Plan for Surveillance and Monitoring of the Marine Protected Areas of Tonga

Seiji Nakaya, DoE/JICA

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1. Introduction

To achieve conservation and wise use of coral reefs of Tonga, it is critical to manage MPAs effectively. Since their establishment, the MPAs in Tonga have not been appropriately managed. There has not been organized system for surveillance and monitoring, which is a core part of management of the MPAs. A qualitative survey has been conducted once, but quantitative surveys have yet to be done. It is also critical to understand trends and spatial variations in various parameters on coral reefs. Regular and frequent visits to the reserve areas are necessary to enforce the regulations and appeal the conservation activities of the responsible agency to the public.

2. Objectives

The objective of this plan is to provide guidelines to conduct surveillance and survey/monitoring program for a better management of the MPAs. This will help achieve conservation and wise use of coral reefs of Tonga.

3. Agency in charge

The Department of Environment (DoE) is responsible for day-to-day management, surveillance and monitoring, of the MPAs, under control of the Parks and Reserves Authority. DoE reports to the Authority.

4. System

For surveillance/enforcement, a team should be formed to work under the marine conservation officer of DoE (Table 1)[1]. Basically, one randomly-selected day of every week is spent for surveillance of one or more MPA.

Survey and monitoring will be conducted using 3 different methods – the manta-tow, spot check and Reef Check methods – that compliment each other.

As manpower of DoE is limited, to economize the effort, surveillance/enforcement and survey/monitoring will be combined. The spot check is done during surveillance whenever

[1] In the future, depending on the results of public consultation, some person who the Authority deems is appropriate and who is interested in management, such as resort operators, will be appointed by the Authority to conduct daily patrol (Parks and Reserves Act 1976, Section 5(c)). For example, for Pangaimotu Reef Reserve and Ha'atafu Beach Reserve, the resort managers will be involved and assist in periodical observation of the reserve.

possible at as many sites as possible. On the other hand, manta-tow and Reef Check will be conducted, maybe during a designated period (maybe May is the most stable month), in accordance with carefully made plan.

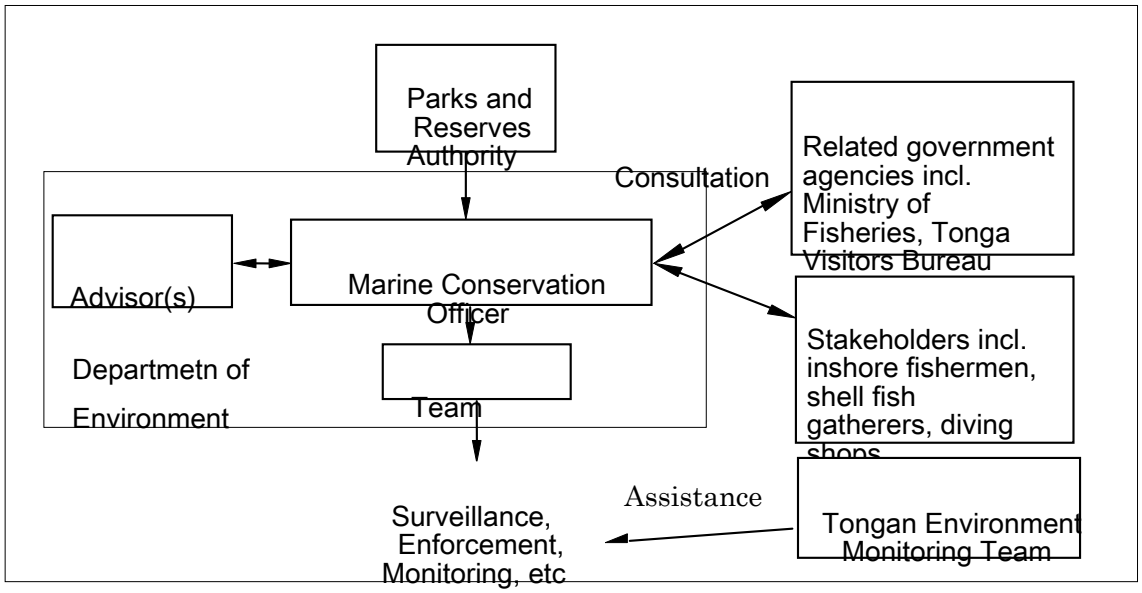


Figure 1. Diagram showing the management of the MPAs.

Table 1. The composition of the Team*

Members for Surveillance	Remarks	SCUBA diving
'Asipeli Palaki	Marine conservation officer	OK
Tukia		
Min. Lands personnel**		
Seiji Nakaya		OK
Fine Lao	After January 2003	
Daniela	Only when free from Climate Change Project	

*: Peter, Dee may join the monitoring

**: 'Asipeli's suggestion; Availability to be confirmed

5. Surveillance/enforcement

Though the rangers will work as an educator rather than a police, they should be given the right to pursuit, apprehension, identification, gathering of evidence, confiscation of equipment and evidence and laying charges in courts of law[2]. The members of the team should wear uniform, badges, cap, emblems or any kinds of markers which distinguish them authorized

[2] Is this realistic? Think why nobody who breaches fishing regulations was prosecuted in 2000 (Min. Fisheries Annual Report).

by the Authority[3].

The tasks of the team include:

- to enforce the rule prohibiting fishing, collection or any disturbance of the reserve area (make the fishers leave to MPAs, ask where to live and names, take photos of boats),
- to clean up the beach (Ha'atafu Beach and if necessary Manuafe and Malinoa Island), and
- to conduct a quick survey/monitoring (mainly spot check).

6. Scheduling

At the end of the month, schedule of the next month will be produced. Ideally, the day of the surveillance made is to be selected randomly in order that people do not expect specific day for surveillance[4].

- Randomly select Day 1 and Day 2 (Day 1 precedes Day 2), among weekdays, for each week.
- On Day 1 of the first week, a trip to the MPA of the highest priority (Hakaumama'u) will be made, weather permitting. If the weather is not suitable, other MPAs (Malinoa, Monuafe, Pangaimotu or Ha'atafu) will be visited, with priority this order (see Table below).
- After visiting all the 5 MPAs, go back to Hakaumama'u.
- If a trip can't be made on Day 1 for any reason, such as bad weather, the trip will be cancelled and will be made on Day 2, instead.

Priority (site hard to visit has high priority)	
1	Hakaumama'u
2	Malinoa
3	Monuafe
4	Pangaimotu
5	Ha'atafu

According to this plan, in total 52 trips (1 trip/week) will be made. The calendar below is an imaginary case of July 2002. If a trip is made on Saturday, those who participated may take one day off in the next week. To make a two day/week plan, just randomly select 3 days in each week and use the same procedure is the same as above.

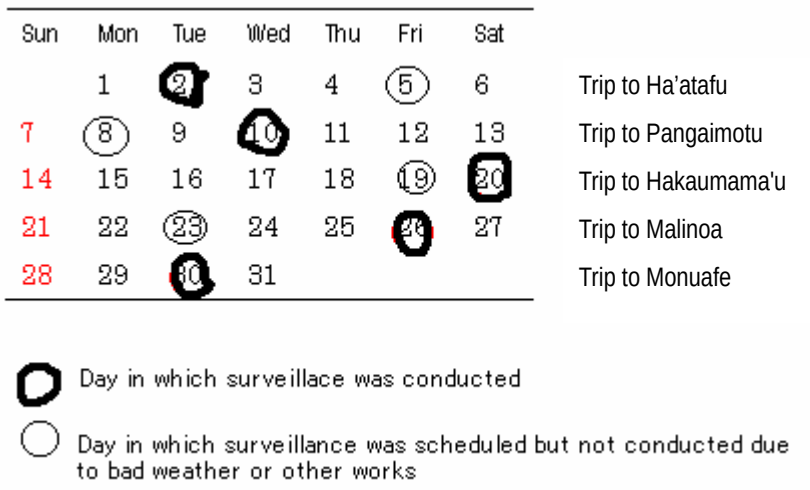
The FRP boast with 40HP motor will be used for the reefs except to Ha'atafu Beach, to which the team go to the site by car. The team should carry radio transceiver and an EPIRB for

[3] At the beginning, a cap may be good.
[4] If random selection of dates are inconvenient, it may be OK for fixed dates at the beginning. But if dates are fixed (eg., on every Friday), does surveillance make sense?

the safety. At least two persons are needed for surveillance and more people needed if reef monitoring/survey (spot check) is included. For spot check, see the below. A rapid ecological assessment (eg. Maragos & Cook 1995) could be conducted during the surveillance anytime of the year.

Imaginary case of July 200x

Circled days were randomly selected and trips were made in those with red lines.



7. Monitoring/survey

Monitoring of coral reefs should be done annually to update the status of the reefs and to clarify the effectiveness of the management means. Not only MPAs but also adjacent areas should be monitored for comparison. At the first year, baseline data are collected by using the same procedures. After obtaining baseline survey, the survey sites will be periodically (once a year) resurveyed. For technical certainty, a researcher(s) will be sought for assisting for the marine conservation officer to conduct periodical survey.

The core variables/parameters to be measured are basic and include live hard coral cover, dead hard coral cover, live soft coral cover, life form of dominant coral species, presence and/or density of coral-eating organisms such as crown-of-thorn starfish and *Drupella*. Information on size distribution of live hard corals may provide useful insight for the future change in coral assemblages (Birkeland 1999)[5]. Presence and extend of bleaching and other damages (such as those due to sedimentation and anchoring) should also be recorded.

Manta tow survey and/or spot check will be conducted at all the MPAs and adjacent areas (Table 1). On the other hand, Reef Check methods will be also used for monitoring several

[5] For obtaining data on size distribution, the point-quarter method (Birkeland & Lucas 1991) may be useful. This method may be incorporated in future.

sites with assistance from private industries such as diving shops and aquarium fish collectors as well as other government agencies, including the Ministry of Fisheries[6].

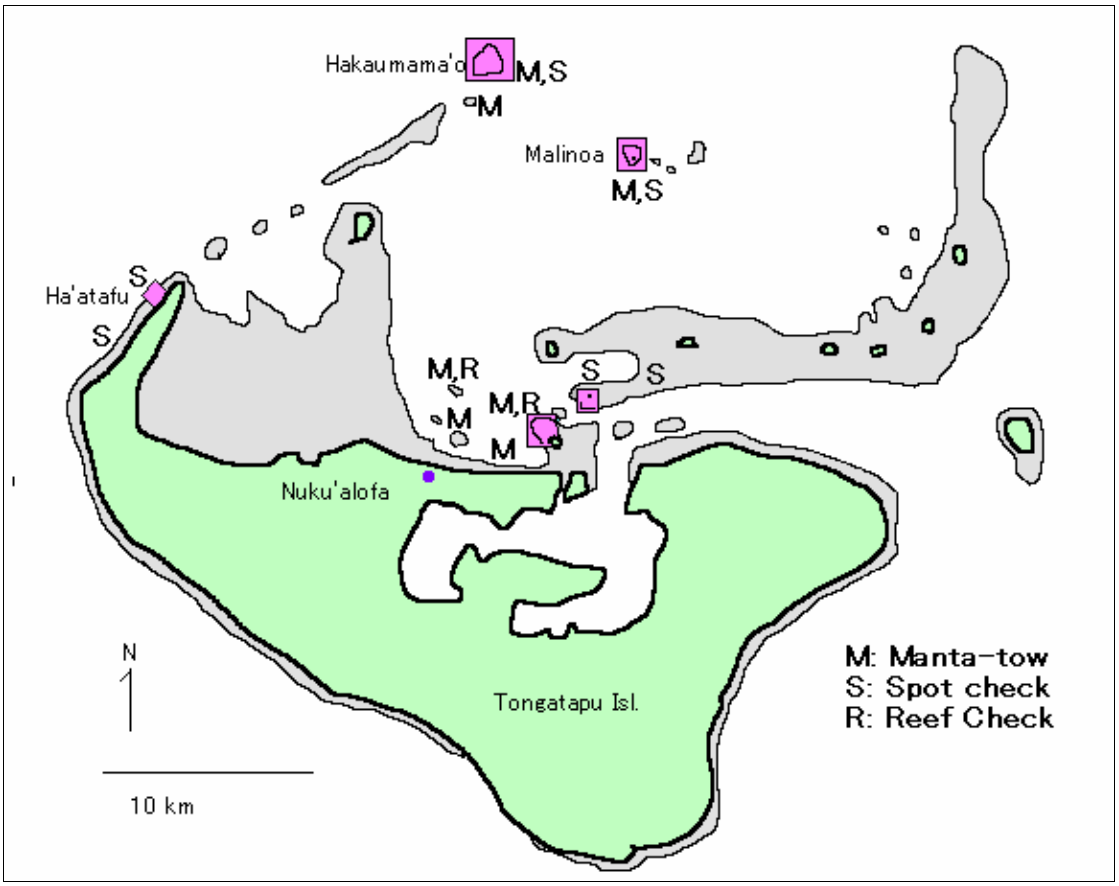
Table 1. Monitoring methods for each of the MPAs

Type of reefs	Reefs	Manta-tow	Spot check**	Reef Check	Remarks
MPAs	Hakaumama'o reef	○	○*		
	Malinoa reef	○	○*		
	Monuafe reef		○		
	Pangaimotu reef	○		○	
	Ha'atafu reef		○		
Non-MPAs	Reefs in front of Vuna road	○			
	Mounu reef	○			Control for Pangaimotu
	Ualanga Lalo reef	○		○	Control for Pangaimotu
	Hakau Manu reef	○			Control for Hakaumama'u
	South Ha'atafu		○		Control for Ha'atafu
	East Monuafe		○		Control for Monuafe

*: supplementary method for reef flat

**: Spot check will be done as often as possible to increase knowledge on haphazard bases, but locations should be recorded by GPS.

[6] Tonga National Monitoring Team may be incorporated to help the reef surveys.



At the beginning, data will be gathered from as many sites as possible to obtain general view of coral reefs; more detailed information such as species diversity will be addressed in due course. In the future, expansion of monitoring may be considered in two ways: spatial expansion and disciplinary expansion. The monitoring of seagrass beds and mangrove areas will also be planed and implemented to coral reef monitoring. Above all, conservation areas suggested in the Environmental Management Plan for Fanga'uta Lagoon System (Department of Environment 2001) should be related to the coral reef monitoring. Besides monitoring natural aspects of coral reefs, some social parameters should also be measured in the future. These include the use pattern of coral reefs by people, values people place on coral reefs, attitudes towards conservation of coral reef ecosystems and behavior of people who use coral reefs as resources (Bunce et al. 2001). The methods applicable to Tongan context are being prepared.

8. Monitoring methods

(1) Spot check method:

On the reef flat and in lagoon, snorkelling survey method will be used when appricable. About 5 points for observatio are selected randomly from the area of interest. Coordinates of the points were recorded by using a GPS. At the point, underwater photos are taken in all directions. Two or more divers snorkel in a direction on haphazard bases for a determined duration of 10 to 15 minutes, within a determined area (an imaginary circle with a diameter of 6 60m) and estimate a small number of basic parameters, such as (Nomura et al. 2001; Appendix 1):

- live hard coral cover on attachable substrate to the nearest multiple of 5%,
- dead hard coral cover on attachable substrate to the nearest multiple of 5%,
- soft coral cover on attachable substrate to the nearest multiple of 5%,
- type and % cover of substrata on which corals are not settled (such as “sand” and “rubble”) to the nearest multiple of 5%,
- diameter of the largest plate-like *Acropora* colony observed,
- mean coral colony size (optional),
- dominant type of coral colonies[7],
- sedimentation (Rank: 0, none; 1, little; 3, some; 4, a lot),
- the number of Crown-of-Thorns starfish observed,
- depth range, and
- other notable findings.

Mean and SE will be calculated for comparison among areas and among different times.

(2) Manta-tow method:

This method has been used to assess a large scale disturbance, such as coral bleaching and outbreaks of crown-of-thorns starfish, *Acanthaster planci* (COTS), in a large area, such as entire reef, within a comparatively short time (English 1997). The survey is conducted by a group: an observer, a boat operator and a recorder. The latter 2 people ride on a small boat towing the observer in the water by a rope (Fig. 1). Procedures will follow English (p. 14-p. 33; 1997).

- After arriving at the reef, record basic information on the boat and fill the data sheet (Appendix 2).
- Set up the gear (Fig. 1).
- Get the Point 0.
- Measure the horizontal visibility.

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[7] ① Branching Acropora, ② Plate & Corymbose Acropora, ③ Mixture of ① and ②, ④ Specific type, ⑤ Various types without dominant types, ⑥ Softcoral.

- Mark the point on the map as “0”; record the direction of the tows.
- Write down the record number of the coordinates of GPS (To go back to the same point for the next survey, these coordinates will be used.)
- Start the 1st tow.
- Tow for 2 minutes slowly (walking speed), stop for about 10 seconds.
- While the boat is standstill, the observer records the data (coverage of live hard coral, dead hard coral and soft coral in categories, the number and average size of *Acanthaster,* as well as other remarks.
- Driver marks “1” on the map; write the record number of the coordinates on GPS.

⑪ Start for the second tow. Tow to the point 2.

- At point 2, driver clearly conveys the number of tow (no. 2) to the observer by gesture or plate on which the number is written.
- Continue until completion.

Communication between the diver and boat driver/recorder is done by gesture such as “OK”, “Stop”, “Go to Right/Left”, “Slow down”, “Speed up”, “Come back” and “Help”.

Manta towing at reef edges of Hakaumama’u reef, Pangaimotu reef, Monuafe reef, Ha’atafu and Malinoa (only if weather conditions are suitable). The DoE zodiac will be used for this method. However, for the safety, a pair of 2 boats will work on remote reefs.

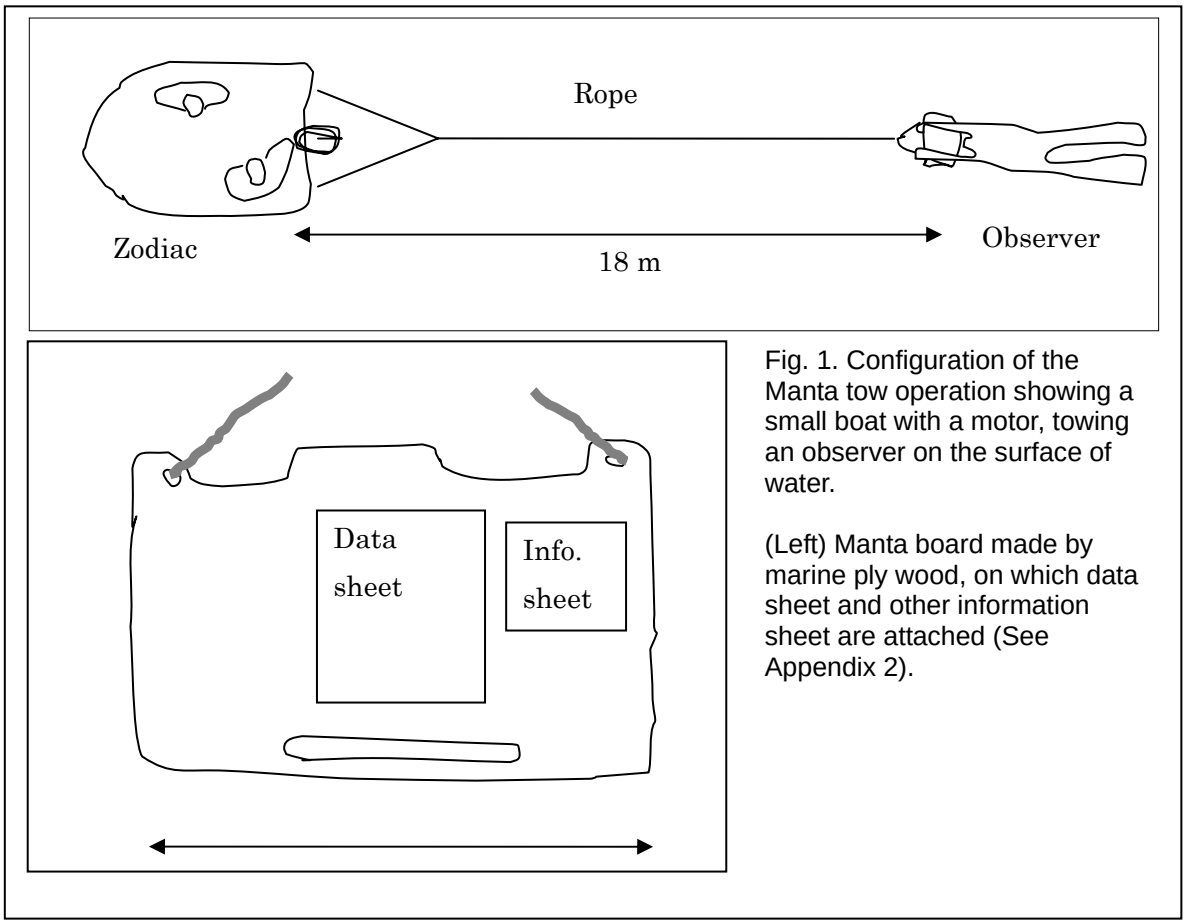


Fig. 1. Configuration of the Manta tow operation showing a small boat with a motor, towing an observer on the surface of water.

(Left) Manta board made by marine ply wood, on which data sheet and other information sheet are attached (See Appendix 2).

(3) Reef Check method:

Reef Check is a standardized monitoring methods used in over 50 countries and incorporated in Global Coral Reef Monitoring Network. For a limited number of reefs, both MPAs and non-MPAs, a Reef Check method is used. Whenever possible, participants from diving shops (guides and customers), other government agencies, especially the Ministry of Fisheries, will be encouraged. Basically Reef Check consists of the belt transect (5m wide x 20m long x 4 replicates x 2 depths (3m and 10m)) for benthic invertebrates and fishes of a small number of indicator species, and the line intercept methods (every 0.5 m using the same line above). See more detail at www site: http://www.reefcheck.org/reefcheck.htm (Appendix 3). The appropriate season will be determined by weather conditions and availability of divers on voluntary bases. The best season for survey may also be the best season for tourism diving, so it may be difficult to expect collaboration from diving shops.

9. Resources

To improve management of the MPAs to comply with the provisions of the Act and to overcome the current "paper parks" status, sufficient resources need to be provided. These include staff, equipment and facilities, training of the staff, budget for surveillance, enforcement, monitoring, restoration and environment education.

The budget includes petrol for vehicle and boats, labor cost including driver, diving gear rental, maintenance of equipment, stationery, printing, expense for meetings, maintenance of sign board and boundary. The table below shows a budget estimate for the first year (2002/2003)[8]. Budget for the following years will be revised based on the processes of public consultations and revision of the management plan.

Items	Amount (Tonga $/year)
Staff (ranger(s))	To be provided by MLSNR
Advisor(s)	Outer foundation
Maintenance of boat and equipment	2,000*
Uniforms or alike	1,000**
Fuel/transport	2,500*
Communications	500*
Public consultation	500*
Total	6,500

* DoE

[8] Budget is said to have been frozen (no increase) in FY 2001/2002 and 2002/2003.

** can be sought from outer foundation;

10. References

Birkeland, C. 1999, Emphasis on colony size distributions in coral-reef surveys, In. Maragos, J. E. and R. Grober-Dunsmore eds, *Proceedings of the Hawai'I coral reef monitoring workshop, June 9-11, 1998, Honolulu*, Hawai'I, East-West Center.

Birkeland, C. and J. S. Lucas 1990, *Acanthaster planci*: major management problem of coral reefs, CRC Press.

Department of Environment 2001, Environmental management plan for Fanga'uta Lagoon System, Part 1, Plan.

English. S, C. Wilkinson and V. Baker (eds.) 1997, Survey manual for tropical marine resources (2nd edition), AIMS.

Nomura, K., T. Kimura, H. Kawagoe, The introduction of the spot check method as a simple monitoring method of large coral reef area, and that practical example in the Sekisei Lagoon, Southern Ryukyus, Marine Parks Journal, 131: 5-11 (in Japanese).

Appendix 1. Data sheet for Spot check method

Snorkel survey data sheet

Reef Name: _____

Date: _____

Diver: _____

Time start: _____ ; Time end: _____

Point #	Live hard coral %	Dead H C %	Soft Coral %	Dominant coral type	No. COTs, Size (cm)	Type of substratum with no corals (%)	Sediment (0, none – 4, a lot)	Largest Plate Acropora size (cm)	Depth range (Xm–Ym)	Other remarks	Photo taken	GPS Site No.
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												

Appendix 2. Preparation for Manta-tow method

(1) Record sheet for observer

Diver's Sheet for Manta Tow Survey

Reef Name: _____

Date: _____ Time start: _____ Time end: _____

Current: Strong……..None; Direction _____

Recorded by: _____ (Boat Driver: _____)

	Coral Coverage					
Map No.	**Live Coral**	**Dead Coral**	**Soft Coral**	**COTs (cm)**	**VIZ (m)**	Notes (Bleaching)
0						
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						

(2) Data sheet for recorder on boat

Map or Aerial Photo

Manta Tow Survey; Reef Name: _____

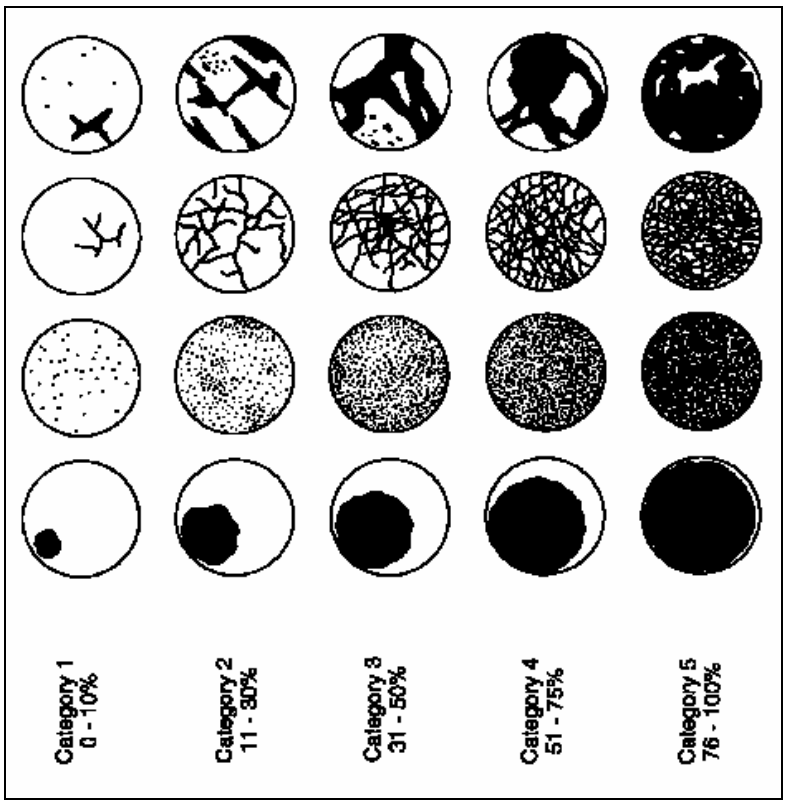
Date:_____ Time start:_____ Time end: _____

Wind:_____meters (Direction_____); Cloud: 0.....8/8

Recorded by:_____(Diver:_____)

Map No.	GPS No.	Coordinates	Remarks	Map No.	GPS No.	Coordinates	Remarks
0				18			
1				19			
2				20			
3				21			
4				22			
5				23			
6				24			
7				25			
8				26			
9				27			
10				28			
11				29			
12				30			
13				31			
14				32			
15				33			
16				34			
17				35			
18							

(3) Information sheet to be attached to the manta board for observer



Appendix 3. Reef Check Methods

The Reef Check surveys can be carried out anytime, however, for inclusion in our annual report, data should be submitted by 30 December. All teams should submit data using the data submission forms by 30 December 2001 to Reef Check Headquarters.

Each group can do whatever additional sampling they like. Reef Check Headquarters will include valid Core results from all properly registered Reef Check groups in our analyses and annual global reef health report, but we do not plan to report extra results unless they are extremely important. Click here for more information on long term monitoring.

Important!
Please submit data within 10 days of field work completion.

DON'T wait until the last minute to submit data, as this creates a traffic jam and increases the chances of your data not being included in the annual press conference and report.

Site Selection

Site selection is a critical factor in the success of Reef Check. One goal of Reef Check is to test the null hypothesis that there are reefs that are not affected significantly by human impacts. In addition, we would like information on the geographic distribution of human impacts of various types on all reefs. For this reason, Reef Check teams that can only survey one site should survey the "best" site they have access to in terms of least likely to have been affected by human impacts, fishing, pollution etc. with high living hard coral cover and dense fish and mobile invertebrate populations.

For groups willing and able to survey multiple sites, we suggest choosing 2 or more additional sites representative of moderate and heavy human impacts. In this manner, we will build up

a picture of the distribution of human impacts on a cross section of reefs.

To standardize Reef Check, we will not be accepting surveys of steep wall reefs (drop-offs), reefs predominantly located in caves or underhangs. We would prefer moderately to fully exposed reefs with a reef crest and outer slope. The transects can then be placed seaward of the reef crest on the outer slope.

It is very important to describe the site and its position in relation to obvious human influences on the Site Description sheet.

Basic Design

The goal is to survey two depth contours, 3 m and 10 m below chart datum (lowest low water). However, on many reefs, the highest coral cover will not be found at these exact depths. Therefore, choose the depth contour with the highest coral cover within the following ranges:

- Shallow (2-6m depth)
- Mid-reef (>6-12m depth).

Note that particularly for the shallow transect, the tide should be taken into account. Along each contour, four 20m-long line transects will be deployed and surveyed. The transects should follow the designated depth contour one after the other, however, transect start and end points should be separated by a 5m space. The distance between the start of the first transect and end of the last transect will be 20 + 5 + 20 + 5 + 20 + 5 + 20 = 95m. The depth contours were chosen for practical reasons of time and safety.

Reefs in many areas are not suitable for survey at both depths. In this case, just survey one depth contour. At some reefs, it may be necessary to lay transects perpendicular to the reef face, i.e. following spurs or ridges. We recommend use of a single 100m fiberglass measuring tape available from hardware and survey equipment supply stores. In locations where reefs are broken into patches with large areas of sand/rock in between, it may be necessary to separate the transect into 20 m segments. A second tape may be useful for measuring distance from shore and for use if the first breaks.

Four types of data will be recorded. The three transect surveys will be made along the same transect line.

1. **Site description**. Anecdotal, observational, historical, locational and other data should be recorded on the Site Description sheet. These data will be important when we attempt to interpret global trends in the dataset.
2. **Fish belt transect.** Four 5m-wide (centered on the transect line) by 20m-long transects will be sampled for fish species typically targeted by spearfishermen, aquarium collectors and others. The fish transect should be carried out first.
3. **Invertebrate belt transect.** Same four 5m-wide (centered on the transect line) by 20m-long transects as above will be sampled for invertebrate species typically targeted as food species or collected as curios.
4. **Substrate line transect.** Same four 20m-long line transects, but this time, point sampled at 0.5m intervals to determine the substrate types on the reef.

Note: Reef Check Core Method protocol may be repeated individually, or as a set, as often as needed. See Monitoring for Management.

Pre-dive Preparation

The training needed for each team will depend on the experience and knowledge level. We recommend a half-day training on land prior to the dive day, so that the training can be absorbed and there is sufficient time for questions and discussion. This can be supplemented with a brief review on the dive day and shallow water training using snorkeling only. Few people can concentrate if training is attempted on board a rocking boat.

The Team Scientist (TS) is responsible for making a presentation that includes:

1. An explanation of the dual PR/science purpose of Reef Check.
2. A review of the sampling design and rationale of the indicator organisms.
3. Field identification training for all organisms and Reef Check definitions for substrata.
4. An introduction to the data recording format, and preparation of slates.
5. An explanation of the difference between work diving and pleasure diving and how to avoid smashing reef corals by proper buoyancy control.

6. Explanation of the post-dive data entry, checking and submission procedures.

The Team Leader (TL) is responsible for safety training and will need to assess the abilities of his or her team so that appropriate work assignments can be made.

There are three field data sheets (pro-forma) for the core protocols; the Site Description sheet, the Line Transect Sheet and a Belt Transect Sheet.

The Belt Transect Sheets are divided into a section for invertebrates and a section for fish.

Teams may use either underwater paper or a plastic writing slate. If you use the latter, the TS should keep a photocopy of each full slate for the records.

Ensure that you have sufficient slates or paper, either pre-printed or filled out manually. For slate users, the Line Transect and Belt Transect format can fit on the front and back of one slate respectively.

Familiarize yourself with the organisms and categories on the species identification chart. Photos can be printed in color and either laminated or placed inside a plastic "zip-lock" bag and then carried underwater for reference. Fill in as much site info as possible before getting into the water.

There are many acceptable ways to divide up the work load depending on the skills of the team members and team size. Some team members will feel more comfortable recording fish and others invertebrates. Others will just want to watch and serve as buddies. Because each team will be different, the data collection strategy will need to be adjusted to match each team's members.

The best quality data will be obtained by allowing the experienced Team Leaders to assign tasks appropriate for the team members. In case of a disagreement, Team Leaders will have the final say in deciding who should do what, and for ensuring that every team member understands their assignment and is capable of carrying it out properly. If there is some question about the reliability of data from a site, we will not include the site in our global report.

Before you jump in the water:

1. Record your location on a chart by hand or by GPS.
2. Record the name of the TL/TS on data sheets.
3. Start to fill in Site Description sheet.

Safety of divers should be a priority. No Reef Check surveys should be undertaken when weather or sea conditions are unsafe or if a diver does not feel well. In particular, teams should plan work to avoid decompression dives during Reef Check.

During the Dive

One buddy pair should lay out a 100m transect line (or four 20m transects separated by 5m breaks) along the specified contour (2-6m or >6-12m). Estimated time to deploy the transect is 30 minutes. After deployment, the entire length of the transect should be examined to ensure it is not snagged or floating too high off the bottom. Small marker floats should be attached to the start and end points and (optional) permanent stakes can be installed so that the site can be located next year.

A GPS reading should be obtained from the float at one end, and the compass bearing to the end marker buoy recorded (only those teams with precision navigation systems such as differential GPS need record the coordinates of both ends). Line-ups with landmarks should also be recorded in case the GPS has given false readings. Teams without a GPS should obtain the most detailed chart of the area available and record the coordinates of the location of the transect. We cannot use your data unless you record the location!

Fish Belt Transect Instructions

The fish belt transect should be the first work done after the transect is deployed. Try to begin the fish transect at about 9 to 10:00 am. Work can be started after a 15 minute period during which no divers disturb the area. Estimated time to completion is 1 hour. The maximum height above the transect to record fish is restricted to 5m. Data should be recorded on a slate using the Belt Transect Sheet format.

Each diver assigned to count fish will swim slowly along the transect and stop to count target fish every 5m. He will then wait 3 minutes for target fish to come out of hiding, before proceeding to the next stop point. This is a combination timed and area restriction survey,

4 sections x 20m long x 5m wide = 400m ². There are four 5m gaps where no data are collected. At each depth contour, there are sixteen "stop-and-count" points, and the goal is to complete the entire 400m ² belt transect in 1 hour.

Indicator fish

The indicator fish have been selected because they are typically shot out of reefs by spearfishing, removed as targets of cyanide fishing, and caught using hand-lines. Size minimums have been placed on some species to reduce the burden of recording many small fish. Given these limits and the magnifying effect of the water, divers should practice estimating sizes before attempting the fish surveys.

A measured 2.5m colored wire or rod can be used to help estimate the 5m belt transect width, and 20 or 30 cm sticks (hand-held or floating tethered to a small weight) can be used to estimate fish length.

We recommend that one diver record fish on one side of the line followed by the other side. By moving from side to side, the diver records 2.5m belts one at a time. If both divers are proficient at fish identification, we suggest that Diver 1 records the first and third 20m segments, while Diver 2 does the second and fourth 20m segments.

Care is needed to carefully label slates. We suggest tallying the fish on the slate using a vertical tick mark for each fish observed and after each four fish, drawing a horizontal line through the four, thus creating easily counted groups of five next to the correct name and under the appropriate column. It is crucial to remember to keep the counts for each of the four segments of the transect separate. For all grouper, a size estimate should be given of each fish.

All of the organisms to be counted within these fish belt transects are listed below and identification photos can be seen on the species identification page.

Indo-Pacific

- Grouper/coral trout over 30 cm (any species)
- Barramundi cod - *Cromileptes altivelis*
- Sweetlips - Haemulidae - *Plectorhincus* spp.
- Humphead (Napolean) wrasse - *Cheilinus undulatus*
- Bumphead parrotfish - *Bolbometopon muricatum*
- Parrotfish over 20 cm
- Butterfly fish (any species)
- Snapper - *Lutjanidae*
- Moray Eel

(Note: off-transect records of the two distinctive species of wrasse and the parrotfish will be accepted as these species roam near reefs at this size rather than strictly resident species).

A note should be made of any sightings of what are now becoming rarer animals such as large manta rays, sharks and turtles, but if these are off-transect records, they should be written at the bottom of the slate under "Comments".

Site Description Form Instructions

During the fish transect work, the other team members should be gathering descriptive site data and one should be responsible for filling out the Site Description form. Only one form is filled out per site. Some larger teams may desire to begin a second Reef Check survey while the first one is underway.

In 1998, some very large individual colonies of Porites were killed. Because it is fairly easy to measure the age of corals, these colonies are good "canaries" i.e. if they die, it may be an indication of an unusually severe stress. As large Porites are globally distributed, they make good indicators. We would like to ask all teams to make an attempt to identify and mark the location of up to five very large Porites colonies (3m or larger) at their sites. We recommend a measurement be made of the longest diameter, the diameter to the first, and the colony height. If it possible to mark the colonies permanently, this could be helpful. If future severe events, e.g. more heating, occur that damage or kill these large historical recorders, the data will be very useful to assess the geographic range and severity of the events.

Please record the data in the comments section of your Site Description form -- feel free to increase the size of this "cell" in the spreadsheet.

Invertebrate Belt Transect Instructions

When the fish belt transect is complete, Divers 3 and 4 could then carry out the belt transect survey for invertebrates. Estimated time to

complete this work is 1 hour. If both divers want to record data, they can alternate 20m segments as above or each do a 2.5m wide strip. To avoid confusion later, it is imperative that divers carefully mark their sheets with location and diver names.

Each belt transect is 5m wide with 2.5 m on either side of the transect line. The reason for choosing the relatively narrow belts is that visibility in many parts of the world is low, therefore it is necessary to restrict them for comparability. Total survey area will be 20m x 5m = 100m2 for each transect, for a grand total of 400m2 for each depth contour, the same as the fish belt transect.

All of the items and organisms to be counted within the invertebrate belt transects are listed below and photographs are shown on the species identification page. It is the responsibility of each team leader to ensure that his/her team is sufficiently prepared to identify these animals before work begins. Special attention should be given to identification tips for sea cucumbers given with the photos.

All sites

- Banded coral shrimp - *Stenopus hispidus*
- Long-spined black sea urchins - *Diadema* spp.
- Lobster (all edible species)
- Trash (describe type and size)
- Recently broken coral (anchor, blast, divers) - estimate area

- Giant clams - *Tridacna* (give size/species)
- Pencil urchin - *Heterocentrotus mammilatus*
- Edible sea cucumbers, holothurians
- Crown of thorns starfish - *Acanthaster planci*
- Triton shell - *Charonia tritonis*

In addition, each group should note the presence of coral bleaching or unusual conditions (eg. that might be diseases) along the transects.

At the base of the Belt Transect Sheet, there is a place to record comments. In particular, if bleaching, suspected diseases or *Acanthaster* predation are observed, it will be useful to record the percentage of the population that is affected, and for affected colonies, the mean percentage of each colony that shows some diseased area. For the belt transects, team members should be encouraged to look in holes and under overhangs to detect organisms, such as lobster, that may be hiding.

Line Transect Instructions

When the invertebrate belt transect is almost completed, the next designated buddy pair can begin point sampling on the line transect. The estimated time to complete this work is 1 hour.

The method chosen for Reef Check sampling of substrata is "point sampling." Point sampling was chosen because it is the least ambiguous and fastest method of survey and is easily learned by recreational divers. In use, the diver can simply look at a series of points where the transect tape touches the reef and note down what lies under those points. In cases where the tape is hanging above the substratum, it is useful to carry a 5mm diameter nut or other metal object tied onto a 2 m long cotton or nylon string for use as a plumb-line. The object is dropped at each designated point and it touches only one substrate type which can be recorded.

For Reef Check, substrate type will be recorded at 0.5m intervals along the line, i.e. at: 0.0m, 0.5m, 1.0m, 1.5m etc. up to 19.5m (40 data points/20m transect segment). This procedure will be repeated for the remaining three transect segments at 3m and the remaining four at 10m depth.

The Line Transect pro-forma has a space for each point sample result, 1-40 for the first 19.5m segment etc. Input the above abbreviations for the substrate types.

As above, Diver 1 could record the substrate types for the first and third 20m segments of the line transect, and Diver 2 could do the second and fourth 20m segments.

Substratum Categories

Abbreviation	Term	Reef Check Definition Note that these are practical definitions not technical
HC	Hard coral	Include fire coral (*Millepora*), blue coral (*Heliopora*)and organ pipe coral (*Tubipora*) because these are reef builders.
SC	Soft coral	Include zoanthids, but not gorgonians or sea anemones (the latter two go into "Other").
RKC	Recently killed coral	The aim is to record coral that has died within the past year. The coral may be standing or broken into pieces, but appears fresh, white with corallite structures still recognizable, only partially overgrown by encrusting algae etc.
FS	Fleshy seaweed	The aim is to record blooms of fleshy algae that may be responding to high levels of nutrient input. Therefore do not include coralline algae in this category. When algae such as *Sargassum* that are a normal part of a healthy reef are present, please note the species in the comments section.
SP	Sponge	All sponges (but no tunicates) are included; the aim is to detect sponge blooms that cover large areas of reef.
RC	Rock	Any hard substratum whether it is covered in e.g. turf or encrusting coralline algae, barnacles, oysters etc. should be placed in this category. Rock will also include dead coral that is more than about 1 year old, i.e. is worn down so that few corallite structures are visible, and covered with a thick layer of encrusting organisms and/or algae.
RB	Rubble	Includes rocks (often laying over sand) between 0.5 and 15cm diameter. If it is larger than 15cm it is rock, smaller than 0.5cm and it is sand.
SD	Sand	In the water, it is sand if it falls quickly to the bottom.
SI	Silt/clay	Sediment that remains in suspension if disturbed.
OT	Other	Any other sessile organism including sea anemones, tunicates, gorgonians or non-living substrata.

Post Dive Tasks

The Team Leader (TL)/Team Scientist (TS) are responsible for gathering the slates and data together as soon as the survey is completed and reviewing it immediately with the team members. The purpose is to make a quick assessment of the data to determine if some error has been made that can be corrected while the team is still on site, and the transect is in place. Typical errors that could be corrected would be "double-counting" of fish, mis-identification of organisms or mis-labelling the slate. When an error is suspected, a re-survey should be made to check or to correct it.

Before departing from the site, the TL/TS are responsible for ensuring that *all* required data has been collected, and that the slates have been filled out properly, in particular with each individual's work identified. This will allow the TL/TS to check with the responsible party if an error is detected later.

Data sheet for general description of the survey site

Site name				
Date				
Time of day that work started				
Time of day that work ended				
Longitude of transect start point				
Latitude of transect start point				
From chart or by GPS? (If GPS, indicate units)	chart_____	GPS_____		
Orientation of transect	N-S___	NE-SW___	E-W___	SE-NW___
Distance from shore	_____ m			
Distance from nearest river	_____ km			
River mouth width	<10m__	11-50m__	51-100m__	101-500m__
Weather	sunny_____	cloudy_____	raining_____	
Air temperature	___ degrees C			
Water temperature at surface	___ degrees C			
Water temperature at 3 m	___ degrees C			
Water temperature at 10 m	___ degrees C			
Distance to nearest population centre	_____ km			
Approximate population size	____x1000 people			
Horizontal visibility in water	_____ m			
Why was this site selected?				
Is this site -	sheltered_____	exposed_____		
Any major coral damaging storms in past years?	yes_____	no_____	unknown_____	
How do you rate this site overall in terms of anthropogenic impact?	none____	low____	moderate____	heavy____
What types of impacts do you believe occur?				
Dynamite fishing	none____	low____	moderate____	heavy____
Poison fishing	none____	low____	moderate____	heavy____
Aquarium fish collection	none____	low____	moderate____	heavy____
Harvest of invertebrates for food	none____	low____	moderate____	heavy____
Harvest of invertebrates for curio sales	none____	low____	moderate____	heavy____
Tourist diving	none____	low____	moderate____	heavy____
Sewage pollution	none____	low____	moderate____	heavy____
Industrial pollution	none____	low____	moderate____	heavy____
Other forms of fishing? (Specify)	none____	low____	moderate____	heavy____
Other impacts? (Specify)	none____	low____	moderate____	heavy____
Is there any form of protection (statutory or other) at this site?	yes_____	no_____		
If yes, what type of protection?				
Other comments				
Submitted by (enter TL/TS and your name)				

Data sheet for fishes and invertebrates

REEF CHECK 2001- Please fill in all Black outlined boxes							
Site Name:							
Depth:			Team Leader:				
Date:			Time:				
Indo-Pacific Belt Transect : Fish							
Data recorded by:							
	0-20m	**25-45m**	**50-70m**	**75-100m**	**Total**	**Mean**	**SD**
Butterfly fish					0	#DIV/0!	#DIV/0!
Sweetlips (Haemulidae)					0	#DIV/0!	#DIV/0!
Snapper (Lutjanidae)					0	#DIV/0!	#DIV/0!
Barramundi Cod (*Cromileptes*)					0	#DIV/0!	#DIV/0!
Grouper >30cm (Give sizes in comments)					0	#DIV/0!	#DIV/0!
Humphead wrasse					0	#DIV/0!	#DIV/0!
Bumphead parrot					0	#DIV/0!	#DIV/0!
Other Parrotfish (>20cm)					0	#DIV/0!	#DIV/0!
Moray eel					0	#DIV/0!	#DIV/0!
Indo-Pacific Belt Transect : Invertebrates							
Data recorded by:							
	0-20m	**25-45m**	**50-70m**	**75-100m**	**Total**	**Mean**	**SD**
Banded coral shrimp (*Stenopus hispidus*)					0	#DIV/0!	#DIV/0!
Diadema urchins					0	#DIV/0!	#DIV/0!
Pencil urchin (*Heterocentrotus mammilatus*)					0	#DIV/0!	#DIV/0!
Sea cucumber (edible only)					0	#DIV/0!	#DIV/0!
Crown-of-thorns star (*Acanthaster*)					0	#DIV/0!	#DIV/0!
Giant clam (*Tridacna*)					0	#DIV/0!	#DIV/0!
Triton shell (*Charonia tritonis*)					0	#DIV/0!	#DIV/0!
Lobster					0	#DIV/0!	#DIV/0!
For each segment, rate the following as: None=0, Low=1, Medium=2, High=3							
Coral damage : Anchor					0	#DIV/0!	#DIV/0!
Coral damage:Dynamite					0	#DIV/0!	#DIV/0!
Coral damage : Other					0	#DIV/0!	#DIV/0!
Trash : Fish nets					0	#DIV/0!	#DIV/0!
Trash : Other					0	#DIV/0!	#DIV/0!
Comments:							
Grouper sizes (cm)							
Bleaching (% of coral population)							
Bleach (% of colony)							
Suspected disease (type/%):							
Rare animals sighted (type/#):							
Other:							

Data sheet for substratum

Site name:															
Depth:							Date:								
Team Leader:							Data recorded by:								
Time:															
Substrate Code															
HC hard coral					**SC** soft coral					**RKC** recently killed coral					
FS fleshy seaweed					**SP** sponge					**RC** rock					
RB rubble					**SD** sand					**SI** silt/clay					
OT other															
(For first segment, if start point is 0 m, last point is 19.5 m)															

SEGMENT 1				**SEGMENT 2**				**SEGMENT 3**				**SEGMENT 4**			
0 - 19.5 m				**25 - 44.5 m**				**50 - 69.5 m**				**75 - 94.5 m**			
1		21		41		61		81		101		121		141	
2		22		42		62		82		102		122		142	
3		23		43		63		83		103		123		143	
4		24		44		64		84		104		124		144	
5		25		45		65		85		105		125		145	
6		26		46		66		86		106		126		146	
7		27		47		67		87		107		127		147	
8		28		48		68		88		108		128		148	
9		29		49		69		89		109		129		149	
10		30		50		70		90		110		130		150	
11		31		51		71		91		111		131		151	
12		32		52		72		92		112		132		152	
13		33		53		73		93		113		133		153	
14		34		54		74		94		114		134		154	
15		35		55		75		95		115		135		155	
16		36		56		76		96		116		136		156	
17		37		57		77		97		117		137		157	
18		38		58		78		98		118		138		158	
19		39		59		79		99		119		139		159	
20		40		60		80		100		120		140		160	

DO NOT TYPE DATA BELOW THIS LINE

Total S1		**Total S2**		**Total S3**		**Total S4**		**Grand total**			**Mean**		**SD**	
HC	0	HC	0	HC	0	HC	0	HC	0		HC	0	HC	0
SC	0	SC	0	SC	0	SC	0	SC	0		SC	0	SC	0
RKC	0	RKC	0	RKC	0	RKC	0	RKC	0		RKC	0	RKC	0
FS	0	FS	0	FS	0	FS	0	FS	0		FS	0	FS	0
SP	0	SP	0	SP	0	SP	0	SP	0		SP	0	SP	0
RC	0	RC	0	RC	0	RC	0	RC	0		RC	0	RC	0
RB	0	RB	0	RB	0	RB	0	RB	0		RB	0	RB	0
SD	0	SD	0	SD	0	SD	0	SD	0		SD	0	SD	0
SI	0	SI	0	SI	0	SI	0	SI	0		SI	0	SI	0
OT	0	OT	0	OT	0	OT	0	OT	0		OT	0	OT	0
#	0	#	0	#	0	#	0							

Comments:

3. 3. Periodical Evaluation of Management

Parks and Reserves Authority meeting will be held regularly to evaluate the management measures taken and revision of the management plan. Public opinions should be incorporated in the review of the management measures. The next meeting for the review and approval of the revised management plan will be held within 12 months. The following meetings will also be held on annual bases.

4. Restoration

One of the objectives of establishing MPAs was originally the enhancement of fisheries resources. Through collaboration with the Ministry of Fisheries, detail plan will be formulated to make use of the existing MPAs for this purposes, or alternatively, to establish other protected areas specific to this purposes, based on necessity and feasibility.

5. Public awareness

It is now fully understood that public support is the pre-condition for the management of MPAs, rather than strict enforcement. Public support will be sought through involvement of the public to the management and environmental education.

For the public involvement, public consultations or workshops will be held by the DoE for a better communication among stakeholders. In such consultation/workshops, the objectives, benefits and exact locations of the MPAs and rules within them will be fully explained. The opinions of relevant stakeholders will be listened and reflected to the management[9].

Effective environment education is necessary. The status, aims, benefits, locations and regulations, people's right and responsibilities related to MPAs should be understood by the people. As DoE's radio program (every 2 weeks) can be used for this purposes. To enhance awareness of the fishermen, local newspaper is an effective tool to protect the reserve area. Publishing educational articles on local newspapers in Tongan language is worth to try. For that purposes, a good collection of underwater photos and videos will be made.

For improve public awareness, giant clam nursery at Pangaimotu Reef has been often recommended as a effective advertisement of resources management and tourists attraction. As there is a history of unsuccessful attempt, the effectiveness will be carefully evaluated before introducing such plan. For formal education, visiting

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[9] Therefore, if support is not obtained at all, entire management of MPAs would be given up.

schools for lectures using visual materials is recommended. Brochure, supplementary material and information sheets are also useful for school education. Systematic approaches may be needed as former experience of only producing education materials proved ineffective.

DoE is also responsible for installing appropriate boundary markers, where applicable (Appendix 8).

7. Researches

For better understanding of the coastal areas of Tonga and the conservation, there are great deals of natural, cultural and socio-economic aspects waiting for further studies. For natural scientific field, quantitative survey of coral reefs, comprehensive survey on marine and terrestrial plants have yet to be commenced. There have been few, if any, studies on the use and values of MPAs related to fisheries, tourism and leisure. Because of the shortage in the number of researchers in Tonga, it may be needed for DoE to have alliances with overseas research institutes and universities.

8. Further Management Options

During implementation of the existing five MPAs, new marine and coastal reserves will be considered. These may include mangrove areas on the coast of Tongatapu's Fanga Uta Lagoon, which may help formulating a future planning for integrated coastal zone management. There are also candidates for MPAs in the Ha'apai and Vava'u groups.