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Niue sustainable coastal fisheries pilot project: Community-based monitoring

By David Fisk

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Glossary and acronyms

CBM community-based monitoring

IWP International Waters Project

ICWP Integrated Coastal and Watershed Management

LPWG Local Project Working Group: village-based committee that will direct IWP-related village activities

Monitoring The activity of taking measurements in a pre-defined and rigorous way so that comparisons of change can be made between sites and within a site over time.

MPA Marine protected area: includes any area that has been selected for special management treatment with the purpose of protecting or enhancing its biological characteristics. It can include defined multiple uses, can be designated as a restricted usage area, or even a no access area. The time scale for the particular management regime can vary as well.

NTA No-take area: restricts the taking of all or some normally harvested organisms for a defined time period.

Organism Any living plant or animal.

PDT Project Development Team: the group of representatives from government and other relevant stakeholder groups. Will direct and provide technical assistance to the LPWG of the pilot village.

SPREP Secretariat of the Pacific Regional Environment Programme

TCA Temporary closure area: a defined area in which harvest and associated activities are restricted for a specified time period.

USD United States dollar

Executive summary

The International Waters Project (IWP) aims to strengthen the management and conservation of marine, coastal and freshwater resources in the Pacific Islands region. It is financed through the International Waters Programme of the Global Environment Facility, implemented by the United Nations Development Programme, and executed by the Secretariat of the Pacific Regional Environment Programme (SPREP), in conjunction with the governments of the 14 participating independent Pacific Island countries.

IWP in Niue is involved in the establishment of a pilot project on sustainable coastal fisheries. During 2003, the Niue IWP National Programme completed a series of island-wide village consultations and a participatory situation analysis (PSA) on coastal marine resources. Through this process, two villages (Alofi North and Makefu) were selected as sites for the initial pilot projects, which are designed to address the priority environmental concerns of local residents with respect to sustainable coastal fisheries.

This report describes the process and outcomes of coastal resource monitoring training and community-based monitoring demonstrations conducted in September 2004 under the auspices of Niue IWP. Activities described in this report follow earlier pilot and baseline assessment visits in December 2003 (see Fisk 2007a) and April 2004 (see Fisk 2007b) and a participatory situation analysis consultation conducted in 2002 as part of the Niue IWP sustainable coastal fisheries project (IWP National Programme 2004).

The main activities of this phase include:

- assisting the two pilot villages determine their objectives with respect to coastal fisheries management and sustainability, and the management mechanisms to achieve those objectives;
- providing training in appropriate methods to allow monitoring of trends in fisheries outcomes that are expected to arise from the management activities; and
- discussion of mechanisms that may be adopted to apply the lessons learned from the pilot village activities on a national scale.

The results from this visit were variable and did not achieve all of the expected outcomes as outlined in the terms of reference for this phase of the work. However, significant progress was achieved during the visit that hopefully has stimulated the pilot village participants and Niue IWP into making final decisions regarding (i) the management actions to be adopted by each village, and (ii) how mechanisms such as Temporary Closure Areas (TCAs) will be managed.

This report documents the activities that were carried out during the visit by the consultant during September 2004. The report contains all the relevant documentation that was used and can be used in the future for monitoring and training of volunteers to carry out the coastal resource monitoring.

It is important that Niue IWP follow up with a number of important issues that were not fully completed at the time of this report. Actions that need to be completed include:

- reach agreement among communities regarding the TCAs (e.g. achieve widespread awareness of the reasons for, extent of, and rules applying to the TCA);
- facilitate completion of a formal or legal framework for the declaration of the TCA (in a relatively short time frame);
- resolve the legal aspects of the TCA, especially in relation to the role of individual villages in enforcing TCA rules (particularly as these pertain to people from other villages);
- provide tangible proof of community decisions by marking TCA boundaries

(possibly with buoys) and deploying signs;

- include more Local Project Working Group (LPWG) members in all aspects of management actions than has been the case in the past;
- make provision for the collation and distribution of biologically relevant information (for informed management decisions) on all fisheries species, as the presentation of this information in this report may be incomplete; and
- combine "scientific" biological information with local knowledge of the distribution and behavior of fisheries species.

Most of the training effort was directed towards the IWP team and Niue Fisheries staff, with the goal of ensuring that sufficient capacity would be present on Niue to continue the monitoring program into the future. On the final community monitoring demonstration day (at Makefu), it was decided that the core IWP team and one of the community leaders who has accompanied the IWP team in the field on a number of occasions would take the lead and guide the community through the monitoring session, with the consultant providing backup support. The decision to approach the training session in this way was because it was thought that by this time the IWP team should be sufficiently familiar with the technique to be competent to do this type of community demonstration and training without outside support.

Although the data collected from the Makefu monitoring demonstration are of questionable value, a number of important problems were highlighted and lessons learned from the session. It was clear from this demonstration activity that directions by IWP and community leaders familiar with the methods will have to be more precise than what was outlined at the Makefu session. In particular, it became clear that the monitoring activities should be overseen by someone designated as coordinator for the particular monitoring exercise, who will repeat and summarize the techniques (this should be done each time, before the data are collected). The coordinator will also allocate specific tasks for each of the volunteers, and identify one or more people as data recorders. The recorders should accompany the observers along the transect; they should ask questions consistently, such as which segment of the transect they have counts for and what organisms they are counting. The coordinator needs to monitor the observers' movements, so that they can be re-directed if they deviate from the exact transect dimensions or from the counting methods (e.g. people may drift away from the defined limits of the transect and begin counting organisms outside the belt). These procedures are necessary due to the high volume of data that can be recorded each time. In addition, the counts can become confusing when both live and dead organisms are counted in addition to the large area that is sampled each time.

Temporary Closure Areas are known to be less effective as a long-term measure in sustaining fisheries productivity. This is because a TCA does not generally exist over a sufficiently long period such that species numbers and sizes build up and start moving out or settling in adjacent areas to the TCA. It is apparent that the traditional management methods involving a ban on harvest activities in a specified area (effectively a TCA of variable time frame which can be at least a year in duration) is a mechanism through which the community can obtain an understanding of this approach to manage unsustainable harvest effort. However, during the consultation process it was not apparent that there was an understanding or acceptance by the community of the concept of a more permanent closure mechanism. It is hoped that given time, and ongoing consultation between IWP and the community, communities will come to understand and support permanent closure areas as a mechanism to effectively sustain fisheries. The next most positive action would be to adopt a contiguous series of TCA's along the coast, and to have high numbers of these in existence at any one time. But even under such a management regime the outcome would probably not be as effective as well chosen and managed permanent closure sites.

Plate 1. Volunteers participating in reef flat monitoring training at Makefu.

1 Introduction

The International Waters Project (IWP)[1] is a 7-year, USD 12 million initiative concerned with management and conservation of marine, coastal and freshwater resources in the Pacific islands region, and is specifically intended to address the root causes of environmental degradation related to trans-boundary issues in the Pacific. The project includes two components: an Integrated Coastal and Watershed Management (ICWM) component, and an Oceanic Fisheries Management component (the latter has been managed as a separate project). It is financed by the Global Environment Facility under its International Waters Programme. The ICWM component is implemented by the United Nations Development Programme and executed by the Secretariat of the Pacific Regional Environment Programme (SPREP), in conjunction with the governments of the 14 independent Pacific Island countries: Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu and Vanuatu. The ICWM component focuses on integrated coastal watershed management, and supports national and community-level actions that address priority environmental concerns relating to marine and fresh water quality, habitat modification and degradation and unsustainable use of living marine resources through a 7-year phase of pilot activities, which started in 2000 and will conclude at the end of 2006.

The theme and location of each pilot project was selected on the basis of community and government consultation. Each project is expected to have adopted an interdisciplinary approach involving the three pillars — economic, social and environmental — of sustainable development. Each project is intended to address the root causes of degradation affecting one or more of four focal areas:

- marine protected areas

[1] IWP is formally titled Implementation of the Strategic Action Programme of the Pacific Small Islands Developing States.

- coastal fisheries
- freshwater resources
- waste reduction.

1.1 Niue IWP

IWP's pilot project on Niue addresses community-based sustainable resource management and conservation issues associated with the focal area of sustainable coastal fisheries. The pilot project has involved three phases:

1) The first phase of the Niue IWP involved a series of island-wide village consultations and a participatory situation analysis on coastal marine resources (IWP National Programme 2004).
2) The second phase of the Project involved the selection of two villages to pilot activities to address the priority environmental concerns of local residents with respect to sustainable coastal fisheries. The villages chosen for pilot activities are Alofi North and Makefu. This phase involved further participatory work to describe the root causes of the non-sustainable use of coastal resources at Alofi North and Makefu, and a process for selecting and evaluating pilot action options to address the identified root causes.
3) The third phase of the process of establishing the pilot sustainable fisheries project had involved three separate elements:
    a) a literature review and determination of pilot project survey and monitoring methods (undertaken in November-December 2003, described in Fisk 2007a);
    b) a baseline assessment of coastal marine resources (completed in march 2004, described in Fisk 2007b); and
    c) training in and demonstrations of methods that can be used by village volunteers to monitor the progress of activities undertaken as part of the IWP project (described in this report).[2]

From the general discussions during the meetings and field demonstrations held in September 2004, both villages appeared to be content with establishing only temporary closure areas (generally understood to be kept closed for one year only). However, at the beginning of the field work in September 2004, no definite decision had been made by either village as to what areas were to be chosen for a temporary closure.[3]

1.2 Activities undertaken in September 2004

The specific activities under this third phase of the programme included:

1. Consultations with villagers from Makefu and Alofi North on options and activities for

[2] This element of the third phase of activities was to be facilitated by the author, a coastal resource monitoring specialist, and was to be undertaken after all consultations with the two pilot villages were complete. The consultations were expected to result in decisions on management options to be adopted by the villages. Building on these outcomes, the consultant was to assist the communities in designing relevant monitoring and training protocols that would be suitable and relevant to chosen management options. Although the management suggestions contained within the author's baseline survey report (Fisk 2007a) were circulated in a joint meeting of the Project Development Team and Local Project Working Group (held in August 2004), no decisions as to the best management action to test had been made by the time of the author's visit in September 2004.

[3] It was also a generally held belief by the two villages that the Namoui Marine Reserve should be opened periodically for exploitation as well; the presence of this already established reserve appeared top influence the villager's decisions regarding IWP activities and recommendations.

the villages, as proposed by the Project Development Team and the Local Project Working Group.

2. Introduction of villagers to the rationale behind monitoring, training of village volunteers, and demonstrations to assess the efficacy of the proposed methods under local conditions.
3. Training of IWP and Fisheries Department staff in basic monitoring methods and in particular, the analysis and use of the monitoring data.
4. Documentation of procedures and assessment of demonstrations conducted with community volunteers, IWP and Government staff.

This is the final report for the biodiversity assessment and monitoring component of the sustainable fisheries pilot project on Niue. This report should be read in conjunction with the two reports outlining the activities and outcomes of the two previous phases (Fisk 2007a, 2006b).

1.3 Structure of the report

This report on the activities undertaken in Niue includes:

1) a description of community consultation and monitoring activities, including the decision-making process with respect to management options;
2) recommendations for ongoing management actions;
3) a monitoring and evaluation plan;
4) identification of possible options for promoting sustainable coastal fisheries at the national level in Niue;
5) a discussion of issues and constraints; and

training materials and description of methods used.

The report also includes an outline of supplementary work, including identification of responsibilities that could support application of the monitoring programme to Niue IWP pilot projects.

2 Community consultations and monitoring training

During the visit in September 2004, community consultations, monitoring demonstrations and training, and information sharing were carried out. The consultation process followed slightly different sequences for the two pilot villages as these meetings and training sessions had to fit in with other local village activities as well as with suitable low tides for reef flat activities.

Well-attended meetings and consultations were held in the two villages during the first week of activities in Alofi North and Makefu. A reef flat monitoring demonstration in Alofi North during an afternoon low tide preceded the first village meeting in the evening of the following day. A similar meeting was held with Makefu on the evening following the Alofi North reef flat demonstration, whereas the reef flat monitoring demonstration for Makefu was not carried out until the end of the following week.

Generally, the introduction to community monitoring commenced with a brief presentation of the concepts and use of monitoring data (see Appendix 3 for an outline of the presentation material), which led into the proposed methods that would be used in the demonstration in the pilot villages, focusing on the target species of concern that have been already identified through prior consultation. Apart from reef fish species of concern, most of the focus was on reef flat invertebrates and seaweeds from this habitat. Many opportunities were available for additional discussion on species of concern, and some additional species of interest were raised during the visit.

Discussions at the meetings also covered the application and use of monitoring methods that could be adopted to target species or indicators not amenable to the belt transect method. For example, *alili* (turban shells) are generally restricted to the crest and slope habitat, so are not amenable to the belt transect monitoring method but can be monitored by using timed or set path searches.

Monitoring methods for these other species were explained at the village meetings and again separately to Niue IWP and to one Fisheries staff member. The activities were brought to the attention of both Environment and Fisheries staff so that they could take advantage of the opportunity to be kept up to date with IWP activities and gain some additional monitoring training. Only one person from both Departments took advantage of the opportunity, but the staff members were not available for the full duration of the training.

2.1 Alofi North Community consultation and monitoring training

2.1.1 Description of activities

Reef flat monitoring activities at Alofi North were carried out in the following sequence (by necessity, due to other village activities and suitable low tides):

1) During the first week, reef flat monitoring training was held in the field using belt transects, with a prior short briefing held at the village community hall (attendance was good with 12-15 people involved, of which 4 were IWP-Fisheries staff).
2) An evening consultative meeting was held the following day, which re-introduced participants to monitoring concepts and methods, and covered the use and interpretation of the data (both data collected the previous day and some prior data collected at the same site in March–April 2004 during the baseline survey [Fisk 2007b]). In addition, theoretical data (as might be generated in the future through monitoring work) was added to illustrate the use of the information. Attendance was good, with approximately 10 villagers present (seven men and three women).

During suitable sea conditions, IWP staff[4] were trained in the use of community-based monitoring methods called set path swims and set path searches. The set path swim method is suitable for monitoring shallow slope habitat for relative abundance and size categories of fish, as well as for descriptions of other major invertebrate and reef community indicators. Training in the management, analysis, and presentation of the data from reef flat and slope monitoring was also carried out for IWP staff and one Fisheries officer. The field component of the set path swim training was done both north and south of the main harbour in Alofi North, though the method was expected to be applicable to Makefu as well if the requirement for this type of monitoring arises. The only restrictions in the use of the method will be access to the slope habitat from shore and suitable sea conditions for snorkeling.

2.1.2 Reef flat belt transects

Community monitoring demonstrations and methods focused on the recommended target species outlined in the second phase (Fisk 2007a). The monitoring demonstrations used one of the monitoring protocols (densities of target species in belt transects) to record the following species (see Plates 2–7):

- *papahua* (oysters, *Chama isostoma*, both live and dead)

[4] The set path swim monitoring method was tested for its suitability for use by competent village volunteers and other government staff to monitor trends in resources in shallow slope habitat. Though invitations were given for other relevant government staff to be involved, none were available during these sessions due to other commitments.

- *ugako* (vermetid tube worms, *Serpulorbis colubrinus*, both live and dead)
- *matatue* (large vermetid tube worm, *Dendropoma maximum*)
- *gege* (clam, *Tridanca maxima*)
- *loli tahi* (holothurian, *Holothuria leucospilota*)
- *loli uli* (holothurian, *Holothuria atra*)
- *lolisea* (holothurian, *Actinophyga mauritiana*)
- *Matupihu* (false limpet, *Siphonaria* cf *sirius*)
- *Alili* (turban shell, *Turbo* and *Australium* spp)

Plate 2. Chama isostoma (*oysters* or papahua) *and* Serpulorbis colubrinus (*vermetid worms* or ugako)

Plate 3. Dendropoma maximum (*large vermetid tube worm* or matatue)

Plate 4. Tridanca maxima (clam or gege).

Plate 5. Holothuria leucospilota (holothurian or loli tahi).

Plate 6. *Holothuria atra* (holothurian or *loli uli*) showing feeding tentacles.

Plate 7. Actinophyga mauritiana (holothurian or lolisea)

Plate 8. Laying out the measuring tape across the reef flat in preparation for belt transect monitoring

Prior to the reef flat demonstration a brief introduction was given at the community center outlining the survey methods, with an explanation of how and why these methods are used. The author and two IWP staff members accompanied approximately 10 village volunteers (and one Fisheries Division staff member) in recording and counting invertebrate target species in two belt transect samples. Belt transects were 40 m long and 5 m wide, starting from the base of the cliff face (where GPS coordinates were recorded). Counts were partitioned into 10 m length segments for ease of recording (these sample dimensions were used in the earlier baseline work; see Fisk 2007a and 2007b). The 40 m length transect from shore did not include the entire mid-reef flat because of its extended width in this area. However, the area sampled by the 40 m-long transects would predominantly remain within the proposed TCA if the outer boundaries were drawn between the headland and a large rock on the northern side (see description of proposed TCA boundaries below).

It was felt that participating villagers acquired a good understanding of the monitoring methods and protocols. Not all volunteers present at the reef flat participated in the monitoring activities; some village members harvested vermetid worms during the demonstration (a few oysters and limpets were eaten as well), mostly from adjacent areas outside the monitoring area. During the reef flat demonstration, the opportunity was taken to make more enquiries about the knowledge these gleaners had of the organisms they were harvesting.[5] A number of queries relating to the use and interpretation of these data were raised by villagers while in the field, and every attempt was made to explain this part of the exercise. It was also pointed out that the complete monitoring process would be explained again at the meeting the next day with the Alofi North community.

Community participants requested additional relevant biological information about some of the target species so that they would have a better understanding of what their management measures were realistically expected to achieve. It was explained by one participant that the additional information was requested so that they understood what might be the best action they could take to enhance the fisheries associated with these species. This may be a pertinent issue to address, as the biological information that may be available could persuade the villagers to extend the closure period for a TCA, or may influence where and when TCAs or other more permanent closures could be adopted. The presentation of all relevant biological information on particular species would require considerable research of the relevant literature, and communication with relevant researchers worldwide. This activity, though quite significant if done as a major review of the literature and knowledge of each species,[6] is beyond the scope of this current work. However, an example of the type of information available for some of the major reef flat invertebrates is presented in Appendix 2 (note this does not constitute all the information probably available for these species).

In reality, the presentation of monitoring methods, villagers' decisions about management actions, and monitoring demonstrations were essentially parallel processes; these did not occur as a linear sequence of events. One significant factor appeared to be the presence of a strong leader who both had authority to make decisions for the village as a whole, and could probably persuade those not in agreement.

The choice of a site for the monitoring demonstration was made for practical and logistical reasons (e.g. ease of access from a sea track and proximity to the village community centre where the field work briefing was conducted). In addition, the IWP team was familiar with the area, and some previous data had been collected during the baseline work (Fisk 2007a). Data collected by IWP in April–May 2004 was available for one of the two transects used for the training, and this was used to present an example of how monitoring over time could give the community feedback regarding the status of their TCA (see below for a summary of these data).

2.1.3 Reef flat demonstration monitoring area and subsequent TCA

A portion of the area used for the monitoring demonstration was selected as a trial TCA for the IWP program. It is not clear to the author precisely how this decision was made, but it is likely that views were formed over time through discussions between the villagers who were to form

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[5] For example, according to villagers, the taste of vermetid worms did not change noticeably throughout the year, whereas the taste of oysters changed seasonally (it was considered better in spring, when oysters were reproducing; vermetids worms may reproduce throughout the year).

[6] Such a review should include as many of the major fish and plant species used in Niue fisheries as possible.

the LPWG (at this point they had not been officially appointed), village leaders, and other village members, during or after meetings with IWP staff. Discussions were also held between the consultant and the chairperson and his deputy during the training, and discussions were also held in the field during the monitoring demonstrations; these may all have been factors in the final decision relating to the trial TCA.

The TCA included potentially good reef flat habitat for many invertebrates and possibly algae of fisheries value. The features of the area included:

- a well defined section of reef flat within two prominent headlands that was not easily accessible from the shore opposite the reef flat, making the area relatively easy to manage and delineate for exclusion;
- an outer crest area that was relatively more exposed at low tide, resulting in a relatively constant deeper pond area over most of the reef flat, reducing the possibility of exposure of organisms to desiccation;
- at least two channels through the reef crest were present in the same area, allowing regular flushing of water into and out of the reef flat habitat at all phases of the low tide, despite the tendency of water to pond and remain on the reef flat longer than in other areas nearby;
- the area that did not experience the full force of waves pushing ocean water over the crest at low tide because of the exposed crest and channels, thereby preventing the extremes of reef flat water temperatures expected in such ponded areas; it also provided relatively safer conditions at low tide periods for villagers to monitor the area; and
- an extensive area of the middle to inner reef flat contained deeper holes covered with a thin layer of sand, making good habitat for sediment grazing animals, mobile gastropods, algae and giant clams.

Not all of the reef flat area with relatively deeper water would be included in the TCA if the boundary is established as proposed (on the south by a headland and on the north by a large rock). This is a disadvantage of the current proposal, and it was strongly recommended that the TCA boundary be extended (at a minimum) to the inner edge of the relatively elevated reef crest zone, and preferably to the lower slope.

2.1.4 Outcomes from village meetings

Several issues were addressed in subsequent village meetings, including:

1. The composition of the LPWG, which appeared to have been made by way of designation by the leaders present (i.e. not by individual members volunteering). The IWP National Coordinator noted that the LPWG members included key individuals from households spaced about equally throughout the boundaries of the village.
2. Extension of the boundaries of the TCA to include the slope habitat (i.e. beyond the crest area).
3. A ban on netting and spearfishing activities within the TCA.

These are critical issues that must be clarified by Niue IWP through followup community consultations. It is encouraging that those types of fishing activities (netting and spear fishing in particular) that have the potential to significantly impact fish stocks were being considered for tighter management control. Fishing techniques that are destructive to habitat were not addressed in any of the initiatives to date, and these may have to be addressed through education and awareness raising over the longer term. It was explained to Niue IWP that the best TCA design should include all of the area of the reef flat as well as the slope area, and that it was important to use follow up discussions with villagers to extend the boundaries if possible. The slope area could also then be used as a potential giant clam nursery, in addition to the protection that would be provided by the reef flat TCA. There was some suggestion that the proposed bans on certain fishing activities could be adopted for the whole of the Alofi North coastal area. This would be a very encouraging outcome, but this issue was not resolved during the author's visit.

It was also explained to the Niue IWP and at a subsequent village meeting that benefits from no-take areas (NTAs) are greatly increased by extending the closure period. Although temporary closures (a maximum of approximately one year) were well understood by the community as a type of *fono* system, such an approach does not substitute for long term protection of critical habitat. At a minimum, it was emphasised that if management was limited to TCAs, forward planning by the community was essential, with other areas undergoing automatic closure at the same time (or prior to) opening of an existing TCA. This would in effect establish a rotational closure system, whereby coastal habitat areas of reasonable extent would be systematically given time to recover.

During village meetings (on this and prior trips by the author) there was a clear interest in obtaining relevant biological information on many of the species of interest or concern. The community has consistently expressed interest in knowing more about many of the key target species, and in particular species information that could be used in making management decisions regarding TCAs, and would help determine how long closures should remain in place (e.g. data on growth rates and size at maturity, and specific life history information). The specific life history of invertebrate species influences how, when, where, and why they are present on a reef at a particular time. This information can be useful in making local decisions on limits to harvesting, especially with respect to the number and sizes of species that are collected. Some perceptions and beliefs expressed by villagers may conflict with the current scientific understanding of these organisms;[7] some of these species-specific perceptions are discussed in Appendix 2.

A summary of readily available information on species of concern was presented or explained to the communities during the consultation meetings (Appendix 2), but unfortunately this information was often incomplete or too general, as not all relevant resource material was available on Niue. This information requirement was not anticipated but is understandable and of great relevance to the future management of these resources. However, such information should be closely integrated with the local knowledge of the species of interest, which will be as important as the general biological information that is available from studies elsewhere.[8]

2.1.5 Presentation regarding the use of monitoring data

The Power Point presentation used during the village consultation included some data from a monitoring training exercise with the villagers and IWP and Niue Fisheries staff, held in Alofi North within the proposed TCA area (see Appendix 3). These data were combined with additional demonstration data to demonstrate the type of summary information that can be graphed and presented from community monitoring activities (Fig. 1). An explanation of how these data are derived from the belt transect samples was also presented. Various potential trend analyses were discussed using these graphs, with examples of what would indicate either positive or negative trends in invertebrate resources.

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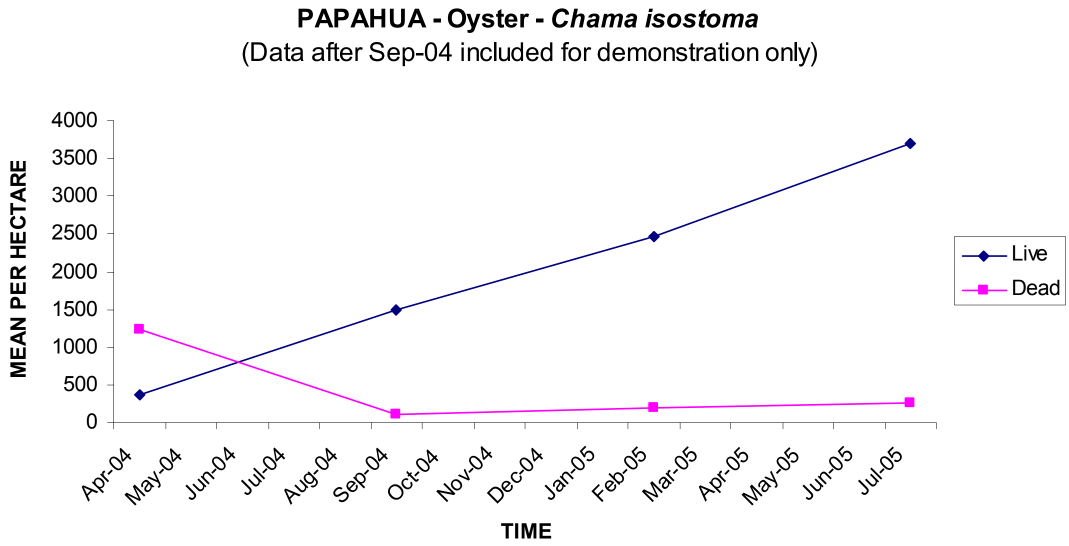
[7] During the PSA activity (IWP National Programme 2004) a wide range of similar perceptions and beliefs were recorded.

[8] A significant amount of further literature research would have to be carried out to access the bulk of the information; this is outside the terms of reference of this current work.



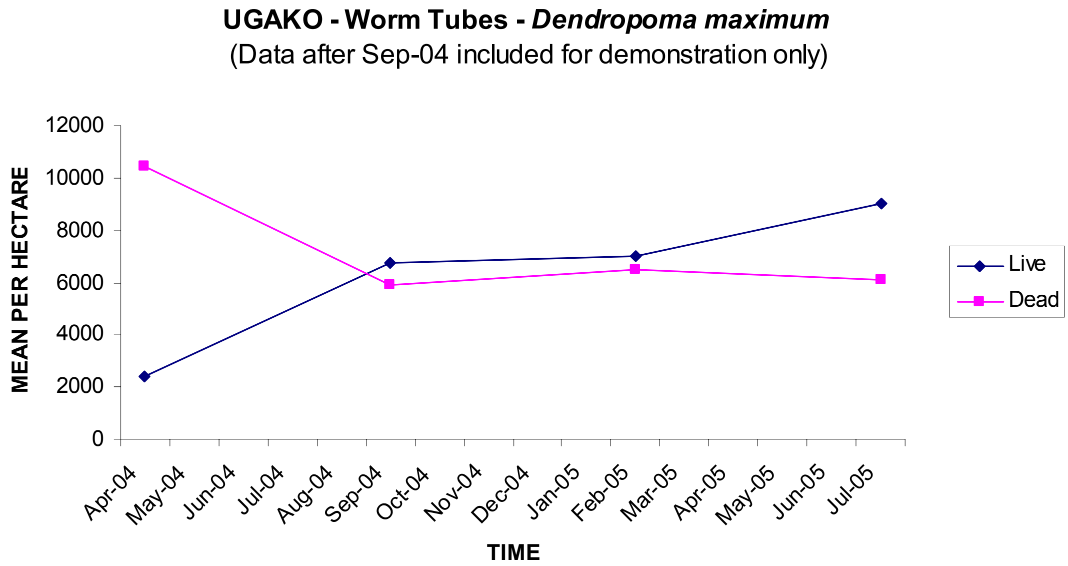


Figure 1. Actual and demonstration *papahua* and *ugako* monitoring data

Data for one 40 m × 5 m belt transect within the proposed Temporary Closure Area at Alofi North.

2.1.6 Decision-making processes

The author outlined that the best course of action, from a biological standpoint, would be the selection of key areas for permanent closure from harvest activities (this was stressed at an evening meeting with the Alofi North community, and during the reef flat monitoring demonstrations). This did not appear to attract any interest, however, and discussions returned to the concept of temporary closure areas.

The author stressed that decisions on closure areas — including the habitat selected — should be relevant to the particular species being targeted for management actions, and that the reasons for this focus should be well understood. The decisions made in this case did follow this prescription to some extent, as the decision to establish a TCA in the area chosen for monitoring training was made with input from the author as to the area's suitability.

The community made a number of decisions very rapidly, and in parallel: in less than two weeks, the Alofi North community made significant decisions relating to the proposed outcomes of the Niue IWP, and to what degree, where, and (to an extent) how it would participate in the project. The trigger for these rapid decisions may have been the community's feeling that tangible actions were being taken by IWP, and through the focus that IWP placed on direct community involvement in monitoring and decision-making.

2.1.7 Recommendations regarding future actions

To maintain the momentum now generated, several significant actions need to be taken by the community, under the leadership of the Local Project Working Group and Project Development Team, and in cooperation with IWP Niue. These include:

1. **The community must reach agreement regarding the TCA**. It needs to define, and reach agreement on, the rules for the TCA, and specifically on the activities that will and will not be allowed within the TCA, how long the TCA will be in force, and on reporting and monitoring that will be carried out (see 5).
2. **Complete a formal or legal framework for TCA declaration.** This is needed if the rules and conditions associated with the area are to apply to all Niueans (and not just those of Alofi North).
3. **Demonstrate the decisions and agreements on the ground.** The presence and boundaries of the TCA should be clearly marked using signs and possibly buoys. Signs should be placed at access points north and south of the TCA, with a summary of the rules and restrictions and simple reasons for establishment of the TCA.
4. **Develop widespread awareness of the reasons, extent, and rules for the TCA,** by undertaking an extensive awareness program once the above actions are completed.
5. **Develop a mentoring schedule.** Establish a schedule for twice-yearly monitoring, using the methods tested and demonstrated (including fish counts and set path swims along the slope, if the TCA boundary includes this habitat). Monitoring should be carried out both inside and outside the TCA, to provide a comparison of the effects of the TCA, and also to possibly show benefits of the closure on recruitment levels adjacent to the TCA.
6. **Consider beneficial activities complementary to the TCA.** If the TCA is proven to be successful in significantly enhancing biological communities, the potential exists to develop an interpretative or ecotourism venture that capitalizes on the success of the TCA. This may not be possible within the current projected TCA timeframe, but if successful could create an impetus for retaining the TCA for an extended time period.
7. **Involvement more village members in the project.** This is an important short-term goal; a good way to achieve this is to actively encourage LPWG members to participate in all management activities. It is desirable that activities are shared among the LPWG so that both ownership of the project and awareness are maintained. It is important that the workload be spread among a number of people, in order to avoid burnout by a few.

2.1.8 Closure options

A central decision that villagers must make (relating to Recommendations 1, 2 and 4 above) is what form the TCA will take (i.e. will it be the equivalent of a *fono*, or be established as a permanently closed or protected area). This influences how long it will be in place, how it will be enforced, and by whom. Determining the enforcement mechanisms and the ability (legally) to enforce the rules may simplified initially if the TCA is adopted as the equivalent of a *fono*, which involves government action to make it law, but a constraint associated with the *fono* model is that there may be no mechanism for adjusting the term of closure of the area

Underlying practical differences in how a *fono* or other closure could be enforced and/or extended are distinctions in the underlying rationale for their establishment. The *fono* is based on the concept of sustainable management of target stocks, and has apparently worked in the past to help maintain stocks and prevent overharvesting. Permanent closures (e.g. marine protected areas) typically have a much broader focus: preservation of biodiversity. It is uncertain whether the *fono* system can still be effective in the preserving target stocks, given the emergence of a cash economy, enhanced technologies (e.g. better harvesting tools and food preservation), and a reduction in the authority of village leaders; it is also uncertain whether the *fono* system can be successful in achieving broader marine biodiversity objectives.

As an alternative to the *fono*, national legislation could be enacted providing for permanent closure of critical habitat. This legislation currently exists under Niuean law, but devolves power to the national government and not necessarily to the village level; there are consequently significant challenges for fisheries mangers with respect to enforcement and community compliance. It is likely that longterm or permanent closures will be more difficult for the community to accept than the familiar *fono*, so it is imperative that the TCA rotation model be well planned in advance. Fisheries enhancement on a national level could potentially be achieved if all villages adopted a similar approach.[9]

2.1.9 Monitoring and evaluation plan

A specific monitoring and evaluation plan is difficult to complete at this writing because of the uncertainties of the final set of decisions by Alofi North. It will also be difficult to develop realistic outcomes as measures of TCA success, as the projected lifespan of the TCA may be no more (and possibly much less than) one year.

In general terms, improvement in the abundance of most of the target invertebrate species will probably be achieved within the time frame of the TCA.[10] It is hoped that there will far greater awareness within the community of the need for and benefit of adopting sustainable coastal fisheries management measures. A sense of ownership and acceptance of initiatives such as the TCA are also potential desirable outcomes. Both of these general outcomes can be included in a monitoring and evaluation plan (see Table 1) but the general plan outlined here would have to be revised once specific decisions have been made.

2.1.10 Set path swim (shallow slope) monitoring (fish, clams, and reef health indicators)

The set path monitoring method (described in detail in Appendix 1) was tested and adapted to local conditions with the IWP team, so that the team could train village volunteers and other interested stakeholders. The uses and limits of this method were also outlined, as were the main aims of such activities. The aim is to produce immediate useful information of trends in

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[9] A concurrent process is being undertaken by the Secretariat of the Pacific Community (SPC) to develop village fisheries management plans for those villages not involved in IWP. These activities should be as integrated to the extent possible, so as to avoid confusion and maximise resources, as both have similar goals. There is a need to ensure, however, that baseline assessments are conducted before final decisions are made on their management plans by those villages working with SPC. It is important that the approaches and rules adopted by villages affiliated with the two projects not differ too greatly, as they would then be very difficult to apply on a national basis. The individual village fisheries management plans will have to be coordinated in some way nationally, so as not to create confusion. The SPC model does not compel individual villages to participate in the fisheries management plans, with the potential result of a piecemeal approach to fisheries management.

[10] An improvement in abundance is for certain invertebrates (e.g. *ugako*, and *papahua*), but is unlikely to be realised for other organisms (e.g. *gege*, *alili*, and *matapihu*), as well as other species that are currently present in very low numbers in most accessible reef flat areas. Some target species may not recruit into the TCA reef flat, due to their specific ecological requirements, which may make this less than ideal (or even unsuitable) habitat.

key resources that can be delivered back to the community in a form that will be of interest. The purpose of this type of monitoring is to provide semi-quantitative data that is repeatable and therefore useful for comparison over time. It is also amenable to presentation in graphic form, though it is not statistically rigorous.

The selection of a suitable set path was discussed for two separate locations adjacent to the wharf and harbour in Alofi North. The reasons behind the final path selection were outlined by using the vantage point of the jetty. Both set paths (north and south of the harbour) were approximately 300-400 m long and the path followed the undulations of the crest and adjacent slope, beginning at the harbour. The return swim to the harbour was used as a repeat trial and as a way of comparing the accuracy of the trainees.

Plate 9. Training in set path swim monitoring of shallow slope north of the wharf in Alofi North.

The path swim monitoring parameters were set at a maximum of 10 m depth for the use of mask and snorkel and included all significant bays and deep gutters that were present along the slope edge. The monitoring method requires each observer to rank the three most abundant fish groups that were seen within the total swim path. A common family or specific Niuean fish name and most common size category were also recorded. A set of invertebrate and reef community indicators were also recorded as an overall summary of the total swim path. These included: the presence or absence of significant macro algae, percent cover categories of live and dead coral, the number of giant clams, urchins and crown of thorns starfish observed within the full set path area.

All information is recorded in the water at the end of the set path, but running totals of different indicators can be written on the sheet as they are encountered. Other descriptive information observed during each swim sample can be added to the field sheet. A full method description, spreadsheet data entry, and descriptive graphing methods are presented in Appendix 1, along with a field sheet design ready for copying onto waterproof paper.

Table 1. Example of a Monitoring and Evaluation Plan for a proposed Temporary Closure Area at Alofi North and Makefu.

Description	Purpose	Verification	Assumptions and risks
Goal 1: To enhance the productivity of the coastal invertebrate fishery within the boundaries of Alofi North.			
Objective: The majority of the target species of concern show positive responses to the presence of the TCA.			
Temporary Closure Area (TCA) established	- Invertebrate resources have been overfished and not allowed sufficient time to recover from natural disturbances. The adoption of a TCA is a mechanism to allow recovery to occur.	- Densities of major invertebrate taxa are significantly increased within the TCA. These invertebrates include: *ugako, papahua, matatue,* (?)*matapihu,* and *gege.*	- The period of existence of the TCA is sufficient to allow natural recovery of resources. - Village members are observing the rules, especially relating to no harvesting within the TCA.
Benefits of the TCA are experienced beyond the boundaries of the designated TCA	- Areas closed to harvest pressure can build up sufficient resources that result in enhancement of resources outside the closed area. This is due to increased reproductive output from dense populations of invertebrates within the closed area.	- Densities of target invertebrate species have increased in areas outside (and/or adjacent to) the TCA. - Increased densities of juvenile forms of the target species are observed in areas outside (and/or adjacent to) the TCA.	- Staff from different agencies are accurate in self-evaluation aspects of process. - Data are also available for similar areas outside the TCA so that the perceived benefits are proven to be most likely due to the presence of the TCA.
Goal 2 : To raise awareness of the need for sustainable management of coastal resources in Alofi North and Makefu.			
Objective: Positive response to and increased community awareness of management decisions relating to sustainable coastal fisheries.			
Raised awareness within pilot village communities	High level of awareness of the IWP project and objectives indicates that the community has been adequately informed and consulted by the project	- Consultative meetings are regularly well attended. - Community monitoring of TCA regularly carried out and results displayed on community notice boards.	- Announcements of consultative meetings are sufficiently wide reaching. - Community monitoring is undertaken by a reasonable number of individuals.
Positive endorsement of management measures	Positive responses to the IWP project mean that there will likely be high levels of compliance with the management initiatives.	- Levels of compliance with no harvest activity within the TCA are high, both from pilot village members and members from other Niue villages.	- Sufficient surveillance and reporting mechanisms in place to accurately record compliance levels. - Non-compliance incidents result in minor harvest impacts within the TCA.

The trials resulted in practical adjustments to aspects of the initially proposed method in order to adapt to local conditions. The trials were also useful in indicating the most difficult portions (in terms of training) of the method, with respect to accuracy and precision between individual observers.

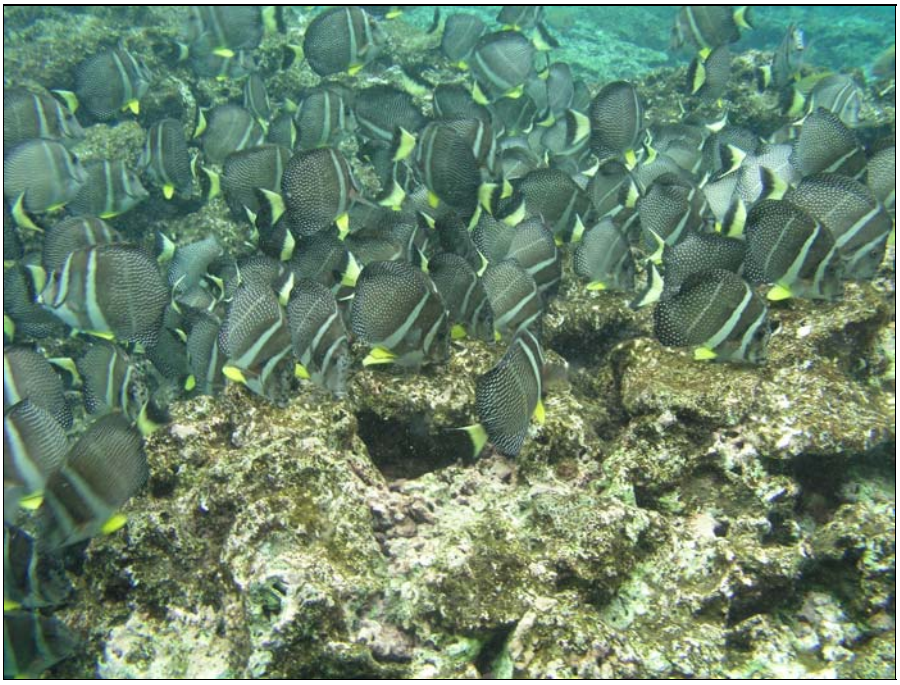

Plate 10. School of *Acanthurus guttatus* (surf surgeon fish or *hapi*) in the set path trials.

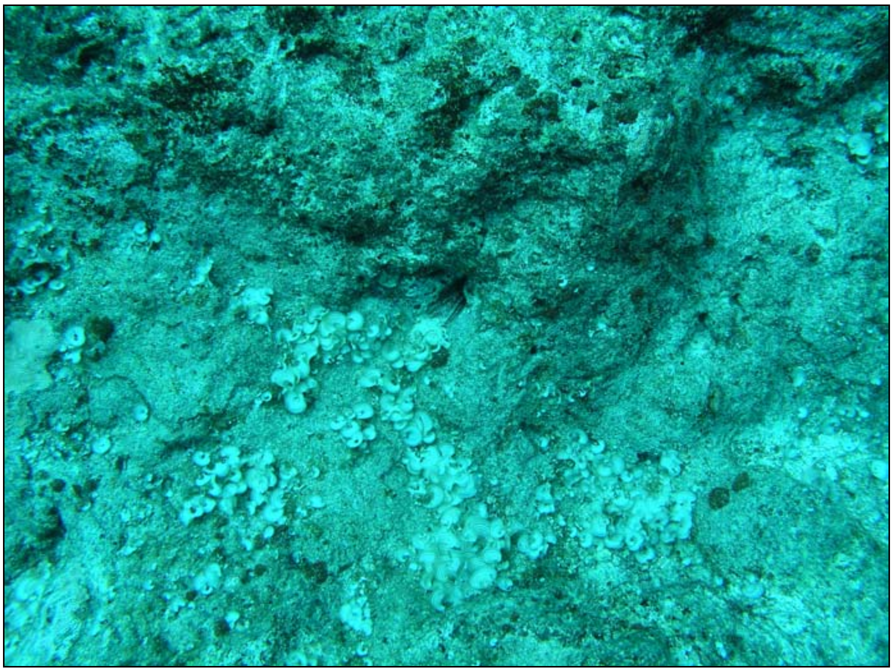

Plate 11. The presence of *Padina* spp (light crescent shapes) at the base of slopes in Alofi North in September 2004, is an example of other useful information that should be recorded from set path swims. This alga has been associated with the presence of ciguatera in this area in the past.

The following significant issues emerged from the trials:

- The fish groups to be included in set path swim monitoring for each village should be clearly outlined – the groups can be specific or general, but the same groups should be recorded each time.
- Similar decisions should be made with regard to recording other features of the reef that are deemed to be important. The factors included in the trials (and on the field sheets in Appendix 1) were thought to be the most appropriate for Niue and were guided by the results of the PSA analyses (Niue IWP National Programme 2003), but they can be varied (with some caution) if necessary. Note that, once chosen, a consistent set of features should be monitored.
- The actual start and finish points of the set path must be clearly defined and recognisable, and should not vary between monitoring sessions. An initial description and basic map should be produced during the planning stage.
- For safety, at least two people should be monitoring at a time, but it is important that not too many people be in the water at once; noise should be kept to a minimum so as not to disturb the fish.
- All monitoring swims should be conducted at the same tide stage, if possible, and it is strongly advisable to do the swim as close as possible to low tide, as this is when all fish will be off the reef flat and probably in the gutters and channels of the slope.
- Care should be taken to ensure that observations between swimmers are exactly the same with respect to which fish groups and what common names are to be used to describe these fish.
- Support that will be required from Niue Fisheries staff and other interested people to maintain this form of monitoring over time. A standard set of monitoring instructions (such as has been produced here) should be used, so that future monitoring efforts can add to the data set established here. This includes a database system that can be used to store and analyse the data (such as that presented here).

2.2 Makefu community consultation and monitoring training

2.2.1 Description of activities

Reef flat monitoring related activities at Makefu were carried out in the following sequence (by necessity, due to other village activities and the timing of suitable low tides).

1. An evening meeting was held during the first week of the visit and management concepts relating to sustainable fisheries and methods for monitoring were introduced. The discussion included a demonstration of the use of monitoring data taken from reef flat sites, using some data recorded during the baseline survey (Fisk 2007b), along with hypothetical future monitoring data. Attendance was good with approximately 10 villagers present (seven men and three women).
2. Reef flat monitoring training using belt transects was held at the end of the following week, after a short briefing to refresh the participants on the methods 12-15 people participated along with many young children).

As was true for the Alofi North training exercise, strong interest shown by the villagers. The fact that clear, tangible actions were being taken (e.g. community training and consultation) appeared to heighten interest. However, no definite decision was made at the completion these activities with respect to the designation of a NTA or to other possible village management actions in support of sustainable fisheries. It is hoped that IWP Niue can capitalize on the increased interest and awareness that developed during this visit and that decisions on village management action are forthcoming.

Plate 12. Makefu group photo at the monitoring training demonstration on the reef flat.

During this visit, descriptions and photographs were taken of a reef flat area in front of the Makefu church site, where there is a relatively deep pool with three marine algae species (*Caulerpa cuppressoides* and two other unidentified species) that are or were previously harvested for food (see Appendix 2). A visit was also made to a relatively inaccessible reef flat area south of Makefu, where extremely high numbers of oysters and vermetid worms were recorded in baseline surveys in April–May 2004. Only Niue IWP staff have visited this site, and it was thought to be important to obtain a description and photographs of the coastal area to determine why the densities of reef flat organisms were high here but not elsewhere. This location supported high numbers of many of the target species, even after the direct impacts of Cyclone Heta in January 2004;[11] the high densities are believed to be due to (i) the relative inaccessibility of the location to gleaners, (ii) the relatively dangerous shoreline features present, especially with respect to wave surge, and (iii) the relatively deeper pooled water on the reef flat. In addition, the reef flat is relatively narrow, which may have had some influence on the impact of the cyclone waves on the reef flat species.

[11] A site a short distance to the north of this location, in the village area of Hio, contained relatively higher abundances of many reef flat species of concern in Makefu and Alofi North. This location is relatively less accessible and the village population is low, so impacts are less than in the pilot villages.

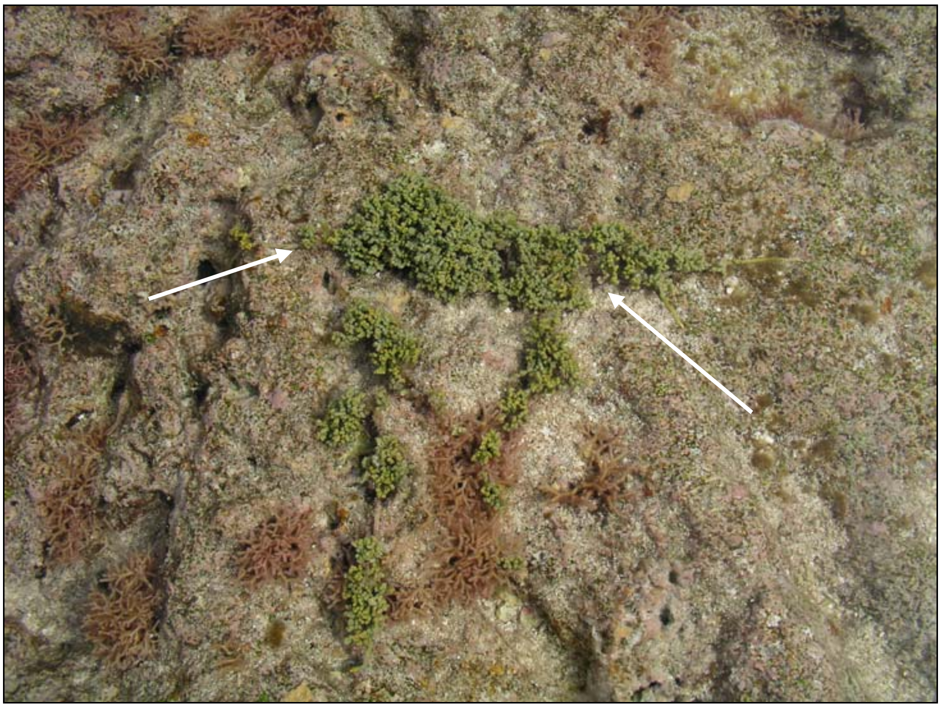

Plate 13. *Caulerpa cuppressoides* (green algae and arrows in photo) on the reef flat at Makefu is an edible species that has survived Cyclone Heta and regular harvesting.

The set path search method is useful for skilled individuals who can estimate the numbers and sizes of animals that are cryptic or present in low densities animals (such as *alili* (*Turbo* spp.) and *gege* (*Tridacna* spp.)) on the crest and outer reef flat habitats, respectively. The trials with the IWP team on assessing clam densities on the reef flat within the Makefu village coastal area used only the set path search method. Similar sample "rules" can be adopted for both the set path search and set path swim methods (see Section 2.1 regarding Alofi North for details).

2.2.2 Location and details of reef flat monitoring training

The community monitoring training was conducted close to and south of the Makefu sea track, at a site that was used for baseline surveys in April–May 2004. As was found previously at this location, the abundance of all typical reef flat invertebrates at this site was low, but it was used to conduct the training because of the ease of access for a large group of people.

Most of the training effort was directed towards the IWP team and Fisheries Division staff, with the intention that sufficient capacity would be present on Niue to continue the monitoring program into the future. On the final community monitoring training day (at Makefu), it was decided that the core IWP team and one of the community leaders who has accompanied the IWP team in the field on a number of occasions would take the lead and guide the community through the training session, with the author providing backup support.

A number of important problems and lessons were learned from the resulting training session. Both IWP staff and community leaders familiar with the methods will have to be more precise in communicating issues to the community than they were at the Makefu training session. In particular, the session made clear that monitoring activities should be overseen by someone (who is designated as the coordinator for that particular monitoring exercise) who repeats and summarises the techniques prior to each data collection activity, and allocates specific tasks for each of the volunteers present, including appointing one or more people as data recorders. The data recorders should accompany observers along the transect; they should frequently ask questions, such as which segment of the transect and what organisms they are counting. Careful attention needs to be maintained by the coordinator of the observers' movements, so that they can be re-directed if they deviate from the exact transect dimensions or from the counting methods during the activity (e.g. people can drift away from the defined limits of the transect and start counting organisms outside the belt). The above procedures are necessary due to the high volume of data that can be recorded each time. The counts can become confusing when both live and dead organisms are counted in addition to the large area that is sampled.

The minister of the Makefu Ekalesia (Church) was interested in the project and many issues were discussed with him prior to the initial briefing and reef flat training. He expressed support for the concept of reintroducing the *fono* system as a mechanism of improving sustainable coastal fisheries and suggested that he could remind people at his regular Sunday service as to any prevailing *fono* that might be in place. Such support mechanisms from key village members are a potentially strong means to maintain momentum with initiatives developed from the IWP pilot village projects.

2.2.3 Outcomes from village meetings

The village consultation commenced with a brief summary of what had been achieved to date and the next steps. The majority of the discussion that followed focused on specific issues related to certain aspects of the resource species under consideration, and not to possible decisions regarding management initiatives. This possibly indicates that there has not been sufficient discussion within the village community as to suitable responses to the issues that are to be addressed by the IWP pilot project.

Community leaders and other meeting participants expressed an interest in obtaining relevant biological information on many of the species of interest or concern in the two pilot villages. They wanted facts about species of concern that could be used in making decisions regarding management of marine protected areas and/or temporary closure areas (the distinction between these was not necessarily clear to participants). The information sought related to how long these closures should remain in place before areas could be reopened for harvesting. Of particular relevance was information on growth rates and size at maturity, in addition to specific life history information. A number of life history traits common to invertebrate species influence how, when, where, and why they are present on a reef at a particular time. The information can be useful in making local decisions on limits to harvesting, especially with respect to the number and sizes of species collected.

A summary of the biological information presented to the communities during consultation meetings is included in Appendix 2. At the time of the meetings this information was often incomplete and general as not all relevant resource material was available during the visit. The level of information requested by the community was not anticipated, but is understandable and of great relevance to the future management of these resources. However, this information should be closely integrated with the local knowledge of the species of interest; the latter will be as important as biological information available from external studies. Note that data included in this report represents only a portion of that available; a significant amount of further literature research (beyond the current terms of reference) would have to be carried out to access the bulk of the data available on these species.

2.2.4 Presentation material used for village meeting

A summary of the PowerPoint presentation used for the meeting is in Appendix 3. The author's role as a resource person was stressed, along with the fact that decisions must be made by the community, with the community ultimately responsible for the success or failure of the attempts to improve sustainability of coastal resources.

No specific decisions had been made by the community as to the management of Makefu's coastal resources at the time of the author's visit. Therefore, it was assumed that there would likely be a decision in favor of a TCA being established in the near future, and that villagers would determine where it would be situated. The benefits associated with longer-term no take designations, and of choosing a productive section of coastal habitat that included all contingent habitats were both stressed.

2.2.5 Decision-making process

No specific decisions had been reached regarding village management preferences for sustainable fisheries at the time of writing, although an LPWG was formed prior to thee author's visit. The community appears to need more time (and possibly more information) to make a decision; it may be possible for IWP Niue to remain involved in and possibly facilitate the decision-making process.

2.2.6 Recommendations for ongoing management action

When Makefu determines an agreed course of action with respect to the IWP project, the recommendations for ongoing management that have been outlined for Alofi North in this report should be consulted and used (assuming the issues are very similar). IWP Niue should be ready to offer additional recommendations and support when the final decisions have been reached.

2.2.7 Issues and constraints

It is important that the Makefu community be given the support needed for it to come to an agreed course of action. The recommendations outlined in the marine baseline report (Fisk 2007b) should be considered (e.g. the recommendation to extend the current Namoui Marine Reserve Boundary), although the adjacent Makefu portion of the reserve does not contain any significant reef flat habitat for a considerable distance to the north. Stricter size and bag limits for many reef flat species could also assist in maintaining the sustainability of resources if applied to the entire village.

The IWP Niue National Coordinator suggested that data on harvest pressure should be included in the monitoring program. At present the lack of such data does serve as an impediment to informed management decisions. Regular surveys can address this, using questionnaires targeting boat (canoe) landings and household consumption and gleaning activities. A restricted independent assessment of gleaning pressure on some species could also be informative (e.g. monitoring of discarded shells of mollusks that are commonly left behind at sea track entrance points to the reef flat.)[12] The belt transect monitoring program that is being used in the pilot villages also registers the potential harvest pressure for *papahua* and *ugako.*[13] Data from both socioeconomic and biological monitoring probably constitutes the best available indicator of harvest pressure when done simultaneously, but this requires considerable effort and coordination.

Once the boundaries of the TCAs have been finalised, it is anticipated that at least one additional belt transect will be established within the defined TCA by IWP Niue staff and village volunteers, to better monitor the effect of the TCAs.

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[12] For example, the Makefu sea track reef flat entrance point is regularly used as a *Turbo* spp (*alili*) shelling place. The operculum (or "cats eye") is left among the broken shells, giving both a harvest number of *alili* and a rough estimate of the size range that is collected (as long as the operculum is taken away each time a census is done). Not all *alili* are shelled before they are taken home, so this may not be an exact estimate, but rather an indicator.

[13] However, this monitoring data is cumulative in nature since both recent and prior mortality remnants are counted. This could be made more relevant if only very recent harvest indicators are only counted (indicated by relatively clean shell remains), though this would require more regular monitoring (approximately every 2–3 weeks).

2.2.8 Monitoring and evaluation plan

A monitoring and evaluation similar to that plan proposed for Alofi North (see Section 2.1.9) could be used for Makefu, if the management options adopted are very similar. However, if Makefu takes a significantly different approach to Alofi North, alternative components will have to be devised to suit these differences.

Plate 14. *Turbo argyrostomus* (*alili*) gastropods of a number of size classes were observed in an outer crest habitat north of Makefu.

2.2.9 Set path (reef flat) search monitoring

The set path reef flat search method is used for monitoring cryptic and low density sessile animals such as *alili* (*Turbo* spp.) and *gege* (clams, *Tridacna maxima*). The ability of volunteers to successfully find *alili* during the daytime is a critical skill for the monitoring team assigned with this task. This is because the *alili* are usually located in the crest zone and are very cryptic during the day. At night the *alili* tend to come out from holes and overhangs to graze on the reef surface, thus making them easier to monitor (and collect). Calm surf conditions and spring low tides provide ideal monitoring conditions. The *alili*'s diurnal and nocturnal behavioural differences means that monitoring must undertaken at the same time, if results are to be comparable.[14]

The method for *alili* involves searching the normal habitat where it *alili* are found (i.e. within a defined length of reef crest habitat). The set length or path must have a constant start and end point for each search. Individual *alili* are monitored by recording the number of individuals in situ for a number of size categories. The same length of coastline is searched repeatedly over time, producing trend data both in terms of abundance and size class distribution. This method cannot be compared directly with searches that are done in other locations, as the distances

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[14] Another method of gauging the harvest pressure on *alili* is to regularly count (and collect) the number of discarded opercula of the *alili*, which are usually dropped after de-shelling, typically at or near the sea track entrances to the reef flat. Some people clean *alili* at their houses, so any estimates of harvest pressure using this method will be conservative. However, *alili* that are kept in their shells are heavy, meaning there is a strong preference to de-shell them before taking them home for consumption.

(and therefore areas) that are searched will probably vary significantly.

This method was not tested during the author's visit, but a related search method was carried out by the IWP team using *gege* as the target species, with searching undertaken for a set period of time (in this case a 15 minute period). As for the *alili*, clams can be grouped into a number of size class categories that will be readily understood by the community.

The summary of a trial monitoring for clams is outlined in Table 2. No clams were recorded on this occasion, and after the trial it was decided that the timed search approach will be too variable (i.e. it will be less repeatable in exactly the same way each time monitoring is undertaken) than a set path search method, as it will depend on the speed of individual searchers, the number of searchers, and on the prevailing sea conditions. Therefore, it is recommended that monitoring for *gege* be done by defining set lengths of reef flat habitat rather than set time searches.

Table 2. Summary of a trial monitoring method (using a timed search) carried out on the Makefu reef flat for giant clams (*gege*).

Trial set time search of reef flat habitat for *gege*
Search Time = 15 mins.
Area Searched = all reef flat habitats from base of Makapapa Sea Track south towards the Makefu Sea Track (ending at a small ava close to the cliff base).
No. Searchers = 3.
No. Clams Recorded = 0.
Summary = 0 clams / 15 min search / person.
(NB. If (x) clams were recorded, the summary figure would be (x / 3 / 15 mins/ person).
In comparison, if a set path method is used, the summary number of clams per set path area will not change according to the number of searchers as it is assumed that the total area within a set path would be searched each time

3 Options for promoting sustainable coastal fisheries in Niue

3.1 Village-based (bottom-up) approach

If IWP's work in Niue is to be successfully transferred and replicated, it will have to be supported by the relevant government departments, with the Fisheries Department being the obvious choice as a lead agency. However, there are too few personnel available to dedicate to a village-by-village consultation and facilitation procedure, as would probably be needed to realise a national policy and action, complete with an appropriate level of consultation.

SPC's coastal fisheries management unit has been invited to trial a process that has been used in some other Pacific island countries, whereby a village fisheries management plan is developed with the local community. This process relies on individual knowledge within each village to arrive at meaningful fisheries management decisions, without any specific baseline surveys or current status information necessarily being available. There is also minimal biological and ecological assistance provided during the decision making process. The assumption is that members of a village will know what the current situation is for their traditional fishing area and that the best solution for each village situation can be determined by the villagers themselves, with a minimum of facilitation and assistance by trained people.

This approach can potentially work if members of a village posses sufficient knowledge and understanding of coastal marine systems . However, the most striking feature of the interactions and meetings conducted with the Niue IWP project is that essential knowledge about the life history of reef organisms is not always available in these communities. Furthermore, there is significant misinterpretation of cause and effect regarding many important animals and plants, as well as about ecological processes in general. So while there may be some level of understanding within a village of the current status of resources, it has been revealed through the PSA process (Niue IWP National Programme 2003) that there have been declines in most target fisheries species; the reasons for these declines are quite varied. Overfishing is one reason commonly given for these declines, but the complex relationship with other factors (including natural fluctuations) are poorly understood.

What appears to be required is integration of the significant knowledge that is often present within village communities, particularly local knowledge of the distribution and behaviour of animals, with broader scientific knowledge that is available externally. The merging of these two sources of information is required for a country to make informed decisions that will support the sustainable management of coastal fisheries resources.

3.1.1 Advantages and disadvantagesof a village-based approach

The **advantages** of a village-based approach to national level fisheries management are:

- High levels of ownership, acceptance, and personal responsibility for adherence to decisions relating to fisheries management.
- High levels of understanding about the management regimes that are adopted. As a consequence high levels of surveillance and enforcement should not be needed, and enforcement of regulations can be largely village-based.
- If village jurisdiction is at relevant (spatial) scales, fisheries management approaches will address relevant localised characteristics of many fisheries.
- Feedback and adjustment of fisheries management regulations can be more effective as they are more responsive to variations and natural changes in the fisheries.

Disadvantages of village based fisheries management include:

- Less likelihood that a coherent national policy and national approach to fisheries management will emerge. Consequently fisheries that are national in extent will have fragmented (and less effective) management.
- Policy and regulations are not unified, and may not be the same for all people, leading to potentially high levels of missunderstanding when people use resources from areas outside their own village.
- Responsibilities for management are subject to local political changes and ad hoc approaches, which can be rapidly implemented at a village level.
- The degree of accessibility to national resources may vary depending on where fisheries are predominantly located (most fisheries species are not uniformly distributed or uniformly available to all members of a country).

3.2 National (top-down) approach

The lessons and examples of possible management approaches from the pilot IWP villages are expected to help provide direction to Niue in deciding the most appropriate management mechanisms to adopt on a national scale. IWP can assist Niue by provide an impetus towards completion of a national coastal management plan that is presently in draft form. The national management plan will hopefully outline clear policy guidelines and identify the roles and responsibilities of stakeholder.

Many of the advantages and disadvantages of a national approach to fisheries management are outlined in the above discussion on the village-based approach. Clearly there will be component species or groups of species within the range of coastal fisheries that are best suited to either village or national level management. It is critical that the appropriate responsibilities and roles are identified in a national management plan and that specific fisheries are identified that could be best managed at the village or national level.

Consistency across the whole country with respect to fisheries rules and regulations is very important, so that the plan contains no ambiguities. Current and future major development plans must also be considered in terms of their impacts on fisheries. Management decisions should incorporate an understanding of variations in harvest pressure and natural disturbance and variations in the abundance of target species.

Mechanisms by which a national management plan can be implemented will probably include long-term permanent closed areas, such as the Namoui Marine Reserve, which are strategically located in critical habitat,[15] and are managed from a national perspective. A system of rotating temporary closure areas should be associated with long-term or permanent closed areas; the former could be managed by villages, be imposed through the well recognised *fono* system. Enforcement of fisheries regulations (with respect to size, sex, and fishing gear limits) is a national responsibility. A national management plan for coastal fisheries could assist in reviewing the reasons for the apparent lack of enforcement, and could compare the degree of likely success of full closure options with proper enforcement of regulations and limited closures.

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[15] Other areas on the west coast have previously been identified (see Fisk 2007 b) but east coast areas have not been assessed.

4 Photo gallery and observations from Alofi North and Makefu coastal marine habitats

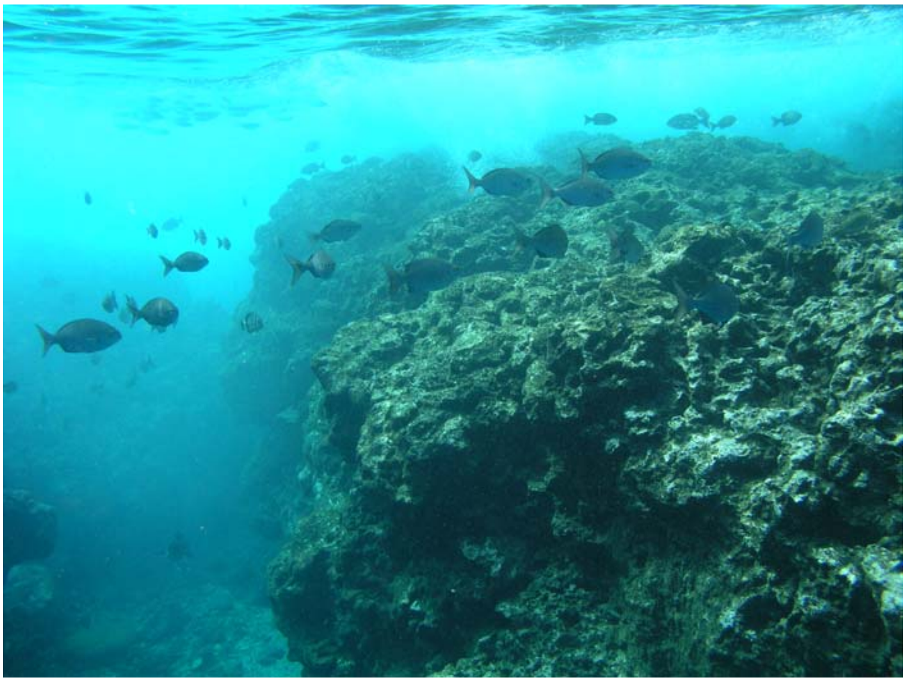

Plate 15. Upper slope with deep gutters south of the wharf in Alofi North, with abundant schools of herbivorous fish species and mostly bare substrate as a consequence of the impact of Cyclone Heta.

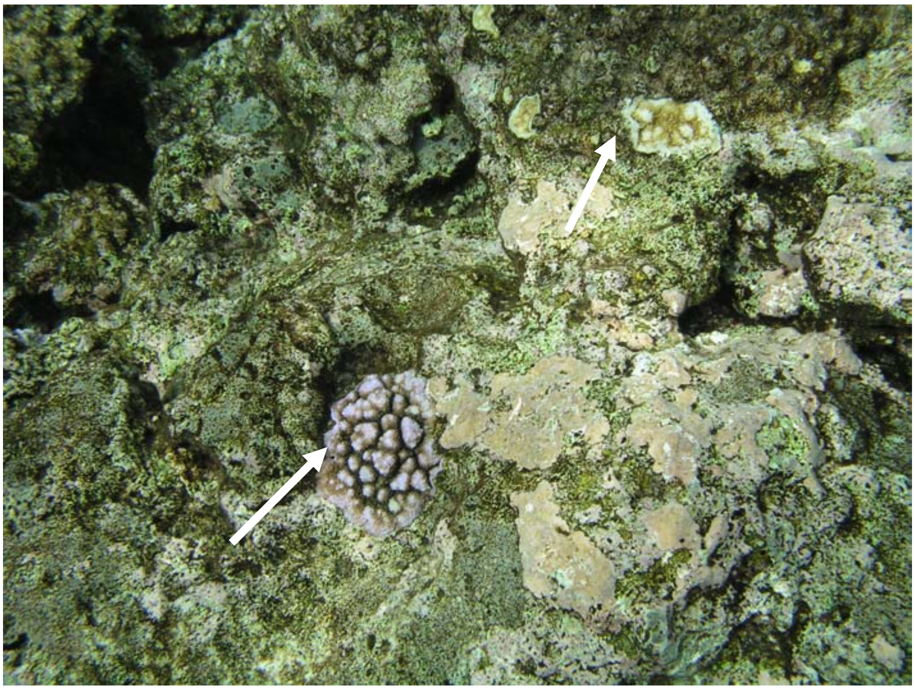

Plate 16. Juvenile corals (purple center and top right hand light brown patches; arrows) on the shallow reef slope (5 m depth) opposite Tomb Point indicate that recovery in under way in the coral communities that were significantly disturbed in January 2004 by Cyclone Heta.

Plate 17. *Liagora* cf *boerggesenii* macro algae dominating reef flat pools in the Makefu area. This species has all but disappeared from the slope where it was dominant for the first 6 months following cyclone Heta.)

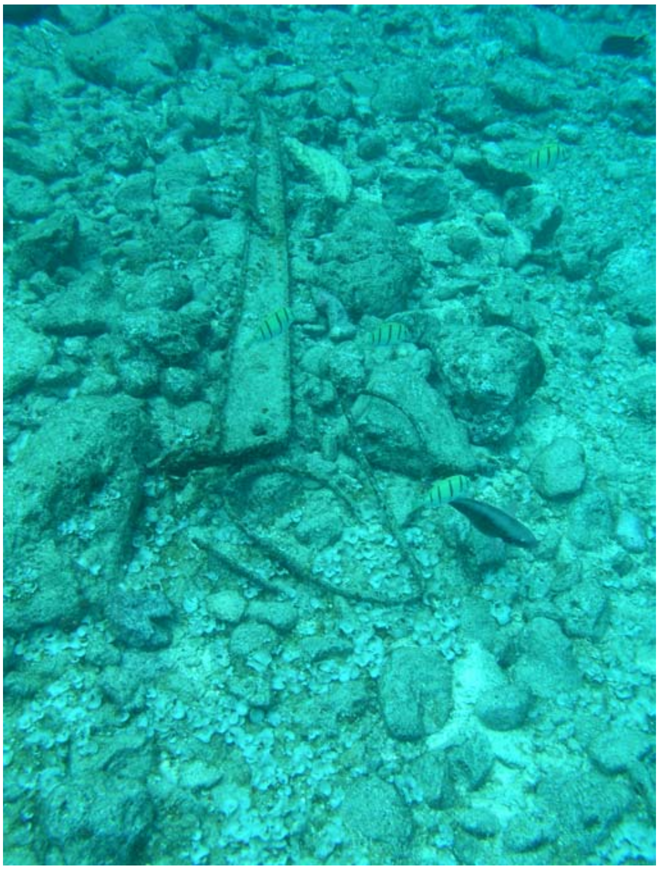

Plate 18. Significant metal debris remains on the western slope terrace after Cyclone Heta. The macro algae *Padina* spp. (lighter crescent shapes in the foreground of photo) is also returning in the vicinity of the harbour (and opposite the former hospital site), and may be an indicator that ciguatoxic organisms are also returning.

Plate 19. The natural rhythms of life are returning on Niue following the damage from Cyclone Heta. Rod fishing (for the seasonal *ume* fish) from the crest at low tide was occurring along the west coast as well as at Makefu in September 2004.

References

Fisk, D.A. 2007a. Niue sustainable coastal fisheries pilot project: literature review and pilot baseline survey. IWP-Pacific Technical Report no. 38. Apia, Samoa: Secretariat of the Pacific Regional Environment Programme.

Fisk, D.A. 2007b. Niue sustainable coastal fisheries pilot project: marine baseline survey. IWP-Pacific Technical Report no. 39. Apia, Samoa: Secretariat of the Pacific Regional Environment Programme.

Niue IWP National Programme (2003). Participatory Situation Analysis : Summary Report of Village Consultations in Niue, June 2003.

Appendix 1 Community-based monitoring methods and data treatment

A1—1 Introduction

Community-based monitoring (CBM) trials involves the use of monitoring methods appropriate for use by village volunteers to monitor their coastal reef habitats. CBM is designed to give immediate and semi-quantitative feedback to a village on changes that attributable to management measures and/or to natural processes. It also should provide the community with regular up-to-date assessments of the health and progress of recovery of their coastal resources.

The community volunteers, IWP Niue staff and Niue Fisheries staff were instructed in methods for monitoring trends in target species, populations, and/or habitats that are important to the community. This phase of the project was also designed to initiate community involvement in, to educate people about, and raise awareness of coastal fisheries management and its functions. In addition, it was expected that scientifically useful data will be collected that will complement more detailed permanent baseline monitoring of resources within the pilot villages.

In principle, CBM should utilise simple techniques that are :

- easily understood;
- easily undertaken
- require minimum accompanying tools; and are
- easily reported.

Monitoring activities have to be relevant to and feasible for the community groups that will be participating. It is important to involve key community members who can serve important roles in helping to raise awareness, and data trends need to be reported back to the community using simple and easily understand terms and formats.

It is important that the objectives and priority issues outlined in the IWP pilot project, as well as the expected effect of no-take areas (NTAs) and other management initiatives, are kept in mind throughout the process if CBM is to be relevant. Frequent and timely feedback to the community regarding the effectiveness of the pilot project and the management approaches is essential; the community needs to be aware of any tangible results, as these can help build further community. While a major goal of the project is to enhance local fisheries, a secondary objective is to conserve biodiversity and ecosystem integrity. The degree to which these objectives are achieved depends on the choice of NTAs and on the adherence of the community to the by-laws outlined in the village management plans.

A1—2 Understanding the effect of harvesting closures on an area

An efficient tool that is readily understood by communities with a long-term, close association with coastal fisheries activities is the concept of banning harvesting in a defined area for a set period. The intention is to allow regeneration of target species within the closed area. This tool was traditionally practised in most Pacific Island countries; the closure of such areas to harvesting was usually looked on as a temporary measure. In Niue, the *fono* was such a temporary closure mechanism, which was undertaken as a show of respect on the death of a person from a particular village (most villagers spent most of their time harvesting resources within their village area). The *fono* was set by local village leader(s) and typically extended to an area of generally less than 100m in width; it was generally left in place for less than a year (S. Leolahi, pers. comm.). A village by-law legislation mechanism provides a means to extend a *fono* to people who live outside a particular village.

Sustainable enhancement of fisheries requires that the benefits of closed areas extend beyond the boundaries of protected areas; otherwise the temporary closure of specific areas will at best result in an increase in the abundance of certain targeted marine species that have been reduced in abundance due to continual harvesting. After an area is reopened, resumed harvesting usually reduces the abundance of the target species back to its previous level. Research has shown that the positive effects of long-term NTAs include an increase in the size, abundance, and (to a lesser degree) species richness of exploited species. These increases are commonly observed even in small reserves within one to three years of a closure; greater gains can be achieved with longer protection periods. Such effects are not universal over short time frames, as there are reported examples of some species not showing positive responses to protection, perhaps due to failure of recruitment and/or inappropriate or degraded habitat within an NTA.

Although it may take a number of years before a significant change can be detected, in the shorter term, the monitoring of target species within NTAs can encourage the community to continue to support the management regime until such time as spillover and seeding effects are noticed.

To benefit fisheries, any increase in the biomass of target species within an NTA must eventually result in the export of target species from the protected area to the general fishing areas. This can occur by seeding of new post-recruitment individuals outside NTAs due to spawning activity, or successful settlement of juvenile species within protected areas. Fully protected (long-term) NTAs are particularly important in this regard as there is often an exponential relationship between target species size and fecundity (the abundance of offspring produced). That is, relatively larger individuals have exponentially greater number of potential offspring. Also, benefits are greatly enhanced as higher population densities can result in higher rates of spawning success. Alternatively, transport of larvae or movement of juveniles to adjacent areas is also required from the NTAs to produce the seeding effect.

The spillover of juveniles and adults of target species may be dependent on relative densities within no-take and adjacent areas, but not all spillover effects are beneficial to fisheries in the long term. This can be the case where periodic movements of individuals occur due to normal migration to spawning sites, which expose the species from within the NTAs to harvest pressures. This can result in no net build up of biomass inside the protected areas. However, this effect depends on the species' vulnerability to fishing and on its mobility. Therefore, unless spillover occurs due to an excess of individual densities per unit area within the NTA (referred to as density dependent effects), there will not be fisheries enhancement. Spillover may be minimal for highly site-attached fish and obviously will not occur in sessile (immobile as adults) invertebrates like giant clams. In general, seeding by mobile offspring is more likely to be the short-term mechanism for enhancing surrounding fisheries, and spillover benefits will occur mostly near NTA boundaries when fishing mortality outside the protected areas is high.

A1—3 Project approach

The scale and complexity of the project requires innovative approaches and techniques, and constant review of all steps of the process. Extensive consultation and due consideration of local community dynamics must be the cornerstones of community involvement and awareness raising, and are important in addressing community expectations. To achieve the project's objectives, the design and implementation of CBM activities was approached by adopting a two-phase process.

The first phase involves a series of trials and review of appropriate monitoring activities focusing on natural resources that were widely accepted as priorities for regular monitoring, namely, selected macro invertebrate species groups. The involvement of key village individuals (and particularly village leaders) in the trials is critical, as the project will rely on these people to follow through and provide the understanding and drive to maintain interest in sustainable coastal fisheries management in the future.

The second phase involved implementing the lessons learned from the trials to a village-wide CBM program to be coordinated by the Project Team under the specific guidance of the Niue's IWP staff.

3.1 Sample units

Transects, set path swims and timed swims are all sample units that cover either a defined area (distance × width) or defined time periods (including a defined width), and are placed within homogeneous habitat. Assessments of biological or habitat characteristics within the defined limits of a transect make up the sample.

To simplify field methods for CBM activities, pre-determined distances can be outlined by setting a particular path, thereby eliminating the need for measuring tapes. Although natural habitats can have clear boundaries (it is usually possible to define the boundaries of one habitat and another adjacent one), the variability of resources within a habitat is still usually quite large. To overcome these problems, a number of replicate transects (with the same dimensions) placed within a habitat can produce data that can be used to calculate a mean value for the species, habitat characteristic, or indicator being assessed. Alternatively, a single sufficiently long swim or transect can overcome many of the problems inherent in proper sampling techniques, providing that the type of data that is recorded is appropriate to the single swim method.

In summary, a sample unit can be a:

1. **Transect** (for reef flat surveys, 40 m × 5 m wide transects are appropriate).
2. **Defined Path**, with decisions made regarding the direction and length, and a starting and finishing point, before the sample is taken.
3. **Defined Time Search** (e.g. a 15 minute search time).

Transects

Transects are lines of specified length and width that define the boundaries and extent of a sample.

Transects vary with respect to the area they sample so as to accommodate the natural distribution patterns of the particular organisms that are targeted in the monitoring program. Thus for small numerous organisms, a small sample (here 40m × 5m) is used, with replicates of that sample repeated a number of times within a site. The number of samples or replicates within a site must be sufficient to include the natural distribution of the organism at that site. The number of replicate transects used at a site will have to be sufficient to calculate an accurate mean density value (for which the variance is not too large). In Niue it was thought advantageous to maintain the standard 40 m × 5 m belt transect that is used to compare different locations along the whole coastline within the two pilot villages.

It is important that the same specified number of replicate transects are used at all sites within any particular monitoring program.

Monitoring methods and the standard number of transect replicates must remain unchanged after a monitoring program has commenced, because every method has a certain bias in what is recorded. That is, comparisons cannot be made between different samples if the methods are altered in any way, as the inherent bias of each different sample method will change.

In summary, it is essential that the transect dimensions and the number of transects to be monitored per site be consistent**.** These must be appropriate to the distribution patterns of the target organism or target groups, with the resulting data giving a good representative estimate of the density of organisms present in that site. The transect dimensions (and number of transects) must be unchanged for each target organism or group of organisms, both within sites and between sites, if the sites are to be compared, and if data from one monitoring session is to be compared with that from another.

A1—4 Details of set paths or timed swim method

A full outline of the CBM trial topics are presented below. Reporting protocols are presented in the Results section with a guide to storing, retrieving, and presenting the information. Throughout the text, Niuean names for organisms or activities are included in italics.

4.1 Recording abundance and presence/absence of organisms and benthic indicators

In this CBM trial, single set path swims were used as the standard monitoring technique for a site. A standard field sheet for recording data is presented below, following the method descriptions. The field sheet presents all the categories of information that are to be recorded for up to three set path swims for fish, macro invertebrates and reef condition.

4.1.1 Reef fish visual census method

The width of each swim is estimated by the observer (without the use of measuring tapes). This was set at approximately 10 m width (5 m on each side of the observer, from the surface to the substrate), with a swim path at approximately 10 m depth, which is a reasonable distance to restrict observations on the slope, given the clarity of the water and the necessity to remain outside the open wave surge zone. The 10m depth is also where the majority of shallow reef slope fish can be found.

☞NOTE

The general path is determined from the shoreline before entering the water and should have a recognizable starting and finishing point (e.g. the edge of a marked reserve, or a well recognized boundary between *avas* (indentations) in the reef).

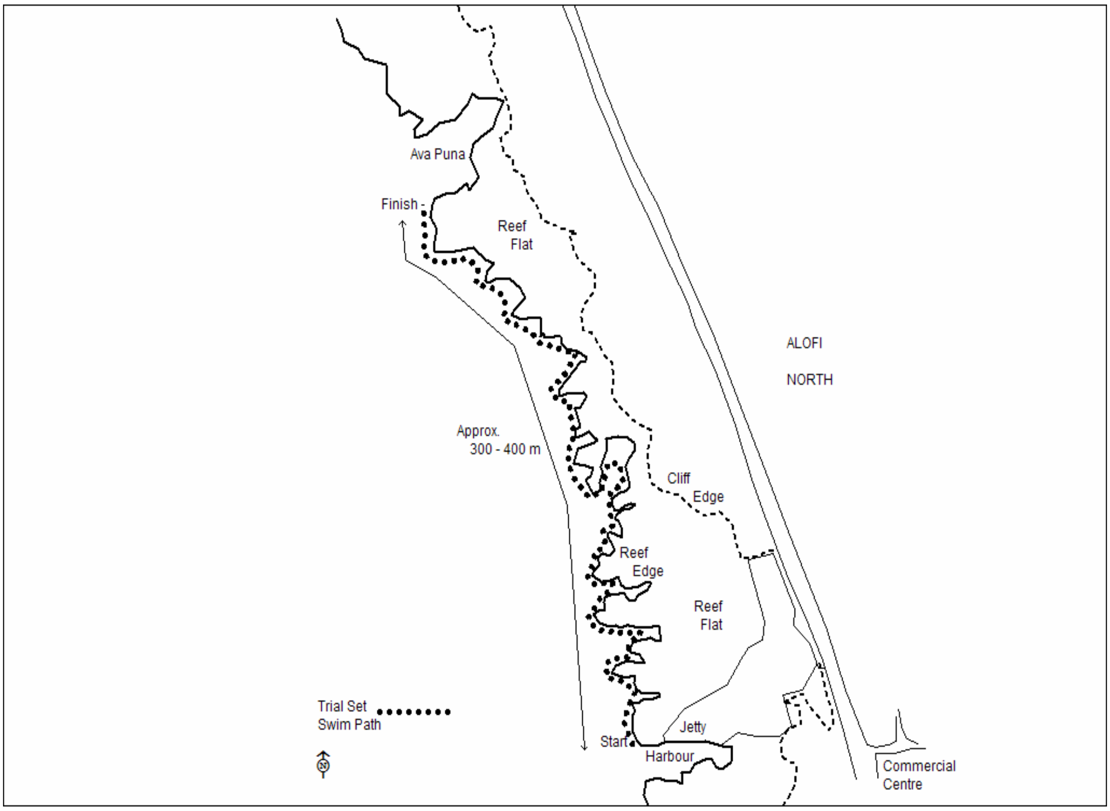

Figure A1-1. Illustration of the trial set path monitoring swim for fish, invertebrates and reef condition at Alofi North, conducted in September 2004.

Once paths are decided on, they should be carefully described and included in a map, so that the same path can be repeated in the future. An example of the set path swim is shown in Fig. A1–1 (this shows the training swim, defined as a 3–400 m swim, north from the harbour in Alofi North to the finish at the southern corner of Ava Puna).

The families of fish recorded are those that are most obvious and appropriate, with respect to villagers' interests. The indicator fish groups are usually always the most desirable fishery species. As a general rule it is recommended that no records be taken of the presence of damsel fish, small wrass, and butterfly fish, as they are ubiquitous and most likely will always be present in large numbers.

The method used for undertaking a fish visual census by village volunteers requires an estimate of:

a) The three most numerically abundant fish families or groups (1st, 2nd, and 3rd most abundant groups). In each case the group or family name is written on the dotted line in the data sheet.

b) The most common size of each of the three most abundant groups (length based on different arm section lengths, starting from the fingertips). A tick is placed in one of the size category circles.

c) The total number of all fish observed along each set path. This is written at the end of each set path by using the abundance categories outlined on the data sheet. A tick is recorded for only one of the abundance categories squares. It is important to emphasise that only one tick is to be entered.

Information noted above (in a, b and c; see also details below) is entered in this section of the data sheet:

 # FISH SWIM #1 :

Total Number Fish	1. 1st Most Abundant	2. 2nd Most Abundant	3. 3rd Most Abundant
	-----------------------	------------------------	-------------------------
☐ 1 - 60	1. Knuckle ○	1. Knuckle ○	1. Knuckle ○
☐ 60 - 250	2. Wrist ○	2. Wrist ○	2. Wrist ○
☐ 250 - 1000	3. Elbow ○	3. Elbow ○	3. Elbow ○
☐ 1000 - 4000	4. Shoulder ○	4. Shoulder ○	4. Shoulder ○
☐ > 4000			

. ☞NOTE

Although these parameters are subjective estimates by the volunteers and are based on the perceived number and identity of fish observed during each set path swim, it is important that:

- **Before a set path swim monitoring program begins, the village agrees on what is to be monitored.**
- **In particular, the identification of the organisms must be agreed on and the categories and names to be used understood by all participants.**

Fish identification. It is imperative that the chosen groupings of fish relate to the way that local people can describe the fish types. This can present a challenge to the scientific approach to categorising fish, but it is important that the Niuean way of describing fish is used in these activities. There are some limitations that have to be applied to the use of the Niuean fish descriptions, because of the need to standardise data recording. While there may be accurate Niuean equivalents to various levels of scientific fish classification, the Niuean term that equates to the family level should be used.

Size groupings. The sizes of fish are placed into a number of standard size classes following the completion of each transect. In CBM, the size estimates of fish emulate the commonly used descriptive categories which are based on parts of the human arm (Table A1–1). Corresponding maximum sizes and median sizes of fish categories for summary statistics are shown in Table 2.

Table A1-1 Fish size categories and the corresponding maximum and median lengths used in the CBM trials.

Size Category	Maximum Size (cm)	Median Size (cm)
1. Finger tip to Knuckle	20	10
2. Finger tip to Wrist	50	25
3. Finger tip to Elbow	80	40
4. Finger tip to Shoulder	160	80

Fish abundance. The categories for abundance or number of fish for each swim or replicate are summarized in Table A1–2. Abundance categories of total fish numbers have maximum range cut off points of 60, 250, 1000, 4000 and 16,000 individual fish. The maximum number of fish was set at 16,000 as it was thought that abundance categories higher than this would not be necessary given the average length of set path swims.

Table A1-2 Abundance categories used in estimates of abundance of numerically dominant fish species and the median abundance value used for population estimates.

Category	Range Number of Fish	Median Number
1	1–60	30
2	60–250	155
3	250–1000	625
4	1000–4000	2,500
5	4000–16000	10,000

NOTE

If there is some doubt as to what category of abundance is to be entered (1–60, 60–250, etc.), it is up to the recorder to make that judgment in the field, as that person is in the best position to make the right decision.

This also applies to all other data to be entered on to the datasheet.

4.1.2 Reef macro invertebrates

The CBM trial data sheets also include a section (see below) for recording macro invertebrates of interest or of concern for the villagers who are undertaking the monitoring.

 # INVERTEBRATE & REEF CONDITION SWIM #1 :

Limu Present	% Coral Cover	Clams	Urchins	COTS
Limu fua ☐	% Live ☐	Number ☐	Number ☐	Number ☐
Other Limu ☐	% Bleach ☐	>20 ☐	> 20 ☐	> 20 ☐
(Present (√), Absent (x))	(% Category)	(Total Count)		

(% Live Coral Categories = **0**, **1** = 1-10%, **2** = 11=30%, **3** = 31-50%, **4** = 51-75%, **5** = 75-100%)

☞NOTE

The invertebrate species list can be modified to include any organism of interest to individual villages, but after the monitoring has begun the list should not be changed unless there are good reasons to do so.

As is true for fin fish surveys, invertebrate monitoring has to be kept constant within each site and between surveys. Swim path widths are 10 m for invertebrate species, as they are normally present in low densities, which means that a greater sample area is required to ensure sufficient numbers are recorded.

If the conditions in the monitoring area mean that there is only one safe-water entry point, macro invertebrates and reef condition can be recorded on a return swim path which covers exactly the same path that is used for the fish monitoring paths. The macro invertebrate and reef condition surveys can also be carried out by additional volunteers who follow behind the fish recorders at a distance that will not disturb the fish present in the area.

It is suggested that for coral reef habitats, suitable macro invertebrates may include:

- **giant clams** (*gege*),
- common **sea urchins** (*vana*), and
- **crown of thorns starfish** (*fetu tahi fotofoto*),

Other invertebrates of interest or concern can be added or substituted for those above. Once the categories of invertebrates are chosen for use in a CBM program, the same species should be re-surveyed each time. Additional invertebrates or indicators can be added to the monitoring protocol, but care should be taken in changing the basic monitoring design after it has been established.

Estimates of abundance are recorded in the following categories for each belt transect or set path swim :

- 1–20 individuals (the actual number of individuals observed is added to the sheet), or,
- >20 individuals.

If more than 20 individual species of macro invertebrate are observed along set paths or timed swims that are suitable for village management areas, it is generally expected that there will be too many to count individually and that no further useful information will be obtained by counting every one present.

☞NOTE

Accurate counts of macro invertebrate and total fish numbers can generated by noting groups of individuals as they are observed (in the field sheet columns) and then tallying the total number at the end of the set path or timed swim.

4.1.3 Reef condition indicators

During each swim very useful information on the status and health of a habitat should be recorded. This requires very little effort and provides an important overview of the condition of a site. The reef condition information is written down at the end of each swim and is recorded as being either present or absent (the appropriate box is ticked if present). The suggested indicators (for which tick boxes are provided under the **INVERTEBRATE & REEF CONDITION** category include:

- Presence of significant cover of the substrate by **large edible algae.** Tick boxes can be included for *limufua* (*Caulerpa racemosa*), *limu tahi* (*Caulerpa cuppressoides*) or “other limu”.
- **Live coral cover** visual estimate. This is indicated in the % live box, using the categories shown on the sheet : 0 = no coral, 1 = 1-10% cover, 2 = 11-30% cover, 3 = 31-50% cover, 4 = 51-75%, 5 = 76-100% cover;
- Of the live corals present, the percentage of these that were showing clear signs of pale colour (indicating that **bleaching** of is occurring). The same categories are used as for the live coral estimates.

☞NOTE

The indicator "Significant cover or presence of large edible algae" is subjective, but can be defined as the presence of sufficient quantities that would warrant effort to harvest.

The presence of significant cover of other macro algae of interest (e.g. such as *Padina* spp., which appears to be associated with the presence of ciguatera in Niue) can also be recoded, as long as a distinction is made between edible and non-edible algae.

REEF FISH & OTHER INDICATORS - TIMED SWIM / SET PATH - MONITORING

VILLAGE: ______________ SITE : ______________ DATE: ________ RECORDER: ______

TIME PERIOD OF SWIM :____________________ TIME OF LOW TIDE : ________________

FISH SWIM #1 :

Total Number Fish

☐ 1 - 60
☐ 60 - 250
☐ 250 - 1000
☐ 1000 - 4000
☐ > 4000

[1]. 1st Most Abundant	[2]. 2nd Most Abundant	[3]. 3rd Most Abundant
----------------------	----------------------	----------------------
1. Knuckle ◯	1. Knuckle ◯	1. Knuckle ◯
2. Wrist ◯	2. Wrist ◯	2. Wrist ◯
3. Elbow ◯	3. Elbow ◯	3. Elbow ◯
4. Shoulder ◯	4. Shoulder ◯	4. Shoulder ◯

INVERTEBRATE & REEF CONDITION SWIM #1 :

Limu Present	% Coral Cover	Clams	Urchins	COTS
Limu fua ☐	% Live ☐	Number ☐	Number ☐	Number ☐
Other Limu ☐	% Bleach ☐	>20 ☐	> 20 ☐	> 20 ☐
(Present (√), Absent (x))	(% Category)	(Total Count)		

(% Live Coral Categories = 0, 1 = **1-10%,** 2 = **11=30%,** 3 = **31-50%,** 4 = **51-75%,** 5 = **75-100%)**

FISH SWIM #2 :

Total Number Fish

☐ 1 - 60
☐ 60 - 250
☐ 250 - 1000
☐ 1000 - 4000
☐ > 4000

[1]. 1st Most Abundant	[2]. 2nd Most Abundant	[3]. 3rd Most Abundant
----------------------	----------------------	----------------------
1. Knuckle ◯	1. Knuckle ◯	1. Knuckle ◯
2. Wrist ◯	2. Wrist ◯	2. Wrist ◯
3. Elbow ◯	3. Elbow ◯	3. Elbow ◯
4. Shoulder ◯	4. Shoulder ◯	4. Shoulder ◯

INVERTEBRATE & REEF CONDITION SWIM #2 :

Limu Present	% Coral Cover	Clams	Urchins	COTS
Limu fua ☐	% Live ☐	Number ☐	Number ☐	Number ☐
Other Limu ☐	% Bleach ☐	>20 ☐	> 20 ☐	> 20 ☐
(Present (√), Absent (x))	(% Category)	(Total Count)		

(% Live Coral Categories = 0, 1 = **1-10%,** 2 = **11=30%,** 3 = **31-50%,** 4 = **51-75%,** 5 = **75-100%)**

FISH SWIM #3 :

Total Number Fish

☐ 1 - 60
☐ 60 - 250
☐ 250 - 1000
☐ 1000 - 4000
☐ > 4000

[1]. 1st Most Abundant	[2]. 2nd Most Abundant	[3]. 3rd Most Abundant
----------------------	----------------------	----------------------
1. Knuckle ◯	1. Knuckle ◯	1. Knuckle ◯
2. Wrist ◯	2. Wrist ◯	2. Wrist ◯
3. Elbow ◯	3. Elbow ◯	3. Elbow ◯
4. Shoulder ◯	4. Shoulder ◯	4. Shoulder ◯

INVERTEBRATE & REEF CONDITION SWIM #3 :

Limu Present	% Coral Cover	Clams	Urchins	COTS
Limu fua ☐	% Live ☐	Number ☐	Number ☐	Number ☐
Other Limu ☐	% Bleach ☐	>20 ☐	> 20 ☐	> 20 ☐
(Present (√), Absent (x))	(% Category)	(Total Count)		

(% Live Coral Categories = 0, 1 = **1-10%,** 2 = **11=30%,** 3 = **31-50%,** 4 = **51-75%,** 5 = **75-100%)**

COMMENTS :

Figure A1-2 Field data sheet for recording CBM monitoring data.

4.2 Data treatment and summary description

Data entry, analysis, and preparing a summary of the information are the next most important steps in the program (diagram below). The data that is used is taken from the field sheets shown above.

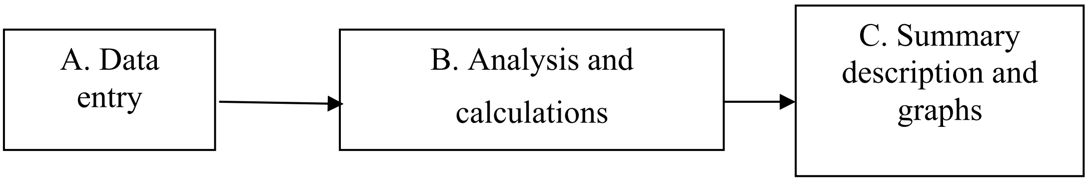

Figure A1-3. Diagrammatic representation of the steps in summarizing the data collected from the CBM activities.

4.2.1 Data entry

The data can be entered directly onto an Excel spreadsheet as shown in Tables 15 and 16 in Results below for both Reef Fish and Other Indicators data. The same file for these two types of data can be updated with data collected from successive surveys using separate worksheets within each file, and can include data from each village separately (note : not like it is presented in the appendix of this report). Each worksheet can be renamed to indicate which survey period the data are from. That is, monitoring from each village should be kept separate and for each of these villages, two files should be kept, one for Reef Fish data, and one for Other Indicators data.

4.2.2 Analysis and calculations using Excel Spreadsheets

An example of data records for Niue CBM for fish and other invertebrates on the reef slope is explained below step by step. The status of resources is regularly monitored, with the sample unit defined as a swim that follows a path defined at the beginning of the monitoring program. The type of information that is recorded is entered into an Excel spreadsheet (Table A1–3) from a standard datasheet taken into the field (Fig. A1–2).

Table A1-3 Excel spreadsheet for recording CBM data

Village	Alofi Harbour		
Site	Wharf south to Ugako Sea Track		
Monitoring Time	1 (Baseline)		2
Date	22/09/04		
Period Since Last (months)	0	0	X (mths)
Recorder	SL	RP	
Swim Type	Set Path	Set Path	
Management Type	Open	Open	
Swim Number	1	1	
FISH :			
Tot Fish Number	1000-4000	250-1000	
Tot. Fish (Median)*	2500	625	
Abundance 1 :			
ID (Niuean)	Meito ago, Meito uli, Tukutea, Hapi (main surgeon fish species)		
ID (Common)	Surgeon	Surgeon	
Size Category 1	2 (wrist)	2 (wrist)	
Median Size (cm)*	10	10	
Abundance 2 :			
ID (Niuean)			
ID (Common)	Drummer	Parrot	
Size Category 2	2 (wrist)	1 (knuckle)	
Median Size (cm)*	10	5	
Abundance 3 :			
ID (Niuean)			
ID (Common)	Parrot	Drummer	
Size Category 3	3 (elbow)	1 (knuckle)	
Median Size (cm)*	25	5	
OTHER INDICATORS :			
Limu Fuafua or edible limu	N	N	
Other non-edible Limu	Y	Y	
CORAL :			
Coral Cover Category	1	1	
Median % Coral Cover *	5	5	
% Bleached Coral	0	0	
MACRO INVERTEBRATES :			
Gege (Clam) Numbers :	2	0	
Clam Status *	Low	Nil	
Vana (Urchin) Numbers :	9	0	
Urchin Status *	Medium	Nil	
Fetu fotofoto tahi (COTS) Numbers:	0	0	
COTS Status *	Nil	Nil	
NOTES	Mullet school (~60);		

Notes:
1)The shaded fields (also marked with a *) are added when the data is entered into the spreadsheet (see text).
2) Note that normally only one set of monitoring records will be recorded at one time. This example shows two of the trainee's records (identified as "SL" and "RP" under the "Recorder" field in line 6).

4.3 Summarising the data from the field sheets

4.3.1 Fish

Total number of fish

Categories of the abundance or number of fish for each swim are summarised in Table A1–4. Abundance categories of total fish numbers have maximum range cut-off points of 60, 250, 1000, 4000 and 16,000 individual fish. The maximum number of fish was set at 16,000 as it was thought that abundance categories higher than this would not be necessary given the average size of temporary-closure or no-take areas.

Table A1-4. Abundance categories used in estimates of abundance of numerically dominant fish species and the median abundance value used for population estimates.

Category	Range Number of Fish	Median Number
1	1–60	30
2	60–250	155
3	250–1000	625
4	1000–4000	2,500
5	4000–16000	10,000

Relative abundance of fish

The three most abundant fish groups are recorded at the end of each swim using a subjective estimate of the relative numbers of the more abundant fish groups.

☞NOTE

Without training, it is difficult to accurately count large numbers of fish, but good approximate estimates can be made by counting the number of individuals in fish schools using multiples of 10, 20, 50, or even 100 individuals (whatever the observer is most comfortable with).

If an observer can add additional information on the types (e.g. the Niuean names) or even species of fish present it should be *added* to the data sheet and subsequent summary report. This guide represents the minimum information, which should ALWAYS be recorded, even if other information is added.

Local Niuean names can be written on the field sheet, but it is essential that basic information about the fish groups — relating to the major fish families and not to individual species or species groups — is recorded consistently (see Table A1–5 for the major fish families typically of interest in Niue). If a few species or recognizable species groups are clearly dominant then these can be added (in Niuean) in the margins of the field sheet, or in the area where the relative fish abundance is recorded. The additional information adds extra value to a monitoring report and is therefore strongly encouraged. When the data is entered and a report written, this extra important information can be included in the summary report.

Table A1-5. Major fish families most often of interest in Niue include the following:

Angel fish	(Pomacanthidae)
Emperor	(Lethrinidae)
Goat fish	(Mullidae)
Grouper	(Serranidae)
Mackerel	(Scombridae)
Mullets	(Mugilidae)
Parrot fish	(Scaridae)
Rabbit fish	(Siganidae)
Rays	(Dasyatidae and others)
Sharks	(Carcharhinidae).
Snapper	(Lutjanidae)
Surgeon fish and Unicorn fish	(Acanthuridae)
Sweetlips	(Haemulidae)
Trevally	(Carangidae)
Trigger fish	(Balistidae)
Wrass	(Labridae)

Common size of most abundant fish

Size categories of the three most abundant fish groups are included following the completion of each transect. In CBM, the size estimates of fish emulate the commonly used descriptive categories which are based on parts of the human arm. Corresponding maximum sizes and median sizes of fish size categories for summary statistics are shown in Table A1–6.

Table A1-6 Fish size categories and the corresponding maximum length and median length used in CBM activities. This information is then used to compile a status report for the village managing the area being monitored.

Size Category	Maximum Size (cm)	Median Size (cm)
1. Fingertip to knuckle	10	5
2. Fingertip to wrist	20	10
3. Fingertip to elbow	50	25
4. Fingertip to shoulder	80	40

4.3.2 Other Indicators

Limu

Limu fua and/or *limu tahi*, as well as other *limu* observed during the set path swims are recorded as being either present or absent. As with all other indicator records, any additional information should be added to the data sheets if the recorder thinks this information is relevant or important. In particular, additional information may be added that relates to very obvious changes to reef characteristics (e.g. composition of the reef algae or animals, and recent disturbance events that may have affected the area, such as large storms or reported bleaching).

Table A1-7 Median cover values equating to the cover categories used in the monitoring program.

Coral Cover Category	Cover Range (%)	Median Cover (%)
1	1 – 10	5
2	11 – 30	20
3	31 – 50	40
4	51 – 75	62.5
5	76 – 100	87.5

Coral

Coral Status. Percent cover of live coral is estimated in the field using coral cover categories. The median values for these categories are given in Table A1–7.

Bleached coral (*feo hina*). The percentage of live coral colonies that are affected by bleaching is recorded using the same percentage categories that are used to estimate live coral cover.

Macro invertebrates

A number of macro invertebrates are recorded at the end of a swim that are considered to be either good indicators of reef health and/or are of interest to villagers. These include giant clams (*gege*), sea urchins (*vana*), and crown of thorns starfish (*fetu tahi fotofoto*). Other indicators can be considered at the planning stage, but the decision to monitor specific species should be finalised at the outset, and the list of macro invertebrates monitored altered only in compelling circumstances. Additional indicators should be added to the list if deemed necessary, but no indicators should dropped to make way for new indicators).

The status of clams, urchins, and COTS are described in the summary report by categorising the numbers of each group into the following status classes :

- 1 – 5 individuals = **Low**;
- 6 – 10 individuals = **Medium**;
- 11 – 20 individuals = **High**; and
- Greater than 20 individuals = **Very High**.

These are relative measures that are appropriate for survey areas that normally do not cover more than 300 m of reef slope in length (most village reserves will generally be smaller than this).

A1—5 Details of reef flat belt transects

5.1 Recording abundance of macro invertebrates and presence/absence of recent harvesting activity targeting certain macro invertebrates

Indicator reef flat "target" species are selected for monitoring the effects of village management measures, and for assessing the health of the reef flat habitat. These species of concern are those most frequently targeted for harvesting and are perceived to have declined in abundance and distribution in recent times.

The main steps involved in CBM of reef flat target species (following site selection) are as follows:

1. Make a hand drawn map of the site, including as many recognizable physical features as possible, including the location of belt transects (see 2).
2. Choose at least two areas (well within the site, and not close to the boundaries) for the location of two permanent belt transects. These will run from close to the base of the cliffs (or opposite a beach), perpendicular to the reef crest and shoreline, out for a distance of 40 m.
3. Describe the position of the start of each belt transect and any other features that will help in returning to the site in the future. The starting point should have a recognisable landmark; a photo of the starting point, including a view of the background cliff face, is a good way to permanently record the location.
4. Secure a measuring tape at the shore end and lay the tape in a straight line, keeping it taunt with as little movement as possible (by using rocks or other features to weigh down the tape); then secure the tape on the bottom at any point beyond the 40 m length mark.
5. Allocate counting and recording tasks to the volunteers present. Then commence counting the target species (both live and dead individuals of *ugako* and *papahua*). Count all individuals found within 2.5 m of each side of the tape (thus the total area being monitored is 5m wide × 40 m long). All individuals should be counted, except in situations where many thousands of individuals are present (in this case, sub-sample the densest patches, as outlined below).
6. Sections of the belt transect can counted at a time, so that large numbers are not forgotten. Normally, figures are written on the field sheet after a 10 m (× 5 m) portion of the belt transect has been surveyed.

5.1.1 Procedure for sub-sampling very dense patches of target species

Usually, dense patches of *ugako* or *papahua* are encountered in areas that are infrequently harvested. In such areas it will be acceptable to use a sub-sample method and to extrapolate the count of individuals from the sub-sample area to a larger area. Only adopt this procedure for those areas within the transect that have very dense population concentrations; count all other areas by individual, using the normal method. The recommended sub-sampling procedure involves the following:

1. Choose a section of the substrate that contains dense concentrations of the species. Measure the area of that section (for example, 1 m × 1m) and count all those present in that particular area.
2. Estimate the total area within the belt transect that has similar concentrations of individuals of the species being measured (for example, 15 m^2), and multiply the number of similar-sized areas by the actual count made in the sub-sample area.

5.2 Data treatment and summary description

The same observations made in Section 4.2 regarding data entry, analysis, and the preparation of summary information apply here as well.

5.2.1 Data entry

Data are entered into an Excel template or data sheet (copy the sheet layout shown below in Tables A1–8 and A1-9). The data recorded in the field should be added manually from the field sheets (there will be a number of sub totals, depending on the number of individuals present, whether a number of people were counting the same organisms in different parts of the same transect, or surveying different 10 m sections of the same transect).

Note also that the column headings are exactly the same for the sheets "**1. RAW DATA"** (where the initial data is entered and checked for accuracy) and "**2. WORK TABLES**" (in which the calculations are carried out).

5.2.2 Analysis and calculations using Excel Spreadsheets

Data from belt transects should be entered into an Excel spreadsheet, both for storage and for generating summary data. Summary data can be extracted at ant time, but the same procedure will have to be done each time a new summary report is to be created with additional data. Note that there are simple ways to add another set of data from a new monitoring session to an existing summary table (especially for graphing the trends over time).

The basic process for entering data and summarizing the information incorporates the use of different sheets within a single Excel file. Each sheet is named and refers to each of the stages in the summary procedure.

The Summary Procedure is as follows :

1. Enter the data into a sheet named **1. Raw Data** (Table A1–8).
2. **Copy** all the raw data from Sheet 1. Raw Data (including the headings) and **paste** the raw data to the first cell of Sheet 2. Work Tables (TableA1–9). This is recommended so that the original raw data are not touched, thereby providing a backup system in case something goes wrong with the calculations and summarising procedures.
3. Create additional columns for density measurements (see Table A1–9). The mean density per metre is calculated in an additional column of the belt transect data by dividing the number recorded in the transect by 200. If as is recommended, there are at least 2 permanent transects used for monitoring the density of target species in a specific area like a TCA, the total number of individuals for each species from both transects are summed in another column, and the mean density per metre is calculated in an adjacent column by dividing the sum from both transects by 400. The procedure for calculating means per hectare are to multiply the mean density of individuals per metre from the 40m x 5m wide belt transect(s) by 10,000.
4. Re-select all the data in Sheet 2. Work Tables, including the headings, and create a Pivot Table (see number 5 below) using the raw number of live and dead individuals.

Table A1-8. Excel sheet format for "1.Raw Data."

Includes no formulas; used for data storage.

	A	B	C	D	E	F	G	H	I	J	K
1	VILLAGE	DATE	MGT REGIME	SITE	TRAN NO	LGTH TRAN (m)	GPS Start	SPP	NO. LIVE	NO. DEAD (ugako, papahua)	RECENTH ARVEST (Y / N)
2											
3											

Table A1-9. Excel sheet format for "2. Work Tables."

Includes the same headings as shown above but also includes formulas for calculating the mean number of individuals per meter and mean number of individuals per hectare. These formulae can be copied down the relevant columns for all records of each species. This is done by selecting the cell with the formula, then placing the cursor over the bottom RH corner of the cell where the '+' sign is highlighted, and by holding down the cursor and dragging the formula down the column below the highlighted cell.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	VILLAGE	DATE	MGT REGIME	SITE	TRAN NO	LGTH TRAN (m)	GPS Start	SPP	NO. LIVE	NO. DEAD (ugako, papahua)	RECENTH ARVEST (Y / N)	MEAN LIVE / sq m2 Transects (40x5m) = 400 sq m	MEAN LIVE / ha (1 Ha = 10000 sq m)	MEAN DEAD / sq m2 Transects (40x5m) = 400 sq m	MEAN DEAD / ha (1 Ha = 10000 sq m)
2												0.00	0	0	0
3												0.00	0	0	0
4						(Formula used for each column which is normally hidden) =						(= I4/400)	(= L4 * 10000)	(=J4/400)	(=N4 * 10000)
5						(The cell reference numbers in the formula refers to each row number)									

Note that each sheet within a single Excel file can be renamed by RH clicking the cursor when it is placed on the tag at the bottom LH corner of the screen, which by default is named 'Sheet 1..2…3…etc'.

5. **Create a Pivot Table** in Sheet: 2. Work Tables. The steps are : Select *Data –Pivot Table & Pivot Chart… -- Next – Next – Layout* – (drag with mouse) items from the RH set of items (each refers to a column heading) the following : DATE 'box' is dragged to ROW position on Layout; TARGET SPECIES 'box' is dragged to the COLUMN (top) position; drag NO LIVE 'box' to DATA position in Layout, 2x click the Count of NO LIVE (the default) and select the SUM of NO LIVE; repeat dragging NO DEAD 'box' to the DATA position and change to the function SUM of NO DEAD. – Select OK. – Select OPTIONS – de-select all options (esp. Totals of Columns, Totals of Rows). – click OK. – Select EXISTING WORKSHEET – Select a position in the sheet **3. Calculations**.—*Next – Finish.*
6. Select the finished Pivot Table and Copy to **Sheet**: **3. Calculations.**
7. To **generate graphs** in **Sheet**: **4. Graphs** the procedure is as follows : 1. **Copy** Pivot Table – *Paste Special – Values – OK*; 2. Change Row Headings pf 'Sum of NO LIVE' and 'Sum of NO DEAD' to 'LIVE' and 'DEAD' respectively; Insert a line (row) above each Target Species list of number of Live/Dead, Copy top DATE headings -- **Select each Target Species and Data** (including the date) – **Select Graph Icon** – Select *Line* type of graph – Select second row option (LH side) – *Next – Next* – Add Titles and x, y axis (Date, No Individuals, respectively) – Select **Gridlines** – De-select all options – *Next* – Select as 'Object in "Graphs" – *Finish*.
8. Move, size graph. Also, 2x click graph – Format Chart Area – Select **Border – None** and **Area – None**.

C. Summarising the data from the field sheets

Data summarising is best done by creating a graph from the calculations outlined above. When a number of monitoring data summaries have been collected, copy the data set from each monitoring period into a separate spreadsheet (it is recommended that this procedure is kept separate from the raw data and initial calculation activities, either in a separate sheet or even in a separate file specifically maintained for this purpose).

To create a graph from the final dataset, the data to be used on the graph are selected and then the graph icon at the top of the screen is selected and the prompts are followed.

Some of the steps are described here:

1. Select data with headings only (suggest this be done in a separate worksheet or separate file), which can include a number of dates and data sets (each species separately).
2. "Standard Types" refers to the graph types – Select 'Line' – then 'Line with markers displayed at each data value' – then 'Next'.
3. "Data Range" should be already selected.
4. Type in suitable text for "Titles", "Category X", "Category Y", and de-select the "Gridline" in the folder "Gridline" – then select "Next".
5. Select "As object in a worksheet in the same or alternative file".
6. Select "Finish".

The graph can now be moved, and/or re-sized to suit. One aspect that may be worth changing is the fill in the centre of the graph. To make the fill at the graph centre transparent, the filled or coloured area of the graph is selected (by double clicking the cursor from anywhere within the filled area. Then a menu pops up where you can select the options for Border (select "None"), and Area (select "None).

By selecting the graph in Excel and copying it, you can directly transfer a copy of the graph into a Word document for summary reporting or for printing and display.

An example of a graph used to demonstrate the graphing procedure to the Niue IWP and Fisheries staff is shown below using the standard data format (data are hypothetical).

Table A1-10 Excel datasheet used for the graph in Fig. A1-4.

		1/04/2004	1/09/2004	1/10/2004
Papahua	Sum of NO. LIVE	15	60	120
	Sum of NO. DEAD	47	58	22

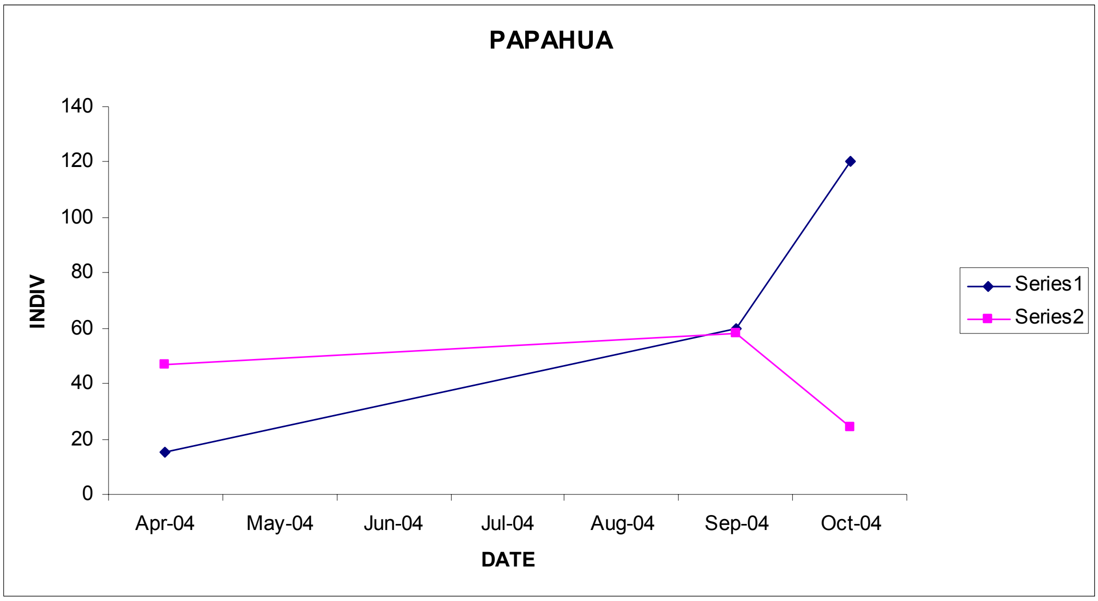

Figure A1-4. Graphed data derived from Table A1-10.

In this instance Series 1 and 2 refer to live and dead *papahua*, but this can be changed by formatting the graph and changing the legend headings from Series 1/2 to Live/Dead.

Appendix 2 Summary information on species of concern

The information on species of concern for the two pilot villages was either (i) presented to the villagers during meetings or (ii) has been supplemented by the author with easily obtained information. Note that not all information is complete and/or reflects the most recent available for the organisms.

Some of the most useful information that is required for good management decisions relates to individual species growth rates, age and/or size at reproductive maturity, life span, and reproductive success (especially recruitment rates).

A2—1 Finfish

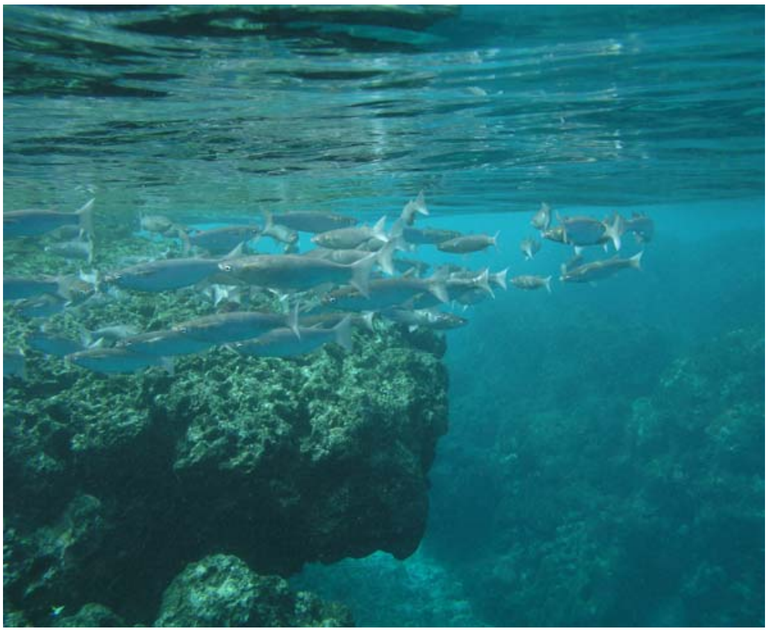

Plate A2-1. Schools of fringe lip mullet *Crenimugil crenilabis (fuafua)* in gutters close to the crest, just north of the harbour in Alofi North (Sept. 2004).

Over 222 species of fish are reported to occur in Niue (FishBase database[16]), and many reef fish are utilised in a multi-species finfish fishery. Reef fish demonstrate complex physical and reproductive changes over their full life span. The changes in physical appearance generally correlate with changes in their reproductive status. For example, some larger predators (such as certain species of grouper), mature first as females and then change to males; smaller grouper species can mature in one year, while larger species may take many years to reach sexual maturity. Spawning in groupers is seasonal and controlled by moon phase, with many of the larger species travelling long distances at precise times to spawn in mass aggregations at traditional sites. High concentration of fishing effort on these traditional aggregation sites can easily deplete the ability of local populations to sustainably maintain their numbers.

[16] Accessed 06 November 2006 at http://www.fishbase.org/

Plate A2-2. School of surf surgeon fish Acanthurus guttatus (hapi) in close to the reef crest just north of the harbour in Alofi North (Sept. 2004).

Colour and body shape changes can also accompany these changes in reproductive status. For example, parrot fish often have three distinct phases: juveniles, intermediate (predominantly female) adult forms that generally form schools, and larger individual males. Each of these phases in parrot fish are accompanied by distinct differences in appearance within the same species. Most parrotfish live in harems, with a single dominant male and two to seven females with which they exclusively mate. All species are pelagic spawners that typically release gametes in paired male-female spawning events, which can occur daily at traditional times and locations. Niueans often use different names for these phases.[17]

It is important that the impact (both positive and negative) of the deployment of near shore (lighted) fish aggregating devices (FADS), which are to be funded by IWP, is fully assessed. In particular, a full evaluation of the impacts of providing improved harvesting technology for some fisheries should be assessed in terms of total impact on those resources as well as the impacts on predators and other organisms dependent on these resources. The near shore FADS are expected to improve the efficiency of harvests of *kaolama*, *atule*, and possibly other species.

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[17] The extent to which villagers understand these different fish phases that occur within the same species was not determined by the author during the current consultation.

A2—2 *Alili* (Turban Gastropod Shells, *Turbo and Australium spp.*)

Plate A2-3 *Australium calcar* at Namoui Reef Flat, December 2003.

Plate A2-4 *Australium calcar* at Namoui Reef Flat, December 2003.

A. calcar was relatively uncommon prior to the arrival of Cyclone Heta, and this species is now rare along the west coast.

It is possible that three or four species of turban shells are present on Niue's reefs. At present the most dominant species on the west coast is *Turbo setosus* (the silvermouth turban). Individuals of *Australium calcar* are less commonly observed on the west coast. Other locally common species (especially *Turbo petholatus*) have been observed elsewhere, particularly on the east coast. A few individual specimens of *Turbo crysostomus* were also observed on the west coast prior to Cyclone Heta in January 2004 but not since that event.

Plate A2–5 ***Turbo setosus*** **(Alofi Wharf reef flat)**

Plate A2–6 ***Turbo setosus*** **at Alofi Wharf reef flat, December 2003)**

T. setosus are the most abundant species currently present along the west coast; both it and *A. calcar* tend to be found in channels on the reef crest, so are accessible only at very low tides and under relatively calm sea conditions.

Turban shells are herbivorous animals, feeding on small algae (predominantly red turf algae) attached to rocks as well as on detrital plant matter that has broken off and is free floating. The sexes are separate (i.e. individuals are either male or female). Fecundity (numbers of eggs per individual) increases with size; a 2 kg female produces about 7 million eggs. Sexual maturity is reached at 3–4 yrs of age. Eggs are released in gelatinous masses that stick to the substrate. After fertilisation, free swimming larvae develop and hatch from the eggs. The larvae float and swim in the ocean currents (probably for a number of days) before changing form and settling to the reef where they grow into juvenile forms of the adults.

A2—3 *Gege* (Giant clams, *Tridacna maxima*)

Plate A2-7. *Tridacna maxima* on the reef slope off Omahii sea track, December 2003).
Following Cyclone Heta in early January 2004, most of the remaining larger clams were no longer present (along with most of the coral forms shown here), but a few smaller clams remained in depressions in the reef.

Two species of giant clam are found in Niue: *Tridacna maxima* (the most common species) and *Tridacna squamosa* (now reported to be very rare). Clams derive most of their nutrition from a symbiotic association with zooxanthellae algae living in the tissues of the clams (the same species of algae inhabit the cells of coral polyps). The algae require sunlight (for photosynthesis), meaning that clams inhabit shallow (< 20 m deep) water.

In the juvenile stage, giant clams start out as males. At about eight years of age some will mature into females. A few become sequential hermaphrodites, that is, they may function as both males and females each spawning season. During spawning, which takes place within a space of about 20 minutes, some clams start releasing eggs and others release sperm. Fertilization takes place in open water and is followed by a planktonic larval stage. The largest clams can release around 500 million eggs at one time.

After the eggs hatch, the larvae (veligers) must swim, feed and develop through several stages while drifting in the water column. Normally within ten days of being released, the larvae are fully developed and settle on suitable substrate (usually sand or coral rubble) if available. The larvae change into juvenile forms of the adult and begin to produce a shell, attaching themselves by sticky strings called byssal threads.

Growth can be quite rapid, with clams reaching mature size within 5 years. This growth rate will vary according the natural conditions of an area, and is determined by the degree of sunlight available and the water temperature range.

A2—4 *Papahua* (Oyster, *Chama isostoma*)

Plate A2-8 *Papahuaon* the vaioluapo Reef Flat, December 2003). Note the presence of ugako (vermetids tube "worms") among the *papahua*. Both species appear to have the same habitat requirements.

The oyster can be found in moderate densities in some reef flat areas on Niue. They are filter feeders, trapping food in the gill chamber as water is drawn in during respiration. The food is presumably in the form of tiny planktonic animals and possibly plant detritus and other substances of food value.

The sexes of oysters are separate, i.e. individuals are either male or female. Fertilisation occurs externally in the water so the timing of reproduction has to be exact for successful fertilisation. After eggs are fertilised they rapidly develop into planktonic larvae in the egg and hatch to commence a free floating phase (with some ability to swim as well). After an unknown period, the larvae change into juvenile forms of the adult, settle on a suitable location, and lay down a shell with one valve attached to the substrate. Many oyster species show strong aggregation behaviour and tend to choose locations where there are other adult oysters present. This appears to be the case with the *papahua* as well.

A2—5 *Ugako* (Vermetid Polychaete Worm, *Serpulorbis colubrinus*)

Plate A2-9 *Ugako* are widely distributed along the west coast of Niue and can be locally very abundant.

However, concern over a perceived decline in abundance of this species has resulted in communities wanting to improve the availability of this species. *Ugako* are found in very low densities along most of the reef flat habitat in similar locations to the papahua oyster.

The vermetid tube worm can occur in dense aggregations in some areas of the reef flat. They are filter feeding animals, capturing tiny planktonic organisms and plant detritus from the water surrounding them. They do this by filtering water that is drawn in over the gills as part of respiration. They also produce mucous threads that are released into the water, food is trapped on the sticky surface, and then the threads are drawn back into the mouth.

The sexes are separate i.e. individuals are either male or female. Fertilization occurs internally by water borne sperm reaching females with eggs. The eggs are held by the female and either hatch as free swimming larvae or the eggs hatch as fully formed juvenile adult worms. These juvenile forms then move out away from the female and settle nearby and start producing their own worm tube. Little is known of the free swimming larvae characteristics, especially in relation to how long the larval stage is and whether there are a number of different larval forms.

A common belief in Niue is that a greater number of individuals will return to an area if there is regular harvesting. It is difficult to understand a mechanism whereby adult removal will result in more juveniles in a specific area. A number of possible mechanisms could explain this apparent paradox: by reducing the density of adults, more very small juveniles already present in the same area are able to grow due to the reduced competition for food from adults; by breaking open the calcareous tubes and body cavities, brooding juveniles are released; or by reducing spatial densities, there is more available space for new gregarious settlement from elsewhere.

A2—6 *Uo* (Crayfish; *Panulirus versicolor, Panulirus pencillatus, Panulirus longipes*)

Tropical spiny crayfish are nocturnal (active at night) and usually not gregarious. The most commonly occurring crayfish species, *P. pencillatus*, sometimes does occur in a group of both sexes, with females apparently reproducing year-round in the southwest Pacific. Crayfish generally feed on algae at night, when they leave their cryptic hollows and overhangs. Typically there is a long larval stage in their life cycle that lasts for 7 to 8 months, involving 10 substages (in *P. pencillatus*), with females recorded as having as many as 132,000 eggs (in *P. longipes*).

The crayfish larvae float with the currents before changing to a juvenile form of the adult, and settling out of the water column and onto a suitable substrate. If suitable substrate is not present this final metamorphosis stage to the juvenile form can be delayed for a short time, but eventually the larvae will perish. The larval stage is when the highest mortality of individuals occurs. Very high mortality also occurs due to the lack of a suitable substrate being available when the larvae are ready to change to the juvenile form (e.g. if larvae are transported away from isolated islands and reefs).

A2—7 *Tapatapa* (Slipper Lobsters, *Parribacus caledonicus*)

Tapatapa are nocturnal, feeding at night on algae, and are predominantly found in shallow water (to 6 m depth). The slipper lobster hides in crevices during the day (usually on the exposed side of the reef, and in surge channels). The maximum body length is thought to be approximately 18 cm. The eggs are generally very small and numerous, and larvae have a very long planktonic period similar to that of spiny lobsters (i.e. up to 7–8 months)

A2—8 *Limu* and *limu fua* (*Caulerpa cupressoides* and *Caulerpa racemosa*, respectively)

The edible *limu* (*Caulerpa cupressoides*) has found to be persistent in a large reef flat pool at the entrance to Makefu sea track (even following the devastating cyclone conditions at the site). The ecological conditions found in this location are an indicator of the conditions required by the alga for successful growth. The physical features include a relatively deep pool (average depth 0.5 m) which accumulates a layer of sediment, an outer raised crest with good water flow channels to the open ocean and raised portions of the reef flat on each side of the pool, and a large cave with freshwater flows that run into the pool.

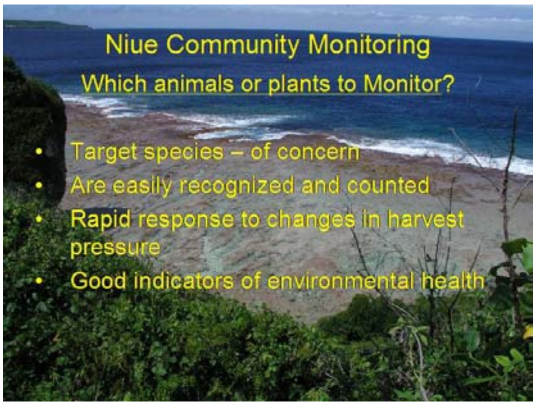
Limu (*Caulerpa cupressoides*) grows in a very similar way to *C. racemosa* (which was not observed on the reef flat): by producing runners (horizontal stolons) with erect branches, and roots (rhizoids) that firmly attach to the substrate, especially in cracks. Intact sections of plants are extremely hard to dislodge as there is a tendency for the upper sections to break off when they are pulled. It is therefore difficult to remove relatively intact long portions of individual plants, a feature that no doubt has contributed to its persistence under both constant harvest pressure and even direct cyclonic wave conditions.

Villagers inquired about the potential of *Caulerpa* spp. to be transplanted to other reef flat locations, such as in established TCAs. The *Caulerpa* spp. attachment mechanism poses the biggest challenge to successful transplantation; the extent to which sufficiently long sections of the algae can be obtained for transplanting may also prove to be a limitation (longer sections of the algae will generally transplant more successfully). Attaching the transplanted sections will be very difficult, due to the strong wave conditions usually experienced on the reef flats.

It was pointed out during village consultations that another *limu* is also sometimes collected (by scraping it off the rocks). This was described as possibly a green turf algae (*Enteromorpha* spp.), called *limu olua* in Niuean.

Appendix 3 Presentation materials used in village consultations

A copy of the PowerPoint slides used in village consultations are outlined below.



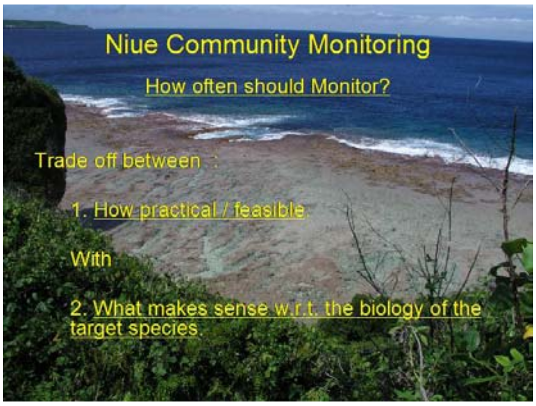
Slide 1

Slide 2

Slide 3

Slide 4

Slide 5



Slide 6

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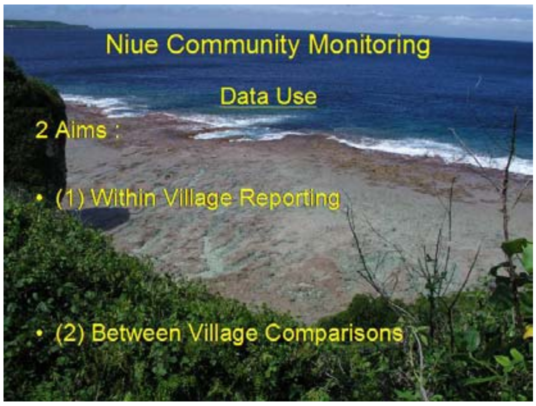
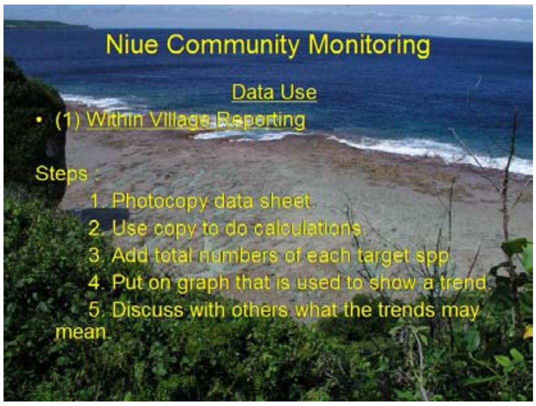


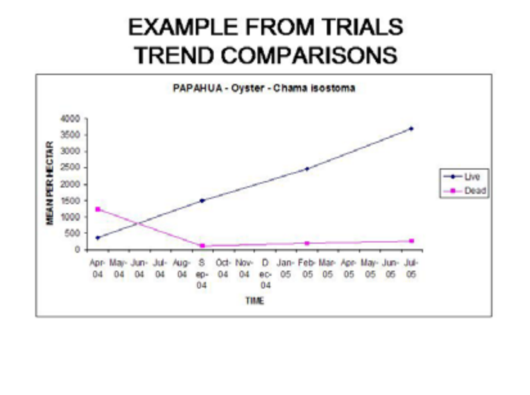
Slide 11



Slide 12

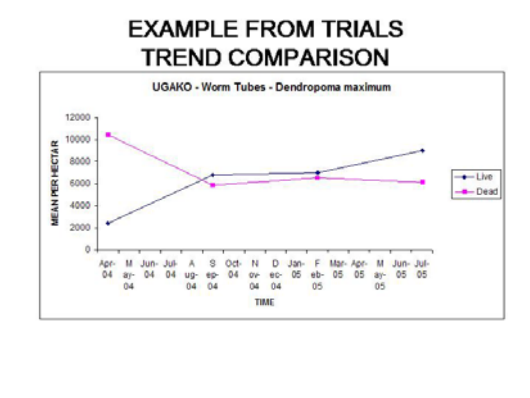
Slide 13

Slide 16

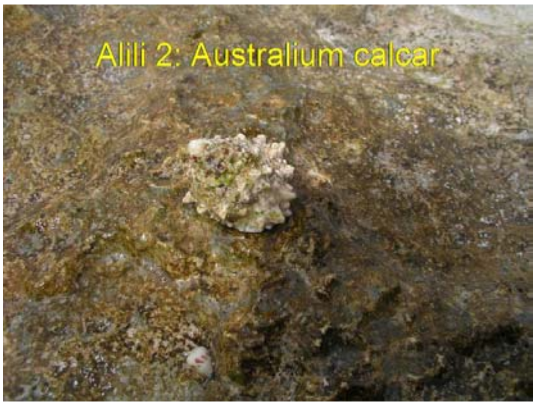


Slide 14

Slide 17



Slide 15



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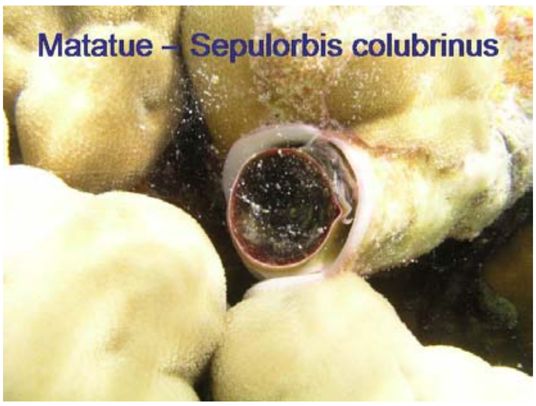

Slide 22

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Slide 24

Slide 25

Note: the photos of common reef flat organisms generated significant discussion by those villagers present, underlying the value of "talking to pictures" and keeping text to a minimum.