Tuvalu Marine Life

an Alofa Tuvalu Project

with the Tuvalu Fisheries Department and Funafuti, Nanumea, Nukulaelae Kaupules

Fieldwork Report

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Fieldwork Report

International Year of Biodiversity - Alofa Tuvalu plunges into the water !

Global warming affects Tuvaluan marine life as surely as sea-level rise threatens this South Pacific micro-nation with disappearance within the next few decades. As the main source of protein to the Tuvaluan people, the ocean that surrounds the archipelago is home to a vital marine biodiversity whose size and nature is still largely unknown.

For 3 years, the French and Tuvaluan NGO, Alofa Tuvalu, has been leading « Tuvalu Marine Life », an extensive study and documentation project aimed at reinforcing Tuvalu's capacities to survey, monitor and manage its marine resources, along with increasing its local and scientific knowledge of them.

In 2009, the project's first phase consisted of summarizing existing data and identifying gaps in knowledge. After consultations with the project's stakeholders, 3 out of 9 islands of Tuvalu have been chosen to host the needed remaining investigations : Funafuti (the capital atoll, at the center of the archipelago), Nanumea (to the north) and Nukulaelae (to the south).

Alofa Tuvalu's experts in marine biodiversity, Sandrine Job, Daniela Ceccarelli, Semese Alefaio, are carrying out this second phase in partnership with Tuvalu fisheries (Tupulaga Poulasi and Nikolasi Apinelu), the environment office, local governments, the NBSAP program (National Biodiversity Strategy and Action Plan), New Zealand Aid, University of South Pacific and others.

Data will be analyzed and shared with other existing networks. Communication tools will then be produced : a reference and patrimonial book about Tuvalu's biodiversity and traditional knowledge, along with useful materials for local communities.

Implemented under the aegis of Unesco, the Tuvalu Marine Life project is supported by the Total Foundation for Entreprise and CRISP (Coral Initiative for the Pacific, French Agency for Development).

**The project is an integral part of the « Small is Beautiful » plan : helping Tuvalu -- the first sovereign nation threatened to be wiped off the map due to the effects of climate change -- survive as a nation and to preserve its identity and culture. These goals are addressed via a range of concrete, reproducible actions (biodiversity, energy, waste) in Tuvalu and their promotion elsewhere in the world. (www.alofatuvalu.tv)*

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1. EXECUTIVE SUMMARY

Tuvalu is one of the world's nations most severely affected by global climate change, particularly through predicted sea level rise. The expected consequences for people's livelihoods are disastrous, increasing their dependence on marine resources. To address this issue, the French and Tuvaluan NGO Alofa Tuvalu has launched a marine project that aims to inventory Tuvaluan marine life and support the Tuvaluan government in the establishment and management of marine Conservation Areas. This project is a collaboration between the Tuvaluan Fisheries Department and Alofa Tuvalu.

This project was conducted in two stages: a literature review and a field study. The literature review listed all marine species known from previous studies in Tuvaluan waters and highlighted gaps in existing knowledge. The literature review was presented to all stakeholders and decision was made to conduct a field survey on fish biodiversity and marine resources in Nanumea, Nukulaelae and Funafuti. It was further decided that marine resources would be surveyed in collaboration with Fisheries officers and local communities, focusing on established Conservation Areas and using low-cost and low-tech investigative methods in order to facilitate following up, ownershiping and reproductions by communities. This report describes the fieldwork phase carried out in May/June 2010. The reporting work will end up as a global publication including the current field trip report, the scientific report and a revision of the already published literature review.

Prior to fieldwork activities meetings with the local Kaupule (elected island council) were held in order to both explain the project's scope and hear about community needs and expectations. Upon community requests, we conducted training for marine resource assessment, both on land and in the water. Local community members also assisted in the selection of target species for the marine resource assessments, including fish, macroinvertebrates, substrate types and disturbance. SCUBA was only used for the Funafuti lagoonal sites; all other sites were surveyed by free diving.

Standard methods for assessing tropical marine resources were used, including belt transects for fish, macroinvertebrates and disturbance, and Point Intercept or Line Intercept Transects for substrate composition. On the outer islands (Nanumea and Nukulaelae), 10 sites were surveyed (5 inside and 5 outside Conservation Areas), constituting the baseline assessment for these islands. In Funafuti, we followed the protocols of an existing monitoring program. Six sites were surveyed (3 inside and 3 outside the Funafuti Conservation Area), and 3 habitats were surveyed at each site (reef flat, reef slope and lagoon).

The fish biodiversity survey resulted in the collection of two types of data: firstly, a record of all reef fish species encountered on a relative abundance scale, and secondly, quantitative data on reef fish biomass and density. Sites were selected inside the lagoon, and on the exposed and sheltered sides of the atolls. Biodiversity counts involved recording all species encountered during a 45 min dive (timed swim method), and quantitative data on fish density and biomass, benthic composition and habitat complexity were gathered along 50m transects. Overall, 12 sites were surveyed in Nanumea, 9 sites in Nukulaelae, and 14 sites in Funafuti.

2. INTRODUCTION

2.1. CONTEXT

Tuvalu, with a total landmass of only 26 km^2 composed of 9 low-lying islands, 11,000 citizens, is the earth's first sovereign nation threatened to disappearing due to global-warming related flooding.

With an average elevation of 3 meters, sea level rise already has severely impacted agriculture. Recent observation shows a reduction in islands' surface area and in agriculture areas. The greater frequency of very high tides results in increased saltwater intrusion into freshwater lenses, decline of soil quality and fertility, increased coastal erosion. Historically and geographically, Tuvaluans rely on the sea. The use of marine resources is part of the Polynesian identity and is expected to play an even greater role in the future, as their land erodes and as an effort is made to limit the consumption of imported goods.

Today a number of factors are putting marine environment under even more pressure (overfishing due to population increase, development of leisure, rather than subsistence, fishing, exploitation of rare and threatened species for traditional ceremonies, increased fishing by foreign fishing fleets). It is critical that these marine resources be sustainably managed for future generations.

The island inhabitants have an extensive traditional knowledge of their marine resources and a traditional system of sustainable management. In addition, marine resource management is undertaken collaboratively between local communities and the Tuvaluan Fisheries Department, following the philosophy and recommendations of the Locally Managed Marine Area Network (LMMA Network). Therefore, all islands of the archipelago have established Conservation Areas managed by local communities, also called Community Conservation Areas (Govan et al., 2009). It is now of paramount importance to provide communities all necessary means to fit their wish to sustainably manage and preserve their marine resources in the pressing context of global warming.

In that perspective, Alofa Tuvalu, a French-Tuvaluan NGO born in 2005, initiated the *Tuvalu Marine Life* project (TML), as part of its *Small is Beautiful* plan: helping Tuvalu survive by becoming a living, breathing, replicable model of an environmentally respectful and exemplary nation.

TML fulfils local communities requests to preserve inheritance and resources and answers the Tuvalu government's needs for reaching his management objectives.

TML aims at compiling an exhaustive documentation of Tuvalu's marine biodiversity, including fish, corals, algae, mangroves, seagrasses, turtles, marine mammals and seabirds.

To avoid replicating previous field efforts, the first stage of the project (November 2008 - July 2009) involved a literature review of previous data, publications and reports (Job, 2009). Over one hundred documents were reviewed, numerous experts were contacted directly, and databases were consulted to produce a species list. A revision before onsite survey found 1449 marine species, including 541 fish, 398 macroinvertebrates, 379 cnidarians, 59 algae, 41 seabirds, 21 marine mammals, 4 sponges, 4 turtles and 2 species of mangroves.

This work showed the need to gather complementary data essential for local resources management. These results were presented to all project participants (Fisheries Department, Department of Environment, members of the Funafuti Kaupule, and representative of the Funafuti Conservation Area (FCA), the National Biodiversity Strategic and Action Plan (NBSAP) and Tuvaluan Association of Non-Governmental Organisations (TANGO)) in May 2009. Recommendations on priority requirements were received according to the needs of local communities and the Fisheries Department (in their role as marine resource managers). 3 of the 9 Tuvaluan islands were selected: Funafuti (the capital atoll, at the center of the archipelago), Nanumea (to the north) and Nukulaelae (to the south). Awareness tools were also discussed such as a book or children publications.

It was established that as a priority, field biodiversity studies should concentrate on fish (as a major component of food security) and marine resource surveys within established Conservation Areas should hinge on simple, replicable methods easily applied by members of local communities to assess their local stocks. These study components fulfil Alofa Tuvalu's goal to gain an increased knowledge of marine biodiversity, as well as to serve management purposes through the collection of data on fish distribution and biomass. Knowledge of fish biodiversity is important for determining the structure and distribution of populations of important fish species, and to inform decisions on the placement and management of Conservation Areas or the protection of species of potential concern.

2.2. OBJECTIVES AND SCOPE

This project constitutes the second step in the process of documenting Tuvalu's marine life.
Based on the identification of knowledge gaps through the literature review and consultation with stakeholders, this 2nd step involved the collection of field data on reef and food fish biodiversity. The primary goals of the fieldwork were to collect data on fish biodiversity, density and biomass, associated with habitat characteristics, and marine food resources within and outside Conservation Areas. The fish biodiversity component of the field surveys served to update and expand the existing species list. It also provides additional information on biodiversity and distribution patterns. The resource assessments were designed to link into the existing Pacific-wide Locally-Managed Marine Area (LMMA) Network.

The collection of data on marine resources through a participatory approach fullfiled a broader goal of strengthening local capacity in terms of using methods of assessment, identification of target species and understanding the usefulness of resource management.

The field surveys were carried out in Nanumea, Nukulaelae, and the capital atoll, Funafuti. They took place between April 27th and May 27th 2010, with between 6 and 10 days spent at each location. While the biodiversity survey began immediately upon arrival in each place (after consultation with the local Kaupule), resource assessments were preceded by one day of land-based and in-water training for members of the local communities. The trainees then participated in the collection of baseline data in Nanumea and Nukulaelae. Baseline surveys in the Funafuti Conservation Area (FCA) had already been carried out several years ago, at the time of implementation of the FCA (1997). Therefore, the resource assessment in the FCA formed part of the ongoing monitoring and used methods identical to those of previous surveys.

2.3. PROJECT TEAM

Many people participated in the TML project on each island. A core team developed and carried out the project (*Table 1*), and was joined by local field survey participants in each location (*Table 2*).

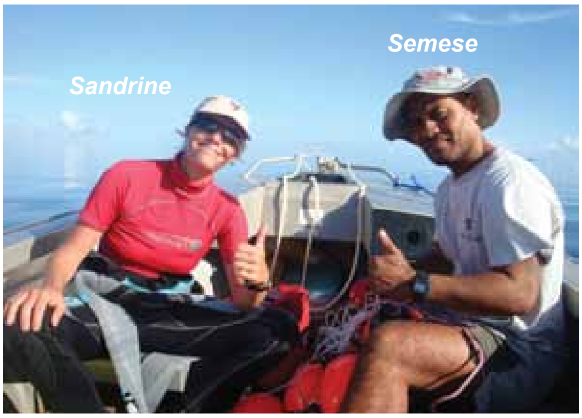

Table1. List of the main people involved, their title and role in the project.

Name	Title	Role
Gilliane Le Gallic	President Alofa Tuvalu	General coordination
Fanny Héros	Alofa Tuvalu member	Assistant general coordination
Sandrine Job	Marine biologist	Field coordination, CA* surveys, habitat survey
Daniela Ceccarelli	Marine biologist	Coral reef fish biodiversity survey
Tupulaga Poulasi	Fisheries officer	Community-based related aspects, CA surveys
Semese Alefaio	Marine biologist	Community-based related aspects, CA surveys
Thomas Vignaud	Marine biologist	Underwater photographer

Table 2. List of the field survey participant, their role in the project and geographic location.

Name	Role	Island
Patea Sela	CA survey	Nanumea
Esela Lopati	CA survey	Nanumea
Tahaoga Isako	Boat driver	Nanumea
Patrick Malaki	Boat driver and CA survey	Nanumea
Kaufiti Saloa	Boat driver	Nanumea
Morris Melitiana	Boat driver and CA survey	Nanumea
Iosua Filiki	Boat driver	Nukulaelae
Monise Peni	Boat driver	Nukulaelae
Faiva Namoliki	CA survey	Nukulaelae
Kinieti Pene	CA survey	Nukulaelae
Iosua Tepaolo	CA survey	Nukulaelae
Mataua Lima	CA survey	Nukulaelae
Lee Moresi	CA survey	Nukulaelae
Simon Salea	CA survey	Nanumea & Nukulaelae
Tennis Manu	Boat driver	Funafuti
Nelly Senida	Boat driver	Nanumea & Funafuti
Panei Togapili	CA survey	Nukulaelae & Funafuti
Teulu Sigalo	CA survey	Nanumea & Funafuti
Paeniu Lopati	CA survey	Funafuti
Kirisi Salanoa	CA survey	Funafuti
Moio Finauga	CA survey	Funafuti
Aso Veu	Boat driver	Funafuti

2.4. CONSULTATION

All components of the TML project were underpinned by discussions and consultation with local stakeholders, particularly the Fisheries Department who has jurisdiction over the marine environment. This ensured that all actions complied with community needs and expectations and with the governmental action plan for marine management.

Prior to fieldwork activities in the Conservation Areas, species were selected to be representative of the exploited resource (edible fish and macroinvertebrates) and easily identified by local assessors. Animals that were morphologically similar and of similar use and value were grouped under the same name. The substrate categories were chosen to represent the highest level of detail based on the mean level of expertise of local assessors. Species lists were adapted to each island visited, in consultation with community members.

On arrival, a meeting with the Kaupule (elected island council) was organised on each of the visited islands, to seek approval for the intended work, to explain the objectives and schedule of the fieldwork and to gather information about existing traditional management, community needs and expectations. At these initial meetings, the team members were presented, the methodology to be used during fieldwork was explained, any logistical concerns associated with our activities were addressed, the participants of the training session were selected and the future use of the project data in management, education and communication purposes was highlighted.

The Kaupule on each island was also consulted once fieldwork was finished. This closing meeting allowed us to debrief the community representatives on the fieldwork and the problems encountered, and to present our initial results (based on visual observations rather than analysed data) and to show some underwater pictures.


Launching


Targeted species


Funafuti Kaupule meeting


Nanumea closing


Nanumea initial meeting with Kaupule

3. METHODOLOGY

3.1. CONSERVATION AREA SURVEYS

3.1.1. Methods overview

In order to meet our capacity building objective (i.e. train people to assist the Fisheries Department in monitoring marine resources within Conservation Areas) and for safety and logistical reasons on outer islands, we opted for the use of simple and replicable (low-cost and low-tech) methods to assess marine resources.

The survey assessed 4 reef components:

- Fish populations
- Macroinvertebrate populations
- Substrate composition
- Disturbance

On the outerislands (Nanumea and Nukulaelae), we carried out the first survey of marine resources: it is therefore considered a baseline survey, describing the initial state of the marine environment. In Funafuti, we assessed marine resources according to an existing monitoring program. Both methods are described below.

The main constraint on the outer islands was the lack of SCUBA diving gear and the lack of training in its safe use. Thus, investigative methods involving free diving were preferred on the outer islands. However, in Funafuti some sites were surveyed using SCUBA to maintain consistency with previous survey methodology. The proximity of the hospital and the aircraft also allowed a higher degree of safety (in the case of decompression sickness or other SCUBA diving related accidents) and these sites were surveyed by Fisheries officers, all trained SCUBA divers.

The fish surveyor, entering the water first, marked the beginning of the first transect with a float and counted all target fish and estimated their total length along a 50 x 10m transect. The second diver followed immediately behind to lay down the transect tape. The macroinvertebrates team followed, composed of 2 surveyors (one on each side of the tape), recording and measuring macroinvertebrates and disturbances in a 2m belt each. The substrate surveyor then recorded the substrate composition, according to a pre-determined set of categories, under every 0.5m point along the tape.
Counts were made using a pre-agreed list of selected species *(Table 3, Table 4)* of fish and macroinvertebrates. Some species were important food sources (oysters, clams, surgeonfish), whereas some were chosen as bio-indicators of reef health or disturbance (e.g. Crown-of-Thorns, butterflyfish). Substrate categories were chosen to represent the highest level of detail based on the local surveyors' levels of expertise *(Table 5)*.

3.1.2. Detailed methodology: outer islands

Three 50m transects were censused at each station, in similar reef flat habitats. The next section ("Chapter 4: Outcomes") will present detailed information about the location of each station within the islands and transects within the stations.

Fish counts were made using an underwater visual census protocol which involved swimming along a 50 meter transect tape and recording all selected species seen within a 10 meter belt (5m on each side of the transect line) *(Figure 1)*. Data recorded were abundance (number of fish of selected species within the belt transect) and size (based on size classes, see Appendix 1).

Macroinvertebrates were counted along 50 x 4m belt transects *(Figure 1)*, 2m on each side of the transect line. As for fish, target invertebrates were selected *(Table 4).* Data recorded were abundance (number of animals of selected species within the belt transect) and the size of sea cucumbers, trochus (top shells) and clams *(Figure 2).*

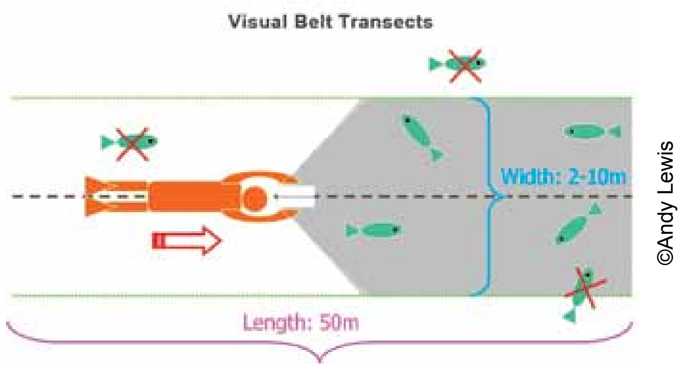

Figure 1. Illustration of a belt transect for gathering data on fish or macroinvertebrates.

Figure 2. Size measurements of sea cucumbers, trochus and clams.

Substrate composition was assessed with the Point Intercept Transect method. This involved recording the substrate composition every 50 cm directly below the transect tape *(Figure 3)*.

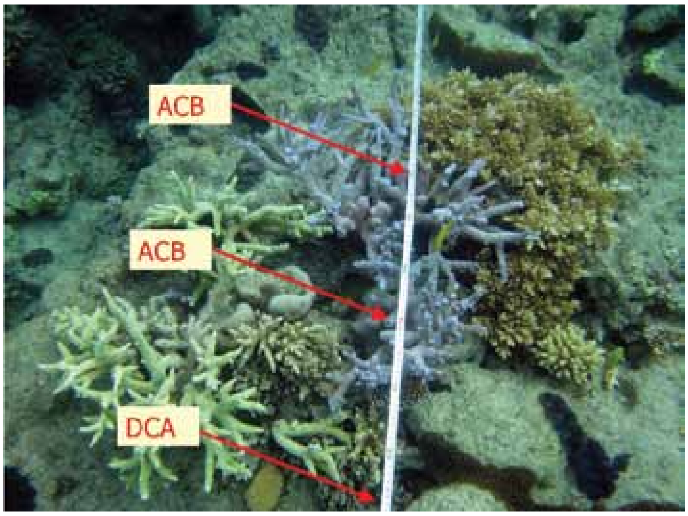

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Figure 3. Illustration of the Point Intercept Transect method.

3.1.3. Detailed methodology: Funafuti

The marine resource assessment within the Funafuti Conservation Area (FCA) was conducted as a part of ongoing monitoring activities rather than a baseline survey. We therefore applied the techniques previously developed and used in 1997, 1999, 2002 and 2006.

Fish were assessed along belt transects 20 x 10m (5 m on each side of the tape) using visual census to record fish density (abundance of selected fish species) and size (categorized by size classes) *(Figure 1)*.

Macroinvertebrates were assessed along the same transects (20 x 5m, 2.5m on each side of the tape) recording selected species abundance and size of trochus and clams *(Figure 2)*.

Substrate composition was recorded using the Line Intercept Transect method: measurements were taken along the entire length of the line, recording the number of centimetres taken up by each substrate category *(Figure 4)*.

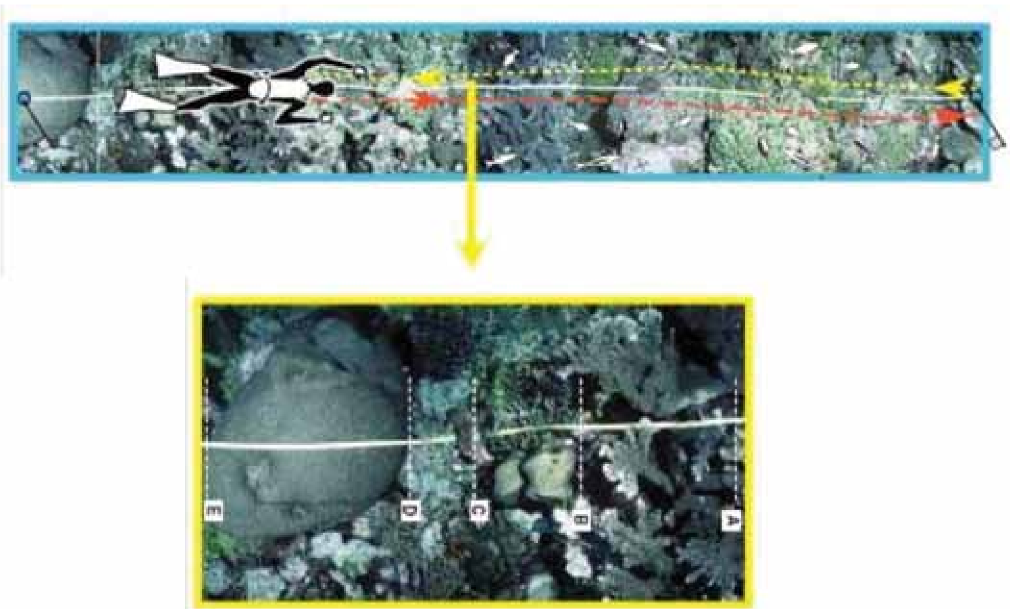

Figure 4. Illustration of the Line Intercept Transect method.

Each station was composed of 3 habitats: reef flat, reef slope and lagoon.

Seven 20m transects were censused in each habitat.

Reef flats and reef slopes were assessed by free diving, while lagoon habitats were investigated using SCUBA.

3.1.4. Training

Training sessions were organised to teach local surveyors the protocol developed for the survey, to present the field data sheets and to establish a list of selected species.

On each island we first conducted training on land *(Figure 5)* by laying down a tape on the ground and simulating different habitats (using gravel, grass, fabric, rocks, flowers, fishing nets, etc.) and marine animals (dead shells, images of fish and macroinvertebrates, etc.), placed inside and outside the transect belt.

Figure 5. Pictures of the training on land organised prior to underwater field surveys.

 

Figure 6. Pictures of the in-water training prior to data collection.

3.1.5. Target species and substrate categories

The purpose of this evaluation was to estimate the quantity of edible, commercial or otherwise valuable fish and invertebrates, from the perspective of food security. Some species indicative of the state of health or degradation of the marine environment were also recorded. The following tables list the species identified on each island and the justification for their selection. These lists are temporary; the final fish lists will be presented in the next report, with their Tuvaluan names.

Table 3. List of targeted fish species and the justification for their selection.

Nanumea survey		
Latin Name	Common name	Justification
Acanthurus lineatus	Lined surgeonfish	Edible
Ctenochaetus striatus	Striped bristletooth	Edible
Chaetodon trifascialis	Chevron butterflyfish	Indicative
Chaetodon semeion	Dotted butterflyfish	Indicative
Chaetodon recticulatus	Reticulated butterflyfish	Indicative
Chaetodon auriga	Threadfin butterflyfish	Indicative
Chaetodon ephippium	Saddled butterflyfish	Indicative
Chaetodon lunula	Racoon butterflyfish	Indicative
Chaetodon lunulatus	Oval butterflyfish	Indicative
Chaetodon rafflesi	Latticed butterflyfish	Indicative
Pygoplites diacanthus	Regal angelfish	Indicative
Zanclus cornutus	Moorish idol	Indicative
Cephalopholis argus	Peacock hind	Edible
Acanthurus triostegus	Convict surgeonfish	Edible
Chlorurus japanesis	Reef crest surgeonfish	Edible
Acanthurus blochii	Ringtail surgeonfish	Edible
Scarus ghobban	Bluebarred parrotfish	Edible
Lutjanus monostigma	Onespot snapper	Edible
Lutjanus fulvus	Blacktail snapper	Edible
Sargocentron spiniferum	Sabre squirrelfish	Edible
Epinephelus hexagonatus	Starspotted grouper	Edible
Epinephelus merra	Honeycomb grouper	Edible
Epinephelus fuscoguttatus	Brown marbled grouper	Edible
Lethrinus xanthochilus	Yellowlip emperor	Edible
Monotaxis grandoculis	Bigeye emperor	Edible
Kyphosus spp.	Sea chubs	Edible
Caranx melampygus	Bluefin trevally	Edible
Pseudobalistes flavimarginatus	Yellowmargin triggerfish	Edibale
Rhinecanthus aculeatus	Lagoon triggerfish	Edible
Platax orbicularis	Circular spadefish	Edible
Chlorurus microrhinus	Humphead parrotfish	Edible
Aprion virescens	Green jobfish	Edible

Nukulaelae survey		
Latin Name	Common name	Justification
Acanthurus lineatus	Lined surgeonfish	Edible
Acanthurus olivaceus	Orangeband surgeonfish	Edible
Ctenochaetus striatus	Striped bristletooth	Edible
Chaetodon trifascialis	Chevron butterflyfish	Indicative
Chaetodon semeion	Dotted butterflyfish	Indicative
Chaetodon reticulatus	Reticulated butterflyfish	Indicative
Chaetodon auriga	Threadfin butterflyfish	Indicative
Chaetodon citrinellus	Citron butterflyfish	Indicative
Chaetodon ephippium	Saddled butterflyfish	Indicative
Chaetodon lunula	Racoon butterflyfish	Indicative
Chaetodon ulietensis	Pacific double-saddle butterflyfish	Indicative
Chaetodon lunulatus	Oval butterflyfish	Indicative
Chaetodon rafflesi	Latticed butterflyfish	Indicative
Chaetodon ornatissimus	Ornate butterflyfish	Indicative
Chaetodon vagabundus	Vagabond butterflyfish	Indicative
Cephalopholis argus	Peacock hind	Edible
Acanthurus triostegus	Convict surgeonfish	Edible
Chlorurus japanesis	Reef crest surgeonfish	Edible
Acanthurus blochii	Ringtail surgeonfish	Edible
Scarus ghobban	Bluebarred parrotfish	Edible
Lutjanus monostigma	Onespot snapper	Edible
Lutjanus fulvus	Blacktail snapper	Edible
Sargocentron spiniferum	Sabre squirrelfish	Edible
Epinephelus merra	Honeycomb grouper	Edible
Naso lituratus	Orangespine unicornfish	Edible
Lethrinus xanthochilus	Yellowlip emperor	Edible
Monotaxis heterodon	Bigeye emperor	Edible
Kyphosus spp.	Sea chubs	Edible
Caranx melampygus	Bluefin trevally	Edible
Rhinecanthus aculeatus	Lagoon triggerfish	Edible
Pseudobalistes flavimarginatus	Yellowmargin triggerfish	Edible
Siganus argenteus	Forktail rabbitfish	Edible
Naso unicornis	Bluespine unicornfish	Edible
Parupeneus barberinus	Dot-dash goatfish	Edible
Lutjanus gibbus	Humpback snapper	Edible
Crenimugil crenilabris	Fringelip mullet	Edible
Lethrinus harak	Thumbprint emperor	Edible
Cheilinus undulatus	Humpheaded Maori wrasse	Edible
Liza vaigensis	Diamond-scale mullet	Edible
Chlorurus microrhinus	Humphead parrotfish	Edible
Canthigaster solandri	Spotted toby	-

Funafuti survey		
Latin Name	Common name	Justification
Parupeneus barberinus	Dot-dash goatfish	Edible
Mulloidichthys flavolineatus	Yellowstripe goatfish	Edible
Mulloidichthys. vanicolensis	Yellowfin goatfish	Edible
Lethrinus obsoletus	Orange-striped emperor	Edible
Lethrinus harak	Thumbprint emperor	Edible
Lethrinus olivaceus	Longface emperor	Edible
Chaetodon ephippium	Saddled butterflyfish	Indicative
Chaetodon auriga	Threadfin butterflyfish	Indicative
Chaetodon citrinellus	Citron butterflyfish	Indicative
Chaetodon trifascialis	Chevron butterflyfish	Indicative
Chaetodon vagabundus	Vagabond butterflyfish	Indicative
Chaetodon ulietensis	Pacific double-saddle butterflyfish	Indicative
Chaetodon reticulatus	Reticulated butterflyfish	Indicative
Chaetodon lunula	Racoon butterflyfish	Indicative
Chaetodon lunulatus	Oval butterflyfish	Indicative
Chaetodon ornatissimus	Ornate butterflyfish	Indicative
Chaetodon rafflesi	Latticed butterflyfish	Indicative
Chaetodon semeion	Dotted butterflyfish	Indicative
Ctenochaetus striatus	Striped bristletooth	Edible
Pygoplites diacanthus	Regal angelfish	Indicative
Lutjanus bohar	Red snapper	Edible
Lutjanus gibbus	Humpback snapper	Edible
Lutjanus monostigma	Onespot snapper	Edible
Lutjanus kasmira	Bluestripe snapper	Edible
Lutjanus fulvus	Blacktail snapper	Edible
Epinephelus fuscoguttatus	Brown-marbled grouper	Edible
Epinephelus merra	Honeycomb grouper	Edible
Cephalopholis argus	Peacock hind	Edible
Scarus gobban	Bluebarred parrotfish	Edible
Rhinecanthus aculeatus	Lagoon triggerfish	Edible
Acanthurus nigricans	Whitecheek surgeonfish	Edible
Acanthurus triostegus	Convict surgeonfish	Edible
Acanthurus lineatus	Striped surgeonfish	Edible
Naso lituratus	Orangespine unicornfish	Edible
Naso unicornis	Bluespine unicornfish	Edible
Monotaxis grandoculis	Humpnose bigeye bream	Edible
Kyphosus spp.	Sea chubs	Edible
Chlorurus microrhinus	Humphead parrotfish	Edible
Siganus argenteus	Forktail rabbitfish	Edible
Aprion virescens	Green jobfish	Edible
Pseudobalistes flavimarginatus	Yellowmargin triggerfish	Edible

Table 4. List of targeted macroinvertebrate species and the justification for their selection.

Nanumea survey

Latin name	Common name	Island name	Justification
Turbo sp.	Turban shell	Alili	Food source
Lambis sp.	Spider shell	Kalea	Food source
Strombus luhanus	Strawberry conch	Panea	Food source
Trochus niloticus	Top shell	Munikau	Food source
Cypraea sp.	Cowrie	Pule	Handicraft
Tridacna sp.	Clam	Fasua	Food source
Pinctada margaritifera	Black lip pearl oyster	Tifa	Food source and commercial value
Spondylus varius	Thorny oyster	Hopu nifo	Food source
Spondylus variegatus		Hopu teka	Food source
Chama imbricata	Oyster	Hopu papa	Food source
Octopus sp.	Octopus	Feke	Food source
Panulirus sp.	Lobster	Tapa tapa	Food source
Conus sp.	Cone	Uga	Handicraft
Holothuria atra	Lollyfish	Loli	Ecological function
Holothuria fuscogilva	Teatfish	Funafuna faiu	Commercial value
Holothuria sp., Bohadshia sp., Actinopyga sp.	Sea cucumber	Funafuna	Ecological function and commercial value
Acanthaster planci	Crown-of-thorn starfish	Kalauna	Ecological function
Drupella	Coral-eating snail	Drupella	Ecological function
Echinometra mathaei, Diadema setosum, Echinotrix diadema	Sea urchin	Vana	Ecological function
Arca ventricosa, Modiolus sp.	Ark and mussel	Kohi	Food source

Nukulaelae survey

Latin name	Common name	Island name	Justification
Turbo sp.	Turban shell	Alili	Food source
Lambis sp.	Spider shell	Mataga	Food source
Strombus luhanus	Strawberry conch	Panea	Food source
Trochus niloticus	Top shell	Munikau	Food source
Cypraea sp.	Cowrie	Pule	Handicraft
Tridacna sp.	Clam	Fasua	Food source
Pinctada margaritifera	Black lip pearl oyster	Tifa	Food source and commercial value
Spondylus sp.	Thorny oyster	Sopuu	Food source
Octopus sp.	Octopus	Feke	Food source
Panulirus sp.	Lobster	Ula	Food source
Conus sp.	Cone	Fakamili	Handicraft
Holothuria atra	Lollyfish	Loli	Ecological function
Holothuria fuscogilva	Teatfish	Funafuna faiu	Commercial value
Holothuria sp., Bohadshia sp., Actinopyga sp.	Sea cucumber	Funafuna	Ecological function and commercial value
Acanthaster planci	Crown-of-thorn starfish	Kalauna	Ecological function
Drupella	Coral-eating snail	Drupella	Ecological function
Cerithium nodulosum	Nodulose coral creeper	Sipo	Bait
Echinometra mathaei, Diadema setosum, Echinotrix diadema	Sea urchin	Vana	Ecological function

Funafuti survey			
Latin name	Common name	Island name	Justification
Turbo sp.	Turban shell	Alili	Food source
Lambis sp.	Spider shell	Mataga	Food source
Strombus luhanus	Strawberry conch	Panea	Food source
Trochus niloticus	Top shell	Munikau	Food source
Cypraea sp.	Cowrie	Pule	Handicraft
Tridacna sp.	Clam	Fasua	Food source
Pinctada margaritifera	Black lip pearl oyster	Tifa	Food source and commercial value
Spondylus sp.	Thorny oyster	Sopuu	Food source
Octopus sp.	Octopus	Feke	Food source
Panulirus sp.	Lobster	Ula	Food source
Conus sp.	Cone	Fakamili	Handicraft
Holothuria atra	Lollyfish	Loli	Ecological function
Holothuria fuscogilva	Teatfish	Funafuna faiu	Commercial value
Holothuria sp., Bohadshia sp., Actinopyga sp.	Sea cucumber	Funafuna	Ecological function and commercial value
Acanthaster planci	Crown-of-thorn starfish	Kalauna	Ecological function
Drupella	Coral-eating snail	Drupella	Ecological function
Cerithium nodulosum	Nodulose coral creeper	Sipo	Bait
Echinometra mathaei, Diadema setosum, Echinotrix diadema	Sea urchin	Vana	Ecological function

Table 5. Categories used to describe substrate composition.

Nanumea/Nukulaelae surveys		Funafuti survey	
Code	Description	Code	Description
BC	Branching Coral	ACB	*Acropora* Branching
EC	Encrusting Coral	ACD	*Acropora* Digitate
FC	Foliose Coral	ACS	*Acropora* Submassive
MC	Massive Coral	ACT	*Acropora* Table
TC	Table Coral	BC	Branching Coral
OC	Other Coral	EC	Encrusting Coral
SC	Soft Coral	CHL	Blue Coral
SP	Sponge	MC	Massive Coral
OL	Other Living Organisms	SC	Soft Coral
MA	Macroalgae	SP	Sponge
TA	Turf Algae	DC	Dead Coral
SG	Seagrass	DCA	Dead Coral with Algae
DC	Dead Coral	CA	Coralline Algae
RC	Rock	HA	*Halimeda*
RB	Rubble	MA	Macroalgae
SD	Sand	AA	Algae Assemblage
SI	Silt	TA	Turf Algae
		RC	Rock
		RB	Rubble
		SD	Sand
		SI	Silt

3.2. BIODIVERSITY

3.2.1. Overview of the sampling design

Biodiversity surveys were conducted using two standard methods: 1) timed swims with towed GPS to record reef fish biodiversity and large predators and herbivores, and 2) replicated underwater visual census using transects to determine relative abundance and species composition of the mid-slope reef fish communities. The use of these two methods allows for a comprehensive species list, statistical rigor, the identification of habitat associations, and the comparison between Tuvalu and other reefs on a regional scale. These two methods are widely used throughout the whole Indo-Pacific region and are recommended methods to survey tropical marine resources (English *et al*., 1997).

Biodiversity sites were surveyed using one 45 minute timed swim. Transect sites were conducted in the same location as the Biodiversity timed swims, and were surveyed using four 50m transects per site.

Whenever possible, the sampling design included (at least) three replicate sites in exposed, sheltered and lagoonal locations on each atoll, resulting in a minimum of nine sites per atoll. Weather conditions imposed a number of variations on the sampling design (*Table 6* and *Figure 7*).

Table 6. Number of sites completed in exposed, sheltered, lagoon and lagoon pinnacle habitats on each atoll surveyed.

Exposure	Nanumea	Nukulaelae	Funafuti
Exposed	3 Biodiversity	3 Biodiversity	3 Biodiversity
Sheltered	6 Biodiversity	3 Biodiversity	4 Biodiversity
	3 Transect	3 Transect	4 Transect
Lagoon	3 Biodiversity	3 Biodiversity	4 Biodiversity
	3 Transect	3 Transect	4 Transect
Lagoon Pinnacle			3 Biodiversity

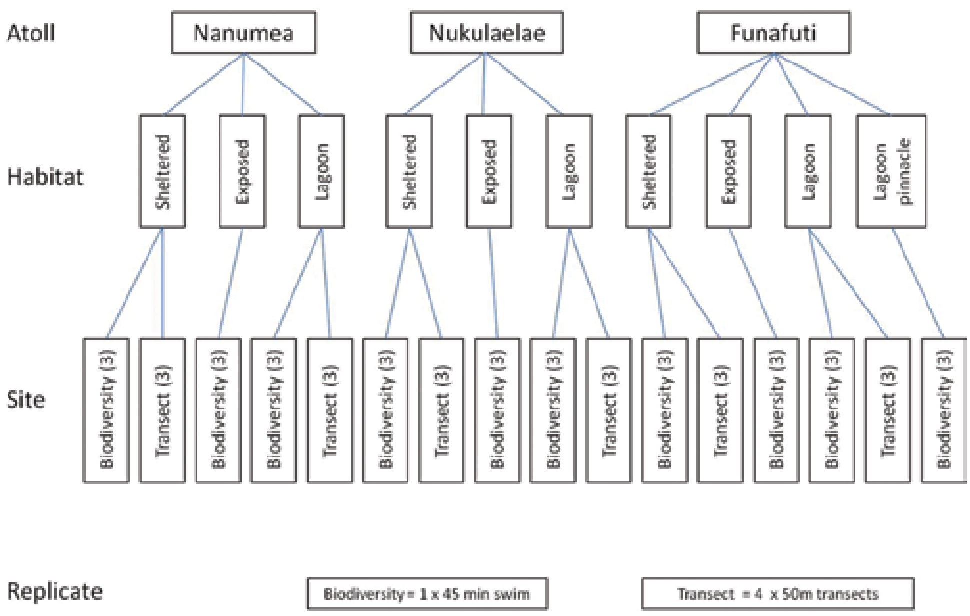

Figure 7. Illustration of the sampling design developed for the biodiversity assessment.

Two SCUBA dives (see also *Table 7* and *Figure 7*) were performed at each site, including:

- One fish biodiversity timed swim (45min), with towed GPS, to assess overall fish diversity and relative abundance, and the density of large predators and herbivores;
- Replicate fish surveys along four 50m transects at each site, with the surveyor recording larger, more mobile fishes during the first pass and smaller, more site-attached fishes on the second pass (abundance and species composition); and
- Four replicate Point Intercept Transect benthic surveys along the same four transects at each site to assess benthic % cover, particularly hard and soft coral, sponges and algae.

Personnel	Dive 1	Dive 2
D. Ceccarelli	Fish biodiversity timed swim (45min) with towed GPS, covering as many habitats as possible	50m transects, large fish (way out, 10m width) and small fish (way back, 2m width), 4 replicates
T. Vignaud	Photography	
S. Job		50m transects, benthos, 4 replicates

Table 7. Tasks to be performed at each site.

3.2.2. Detailed methodology

Timed swims were conducted to achieve a rapid visual assessment of fish biodiversity and relative abundance. During the timed swim (which generally covered 2,000m^2 depending on currents), the diver searched all site-specific microhabitats. All fish were identified to species level. The abundance of fish species was recorded on a log-scale *(Table 8)* and later converted to ranks or scores for ease of statistical interpretation of community structure.

Fish abundance and species composition were then more accurately quantified using the visual transect census method. The list of fish species was selected according to the following criteria (matching fish lists employed in previous surveys):

- Ease of identification underwater,
- Non-cryptic behaviour and ease of counting,
- Commercially important, biological indicator species, rare and scientifically interesting species.

Abundance Category	Number of Individuals
0	0
1	1
2	2-5
3	6-25
4	26-125
5	>125

Table 8. Abundance scale used in fish biodiversity timed swims.

Four replicate transects were laid out at each site.

The abundance of larger, mobile fish species was recorded along 50 x 10m transects on the first pass, as the diver simultaneously deployed the transect tape. Smaller and more site-attached fishes (e.g. damselfishes) were recorded along a 2m belt along the same transect on the return pass. This widely used method will facilitate comparisons with fish diversity on other Pacific reefs, and will result in data that is publishable in the peer-reviewed scientific literature.

During both fish census methods, incidental sightings of all species were noted and the previous species list for Tuvalu will be updated with this information.

At each site, four replicate 50m point-intercept transects were conducted for robust benthic cover and coral abundance estimates. Hard corals were identified to growth form level and other benthic organisms such as soft coral/sponges/algae were distinguished.

Additionally, to measure the complexity of the reef framework, a 2m chain was used at every 10m point of the transect line. The chain was draped over the reef in a straight line underneath the transect tape, following the reef contours. The complexity index was calculated by subtracting the length of the tape at the endpoint of the chain (distance D1) from 2 *(Figure 8)*.

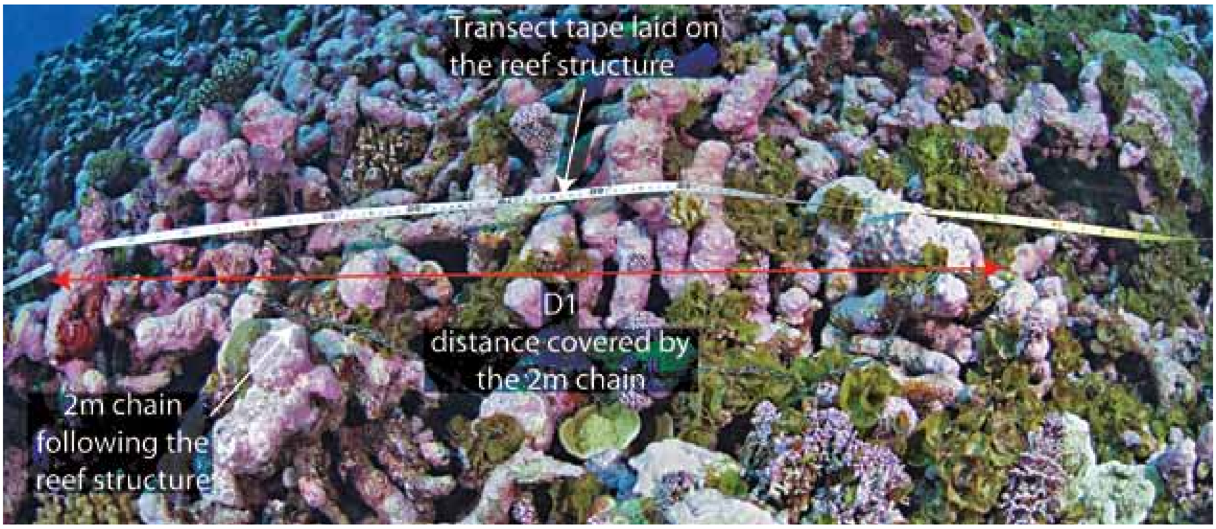

Figure 8. Illustration of the reef complexity method.

3.2.3. Data analysis

• Reef fish biodiversity patterns will be described and compared between exposure regimes, atolls, previous surveys in Tuvalu and regionally relevant reefs.

• Reef fish abundance of all species will be reported as density estimates (individuals per hectare or $1000m^2$). The diversity of reef fish will be described spatially using multivariate techniques (e.g. Principal Components Analysis or non-metric Multidimensional Scaling). Density and diversity of reef fish will be compared between exposure regimes, atolls, previous surveys and regionally relevant reefs.

• The percentage cover of all benthic groups (especially hard and soft corals, algae and sponges) will be compared between exposure regimes, atolls, previous surveys and regionally relevant reefs.

• The hard and soft coral communities will be described spatially using multivariate techniques.

4. OUTCOMES

4.1. FIELDWORK SCHEDULE

The following table *(Table 9)* shows the progress of the project. The total duration of the fieldwork phase was 36 days: from the 27th of April until the 1st of June 2010.

The first days in Funafuti were dedicated to ensuring the logistics were in place for the outer islands, as we planned to depart for Nanumea on the 1st of May. We also used this time to present the TML project at an environmental workshop on the 27th of April, organized by NBSAP (National Biodiversity Strategic and Action Plan); and to all stakeholders (see *Table 10* for the list of participants and Section 7.2 for the content of the presentation).

We departed on the 1st of May from Fongafale aboard the Fisheries vessel Manaui for a 32 hour journey to Nanumea, the northern-most island of the archipelago. Once arrived, we met with members of the Kaupule (*Table 11*) to receive their blessing and approval for the project. We then split the team into two groups: the Conservation Area team was responsible for providing training to local people (training on land followed by training at sea) and conducting the Conservation Area baseline study, and the Biodiversity team was responsible for the collection of fish biodiversity data.

We stayed six days on the atoll of Nanumea, the two teams making their assessments independently. Approximately 6 hours per day were spent working underwater, the rest of the day was spent organizing the logistics of our activities and entering our field data into a database.

At the end of our trip, we were invited to a meeting with the Kaupule to report our first observations and results, share our knowledge with local people, answer specific questions about the marine environment, and show some underwater photographs of marine organisms found in Nanumea.

We then returned to Funafuti for refuelling and the exchange of equipment and personal effects, before heading south for a 10 hour steam to Nukulaelae. The progress of our fieldtrip on Nukulaelae was similar to Nanumea, with an initial meeting with members of the Kaupule *(Table 12)*, which was followed by land-based training and in-water training. Baseline and biodiversity assessments were then carried out. As in Nanumea, we completed our stay with a meeting with the Kaupule members to share our initial findings.

Finally, we conducted the evaluation of marine resources and biodiversity on the atoll of Funafuti. We first met with the members of the Funafuti Kaupule *(Table 13)* to seek approval. As fisheries officers were already trained (and more familiar with underwater work and assessment techniques) we immediately started assessing marine resources without additional training. The field survey was longer in Funafuti than on the outer islands due to the larger area covered by the FCA and the larger number of stations surveyed. In addition, stations were relatively far from Fongafale (average travel time was about half an hour). We spent 6 days surveying the reef flats and reef slope stations by free diving and 2 days visiting the lagoon stations using SCUBA. We then presented our initial results to the Kaupule members, which were followed by an open discussion about marine issues, and a slide show of underwater photographs of Funafuti marine life.

Table 9. Fieldwork schedule.

			General activities	Biodiversity survey team	Conservation area survey team
Tuesday	27	April	Team arrival		
Wednesday	28	April	Presentation of the project to NBSAP workshop		
Thursday	29	April	TML presentation to stakeholders		
Friday	30	April	Fieldwork preparation and training on land with Fisheries officers		
Saturday	1	May	Funafuti-Nanumea		
Sunday	2	May	Funafuti-Nanumea		
Monday	3	May	Meeting with Nanumea Kaupule	2 biodiversity dives (sheltered side)	Training on land and training at sea
Tuesday	4	May		3 biodiversity dives (lagoon)	Data collection (within CA)
Wednesday	5	May		4 biodiversity dives (sheltered side)	Data collection (within CA)
Thursday	6	May		3 biodiversity dives (exposed side), 1 transect dive (lagoon)	Data collection (outside CA)
Friday	7	May	Closure meeting with Kaupule	4 transect dives (3 sheltered, 1 lagoon)	Data collection (outside CA)
Saturday	8	May		1 transect dive (lagoon)	
Sunday	9	May	Nanumea-Funafuti		
Monday	10	May	Nanumea-Funafuti		
Tuesday	11	May	Funafuti-Nukulaelae		
Wednesday	12	May	Meeting with Nukulaelae Kaupule,	2 biodiversity dives ('sheltered' side)	Training on land and training at sea
Thursday	13	May		4 biodiversity dives (3 'exposed', 1 'sheltered')	Data collection (within CA)
Friday	14	May		3 biodiversity dives (lagoon)	Data collection (within CA)
Saturday	15	May		3 transect dives ('exposed' side)	Data collection (outside CA)
Sunday	16	May			
Monday	17	May	Closure meeting with Kaupule	3 transect dives (lagoon)	Data collection (outside CA)
Tuesday	18	May	Nukulaelae-Funafuti		
Wednesday	19	May	Meeting with Funafuti Kaupule		
Thursday	20	May		4 biodiversity dives (lagoon)	Data collection (within CA)
Friday	21	May		4 biodiversity dives ('sheltered' side)	Data collection (within CA)
Saturday	22	May		4 transect dives ('sheltered' side)	Data collection (within CA)
Sunday	23	May		4 transect dives (lagoon)	
Monday	24	May		3 biodiversity dives ('exposed' side)	Data collection (outside CA)
Tuesday	25	May		3 biodiversity dives (lagoon pinnacles)	Data collection (outside CA)
Wednesday	26	May	Closure meeting with Kaupule		Data collection (outside CA)
Thursday	27	May			Data collection (dive-inside CA)
Friday	28	May			Data collection (outside CA)
Saturday	29	May			
Sunday	30	May			
Monday	31	May			
Tuesday	1	June	Team departure		

4.2. CONSULTATION AND COMMUNICATION

We organised and were invited to various meetings throughout the course of our visit to Tuvalu.
Most of these meetings were to solicit the approval of the Kaupule for the project activities, as a mark of respect and thanks for letting us have access to their marine resources, and to share our knowledge and expertise with the communities. The lists of participants in these meetings are presented in *Table 11*, *Table 12* and *Table 13*.

During the initial Kaupule meetings, the following points were discussed:

- Explanation of the partnership developed through this project (Alofa Tuvalu, Fisheries Department, Semese Alefaio).
- Presentation of the team members
- Main goals of the project
- Brief description of the methodology used to achieve our goals
- Description of the training: why? Who should be involved? How is it organised?
- Uses of the data collected (management, book, education purposes, scientific publication, etc.)
- Description of our needs (logistics: boat, boat driver, food, etc.)
- Open discussion about the project: questions and answers.

We completed each visit to an island with a meeting with the same members of the Kaupule, to address the following points:

- Our thanks for the community's hospitality
- Our initial findings and observations through both assessments
- Remarkable sites or observations
- Slide show of Thomas's underwater pictures

Apart from Kaupule meetings we were also invited to present the Tuvalu Marine Life project at the NBSAP meeting that was held in Fongafale from the 26th until the 30th of April 2010. This conference was an opportunity to present the context, objectives and methodologies used to achieve our objectives, to an audience consisting of representatives of the entire Tuvalu archipelago Kaupule, members of the Government of Tuvalu and all the persons and organizations involved in Tuvalu's environmental protection.

We finally organized a more formal meeting to launch the TML project with all stakeholders *(Table 10)*, which allowed us to detail the content and organisation of the project. The PowerPoint presentation is appended (Appendix 2).

Name	Title
Gilliane Le Gallic	President of Alofa Tuvalu
Daniela Ceccarelli	TML Fish biodiversity expert, consultant, marine biologist
Sandrine Job	TML coordination, consultant, marine biologist
Semese Alefaio	Consultant, marine and coastal studies
Tupulaga Poulasi	Fisheries officer
Thomas Vignaud	TML underwater photographer
Kirisi Salanoa	FCA representative
Mataio Mataio	Director of Environment
Nikolasi Apinelu	Acting director Fisheries Department
Tima Talapai	Fisheries vessel captain
Simon Salea	Fisheries vessel crew
Taukiei Kitara	TANGO officer/GEF small grant country programme coordinator
Fumiko Matsudate	ForamSand project officer
Uluao Lauti	Funafuti Kaupule member
Annie Wheeler	Acting Manager Community Outreach and Education (NZ Department of Conservation)

Table 10. List of participants at the initial presentation meeting (29th of April, 2010).

Name	Title
Eli Teuea	Pule Kaupule
Tie Maheu	Tokolua Kaupule
Isala katalake	Kaupule member
Tuivaka Paitela	Kaupule member
Toai Vevea	Kaupule member
Muna Tefeke	Kaupule member

Table 11. List of Nanumea Kaupule members met for the TML project approval.

Name	Title
Ekueta Telava	Pule Kaupule
Tom Lake	Secretary Kaupule
Petaia Mose Paeniu	Kaupule member
Kelisiano Iosefa	Kaupule member
Fiavai Tinei	Kaupule member

Table 12. List of Nukulaelae Kaupule members met for the TML project approval.

Name	Title
Andrew Ionatana	Pule Kaupule
Meneua Teagai	Vice President
Uluao Lauti	Kaupule member
Kaitu Nokisi	Kaupule member
Apinelu Tili	Kaupule member
Heiloa Loua	Kaupule member
Suka Taupale	Kaupule member

Table 13. List of Funafuti Kaupule members met for the TML project approval.

Some additional communication activities were carried out during our stay in Tuvalu: A press release written by Gilliane Le Gallic/Alofa Tuvalu - Radio interviews by Radio Australia and Radio Tuvalu.

4.3. CONSERVATION AREA SURVEY OUTCOMES

4.3.1. Nanumea survey

A total of 10 sites were surveyed on Nanumea atoll: 5 sites within the Conservation Area (labelled CA in *Figure 9*) and 5 sites outside the Conservation Area (labelled OCA). The Conservation Area boundaries are shown schematically below, in white dots.

Figure 9. Location of survey sites for marine resource assessment on Nanumea atoll.

Figure 10. Example of transect location for marine resource assessment on Nanumea atoll (CA Site 4).

Three 50m transects were laid out at each site, following the reef contour: an example of transect location is shown in *Figure 10.*

4.3.2. Nukulaelae survey

Figure 11. Location of survey sites for marine resource assessment on Nukulaelae atoll.

A total of 10 sites were surveyed on Nukulaelae atoll: 5 within the Conservation Area (labelled CA in *Figure 11*) and 5 sites outside the Conservation Area (labelled OCA).

The Conservation Area boundaries are shown schematically below, represented by white dots.

Three 50m transects were laid out at each site, following the reef contour: an example of transect location is shown in *Figure 12*.

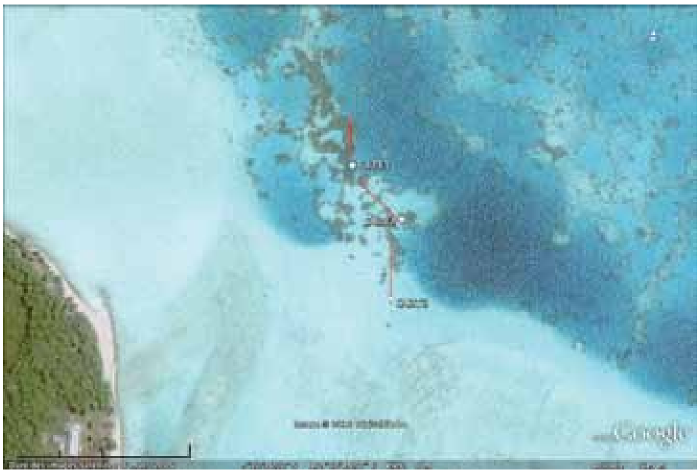

Figure 12. Example of transect location for marine resource assessment on Nukulaelae atoll (CA Site 2).

4.3.3. Funafuti survey

A total of 6 sites were surveyed on Funafuti atoll: 3 sites within the Conservation Area (Fualopa, Fuafatu and Tefala, *Figure 13*) and 3 sites outside the Conservation Area (Fualefeke, Tafualiku and Tepuka). The Conservation Area boundaries are shown schematically below, represented by white dots.

Figure 13. Location of survey sites for marine resource assessment on Funafuti atoll.

At each site, 3 habitats were surveyed: the reef flat, the reef slope and the lagoon (*Figure 14*). In each of these habitats, seven 25m transects were laid one after the other, spaced 5 to 10 meters apart, following the reef contour and structure to ensure the assessment was done within the appropriate habitat.

Figure 14. Habitats surveyed for marine resource assessment. Example of Tepuka Islet.

4.4. BIODIVERSITY OUTCOMES

4.4.1. Nanumea survey

A total of 12 sites were surveyed on Nanumea atoll. Biodiversity swims were conducted at all 12 sites, including 6 sheltered sites (green dots in *Figure 15*), 3 exposed sites (red dots) and 3 lagoon sites (yellow dots), with an additional reef flat location surveyed on snorkel (pink dot). Fish biomass and density were assessed at 6 of the sites, including 3 of the original sheltered sites and the three lagoon sites (*Figure 16)*. Site selection at each atoll was influenced by exposure to prevailing swells and by weather conditions during the survey period. An extended period of strong winds from the southeast made the eastern side of the atoll of Nanumea inaccessible until the last days of the 6-day period spent there. Three additional sites were therefore surveyed on the leeward side of the atoll, as well as the three sites originally planned and the three sites in the lagoon. When the exposed side became accessible, it was found that the surge was too strong for transect surveys.

Incidental sightings and photographs of fish that were not seen in the surveyed habitats were recorded. Additionally, anything caught by the Manaui's crew or other fishermen was identified to species where possible, and added to the species list. It was noted that the target fishes were dominated by open-water, pelagic species.

Figure 15. Preliminary map of Nanumea sites for fish surveys: sites used for biodiversity assessment.

Figure 16. Preliminary map of Nanumea sites for fish surveys: sites used for transect surveys.

4.4.2. Nukulaelae survey

Site placement in Nukulaelae followed the intended framework (*Table 6*). A total of 9 sites were surveyed. Biodiversity swims were conducted at all 9 sites, including 3 sheltered sites (green dots in *Figure 17*), 3 exposed sites (red dots) and 3 lagoon sites (yellow dots), with an additional reef flat location surveyed on snorkel (pink dot). Transects for biomass and density assessments were laid out at 6 of the sites, including 3 on exposed sites and the 3 lagoon sites (*Figure 18*).

The generally favourable weather conditions allowed for more consistent planning. Survey days outside the atoll were strictly controlled by the tide, as Nukulaelae has no deep channel for access to the lagoon. The hiring of local boat drivers made the passage more easily negotiable.

Prevailing wind and swell in Nukulaelae were variable and the sites originally labelled as 'sheltered' will be reclassified as 'exposed' for data analysis. Initially expecting a similar exposure regime as in Nanumea, we noted that reef communities on the east-facing side of the atoll were much more typical of sheltered or semi-sheltered habitats, including a variety of relatively large and delicate plate-forming and branching *Acropora* corals.

Extra observations, outside the scope of the survey, were recorded during the stay in Nukulaelae. The first was a pod of spinner dolphins, numbering between 30 and 50, seen over two consecutive days outside the east-facing side of the atoll. The second observation, made on request of the Kaupule, was in the deep lagoon (depth ~ 25m), where a Chinese company had collected sea cucumbers at a commercial scale. One dive was made, and the sandy bottom searched, but no sea cucumbers were found.

Figure 17. Preliminary map of Nukulaelae sites for fish surveys: sites used for biodiversity assessment.

Figure 18. Preliminary map of Nukulaelae sites for fish surveys: sites used for transect surveys.

4.4.3. Funafuti survey

As Funafuti lagoon is much larger than the other two surveyed atolls, additional sites were chosen for fish biodiversity surveys to better capture the range of existing habitats, and therefore a gain better representation of fish communities. A total of 14 sites were surveyed. Biodiversity swims were conducted at all 14 sites, including 4 sheltered sites (green dots in *Figure 19*), 3 exposed sites (red dots), 4 lagoon sites (yellow dots) and 3 lagoon pinnacle sites (blue dots), with an additional reef flat location surveyed on snorkel (pink dot). Transects were laid out for fish biomass and density assessment at 8 of the sites, including 4 sheltered sites and 4 lagoon sites *(Figure 20)*.

As in Nukulaelae, the reef habitats challenged our views of which side was exposed and which was sheltered. Observations suggest that the west-facing side may be more consistently subject to high-energy winds and waves. This side had a more uniform reef structure, while the east-facing side had a greater variety of structurally complex habitats with a high cover of plate and branching corals. However, during the survey time the east-facing side was more difficult to access, and only three dives were carried out there. Four sites were chosen to survey the other habitats (sheltered side and lagoon), and three sites were located in an additional habitat – lagoonal pinnacles. These pinnacles were distributed widely, especially towards the western side of the lagoon, emerging from the lagoon floor to just below the surface.

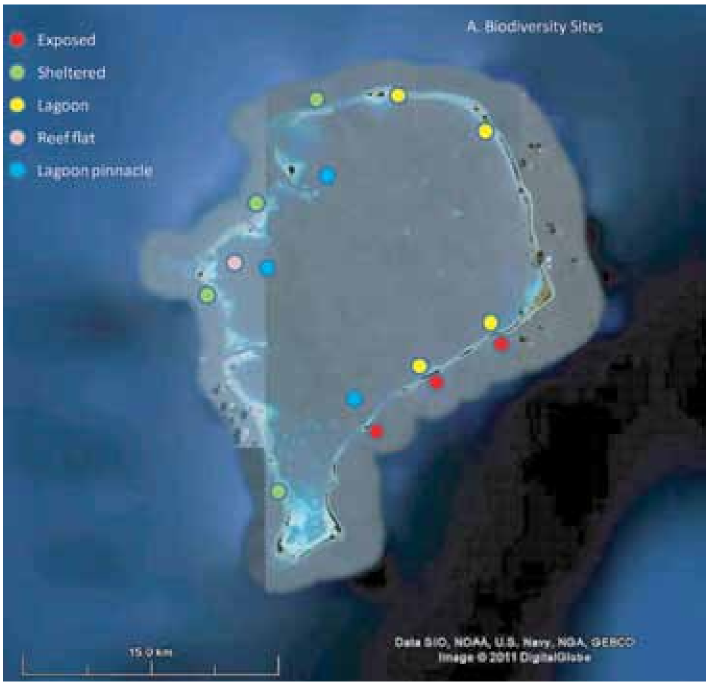

Figure 19. Preliminary map of Funafuti sites for fish surveys: sites used for biodiversity assessment.

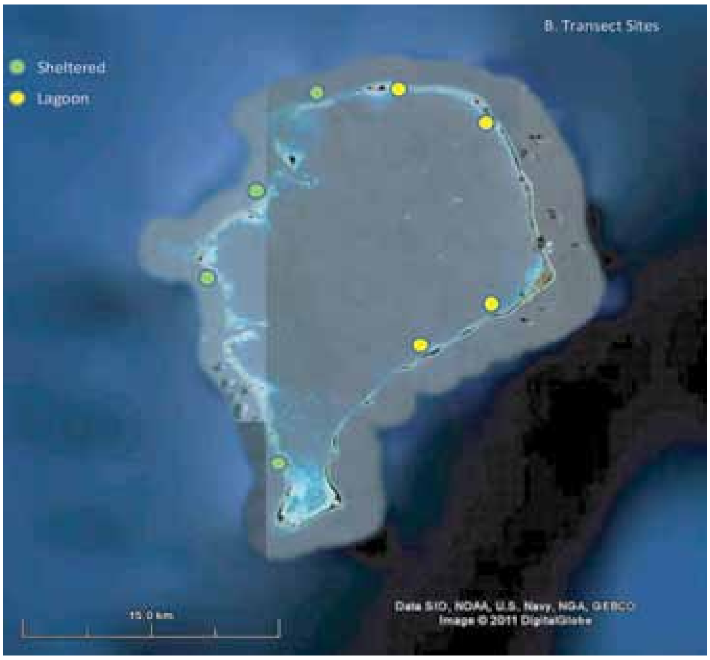

Figure 20. Preliminary map of Funafuti sites for fish surveys: sites used for transect surveys.

5. CONSTRAINTS

The marine resource assessment methods used for the Conservation Areas were chosen to be sufficiently simple and inexpensive to be replicable without the need for high-tech equipment, advanced skills or scientist participation. At the same time, these methods were based on sound science to produce reliable results on the dynamics of marine resources.

This participatory approach imposed a number of constraints:

1. Marine resources were surveyed in shallow reef flat and lagoon areas accessible by snorkelling and free-diving. Resources at depths greater than 5 meters were not surveyed.

2. This survey focused on species of value to the local communities, either as food or material for handicrafts, and therefore does not constitute an exhaustive inventory of fish or invertebrates. A species list of target organisms was compiled that reflected local resource use and not biodiversity.

3. Local daily life priorities, interisland boat availability, etc., were obviously to be taken into account in the schedule. The participation of local islanders to the survey imposed a number of time constraints related to their additional activities (feeding livestock, working in the fields, collecting toddy, etc).

The limitations affecting the biodiversity survey were as follows:

1. The biodiversity survey was focused on the fish communities, and did not encompass the biodiversity of corals, sponges, algae, ascidians, or mobile invertebrates.

2. The scope of this project was limited to visual surveys on the reef and lagoonal communities: no collections were made. Collection usually involves the use of poison to capture cryptic and noctural fish. This is a destructive sampling method and this survey was dedicated to non-destructive methodologies.

3. Although incidental observations were made of fish catch during the field survey period, and some existing data on inshore and offshore fisheries (e.g. tuna catches from the SPC database) will be included in the final fish biodiversity dataset, the gathering of fisheries information in the field was not an objective of the present survey.

4. The field survey was conducted on 3 of the 9 islands of the Tuvaluan archipelago: a complete list of fish cannot be developed without visiting the entire archipelago, especially since the islands are relatively distant from each other and distributed along an latitudinal gradient (05°S to 14°S from Nanumea to Niulakita; whereas in this survey we only covered islands that ranged from 05°S to 09°S). Fish species composition (such as most marine animals, and biodiversity more generally) is known to vary with latitude, longitude and depth.

5. Given the remoteness of the trip destinations, visual census activities were carried out in the daytime, to safe SCUBA diving depths (with a depth limit of 20m), and therefore resulted in limited information on nocturnal and deep-water fish.

6. Selected representative sites were surveyed. The resulting species list is unlikely to include every species existing on Tuvaluan reefs as it probably did not cover all existing reef habitats.

7. The surveys were conducted in one season only. However, at low latitudes such as this region, there is little seasonality in reef fish communities, making it unlikely that species were missed due to seasonality.

6. REFERENCES

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7. APPENDIX

APPENDIX 1: FIELD DATA FORM

Fish Assessment

Name of the observer:

Name of the station: Distance to the shore/village/feature (and which):

Date: Time (begin): Time (end):

GPS Point: Direction of the transect: Visibility (m):

Depth (m): Habitat Description:

Name	**#**	**Size**	**Tr**	**Name**	**#**	**Size**	**Tr**

Fish Codes

Size Class

1	2	3	4	5	6	7	8	9
0-5 cm	6-10 cm	11-15 cm	16-20 cm	21-25 cm	26-30 cm	31-40 cm	41-50 cm	>50cm

Tr: Transect number

Macro-invertebrates assessment

Name of the observer:

Name of the station: Distance to the shore/village/feature (and which):

Date: Time (begin): Time (end):

GPS Point: Direction of the transect: Visibility (m):

Depth (m): Habitat Description:

Name	#	Tr	Name	#	Tr

Clams, Trochus and Sea-Cucumbers

Name	Size (cm)	Tr	Name	Size (cm)	Tr

Macro-invertebrates and Disturbance Codes

Tr: Transect number

Substrate composition

Name of the observer:

Name of the station: Distance to the shore/village/feature (and which):

Date: Time (begin): Time (end):

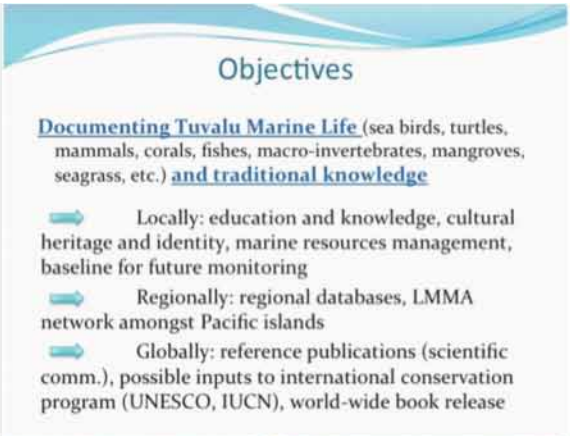
GPS Point: Direction of the transect: Visibility (m):

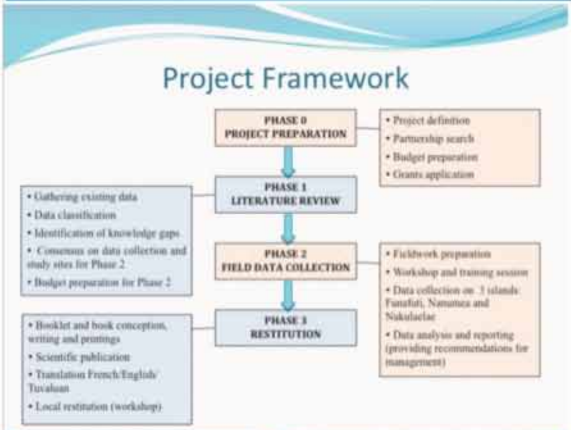
Depth (m): Habitat Description:

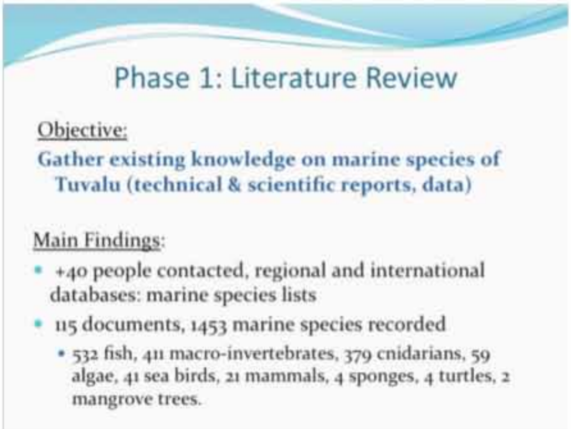
TRANSECT #						TRANSECT #					
0.0		18.0		36.0		0.0		18.0		36.0	
0.5		18.5		36.5		0.5		18.5		36.5	
1.0		19.0		37.0		1.0		19.0		37.0	
1.5		19.5		37.5		1.5		19.5		37.5	
2.0		20.0		38.0		2.0		20.0		38.0	
2.5		20.5		38.5		2.5		20.5		38.5	
3.0		21.0		39.0		3.0		21.0		39.0	
3.5		21.5		39.5		3.5		21.5		39.5	
4.0		22.0		40.0		4.0		22.0		40.0	
4.5		22.5		40.5		4.5		22.5		40.5	
5.0		23.0		41.0		5.0		23.0		41.0	
5.5		23.5		41.5		5.5		23.5		41.5	
6.0		24.0		42.0		6.0		24.0		42.0	
6.5		24.5		42.5		6.5		24.5		42.5	
7.0		25.0		43.0		7.0		25.0		43.0	
7.5		25.5		43.5		7.5		25.5		43.5	
8.0		26.0		44.0		8.0		26.0		44.0	
8.5		26.5		44.5		8.5		26.5		44.5	
9.0		27.0		45.0		9.0		27.0		45.0	
9.5		27.5		45.5		9.5		27.5		45.5	
10.0		28.0		46.0		10.0		28.0		46.0	
10.5		28.5		46.5		10.5		28.5		46.5	
11.0		29.0		47.0		11.0		29.0		47.0	
11.5		29.5		47.5		11.5		29.5		47.5	
12.0		30.0		48.0		12.0		30.0		48.0	
12.5		30.5		48.5		12.5		30.5		48.5	
13.0		31.0		49.0		13.0		31.0		49.0	
13.5		31.5		49.5		13.5		31.5		49.5	
14.0		32.0		50.0		14.0		32.0		50.0	
14.5		32.5				14.5		32.5			
15.0		33.0				15.0		33.0			
15.5		33.5				15.5		33.5			
16.0		34.0				16.0		34.0			
16.5		34.5				16.5		34.5			
17.0		35.0				17.0		35.0			
17.5		35.5				17.5		35.5			

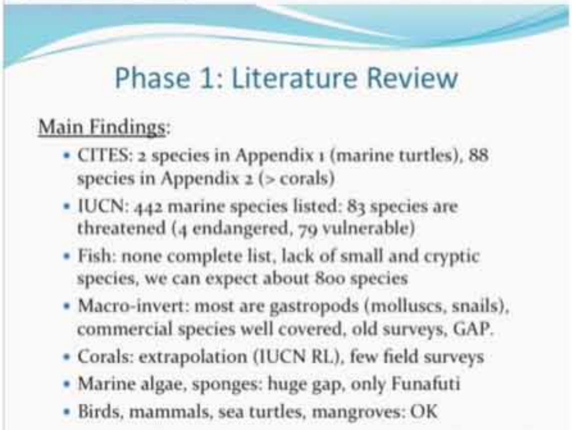
BC	Branching Coral	SC	Soft Coral	RC	Rock (>15 cm) & Limestone
MC	Massive Coral	MA	Macro-Algae	RB	Rubble < 15 cm
TC	Table Coral	TA	Turf Algae	SD	Sand
FC	Foliose Coral	SG	Seagrass	SI	Silt
EC	Encrusting Coral	SP	Sponges		
OC	Other Corals	OL	Other Living organisms		
DC	Dead Coral (recent)				

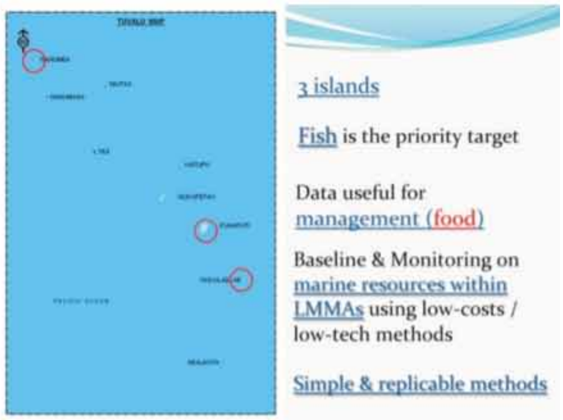
APPENDIX 2: POWERPOINT PRESENTATION

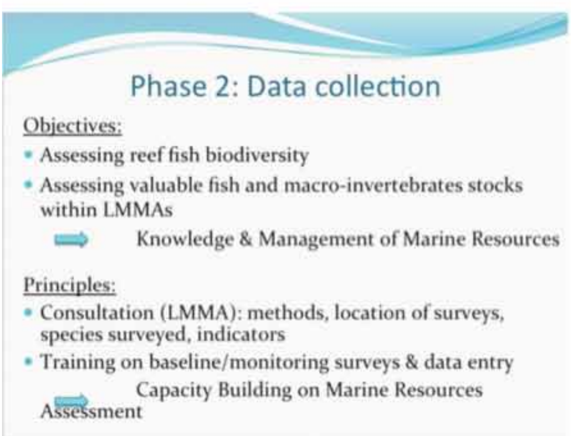


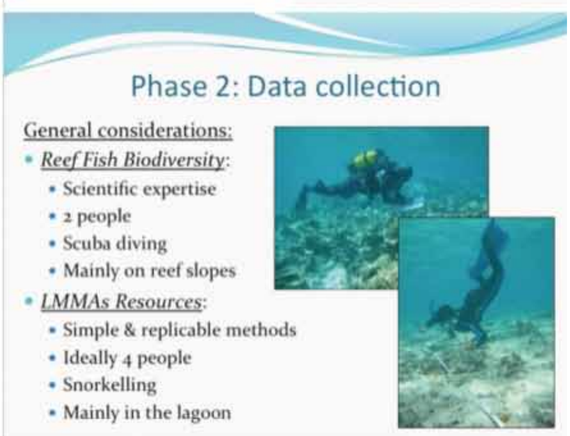












Phase 3: Data Analysis & Restitution

Objectives:

- Using data for **management**:
  - Biodiversity hotspots
  - LMMAs boundaries
  - Baseline for marine resources monitoring
- Using data for **awareness and communication**:
  - Basis for local, regional and international publications
  - Local traditional knowledge, large audience (adults and kids) and scientific community
  - Restitution in Tuvalu + School visits

Project Time Frame

- Project preparation: From 2006 until now…
- Literature Review: November 2008-June 2009
- Data Collection:
  - Preparation: these last 6 months
  - Launching meeting: today!
  - Data collection: 1^{st} May-1^{st} of June 2010
  - Data analysis & Reporting: 1^{st} of June 2010-end of 2010
- Restitution:
  - Restitution in Tuvalu: end of 2010
  - Art book, scientific publication: end of 2011

And after?... Data collection on 3 other outer islands??

Tuvalu Marine Life Project

Reef Fish Biodiversity and LMMA Methods

Survey Types

- *Reef Fish Biodiversity*:
  - Scientific expertise
  - 2 people
  - Scuba diving
  - Mainly on reef slopes
- *LMMA Resources*:
  - Simple & replicable methods
  - Ideally 4 people
  - Snorkelling
  - Mainly in the lagoon

Reef Fish Biodiversity

Measures of biodiversity

- Number of species
- Relative abundance or density
- Number of habitats
- Degrees of difference

Why measure biodiversity?

- Planning for conservation
- Ecosystem health and stability
- Ecological functions
- Biogeography

Measuring Fish Biodiversity

Method 1

- Timed swims
- Habitats deep to shallow
- Record and count all species
- Record habitat types by depth
- GPS tracks for mapping and density estimates

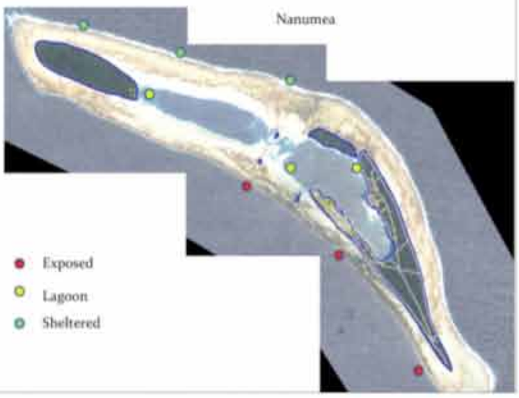
Benefits: Covers many habitats and range of depths, allows sighting of most species, good estimates of large fish

Measuring Fish Biodiversity

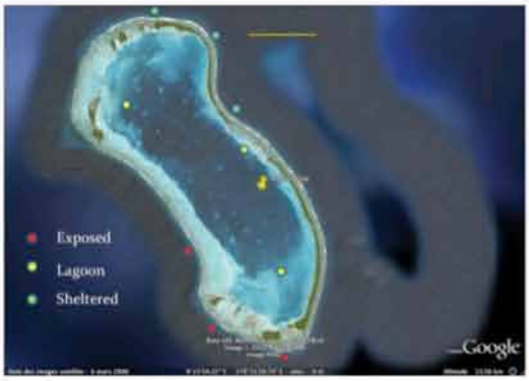
Method 2

- Transects
- Mid-slope habitat
- Record and count all species
- Record benthic categories
- GPS tracks for mapping

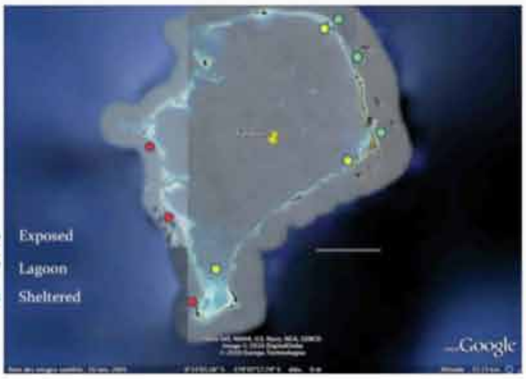
Benefits: Accurate density estimates for medium and small fish, allows good habitat associations, best for comparisons between habitats, atolls and other regions.



Nukulaelae



Funafuti



Locally-Managed Marine Areas

(LMMA)

Community-based adaptive management

- Enhancing traditional management systems
- Marine conservation to benefit communities
- Refuge from exploitation for stock recovery
- Maintaining resilience for ecosystem recovery

LMMA Sampling Methods

Considerations

- Species (valuable fish and macroinvertebrates – edible, indicators, keystone, emblematic, etc.)
- Habitat
- Accessibility
- Equipment
- Personnel
- Use of information
- Spreading of knowledge

LMMA Sampling Methods

- Habitats chosen to represent all indicator species
- Transects at least 50m long, 2m each side
- Consideration for rare species
- At least 3 transects in each habitat
- Record number and size of all individuals
- Record broad habitat characteristics
- Benthic community (LIT)
- Catch rates

LMMA Sampling Methods

Macroinvertebrates – belt transects (50 x 4m)

Fish – belt transects (50 x 10m)

Benthic composition – line transects (50m, one point every 50cm)

LMMA Sampling Methods

Catch – number and size of fish and macroinvertebrates

High-density aggregations - quadrats

What's Next?

- Species lists
- Species identification
- Datasheet preparation
- Equipment check
- Boat availability

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