Marine Resources of Tokelau Atolls

NUKUNONO

Marine Resource Management Plan

Background Report

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Government of Tokelau

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for

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Executive Summary & Recommendations

Background to this Survey

In 2002, the Tokelau government approached SPREP for assistance with marine resource management and conservation in the Atolls. A scoping study was undertaken in Tokelau over two separate visits in 2002 / 2003 to assess the level of community and leadership interest in revitalizing the previously proposed marine resource management project[1]. 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 visit each of the Tokelau Atolls to undertake an assessment of the possible options for conservation areas and looking at the status of the inshore and lagoon resources of the atolls (from a conservation perspective) as 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 resources and community attitudes towards conservation of marine resources.

These surveys were not focused on assessing the biodiversity of Tokaleau's marine resources but were designed to address issues raised by the community in particular, and to assess the general state of the marine environment and the impacts on it, the status of harvested resources and 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;
- 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; 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 Nukunonu Atoll that should be taken into account when considering the sustainable management of marine resources.

The relative geographical isolation of Nukunonu atoll from other Tokelau atolls, and from other reef systems means that marine resources on Nukunonu are effectively isolated from all other sources of marine species replenishment. The atoll is, in effect,

[1] Marine Conservation Areas previously proposed to SPREP under the South Pacific Biodiversity Conservation Project. 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.

a “closed” biological system. 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 within Nukunonu Atoll.

Nukunonu lagoon is an open expanse of water with small steep sided patch reefs scattered throughout which are surrounded by deep water. Steep edges inside the perimeter drop away from the surrounding inner reef flat. A particularly gradual depth transition is located in the NE corner adjacent to Tokelau Island extending from the lagoon edge out to the SW to approximately the large patch reef known as Akau o le Whaga. The lagoon does not have any deep 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. Water exchange occurs between the lagoon and the open sea through tidal inundation of the reef flat and from water pushed over the crest by oceanic waves and swells. The relatively most well flushed section of the lagoon is located along the northern atoll margin (Te Ahaga Loa) where there are no permanently exposed intertidal areas or motus.

The closed lagoon means that the removal of pollutants (sewage, chemicals) and other introduced substances will be very slow and possibly these will remain in the deeper parts of the lagoon for a considerable time. Therefore the lagoon is highly susceptible to natural disturbances as well as to human induced ones, for example toxic substances from land based sources of pollution.

The status of marine resources on Nukunonu 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 in addition to contemporary 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.

Giant clams (predominantly *Tridacna maxima*) were generally in high numbers and were mainly observed in the lagoon. The only other species of clam observed on Nukunohu was an occasional individual of *Tridacna squamosa*. The distribution of clams is highly variable over the whole lagoon. Clam densities within the lagoon are highly dependent on the availability of suitable hard substrate for settlement.

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 (i.e., 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 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.

Surveys of the slope habitat confirmed the general pattern of absence of clams, large sponges and ascidians, and with very few holothurians present. The holothurians observed on the slope were relatively uncommon and in very low densities. *Actinopyga mauritiana* was the only holothurian observed on the slope (mostly on the crest) in contrast to the lagoon where predominantly *Holothuria atra* were observed. 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 from 1983.

Nukunonu 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 implementing in management prescriptions. Some of the issues and perceptions are outlined below.

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

The Nukunonu community generally feel that changes in lifestyle in Nukunonu have lead to a dramatic increase of rubbish and pollution from introduced goods and fuel. There is great concern over what to do with the rubbish on Nukunonu and where to store rubbish such as plastics and tins. There are fears that this is damaging the lagoon and its corals and fisheries resources.

People are generally concerned about declines in resource numbers and sizes, particularly fish. There was also concern expressed about decreasing in coconut crab sizes, and the loss of seashells used for handicraft such as cowry, *pule*, and *mimiha* shell. Respondents noted that the coral reef was now degraded as corals throughout the lagoon had been damaged, changed colour and some had died.

Resource management
Resource management activities in Nukunonu have been traditionally practiced to ensure enough for tomorrow (sustainable use). Community members felt that fakahao (conservation) was a new idea and practice, different to traditional resource management practices. Most people interviewed felt *fakahao* was something for future generations Resource management, traditional and new, is the responsibility of the *taupulega.*

The Conservation Area

There are two *fakahao* areas in Nukunonu, one is a clam reserve, the other *fakahao* area, *Te Ahaga Loa Fakahao*, in theory restricts all fishing and clam harvesting. This section will focus on the later area. The *Te Ahaga Loa Fakahao* is considered an idea from outside and is generally viewed by community members as a positive and important for Nukunonu.

Many community members agree with the idea of a *fakahao* area because they see it as an important back-up supply to be fished in the event of cyclone damage, bad weather restricting access to parts of the lagoon or outer reef, for special events on island or for family in Samoa. Many of the people interviewed felt it should be an area that is opened up occasionally for these reasons and closed in the meantime to allow resources to increase. Not all community members agree with the concept of a Coservation Area in Nukunonu. A few community members felt there is no need for a *fakahao* area in Nukunonu because it has the biggest lagoon, a small population and large fish and clam populations. Other respondents expressed a dislike of the *fakahao* area because they felt it restricts their rights, and they do not like having an area in the lagoon that they cannot go to or access.

The management of the *fakahao* area is considered the sole responsibility of the *taupulega*. There has not however been a unified effort to implement the Conservation Area. Respondents feel that the *fakahao* area will be managed as a fish larder, occasionally opened for resource harvesting.

Community awareness of the fakahao area is very low in Nukunonu, there is a general lack of understanding as to the purpose and goals of the Conservation Area. Community compliance of the *fakahao* area is currently low. It was felt that this was because there was limited awareness amongst community members about the area, a lack of general management (i.e. lack of general purpose, rules, enforcement and punishment), as well as a generally poor attitude amongst community members towards the *fakahao area.* While many community members are unsure of the need and purpose of the *fakahao* area most respondents felt the *fakahao* area is for the future generations.

Status of the Conservation Area

The community generally perceives the *fakahao* area as unsuccessful in its current state. This is because there have been no substantial changes in resources, there is a low level of awareness and management, and people are generally not obeying the rules. The low level of compliance is associated with a lack of serious penalties and enforcement of the rules. It is felt that people have not yet committed themselves to the *fakahao* area and there has not been a concerted attempt to implement it. "*They say it is fakahao and then people still go there and fish and they change the rules, it's not constant, that's why it is not a success now*". The lack of consistency in rules and regulations and the lack of compliance was a major reason identified by participants for the *fakahao* areas lack of success.

In discussion about what a successful *fakahao* area would be, it was generally agreed that it will be one in which fish, coral, clams, and other marine resources are able to grow and increase in size and population. It will be somewhere that can be compared

to other areas within the lagoon and changes and improvements can be seen. The majority of people see a successful Conservation Area as an essential place '*to keep our atoll alive because it is all we have'*. Success in Nukunonu's *fakahao* area would also have greater community ownership and responsibility for it.

It was generally felt that success in the Nukuonu *fakahao* area will be reached through wise leadership, community awareness and education, and through increased community compliance. Success will be reached in the opinion of many community members when a serious commitment is made by the *taupulega* and the village to a *fakahao* area.

Recommendations

Considering the findings of the resource surveys and community consultations, the following recommendations are seen as a way to improve Nukunonu Atoll's resource management. 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***
   - conserve the integrity of the natural and cultural values of Nukunonu 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;
   - 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

Specific high value areas that could significantly benefit long term sustainable fisheries, if managed effectively, are mostly related to seasonally occurring phenomena. That is, the well known fish aggregation sites spread around the lagoon near passes and channels will have to be effectively allowed to fulfil their

reproductive function before too many breeding adults are taken from the population to maintain adequate numbers of those species. 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. It is also wise to nominate 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 not be targeted 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

Giant clams populations comprised predominantly *Tridacna maxima*, as only a few individuals of *T.squamosa* were observed during the whole period of the survey. The densest aggregations of clams were observed in the eastern sectors of the lagoon. 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 on the northern margin 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

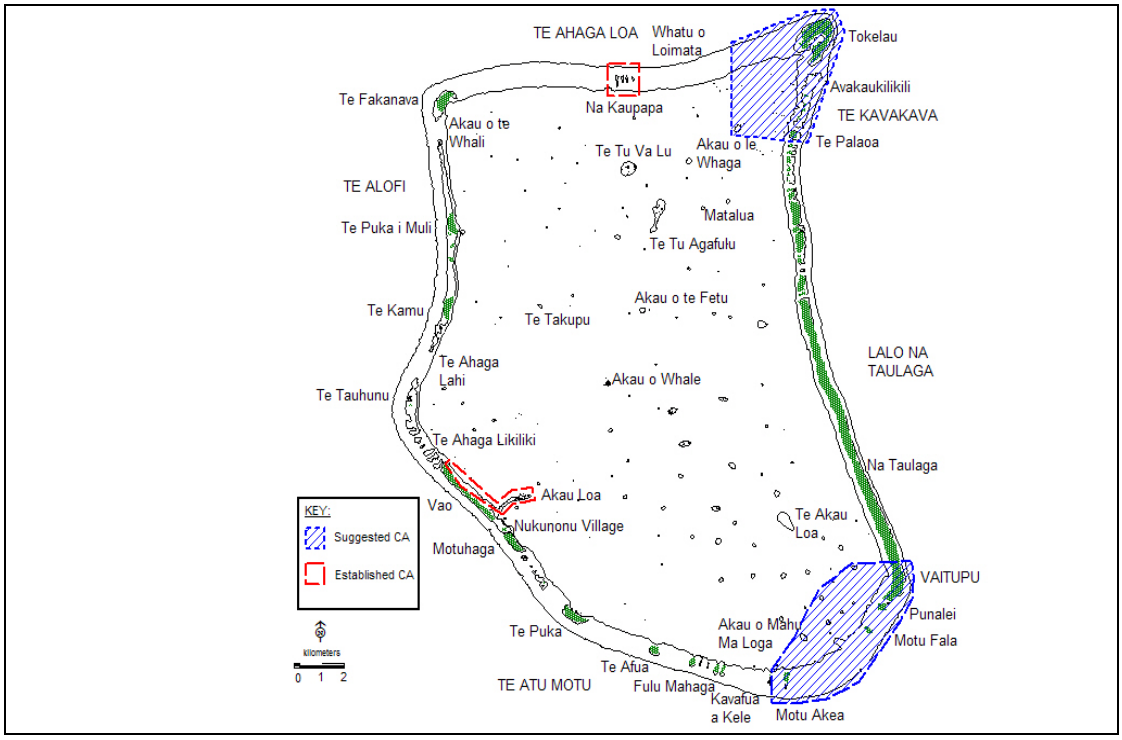
The current Conservation Areas includes the western edge of the lagoon (Akau Loa) adjacent to the village on Nukunonu Island (Figure 7) and the mid northern atoll margin in the area known as Na Kaupapa. The NE corner with Tokelau Island at the centre, is a highly productive part of the atoll. The acute angle to the atoll margin at this point is where currents sweeping along the slope meet from different directions. Clam numbers are very high on patch reefs in this sector of the atoll, and fish diversity is relatively high.

RECOMMENDATION 3

It is recommended that the two current Conservation Areas be maintained as specific clam recovery areas, though it is noted that a low percentage of clams are at a reproductive mature size

RECOMMENDATION 4

It is recommended that consideration be given to making the NE corner of the atoll (based on Tokelau Island) a major Conservation Area which would be of ecological significance to the whole of the atoll. The reef slope, reef flat, and a portion of the adjacent lagoon (to approximately 12 m depth) should be included in an area that excludes 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.



Existing Conservation Areas and suggested new Conservation Areas for Nukunonu.

Permanent and Temporary Closures of Areas

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 5

Where harvesting is to be periodically allowed, 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 6

It is recommended that both types of closure systems be employed to enhance overall fisheries yields for Nukunonu. 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).

Harvest Practices

Current harvest activities on Nukunonu have several characteristics that are significantly contributing to the over harvesting of resources. These include the widespread use of gill nets in the shallow and narrow channels that dissect the reef flat; the targeting of fish aggregations and the taking of all fish of any size are damaging factors that should be controlled if sustainable fisheries are to be maintained.

RECOMMENDATION 7 :

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 exporting marine products for either family reasons or for income needs should be carefully managed so that over exploitation of limited resources does not occur.

RECOMMENDATION 8

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.

Waste Management

RECOMMENDATION 10 :

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. Seabird and turtle numbers appear to have significantly declined according to the community.

RECOMMENDATION 11

It is strongly recommended that turtles and sea birds be placed on an atoll wide list of resources that should be excluded from any harvest activities.

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 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.

As first step towards establishing a marine conservation program in Tokelau, SPREP put together a multi-disciplinary team of scientists, educators, managers and community specialists to visit each of the Tokelau Atolls. The team's task was 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 communities to establish a picture of community perceptions of the status of resources and community attitudes towards conservation of marine resources

These surveys were not intended to develop a complete assessment of the biodiversity of Tokaleu's marine resources. The purpose of the visit was:

- to assess the general state of the marine environment,
- to assess past and present impacts on marine resources,
- to assess the status of harvested resources, and,

[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.

- to assess the effectiveness of any management measures in place and the level of community support for present and future management actions by the local community leaders.

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

The surveys goals were to:

- **Undertake a rapid assessment of the status of significant marine resources and ecosystems;**
- **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).

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 awareness.
   - Working cooperatively.
   - Clean up the environment.

These points were reinforced during the scoping visit and the marine assessment visit in 2003 by community members and leaders.

1.2 Methodology

Consultations and Community Surveys

The development and sustainable management of Nukunono'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. 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.

Community Consultations

Issues raised

- Depletion of marine resource stocks.
- Recent depletion of certain 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.

- **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.

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 to ensure there was widespread ownership of the process and thereby the proposed management initiatives.

Ecological Surveys

Ecological surveys 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 finer scale surveys (timed swims in the lagoon or slope, walking transects 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 (including density estimates for specific reef species; distribution patterns, relative presence / absence or broad relative abundance category estimates; and the presence and distribution pattern of 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 approach adopted was considered the most appropriate to yield a holistic assessment of the general health of the ecosystem and major reef populations with the time and resources at hand, to support decision making with regard to recommendations on future best management options. Extensive use was made of photographic and video records so that permanent records were obtained of the major habitat features and major species present.

Two sites were assessed using rigorous quantitative assessment methods to establish permanent monitoring sites for the slope habitat. One site was established in the western slope of the Te Ahaga Loa Conservation Area, and a comparative site was established some 500 m south of this site, outside the Conservation Area and south of the harbour entrance.

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

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

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.

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

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

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

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

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.

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 NUKUNONU 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, Atafu, Nukunonu, and Fakaofo are located at between $8^{0}20^{'}$S, $172^{0}30^{'}$W (Atafu) and $9^{0}\ 20^{'}$S, $171^{0}15^{'}$W (Fakaofo), with Nukunonu approximately midway between the other two atolls (Figure 1). 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.

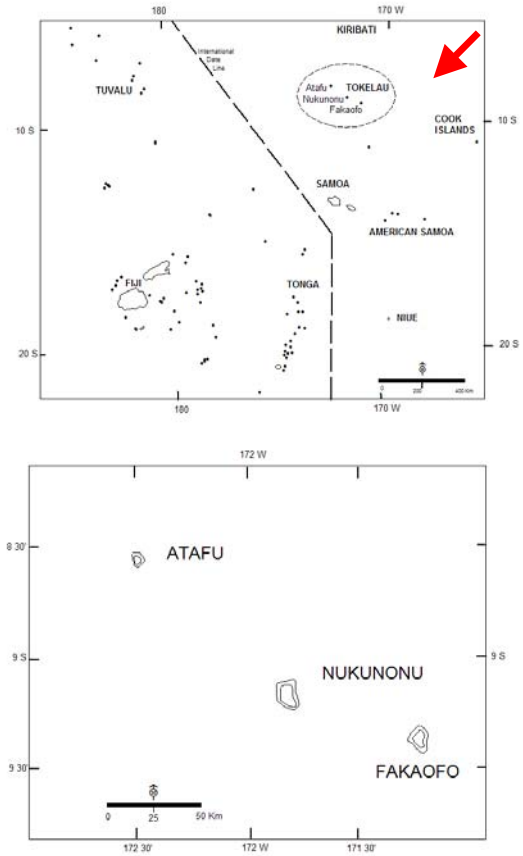


Figure 1. Location of Tokelau in the Pacific (Top) and relative location of the three atolls to each other (Bottom).

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 Nukunonu as discussed in this section.

Motus or Islets

Nukunonu atoll is relatively small in total area compared to many other inhabited Pacific Ocean atolls (Figure 2). The land area of Nukunonu consists of about 24 small motus sitting atop an approximately rectangular reef, 14.5 km in its longest axis (approximately south to north) and 8 km wide (approximately west to east), and a total land area of only about 4.7 sq km, which with their linking reef system encircle a large lagoon of about 98 sq km[6]. Individual motus vary greatly in size from (12 km to less than 100m in length, measuring parallel to the outer reef edge) and none are greater than 5 m above mean sea level. Most motus have extensive accumulation of shifting coral sand around the intertidal shoreline and more permanent sand deposits above high tide levels. The intertidal 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 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.

The populated Nukunonu motu where Nukunonu Village is located, is on the mid south-western side of the lagoon. Nukunonu Village includes a communal piggery situated on the north western end of the island and village.

Significant reef and coastal alteration from major cyclones appear to be most destructive in the northern and western sections of the atoll. This is very similar to other island states in this part of the Central South Pacific (for example, in Samoa and Niue, pers.obs.), and represents a regional pattern of natural disturbance due to cyclones.

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

Lagoon

The 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 are most are no wider than approximately 50 m. Nukunonu lagoon is a relatively open expanse with small steep sided patch reefs scattered throughout which are surrounded by deep water. There are approximately 10 patch reefs that are relatively larger than all the others (approximately 200 to 300 m diameter) present in the lagoon, and approximately 25 to 30 moderate sized patches (75 to 125 m diameter) with the remaining numerous patches of a much smaller size (50 m or less diameter). Figure 2 shows the scattering of patch reefs within the lagoon and the relative range of sizes present. The relatively most well flushed section of the lagoon is located along the northern atoll margin (Te Ahaga Loa) where there are no permanently exposed intertidal areas or motus.

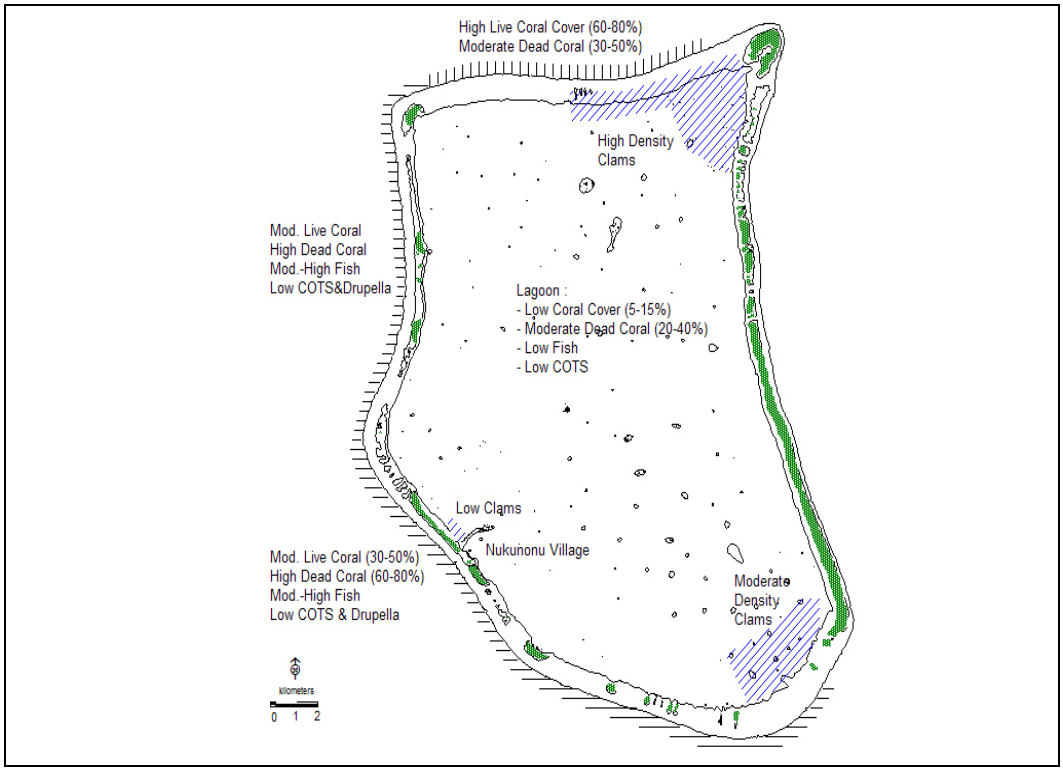


Figure 2. Nukunonu Atoll and lagoon – physical structure.

The closed nature of the lagoon means that the removal from the lagoon of rubbish, 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 occurring conditions, such as elevated sea temperatures during prolonged dry and calm weather, will also persist inside the lagoon for longer than periods (than would occur in a more open

lagoon system). 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.

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. The lagoon is shallow in places around the lagoon margin though the majority of the perimeter rapidly drops off into deep water from 40 to 70 m depth. A particularly gradual depth transition is located in the NE corner adjacent to Tokelau Island extending from the lagoon edge out to the SW to approximately the large patch reef known as Akau o le Whaga.

The shallow patch reefs in the NE lagoon adjacent to Tokelau Island (Photo 1) are dominated on the surface by profuse growth of coralline algae[7]. 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 crevices and holes that are frequently formed under the surface growth offer refuge for many reef organisms. Eventually these overhanging 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.

Photo 1. Coralline algae dominating the shallow near surface portions of reef surfaces in the lagoon.

(Photo David Fisk)

[7] **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.

The closed nature of the lagoon has implications if fishery species for mariculture are introduced (as was discussed by the Taupelega). High density mariculture of molluscs (pearl shell, clams) produces high nutrient loads in the surrounding water that can kill the animals if water exchange is not sufficiently high to remove these potentially 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.

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 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[8] of butterfly fish, damsel fish and wrass species.

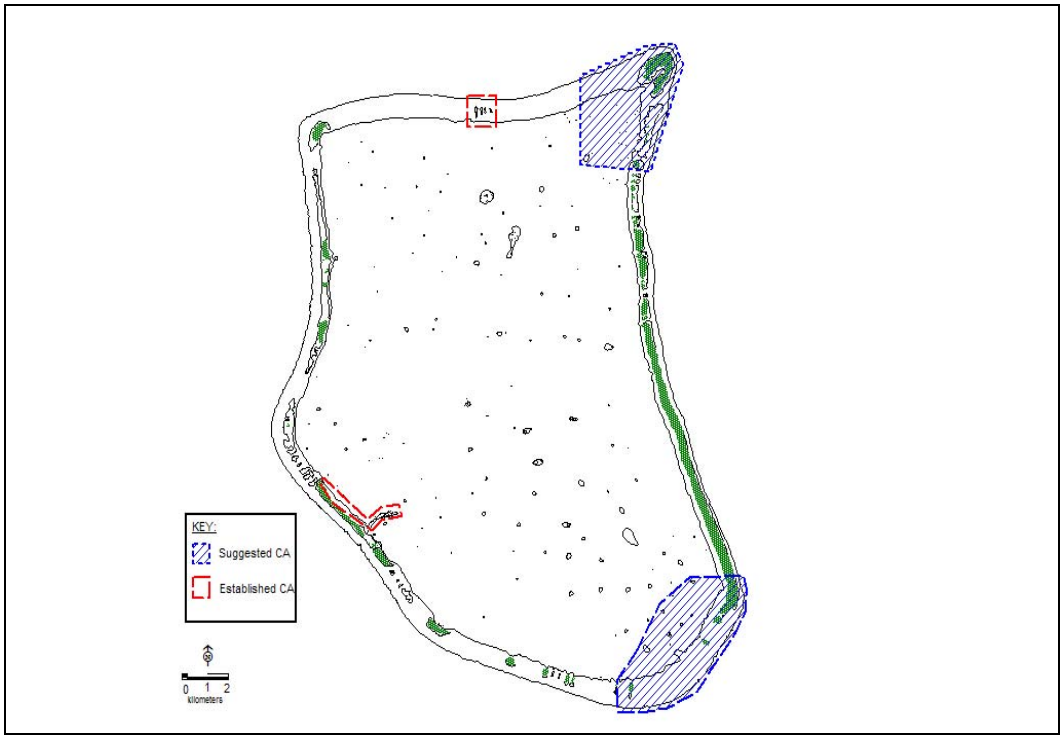


Figure 3. Existing Conservation Areas on Nukunonu Atoll and suggested new or alternative Conservation Areas.

[8] **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 utilize 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.

Photo 2. Inner reef flat on the northern lagoon margin with good coral cover and shallow pools along this back edge. The inner reef flat can be good giant clam habitat but clams were not often observed here during the 2003 surveys. Large boulders that are tossed up by cyclone waves are also common.

(Photo Mary Power)

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 width 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.

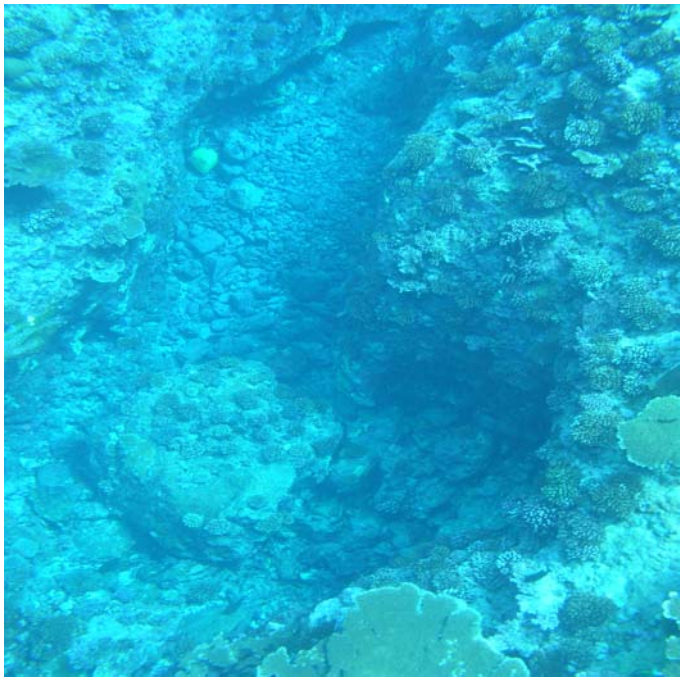


Photo 3. Typical spur and groove formation on the upper slope - crest - wave break zone. Grooves are used by many fish as feeding locations and refuges, and entrances to the reef flat. Here large boulders and broken coral move out to deeper water in high wave conditions, making the walls of the grooves smooth from constant erosion, which in turn is good habitat for turf algae on which the herbivorous fish feed. (Photo Dave 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 can vary 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 are 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 also be located. The

corners of the atoll are probably attracting these predators because they are zones of tidal convergence and hence a place where many food sources meet, setting up a food chain that attracts the predators in high numbers. The timing of the survey team's visit also coincided with the annual early summer fish spawning period, and aggregations of spawning fish species were sometimes observed at these corner locations.

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. It is a relationship that is highly dependent on (safe) weather conditions, the level of technology available to the people, and the knowledge of the community to the cycle of resources. For example, access to outer reef resources is weather dependent as reef attached species can only be harvested close to the reef edge due to deep water near shore which is also where strong oceanic swells impact on the reef edge. In contrast, offshore pelagic[9] 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 Nukunonu, and Tokealu generally 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, locations in the lagoon distant from the centralised village residences still require special effort and / or mechanized boats which increase costs of accessing the resources. This effect is evident with the distribution of many fishery species within the Nukunonu 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

[9] **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.

of Nukunonu have a wealth of traditional 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 rhythms particularly to spawning cycles. 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 species.[10] 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 as larvae are retained within the lagoon.

2.4 Resource Management

The limited land availability and impoverished soil of Nukunonu 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[11] and having regular transport to Samoa, Nukunonuans remain highly dependent on their marine resources for subsistence. Marine resources in Nukunonu are open access to the village level. Traditionally the management of atoll resources lies in the hands of the *taupulega*.

Resource management in Nukunonu 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 Nukunonu 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*[12] system and the *taupulegas*' rule, enabled to a certain degree the

[10] **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.

[11] 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).

[12] 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.

sustainable use and management of each of the atolls limited resources. Growing individual expectations are increasing the pressure on Nukunonuans 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.

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[13]: marine ownership and resource (offshore and lagoon) rights are restricted to Nukunonuans, 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

[13] 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).

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[14]. *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 Nukunonuan 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 Nukunonu, and fishing effort was relatively even (between offshore and the lagoon) according to workshop participants and respondents. This could 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[15].

Conservation Area

Currently there are two "no-take" or '*fakahao'* (conservation) areas in Nukunonu. 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, Te Ahaga Loa Fakahao, is situated in the northern corner of the atoll and encompasses a small portion of lagoon. 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 Nukunonu 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[16]. It appears the general community has not been able to conceptualise the conservation area ideal beyond a communal fish larder.

[14] i.e. "*we did have lafu before …(but) lafu was just for land*

[15] 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).

[16] This was noted by community leaders and community members.

2.5 Ecosystem and Resource Status

2.5.1 Habitat Characteristics

Underwater visibility can be an indicator of relative turbidity or the amount of material that is suspended in the water. At Nukunonu, manta tows recorded very good visibility in nearly all 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 observed. In some of the lagoon sections the clarity was much less than 6 m visibility, especially around the lagoon perimeter adjacent to the larger motus where the turbidity levels can be 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 makes it unsuitable habitat for most filter feeding animals. The relative visibility of areas within the lagoon is indicative of the relative level of water flushing. Most of the isolated patch reefs away from the lagoon perimeter are surrounded by very clear water as little resuspension of sediment from the lagoon floor occurs due to the depth of surrounding water.

Photo 4. Sponges are a very common feature of the lagoon which is indicative of abundant microscopic food for these filter feeders, despite the absence of strong water flows. This very common yellow-orange coloured sponge is shown in the middle of a common lagoon coral, *Echinopora pacificus.*

(Photo Dave Fisk)

The broad assessment of the lagoon and outer slope by manta tow showed 80% of tows in the lagoon and 100% of tows on the outer slope were dominated by live coral (Table 1). The lagoon habitat also recorded a low number of tows where the benthos was dominated by filter feeding invertebrates like sponges, bivalves, and ascidians[17]. 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

[17] **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.

spiny oyster (*Spondylus* spp) and other bivalves (especially the boring date mussel, *Lithophaga* spp).

Habitat	Benthos					# Tows
	ASC	CA	LC	MA	SP	
Lagoon	0.0	18.0	80.0	0.0	2.0	50
Slope	0.0	0.0	100.0	0.0	0.0	36
All Habitats	0.0	10.5	88.4	0.0	1.2	86

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

2.4.2. 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.

Photo 5. Typical scene of the outer slope with a high level dead coral present. Here the foliose *Montipora* spp is rapidly overgrowing dead *Pocillopora* spp colonies with a large dead *Acropora* spp also present (LHS).

(Photo David Fisk)

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.
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[18]. 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.

The massive growth form was relatively low in abundance on the slope compared to other more dominant forms, however, it was very conspicuous especially on the mid to lower slopes. The massive growth form on the outer slope is probably more accurately described as a flat or plate like form whereas the lagoon massive form is the more typical hemispherical form. The domination of massive and encrusting forms in 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	34.0	6.0	22.0	0.0	38.0	0.0	0.0	50
Slope	8.3	0.0	0.0	11.1	30.6	33.3	0.0	16.7	36
All Habitats	3.5	19.8	3.5	17.4	12.8	36.0	0.0	7.0	86

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 (15.8%) compared to the slope (45.5%), and dead coral cover of 22.7% in the lagoon and 48% on the slope. The mortality index was similar in the lagoon and on the slope (0.4 compared to 0.5, respectively) reflecting the much higher recent death of corals that has occurred in the lagoon. Soft coral was extremely rare and was not recorded from any of the survey sites, though incidental observations were made on the presence of small colonies in a few slope sites.

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 for the percent cover of live coral. 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

[18] 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.

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 lagoon 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 Nukunonu 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 28% cover with approximately two to three times as high cover on the slope compared to the lagoon.

TOWS	%LC	%DC	%SC	MI
Lagoon	15.8 (15.7)	22.7 (33.4)	0.0 (0.0)	0.4 (0.4)
Slope	45.5 (21.3)	48.3 (13.4)	0.0 (0.0)	0.5 (0.2)
Combined	28.2 (23.4)	33.4 (29.7)	0.0 (0.0)	0.4 (0.3)
SWIMS				
Lagoon	18.7 (18.8)	7.8 (6.8)	0.0 (0.0)	0.39 (0.26
Slope	70.0 (0.0)	25.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Combined	21.6 (21.0)	8.5 (*7.6)	0.0 (0.0)	0.36 (0.24)

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 = 50 and slope tows = 36. Number of lagoon swims = 14 and slope swims = 1.

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 42.9 % of timed swims (total of 14) 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 not observed in lagoon swims (Table 4) and filter feeding macro invertebrates (targeted visible bivalves, sponges and colonial or solitary ascidians) were present in 42.9 % of swims in the lagoon, and particularly on the more centrally located larger patch reefs.

Holothurians were recorded in approximately 36 % of tows in the lagoon (9 % with high abundances, and 21 % with low abundances, number of tows = 50). None of the slope tows recorded the presence of holothurians (number of tows = 36). Giant clams were present in 71 % of lagoon tows and in none of the slope tows. Urchins were not recorded in either the lagoon or slope tows.

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 with very few holothurians. The holothurians observed in swims on the slope were relatively uncommon, in very low densities, and were different species to those observed in the lagoon, namely, *Holothuria atra* in the lagoon compared to *Actinopyga mauritiana* on the slope.

HABITAT	MACRO INVERTEBRATE	No (% Swims)	No (% Tows)	TOTAL SITES
LAGOON	CLAMS	6 (40 %)	49 (71 %)	69
	HOLOTHURIANS	3 (20 %)	36 (52 %)	50
	OTHER	7 (47 %)	N/A	50
SLOPE	CLAMS	0 (0 %)	0 (0 %)	36
	HOLOTHURIANS	1 (6 %)	0 (0 %)	36
	OTHER	0 (0 %)	N/A	36
TOTAL	CLAMS	6 (18 %)	49 (47 %)	105
	HOLOTHURIANS	4 (13 %)	(21 %)	86
	OTHER (Filter Feeders)	9 (27 %)	N/A	86

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

Giant clams (mainly *Tridacna maxima*) were generally in high numbers and were mainly observed in the lagoon of Nukunonu during manta tow surveys (Table 5). The only other species of clam observed on Nukunohu were an occasional individual of *Tridacna squamosa*. 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 further away from the principal settlement on the west side of the atoll. Estimates of densities were taken from a good representative sample of 69 manta tows within the lagoon, which included a number of tows used for the sole purpose of recording clam densities. Table 5 shows the clam density estimates from manta tows which averaged 340 individuals per tow (each tow covered approximately 3000m^2).

	MEAN (SD)	TOTAL
Lagoon :		
Clams / Tow (SD)	340 (1033)	
Clams./Ha (SD)	2939 (8159)	
Slope :		
Clams / Tow (SD)	0	
Clams./Ha (SD)	0	
Overall :		
Clams / Tow (SD)	214 (833)	
Clams./Ha (SD)	1931 (6745)	

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

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 2939 clams per hectare. Almost all clams were of the one species, *Tridacna maxima*, with very low numbers of *Tridacna squamosa* observed in a few locations. Timed swims recorded clams present in 40 % of lagoon swims, and none were present on the slope swim sites.

Photo 6. High densities of clams (*Tridacna maxima*) among live *Porites* spp patch reefs are typical of the northern lagoon margin. (Photo David Fisk).

Specific *Tridacna maxima* clam densities and size classes were recorded from the reef flat and from the lagoon margin, as well as from inside and outside of the Na Kaupapa Conservation Area on the north atoll margin. This was undertaken to gauge the effectiveness of the Conservation Area to enhance clam abundance and size structure. Clam sizes were marginally larger inside the Conservation Area compared to outside (Figures 4, 5). The size class distribution pattern was well represented either side of the median size value (approximately 7 cm outside the CA and approximately 8 cm inside the CA). The median clam size of 7 to 8cm from both sites is the minimum size that clams are reproductively mature. This pattern indicates that very little disturbance or harvesting pressure is affecting the population as there is no obvious variation in the size pattern.
Figure 5 shows the size class distribution of *T.maxima* clams on the mid reef flat from inside and outside the CA. Though the size classes are different to those recorded on the lagoon margin (Figure 4), there is nonetheless a clear pattern of the reef flat clams inside the CA being generally smaller than those outside the CA.

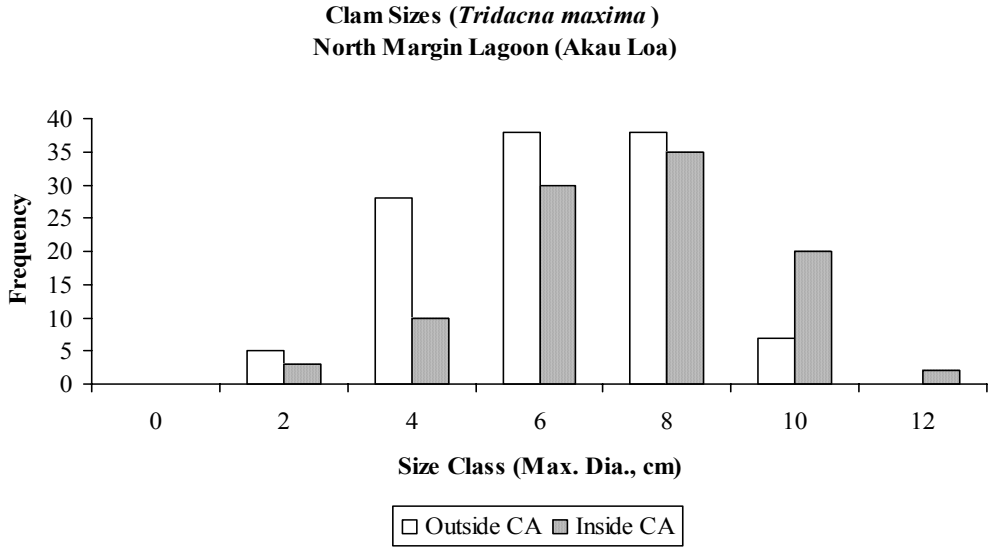


Figure 4. Giant clam size frequencies from the northern lagoon margin and from inside and outside the Conservation Area. Sample size was from 100 individuals in each of the two areas.

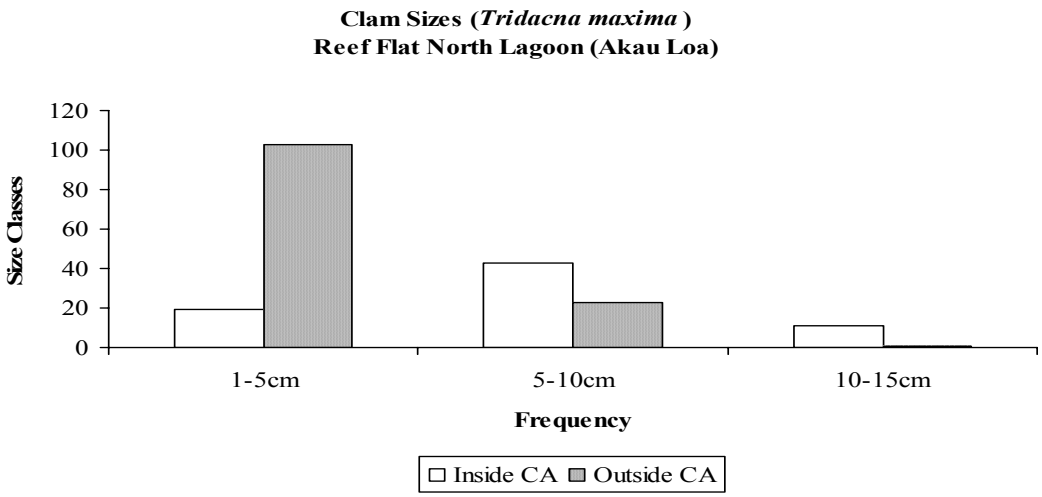


Figure 5. Sizes of giant clams (*Tridacna maxima*) from the reef flat inside and outside the Conservation Area on the northern atoll margin.

The *T.maxima* clam data from the reef flat and the lagoon margin (and presented separately in Figures 4, 5) were combined (Figure 6) to show that the reef flat clams are much smaller overall, and probably represent a more recent recruitment event that could be separate from the lagoon margin situation.

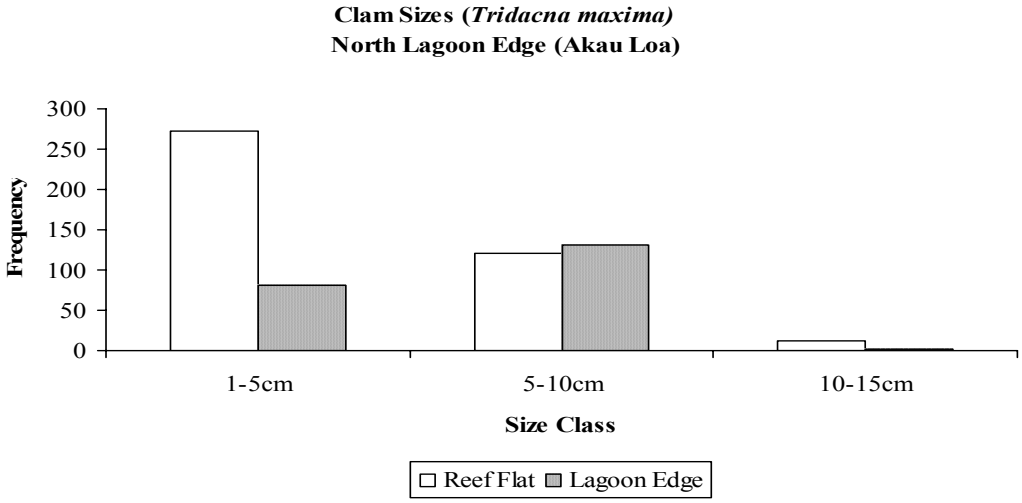


Figure 6. Giant clam (*Tridacna maxima*) sizes from surveys of the reef flat and lagoon margin.

Trochus shell species (*Trochus niloticus*) were introduced to Nukunonu in 1989 at Te Fakanava Island in the NW corner of the atoll at a site on the east reef flat. Extensive surveys of this site on the outer reef flat at low tide revealed no individuals.

DOMINANCE :	Lagoon	Slope	Total
Butterfly fish	2.0	0.0	1.2
Damsel fish	0.0	0.0	0.0
Grouper	2.0	0.0	1.2
Mixed Families	18.0	11.1	15.1
Paddletail	0.0	0.0	0.0
Parrot fish	46.0	22.2	36.0
Rabbit fish	0.0	0.0	0.0
Snapper	8.0	5.6	7.0
Surgeon fish	16.0	13.9	15.1
Trevally	0.0	0.0	0.0
Trigger fish	0.0	47.2	19.8
Wrass	8.0	0.0	4.7
ABUNDANCE :			
High	2.0	30.6	14.0
Medium	26.0	38.9	31.4
Low	72.0	30.6	54.7
NUMBER OF TOWS	50	36	86

Table 6. The percentage of manta tows recording the dominant fish families and abundance categories in lagoon and slope habitats.

Fish Communities

The status of fish from manta tow surveys (Table 6) showed that abundances varied in the lagoon from 72 % of tows with low fish (less than a total of 100 fish per 3 min tow), 26 % with medium fish (100-500 fish per 3 min tow), and 2 % with high abundances (> 500 fish per 3 min tow). In contrast, tows on the slope recorded high fish numbers in 31 % of tows, and tows recording medium and low abundances with 39 % and 30 % of the remainder of tows (respectively).

Dominance of fish families (Table 6) showed that parrot fish (F. Scaridae) are the most dominant family in the lagoon (46 % of tows) and trigger fish the most dominant in the slope habitat (47 % of tows). Mixed families (usually a combination of parrot fish and surgeon fish (F. Acanthuridae)) were the second most abundant (18 % of tows) in the lagoon. This compares to the slope where parrot fish (14 % of tows) were the second most dominant family. The slope and lagoon habitats showed a different range of family dominance outside the top few dominant family groups. Butterfly fish, grouper, snapper, and wrass families were recorded as dominant in some lagoon habitats in contrast to the slope where snapper, surgeon fish, and mixed fish families were sometimes dominant.

Photo 7. Schools of big eye trevally were occasionally observed at the edge of the dropoff on the lower slope.

(Photo David Fisk)

Photo 8. School of Splendid Soldier Fish (*Myripristis botche*) under a large plate coral colony on the mid slope. Coral colonies like these provide essential habitat for fish.

(Photo David Fisk)

Photo 9. Schools of surgeon and parrot fish are commonly found in the spur and groove zone that lead up to the crest. Here local fishermen target surgeon fish with hand spears. (Photo David Fisk)

Large indicator species (fish, turtles, and dolphins) were occasionally observed during tows which can be a good indicator of the degree of fishing pressure (Table 7). Black-tip sharks were the most commonly recorded large species observed (17 % of all tows). Green turtles were the next most frequently observed species, both in the lagoon and on the slope. Most turtles were relatively small in size though a few possibly breeding adults were also included in these observations.

SPECIES	LAGOON	SLOPE	TOTAL
Green Turtles	4 %	6 %	5 %
Black-Tip Shark	4 %	31 %	17 %
Big-Eye Trevally School	0	3 %	1 %
Spinner Dolphin School	0	3 %	1 %
Barred Barracuda	0	3 %	1 %
NUMBER Of TOWS	50	36	86

Table 7. Percentage of tows on which large indicator species were observed.

A checklist of fish species that were observed during all field work was compiled for Nukunonu 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.

2.4.3. 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 thick '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 impacts in the recent past. In contrast to the lagoon, mortality 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. Due to the drop in cover of the above dominant species, foliose *Montipora* spp are rapidly increasing in cover and are growing over dead colonies (see Photos 10, 11).

Natural disturbances to the coral reef (Table 8) of Nukunonu also are occurring from other factors in addition to bleaching, and include coral disease (Photo 11), feeding scars from a gastropod (*Drupella* spp) and from crown of thorns starfish (COTS, *Acanthaster planci*, Photo 10).

Photo 10. White feeding scars from a crown of thorns starfish is evident on a plate *Montipora* spp on the southern mid slope.

(Photo David Fisk)

Photo 11. A dying colony of *Stlyophora* spp on the slope with disease (pale section; with the dead parts of the colony showing a darker colour).

(Photo David Fisk)

	BLEACHED	DISEASE	SCARS	DAMAGE	ALL	NO. TOWS
LAGOON	0.0	6.0	8.0	0.0	14.0	50
SLOPE	0.0	2.8	13.9	2.8	19.4	36
TOTAL	0.0	4.7	10.5	1.2	16.3	86

Table 8. Disturbance indices recorded from mant tows from the lagoon and the slope. ALL refers to all tows with one or more disturbances recorded.

Moderately higher incidences of disturbance were observed on the slope (19% of tows (compared to 14 % in the lagoon) were observed with at least one type of disturbance) and some tows were observed with more than one disturbance type present. Very few bleached corals were observed with occasional sites in the lagoon showing mild signs of bleaching only. Coral disease was observed on a small percentage of corals but it was not widespread (6% and 2.8 % of tows from the lagoon and slope, respectively) in the 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 observed in both the lagoon (14 % of tows) and the slope (8 % of tows) and were a result of either *Drupella* spp or COTS activities. The feeding characteristics of either organism are quite different so it is relatively easy to distinguish between the two types of scars. Feeding scars were more common in the lower slope at the edge of the steep drop off in approximately 20 m depth. Scars observed in the current survey were manly 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 in a few incidences 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.

Crown of thorns starfish (COTS) were noted during consultations to be present on the north atoll margin (Ahaga Loa). However, during the current survey, feeding scars were confined to the south west atoll margin slope (Tetafa), though the north east and east coast slope was not surveyed. Overall, the effect of these feeding scars was minor as they were low in abundance within most sites.

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.

A pesticide spill was recorded in 1969, where a mix of possibly DDT and Malathion entered the lagoon causing significant damage. In particular, a 2 km stretch of lagoon along Motu Te Kakai was severely affected with most corals aside from *Porites* spp died, and no recovery was observed at least till after 1975 (Salvat, 2000). Chemicals were also washed into the lagoon from storm surges associated with cyclone Tusi, which severely impacted on Nukunonu in 1987. Cyclone Tusi was reported to have severely affected coral communities on the north and north-western slopes, but not in the lagoon.

The susceptibility of the lagoon ecosystem to natural and man made disturbances is a critical factor that must be taken into account in the consideration of management options.

2.4. Conclusions

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

1. The relative **geographical isolation** of Nukunonu atoll from other Tokelau atolls, and from other reef systems means that marine resources on Nukunonu 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 individual atolls like Nukunonu, 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 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 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 the food chain) for long periods.

4. 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.

5. The significantly low rate of water flushing from and within the lagoon **will have major implications for the potential to develop mariculture** activities.

6. The attempt to seed Nukunonu reefs with an **introduced trochus species has not met with success** with the one seeded site showing no survival of trochus.

7. Nukunonu 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 Nukunonu and therefore they should be managed as a single area.

8. The overall status of marine resources on Nukunonu 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.

9. 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 highly efficient gill nets into these sites has meant that the catch of fish for the amount of effort is far higher than it ever has been in the past.

10. The current reef system and its biological components on Nukunonu 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.

11. There is clear evidence that **significant impacts have occurred from recent bleaching events** and major components of the reef have been affected, particularly on the outer slope and less so in the lagoon where it would be expected that species in the lagoon were relatively adapted to high temperature fluctuations.

12. **There are additional indicators of current stress** in the reef system which 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. Stress indicators from the slope include the presence of low levels of coral disease, and the presence of higher

than normal levels of feeding scars on some corals from (mainly) coral eating gastropods (*Drupella* spp) and crown of thorns starfish.

13. 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 locally desirable predator fish species such as black trevally and groupers, that were apparently once quite abundant.

14. 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.

415. The one exception to the lack of abundance of fishery species is the **very high densities of giant clams** (*Tridacna maxima*) in certain sectors of the lagoon. The highest densities of clams are found on patch reefs in depths of more than 5 m. However, the average size of clams is quite small with the median size of most clams averaging less than <12cm, which are slightly above the minimum breeding size. There were very low densities of *Tridacna squamosa* in all habitats

3 Community Perceptions on Resources and Resource Management

3.1 Rationale for investigation into community perceptions

It is now widely accepted that local knowledge, concerns and priorities should be incorporated into any resource management strategy. In addition, addressing social concerns deemed important and a priority by the focus community is essential for the success of any resource management and conservation initiative. This is especially relevant and necessary in Tokelau where the *taupulega* (local council) is the community voice and the main body responsible for the management of the local community and atoll environment, including resource use and conservation.

The following is a general summary of the main issues and themes that were raised during community meetings and interviews in Nukunonu. Twenty-five semi-structured interviews were conducted with a cross-section of community members (male and female) over the age of eighteen. Community workshops were held with the *fatupaepae*, *taulelea* (married men) and *taumalo* (unmarried men), *taupulega, kau talavou* (youth) and sport and public service. In addition resource mapping and story telling sessions were conducted with *toeigas* as well as casual discussions with community members. The opinions expressed are therefore those of the community members of Nukunonu, not the team.

Note the in-text italics are statements taken directly from interviews.

3.2 Socio-cultural setting of Nukunonu Atoll

Nukunonu's central governing authority is the *taupulega* (local government council). This is the 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). In Nukunonu the *taupulega* is composed of male representatives of families from within the village regardless of age but with a focus on *toeigas* (elders). The *faipule* (administrative officer, village representative to the National Government) and *pulenuku* (mayor, charged with the oversight of internal affairs) also sit on the *taupulega*. Huntsman and Hooper (1996, 3) describe Nukunonu's *taupulega* as, "*basically a coalition of distinct corporate descent groups; decisions in the council are affirmed by consensus and its members are charged with transmitting them to the groups they represent"*.

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, the *taupulega's* power and role is currently being reinvigorated. The strength of the *taupulega* and the community's reliance on them was starkly evident in Nukunonu Atoll.

3.3 The important qualities of Nukunonu

"I was born in Nukunonu, this is where I'm from…my heart is Nukunonu"

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

The qualities of Nukunonu that are most important to the community, according to respondents, are the things which "*we use and depend on*". This includes resources from the motu's, lagoon, and ocean. "*I love living in Nukunonu…because you can live here and not need money, you can get food and materials from the land and sea…that is the reasons I want to stay here until I die*".

Nukunonu is different from the other atolls, the lagoon and it's resources are considered by community members as being unique. According to respondents, the lagoon is the backbone of the atoll, "*we rely on the resource found in there for our subsistence*". The lagoon provides important resources as well fostering the lifestyle of Nukunonu, "*fishing, that's the lifestyle here…both in the moana and the lagoon but mostly in the lagoon...the fish that I catch in the lagoon are tastier and smell better*". Some respondents pointed out the importance of the coral in the lagoon as this is where the fish feed and live.

The community itself, its culture and traditional practices, the Nukunonu lifestyle and doing things *faka-Tokelau* (the traditional Tokelauan way), were considered paramount to life in Nukunonu. This encompassed working and socialising together, as well as sharing food and resources through the traditional *inati*[19] system. Respondents felt the community is an important and unique quality of the atoll, the sharing of food and experiences, the community working together are amongst the things that endears them to the atoll. "*The most important quality to me is* e*veryone coming together in a group and the group associations we have*". The love and respect felt for each other and the sharing of resources and experiences, *"that's how from the beginning until now that it's always been...the sharing and the love, doing things together".* Another respondent commented, "*The culture and Nukunonu's natural resources…because Nukunonu is totally dependent on limited resources… sharing, whatever you have we just share it*". The church plays a central role in the Nukunonu community, *"the church, it keeps people together, it's a way of people gathering together to share their thoughts, especially because here there is only one church".*

It was felt that Nukunonu provides an easy life for members of the community, money is not required for daily needs as the islets and surrounding marine environment provides all that is needed for day-to-day living. The village of Nukunonu is considered safe and peaceful. It was felt this lifestyle is possible because of the leadership of the *taupulega* and *toeiga*, and the respect community members have for them and their decisions. One participant commented that the most important qualities for him were, *"first would have to be our culture for example when we*

[19] 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.

divide fish everyone gets equal share, second would be looking up to the elders hey, respect for elders". One of the younger members of Nukunnu commented, "*I feel grateful to the taupulega and obliged to do the same for future generations*".

Photo Joanna Axford

Due to the limited amount of land area in Nukunonu the small islets (motus) that bound the lagoon are considered a vital quality. The scarceness of land means the terrestrial resources are very important. Especially those that are useful for handicraft and food, "*we are very proud of our pandanus that we use for weaving the mats and the nonu tree we use the juice for medication even the leaves we use for massage*".

The important resources of Nukunonu according to respondents are those that are used for food and handicrafts. It is the *"things we depend on that are the most important, such as coconuts, pandanus and fish"*. It is the resources of the atoll that define the place and the lifestyle of the community, "*the land, this is where we live, and the fish the vitamins from the fish that we eat to live and the trees, the coconut tree is number one because we use the whole tree from the roots to the top"*. Respondents felt all of these resources were equally important and required care and wise use.

3.4 Nukunonu Community Concerns

The Nukunonu community generally feels that changes in lifestyle in Nukunonu have lead to a dramatic increase of rubbish and pollution from introduced goods and fuel. There are fears that this is damaging the lagoon and its corals and fisheries resources. Rubbish is also considered by many to be an eyesore that is having a negative affect on the health of the Nukunonu community.

People are generally concerned about declines in resource numbers and sizes, particularly fish, "*the fish use to come to us and now we have to go looking for them*". Fish declines include amongst others: *atuli* (big eyed scared), mackerel, rabbit fish, *tonu* (coral trout), *uluakata* (giant trevally), *ihe* (garr fish), *atu*, black trevally and *maiava*. In addition the size of many fish species has declined, *"fish aren't as big, sometimes there are big fish but not like before".* The *tonu*, considered a particularly important fish in Nukunonu, is no longer seen. A *toeiga* explained that he thought this was because, "*they took too many and the water was a bit rough and in the years after that the tonu started dying out and I think no one has ever seen it again*".

There was concern expressed about decreasing in coconut crab (*uga'uga*) sizes, and the loss of seashells used for handicraft such as cowry, *pule*, and *mimiha* shell. "*these months there should be millions of Cowry shells but we hardly see any of them*" and "*Uga'uga(coconut crab) is getting harder to find these days, find plenty of small ones (indicates wrist), just large ones hard to find*". Respondents noted that the coral reef was now degraded as corals throughout the lagoon had been damaged, changed colour and some had died, "*The coral seems to be dying…mainly in the lagoon, the colour of the coral has changed, I hardly see yellow corals now"*.

Pollution and rubbish is a major concern for all community members on Nukunonu. *"Things from outside are bringing in sickness and rubbish to Nukunonu*". It is an issue affecting the health of the community, the visual appeal of the atoll "*it is an eye sore*" and having an effect on the marine and terrestrial environment. "*Rubbish is being thrown into the sea including batteries, people just throw them into the sea when fishing at night with torches, now we are starting to see a change to fish*". There is great concern over what to do with the rubbish on Nukunonu and where to store rubbish such as plastics and tins, "*The problem now is there is nowhere to store the rubbish*" and "*if get a big wind may end up in the lagoon*".

One respondent commented that their greatest concern is the attitude and behaviour of the community, "*the only threat is ourselves really…for example when we go out to get the clams we take the small and the big even though we know its wrong…its laziness*".

Perceived changes in Nukunonu's lifestyle

"For certain kinds of fish like atuli we use to catch before with nets but now we are so use to spear guns and rods, we get them more quickly with spear guns, but before had to wait until a special month to get atuli and maiava but now people don't wait they go all the time, this is the problem I forgot the special months, I never learnt them".

Respondents noted changes in the population, lifestyle and habits of the people of Nukunonu over the past few decades. As the population has slowly declined since the 1960's new technology, produce, tools and knowledge from overseas, have changed the way people do some things. It was felt by some that the village community is moving towards a society composed of nuclear families (in terms of fishing and sharing) rather than extended families, and a "*more palagi (western) lifestyle*". "*The way they (community members) look after the village and their children now days has changed, now there's a feeling that it's up to the individual, it was never like that before it was up to the whole community*". It was noted that changes in fishing technology and transport as well as new work requirements has changed the way people in the village fish, "*in the olden days we fished for food but now we fish for sport*".

Photo Joanna Axford

Some respondents questioned the fact that marine resources had continued to decline despite the decreasing population of Nukunonu and the community's reduced reliance on marine resources due to the availability of foreign substitutes (such as meat). There are, "*less people in the village than when I was a boy but the fish size is smaller*". Subsequently participants felt that men are now fishing less and spending more time working on land. These respondents felt that people are therefore now having a much smaller impact on the marine resources and declines may be attributed to the natural flow of things and changes in the behaviour of marine species, "*I'm just curious, how can there be hardly any fish if less people fishing… I think they are still there we are just have to go deeper water to get them*". This was not however a view

held by all, strong links between new more efficient practices and demand, and, resource declines and degradation were noted by some.

The introduction of technology such as freezers, "*everyone has a freezer, some have two*", has meant that food such as fish can now be caught in bulk and stored. "*Men aren't going out fishing as much as they use to, still go fishing but now they use nets and catch heaps*" and another respondent noted, "*people don't fish for daily needs or fish with the phases of the moon anymore*". The introduction of the cash economy and petrol driven boats has meant that the men are less likely to go fish together as a group and more likely to fish on their own. *"Before the cash economy people just worried about their daily needs…now they go any day and catch the smaller fish, the cash economy is having a big impact on way things are done here"*. In addition the requirements from relatives now living in Samoa and New Zealand means more resources are being exported, "*when I was a boy the food in the lagoon was just for those on island now family in Samoa and New Zealand call for it a lot*" and "*I'm worried about the clams because there are more being taken out then are being eaten in Nukunonu… they are mainly for family in Samoa, probably once every second boat a load is taken*". Another respondent stated, *"clams, fish, coconuts are all taken out of Tokelau"*.

Some people felt that these changes have had a negative affect on Nukunonu's environment and community. For example the outboard motors of small lagoon boats, *"they might be chasing away the fish"* and they are felt to be the source of pollution, *"Petrol and oil waste from outboard engines spilling onto the reef it might be damaging the coral, from what I heard before Tokelau was beautiful with the old vaka, now the petrol and pollution is effecting the sand on the lagoon side of the village"*.

A *toeiga* commented at the teams final meeting, "*fifty years ago we had different ways of fishing and sharing resources, now things have changed, new impacts on resources and this is perhaps why people feel the way they do*".

3.5 Traditional Resource Management

The people of Nukunonu have a variety of traditional resource management practices. The *taupulega* and *toeiga* are the decision-makers for all issues related to Nukunonu's resources. "*It has always been up to the taupulega to make the rules, it is their authority*". Traditionally the *toeiga's* knowledge, foresight, advise, decisions and rules would guide the community and direct how, where and when they interacted with the environment.

The *lafu* system (seasonal or species bans) is an important way the atoll's limited resources were traditionally managed. The *taupulega* would control resource use in these areas. Respondents explained that *lafu* was mainly practiced in terrestrial areas, not in marine. *"there was fakahao like lafu in the uta and there were certain areas we couldn't go (lagoon?) no just the land side"* and "*lafu was mainly for the outer islets, not lagoon or ocean*". 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 following are some of the traditional practices identified by participants:

- size restrictions, "*never take the small only the big*" and *" the good size fish we keep and throw away the small ones for another day"*;
- wise controlled use for the villages daily needs, "*we were not allowed to over do it…take more than we needed*" and *"before the toeigas would say if there are too many fish in the nets, let them go for tomorrow";*
- restriction on female coconut crabs, "*we were not allowed to harvest the female uga'uga, especially if she had eggs*";
- sharing sacred species amongst the village, such as: turtle, marlin, flying fish or skip jack, "*these have to be shared with the whole village*";
- temporary resource restrictions on target species, for example on coconut and pandanus (for handicraft) were implemented by the *taupulega* and *pulenuku*; and
- temporary restrictions on harvesting methods, for example *"at certain times of the year men were not allowed to throw their nets"*.
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Photo Joanna Axford

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. Some community members expressed concern that knowledge was being forgotten, *"I'm not sure because now the younger generation never listen to the elders, but we should have*". The changes that have taken place in Nukunnu over the past few

decades has however meant that a lot of these traditional practices are either no longer practiced or are not able to cope due to new practices and technology. Subsequently the majority of respondents had never heard of *lafu* or had limited knowledge of it. *"in the past especially on outer motu's we usually had specific places to get coconuts and crabs and other areas were prohibited, the taupulega usually did that before, we didn't have outboards then, but now we hardly do that because everyone has to help and has their own jobs".* **It is however clear that resource management, traditional and new, is seen as the responsibility of the *taupulega*.**

3.6 *Fakahao* (Conservation)

Resource management activities in Nukunonu have been traditionally practiced to ensure enough for tomorrow (sustainable use). Community members felt that *fakahao* (conservation) was a new idea and practice, different to traditional resource management practices, *"it's a new idea, when I was a young man and went fish the old men would tell us to throw back the smaller fish, people still do it but it's different to the fakahao".* Workshop participants and interviewees generally expressed a lack of knowledge and understanding about *fakahao*. It was generally felt that it is an, "*idea from outside*"(foreign idea) that the *taupulega* had agreed to. There was however some similarities between *fakahao* and traditional ways of resource management identified by a few participants, "*fakahao is a new program in Tokelau but…we did have te lafu before*".

Before colonization, environmental factors, technology and development conditions imposed limitations on resource harvesting, for example a lack of storage capacity (no refrigeration) and a lack of technology to take more than needed (i.e. no motorised boats or fine mesh nets). One workshop participant noted another important and traditional form of conservation practiced by the community and often misunderstood by outsiders, *"I think keeping them (fish spawning sites) a secret is another form of conservation, and it only concerns our people…there are two ways of conservation mental and physical, its good not to know about sites".*

Conservation is seen by some community members of Nukunonu as "*really important to Tokelau because have limited resources and need to control the amount of fish we catch and the number of clams we harvest*". Most people interviewed felt *fakahao* was something for tomorrow, for future generations, "*I agree with the idea of fakahao, it is for the children's future, I think this is something the taupulega should look into.*"

3.6.1 *Te fakahao* area (the Conservation Area)

There are two *fakahao* areas in Nukunonu, one is a clam reserve, the other *fakahao* area, *Te Ahaga Loa Fakahao*, in theory restricts all fishing and clam harvesting. This section will focus on the later area.

It was generally felt that while the *Te Ahaga Loa Fakahao* is an idea from outside, that the *toeiga* and *taupulegas* agreed to and chose an area for implementation. The design and management of the *fakahao* area is currently considered ineffective by community members. The *toeigas* selected the position and the boundaries of the *fakahao* area in an ad hoc fashion. One *toeiga* explained where the boundary posts

were erected, "*wasn't where they were suppose to put it but when we got there we thought, well, this will do…you can still put it anywhere you want to, just not too big*". Others commented that the site was chosen "*because that is where the clams are good and the fish are free to come in and out*". Others felt it was selected because it is an area of low use, "*it was picked because hardly anyone goes there*". Some respondents believe the *fakahao* area is temporary and will soon be opened up for village use.

Community awareness of the *fakahao* area is very low in Nukunonu, there is a general lack of understanding as to the purpose and goals of the Conservation Area. A few people in the community had not heard of the *fakahao* area, and many of those interviewed did not know where the boundaries are located, "*I'm not too sure of the boundaries*" and **"***all I know is it is closed but I don't know why, from the meetings of the taupulega all I know is its closed, but why should it be?"*. Many people did not know where in the lagoon the Conservation Area is, "*only the taupulega know where the fakahao is, no one else*" and another respondent commented, *"I don't go to the outer islets so I don't see the fakahao…as far as I know I'm allowed to go there, I was away for a bit and wasn't able to go to the fono so I didn't know about the fakahao…since I haven't been able to go (to the taupulega meetings) I don't know anything"*.

Community compliance of the *fakahao* area is currently low, and poaching is generally accepted, "there *are rules but people don't obey them*" and "*we haven't committed ourselves to the laws*". Some respondents and workshop participants felt that this meant the area was ineffective, "*(the area) can't be fakahao because people still go there…the taupulega say it is a fakahao area but people don't obey*".

Community perceptions of the *fakahao* area

The idea of a Conservation Area is seen as an important resource enhancement fish and clam "larder' for communal consumption. Many community members agree with the idea of a *fakahao* area because they see it as an important back-up supply to be fished in the event of cyclone damage, bad weather restricting access to parts of the lagoon or outer reef, for special events on island or for family in Samoa. Many of the people interviewed felt it should be an area that is opened up occasionally for these reasons and closed in the meantime to allow resources to increase. "*To me looking at the small area we have to use, it should not be closed all the time, it should be opened when we really need it like hurricanes that's when we can use it but for other times and uses it should be closed"*. Another respondent commented, *"if something is important and we need things (food) fast the toeigas say go there to the fakahao and get fish… (it is) just for the village"*.

Not all community members agree with the concept of a Coservation Area in Nukunonu. A few community members felt there is no need for a *fakahao* area in Nukunonu because it has the biggest lagoon, a small population and is '*the land of fish'*. Other respondents expressed a dislike of the *fakahao* area because they felt it restricts their rights, and they do not like having an area in the lagoon that they cannot go to or access. Community members also expressed a generally concern that the restrictions on clam and fish harvesting is leading to declines, "*since the fakahao there are less clams*". There is a wide spread belief within the village that when a

clam is harvested the '*tama*' (egg sack) is popped and this allows the clams to spread. Without harvesting therefore it is generally believed that the clams will not spread. Subsequently, a few believe it should be opened up and given back to the village.

At the final whole village meeting the team presented a variety of options for no-take areas within the lagoon and outer area to assist in the sustainable management of the atolls resources. In reply to the options proposed one community members stated, "*This is a small place, and these are big no-take areas that you are proposing, they will be taking food out of our mouths*". Subsequently, a few believe it should be opened up and given back to the village. Not all share this view however, at the same meeting another community member stated, "*before people were ignorant now everyone is understanding…people know about it but still go there, but now we know why its fakahao for fish to expand, so I'm a number 1 fan, I really agree, I understand the fakahao is not just a restricted area, it's a breeding area*".

While many community members are unsure of the need and purpose of the *fakahao* area most respondents felt the *fakahao* area is for the future generations, "*it's for the future of the children here so they can see what we saved for them*". It was seen as an important area to ensure future Nukunonu generations had food to eat, "*food for our future children*", and so they can se and enjoy the natural wonders of the atoll, "*so children in the future can see how the coral grows*".

Photo Joanna Axford

3.6.2 *Fakahao* management

"*The taupulega have prioritised Protected Areas in Nukunonu, but we need advice on design and selection. Before we just picked an area, however it may not be the best place or size*".

The management of the *fakahao* area is considered the sole responsibility of the *taupulega*. There has not however been a unified effort to implement the Conservation Area. Respondents feel that the *fakahao* area will be managed as a fish larder, occasionally opened for resource harvesting. It was generally felt that management directions and emphasis will come from the taupulega, "*It's up to the taupulega, when they say leave it we have to leave it when they say its open then its open*".

According to the community of Nukunonu there is currently little to no compliance with the *fakahao* area's rules, *"the area that is fakahao, no one listens or obeys the rules, they still go there ... it's a good spot for figota, faisua, shells".* It was felt that this was because there was limited awareness amongst community members about the area, a lack of general management (i.e. lack of general purpose, rules, enforcement and punishment), as well as a generally poor attitude amongst community members towards the *fakahao* area.

The reasons for lack of compliance included:

1. Conservation Area design
   - The location of the Conservation Area: *"The fakahao area is too far away and they never look forward to the future"* and another respondent commented, *"they go there probably because they can't be seen and the ones that go with them won't tell ... if it was close to the village no one would go there";*
   - The area is rich in desirable resources: *"there is a certain place we go netting and after netting have a dip in the lagoon and see all the clams and it's too tempting".*

2. Management:
   - Lack of enforcement of the rules: "*no one polices it and so people do go there and get clams"*;
   - Lack of punishment for rule breakers: *"(it is) just people's attitudes, they don't listen to the taupulega's rules because there is no way of policing the area… there's no punishment at the moment".*

3. Community
   - Lack of community agreement: "*people over here don't follow the rules they do it even though they know its wrong… things are changing so quickly and people don't agree";*
   - Concern that conservation inhibits resource growth: *"back in days when there was no rules we could get as many clams as we wanted but when declared fakahao they died, it seems the more we used it the more there use to be*";
   - Lack of community awareness and understanding of the *fakahao* area: *"although we had a fakahao since 1998 people still going to it because don't understand";*

- Lack of respect for the Conservation Areas rules: *"with laws over here…there are certain laws that you have to go by and others are a game, with the fakahao it's like who cares no one can see me"*.

Few people in meetings and interviews had good knowledge of the Conservation Area, its boundaries, purpose and rules. It was felt that the Conservation Area at this stage is not taken seriously, however the *taupulega* made it clear to the team that they want to make a new start.

The design (location and size) of the *fakahao* is one of the reasons respondents and participants in the meetings felt there was low compliance. After Dr Dave Fisk presented the teams recommendation for a Conservation Area around the islet of Tokelau, a community member stated the following, *"what is wrong with the other side (referring the north-west side) it's just as good, because Tokelau is family land and the other side is village land?"* This according to respondents would be easier to enforce.

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

"It's not really successful at the moment because people still go there, they don't listen to the laws"
The community generally perceives the *fakahao* area as unsuccessful in its current state. This is because there have been no substantial changes in resources, there is a low level of awareness and management, and people are generally not obeying the rules. The low level of compliance is associated with a lack of serious penalties and enforcement of the rules. It is felt that people have not yet committed themselves to the *fakahao* area and there has not been a concerted attempt to implement it. "*They say it is fakahao and then people still go there and fish and they change the rules, it's not constant, that's why it is not a success now*". The lack of consistency in rules and regulations and the lack of compliance was a major reason identified by participants for the *fakahao* areas lack of success.

Some community members expressed a concern that the current *fakahao* area was too small to be successful, "*it's not a good area a better place for the Conservation Area would be closer to the motu of Tokelau*" and "*look at how big Nukunonu is and how small the Conservation Area is*". Some felt it would be better placed closer to the islet of Tokelau and should encompass spawning areas.

In discussion about what a successful *fakahao* area would be, it was generally agreed that it will be one in which fish, coral, clams, and other marine resources are able to grow and increase in size and population. It will be somewhere that can be compared to other areas within the lagoon and changes and improvements can be seen, "*so we can see if fakahao really works*". The majority of people see a successful Conservation Area as an essential place '*to keep our atoll alive because it is all we have'*. Success in Nukunonu's fakahao area would also have greater community ownership and responsibility for it.

3.6.4 Reaching Success in te fakahao (increasing success)

It was generally felt that success in the Nukuonu *fakahao* area will be reached through wise leadership, community awareness and education, and through increased community compliance. One elder commented that success will be reached by, "*letting the people know and understand what the idea of conservation means, if everyone has an understanding of the issues, conservation I think will be a successful program*".

Most people interviewed indicated that they would like to know more about *fakahao* and the *fakahao* area. Many expressed a desire for *fakahao* education and awareness for the village. One respondent also pointed out the need for signage within the village indicating the position of the *fakahao* area and its rules, *"I want a map in an area of the village where everyone can see it to clearly mark out where the fakahao is, so people will know where it is and then there will be no excuses"*. Some felt that knowledge gained through a *fakahao* education program would lead to an increase in ownership and responsibility. *"If we really want to make this a success we need a really good education program for the village about all the good the fakahao will bring…(it) will belong to everyone… there is currently a lack of responsibility, people don't have feelings of ownership"*.

Success will be reached in the opinion of many community members when a serious commitment is made by the *taupulega* and the village to *fakahao*. Most people feel stronger management of the *fakahao* area is essential if it is to be successful. This will require strong consistent local laws, *"they need to make a plan and stick with it"*. According to respondents this will encompass stricter rules, enforcement and

punishment for non-compliance, *"to make it successful if they (the taupulega) love us they have to be stronger, this fakahao area failed so they have to be stronger with the next one"*. Community members felt there is a need for consistency in rules and laws associated with the *fakahao* area. It is broadly felt that these rules should come from the *taupulega* as it is believed that local rules are stronger and have more resonance within the Nukunonu community than *malo* (National Government) rules.

Respondents feel there is a need for everyone in the village to commit to the *fakahao* area and respect its rules. Success in Nukunonu's *fakahao* area will be reached if everyone works together, therefore the rules need to be obeyed and enforced, "*the rules and ideas stay and are upheld, the village must pay attention to the law*". In addition community members felt success will require the village to unite and commit to the new *fakahao* area. "*The fakahao we put aside…was too small…(and) I know most of the men have been fishing in that area, this time we will have a better start*".

Some respondents felt that if it is to be successful as a Conservation Area, it needs to be moved to a better position and needs to be bigger. *" We need a place, for example like the end of an islet if the end of the islet belongs to the village but unfortunately families have shares in them, so when you go to their land they can have a feed on clams and fish, you need somewhere that belongs to the village and put a tapu on it"*.

Some people feel that because of the location of *fakahao* area and it's distance from the village, enforcement will require patrols and some even feel it will require a permanent person who responsible for looking after the Conservation Area. In addition community members felt it is necessary to implement a monitoring program so community members can see the changes and success of the resources in Nukunonu's *fakahao* area. This would enable the site to be "*compared to other sites so we can see the change and we can see if fakahao really works*". It was felt that there is a need for community members to be trained to monitor the *fakahao* area.

3.6.5 Future hopes for Nukunonu

Respondent's vision for the future of Nukunonu generally focused on a higher standard of living. This encompassed a cleaner healthier and safer environment with improved waste management and more natural resources, *"for there to be an increase in all the rich resources from the sea to the land*" and "*for the village to be nice, and, lots of clams and fish for the future"*.

Community members also expressed desires for the community of Nukunonu to remain culturally strong and to maintain traditional practices in the future. Many respondents expressed a future vision for Nukunonu to be, *"as it is now, everyone knows everyone, there are no boarders between families or family feuds, the culture is still intact, and also for the Tokelauan language to remain"*. Another respondent commented, *"I want Nukunonu to be how it was when I was growing up, when the family would share it with the whole extended family"*.

It was felt that these future hopes for Nukunonu will be reached if the community works together and respects the *taupulega* and *toeiga's* rule, *"for everyone to respect the toeiga and everything will be good, for example there will be lots of clams and the*

village will be beautiful". It was felt that the *taupulega* and *toeiga* need to lead the way and make a strong plan to address the issues facing the atoll, to ensure a better future, "*set the program with the toeiga, set the plan and stick with it (and everyone else) to pay attention to the laws*".

In closing the final team meeting a *toeiga* stated, *"now the whole village knows about the fakahao, we need to educate people about the fakahao and its uses, educate for the future, your coming is not for now but for the future, it is very important you are here, you've been around the whole atoll, what you saw you have been telling us, I'd like to say thankyou, thankyou for your love and work you've done for Tokelau, god bless us all, now we have to plan for future*".

3. 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 Nukunonu .

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.

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.

4.1. Specific High Value Areas (incl Target Species/Objectives)

Fish Aggregation Sites

Specific high value areas that could significantly benefit long term sustainable fisheries, if managed effectively, are mostly related to seasonally occurring phenomena. That is, the well known fish aggregations that occur around the lagoon near passes and channels will have to be effectively allowed to fulfil their reproductive function before too many breeding adults are taken from the population to maintain adequate numbers of those species. 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. It is also wise to nominate 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 not be targeted 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

Giant clams populations comprised predominantly *Tridacna maxima*, as only a few individuals of *T.squamosa* were observed during the whole period of the survey. The densest aggregations of clams were observed in the eastern sectors of the lagoon. 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 north eastern 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. This includes the adjacent shallow lagoon area where large *Porites* spp patch reefs and other composite types of patch reefs are located.

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 on the northern margins be considered as long term refuges for giant clams, which will act as sources of clam larvae for other parts of the atoll.

4.2. Conservation Areas

The current Conservation Areas include the western edge of the lagoon at Akau Loa adjacent to the village on Nukunonu Island (Figure 7) and the area situated in the mid northern atoll margin known as Na Kaupapa. The principal aim of both Conservation Areas is to allow the build up of giant clams. The Conservation Areas are periodically opened for harvesting of clams when required.

The NE corner with Tokelau Island at the centre is a highly productive part of the atoll. The acute angle to the atoll margin at this point is where currents sweeping along the slope meet from different directions. It is probably a place of high productivity and is a likely location for fish spawning aggregations due to its location and bottom features[20]. Clam numbers are very high on patch reefs in this sector of the atoll, and fish diversity is relatively high.

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

RECOMMENDATION 3

It is recommended that the two current Conservation Areas be maintained as specific clam recovery areas, though it is noted that a low percentage of clams are at a reproductive mature size

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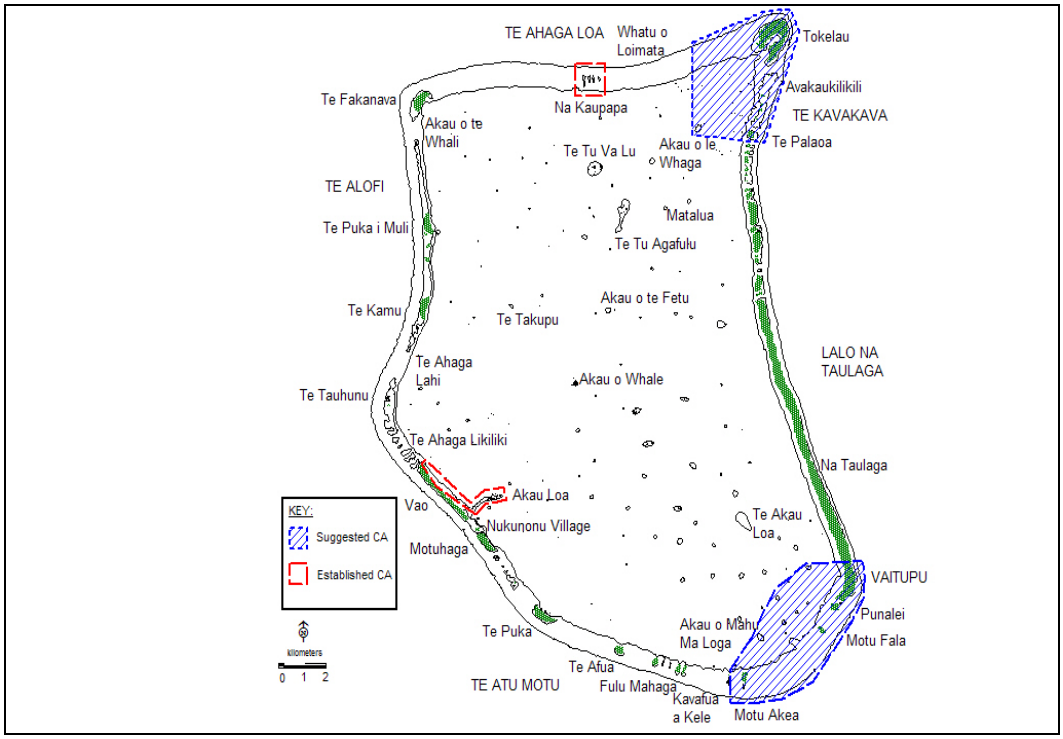

Figure 7. Existing Conservation Areas and suggested new Conservation Areas for Nukunonu.

RECOMMENDATION 4 :

It is recommended that consideration be given to making the NE corner of the atoll (based on Tokelau Island) a major Conservation Area which would be of ecological significance to the whole of the atoll. The reef slope, reef flat, and a portion of the adjacent lagoon (to approximately 12 m depth) should be included in an area that excludes 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.

4.3. Permanent and Temporary Closures of Areas

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 5 :

Where harvesting is to be periodically allowed, 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 6 :

It is recommended that both types of closure systems be employed to enhance overall fisheries yields for Nukunonu. 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).

4.4. Control on Current Harvest Practices.

Current harvest activities on Nukunonu 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; and the taking of all fish of any size.

All are damaging factors that should be controlled if sustainable fisheries are to be maintained.

RECOMMENDATION 7 :

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.

4.5. Policy on Export Activities

The practice of exporting marine products for 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 8 :

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.

4.6. Waste Management Plan

There is obviously an issue on Nukunonu 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 10 :

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.

4.7. Atoll Wide Issues

There are certain resource issues that should be approached on an atoll wide basis and an atoll wide exclusion from harvesting will be required. Specifically, the low numbers of turtles and sea birds that were apparently once abundant. The practice of collecting turtles as pets should be restricted to one or two per nest as this

displacement of a turtle before it can imprint on its birth beach mean that it will unlikely ever return to its birth beach for reproducing (assuming it is eventually released).

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 11

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

5. References

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

Angelo A. H. 1993 *Environmental Legislation Review –Tokelau*. Report for SPREP and the Tokelau Affairs Office, SPREP, Samoa.

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. 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.

Laboute, (19__). Mission to the Tokelau Islands to evaluate cyclone damage to coral reefs. SPREP Topic Review 31, South Pacific Commission, Noumea, New Caledonia.

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.

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

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

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

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

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.

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

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

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

Annex 1 Nukunonu Fish List with vernacular 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
Carangidae	Black Trevally	Caranx lugubris	Tafauli	Deep Slope	Uncommon	Individuals
Carangidae	Blue Fin Trevally	Caranx melampygus	Aheu	Slope	Common	Small schools of relatively small individuals; Occasional larger individuals
Carangidae	Big Eye Trevally	Caranx sexfasciatus	Komulo	Slope	Common	Large Schools
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
Chanidae	Milkfish	Chanos chanos	Ava	Deep water	Common	
Cirrhitidae	Halfspotted Hawkfish	Paracirrhites hemistictus	Patukilaufala	Slope	Very Common	Juveniles in passes
Holocentridae	Scarlet Solderfish	Myripristis pralinius	Talatala	Slope&Lagoon	Common	Migrate between slope and lagoon
Labridae	Red Brested Wrass	Cheilinus fasciatus	Papo	Slope	Common	Individuals
Labridae	Maori Wrass	Cheilinus undulatus	Malatea	Slope	Common	Usually large individuals
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	

Scientific Family	Common Name	Scientific Name	Tokelau Name	Habitat	Abundance	Notes
Labridae	Bluestreak Cleaner Wrass	Labroides dimidiatus		Slope&Lagoon	Common	
Labridae	Six Bar Wrass	Thalassoma hardwicke	Sugale	Slope	Common	Schools
Lethrinidae	Goldlined Seabream	Gnathodentex aureolineatus		Slope	Common	Schools
Lethrinidae	Orangefin Emperor	Lethrinus erythracanthus	Hapute	Deep slope	Uncommon	Individuals
Lethrinidae	Thumbprint Emperor	Lethrinus harak	Filoa	Lagoon	Common	
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 Seaperch	Lutjanus kasmira	Havane	Slope	Common	Schools
Lutjanidae	Scribble Snapper	Lutjanus rivulatus		Deep slope	Uncommon	Individuals
Lutjanidae	Black Snapper	Macolor marcuaris	Mu mea	Corner slope	Common	Aggregations
Lutjanidae	Black&White Snapper	Macolor niger	Mu mea	Deep slope	Common	Associated with caves
Monodactylidae	Teira Batfish	Platax teira		Lagoon	Uncommon	
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	
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	
Scaridae	Bullethead Parrot	Chlorurus sordidus	Uhu	Slope	Common	Schools
Scaridae	Pacific Long nose Parrot	Hipposcarus longiceps	Ulafi	Slope	Common	Large schools
Scaridae	Reefcrest Parrot	Scarus frontalis	Kamautu	Shallow Slope	Common	Schools
Scaridae	Schlegels Parrot	Scarus schlegi	Koti	Slope	Common	Individuals
Serranidae	Slender Grouper	Anyperodon leucogrammicus	Faloa	Slope	Uncommon	

Scientific Family	Common Name	Scientific Name	Tokelau Name	Habitat	Abundance	Notes
Serranidae	Peacock Grouper	Cephalopholis argus	Loi	Slope	Very Common	Individuals
Serranidae	Flagtail Grouper	Cephalopholis urodeta	Matele	Slope		
Serranidae	Brown-marbled Grouper	Epinephelus fuscoguttatus	Fapuku	Slope	Uncommon	
Serranidae	Hexagon Grouper	Epinephelus hexagonatus	Eve	Lagoon	Common	
Serranidae	Honycomb Grouper	Epinephelus merra	Gatala	Lagoon	Common	
Serranidae	Lowfin Rudderfish	Kyphosus vaigiensis	Nue	Slope&Surf zone	Common	Schools
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

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 assessment should duplicate the original marine assessment undertaken in this exercise using all techniques and organisms targeted (as described 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 (ie, 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 (particularly turtle nesting), coconut crab numbers and sizes, and sea bird colonies on remote motus.

The monitoring of species such as these will be very important if there is any action taken to attempt to remove some of the threats to these species. Threats to these species 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 SPREP 2003 marine assessment 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 Projects 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.