (COTS, *Acanthaster planci*).

Most of the current disturbances were observed on the slope (58% of tows were observed with at least one type of disturbance) and some tows were observed with more than one disturbance type present. Coral disease was observed on a small percentage of corals but it was not widespread (8.3% of tows) in the slope sites that were surveyed. Disease is often a secondary effect from a previous disturbance or stress. In this case the disease was probably a consequence of the prior bleaching event. Feeding scars were more common (50% of tows) particularly in the lower slope at the edge of the steep drop off in approximately 20 m depth.

Crown of thorns starfish (COTS) were noted during consultations to be present on the north atoll margin (Ahaga Loa). Scars observed in the current survey were mainly observed on foliose *Montipora* spp and were probably due to the feeding activities of the gastropod *Drupella* spp. It is probable that some of the scars were also due to crown of thorns starfish though none were directly observed due to their cryptic nature. In a few sites, the scars were moderately severe and are impacting on the coral cover at those places (on the lower slope drop off). Feeding scars were confined to the south west atoll margin slope (Tetafa). Overall, the effect of these feeding scars was minor as they were low in abundance within most sites.

The presence of the wreck of a fishing vessel on the northern reef flat has had a significant impact on the surrounding reefs. The wreck is an advanced stage of disintegration with metal pieces found across the flat and into the shallow inner flat. The most pronounced effect has been the dominance of a black turf alga (possibly *Lyngbya* spp) that is smothering much of the reef substrate. An additional effect has been the death of the typically occurring encrusting coralline algae on the crest habitat that extends for kilometers from the wreck. Villagers reported high incidences of fish poisoning (ciguatera) from fish caught in this sector of the atoll which no doubt is associated with the presence of the wreck. Very few reef species that would have been normally present were observed in the vicinity of the wreck (including coral, macro invertebrates, and coralline algae (Photo 21, 22).

Photo 21. The wreck on the reef flat on the NE end of the atoll with signs of the impact shown by the dark colours to the reef lat substrate.

(Photo David Fisk)

Photo 22. Close up photo of the crest habitat adjacent to the wreck showing the complete absence of coralline algae, and an apparently healthy colony of zoanthids (middle).

(Photo David Fisk)

Major disturbances in the past were noted during consultations. These include unusually low water levels in the lagoon that persisted for some time (in 1982-83), which contributed to high mortality of lagoon organisms (corals, fish and turtles) due to the likelihood of higher than normal water temperatures and a build up of toxins from a lack of flushing of the lagoon. The drop in the lagoon sea level is thought to have been associated with an abnormal El Nino episode that affected much of the Pacific during this time.

There was also an incident some time in the 1970's when people from a (possibly) American research boat introduced a white powder into the lagoon in several places during incoming tides. Fish and eels apparently quickly died and the coral died soon after. There was concern that this has had a long term effect on the lagoon resources, which could not be substantiated from this survey due to the lack of data on resources before the incident.

Cyclones have caused major disturbances to Fakaofo in the past (eg, in 1987, 1990, 1991). Damage from cyclone Tusi (in 1987) was assessed by Laboute (1987) where the outer slope along the northern margin was damaged. Portions of the northern side of Fale motu was also washed away, drastically reducing the area of available land and causing destruction to buildings.

The susceptibility of the lagoon ecosystem to natural and man made disturbances is important to note and is critical for the consideration of management options that are available for the atoll and in particular for the lagoon. The limitation of many potential management options and potential developments is the fact that the lagoon is a closed system with very low flushing rates.

2.6 Conclusions

The survey results show that there are specific characteristics of the habitats and biotic communities on Fakaofo atoll that should be taken into account when considering sustainable management of marine resources. These characteristics are :

1. The relative **geographical isolation** of Fakaofo atoll from other Tokelau atolls, and from other reef systems means that marine resources on Fakaofo are effectively **isolated from all other sources of marine species replenishment.** From a biological perspective, the geographic isolation factor is of great significance. This isolation means that Tokelau in general, and possibly the individual atolls like Fakaofo, are in effect "closed" biological systems, i.e., it should be assumed that there is little or no regular or continuous contribution of species to the atoll from outside its boundaries. Any biological inputs (fish, fish eggs, coral eggs, clam eggs etc) other than from highly mobile species like tuna and birds, are likely to be rare events associated with rare favourable oceanic conditions. This means that each atoll ecosystem has to be self-sustaining and that replenishment of reef fish, corals, clams and other stocks of marine species must occur from within each atoll's marine ecosystem. For this to happen there must be viable (or reproductively successful) populations of adults of each species within each atoll. Even when healthy populations of breeding species are present on an atoll, the year by year differences in successful replenishment of different species will vary greatly because of this isolation.

2. There is a significant difference in environmental conditions between inside and outside the lagoon which is due to the difference in water flow and natural water quality, when compared to an atoll with deep wide channels to the open ocean. The **passageways or channels where ocean and lagoon waters transfer are few and they are generally extremely shallow**.

3. The **atoll has a virtually fully separated enclosed lagoon** where water is exchanged with the open ocean or flushed through the lagoon at very low rates. This is significant when waste and pollution from the village are added to the lagoon waters, as they may remain in the lagoon system (including in food chain) for long periods.

4. There are **significant differences in environmental conditions within the lagoon** which are defined by a series of cross lagoon reef structures. These reef structures create approximately 4 separate smaller lagoons or semi-enclosed cells within the outer lagoon perimeter with the most separate cells found towards the southern and eastern sectors of the lagoon. The cells have features such as low water exchange and high sedimentation rates, and as a result, a high potential to produce extreme seasonal temperature and salinity fluctuations.

5. There are also a number of almost **fully enclosed cells and embayments within the lagoon** which also will exhibit lower than normal water flow patterns and environmental conditions.

6. The **northern end of the lagoon is the relatively most open sector of the lagoon**, but even in this area, flow patterns are significantly different to the open ocean.

7. The significant low water flushing potential of the lagoon and major **differences in lagoon environmental characteristics will have major implications for the potential to develop mariculture** activities and also for the potential for pollution prevention in the lagoon.

8. The attempt to seed Fakaofo reefs with an **introduced trochus species has met with only limited success** with one seeded site showing no survival of trochus and another site showing reasonable numbers of large individuals but no juveniles.

9. Fakaofo has very shallow reef flats that are regularly exposed at low tide periods which limit the development of many coral reef components. Therefore, no permanent habitat is available for many fish and other species in these areas. The reef flat can be a high energy habitat due to the constant wave and tidal movements over the area, which further restricts the development of complex reef communities. Many fish and other animals utilize the reef flat for feeding purposes, but have to return to the adjacent deeper reef slopes during low tide periods. That is, the **reef flat and adjacent slopes are effectively one habitat** in Fakaofo and therefore they should be managed as a single area.

10. The overall status of marine resources on Fakaofo is one of **general depletion of most traditionally harvested species**. The reasons for these depletions are not always easy to determine but they no doubt include natural fluctuations and natural disturbance events as well as human harvesting factors that include highly efficient fishing tools, food preserving fridges and freezers, and a cash society that encourages more harvesting than might have been carried out in the past.

11. The passageways or channels over the reef flat are utilized by most reef fish and probably other marine organisms as well, as part of their feeding and reproductive cycles. The **channels are also highly efficient fishing locations** because of the predictability of the periodic fish migrations, and because of the restriction of room that the fish can move through. The introduction of extremely efficient gill nets into these sites of vulnerability for fish has meant that catch of fish for the amount of effort is far higher than it ever has been in the past.

12. The current reef system and its biological components on Fakaofo is not comparatively complex relative to other reef systems though it probably is typical for atoll systems in the Central Pacific. This lack of complexity is demonstrated by the **relative low diversity of many of the essential components of a coral reef and the low abundance of many of the species** that are present. There also is a noticeable lack of representation of some major reef species groups, such as the Echinoderms (starfish, holothurians, etc), Molluscs (gastropods and bivalves), and Crustaceans (crabs, shrimps, etc). However, in the most dominant coral group (that includes relatively low diversity for coral reefs in general), there is the likelihood that a small number of coral species are present that have not previously been recorded from the Central Pacific and that there may be one or two species that will be new to science.

13. There is clear evidence that **significant impacts have occurred from recent bleaching events** that have affected major components for the reef on the outer slope and also in the lagoon where it would be expected that species in the lagoon were relatively adapted to high temperature fluctuations.

14. **There are additional indicators of current stress** in the reef system that have been observed from both inside the lagoon and outside the reef on the slope. These indicators are **most likely due to regional and specific local conditions** rather than from human activities. Lagoon stress indicators include the abundance of encrusting

ascidians and a tough gelatinous algal mat on corals and reef substrate in the enclosed lagoon cells in particular. Stress indicators from the slope include the presence of low levels of coral disease, some bleaching of corals, and the presence of high than normal levels of feeding scars on some corals from (mainly) coral eating gastropods (*Drupella* spp) and crown of thorns starfish.

15. The presence of the **ship wreck on the northern reef flat was significantly impacting on the surrounding habitats**. These impacts include the elimination of the normally occurring encrusting coralline algae for many hundreds of meters of the outer reef flat and crest zone. There has also been high mortality of most normally occurring reef flat corals and algae species, and possibly other reef animals.

16. The **fish communities are generally low in diversity and in many areas are also low in abundance** but there is a representative suite of species from the major fish feeding groups (ie, there are reasonable representations of herbivores (plant eating fish), planktivores (plankton eating fish), detritivores (fish that eat detritus or waste particles) and predators (fish that eat other fish and reef animals), but there appears to have been major reductions in some of the more desirable predator fish species such as black trevalley, and coral trout, that were apparently once quite abundant.

17. The **abundance of many species important to fisheries varies from low to high according to the distance away from the main settlement**. This characteristic is demonstrated in a number of different species and the pattern is similar on the outer slope as well as in the lagoon.

3. COMMUNITY PERCEPTIONS ON RESOURCES AND RESOURCE MANAGEMENT

3.1 Rationale for Investigation into Community Perceptions

It "is now widely accepted that local knowledge and priorities should be incorporated into management strategies for nature reserves…Local-knowledge based management strategies ensure a focus on the species and vegetation types that are most valuable to local societies" (Lykke 2000, 107) . This is extremely pertinent in Tokelau where the local council – the community voice - is the main body responsible for the management of the atoll environment and human community. "Dealing with social concerns that are deemed important by the community is essential for the success of any conservation initiative (Borrini-Feyerabend 1997a).

The following is a general summary of the main issues and themes that were raised during community meetings and interviews in Fakaofo. Seventeen semi-structured interviews were conducted with a cross-section of community members (male and female) over the age of eighteen. In addition community workshops with the fatupaepae, aumaga and Taupulega were conducted with high participation rates, as well as casual discussions with community members. The opinions expressed are therefore those of the community members of Fakaofo, not the author. Note that the in-text italics are statements taken directly from interviews.

3.2 Socio-cultural setting of Fakaofo Atoll

Fakaofo is distinct from the other two Tokelau atolls in that the village, due to necessity, is divided between two islets, Fale the traditional Fakaofo village, and Fenua Fala settled in the late 1960's (Tokelau Government 1995). However, it operates (socio-politically, cultural and economically), and is considered by the *taupulega* and community, as one village.

The central governing authority on each of the atolls is the *taupulega* (local government council). This is the central body responsible for village matters and the atoll's environment and resources. The *taupulega* has formal legal power under the Tokelau Village Incorporation Regulations 1986 to pass village regulations including resource management controls (Tokelau Government 1995, 13). In Fakaofo the *taupulega* is a self-selected group of *toeigas* (male elders), with representation from the *fatupaepae* (women committee), *faipule* (administrative officer, village representative to the National Government) and *pulenuku* (mayor, charged with the oversight of internal affairs). In recent times, the *taupulega's* power has eroded due to the presence of the external administrative body. However, according to the Tokelau Office in Apia, this is currently being reinvigorated. The strength of the *taupulega* and the community's reliance on them was still starkly evident in Fakaofo atoll.

3.3 Important qualities of Fakaofo Atoll

Community members identified a number of Fakaofo's qualities and resources that are especially important to them. Most qualities are related to daily subsistence needs and the Fakaofo lifestyle including the atolls socio-cultural environment.

The ocean surrounding the atoll is vital to life on the atoll because, "*it will always to be there, it provides a constant supply of resources*". However it is Fakaofo's lagoon that is considered by community members as the backbone of the atoll, "*we rely on the resource found in there for our subsistence"*. Community members expressed a preference for fishing within the lagoon because it is easier than fishing from the ocean, and reef fish are a dietary preference. This practice has however been inhibited in recent years by the increasing rate of fish poisoning incidents from reef fish caught in the lagoon.

Due to the limited amount of land area in Fakaofo the small motus (islets) that bound the lagoon are essential to the Fakaofoan lifestyle. They provide the soil for important plantations such as *pulaka* (swamp taro) and the habitat for the greatly valued *uga'uga* (coconut crab) as well as birds and turtles. On the islet of Fale, the seawall is believed to be very important because it provides protection, for families and infrastructure, from extreme weather events as well as the constant erosive forces of the ocean. "*The seawall makes the motu more unique and protects us from the pigs and big winds*"

The community itself and the Fakaofoan culture are considered paramount to life in Fakaofo. Cultural practices and doing things *faka-Tokelau* (the traditional Tokelauan way) were identified by most respondents as the most important characteristic of life in Fakaofo. This encompassed doing things together and the church as well as sharing food and resources through the traditional *inati*[20] system. The culture "*taught me how to give respect and how to receive respect, the culture underlies everything we do and are"*. Fakaofo provides an easy life for members of the community, money is not required for daily needs as the atoll and surrounding marine environment provides all that is needed for day-to-day living. The village of Fakaofo is considered safe and, "*there are not many problems compared with those you have overseas*".

The important resources of Fakaofo according to respondents are the resources found in the ocean and lagoon; fish are considered the most important of these. Fisheries provide the main source of subsistence for each family and the whole village. The coconut and pandanus tree are also of vital importance as they provide food and weaving material for handicrafts. The coconut tree is highly valued because it's versatility helps to meet a wide range of daily needs as well as the material for handicrafts.

3.4 Changes in Fakaofo Atoll

The greatest change noted by respondents and workshop participants, is the declining populations of reef fish and giant clams (*faisua*) found within the lagoon. There are some species of fish that once came in large schools that are rarely or not ever seen now. A Fakaofo *toeiga* noted, "*in the old days there was larger numbers of fish and faisua in the lagoon and*

[20] Traditional institutionalized sharing, where every member of the village (infant, child, adult and elder) receives and equal portion of harvested resource i.e. fish, coconut etc.

ocean, now it seems there is a big decline in the fish numbers, in those years when I was young there was a huge amount of faisua now I can see there is a big change … most of the resources in the lagoon have declined in my opinion".

Respondents noted that these changes have occurred along with other changes in the way in which things in Fakaofo are done. Previously, "*we fished together and shared the catch equally amongst the village members*". Now however, more people fish individually, "*in old days use to share fish regularly, but now days we don't*", and subsequently there is less community sharing. Village members now rely more heavily on nets, including those with fine mesh. The different variety of net mesh sizes available has meant that a variety of fish species and sizes can now be caught in large numbers. Some respondents expressed fears that if this practice continues there will be nothing left in the future. "*In the old days we used traditional methods of trawling tuna, but now there are a number of dinghies with outboards, I think this is affecting tuna*". Due to the cash economy and regular supplies from Samoa people do not rely on fish as their main source of subsistence as heavily as before. *"Now we have tinned foods and imported meat, we don't have to fish as much".*

Some community members associated the decline in fish and clams with an American research vessel that came to Fakaofo sometime in the 1960's. Details of this expedition are sketchy but older members of the community recall that the research group used poisons in the lagoon and many fish died. In the *taupulega* meeting it was noted that it was around this time that fish and clam numbers began to decline. It was however around this time that other changes also began to occur within the community, such as: access to imported goods, overseas education, freezers, new fishing technology and gear and new resources and products.

Photo: Taupulega Meeting
(photo Gordon Lapraik)

It was noted by some respondents that many of the new practices have resulted in chemicals and other pollutants entering the lagoon. Respondents commented on the possible relationship between declines in fish and lagoon health and the use of Clorox and other chemicals used for washing, as well as the petrol from outboard motors, and general rubbish from introduced products. Others however felt that perhaps the declines were temporary and "*just the natural cycle of things*". One respondent commented, "*Nowadays we hardly see or catch fish like pone…I'm not really sure why; there were a lot of fish before…maybe there are less now*

because the men don't fish as much". Few suggested that the reasons for the declines in clams and fish were due to over-harvesting by the community for their own use and for export overseas mainly for relatives.

3.5Concerns

"The major concern is if you look at the spot where the shipwreck is you can see a big change in the colours on the reef and that is the area where the fish poisoning start. Secondly is the rubbish, the land that was used as a rubbish area if you look around the motu on the shore side you can see the same thing as where the shipwreck is, the colour of the reef"

The shipwreck on the reef northern flat and the perceived associated fish poisoning were identified by the Fakaofo community as their main concerns. A large variety of fish according to respondents and workshop participants are now poisonous[21]. Several people have been affected, it was estimated by some participants that approximately twenty members of the community have been affected in the past year. Most people in the community relate the high rate of fish poisoning incidents to the shipwreck. One respondent commented, "*I'm concerned about the shipwreck and the fish poison, that's the main concern for the future"* and another stated, "*the shipwreck, its destroying the fish and coral reefs, its poisoning the fish like ulafi, ono*". Subsequently the eroding shipwreck is foremost in community members concerns. The shipwreck, according to respondents, is the cause of the degradation of coral and the growth of black algae in the area surrounding it. Community members also believe it is also the cause of the fish poisoning that is affecting many of the reef fish found within the lagoon.

Community (social) concerns include: inadequate protection from the elements, solid waste and pollution, the safety of children, education, and, health and dietary issues. The solid waste problem is a major issue for the community according to respondents. Rubbish disposal is problematic due to the lack of land space available, consequently there is rubbish lying around. Respondents felt this was an eyesore and a health issue, "*I am concerned there is so much rubbish and the way of living here, there is rubbish lying all around and it's not good to look at or live with… especially because of the health issues*". There was concern that the community of Fakaofo do not have the capacity to effectively address this issue, and uncertainty was expressed about the current way in which the community is disposing of their waste. "*We cannot manage it (rubbish); we are now putting it into drums and dumping it out at sea*". Another respondent asked, "*we have no idea whether we are doing the right thing or not regarding the ocean dumping… what do you think…"*

[21] The following are fish that were quoted as having either declined or disappeared by people interviewed and participants in workshops: algo, api, aheu (*Caranx melampygus*), filoa (*Lethrinus xanthochilus*), fapuku (*Epinephelus fuscoguttatus*), fito, gatala (*Epinephelus merra*), haputu, hulu, kata, laulaufau, loi (*Cephalopholis argus*), munua, mu (*Monotaxis grandoculis*), mago (shark), malatea (*Cheilinus undulatus*), pugamea, ono (*Sphyraena putnamiae*), puhi (*Siderea picta*), pone (*Acanthurus achilles*), taiva (*Lutjanus fulviflamma*), tagau *(Lutjanus fulvus*), tonu (*Plectropomus areolatus*), ulafi (*Hipposcarus longiceps*), uhu *(Aprion virescens*)

Photo : Augmaga Meeting –
(photo Gordon LaPraik)

The following concerns related to resource availability and environmental conditions were also raised:

- coral bleaching is increasing in the lagoon and also in the outer reef;
- clam numbers are decreasing;
- shark numbers are increasing;
- fish numbers (abundance) and diversity is declining. Many fish have declined in size and numbers, and some are no longer seen at all;
- pigs in and around the village, they are an eyesore, produce a bad odour within the village, and are considered a health risk. "*The pigs in Fale are an embarrassment, its our landing place and what do you see, pigs*!";
- invasive species, including the rhino beetle (which affects coconut trees), rats and crazy ants;
- climate change and increasing sea levels;
- natural disasters and the strength of the seawall to protect the village; and
- the solid waste issue.

3.6 Traditional Resource Management

The people of Fakaofo have a variety of traditional resource management practices. The *taupulega* are central to traditional resource management because they are the decision-makers for all issues related to Fakaofo's resources. "*It has always been up to the taupulega to make the rules, it is their authority*". While *fakahao* (conservation) is considered by most respondents to be a new idea and practice, one respondent commented, "*the taupulega's power is our traditional way of conservation, the taupulega informing the community that it can or can not go into a particular area*".

The *lafu* system (seasonal or species bans) is an important way the atoll's limited resources were traditionally managed. Most respondents however felt this was an old way that was no longer practiced, "*it is from the olden days, we don't do that anymore*". The *taupulega* would also prohibit the harvesting of particular marine and terrestrial resources at certain times to ensure they were not over-harvested or the population degraded. "*The elders would ban the*

fishing of particular species at certain times…but they don't do that anymore". A few of the older respondents felt that this was a practiced that needed to be reinvigorated, "*I think we need to do that now days*".

Photo 1: .Fatupaepae Meeting (photo Jo Axford)

It was felt by some participants that traditional practices and customs were in a way a form of conservation. An example commonly given is the system of *inati*. When the community fished for *inati* it was done communally, and according to respondents traditionally the immature fish, clams and other resources were left, this was not so much a rule as a general practice or habit. There are also a number of sacred fish such as *hakula* (marlin) and the *honu* (turtle) which when caught have to be shared between the whole *nuku* (village).

It should be noted however that many of the younger respondents were unaware of many of these practices, or if they were aware they felt they were no longer practiced. **What is clear however is that resource management, traditional and new, is seen as the responsibility of the *taupulega*.**

3.7 *Fakahao* (Conservation)

Workshop participants and interviewees expressed a lack of knowledge and understanding about *fakahao* (conservation). One older respondent stated, "*up until now we really don't know what fakahao means…*" and another commented, "*people never think about fakahao, they don't know what it means*". At the *fatupaepae* workshop after discussing Fakaofo's Fenua Loa Fakahao (conservation area) a participant asked, "*What is conservation and how long is it for"?*[22] The women interviewed after this meeting explained that they now had a new understanding of conservation and subsequently felt it was a good and important idea for Fakaofo. Many respondents commented, "*well I didn't really know what fakahao meant until it was explained in the meeting…*" Some participants believe that based on this new understanding, the community of Fakaofo, "*needs to think seriously about conservation*".

[22] An explanation was provided by team members, explaining that conservation in the Fakaofo context, was about making sure there was area(s) of the lagoon, representative of all off the lagoon habitats, where no harvesting was allowed. It is anticipated that this area will act as a source of replenishment for other parts of the lagoon where fishing pressure is high.

Participants expressed the following opinions about *fakahao*, and what it means to them:

- it is an area where you are not allowed to harvest things from;
- it means saving things to get more in the future;
- it is a temporary thing, "*…prohibit now and benefit later when area is opened up*";
- it is the assistance from people from overseas; and
- it is a new idea introduced from outside "*its from over seas… its like new knowledge from outside, that's why we have a conservation area today*".

3.7.1 Te fakahao (the Conservation Area)

There are two no-take '*te fakahao'* (conservation area) in Fakaofo (see Map). Fale Fakahao (Fale Conservation Area) is close to the village and specifically for giant clams. While the harvesting of clams is prohibited, all other activities are allowed, including the harvesting of other species. The other *fakahao* area, Fenua Loa Fakahao (Fenua Loa Conservation Area), is situated in the southern corner of the atoll and encompasses both lagoon and land area[23]. All resource harvesting activities are prohibited in this area unless otherwise directed by the *taupulega*. The following discussion is generally focused on Fenua Loa Fakahao.

It is generally believed that the concept of a *fakahao* area was initiated from outside (i.e. overseas). The idea was accepted by the *taupulega*, who decided to create an area of *fakahao* for the future benefit of the community of Fakaofo. "*The decision (to establish a fakahao) was made by the taupulega… the taupulega said it would benefit us at the end and also it is useful during the laki season*". The *taupulega* thought it was a good idea because, "*we were looking mainly at the welfare of the village so they could have more*".

Some respondents felt the *fakahao* area was established by the *taupulega* to recover lost or declining resources such as fish, clams, coconut crabs and even trees. Generally however respondents considered the area of *fakahao* to be a type of communal fish larder, an area left to allow stocks to be enhanced for future communal harvesting events. The Fenua Loa Fakahao is opened occasionally according to respondents at the *taupulega's* discretion and authority. "*It's only ever for inati, for the whole village to share and also at time of bad weather, during the laki season, and for special occasions*".

The *fakahao* area according to participants is only to be accessed communally and when the *taupulega* decides it is appropriate. Some respondents saw this as one of the great benefits of the *fakahao* area, because it means that all resources harvested from the *fakahao* must be shared equally amongst community members. "*So in the future there will be enough to share from the fakahao, each family will get the same, some families may not have a boat so another advantage is that they will get an equal share from the fakahao*". It was felt by respondents that the close proximity of the *fakahao* to the village means that it is a good back-up area. "*The fakahao is better, that's where we go to save time rather than looking around everywhere else, we know there will always be plenty of things to catch there*".

The rationale for the general location of Fenua Loa Fakahao varied between community members. However in general it was generally believed that the *toeiga's* probably chose the spot because it had healthy fish and clam populations and is considered a good breeding area.

[23] Fenua Loa Fakahao is the only conservation area in Tokelau to encompass both marine and terrestrial environments.

Photo 5: Full Community Meeting to discuss preliminary findings of the survey
(photo Gordon Lapraik)

There were varying perceptions as to what reef and land area is included within the Fenua Loa Fakahao. In the group workshops the *taupulega*, *aumaga* and *fatupaepae* all indicated different boundaries. When this difference was explained, the *fatupaepae* and *aumaga* both agreed that it was the *taupulega's* impression that was the right one, as they are the decision-makers. It did however highlight a general lack of awareness and knowledge of the Fenua Loa Fakahao amongst community members, and especially amongst the fishers (mainly *aumaga*).

Photo :Full Community Meeting – describing the lagoon characteristics
(photo Mary Power)

3.7.2 Fakahao management

The management of the *fakahao* is considered the sole responsibility of the *taupulega*. The *taupulega* determine when people can fish in the *fakahao* and when they can not, "*the taupulega make the rules and the people have to follow*". Some of the older respondents explained that the *taupulega* manage the *fakahao* area, is a similar way to how *lafu* areas were once managed. "*When the fakahao is plentiful the toeiga send the aumaga to harvest and*

divide for inati". Some respondents felt however that the Fenua loa Fakahao was not actively managed and the area was regularly accessed and fished from.

Most community members in workshops and interviews shared the view that generally the rules of the *fakahao* area are not complied with, "*no, we don't look after the fakahao"*. Although the Fenua loa Fakahao has rules, and permission to access the area must be granted from the *taupulega*, "*…people still sneak in there whenever they want*". There were varying opinions for why this was the case, including:

- Leadership, "*because the taupulega open it for fishing, for example it is called a fakahao but if we have visitors from overseas they open it, also the taupulega harvest from there for themselves*";
- The juxtaposition of the area means that it is close to the village and easier to fish than other places, "*some people go out there if you're in a hurry to get home go and harvest clams*";
- The area is too tempting, "*there is a big population of clams there"* and another respondent explained, "*no (people don't respect the rules) maybe they just want to eat the clams and it's easier to go there than other places because its closer and bigger"*;
- Lack of community respect for the *fakahao*, "*people just are not respecting the taupulegas rules*";
- Family ownership of land. Some of the motu's within the Fenua Loa Fakahao are owned by individual families (one motu is owned by the village). According to the *taupulega*, this makes the area difficult to police and the rules difficult to enforce. "*If all the land within the fakahao belonged to the government or the village it would be easier to police*";
- Lack of rule enforcement and punishment; and
- Inadequate boundaries, "*because the inside of the reef is allowed to be fished and its easy to slip over, perhaps if we prohibited both sides of the reef it would be harder to break the rules*".

Punishment for non-compliance is rarely implemented according to respondents. Opinions varied as to what the punishment would be if implemented. Some respondents commented that the perpetrator would be '*given a talking to by the taupulega'*, and other believed that a monetary fine would be required. This fine varied from ten dollars to fifty dollars for the first offence and double if repeated.

3.7.3 Changes in the *te fakahao* area since implementation

Since the *taupulega* established the *fakahao* area, some respondents felt there have been big changes to the resources within the area, and other respondents felt there have been no change at all. Those who felt there have been changes mostly believe these to be positive changes, include an increase in fish and bird populations, and most commonly noted an increase in the size of coconut crabs found within the motus of Fenua Loa Fakahao. "*We see a big difference there now, if we need to go fishing we use the fakahao because it has got a lot of fish in there*".

However many respondents felt there had be no change, or that there has actually been a decline in fish and clams within the *fakahao* area. This was believed to be the result of fishing with nets in the surrounding reef and because the area is accessed so frequently. "*I think because fishing outside the area with nets is affecting the fakahao*". Some participants expressed a concern that the *faisua* (giant clams) population's growth was inhibited by the

fakahao because they were not being harvested. These community members hold the belief that clam reproduction and proliferation occurs when they are harvested by people and their egg sack is popped and spread around. Therefore in the absence of harvesting the individual clams will increase in size but will not increase in population. "*If people don't use the faisua they can't reproduce and so it's like a waste… because before there was a lot of faisua but now since the fakahao there is less*".

3.7.4Status of *te fakahao* (is it successful?)

There were varying opinions amongst respondents regarding the success of the area as a *fakahao*. Most however felt at the time of the teams visit, it was not a success. This was because:

- the area is too disturbed; and
- there has been no increase in resources.

Respondents felt that the reasons for this lack of apparent success included the following:

- the area is frequently fished, "*the elders allow people to fish in there for people overseas*";
- management is not strict;
- low levels of compliance - community members do not obey the rules, "*No it is not successful because there are still people going there without permission for their personal needs…*";
- lack of enforcement and penalties;
- lack of awareness in the community; and
- no one responsible to watch over it and ensure people respect the rules.

2003 had been a year of high impact according to respondents, "*there has been many visitors this year so the fakahao has been used a lot because that's the main area the elders use*". Subsequently the team was told at the beginning of the visit to expect to see diminished resources (especially clams) within Fenua Loa Fakahao.

Those who feel the *fakahao* area is currently successful base this impression on their current interpretation and understanding of conservation and the purpose of a Conservation Area. That is an area regulated by the *taupulega* for communal use, special occasions and in times of poor weather. The respondents felt the area provides an important resource 'back-up' area for the village. "*…the fakahao is a big advantage for the village in times of bad weather and bad seas, that's the spot where we look at to use for the village in terms of fish…*" The juxtaposition of the *fakahao* means that the village can quickly access the area and fulfil the village needs. "*It is successful because the area is large and it is a help to us when we need to go there*". It was also viewed as a success by some because, "*I get a good share of it*". It should be noted that **few people considered the *fakahao* a success because of resource improvements.**

It is felt that the *uga'uga* (coconut crab) has been the most successful component of the Fenua Loa Fakahao because they have increased in individual size and population. This was expressed by most interviewees as well as participants at the workshops.

3.7.5 Reaching Success in te fakahao (increasing success)

"*…it is much easier to have someone looking after the fakahao full-time to make sure no one will disobey the toeiga's rules…(in addition) the size of the fish and animals that are harvested*

should be standardised, at the moment there is no standardised regulations (atoll wide) on the uga'uga and fish that are harvested."

Most respondents felt that success in their *fakahao* area would be an increase in marine and terrestrial resources. This included an increase in fish (abundance, diversity and individual size), as well as an increase in coconut crab and clam size and populations. Respondents felt this outcome can only be reached through the *taupulega*, because the *taupulega* create, implement and enforce the rules for the community to follow. It is important according to community members that the *taupulega* should lead by example.

It was felt by respondents that there is a need for more serious consideration and control of the *fakahao*. Success, according to respondents, will require active stricter management of the *fakahao* area by the *taupulega*. There is a need to establish:

- stronger rules and laws;
- prohibit resources being taken from the *fakahao* area for export;
- enforcement of the rules;
- punishment of these who break the rules;
- monitoring of the *fakahao* area - people responsible for looking after the *fakahao* area, patrolling it to ensure no one breaks the rules; and
- encourage the *aumaga* to be responsible for the fakahao and enforce the laws "*because they are the main user and abuser group*".

Some participants felt that the success of the Conservation Area would require a reassessment of it's design and position:

- leave it, "*don't disturb it and after 5-10 years survey it again*" and then decide on next stage;
- expand the boundary of the *fakahao* to include the top reef, "*that way people couldn't just slip in*"; and
- demonstrate changes in the *fakahao* by monitoring it "*so improvements can be seen"*.

Community members commented that in addition to these requirements, there is a need for the whole village to work together with the *taupulega* to respect their decisions and obey the rules. Within the village there is however a need for education about conservation and for awareness raising activities about the Conservation Area, its purpose and rules. Some respondents felt that this awareness raising should start in the home, "*parents should advise and guide their children about the fakahao*". Others felt that there was a need for broader participation of community members in the management of the Conservation Area, "*the village should work together with the taupulega"*. Respondents felt that these things would assist in addressing the current problem of low compliance, "*people have to respect and follow the rules*".

In addition it was felt by some that regulations needed to go beyond the Fenua Loa Fakahao if the atolls fisheries were to improve. The introduction of standardised regulations for the sizes and numbers of resources allowed to be harvested at any one time by individuals, especially for fish, clams and coconut crabs all over the lagoon. According to respondents this law should only apply when fishing individually not when fishing for the whole village.

3.7.6 General perceptions of the *fakahao*

"Tokelau…has a very unique beauty of its own, the life style is different from anywhere else in the world…I think it has something to do with our environment…we need to preserve it" (Fakaofao resident)

Most people interviewed shared the opinion that a *fakahao* area is a good idea and important for the village to meet their needs and wants, especially in times of bad weather and special occasions. *"I deeply believe these fakahao are a big advantage for the whole village and the future of the people".*

Some respondents expressed problems, personal costs and feelings of inconvenience related to the imposition of the *fakahao* area. This is because they felt that the Fenua Loa Fakahao restricts where village members can fish, "*in the old days we were free to go anywhere…without prohibition*". An older respondent noted, "*I believe there is a certain amount of people having hardship feelings because they are not allowed to fish there compared to the past, so many people ignore the toeiga and go there on their own*"

Respondent's vision for the future of Fakaofo generally focused on a higher standard of living This encompassed a cleaner healthier and safer environment with:

- improved waste management;
- fenced pigs away from the village; and
- stronger seawalls to ensure greater security for the village from the elements.

Respondents hoped the future would bring higher standards of education and training to community members. It was felt that increased development and independence of Fakaofo might aid in providing opportunities for educated children to return to Fakaofo to live and work. A few of the older respondents felt that ideally they would like to see a reinvigoration of traditional customs and practices such as *inati* and *lafu*. "*I am hoping it (Fakaofo) will go back to how it was in the old days, perhaps the fakahao can help that happen*".

4. HOUSEHOLD SURVEYS

A total of 43 household surveys were conducted on Fakaofo during 6-7 November 2003. This represents approximately 50% of the total occupied households of Fakaofo. The standard questionnaires covered topics that focused on the impact of harvesting on fishery resources and included harvest technologies, seafood consumption and use, and target fishery species. The only other similar survey that has been completed for Fakaofo was by Passfield (1998), from which the basic structure of the questionnaire for this survey was designed. Passfield (1998) interviewed 20 households covering 25% of those present in 1996, the year of his survey.

4.1 Results

4.1.1 Fishing Methods

The results of the survey indicate that there is a high frequency of ownership of relatively efficient fishing gear in addition to traditional tools (Tables I & II). In particular, there are high ownership levels of fishing rods and trolling lines (95% and 88% of households, respectively, Table 1). This indicates a potentially high level of fishing pressure on both the inshore reef resources (rods) and offshore fishery resources (trolling lines).

Equipment	% H'holds (1 or more items)	Mean / Household (sd)	Max	Min
Fishing Rods	95	3.6 (4.4)	23	0
(Gill) Nets	79	2.0 (1.9)	11	0
Spears	59	1.4 (3.4)	21	0
Spearguns	36	0.5 (0.7)	2	0
Trolling Lines	88	6.4 (5.2)	20	0

Table I. Fishing equipment ownership expressed as the mean number of each type of fishing gear per household as well as the maximum and minimum per household.

There is also a high level of ownership of gill nets (70% of all households surveyed have at least one net), which are used to harvest fish resources that pass through the shallow passes connecting the lagoon and the open sea. This is a slight increase in the proportion of household net ownership estimated in 1996 (65% of households, Passfield, 1998). The 1996 survey recorded a maximum of 4 nets per household, in contrast to the SPREP survey that showed up to 11 nets were owned by a single household. Passfield (1998) pointed out it is likely that all households can also obtain access to nets by "loan" from those who own them. The best indicator of potential harvest pressure from this fishing method could be the estimated total number of available nets. The estimated total number of nets on Fakaofo, based on this survey, is 170, in contrast to an estimated 120 nets in 1996.

Most netting is carried out on the reef flat as fish move in and out of the lagoon through the narrow shallow passes. Fish targeted in this way include parrot fish, trevally, surgeon fish, grouper, and laulaufau (Moorish Idol). Often the large seasonal spawning aggregations are

targeted as the fish migrate from the lagoon to the outer slope to spawn. In November 2003, during this survey, the main laulaufau spawning run was targeted by netting specific passes known to be the used by this species. Many species specific spawning migrations are targeted in the same manner. This apparently included the grouper migrations (tonu), which previously yielded high catches. However, in recent times this species has not been caught or observed and is apparently locally extinct. This is a major source of concern for villagers (community consultation information).

Boat ownership by household is also a likely proxy indicator of potential harvest pressure, especially if outboard motors are also available (Table II). Of the households surveyed, 86% owned one or more aluminium boats (a total of 66 aluminium boats for the survey sample and more than 120 if extrapolated to the total number of households) and approximately the same percentage (88%) also owned one or more outboard motors (total of 70 (140)outboard motors). Traditional canoes were owned by only 5% of households surveyed and only two of these were operational. This level of boat ownership represents a significant increase in the available aluminium boats since 1996.

Boat Type	% H'holds (1 or more)	Mean (sd)	Boat # per Household	Frequency	% All Households Surveyed
Al Dingy	86	1.5 (1.2)	0	6	14.0
			1	17	39.5
			2	15	34.9
			3	2	4.7
			4	2	4.7
			5	1	2.3
Canoe	5	0.05 (0.2)	0	41	95.3
			1	2	4.7
Outboard Motor	88	1.8 (1.3)	0	5	11.6
			1	16	37.2
			2	9	20.9
			3	8	18.6
			4	4	9.3
			5	1	2.3

Table II. Household ownership of aluminium boats, outboard motors, and traditional canoes.

4.1.2 Sea Food Consumption

Seafood is a significant part of the Tokelau diet with fish being the most frequently eaten food type. The ten most commonly eaten fish species are listed in Table III. Four of the top ten ranked fish species were reef herbivores, with the majority of species being predators. Similarly, Passfield (1998) found in 1996 that kakahi (yellowfin tuna) and atu (skipjack tuna) were the most commonly eaten fish along with the seasonal atule (scad) and hahave (flying fish). A high proportion of households regularly ate pelagic species are harvested offshore, especially kakahi, atu, and hahave.

Tokelau Name	Common English Name	Scientific Name	Trophic Group	Rank	% H'holds
Kakahi	Yellowfin Tuna (small)*	Thunnus albacares	P	1	13.0
Atu	Skipjack Tuna*	Katsuwonus pelamis	P	1	13.0
Malau	Soldier fish	Myripristis spp	P	2	10.1
Kamutu	Tanface Parrot	Chlorurus frontalis	H	3	8.7
Gatala	Honeycomb Grouper	Epinephelus merra	P	4	6.5
Aheu	Blue Fin Trevally	Caranx melampygus	P	5	5.1
Ume	Unicorn fish	Naso unicornis	H	6	4.3
Talatala	Scarlet Solderfish	Myripristis pralinius	P	7	3.6
Atule	Big eye scad	Selar crumenopthalmus	P	8	2.9
Hahave	Flying fish*	Cypseluris spp	PL	8	2.9
Ono	Chevron Barracuda	Sphyraena qenie	P	8	2.9
Taiva	Onespot seaperch	Lutjanus monostigma	P	8	2.9
Aua	Silver Mullet	Neomyxus chaptali	H	9	2.2
Gutuloa	Slingjaw wrass	Epibulus insidiator	P	9	2.2
Kanae	Wart-lip mullet	Crenimugil crenilabis	H	10	1.4
Ulihega	Blue streak fuselier	Pterocaesio tile	PL	10	1.4

Table III. The ten most commonly eaten fish species in Fakaofo compiled from questionnaires listing the four most common fish eaten in each household. * Fish species that are caught in the deeper offshore pelagic habitat; the remaining species are closely associated with shallow coral reef habitats; P = Predator; H = Herbivor; PL = Planktivor.

Consumption of other types of seafood was also high. (Table IV). Coconut crabs and giant clams are consumed one or more times per week in 28% of households and occasionally (less than weekly) in another 64% of households. Crayfish are consumed frequently (more than or equal to 1 x wk) or occasionally in 95% of households, compared to the consumption of octopus (at the same frequency) in 74% of households.

Resource	Frequent (>= 1 x wk) (%)	Occasional (%)	Never (%)
Coconut Crab	28.2	64.1	7.7
Clams	28.2	64.1	7.7
Crayfish	23.1	71.8	2.6
Octopus	20.5	53.8	25.6
Sea Birds	17.9	61.5	20.5
Turtles	10.3	74.4	15.4
Holothurian	0.0	5.1	94.9
Urchins	2.6	7.7	64.1

Table IV Frequency of household use of coral reef and island resources other than fish. % = percentage of households consuming food species frequently more than or = 1 x wk), occasionally (less than 1 x wk), or never.

An unexpected result was that approximately 80% and 85% of households reported that they consume sea birds and turtles (respectively) either frequently or occasionally (Table IV). This was not predicted as both sea birds and turtles were commonly reported as being very scarce

currently, as compared to the past. This scarcity was also confirmed in the field surveys. In contrast, holothurians and sea urchins are rarely consumed (never consumed in 95% and 64% of households, respectively).

Sea food is shared among family members and in the village when there are excess supplies. Generally the distribution of food goes to immediate family members first (46% of households), then to the village people (31%). Some respondents stated that there were village rules pertaining to the distribution of certain types and quantities of food. For example, turtles, swordfish, and possibly reef sharks, had to be given to the village for distribution. When greater than 30 tuna (or in another case, >40 bonito) were caught they were required to be also presented to the village for distribution.

4.1.3Exports

The ability to store seafood in freezers is a significant benefit to Tokelau communities to offset lean food periods. As well, freezers are a way to preserve excess catch and to hold foodstuffs until they can be exported to family members and/or sold overseas. There is a very high level of ownership of freezers with all but one household having one or more freezers (98% of all households). In addition, 3% of surveyed households owned two freezers. There was an equal distribution of small, medium, and large size freezers among households. The incidence of freezer ownership has increased since Passfield's (1998) study where he found that 85% of households owned freezers in 1996.

Sea food is also regularly exported overseas with 93% of households exporting some sea food every year. The majority of the exported sea food goes to family members residing overseas (86% of exporting households send sea food to family members). The remaining 14% of exporting households send sea food overseas for sale. No estimate of the quantity of sea food that was exported for sale was made in the 1996 study (Passfield, 1998). The export includes fish that is brought as gifts for family when people travel to other countries, as well as fish that is sent unaccompanied on the ferry service ti Apia. The most commonly exported fish (Table V) are the pelagic species (atu and kakahi, 30% of all fish combined), followed by a range of near-reef mid water species (atule, hahave, ono, aheu, kanae), and reef associated fish (especially kamutu, malau, pone). Fish sent overseas for sale included atu, kakahi, kamutu and malau (Table V). The responses did not indicate that any sea food other than fish was exported but is likely that considerable quantities of clam meat crayfish, and coconut crabs, in particular, are known to be exported as well (information from other non survey discussions with residents; and through the previous report by Passfield (1998)).

The response to the questionnaire on the quantity of fish that is sent overseas was variable and the data was not sufficiently specific for accurate calculations of the amount that is exported. However, we know from the survey that some people send sea food on every ferry trip (approximately once per month) and some only send sea food a few times per year. The amount of food sent is measured in terms of bags or packets of approximately 5 kg frozen weight, and in biscuit barrels which may weigh up to 20-30 kg each when full (estimate only).

Tokelau (common) Name	**Scientific Name**	**% H'holds**
*Atu (Skipjack Tuna)	Katsuwonus pelamis	17.1
*Kakahi (Small Yellowfin Tuna)	Thunnus albacares	12.8
Atule (Purse eyed Scad)	Selar crumenopthalmus	7.7
Hahave (Flying fish)	Cyphselurus spp	7.7
*Kamutu (Green parrot fish)	?Scarus frontalis	6.8
*Malau (Soldier fish)	Myripristis spp	6.8
Ono (Barracuda)	Sphyraena barracuda	4.3
Aheu (Small Trevally)	Caranx spp	3.4
Kanae (Wart lip Mullet)	Crenimugil crenilabis	3.4
Assorted (any) Fish		2.7
Pone (Achilles Surgeon fish)	Acanthurus achilles	2.6
Tuna		2.6
Bonito		1.7
Hina (?)		1.7
Paala (Wahoo)	Acanthocybium solandri	1.7
Ulafi (Long nose Parrot fish)	Scarus longiceps	1.7
Ume (Unicorn Surgeon fish)	Naso unicornis	1.7
Aku (Long tom)	Strongylura spp	0.9
Alaala (Thicklip Trevally)	Carangoides orthogrammus	0.9
Gatala (Honycomb Grouper)	Epinephalus merra	0.9
Maiava (Soldier fish)	Myripristis spp	0.9
Moaga Goat fish)	Mulloidithys spp	0.9
Mullet		0.9
Taina?		0.9
Tala tala		0.9
Tiana?		0.9
Ufu?		0.9
Ufutafega Rainbow Parrot fish)	Scarus flavipectoralis	0.9
Uhu (Bullethead Parrot fish)	Chlorurus sordidus	0.9
Uma (?=Ume, Unicorn Surgeon fish)		0.9

Table V. List of commonly exported fish species by households. * indicates the species that are also exported for sale. Some of the Tokelau names that were listed are uncertain because of the recorder's writing style or the recorder's questionable interpretation of the spoken word.

4.1.4Women's participation in Fishing Activities

Women's harvesting activities include the collection of ornamental shells for making necklaces, earrings, bracelets, and decorations for bags and hats (a total of 57% of households recorded activities associated with handcrafts, Table VI). Women also significantly contribute to food harvesting efforts (43% of households listed food related species as part of women's activities). This is a lower percentage than the 1996 survey by Passfield (1998) where 60% of households recorded women as spending some time fishing in 1996. A total of approximately 120 harvest species were listed as being associated with women's activities. Not all are exclusively related to women's fishing activities, eg, many of the fish species such as tuna are

also targeted by men. This indicates that there is not a strict separation of harvest activities between the women and men for certain groups of species though this is probably the case for the harvesting of ornamental species. The overlap of harvest effort with men and women should be noted and taken into account when species specific surveys are carried out in fisheries related assessments.

Target Species	% H'holds	Target Species	% H'holds
*Mimiha (snail)	13.1	Atule (scad)	2.5
*Pule (cowrie)	11.5	Havane (sea perch)	2.5
Feke (octopus)	8.2	Ihe (gar fish)	1.6
*Makulu (snail)	7.4	Kakahi (tuna)	1.6
*Ulapepa (snail?)	7.4	Pone (surgeon fish)	1.6
Fahua (clam)	6.6	*Tifa (pearl oyster)	1.6
Tala tala (soldier fish)	3.3	Atu (skipjack tuna)	1.6
Pipi (oyster)	3.3		

Table VI. The top 15 most common target species of women fishers. * identifies those species that are collected for decoration purposes.

5 Recommendations

Considering the findings of the resource surveys and the interaction with the all groups of the community the following recommendations are put forward as a way to improve resource management on Fakaofo.

The recommendations are for management actions that will contribute to the conservation and preservation of the atoll by providing a framework for achieving sustainable resource management of human activities. The goals address the major management issues and encompass the following principles:

1. ***Conservation***

Protect, conserve and, where possible, restore the natural biodiversity and cultural values of the atoll.

2. ***Community involvement and support***

Develop community awareness, understanding and appreciation of the biological and physical diversity of the atoll, and promote community involvement in, and support for, its protection, conservation, and restoration.

Incorporate traditional and modern resource management practices to form a comprehensive and integrated community-based Resource Management Plan.

3. ***Commercial and other uses***

Manage commercial and other uses in an ecologically sustainable way.

4. ***Research and Monitoring***

Implement a data collection and analysis program that provides for a much greater understanding of the impacts of use and management activities within the atoll to better understand the potential and real impacts resulting from resource use.

5.1 Specific High Value Areas (incl Target Species/Objectives)

Fish Aggregation Sites

Effective management of specific high value areas, which are mostly related to seasonally occurring phenomena, could significantly benefit long term sustainable fisheries. These include the well known fish aggregation sites spread around the lagoon. Aggregation sites are probably of two types: sites where fish congregate (waiting for high tide to access the outer slope) on their way to spawning locations, and sites where spawning occurs, which are usually located on the outer slope or in areas that provide direct access / strong water flows to the open ocean. Aggregation sites near passes and channels will have to be effectively protected so as to allow the aggregated fish to fulfil their reproductive function before too many breeding adults are taken from the population, leaving inadequate numbers of those species for future generations. It has been noted that fish on their way out of the lagoon through the shallow channels are often full of eggs whereas the same fish species returning from the outer slope into the lagoon, do not have eggs. This strongly supports the understanding that many fish may move to outer slope spawning aggregation sites for reproduction, then return to their lagoon habitat.

It is apparent that some aggregation sites are mostly used by specific species or a small group of specific species, and that the aggregation sites are spread around most of the lagoon. Seasonal protection for these aggregations, especially from the very effective netting practices currently being used, would be a very significant step forward for long term sustainable management of finfish stocks of importance to subsistence livelihoods. It is also wise to nominate for protection more than one such species-related aggregation site for each species, so that annual variations in the degree of use of these sites is taken into account by protecting more than one of each of the species-specific sites.

RECOMMENDATION 1:
It is highly recommended that more than one species-specific site known for their seasonal fish aggregations be protected from harvest activities during these critical phases and that this be applied to sufficient sites so that all the major fish target species are represented under this management goal.

Giant Clams

The status of giant clams is restricted to the species *Tridacna maxima* as only one individual of another species (*T.squamoasa*) was observed during the whole period of the survey. The densest aggregations of clams were observed in very small areas within the Fenua Loa Conservation Area. In all other locations densities were low or clams were not present at all. If clam densities are to be improved, strict restrictions on their harvesting will have to be enforced.

The reef flat habitat along the northern margin of the atoll is probably the most suitable habitat for clams as it is more regularly flushed by clean clear oceanic water and also there are suitable shallow back reef flat pools available for clams. The NE area affected by the wreck is obviously not suitable until that threat has been eliminated.

RECOMMENDATION 2:

It is recommended that a relatively large total area (on the scale of 500m - 1 km) of reef flat and adjacent shallow lagoon area be considered as long term refuges for giant clams, which will act as sources of clam larvae for other parts of the atoll.

5.2 Conservation Areas

Conservation Areas

The current southern Conservation Area includes a totally enclosed lagoon cell within the main lagoon and the surrounding reef flat. The reef flat is periodically opened for harvesting of some resources when required. The enclosed lagoon cell has very low productivity potential[24] so the greatest value for the CA is in the outer reef flat and the adjacent slope habitat. There is regular movement of particularly herbivorous fish species between the slope and the reef flat during tidal cycles so these fish have not be afforded effective protection from harvesting.

In addition, the current Conservation Area includes a highly productive and potentially important slope habitat that is situated on an acute angle to the atoll margin. This acute angle to the atoll margin is where currents sweeping along the slope meet from different directions. It is probably a place of high productivity, and appeared to contain higher than normal abundance and diversity of fish species. It also is a likely location for fish spawning aggregations due to its location and bottom features[25].

RECOMMENDATION 3

The reef slope habitat that is currently not within the Fenua Loa Conservation Area should be included to exclude the harvesting of any species. The highest value of this conservation area to sustainable fisheries lies in the exclusion of harvest activities on the outer reef flat and crest. An effective long term sustainable fishery management option would be greatly enhanced by extending the exclusion zone to the slope which will greatly improve the potential for an increase in biomass of fish for the whole atoll as numbers move outside the reserve area.

[24] **Productivity potential** refers to the ability of a particular habitat and its environment to support high biomass or numbers of fishery species and individuals. Low nutrient and energy regimes are typical of a low productivity environment and this is the situation in the enclosed lagoon cells.

[25] **Fish spawning locations** are characterised by heterogeneous substrate features, adjacent deep water, and the presence of strong offshore directed currents.

5.3 Permanent and Temporary Closures

Modern fisheries knowledge recognizes that the periodic opening and closing of specific areas for harvest activities is not very effective in the long term for maintaining sustainable fisheries. This system of conservation has been traditionally practised by Tokelauans for a very long time and it obviously has contributed to the long term viability of the society on these atolls. However, current understanding of fisheries viability indicates that the ability of specific fisheries to supply resources is limited and that this is particularly the case in isolated reef systems like the atolls of Tokelau. The impact of modern society along with food preserving and efficient harvesting technologies, and the opportunity to export resource products, has meant that some fishery species have been rapidly over harvested, which is very clear from the current surveys. The addition of these modern factors into traditional livelihoods also means that traditional methods of managing resources may not be sufficient to maintain sustainability of resources.

While there is a role for traditional temporary closures of areas in modern society it must be recognised that it will be limited in its ability to sustain long term fisheries if that is the only management technique that is adopted. The choice of areas for periodic closure should be targeted towards the most productive areas and should be rotated around a number of similar areas that are important for the aims of the resource conservation measure or species of concern.

RECOMMENDATION 4
Where harvesting is to be periodically allowd following temporary closures, there should be a systematic rotation of open and closed areas that are easily applied and the boundaries readily understood with reference to reef features. This will allow regular replenishment of species that can rapidly re-establish their numbers if left sufficient time to do so.

RECOMMENDATION 5
It is recommended that both temporary and permanent closure systems be employed to enhance overall fisheries yields for Fakaofo. Also, a clear distinction should be made between areas that are intended to be permanently closed to harvest activities and those that are to be more temporary (in terms of a number of years or on a seasonal basis).

5.4 Control on Harvest Practices.

Current harvest activities on Fakaofo have several characteristics that are significantly contributing to the over harvesting of resources. These include the widespread use of fish gill nets in the shallow and narrow channels that dissect the reef flat. The targeting of fish aggregation areas is also a significant contribution to over fishing, including the permanent location of a major fish trap in one of a significant fish aggregation area (in terms of the diversity of fish that are known to aggregate there) on the reef flat east of Fenua Fala. The

practice of taking all fish of any size is a further damaging factor that should be controlled if sustainable fisheries are to be maintained.

RECOMMENDATION 6
Good practice fisheries regulations need to be adopted that address the common causes of over fishing like small mesh net sizes, the targeting of most fish aggregation sites in any one year, and the taking of small fish sizes. These regulations have to be understood by all members of the community and have to be adequately enforced if they are not automatically adopted by all fishers.

5.5 Policy on Export Activities

The practice of exporting marine products for either family reasons or for income producing reasons both need to be carefully managed so that over exploitation of limited resources does not occur. A number of management arrangements that will help include obtaining a more accurate estimate of the current export level to families overseas. A careful policy in relation to commercial export industries will have to be developed before any scheme is approved.

RECOMMENDATION 7
It is recommended that the export of marine resources be significantly controlled or preferably be stopped as an essential measure to manage resources more effectively.

5.6 Plan Removal of Wrecks

It may be possible with a small grant and a high contribution of work effort from locals to effectively removal the bulk of the wreck in the NE corner of the atoll. This is a desirable outcome as the wreck is breaking up slowly and is impacting on a large area of the atoll and probably is causing. Fortunately, there are experienced people in the region that can be approached to give some initial advice and perhaps be available to undertake the task.

RECOMMENDATION 8
It is recommended that funds be accessed to undertake the removal of the ship wreck including the removal of metal fragments that are scattered over the reef flat. The removal should be done under experienced supervision with the fragments disposed in very deep water off the reef edge.

5.7 Waste Management Plan

There is obviously an issue on Fakaofo relating to the treatment of solid rubbish and this includes the issue of the importation of plastics. Waste management plans should also address the potential important issues of effluent and chemical use. This is because there is very poor circulation in the lagoon which means that any introduction of nutrients or chemicals can be very damaging due to the time that these chemicals can spend in the lagoon system.

RECOMMENDATION 9

It is recommended that a wide ranging management plan for waste in all its forms be developed as a matter of urgency and that it be implemented as soon as is practical.

5.8 Atoll Wide Issues

There are certain resource issues that should be approached on an atoll wide basis and this usually means that an atoll wide exclusion from harvesting will be required. Specifically the low numbers of turtles and sea birds that were apparently once abundant. Sea birds are important to the ecology of the motu vegetation by providing nutrients to poor soils. While sea birds can provide food for the community, it is recommended that they be used for this purpose only during food emergency situations. Islands that supported large colonies of seabirds no longer do so and no substantial colonies of sea birds were observed on any motu. A combination of natural disturbances (direct and indirect cyclone effects), and changes to the vegetation structure of the motus due to the expansion of coconut plantations, has probably contributed to the reduction in sea bird numbers.

RECOMMENDATION 10:
It is strongly recommended that an atoll wide ban on the harvesting of turtles and sea birds be put in place.

5.9 Biological Monitoring

Biological Monitoring provides ongoing data on the health and status of resource stocks. This data is essential for re-assessing and reviewing management issues with regards to specific animals and resources. This information is essential to provide the community with regular status reports of the marine environment (in particular specific resources of concern), and to highlight management actions that may need to be taken to ensure sustainable management of these resources.

RECOMMENDATION 11

It is strongly recommended that a Biological Monitoring Program be established once the final decisions are made on a sustainable management approach, so that information can be provided to the decision makers on the effectiveness of their decisions. Alterations and improvements to the rules governing the management of resources can also be made using the information obtained from monitoring efforts.

See Appendix 2 for the outline suggest approach for the Biological Monitoring Program.

6. References

Alailima K. 1998 Equitable & Sustainable Human Development – Situation Analysis Tokelau (revised and edited A Hooper 1999 & 2003) UNDP Unpublished.

Anon. (1991) Matagi Tokelau: history and traditions of Tokelau. Apia, Samoa, Office for Tokelau Affairs & Institute of Pacific Studies, University of the South Pacific. Gillet R. 1985 Traditional Tuna Fishing in Tokelau: Topic Review Number 7: South Pacific Regional Environment Programme

Blythe, D.G., D.P. de Sylva, & S. Cramer-Castro (1992)*"Ciguatera: Fish Poisoning"* [online] http://www.rehablink.com/ciguatera/poison.htm (Accessed August 2004).

Hooper, A. (1983). Tokelau Fishing in Traditional and Modern contexts. The Traditional Knowledge and Management of Coastal Systems in Asia and the Pacific: Papers presented at a UNESCO-ROSTSEA Regional Seminar held at the UNESCO Regional Office for Science and Technology for Southeast Asia 5-9 December 1983. K. Ruddle and B. Johannes. Jakarta, Indonesia, UNESCO. **1**.

Huntsman, J. and A. Hooper (1996). Tokelau: A Historical Ethnography. Auckland., Auckland University Press.

Huntsman, J. and A. Hooper (1996). Tokelau: A Historical Ethnography. Auckland., Auckland University Press.

Ioane M K 1994 Tokelau State of the Environment Report, SPREP, Apia Samoa.

Johannes, R. E. (1998). "Government-supported, village-based management of marine resources in Vanuatu." Ocean & Coastal Management **40**(2-3): 165-186.

Johannes, R. E. (2002) “The renaissance of community-based marine resource management in Oceania” . Annual Review of Ecology and Systematics **33**: 317-340.

Lear, B. (1989). "Conservation of the Indigenous Marine and Terrestrial Species and the Associated Traditional Knowledge and customs found in Tokelau."

MacGregor, G. (1937). Ethnology of Tokelau Islands. Honolulu, Hawaii, Bernice P. Bishop Museum.

Laboute, (1987). Mission to the Tokelau Islands to evaluate cyclone damage to coral reefs. SPREP Topic Review 31, South Pacific Commission, Noumea, New Caledonia.

Martin S, Allan M. Yska G. Tokelau 1006 Women’s Craft Project – Feasability Study and Project Design, Ministry Foreign Affairs and Trade.

Statistics New Zealand (1993) Tokelau Census of Population and Dwellings 1991: Analysis and Report. Statistics NZ, Wellington, NZ.

Passfield, K (1998). Report of a Survey of Marine Resources of Fakaofo Atoll Tokelau, July/August 1998. Draft Report to SPC 1988.

Ruddle, K. (1998) "Introduction to the special issue on a modern role for traditional coastal-marine resource management systems in the Pacific Islands". Ocean & Coastal Management **40** (2-3): 99-103

SPREP 1994 A Waste Management Study for TokelauTokelau Government 1995. Tokelau marine Conservation Area Project: Concept Proposal – A submission to the South Pacific Biodiversity Conservation Program. Environment Unit, Division of Natural Resources and Environment, Government of Tokelau.

SPC 1998 Tokelau Population profile – Based on 1996 Census: A Guide for Planners and Policy Makers. Secretariat of the Pacific: Community, Noumea.

SPC 1993 Document No. 5. Workshop on People, Society and Pacific Islands Fisheries Development and Management: Selected Papers. SPC, Noumea, New Caledonia.

Toloa, F., R. Gillett, et al. (1993). Traditional Marine Conservation in Tokelau. Can it be adapted to meet today's situation? Inshore Fisheries research Project Technical

Tokelau Government 2002 Report on the National Assessment for the World Summit on Sustainable Development - Tokelau Islands

Tokelau Government 1995 Tokelau Marine Conservation Area Project: Concept Proposal – A submission to the South Pacific Biodiversity Conservation Program. Environment Unit, Division of Natural Resources and Environment, Government of Tokelau.

Annexes

Annex 1 Fakaofo Fish List with Local Names. :

Scientific Family	Common Name	Scientific Name	Tokelau Name	Habitat	Abundance	Notes
Acanthuridae	Orangebar Surgeon fish	Acanthurus olivaceus		Slope	Very common	Schools
Acanthuridae	Convict Surgeon	Acanthurus triostegus		Slope	Very common	Schools
Acanthuridae	Striped Bristletooth	Ctenochaetus striatus		Slope	Very common	Schools
Acanthuridae	Yellow Tang	Zebrasoma flavescens		Slope	Very common	Schools
Balistidae	Titan Triggerfish	Balistoides viridescens		Lagoon & Slope	Very Common	Individuals
Balistidae	Black Triggerfish	Melichthys niger		Slope	Very Common	Large Schools
Balistidae	Pinktail Triggerfish	Melichthys vidua		Shallow Slope	Common	Individuals
Balistidae	Wedge Picassofish	Rhinecanthus rectangulus		Crest & Reef Flat	Uncommon	Individuals
Carangidae	Blue Fin Trevally	Caranx melampygus	Aheu	Slope	Common	Small schools of relatively small individuals; Occassional larger individuals
Carangidae	Big Eye Trevally	Caranx sexfasciatus	Komulo	Slope	Common	Large Schools
Carangidae	Golden Trevally	Gnathanodon speciosus	Alala	Slope	Common	Large Schools of Juveniles
Carcharhinidae	Grey reef Shark	Carcharinus amblyrhynchos	Ikapo	Slope	Uncommon	
Carcharhinidae	Reef Blacktip Shark	Carchhinus melanopterus	Malu	Slope&Lagoon	Common	
Carcharhinidae	Reef Whitetip Shark	Triaenodon obesus	Kili	Slope&Lagoon	Uncommon	
Chaetodontidae	Ornate Butterfly	Chaetodon ornatissimus	Tifitifi	Slope&Lagoon	Common	
Chaetodontidae	Spotnape Butterfly	Chaetodon oxycephalus		Slope&Lagoon		
Chaetodontidae	Fourspot Butterfly	Chaetodon quadrimaculatus		Slope		
Chaetodontidae	Reticulated Butterfly	Chaetodon reticulatus	Tifitifi	Slope	Very Common	
Chaetodontidae	Pacific Doublesaddle Butterfly	Chaetodon ulitensis		Slope & Lagoon	Common	Pairs
Cirrhitidae	Halfspotted Hawkfish	Paracirrhites hemistictus	Patukilaufala	Slope	Very Common	Juveniles in passes
Holocentridae	Big scale Soldierfish	Myripristis berndti	Malau tea	Slope	Common	Schools
Holocentridae	Spotfin Squirrelfish	Neoniphon sammara	Putalaloa	Reef Flat		
Holocentridae	Sabre Squirrelfish	Sargocentron spiniferum	Ta	Slope		
Holocentridae	Tahitian Squirrelfish	Sargocentron tiere	Malauloa	Slope	Common	Targeted at night
Kuhliidae	Fivebar Flagtail	Kuhlia mugil	Safole	Shallow slope	Common	Schools
Labridae	Red Brested Wrass	Cheilinus fasciatus	Papo	Slope	Common	Individuals
Labridae	Maori Wrass	Cheilinus undulatus	Malatea	Slope	Common	Usually large individuals&smaller individuals

Scientific Family	Common Name	Scientific Name	Tokelau Name	Habitat	Abundance	Notes
Labridae	Harlequin Tuskfish	Choerodon fasciatus		Slope	Common	Usually individuals
Labridae	Sling jaw Wrass	Epibulus insidiator		Slope	Common	Usually individuals
Labridae	Bird Wrass	Gomphosus varius	Mutuhiko	Slope	Common	Individuals
Labridae	Bicolour Cleaner Wrass	Labroides bicolor		Slope&Lagoon	Common	
Labridae	Bluestreak Cleaner Wrass	Labroides dimidiatus		Slope&Lagoon	Common	
Labridae	Six Bar Wrass	Thalassoma hardwicke	Sugale	Slope	Common	Schools
Labridae	Surge Wrass	Thalassoma purpureum	Uloulo	Slope	Common	Individuals
Lethrinidae	Orangefin Emperor	Lethrinus erythracanthus	Hapute	Deep slope	Uncommon	Individuals
Lethrinidae	Thumbprint Emperor	Lethrinus harak	Filoa	Lagoon	Common	
Lethrinidae	Yellowlip Emperor	Lethrinus xanthochilus	Filoa	Slope	Common	Schools
Lethrinidae	Bigeye emperor	Monotaxis grandoculis	Mu	Slope	Common	Schools and individuals
Lutjanidae	Red Bass	Lutjanus bohar	Fagamea	Slope	Common	Individuals & occasionally large
Lutjanidae	Longspot Snapper	Lutjanus fulviflamma	Taiva	Slope	Common	Schools
Lutjanidae	Yellow margin Seapearch	Lutjanus fulvus	Tagau	Slope&Lagoon	Common	Schools
Lutjanidae	Paddletail	Lutjanus gibbus	Taea	Slope	Common	Schools
Lutjanidae	Five lined or blue-lined Seaperch?	Lutjanus kasmira	Havane	Slope	Common	Schools
Lutjanidae	Scribble Snapper	Lutjanus rivulatus		Deep slope	Uncommon	Individuals
Lutjanidae	Black Snapper	Macolor marcuaris	Mu mea	Slope	Uncommon	Individuals
Lutjanidae	Black&White Snapper	Macolor niger	Mu mea	Deep slope	Common	Associated with caves
Mullidae	Yellow Goatfish	Mulloides varicolensis	Memea	Slope	Common	Schools
Mullidae	Dash-dot Goatfish	Parapensis barberinus	Tuita	Slope	Common	Individulas
Mullidae	Manybar Goatfish	Parupenus multifasciatus	Hulu	Slope	Common	Individulas
Muraenidae	Peppered Moray Eel	Siderea picta	Puhitea	Lagoon	Very Common	Schools
Pomacantridae	Lemonpeel Angelfish	Centropyge flavissimus		Slope	Very Common	Small Groups
Pomacantridae	Flame Angelfish	Centropyge loriculus		Slope	Very Common	Individuals
Pomacantridae	Regal Angelfish	Pygoplites diacanthus		Slope & Lagoon	Common	Individuals
Pomacentridae	Blue green Chromis	Chromus	Palulaufala	Slope&Lagoon	Very Common	Schools
Pomacentridae	Dicks Damsel	Dascillus		Slope	Very Common	
Pomacentridae	Three spot Dascillus	Dascillus		Slope	Common	
Puffer	Spotted Toby	Canthigaster solandri		Slope	Uncommon	Individuals
Scaridae	Tanface Parrot	Chlorurs frontalis	Kamutu	Shallow Slope	Common	
Scaridae	Bullethead Parrot	Chlorurus sordidus	Uhu	Slope	Common	Schools
Scaridae	Pacific Long nose Parrot	Hipposcarus longiceps	Ulafi	Slope	Common	Large schools; ciguatoxic in areas at Fakaofo only

Scientific Family	Common Name	Scientific Name	Tokelau Name	Habitat	Abundance	Notes
Scaridae	Reefcrest Parrot	Scarus frontalis	Kamautu	Shallow Slope	Common	Schools
Scaridae	Bluebeard Parrot	Scarus ghobban	Alamea	Slope	Common	Individuals
Scaridae	Schlegels Parrot	Scarus schlegi	Koti	Slope	Common	Individuals
Serranidae	Peacock Grouper	Cephalopholis argus	Loi	Slope	Very Common	Individuals
Serranidae	Flagtail Grouper	Cephalopholis urodeta	Matele	Slope	Common	
Serranidae	Brown-marbled Grouper	Epinephelus fuscoguttatus	Fapuku	Slope	Common	
Serranidae	Hexagon Grouper	Epinephelus hexagonatus	Eve	Slope		
Serranidae	Honycomb Grouper	Epinephelus merra	Gatala	Slope		
Serranidae	Slender spine Grouper	Gracila albomarginatus		Slope	Uncommon	
Serranidae	Lowfin Rudderfish	Kyphosus vaigiensis	Nue	Slope&Surf zone	Common	Schools
Serranidae	Squaretail Grouper	Plectropomus areolatus	Tonu	Slope	Rare	Not presently seen - targeted in the past
Serranidae	Whitmargin lyretail Grouper	Variola albimarginata	Papa	Slope&Lagoon		Not presently seen - targeted in the past
Sphyraenidae	Great Barracuda	Sphyraena barracuda	Pananua	Slope	Common	
Sphyraenidae	Chevron Barracuda	Sphyraena qenie	Ono	Slope corners	Common	Large Schools
Zanclidae	Moorish Idol	Zanclus candescens	Laulaufoau	Lagoon&Slope	Very Common	Targeted in passes
	?	?	Kamutu	Slope		

Annex 2 Biological Monitoring Program

There are five main elements to the Biological Monitoring Program. They are listed below in order of greatest priority.

Element 1. Atoll Wide Marine Assessment

An atoll-wide rapid assessment should be every 3-5 years to provide a general assessment of the health of all marine habitats and stock populations of selected indicator species within the atoll. This will duplicate the original marine assessment undertaken in this exercise and all techniques and organisms targeted are described the in detail in the Technical Report. Capacity building, training and community awareness programs on all aspects of this program should be included in these activities. Community based monitoring should be an integral component of the long term monitoring as it serves to maintain local awareness of the trends in the atoll's resources, and also provides a mechanism for the trends to be directly passed on to the community (the information stays with the village).

These data then need to be analysed to provide information on the success of the management actions. This information is extremely important to provide direct scientific evidence that the management actions are conserving and protecting marine species and habitats. The Permanent monitoring sites should used to provide long-term repeatable data sets. The permanent long term monitoring activities are more technical and probably will have to be carried out with the help of specialists.

It is expected that the conservation areas will provide a habitat that is free from human interference, thus allowing the natural processes of reproduction and recruitment to occur resulting in stock population increases of previously targeted species. These conservation areas are an essential component to the management of the marine resources of the Atoll and must be maintained and monitored.

Element 2. Monitoring Effects of Atoll Wide Bans

The Atoll-wide Bans on selected species must be reviewed through data assessment to determine if and when stock populations have recovered enough to allow subsistence and/or commercial activities to recommence. Suggested species include : turtles (particulalry turtle nesting); coconut crab numbers and sizes; sea bird colonies on remote motus.

The monitoring of species such as these will be very important if there is any action taken that sttempts to remove some of the threats to these specis. Threats include, wild pigs, cats, and rats, that are affecting population numbers and disturbing motu habitats.

Element 3. Monitoring Spawning Aggregation Sites

It is recommended that there be an investigation into the exact reef locations and timing of spawning aggregations within the atoll. This will have to be carried out so that the most effective decisions can be made on protecting this vital aspect of an atoll's fishery. This is because there has to be a decision on which aggregation sites are most worthy of protection from harvesting so that the maximum number of important fish species can be afforded

protection to complete their reproduction functions and so help to reverse the trend towards depletion of stocks.

Information gained from the marine assessment (SPREP, 2003) and anecdotal information gleaned during the community discussions have provided valuable information on the locations of fish spawning aggregation sites.

However, verification of these and other sites within the lagoon is required to allow the successful management of these important resources to be achieved.

Element 4. Evaluating Specific Species

A resource evaluation should be undertaken to assess the existence, locations, and abundance and population size of coconut crab and turtle populations within the atoll.

Element 5. Capacity Building

There is an urgent need to run an extensive training program on resource management and monitoring protocols. This training program must include data collection techniques for both terrestrial and marine environments, data recording and analysis. An urgent requirement is to include clear demonstrations of the life cycle of many important species so that the community understands what is required to be addressed with respect to the management of those species.

It is recommended that the Conservation Project seek the participation of a local science graduate (and perhaps an overseas volunteer in the first instant) to assist in all aspects of the program.

In the short term many aspects associated with the marine monitoring program may require external technical support.