MARINE ENVIRONMENT SURVEY :

PROPOSED ALEIPATA ISLANDS NATIONAL PARK , WESTERN SAMOA

Andrews , G. J. * and Holthus, P . F . **

Report to the Western Samoa Government

1989

* Tropical Marine Consultancies
P . O . Box 30
TOWNSVILLE 4810
Australia

** SOUTH PACIFIC REGIONAL ENVIRONMENT PROGRAMME (SPREP)
South Pacific Commission (SPC)
P . O. Box D 5
NOUMEA CEDEX
New Caledonia

CONTENTS

TABLES AND FIGURES

TABLES

FIGURES

1. Foreword

The report documents the results and recommendations of a marine environment survey of the Aleipata area, Western Samoa, carried out by the authors from 16 to 26 June 1988. The purpose of the survey was to describe the reef and lagoon habitats, and their constituent organisms, found in the proposed Aleipata Islands National Park area. In particular, the distribution of fish, corals, algae, seagrass and benthic macro-invertebrates was recorded. Information was gathered on the types and patterns of marine resource use and on degradation or destruction of the marine resources or their associated habitats.

The government of Western Samoa requested the South Pacific Regional Environment Programme (SPREP) to organise this survey under the auspices of the South Pacific Commission (SPC) provision of Short-Term Experts and Services in mid-1986. This request followed recommendations from a feasibility study undertaken by a consultant to UNESCO in late 1985 (Chew, 1987) calling for an "inventory of marine life" and "survey of submarine sea scapes" in the proposed park. The feasibility study was sought by Western Samoa in July 1985 at the Third South Pacific Conference on National Parks and Reserves. The Aleipata Islands (Nu'utele, Nu'ulua, Namu'a and Fanuatapu), also referred to as the Nu'utele Island group, were originally suggested as a national park in an IUCN/UNDAT survey proposing a national park system for Western Samoa (Holloway, 1976). In 1978, the SPC Ecological Advisor further recommended the establishment of a recreational reserve at Namu'a Island as a first step (Dahl, 1978).

The results reported here are restricted by a number of conditions. The survey was conducted during daylight hours only. Thus, nocturnal populations and aspects of the Aleipata marine environment have not been recorded. In addition, the results only reflect that information gathered during a ten-day period in June 1988 and therefore cannot account for seasonal or long-term variations in the marine communities. Finally, the Aleipata area was influenced by strong tradewinds and high seas during the survey and these conditions may have influenced the marine environment and organisms observed.

2. Abstract

The Aleipata area surveyed includes the south-eastern coast of Upolu Island, Western Samoa. The survey consisted of general descriptive ecology and morphology for the Aleipata coastal fringing reef and the fringing reefs of the two detached islands, Nu'utele and Nu'ulua. The area behind the coastal fringing reef to the shoreline was a shallow (<4 m deep) area of sand, rubble, seagrass beds and mixed coral assemblages. A shallow reef platform and algal ridge characterised the reef edge. The reef slope was generally low in hard coral cover except for a few areas. Extensive areas of dead, standing coral colonies covered with algae indicate the effects of Crown-of-Thorns starfish (*Acanthaster planci*) outbreaks in the past decades. The reefs around Nu'utele and Nu'ulua and the south-facing coastal reef were consistently higher in coral cover and diversity. The fish populations appeared to be large and diverse and dominated by the herbivores and corallivores.

The Aleipata area reefs supply the local population with much of their food resources, and a survey of resource use and techniques was conducted. Interviews with village fishermen indicate that a variety of fish and invertebrate food resources are harvested from the reefs. Numerous techniques are employed and most fisheries are pursued throughout the year, with the harvest mainly for local consumption. Some information on fishing rights, destructive fishing practices and local oceanographic conditions was also gathered.

The survey revealed that the Aleipata marine environment supports typical coral reef habitats and associated plant and animal communities, and does not contain particularly unique or spectacular organisms, communities or morphologic features. However, the Aleipata area marine resources are important to the local villages. The villages' use of these resources and traditional community-based resource management practices must be taken into consideration if national park development proceeds.

3. Introduction

The Aleipata area is situated on the south east coast of the island of Upolu, in Western Samoa (Figure 1.). The area consists of a narrow coastal strip backed by high cliffs which reach a height of around 150 m and slope towards the coast. The underlying substrate is volcanic rock of the Salani volcanics. The soils are relatively shallow and generally of poor fertility. The four islands off the coast of Aleipata: Fanuatapu, Namu'a, Nu'utele and Nu'ulua all consist of heavily eroded tuff cones with coral fragments incorporated within the rock (Ollier et al. 1979). The Aleipata coastline is heavily populated and cultivated whereas its associated islands are uninhabitated.

A marine environmental survey was conducted in the coastal area between the villages of Latu in the south and Sale'a'aumua on the east coast. The reef front survey was conducted between Tuluinga passage in the south and Fuinu'u passage in the northeast. The marine environment surrounding Nu'utele and Nu'ula Islands was also included (Figure 2.). This area coincides generally with the park boundaries originally proposed in the draft feasibility study (Chew, 1986), but is based on prominent natural features (i.e. reef passes) rather than map co-ordinates. Within this area, the survey extended from mean high water to the bottom of the outer reef slope (depths of approximately 30 m) including the coastal fringing and detached island reefs, and isolated patch reefs (Figure 3.). The intertidal areas immediately adjacent to the Aleipata mainland are described as the shoreline.

The submerged back reef area extending from the shoreline to the fringing reef edge was shallow (maximum depth of 4 m, average depth 2-3 m) with sand and rubble, seagrass and coral patches and is described as the lagoon. To facilitate description, the lagoon area was sub-divided into two sections, north and south, separated by the jetty and adjacent reef pass (Ana). The southern lagoon extends from the jetty south to Cape Tapaga. The wider northern lagoon extends north from the wharf to the pass at Fuinu'u and across to Utufa'alalafa village. In addition, the narrow back reef area from Cape Tapaga west to Tuluinga pass is referred to as the south-facing lagoon. The back reef areas of the two southern islands, Nu'utele and Nu'ulua, were relatively narrow and of limited extent, and were not fully investigated.

Lagoon depths decrease towards the reef edge, with a zone of coral patches and rubble. A very shallow reef platform and crest of coralline algae characterise the reef edge. This drops off to the spur and groove or terrace formations of the reef front. The reef slope then continues sharply downward to a sediment dominated bottom. One submerged patch reef with a pinnacle was identified and investigated in the waters off the Aleipata fringing reef.

There is little published information specific to the environment of the Aleipata area. A brief description of the area's geology, coastal geomorphology and wildlife was included in Ollier, et al. (1979). Other background information concerns the nesting of hawskbill turtles (*Eretmochelys imbricata*) on the islands (Witzell and Banner, 1980; Hansen, No Date). More recently, a comprehensive review of the vegetation of the Aleipata Islands (Whistler, 1983) and a reconnaissance survey of the Aleipata lagoon's landfill and construction materials were conducted (Richmond, 1985).

More general information for Western Samoa was also available on: reef and lagoon resource management (Johannes, 1982); inshore fisheries (Zann et al., 1984); coastal management (Bell, 1985) and Crown-of-Thorns starfish (Garlovsky and Bergquist, 1970). The latter subject is of considerable importance to the condition of Aleipata reef communities and additional information from nearby American Samoa was consulted (Birkeland, et al., 1987; Wass, 1980).

Figure 1. Location of Western Samoa and Aleipata area

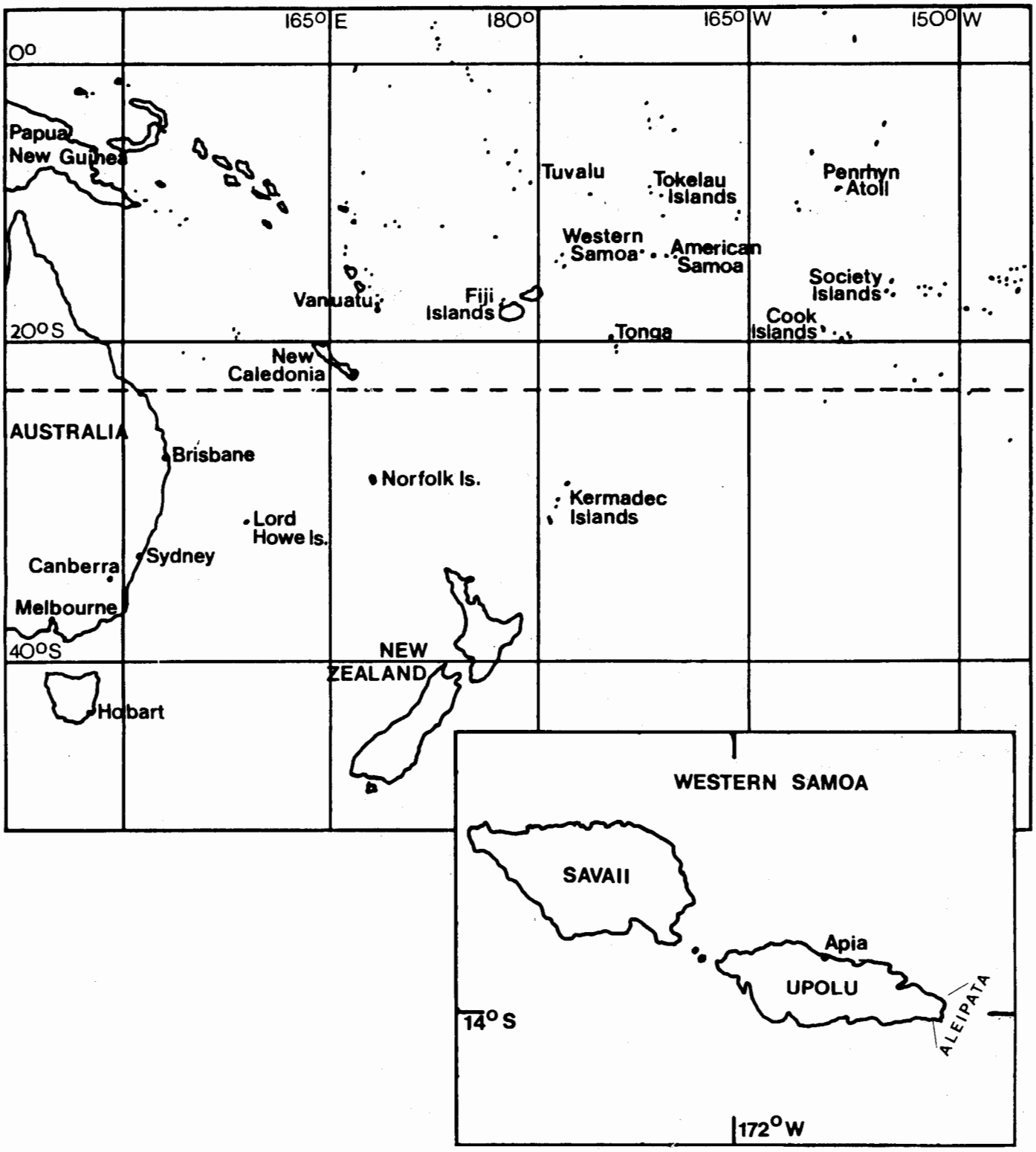


Figure 2. Aleipata survey area

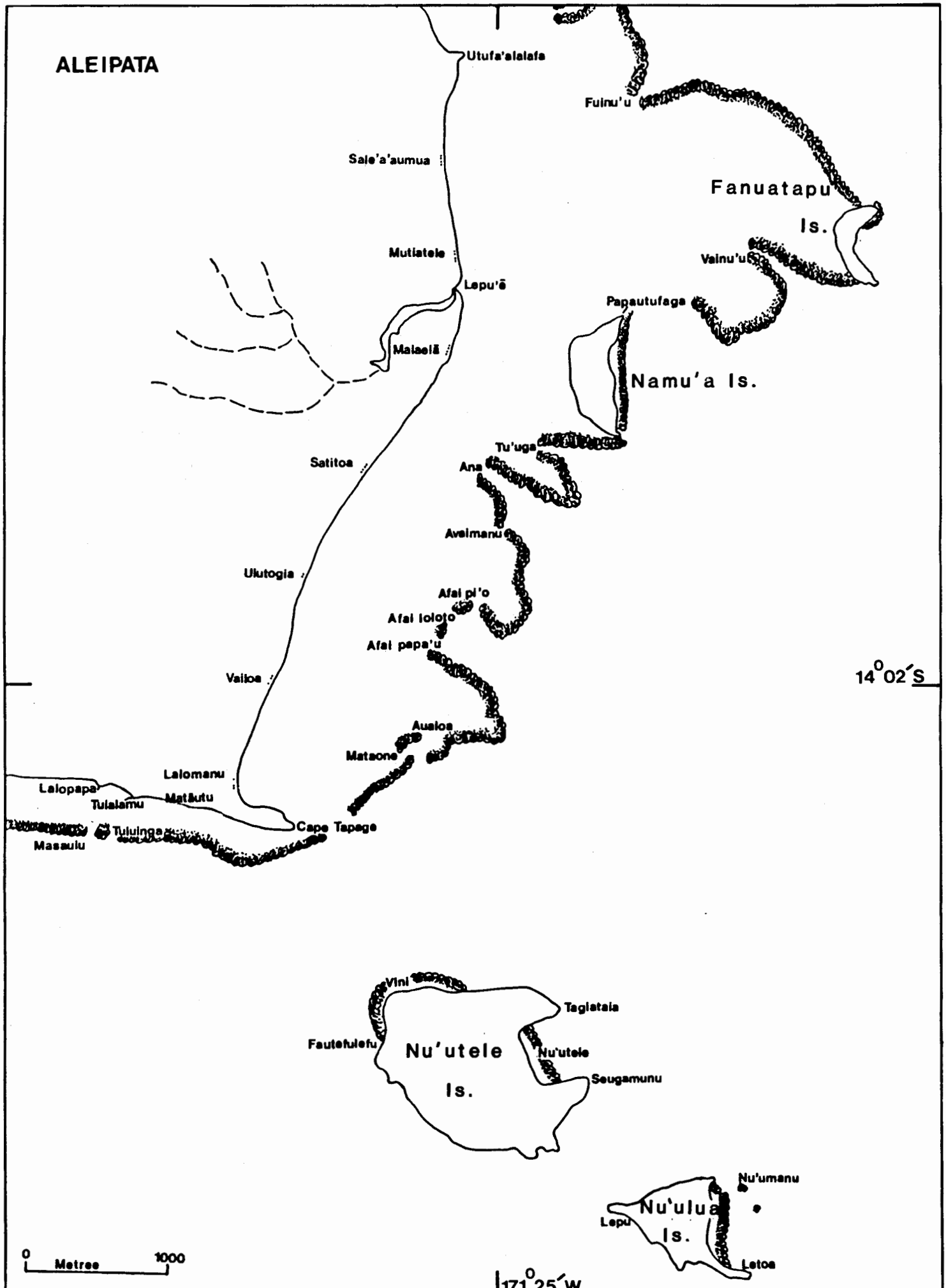
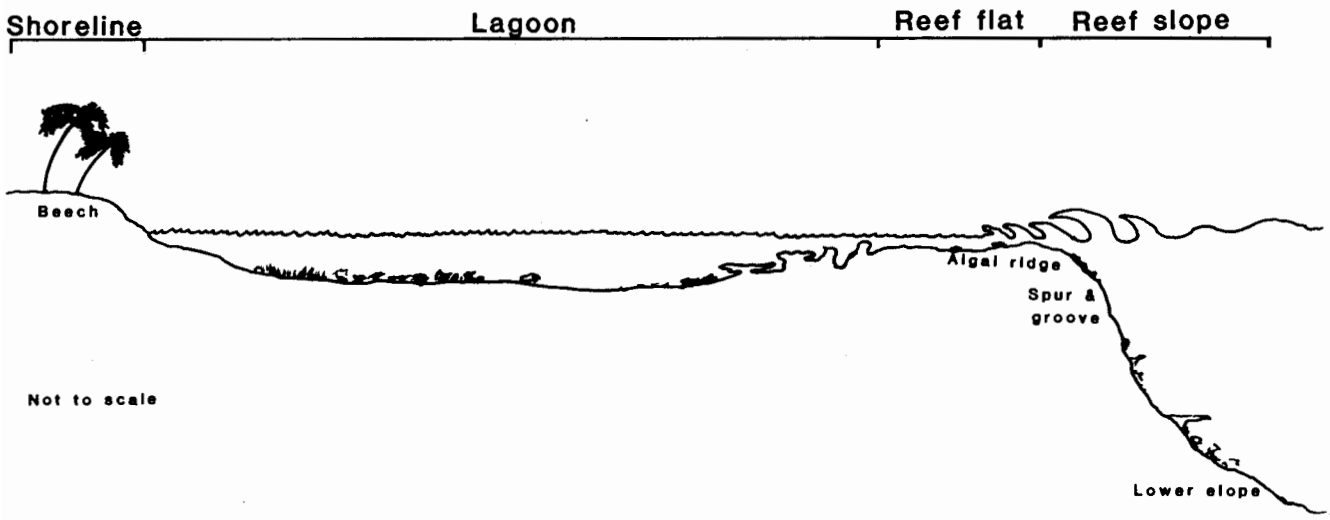


Figure 3. Diagrammatic cross section of survey area



4. The Shoreline, Lagoon And Shallow Reef Environment

Aerial photographs of the shoreline, lagoon and shallow reef were reviewed. A working map of major lagoon habitat types was drafted. The lagoon and reef flat habitats were verified and their communities documented through ground truthing conducted by extensive surveys using snorkeling equipment. A map of shoreline, lagoon and reef habitats was produced (Figure 4.).

A combination of dominant seagrass, corals, substrate type and geomorphology was used to differentiate 11 types of lagoon habitat:

1. Shoreline
2. Sand substrate
3. *Syringodium* seagrass beds
4. *Halophila ovata* seagrass beds
5. Sand/*Halophila* assemblage
6. Mixed coral assemblage
7. *Porites cylindrica* dominated coral assemblage
8. Massive *Porites* dominated coral assemblage
9. Sand/rubble substrate
10. Reef crest
11. Dredge and fill

4.1. Shoreline

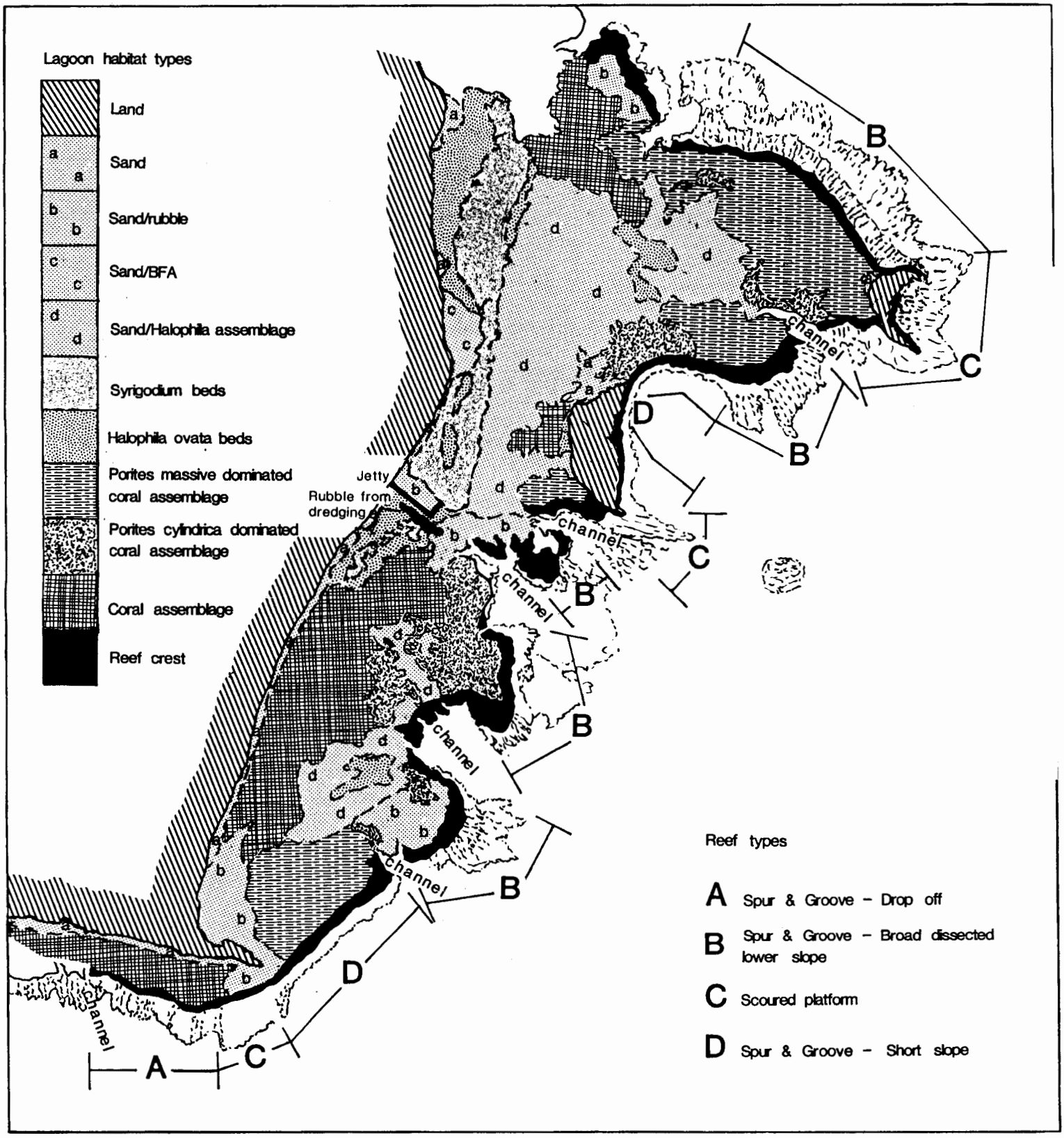
The shoreline of the area surveyed consisted mainly of sandy beaches. Much of the east-facing shoreline was eroding (see Section 7.6., this report; Richmond, 1985). There were short, steep erosion scarps with the root bases of mature tree exposed. Some trees had fallen into the lagoon. A number of house sites seaward of the coastal road, and parts of the road, had been fortified with seawalls.

The shoreline of Cape Tapaga, in the south-east, consisted of basalt cliffs from 3 m to 5 m high. On the south-facing side of Cape Tapaga, wide beachrock flats were exposed at low tide. West from Cape Tapaga, the beaches became wider with little evidence of severe erosion. Occasional outcrops of basalt boulders punctuated the south-facing beaches.

4.2. Sand substrate

A narrow band of sand in the immediate sub-tidal zone was adjacent to most of the Aleipata shoreline. Large sand deposits extended into the lagoon in places. On the north-west side of Namu'a island a sand bank extended into the lagoon. At Utufa'alafa towards the northern end of the area surveyed another large sand deposit extended from the shore into the lagoon.

Figure 4. Habitat map of Aleipata lagoon and reef front morphology



In front of the stream mouth at Lepu'e, there was an area of fine sand supporting a mass of fine blue-green filamentous algae. The shallow area had very poor water visibility due to the filamentous algae and suspended particulate matter. Heavy algae growth appeared to be related to the stream outflow, as it was restricted to the area directly adjacent to the stream mouth.

4.3. *Syringodium isoetifolium* seagrass beds

A large area along the northern lagoon was occupied by dense beds of *Syringodium isoetifolium* seagrass. For much of this area the flat sandy substrate had 100% cover of the dark-green seagrass. The seagrass had cylindrical blades 10-25 cm long and formed mono-specific meadows which were readily identified from aerial photographs. South of the jetty, smaller, less-continous *Syringodium* beds occurred. In these areas, and on the edges of the northern inner reef, hummocks of seagrass were raised above the intermittent sand patches within the seagrass area.

Very few other organisms were observed within these dense seagrass beds. Sand patches between *Syringodium* hummocks were occupied by small patches of the brown algae *Dictyota sp.*. Branching black and orange sponges were occasionally encountered within the *Syrigodium* beds.

Water temperatures, though not quantified, were noticeably higher within the *Syrigodium* beds and visibility was greatly reduced indicating a lack of water circulation in these areas. Large masses of *Syringodium* blades were also noticed washed up on the adjacent shore and rafts of the blades were seen drifting out the reef passes during ebb tides.

4.4. *Halophila ovata* seagrass beds

Broad expanses of sand flats within the lagoon were dominated by the seagrass *Halophila ovata*. Dense beds of *Halophila* occupied areas of compact, medium-grained sand between the shore and the much denser *Syringodium* beds. A number of *Halophila* patches were completely surrounded by large *Syringodium* meadows. A narrow band of *Halophila* bordered the seaward side of the *Syringodium* beds towards the northern end of the survey area. Immediately south of the jetty, *Halophila* beds surrounded, and were interspersed with, the patchy *Syringodium*.

Within the *Halophila* beds, the irregular sponges found in the *Syringodium* were also present. Small colonies of hard coral (predominantly *Pocillopora damicornis* and *Porites cylindrica*) were found scattered throughout the seagrass. The sea urchin *Echinometra mathaei* was also present. Within larger, shoreward *Halophila* beds, visibility was again noticeably reduced but not to the extent within the *Syringodium* beds.

Some *Halophila* beds were located away from the shoreward lagoon area. One of these was near the centre of the large northern lagoon, between the shore and Fanuatapu island. Similarly, towards the centre of the widest point in the southern lagoon there was a small *Halophila* bed. Both of these areas were surrounded, and graded into, areas of sparse *Halophila* and sand, which are described in the following section. In addition, there was a narrow bed of *Halophila ovata* along the western side of Namu'a island.

4.5. Sand/*Halophila* assemblage

Sparsely distributed *Halophila ovata* dominated the sand substrate of the wide northern lagoon. The *Halophila* varied in abundance from very little to isolated patches similar in density to the large, dense *Halophila* beds described above. The substrate consisted of medium-grained sand, with patches of coarser sand and coral rubble. The sand and *Halophila* area in the southern lagoon was similar to most of the larger northern lagoon assemblage.

Few other organisms were observed within the sand and *Halophila* area. Small branching coral colonies of *Pocillopora damicornis* and *Porites cylindrica* occasionally were found. Small sea urchins (*Echinometra sp.*) were present. Massive corals (*Porites sp.*), up to 2 m in diameter, were sporadically distributed throughout the sand and *Halophila* areas. These massive coral colonies were especially common in the eastern portion of the large sand and *Halophila* assemblage in the northern lagoon. In some cases these *Porites sp.* colonies had reached the mean low water level and their upper surfaces had died, creating microatolls.

4.6. Mixed coral assemblage

A large portion of the inner southern lagoon and most of the south-facing lagoon contained a mix of coral types and substrate. Smaller areas of this assemblage were found in the far north of the survey area and just west of Namu'a island. The substrate in these areas was variable, but generally consisted of sand and rubble with scattered large reef blocks and dead, standing coral colonies. Sand predominated closer to shore, with patches of coarse (3-5 cm) rubble in the central lagoon. In the narrow south-facing lagoon, a mix of coarse sand and rubble, with patches of scoured reef pavement, was found towards the reef crest.

In the mixed coral areas, hard coral coverage was highly variable and ranged from 20-30%. Coral species found in these areas commonly included: *Porites cylindrica*, *Pocillopra damicornis*, *Psammocora contigua* and heads of the massive coral, *Porites sp.* Other hard corals encountered less frequently were: *Fungia spp.*, *Millepora exaesa*, *Alveopora sp.*, *Sandolitha robusta*, *Pavona decussata*, branching *Acropora spp.*, *Cyphastrea sp.*, *Leptastrea sp.* and *Pocillopora verrucosa*. In the south-facing lagoon, the mix of corals included: *Acropora robusta*, *Acropora humilis*, *Pocillopora eydouxi*, *Lobophyllia sp.*, *Euphillia sp.* and other low branching and small plate *Acropora* colonies.

Soft coral colonies and zoanthids (predominately *Sinularia* and *Palythoa*) were present within the mixed coral assemblage. Holothurians (sea cucumbers) occurring in the sand/rubble areas included *Holothuria atra* and *Synaptid sp.*. The sea urchins *Echinometra mathai*, *Diadema setosum* and the pin cushion urchin *Culcita novaeguineae* were present. In addition, occasional encrusting and small branching sponges were encountered. The macroalgae *Halimeda sp.*, *Chlorodesmis sp.* and the brown algae *Dictyota sp.* were also present. Bare sandy portions of the mixed coral assemblage areas supported the seagrass *Halophila ovata*.

4.7. *Porites cylindrica* dominated coral assemblage

Between the reef crest and the mixed coral assemblage or the sand/*Holophila* areas, shallow lagoon areas were dominated by colonies of *Porites cylindrica*. These areas consisted of monospecific beds of the finger coral *Porites cylindrica*, up to 5 m in diameter, and associated beds of rubble. The largest expanse of this occurred in the southern lagoon, but it was also present to the north and east of Namu'a Island in the northern lagoon. Extensive colonies of the soft coral *Sinularia sp.* were also present in the *Porites cylindrica* areas.

Other hard corals present within this area included: *Porites rus*, *Seriatopora hysterix*, *Millepora exaesa*, *Pavona varians*, *Acropora humilis*, *A. robusta*, *A. hyacinthus*, and *Millipora dichotoma*. Other corals which were less conspicious included: *Merulina ampliata*, *Galaxea fascicularis*, *Astreopora sp.*, *Fungia sp.*, *Pavona decussata*, *Leptastrea purpurea*, *Pocillopora eydouxi* and *P. meandrina*.

Invertebrates which occurred within this *Porites cylindrica* area included the sea urchins *Echinometra mathai* and *Diadema setosum* and the blue starfish *Linkia laevigata*. Numerous Holothurians and anenomes were also present. Algae similar to that which were found in the mixed coral assemblage (*Halimeda*, *Chlorodemis* and *Dictyota*) were also present within this assemblage.

4.8. Massive *Porites* dominated coral assemblage

A large area immediately behind the reef crest between Fanuatapu and Namu'a islands was characterised by a coral assemblage dominated by massive *Porites* colonies. Similar areas were found in the southern lagoon, northeast of Cape Tapaga, and in the northern lagoon immediately southwest of Namu'a island. These areas were associated with reef fronts exposed to consistently strong wave action and wave set currents which sweep into the lagoon. Evidence of this was obvious from the striated, reef boulder tract patterns, visible from aerial photographs, which were aligned parallel to the direction of the strong current. The massive *Porites* colonies are known to be slow-growing and may be very old by the time they reach the 1-2 m size found in these areas. The upper portions of those colonies which have reached mean lower sea level die back as a result of exposure during extremely low tides while the living coral around their sides continues to grow laterally, creating microatolls. Between the massive *Porites* colonies and microatolls and the lineations of large reef blocks, coarse sand and rubble dominate the substrate.

An assemblage of other hard corals was also present in the massive *Porites* area. *Pocillopora damicornis* was predominant among these assemblages, which also included: *Millepora dichotoma*, *M. exaesa*, *Pocillopora meandrina*, *P. eydouxi*, *Acropora humilis*, *A. hyacinthus*, branching *Acropora sp.*, and, towards the reef crest, *Porites cylindrica*. Many of the corals' morphologies displayed stout, robust and prostrate growth forms, an indication of the strong currents occurring in this area.

Invertebrates similar to those found in the other lagoon areas were present within the *Porites* coral assemblage. The sea urchins *Echinometra mathai* and *Diadema setosum* and the starfish *Linkia leavigata* were again present. *Holothurians*, in particular *Bohadschia argus* and Synaptid sp. were also present.

4.9. Sand/rubble substrate

In the high energy reef front areas were a number of sand and rubble zones located immediately behind portions of the reef crest in both the northern and southern lagoon. There was little live coral found in these areas. The substrate was dominated by 3-7 cm sized coral rubble, which was often covered by an algal turf layer and coarse sand. Sea urchins were common, in particular *Echinometra mathai*. Various *Holothurians*, including Synaptids, were again present.

4.10. Reef crest

The ocean edge of the Aleipata lagoon was characterised by a reef crest influenced by the strong wave action common along this coast. On the shoreward side the reef crest grades into the adjacent sand and rubble, *Porites* dominated or mixed coral assemblage areas. Holothurians, particularly *Holothuria atra*, were common in these adjacent areas. Towards the ocean, the algal turf coated rubble becomes larger, grading into coral cobbles and plates, with scattered reef blocks towards reef front.

Along the reef crest, which may be up to 10 m wide, a shallow scoured reef pavement dominated by the red coralline algae *Porolithon* was found. This crest was fully exposed at low tide and has many pools and crevices containing the fine branching algae (*Jania sp.*) and sea urchins (*Diadema sp.*). Within the pools which retain water at low tide were small, robust colonies of *Acropora humilis*, *A. digitifera*, encrusting *Montipora sp.*, and *Pocillopora meandrina*.

4.11. Dredge and fill

During the mid-1970's, a portion of the shallow inshore lagoon was dredged to construct the solid fill jetty at the central sector of the Aleipata coast (Figure 4.). An area immediately to the south and east of the jetty was dredged, presumably to provide the fill material for the now derelict structure. The dredge site was approximately 5 m deep with a sand and rubble bottom. As with other reef dredge sites, the water remains turbid and cloudy due to the continual resuspension of fine sediments.

5. The Reef Slope Environment

The fringing reefs along the Aleipata coast and surrounding Nu'utele and Nu'ulua Islands were initially surveyed using manta tow techniques to determine broad scale benthic community patterns.

Based on the manta tow survey data, and aerial photograph interpretation, five distinct reef front morphologies were identified for the Aleipata fringing reef (Figure 4.). The detached islands of Nu'utele and Nu'ulua represent distinct environments and are described separately.

Eleven dive sites were selected for more intensive surveys (Figure 11.). During each dive, which lasted from approximately 30 to 50 minutes, reef morphology and relative abundance of coral and fish species was recorded. The data was synthesized into descriptions of the marine environment for each reef front morphology type. A list of the fish species recorded is presented as Appendix 1.

5.1. Reef slope benthic community patterns

Manta tow survey procedures were used to record low resolution data of reef slope benthic organisms (Done et al. 1981). From this, the general pattern of reef slope benthic communities was determined. An observer wearing snorkeling equipment was towed by a small boat at a speed of approximately two knots along the reef perimeter. Observations of the benthos were recorded from below the surf zone (approximately 3 m) down to around the 15 m depth.

Each tow lasted two minutes and covered a distance of between 130 and 250 m along the reef perimeter (tow lengths varied according to boat speed and sea conditions). After each tow the boat was stopped and observations for the area recorded on data sheets attached to the manta board. Six categories were selected for data collection:

1. Hard coral cover
2. Soft coral cover
3. Dead coral cover
4. Macroalgae
5. Colony size
6. Hard coral species diversity

The scoring system for the six categories is presented as Table 1. Dead coral refers to coral that has recently died and was either still bleached and white or had a thin veneer of turf algae. This category was included to ascertain possible damage from corallivores such as *Acanthaster planci* or *Drupella*. Macroalgae refers to all conspicuous, large algae except coralline algae. Colony size is scored on a three point scale; only when colony size is exceptionally large or small is a score other then '2' recorded. Species diversity was recorded on a four point scale (Done et al. 1981).

The path of each tow was recorded on map overlays. Tow areas were mapped in relation to reef morphological features and bearings on permanent points of the reef. After each series of tows the tow sequences were transferred onto a master map.

Table 1. Manta tow observations and scoring system. (after Done et al., 1981)

Categories	Scores	Comments
Hard coral cover	0 - 6	0 = 0%
		1 = 1 - 5%
Soft coral cover	0 - 6	2 = 6 - 10% (percentages
		3 = 11 - 30% of total
Dead standing coral	0 - 6	4 = 31 - 50% area
		5 = 51 - 75% surveyed)
Macroalgae cover	0 - 6	6 = 76 - 100%
Species diversity	1 - 4	1 = Monospecific
		4 = High diversity
Colony size	1 - 3	1 = Exceptionally small
		2 = Unexceptional
		3 = Exceptionally large

The results for the manta survey are presented as a series of shaded maps, Figures 5 to 10. The raw data is presented as Appendix 3. The scores are broken down to represent three categories of substrate cover: 1 to 10% represents low cover, 11 to 50% represents medium cover and above 50% indicates high cover based on experience from other Pacific island marine resource surveys (Andrews, 1987).

The percentage hard coral cover along the coast of Aleipata was generally below 10% (Figure 5.). On the south-facing coast, the area between Mataone passage and Tuluinga passage recorded between 10 and 50% cover. A small area on an exposed point near Afai pi'o and another small area near Fuinu'u passage at the northern limits of the survey also recorded between 10 and 50% cover (Figure 5.).

Coral cover around the islands of Nu'utele and Nu'ulua were restricted by the lack of available substratum. Coral communities around these islands were more diverse and covered a higher proportion of the bottom than on the Aleipata coastal fringing reef. Highest cover was located around the northwestern end of Nu'utele near Vini reef, and a small area on the northern end of Nu'utele reef. The northern side of Nu'ulua had 10 to 50% hard coral cover (Figure 5.). The remaining areas around Nu'ulua were not surveyed because of the poor weather conditions and rough seas.

Overall, the hard coral cover of the Aleipata area surveyed was low. The abundance of dead coral skeletons suggested that this was not always the case and was consistent with areas that have had large aggregations of the Crown-of-Thorns starfish *Acanthaster planci*. Areas of higher coral cover in many cases were represented largely by the massive coral *Porites sp.* which has been shown to be less preferred prey of *A.planci* (Barnes et al., 1970; Brauer et al., 1970; Pearson, 1973; Potts et al., 1985).

The percentage of soft coral was consistently low, generally below 10% (Figure 6.). Isolated areas had higher soft coral cover of the genera *Lobophytum*, *Sarcophyton* and *Sinularia*, with occasional zoanthid areas *(Palythoa)*. The areas of high cover did not appear to reflect any pattern related to reef morphology or substrate cover by other organisms.

Dead coral (coral colonies that are white and bleached) can indicate the presence of corallivores such as *A. planci* or *Drupella*. Only a small amount of white, dead coral was observed on the outer reef (Figure 7.). Recently killed coral was seen within the lagoon and two *A. planci* were observed feeding on corals (*Montipora sp.* and *Acropora sp.*) in the lagoon between Tuilinga passage and Cape Tapanga.

Macroalgae cover was consistently low except for a small area between Ana passage and Afai pi'o passage which had a higher than average percentage of high turf algae (Figure 8.). Areas with low percentage cover of hard coral consistently had extensive cover of coralline algae overgrowing dead coral skeletons.

Benthic community diversity was recorded for hard coral species only (Figure 9.). Overall, those areas which had higher levels of hard coral cover displayed greater species diversity. In general, the Aleipata reef front supports coral communities of low to medium diversity of hard corals.

The size of hard coral colonies can indicate particular habitats or growth stages of the coral community. Along the coastal fringing reef, size of the corals within the coral communities was generally unexceptional (Figure 10.). The areas where coral colonies were particularly small may relate to higher than average wave activity. Exceptionally small colonies located in obviously low wave energy regimes may represent recently established coral colonies.

The south-facing reef, west of Tuluinga passage, was an area of well-established, large coral colonies which may represent the previous conditions which existed along the entire Aleipata fringing reef. Coral sizes on the reef around Nu'utele island are mostly unexceptional except two areas of large single colonies of massive *Porites sp*. The reef along the northern end of Nu'ulua island has many larger colonies, possibly representing Aleipata reef conditions prior to the decimation of much of the live coral cover.

Figure 5. Manta tow data for percentage cover of hard coral

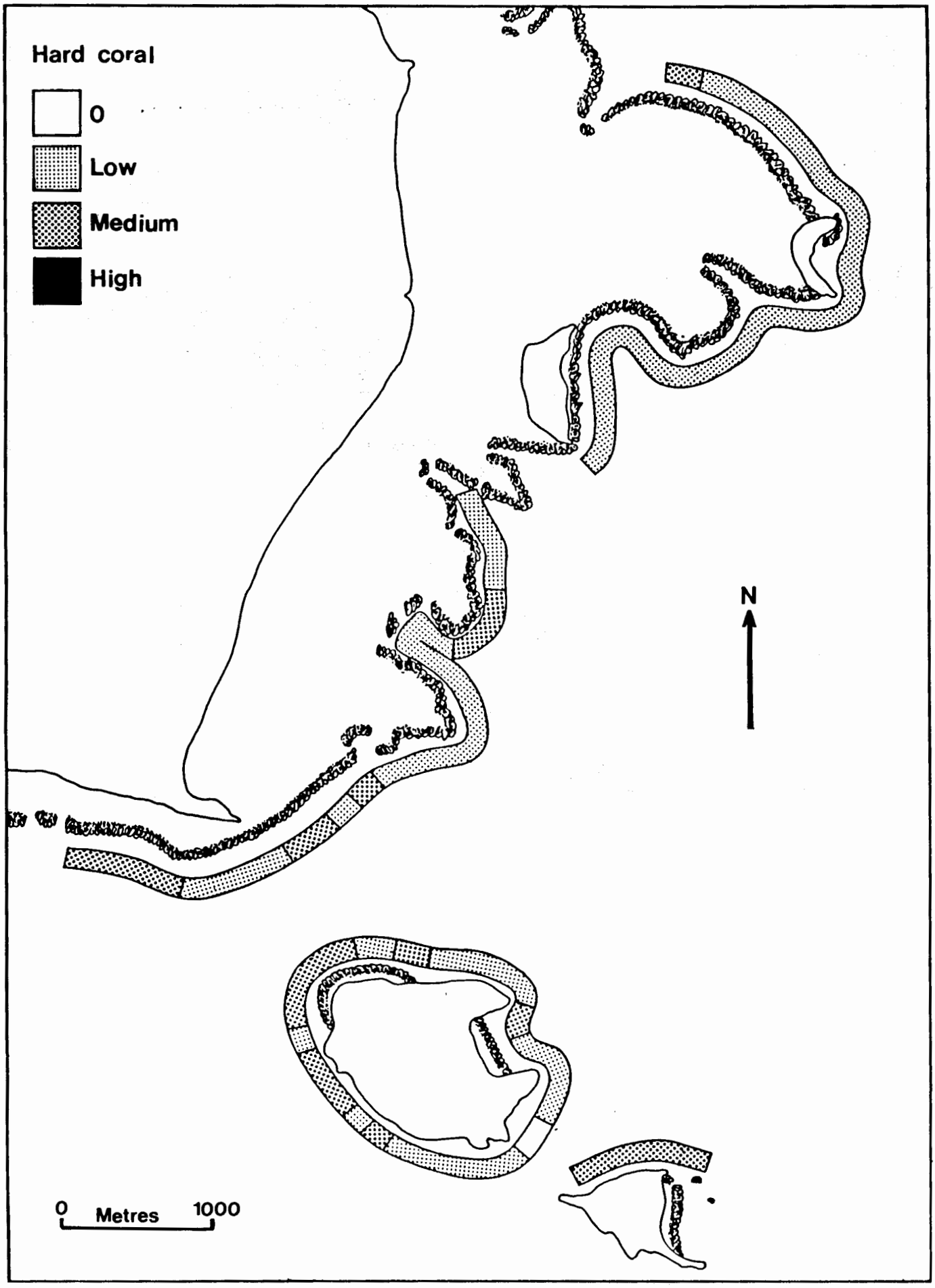


Figure 6. Manta tow data for percentage cover of soft coral

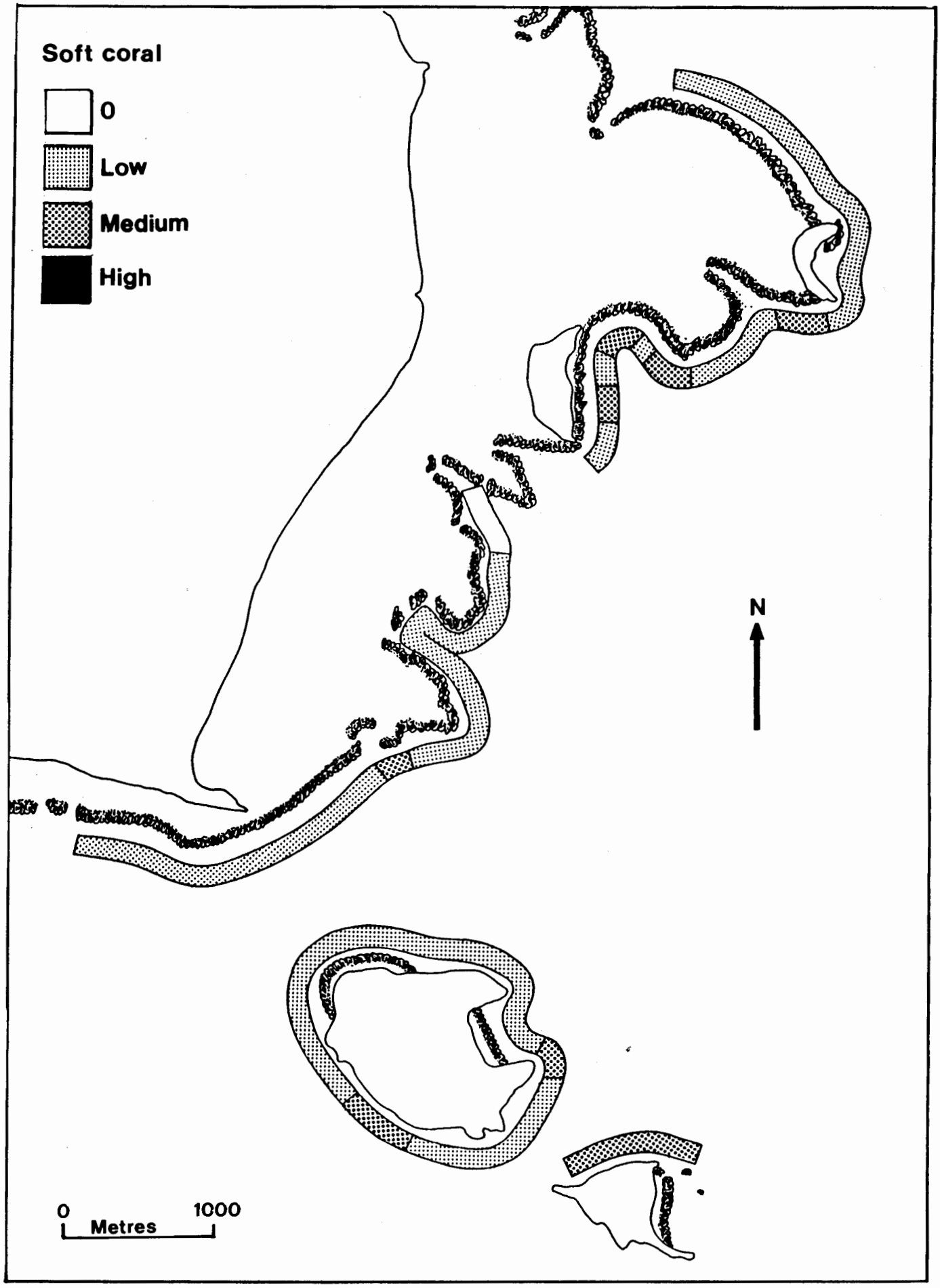


Figure 7. Manta tow data for percentage cover of dead coral

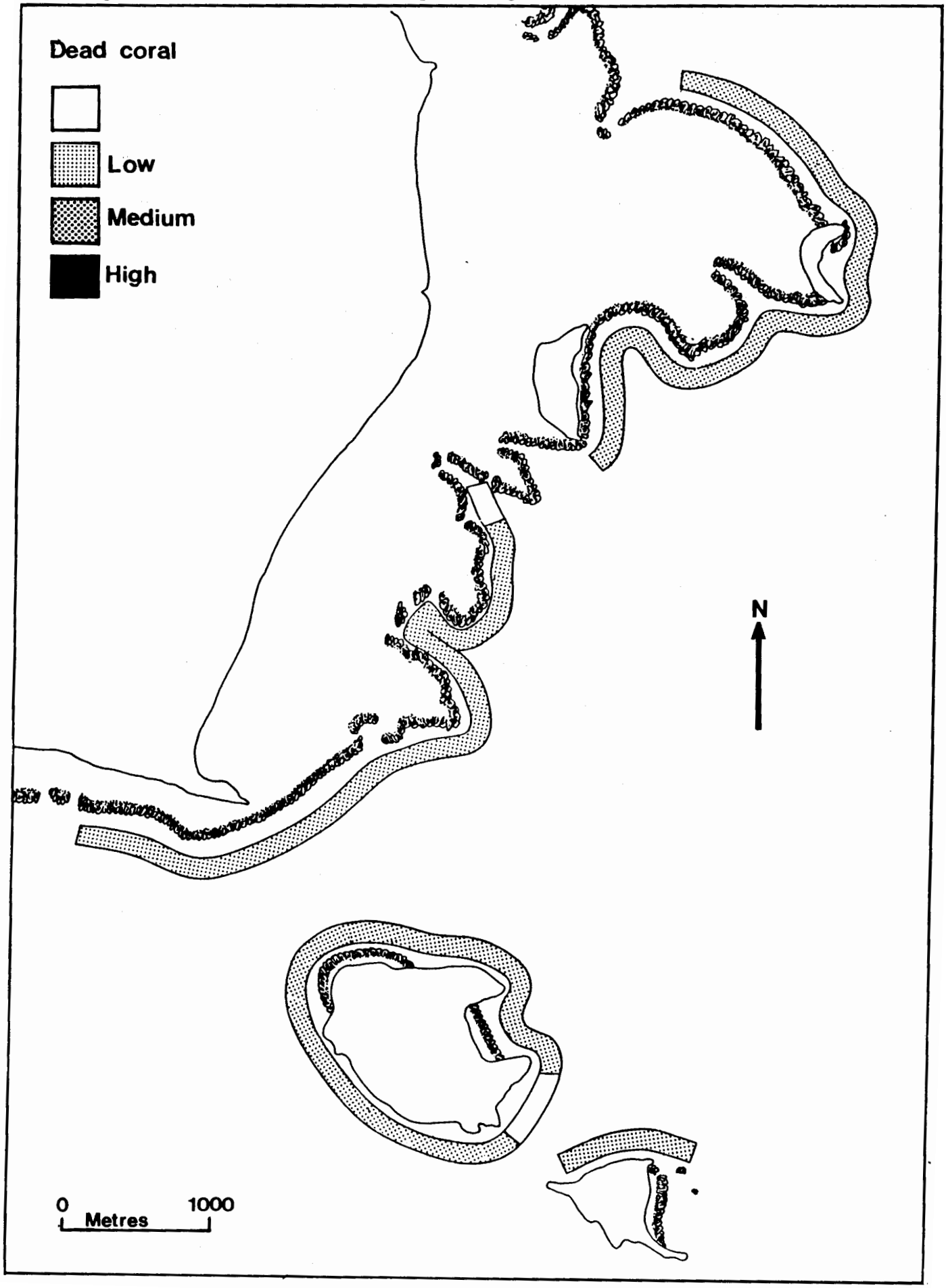


Figure 8. Manta tow data for percentage cover of macroalgae

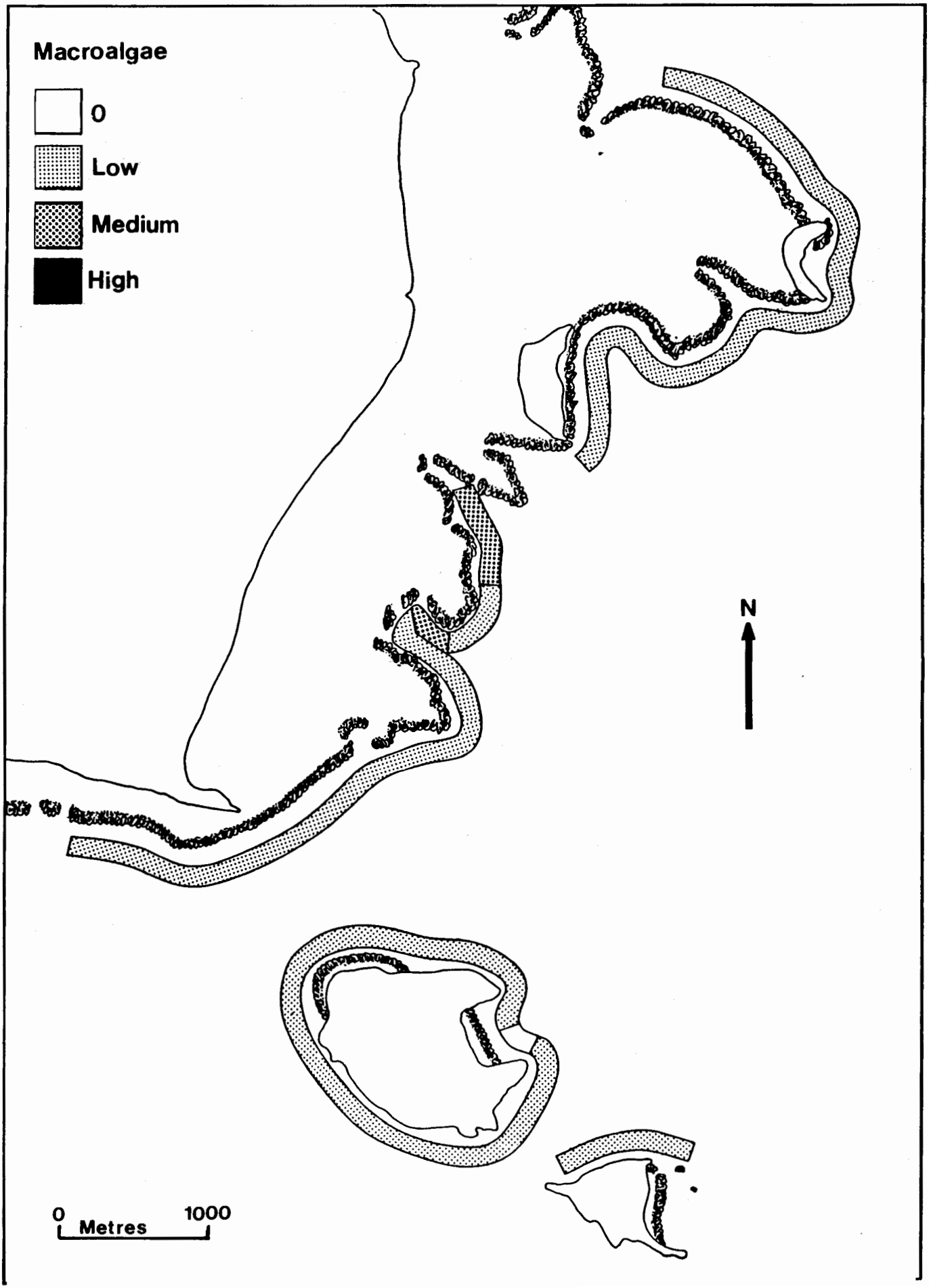


Figure 9. Manta tow data for diversity of hard coral

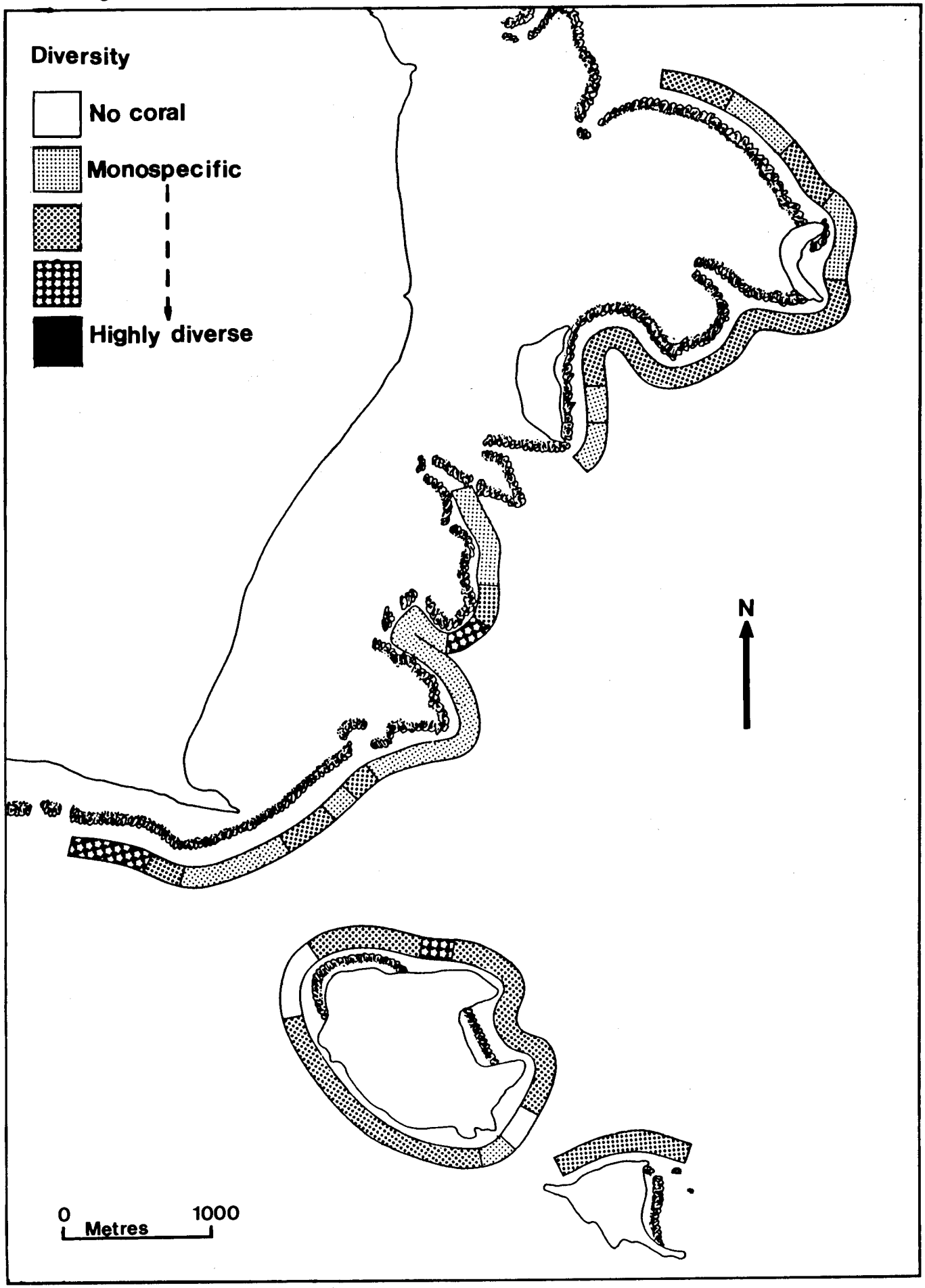


Figure 10. Manta tow data for size range of hard coral

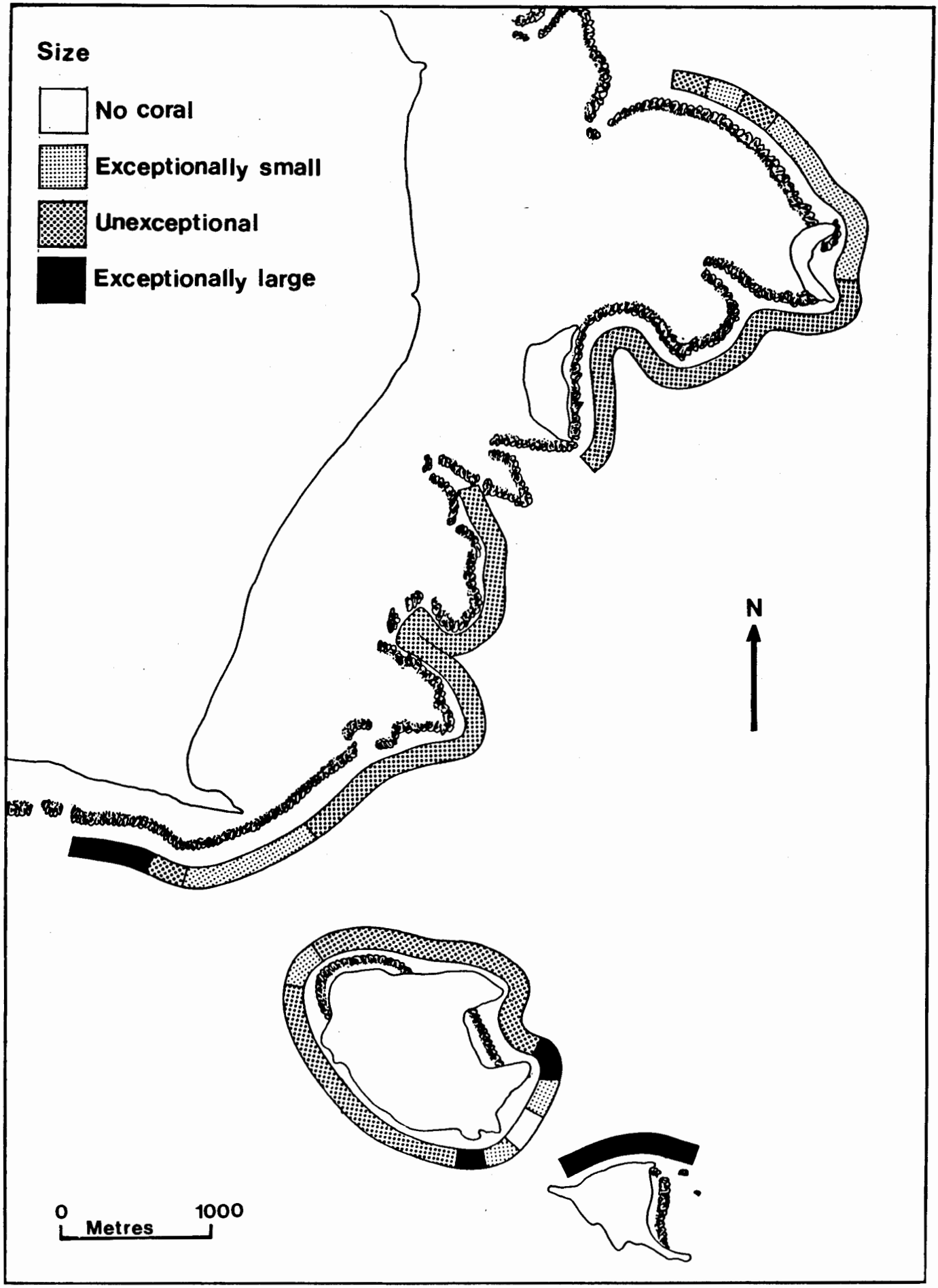
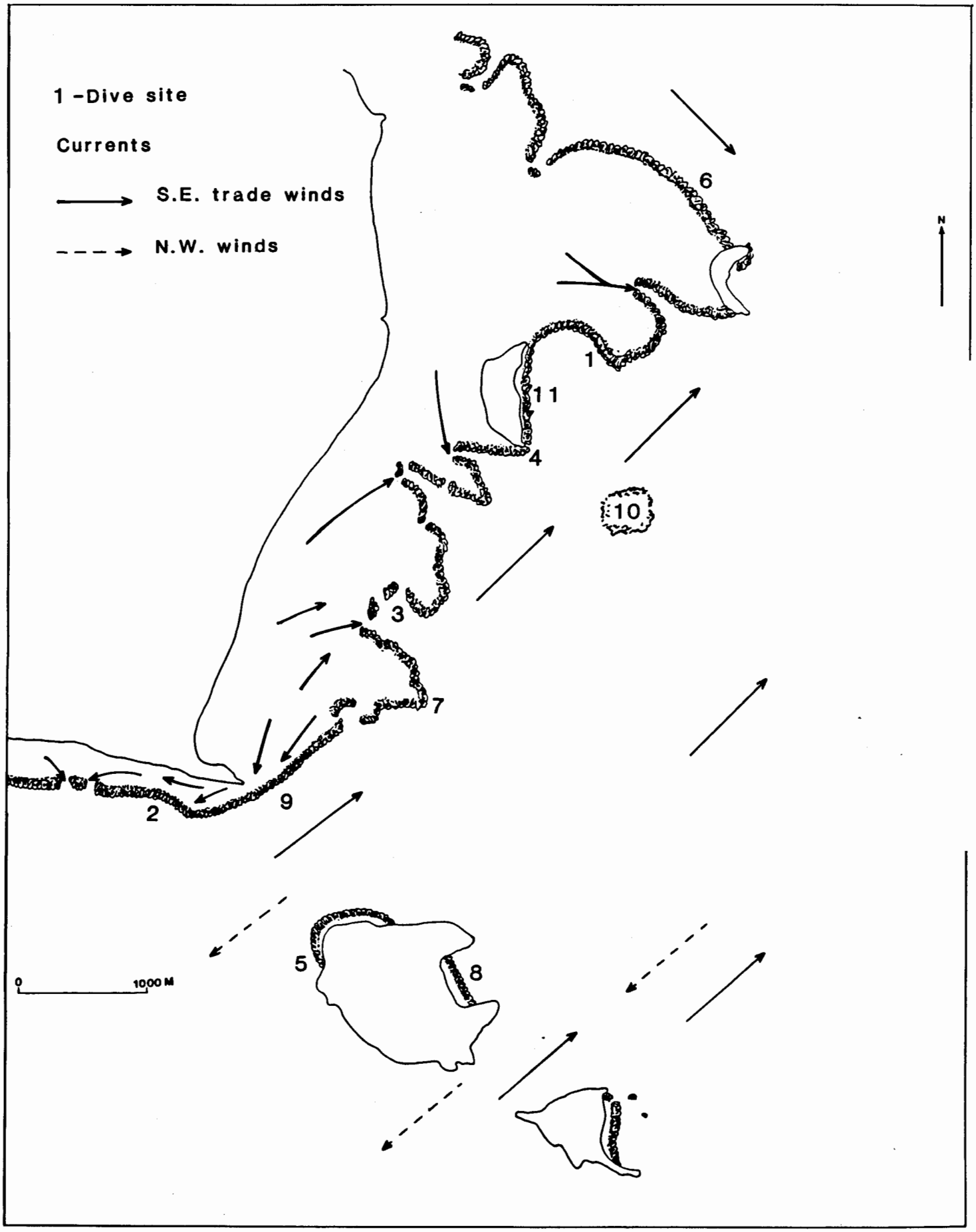


Figure 11. Location of dive sites and current patterns



5.2. Spur and groove with drop off

This type of reef slope occurred on the south-facing section, west of Cape Tapaga, and was unlike other reef slope areas in the Aleipata region (Figure 4.). The difference probably results from its orientation towards the south and the resultant effects of wind, waves and swell. The reef front was characterised by a relatively narrow terrace that quickly sloped down to approximately 5 m deep. Small channels at the shallow reef crest joined to form large channels, or grooves (2-5 m deep), which ran down the reef front. The bottom of the grooves were usually a bare scoured surface, although some contained boulders and cobbles of reef material.

The dissected reef terrace, or spurs, supported well-developed coral growth below the shallow upper areas which were directly affected by wave action. In the upper areas, coral growth was restricted and only a limited number of small sturdy colonies was found. Towards deeper water, but before the steep drop off, abundant coral growth of 30-50% (see manta tow data) was encountered. Sturdy plate and irregular branching *Acropora* colonies dominated. Large colonies of *A. clathrata* and *A. robusta* were particularly common.

At the outer end of the spurs and grooves, the reef front drops off steeply. A more mixed coral assemblage was found in the upper portion of the steep slope with variable coverage of 10-30%. Among the corals occurring in this area were: *Acropora florida*, *Pocillopra eydouxi*, *P. meandrina*, *Stylophora sp.*, *Pachyseris sp.*, *Galaxea fasicularius*, *Monipora verrucosa*, and *Merulina sp.* Many portions of the channel sides and mid-slope of the spur ends were colonised by extensive stands of soft coral (*Sinularia)* and a zoanthid (*Palythoa*) and a grey-green foliose sponge. Both of these groups occupied up to 75% of the substrate in places.

Further down the reef slope, other coral species became evident. These were predominantly: *Leptoria sp.*, *Fungia sp.*, *Acropora palifera* and encrusting *Millipora spp.*, *Porites rus*, and *Echinopora sp.* Coral cover decreased down the reef slope as sand and reef rubble deposits became more predominate with increased depth. The predominately sand bottom was encountered at a depth of around 25 m. Occasional coral pinnacles rise from the sandy flats immediately adjacent to the reef front. These are dominated by massive *Porites sp.* and *Diploastrea heliopora* colonies with the associated coral species indicated above.

5.3. Spur and groove with broad dissected lower slope

Along the Aleipata fringing reef the most common reef slope type was characterised by a spur and groove system that extended a further distance from the reef crest than reef slope type 'A', but was not as well developed as the latter (Figure 4.). Beyond the spur and groove, the shallow reef terrace sloped gently down to depths around 25 m, as opposed to the sharp drop off in the case of the type 'A' reef front described above.

The reef terrace was dissected by shallow (1-2 m deep) channels down to about 7 m. Large, dead, standing *Acropora* plates dominated this section. As described earlier these dead corals were most likely the result of previous large aggregations of *A. planci*. Plate-like coral rubble was also common on the channel floors.

As the 25 m contour was approached down the gentle slope, the channels become more numerous and aligned less perpendicular to the reef crest. At these depths the channels branch and intersect, resulting in a broad, very dissected lower slope.

Above 5 m live coral covered around 5 - 20% of the substrate. Below 5 m the substrate was dominated by dead standing *Acropora* plates. The common live coral species of these areas included: *Porites rus*, large colonies of *Acropora robusta*, *A. humilis*, *Millepora exaesa*, *Stylophora pistillata*, *Pocillopora meandrina*, *P. eydouxi*, *Favia stelligera* and *Merulina sp.*

The open reef surface between corals was dominated by encrusting coralline algae. Other corals present were: *Pavona varians*, *P. clavus*, *Pachyseris sp.*, *Acanthastrea sp.*, *Oxypora sp.*, *Acropora palifera*, *A. clathrata*, *A. nana*, and *Leptoria phyrigia*.

The sides of the grooves in this area were generally not very steep, but some of the spurs end with a 1-2 m scarp where the channels merge. The channel sides include many of the corals found within the spur and groove (reef front type 'A') system but with lower coverage of around 5-15%. In addition, large *Diploastrea heliopora* colonies were scattered on these slopes. Occasional patches of the soft coral *Sinularia* and the calcareous green algae *Halimeda* were also found. Channel bottoms in the mid and lower depths of this broad reef front slope were a mix of sand, plate and branch coral rubble and occasional blocks.

5.4. Scoured reef platform

A distinctive reef slope type occurred in front of Fanuatapu and Namu'a islands, directly off Cape Tapaga and on the isolated patch reef off Namu'a island (Figure 4.). In these areas, except the patch reef, the shallow reef terrace dropped quickly down to a wide submerged platform terrace. The platform sloped gently seaward from depths of 10 m to about 14 m, extending horizontally 10 - 30 m in places.

The platform surface consisted of a scoured, barren surface with evidence of strong current activity. The solid reef surface had irregular, shallow ridges and grooves and coral cover of 0-10%. Of the hardy corals that have survived on these scoured platforms, the most common were small, stout colonies of: *Pocillopora meandrina*, *P. eydouxi*, *Acropora humilis*, *A. robusta*, *Astreopora sp.*, *Pavona varians* and *Porites lutea*. Encrusting calcareous algae, occasional *Sinularia* and *Palythoa* and patches of foliose sponge occupied the majority of the remaining substrate.

The patch reef off Namu'a island had an upper level around 8-10 m below the surface. Most of this upper pinnacle was surrounded by a scoured reef platform at depths of 15-18 m. This scoured platform had similar characteristics to those described above. Throughout all these scoured platforms, scattered colonies of the following may be encountered: *Diploastrea heliopora*, *Favia stelligera*, *Leptoria phyrigia*, *Leptastrea purpurata*, *Pavona clavus*, *Cosinarea sp.*, *Acropora palifera*, *Millepora exaesa*, and, at the patch reef, *Montipora sp.* and *Turbinaria sp.* On the Aleipata reef, the wide submerged platform terminates at about 17-18 m deep. The slope drops steeply down to 18-25 m deep and has 10-15% cover of the corals documented. The slope bottoms out onto a floor of reef blocks and rubble below 25 m.

5.5. Spur and groove with short slope

Two areas of the Aleipata reef front had very narrow reef terraces and short, steep slopes (Figure 4.). The shallow (1-2 m) reef terrace had shallow surge channels cut in its surface and patches of cemented coral rubble. There was little live coral on the narrow terrace, which had dead, standing plate *Acropora* and 5-10% cover by soft corals (predominately encrusting *Lobophytum* and *Sinularia*).

The reef front dropped off rapidly and was dissected by steep grooves infilled with coral blocks, plates, rubble and sand. The spur slope supported variable coral cover of 5-20% below depths of 5 m. Common corals were: *Acropora robusta*, bushes of branching *Acropora sp.*, *A. palifera*, *Pocillopra meandrina* and *P. eydouxi*. All of the corals listed for the previous reef front types were also present.

The remainder of the reef slope surface was occupied by encrusting calcareous algae, scattered large colonies of soft coral and occasional zoanthid colonies. The spur sides had occasional large *Diploastrea heliopora* colonies. The lower reaches of the short steep slope, from about 10 to 18 m, supported increased coral cover of 10 - 20%. In particular, portions of the lower reef slope in front of Namu'a island terminated in tiers of massive *Porites sp.* colonies, increasing the live coral cover to 30-50%.

At depths of 20-25 m the reef slope spurs dropped off onto flats of reef rubble that merge with the reef sand and rubble deposited down the grooves.

5.6. Reef channels

The reef front around Aleipata is dissected in numerous places by channels of various widths (Figure 4.). The nearshore end of the channels were dominated by a slope of reef detritus that extends down 20 m to the sandy channel floor. This slope of reef block, sand and rubble supported a sparse coral cover of 0-5%. The few colonies found there included: *Cyphastrea sp.*, *Favia stelligera*, other *Favia spp.*, *Pavona varians*, *Diploastrea heliopora*, *Millepora sp.*, *Pocillopora meandrina*, and small encrusting *Montipora sp.*

Where the outer channel wall merges into the adjacent reef front type (spur and groove system and/or the broad dissected lower slope) a vertical escarpment is present. This reef cliff extends down to the sandy channel floor. Dead algal encrusted coral and some encrusting soft corals were found along these barren walls.

5.7. Nu'utele and Nu'ulua Islands

The north and west sides of Nu'utele island supported reef development similar to the spur and groove with broad, dissected lower slope common on the Aleipata coastal reef. The Nu'utele reefs, however, were narrower and the reef slopes somewhat more irregular. The fringing reef which fronted Vini beach was backed by an incompletely developed and partially in-filled reef flat. A shallow, very narrow break in the reef allows passage to the beach in calm seas.

The reef front at Vini had a sloping terrace on the upper reef slope which was dominated by dead plate *Acropora* colonies, similar to the Aleipata coastal reefs. In places, small *Acropora humilis* and *A. robusta* colonies had become established on the dead plates. Below depths of 2-4 m, increasing amounts of live coral were found, locally covering up to 30-50% of the substrate. The coral cover was made up of the species mentioned above in addition to: *Pocillopora eydouxi*, an encrusting *Porites sp.*, branching *Acropora florida* and *Millepora platyphyllia*. Soft corals were generally less common than the Aleipata reefs.

From depths of 5-15 m, the terrace was irregularly dissected by 1-2 m deep channels, or grooves. These transported coral rubble and sand down the channel sides to the channel bottoms which were filled with platey coral rubble. Towards the edge of the reef terrace, at about 15 m deep, massive colonies of *Porites lutea* were common, as well as *Porites rus* and *Pavona clavus*. Overall coral cover remained low at around 10-20% towards the terrace edge, where some small clams (*Tridacna sp.*) were present.

From depths of 15-25 m the reef dropped steeply, with near vertical cliffs and overhangs in places. On the upper portions of the slope, moderate size colonies of massive *Porites lutea* and *Diploastrea heliopora* occurred, along with *Montipora sp.* and *Stylophora sp.* Encrusting coralline algae dominated the vertical slopes, with occasional wire coral colonies (*Cirripathes*) along the overhangs.

At the bottom of the slope, at 25-27 m, coral rubble and some terrigenous black volcanic sand were present. Slightly detached from the main reef slope were 2-4 m high, irregular mounds with moderate to high coral cover (30-60%) and increased coral diversity. Additional corals included: *Favia stelligera*, *Pavona varians*, *Leptoria phrygia*, *Pachyseris sp.*, *Leptastrea purpurata* and *Montipora sp.*

The islands of Nu'utele and Nu'ulua were volcanic cones with their craters open to the sea, facing northeast and east, respectively. The embayments formed by the open-sided craters contained well-developed coral reefs. Although rough weather prevented the dive on Nu'ulua from being completed, the following information gathered from Nu'utele is generally applicable to the crater embayment on both islands. From the edge of the islands' sand beaches, scoured reef flats extend out about 20 m and then drop off into a short, fairly steep reef slope supporting moderate to high (30-60%) coral cover. A sand bottomed channel indented the reef slope at Nu'utele, with vertical reef walls on either side extending down to its 3-5 m deep sand floor which sloped gently seaward.

The reef slope coral community was dominated by colonies of plate *Acropora sp.*, *A. robusta*, *Millepora exaesa*, *M. platyphilla* and *Diploastrea heliopora*. At depths of 5-8 m, the steep, coral-dominated slope gradually became a broad slope of mixed coral and sand. Coral cover gradually decreased from 20-30% in the upper portions to 5-20% at around 20-25 m. Large colonies of massive *Porites sp.* were most common, with large soft coral colonies (*Sinularia*) also abundant.

The most diverse coral assemblage of the Aleipata area survey was encountered on these slopes and included: *Pocillopora meandrina*, *P. eydouxi*, *Leptastrea pupurea*, a variety of branching and encrusting *Acropora spp.*, *A. humilis*, *A. clathrata*, *Favia sp.*, *Cosinarea sp.*, *Favites sp.*, *Acanthastrea sp.*, *Leptoria phrygia* and the soft coral *Palythoa*. The corals were generally aggregated into mounds around larger massive colonies. The sandy substrate in between the mounds became more extensive as the slope continued gradually seaward below 25 m depths.

The north and south sides of Nu'ulua island, the south side of Nu'utele, and some of the north side of Nu'utele were characterised by volcanic cliffs and associated sea stacks which plunged steeply into the sea. These cliffs often descended vertically to the adjacent sea floor, at depths of 20-30 m. The substrate was generally scoured and algal encrusted, with very little coral. Towards the crater embayments and the reef development on west Nu'utele, the cliffs were less severe and scattered corals occurred, with massive *Porites* colonies most abundant.

5.8. Fishes of the reef slope

Fish species were recorded on the Aleipata reefs during the intensive spot dive surveys. The common species encountered were typical for Samoan reefs (Appendix 1.).

There were large populations of herbivores (particularly *Ctenochaetus striatus*) and corallivores. *Pomacentrids* (damsel fish) were the most obvious and diverse genus. Large grazing *Scarids* were numerically abundant but appeared to be limited in diversity. The large *Scarid*, *Bolbometopon bicolour*, was particularly common. Wrasses (*Labridae*) were common and diverse. *Cheilinus undulatus* was conspicuous throughout the area.

The common reef piscivores (*Epinephelus* and *Cephalophis* sp.) were present in varying numbers and diversity throughout the area but were more abundant and generally of larger size around Nu'utele and Nu'ulua islands. Fish of the *Lutjanidae* and *Lethrinidae* families were not common. Very few coral trout (*Serranidae*) were observed except *Plectropomus leopardus* and *Variola louti* around Nu'utele island and *Plectropomus leavis* along with numbers of *Lethrinids* and *Lutjanids* around Namu'a island.

Although no quantitative data is available, fish populations and diversity in the Aleipata area were what would be expected for this type of reef environment with the current level of fish harvesting. Samoan fishermen harvest an unusually large range of fish species and therefore do not overly deplete any particular species or group of fish (Johannes, 1982), resulting in the noticeable population differences in the types of fish encountered during the survey. For example, rabbit fish (*Siganidae*) are more easily captured by spearfishing and hand-lining and appear to be more abundant and larger where access by fishermen is limited by environmental parameters.

A limited summary of fisheries resource use in the Aleipata area is documented in Section 6. A list of fish species identified throughout the survey and their Samoan names (where applicable) is presented as Appendix 1.

5.9. Effects of *Acanthaster planci*

The Aleipata area reef slope displayed a paucity of invertebrates other than the corals typical of coral reef communities in this region. The low amount of cover by hard corals was most likely related to the effects of past *A. planci* (Crown-of-Thorns starfish) aggregations. The reef displayed a benthos consistent with observations of other *A. planci* damaged reef communities the authors are familiar with.

Garlovsky and Berquist (1970) reported 'infestations of Crown-of-Thorns starfish existed at several points on the south coast of Upolu' (June 1969). Dahl (1978) reported 'The reef around Namu'a was heavily infested with Crown-of-Thorns starfish (*Acanthaster planci*) during the visit, with densities up to one per square metre in the corals behind the reef, and many observed moving across the sand lagoon floor' (30 August to 14 September 1978).

In American Samoa, in 1977, Wass (1980) reported 'large concentrations of Alamea (Crown-of-Thorns starfish) have heavily damaged portions of the fringing reef of Tutuila, and have denuded Taema bank and several smaller offshore banks'. Birkeland et al. (1987) reported, 'The *Acanthaster planci* population greatly reduced the substrate surface cover by corals in 1979'. They further state that 'It had been found that all corals had increased in abundance at all sites' with exceptions, in their survey of the Fagatele Bay National Marine Sanctuary in April 1985.

The available evidence and similar outbreaks with similar timing in American Samoa provides data to support the authors conclusion that much of the area survey has been largely denuded of coral by *Acanthaster planci*. The poor recovery of corals in the Aleipata area however may suggest that more recent aggregations, probably after the report by Dahl in 1978, may have occurred. It is clear that extensive damage to hard corals has occurred throughout most of the survey area.

6. Marine Resource Use

Information from in-depth interviews with 11 full-time fishermen from Aleipata villages and a brief survey of catch landed during one Saturday by 14 fishermen (or pairs of fishermen) was compiled to give the following indication of marine resource use. The information is not the result of a long-term survey of marine resource use in the area, but is the result of a short-term effort meant to:

1) indicate the types, levels, locations and targets of Aleipata fishermen and women;

2) highlight existing problems in marine resource use; and

3) indicate potential problems of this resource use in relation to the proposed park.

A copy of the questionnaire used is attached as Appendix 4. The names of the 11 fishermen who participated in the detailed interviews are presented as Table 2.

6.1. Fishing methods and catches

The 11 fishermen interviewed provided information on 8 types of fishing conducted (other than low-tide reef gleaning):

1. Gill netting
2. Bait fish cast-netting
3. Shallow-water handlining
4. Deep-water handlining
5. Trolling
6. Fish drives
7. Fish trapping
8. Spearfishing

Not all fishermen participated in, or had information on, all fishing techniques. The responses for each of the methods are summarised below. Fish sizes have all been converted to metric. Information on the location of harvesting by each technique is incomplete, especially for shallow reef fishing activities. In the following summary, the organisms' names are in Samoan, the corresponding scientific and common names can be found in the fish species list (Appendix 1) and the invertebrate list (Appendix 2). The catch information provided is limited in that details on the unit of effort (per net set, day, week, season etc.) was usually not mentioned by the respondents.

Table 2. List of informants.

Name	Age	Village	
Simi Te'openaia	48	Saititoa	
Sua Loli	42	Vailoa	
Amituanai Penata	54	Lalomanu	
Matiu Laulu	58	Sale'a'aumua	
Taikku Feriti *	37	Ulutogia	* Interviewed together
Taikku Fata *		"	
Gu Sio	54	Sale'a'aumua	
Ionatuna	34	Utufa'alalafa	
Asini Paepae	32	Mutiatele	
Amutuana Laulau	54	Lalomanu	
Puleuasafa Matagi	54	Lepue	
Sulu Simio	54	Lalomanu	

Gill netting was carried out every day (except Sundays) throughout the year, weather permitting. Catch estimates ranged from 40-50 up to 100 fish per harvest with size estimates of the fish caught ranging from 15-20 cm to 15-60 cm. Where mentioned, catch was intended both for family and sale. Important species were: anae and mataelelele, also pone and ululou.

Bait fish cast-netting was indicated as taking place 4 times per week, all year round. Catch numbers were said to range from 5-10 to 100-200 per harvest with a size range of 4-10 cm for the fish caught. Both catch and size were estimated to be increasing. The major species caught were: maulauli; with ululou, gatala, isuile and ava also harvested.

Shallow-water handlining on the reef front and within the lagoon was estimated to take place 5 times per week, all year round. The catch ranged from 15-20 to 50-60 fish per harvest, with mixed indications of improved and decreased catches. The size of catch ranged between 15 - 60 cm. The catch included: sugale and utu, as important components; as well as: mataeleele, gatata, malau, and filoa.

Deep-water handlining has only recently started in this area and was undertaken along 60-80 fathom (approximately 200 m) depths. Deep-water handlining was undertaken from 1-5 times per week, throughout the year, weather permitting. Catch was estimated at 20-40 fish per effort. Several interviewees indicated that catch was increasing. Catch size ranged from 30-90 cm and up to 180 cm. The primary species taken were: palumalu, malie, malai, filoa and atu atu.

Trolling was undertaken further offshore than handlining throughout the year, during calm seas (one respondent mentioned 'skipjack season'). Catch estimates vary between 10-100 fish per effort, with most estimates within the upper half of this range. The general indication was that the catch from this method was increasing. The size range of catch is estimated between 30-240 cm and upwards. A variety of species were indicated: bonito, musi musi, yellow tin, palu malu, skipjack, dolphin fish, rainbow runner, and, occasionally, swordfish and sailfish.

Fish drives were conducted within the lagoon, near passes through the reef, and were estimated to take place 3-5 times per week, all year. Catch numbers ranged from 15-20 to 200 fish per harvest. Yield was considered to be decreasing due to overfishing and the use of derris root for fish poisoning. Catch size ranged from 5-45 cm and included a mix of species, such as: mataeleele, pone, fuga, alogo and gatala.

The **trapping of fish** does not take place in the Aleipata area anymore. One individual continued to trap green sea turtles. Catch is said to be declining with average turtle sizes of 60-90 cm.

Spearfishing was common and takes place 5-6 days per week, sometimes all day, and is pursued throughout the year. Catch numbers ranged from 10-40 fish per harvest with mixed responses as to whether yield was generally declining or increasing. Catch sizes were given as 8-45 cm. Important species were: fuga, malau and gatala; with mataeleele, pone, alog, eel and octopus also mentioned. During full moon, rays (90-120 m) are caught by spearfishing.

On Saturday (20 June 1987), the fishermen coming ashore at Sale'a'aumua were briefly interviewed and their catch counted. All of the 14 fishermen (or pairs of fishermen) had primarily been engaged in spearfishing. The species caught, the total number caught and the number of fishermen having that species is recorded in Table 3.

Table 3. Fish catch landed at Sale'a'aumua, Aleipata (20 June 1987)

Species	Total catch	No. of Fishermen
Mataeleele	216	13
Ava (3-5 cm)	200	1
Afa	54	1
Tivao	25	9
Fuga	24	8
Anae	24	1
Ta'ulaia	23	7
Vete	14	5
Marini	13	6
Lo	12	7
Sumu	12	5
Matapuna	5	1
Tifi tifi	4	3
Gatala	3	3
Lalafi	3	2
Filou	3	1
Fugausi	2	2
Mafu	2	2
Malau	2	2
Ali	2	2
Pa'a	2	1
Faisua	1	1
Pusi	1	1
Mo'o	1	1
Taotaoama	1	1
Avaava	1	1
Fai	1	1
Pone	1	1
Fe'e	1	1

6.2. Village fisheries

Information gathered on the number of fishermen and boats in the Aleipata area is compiled in Table 4. A total of 490 fishermen were estimated to be actively fishing from the eight villages within the survey area. Of this figure, approximately 71% were considered to be 'full-time' fishermen (with fishing as a primary activity, whenever possible) and 29% as 'part-time' fishermen (with fishing as a Saturday and secondary activity).

A total of 8 Alia catamarans (both aluminium and wood) were based in the area, although 2 were not operable at the time of the survey. The Alia were used primarily for trolling and deep-water handlining. Approximately 300 canoes were found throughout the villages and were used for spearfishing, shallow-water handlining, and access to reef areas for gleaning.

Table 4. Aleipata area village fisheries

Village	No. Fishermen	% Full Time	% Part Time	No. Alia	No. Canoes
Satitoa	40	-	-	2	40
Vailoa	80	60%	40%	1	30
Lalomanu	120	70%	30%	3 (1*)	40-100
Sale'a'aumua	90	70%	30%	1*	90-100
Ulutogia	40	70%	30%	1	15
Utu fa'alalata	20	80%	20%	0	4
Mutintele	50	80%	20%	0	40
Lepu	50	70%	30%	0	5
Total	**490**	**Ave. 71%**	**29%**	**Total 8**	**264-334**

* Inoperable

6.3. Reef gleaning

The harvest of invertebrates and seaweed from the reef (lama) was primarily undertaken by the women on the reef flats during low tide. A variety of reef organisms were gleaned from the reef. The information on this activity gained from the interviews is summarised below, with results presented by taxonomic groupings. Names of organisms are given in Samoan, which are listed along with scientific and common names in Appendix 2.

Five types of **sea cucumbers** (*Holothurians*) were harvested in the area: sea, fuga fuga, loli, mama'o, and fuatata. Sea was the most commonly collected sea cucumber, at up to 5 times per week. The numbers harvested ranged from 15-200 per harvest and yield is thought to be increasing. They were collected by the women, who twist the animal in two pieces, leaving one to regenerate on the reef. Sea cucumbers were mainly collected for family consumption, with some sold in the village.

Fuga fuga and loli were also collected almost every day. The usual number taken was estimated at 5-10 and numbers were considered to be increasing. Most were collected for family use. Mama'o and faatata were less often identified as harvested sea cucumbers.

Four **sea urchins** were identified which were gleaned from the reef: tuitui, savae, vaga and tapumiti. Tuitui was the most commonly harvested sea urchin, from 3-5 times per week. From 40-100 urchins were taken per harvest and numbers were thought to be increasing. Tuitui was harvested for family consumption. Vaga was also commonly taken, but only 2-4 times per month, at new and full moon. Catch varies from 10-30 urchins and the numbers were said to be increasing. The urchins were all collected for subsistence consumption.

Less commonly harvested urchins were savae and tupu miti. Both were harvested about twice per month, at full moon. They were also for family consumption and 30-40 were harvested per night.

A number of **shellfish** were harvested commonly: alili, faisua, and aliao; others were occasionally taken: pala'ao pu and fole. Alili (turban shells) were harvested during calm periods from 4 times per week to once every 5-6 months. Catch ranged from 40-100 per harvest and was for family consumption and sale in Apia. Aliao (*Trochus*) were harvested at low tide about 4 times per month. From 40-150 were taken per harvest with a size range of 6-15 cm. *Trochus* was harvested for both family use and for sale in Apia, and the numbers of *Trochus* were thought to be increasing.

Faisua (giant clam) were harvested 3-5 times per month, with a few respondents harvesting more frequently (4-5 times per week). Generally 8-50 clams were taken per harvest with the size ranging from 10-45 cm. Most respondents thought that both clam size and numbers were decreasing. The clams were taken primarily for family use, with a few mentioning that the clams were also sold in Apia.

Palaau and pa (triton) were harvested 3-5 times per week at low tide. Generally 2-5 are taken per harvest and the meat was for family consumption while the shell was sold. Fole (razor clam) was not a common harvest, but identified as being sought 3 times per week by one person. From 50-100 were taken per harvest for family consumption.

Of the **crustaceans**, both ulu sami (lobster) and tupa (land crab) were identified by one respondent each as being harvested. The lobster ranged between 15-30 cm in size with 4-5 taken per harvest. They were for family consumption and size was said to be decreasing. Land crab were also caught during full and new moon for family consumption.

Octupus (fee) was sought from 5 times per week to 2-3 times per month. Between 3-15 were caught per harvest with a size range 15-70 cm. The numbers of octopus were thought to be decreasing. Those caught were for family consumption and sale within the village.

A variety of **other invertebrates** were gleaned from the outer reef. Alu'alu (*Cassiopea* jelly fish) were harvested during its season. From 30-50 were caught per harvest for family consumption. Near Pué village, ipo (peanut worm) were commonly collected with 30-100 taken per harvest for family consumption. Gau (green sea hare) were sought twice a month, during full moon, with 10-20 taken per month for family use.

Seaweed (limu) was gathered at low tide from 5 times per week to 3-5 times per month. Approximately 3-5 pounds of seaweed was taken per harvest for family consumption.

7. Specific Resources Issues

The detailed interviews also sought information on a number of specific resource issues. These were: reef tenure and fishing rights, fish spawning aggregations, sea turtle nesting, *Acanthaster planci*, destructive fishing practices and coastal erosion.

7.1. Reef tenure and fishing rights

Villages of the Aleipata area (as described in the introduction) were considered to have exclusive rights to the marine resources of this area. No specific boundaries, or seaward extent, were defined. It was, however, specified that the lagoon area was particularly prohibited to outsiders. Fishing activities such as night torch fishing, poisoning and lama (reef gleaning) were stated as specifically exclusive to the area residents. No traditional regulations, enforcement or punishment aspects were defined by the respondents.

7.2. Fish spawning aggregations

A number of locations in the lagoon area were described as the sites of spawning aggregations (Figure 12.). Seven species were indicated as having spawning aggregations. Location information did not always specify whether the site served for the spawning aggregation of one, or all, of the 1 to 3 species mentioned by each respondent. Despite this the information indicated there were specific areas in the lagoon which were important as fish aggregation sites.

Information on the timing of spawning aggregations was somewhat mixed and has been summarised in Table 5. No respondent felt that any of the spawning aggregations sites habitat were being degraded.

Table 5. Spawning aggregations

Species	Months indicated
Gatala	May-June, June
Malau	All year
Lo, Palaia	October-November, December-January
Pone, Lo, Palaia,	March-April, May June,
Atule, Loloa	June-July, July-August

7.3. Sea turtle nesting

Information on sea turtle nesting, primarily for hawksbill (*Eretmochelys imbricata*) and some green sea turtles (*Chelonia mydas*), reinforced previous data available on this resource (Witzell and Banner, 1980). Most respondents indicated nesting takes place on the two beaches of Nu'utele island (Nu'utele and Vini beaches) and the Nu'ulua island beach. A few also remarked on nesting occasionally occurs at Namu'a and Fanuatapu island beaches (Figure 12). Nesting season was identified as between October and January. November to December were the most often cited months. A few fishermen, however, mentioned June-July, April or all year round as the nesting periods.

In general, the respondents collected turtle eggs when nests were found. Most felt that nests were increasingly difficult to locate and eggs harder to obtain.

7.4. *Acanthaster planci*

Information gathered on the present and past abundance and distribution of the Crown-of-Thorns starfish (*Acanthaster planci*) around Aleipata was not very precise. All respondents felt that *A. planci* populations were decreasing, especially within the past 3-5 years, from what had been very high populations in the late 1970's. One fisherman indicated portions of the lagoon where populations were still large (Figure 13.) although this was not verified by this survey.

When the outbreaks had occurred, some fishermen believed they spread from nearshore, out to the reef and then along the reef front. Most felt that the population had begun to decrease because there was not much live coral left to feed on. Almost all the respondents thought that the corals were beginning to recover with the decrease of *A. planci* populations over the past 3-5 years.

7.5. Destructive fishing practices

Overall, respondents felt the widespread use of dynamite and poison had decreased greatly, if not 'stopped', within the past 2-5 years. Many mentioned that these practices had been banned by the village councils in the area since 1985. The village council has the power to impose fines of taro and/or pigs upon those caught using these techniques.

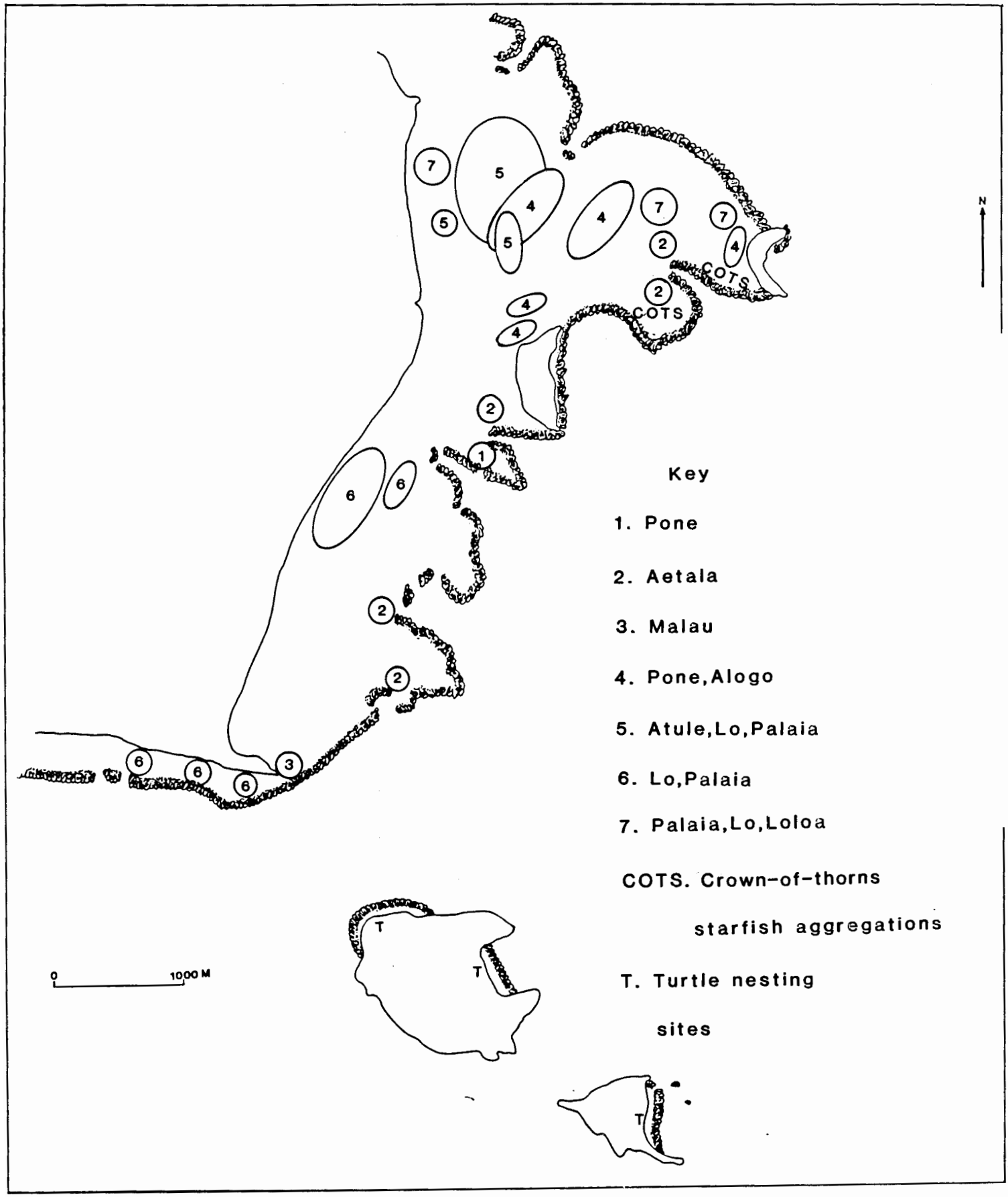
Dynamite fishing was particularly identified as having for the most part been halted in the past 5 years or so. A few fishermen noted that occasional blasts have been heard during the past year. The authors observed a number of coral patches apparently destroyed by blast fishing. One interviewee mentioned that if a fisherman did acquire dynamite, that the use of it would take place at Nu'utele island, as far from the villages as possible.

Fishing with poisons was also thought to be carried out less frequently. *Derris* root is apparently still used on calm days, by a few fishermen, to catch pone, alogo, fugu and malau, although many fishermen know that it can kill corals.

7.6. Coastal erosion

All eleven fishermen interviewed stated that coastal erosion had become more severe in the past few decades. Most indicated that in the last ten years the problem had particularly increased. Estimates of the width of beach and foreshore area lost to erosion ranged from 20-30 m to 40-50 m. A number of fishermen indicated that they believed the Aleipata wharf had nothing to do with the coastal erosion situation. The dedging for and construction of the now abandoned wharf and causeway took place a little over ten years ago.

Figure 12. Fish spawning aggregations, *Acanthaster planci* aggregations and sea turtle nesting sites.



8. Local Current Patterns

The current patterns indicated by the fishermen interviewed are summarised in map form (Figure 11). As would be expected, currents within the lagoon drained towards the major passes during out- going tides. Some passes maintain an out current on all tides, probably as a response to wave action transporting water over the reef crest and into the lagoon.

Outside the lagoon, major current directions were controlled by the predominate southeasterly tradewinds. In response to occasional north-easterly winds, counter-currents were noted, especially around Nu'utele and Nu'ulua islands.

Wave activity is generally in response to local wind strength and direction. A number of reef front areas were noted by fishermen as the locations of greater wave activity when there were large swells. The period of March through June, particularly June, was given as the season of greatest wave activity.

Storm and cyclone winds and waves were most common from December to March, according to the fishermen interviewed. These arrive from the northwest or southeast.

9. Discussion And Conclusions

9.1. Aleipata marine environment

The survey results show that the marine environment of the Aleipata area contains typical Pacific Island reef and lagoon morphologic features and habitats. These support plant and animal communities normally found in Samoan shallow lagoon and reef slope situations. Thus, the reef and lagoon habitats and associated organisms are probably representative of this marine ecosystem in Western Samoa and could be considered for conservation on that account. However, there is not enough information, at any level, on the reef and lagoon ecosystems of Western Samoa with which to compare the Aleipata area and determine its representativeness or otherwise.

The survey results revealed no unusual, unique, or unknown fish or other organisms. Nor were there any particularly spectacular coral formations or reef morphological features. No information was found to support statements that the area's waters are particularly rich in tuna, or other pelagic species (Chew, 1987). Similarly, there is no data known, nor is the survey able, to support claims that the area is an important source area for replenishment of marine life in surrounding seas and an upwelling area (Chew, 1987). The area was found to be recovering from extensive destruction by outbreaks of Crown-of-Thorns starfish, which have probably occurred several times in the past few decades, severely reducing live coral cover.

9.2. Marine resource use and management

Results from the brief survey on marine resource use show the Aleipata marine environment to be supporting an extensive harvest of a variety of marine resources, primarily for consumption within the Aleipata area. It is thus difficult to characterise the area as "pristine" (Chew, 1987).

Numerous fishing techniques are used, mainly: spear fishing, trolling, handlining and gill netting. In addition, a wide range of invertebrates and some seaweed are gathered from the reef. Whether the area can be considered as overfished requires more data. This sort of data is unavailable, expensive and difficult to obtain for subsistence and artisanal, multi-species fisheries in coral reef and lagoon environments.

Destructive fishing practices are illegal, but persist. The use of dynamite and poison for fishing in the Aleipata area is apparently declining due to enforcement and punishment carried out by village councils. These enforcement and regulation activities should be supported and concurrent educational activities developed regarding the problems of destructive fishing practices. Aleipata area villages continue to exercise control over adjacent fishing rights, especially within the lagoon. This village based control of the access to, and use of local marine resources should be further documented and incorporated into any continued action towards protected area development or management planning at Aleipata.

9.3. Tourism, recreation and research

The Aleipata reef, lagoon and islands present a setting of scenic value to visitors to Western Samoa. However, the distance from Apia, via either of two moderately rough dirt roads for much of the way, does not render the area particularly accessible from outside.

Within the area, the beach of Namu'a Island is a nice visitor destination, as has been noted (Dahl, 1978; Chew, 1987). It is reached by a short boat ride across the shallow lagoon and is sheltered from the rough seas of the open ocean. The lagoon immediately west and north of Namu'a supports coral assemblages of interest for snorkeling.

The area does not generally offer good opportunities for visitor supported SCUBA diving operations. Although water visibility can probably be quite good at times, there are strong currents running between the outer reef slope and the detached islands, creating unsafe diving conditions. The strong winds and wave activity often experienced in the area make diving uncomfortable, if not hazardous. These conditions also lead to reduced water visibility, as experienced during the survey. Equally important, the area surveyed does not offer spectacular coral formations or reef morphologic features sought by intertional dive tourists.

As a location for marine science research and education activities, the Aleipata area is not particularly special in its opportunities. However, protected status would theoretically mean that reef and lagoon processes were operating in undisturbed conditions. Thus a relatively typical Samoan marine ecosystem that is recovering from severe degradation by Crown-of-Thorns starfish would be available and could be of interest for ecological research and educational uses. The demand for these uses is not known at this time.

9.4. Park Management

It is beyond the scope of this report to fully develop management proposals or comment on management policies and strategies already proposed (Chew, 1986; 1987). However, certain marine resource issues which were highlighted during the survey require comment and an indication of possible management responses.

A. Marine resource use

A more systematic survey of marine resource use would be valuable as park development proceeds. A catch monitoring programme and more thorough information on the location, timing and methods of resource harvest (mainly fishing) activities would aid management plan development. In particular, more detailed recording of fishing rights and special sites of importance to renewable resources (e.g. fish spawning aggregation sites) would be useful. Fisheries division personnel would be most suited to gather this information.

B. *Acanthaster planci*

The effects of outbreaks of Crown-of-Thorns starfish on the reef slope coral cover has been discussed (see Section 5.9.). The reef coral communities are recovering, a process which may take decades (Pearson, 1981). Monitoring of the recovery of the reefs at Aleipata and of *Acanthaster* population levels would provide useful information on the recovery of Western Samoa reefs and add to Pacific wide data on *Acanthaster* population levels.

C. Sea turtles

Important sea turtle nesting beaches exist in the proposed park area (Witzell and Banner, 1980). Protection of the nesting sea turtles and their nests and eggs should be a high management priority for the park. Population surveys of the turtle should be carried out, as well as investigations to determine the types and levels of threats to the breeding population. The activities of the former hatchery should be reviewed to determine whether this is an appropriate management response for consideration in the context of the proposed park.

D. Coastal erosion

The east-facing coast of the Aleipata shoreline is subject to considerable erosion (Richmond, 1985) which has apparently taken place mainly in the past decade (see Section 7.6.). A systematic survey of the situation is required and investigation into possible causes and appropriate responses. Any proposed shoreline structures and, especially, dredging activities in the area should be seriously evaluated in the erosion problem context.

9.5. Boundaries

The boundaries which determined the survey area were originally proposed by Chew (1986). There were later revised (Chew, 1987), although the mapped version presented in that document does not match the co-ordinates given in its text (Figure 13.). The actual area investigated in this survey was linked to natural features. The survey area extended from a line between the beach promontory at Lalopapa and the Masaulu reef pass in the southwest to a line between the point at Utufa'alalafu and Fuinu'u reef pass in the north (Figure 1.). The marine environment surrounding the detached islands of Nu'utele and Nu'ulua was also surveyed.

Boundaries for the proposed park should, as much as possible, be based on prominent natural features and discrete geographic areas (Kenchington and Hudson, 1984). This is particularly true for the Aleipata area where any boundaries would need to be readily understood by the local community and easily identified, particularly from small boats. Boundary lines between morphologic features would need to be properly surveyed for gazetting.

Based on the above criteria and the results of this survey, the following boundaries are suggested (Figure 14.):

1. Landward extent: Mean high water mark.

2. Seaward extent: Where not otherwise enclosed by the park outline, the park extends to 200 m beyond the outer edge of the shallow reef or cliffed shoreline.

3. Park perimeter:

3.1. From the tip of Cape Tapaga,

3.2. To 200 m west of the western most edge of Nu'utele Island,

3.3. Following around the 200 m boundary along the west and south coast of Nu'utele Island to 200 m south of the southern most point of Nu'utele Island,

3.4. Across to 200 m west from the western most point of Nu'ulua Island,

3.5. Following around the 200 m boundary along the south coast of Nu'ulua Island untill 200 m east of the southern most point of Nu'ulua Island,

3.6. North to 200 m off the south-east point of Fanuatapu Island,

3.7. North to 200 m off the north-east point of Fanuatapu Island, and

3.8. North along the 200 m line which parallels the reef edge to the Northern boundary.

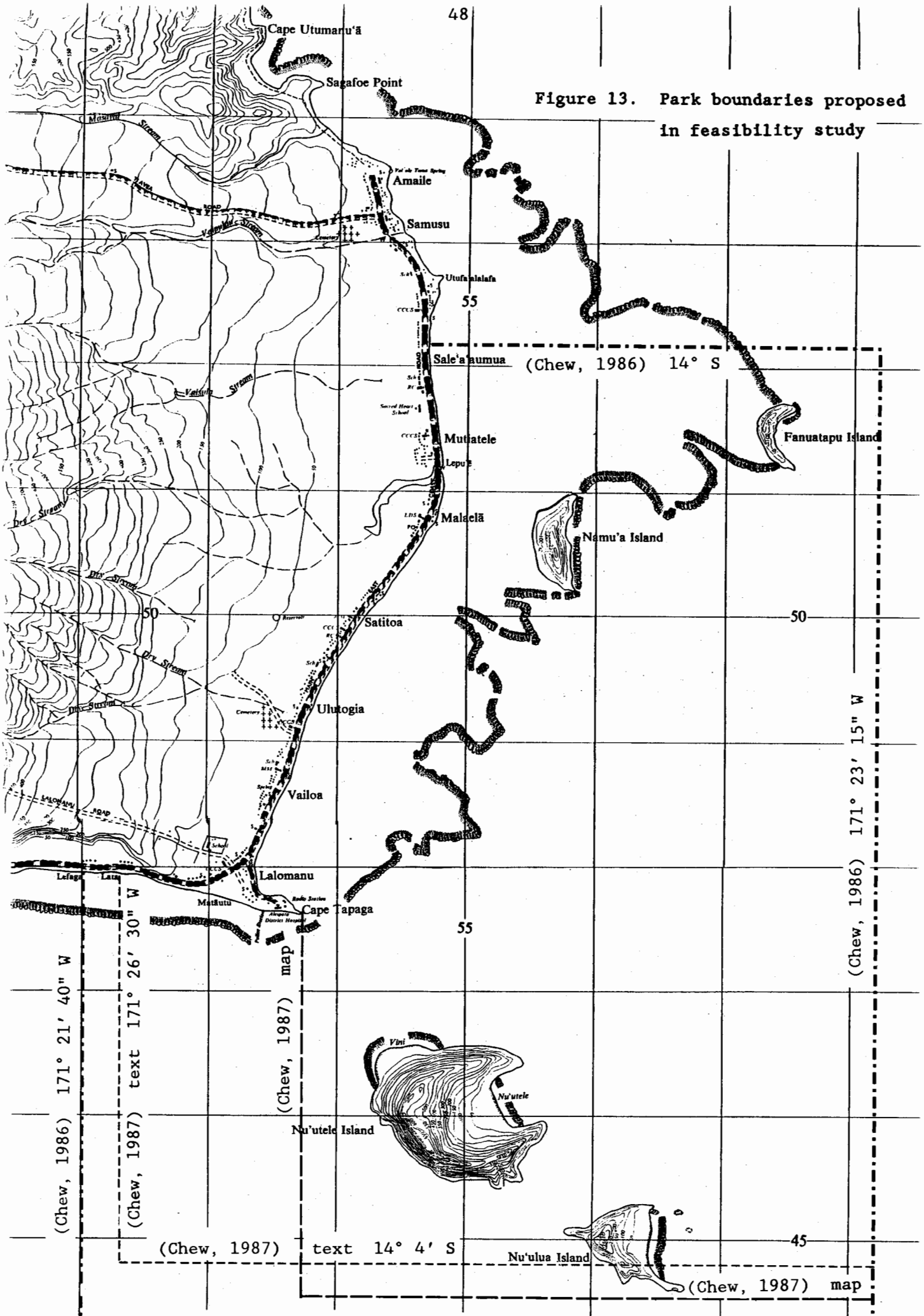


Figure 13. Park boundaries proposed in feasibility study

4. Northern boundary: A series of options are identified for the northern extent of the park (Figure 14.).

Option A - A line between the coastal point at Utufa'alalafa to the Fuinu'u reef pass, and out to the 200 m boundary. (The limit of the survey area).

Option B - The shortest line between the point at Vai ole Tama spring and the major reef pass immediately east and out to the 200 m boundary.

Option C - The shortest line between Saga foe Point, or Cape Utumanu'a, and the adjacent reef edge.

The marine environment north of the survey area is likely to be very similar to the area surveyed. Options B and C allow the northern boundary to be linked to much more prominent coastal features than those which were used to identify the northern extent of the survey area.

5. Southwest boundary:

The suggested southwest boundary is linked to Cape Tapaga, the major coastal feature on the southwest coast. However, well developed sand beaches of potentially important tourist and recreational value are found west of Cape Tapaga.

Option D - A line between a prominent point along the southern coast, west of Cape Tapaga (perhaps as far west as Cape Tuiolemu), and 200 m out from the south-west point of Nu'ulua Island (Figure 14.).

9.6. Zoning

Based on the survey results, a number of zones are proposed for the marine areas within the suggested park area (Figure 14.). Ideally a marine environment zoning plan would be integrated with terrestrial area planning.

A. Conservation zone:

The vast majority of the marine area within the park should be available for continued subsistence and artisanal harvest of renewable marine resources. Commercial exploitation of living resources or disturbance of the habitats supporting these resources should be excluded. Existing fisheries legislation should be strongly enforced, especially those regarding destructive fishing practices. Species which are heavily harvested may require monitoring to determine whether additional regulation is needed.

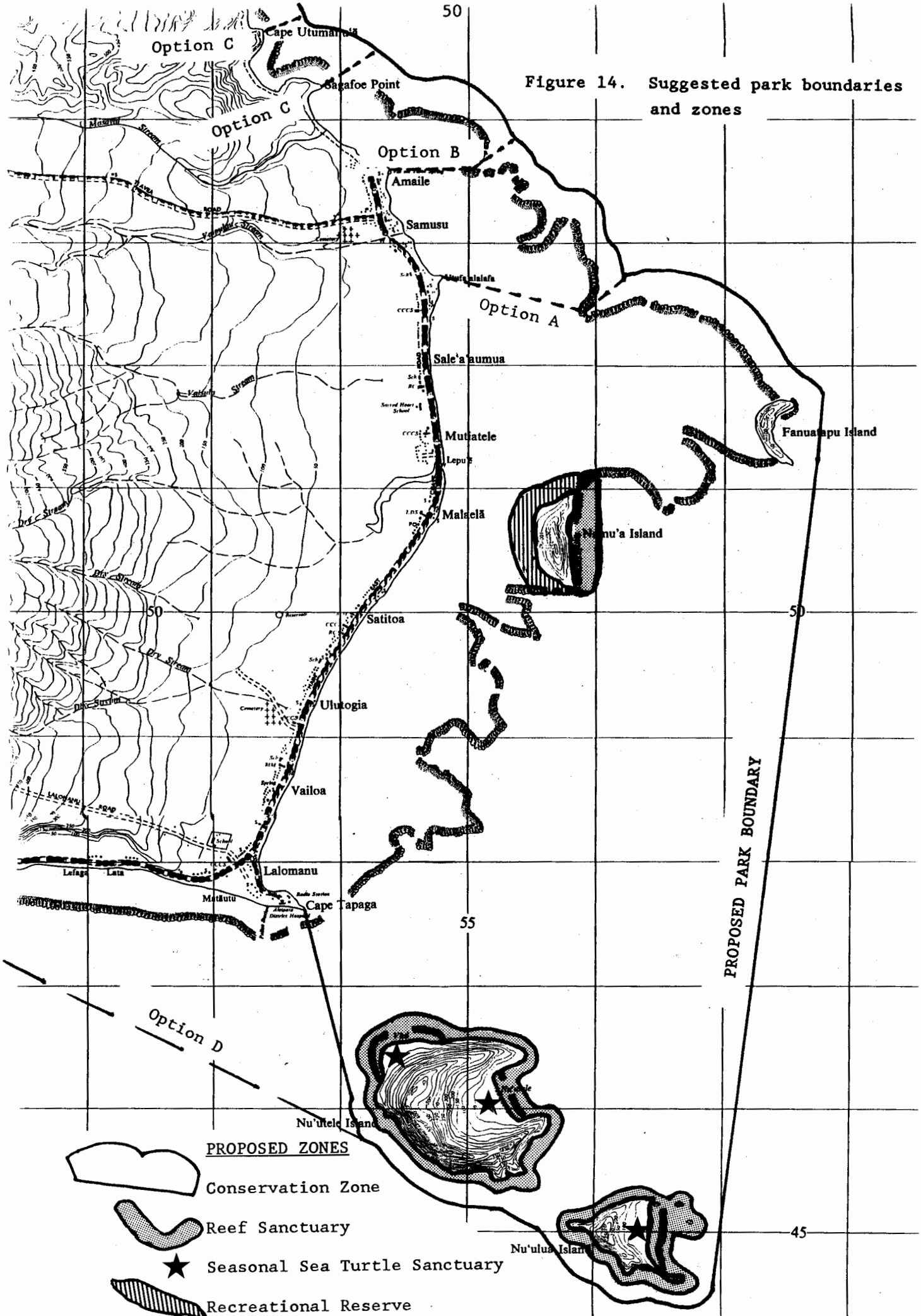


Figure 14. Suggested park boundaries and zones

B. Reef sanctuary:

The reefs around Nu'utele and Nu'ulua islands and along the front of Namu'a island, from mean high water to the bottom of the outer reef slope, should be given sanctuary status. This will constitute a "core zone" for the park's marine environment. All activities removing organisms or disturbing the marine environment, particularly the living resources, would be excluded. Limited recreational, educational and scientific activities could be allowed.

C. Seasonal sea turtle sanctuary:

The beaches of Nu'utele and Nu'ulua islands should have only limited access and use during sea turtle nesting season (September to July). All access to these beaches should be prohibited during the peak nesting months of January and February. Disturbance of nests and collecting of eggs should be strictly outlawed throughout the year, except for scientific or hatchery purposes.

D. Recreational reserve:

The beach, shoreline and lagoon coral formations around Namu'a island should be protected for their recreational value to Aleipata residents, Western Samoans and overseas visitors. Activities which remove or disturb the marine environment, especially corals, should be excluded. It is suggested that the zone extend 200 m into the lagoon from the northern end around to southern end of the island.

10. Acknowledgements

Special thanks to Mr Savale Time (Fisheries Division) and Mr Everett Bishop (Peace Corps Volunteer) for conducting most of the marine resource use interviews. Mr Samuelu Sesega (Forestry Division) and Mr Bishop organised overall logistics and transport for the field work. Mr Lui Bell (Fisheries Division) provided information on Aleipata fisheries and organised use of the Fisheries Division boat. Other personnel from the Department of Agriculture, Forests and Fisheries provided addition support and services.

Special appreciation also to Mr Simi Teropenaia and his family who provided accommodation and meals for our stay in Saititoa Village. Thanks is also due to Simi for his capable and confident boat handling in often less than ideal boating conditions. To all of the above we express our appreciation for the assistance received which made the visit productive as well as enjoyable.

Mr Greg Andrews was supported by funds from the South Pacific Commission (SPC) under its Short-Term Experts and Specialists Services. Additional support for report writing and graphics was provided by the South Pacific Regional Environment Programme (SPREP). Mr Paul Holthus is funded at SPREP by the SPC and United Nations Environment Programme (UNEP).

11. Bibliography

Andrews, G.J. (1987). Marine ecological survey of Pukapuka Atoll. Commonwealth Science Council. 133 pages.

Barnes, D.J., R.W. Brauer, and M.R. Jordan. (1970). Locomotory response of *Acanthaster planci* to various species of coral. Nature. (London) 228: 342-344.

Bell, L.A.J. (1985). Coastal zone management in Western Samoa. Report of the Third South Pacific National Parks and Reserves Conference. Vol. II: 57-73. SPC.

Birkeland, C.E., R.J. Randall, R.C. Wass, B. Smith and S. Wilkens. (1987). Biological resource assessment of the Fagatele Bay National Marine Sanctuary. NOAA Tech. Memo. NOS MEMD 3. 232 pages.

Brauer, R.W., M.R. Jordan, and D.J. Barnes. (1970). Triggering of the stomach eversion reflex of *Acanthaster planci* by coral extracts. Nature (London) 228: 344-346.

Chew, W.L. (1986). Aleipata Marine National Park (Western Samoa): A feasibility report (draft). UNESCO manuscript. 39 pages.

Chew, W.L. (1987). Aleipata Marine National Park and Biosphere Reserve: A feasibility report. UNESCO manuscript. 44 pages.

Dahl, A.L. (1978). Report on assistance to Western Samoa with national parks and conservation. SPC manuscript. 28 pages.

Done, T.J., R.A. Kenchington and L.D. Zell. (1981). Rapid, large area, resource surveys using manta board. The Fourth International Coral Reef Symposium. Vol. 2: 299-308.

Garlovsky, D.F. and A. Berquist. (1970). Crown-of-Thorns starfish in Western Samoa. South Pacific Bulletin Vol. 20 (3): 47-49.

Hansen, A. (n.d.). Islands of Aleipata: Fanuatapu, Namua, Nu'utele, Nu'ulua. Manuscript. 6 pages.

Holloway, C.W. and C.H. Floyd. (1975). A national parks system for Western Samoa. UNDAT. 71 pages.

Johannes, R.E. (1982). Reef and lagoon resource management in Western Samoa. Manuscript. 31 pages.

Kenchington, R.A. and B.E.T. Hudson (eds.). (1984). Coral Reef Management Handbook. Great Barrier Reef Marine Park Authority. UNESCO, Jakarta. 281 pages.

Ollier, C.D., W.A. Whistler and A.B. Amerson. (1979). O Le Pupu-Pu'e National Park, Samoa. UNDAT.

Pearson, R.G. (1973). Recovery of coral reefs on the Great Barrier Reef following attach by *Acanthaster*. Micronesia: 9.223.

Pearson, R.G. (1981). Recovery and recolonisation of coral reefs. Marine Ecology Progress Series 4: 105-122.

Potts, D.C., T.J. Done, P.J. Isdale and D.A. Fisk. (1985). Dominance of a coral reef community by the genus *Porites* (*Scleractinia*). Marine Ecology Progress Series 23: 79-84.

Richmond, B.M. (1985). Reconnaissance survey for construction and landfill materials at Aleipata, Western Samoa. CCOP/SOPAC Cruise Report 110. 14 pages.

Wass, R.C. (1980). Results of an *Acanthaster planci* (Crown-of-Thorns) survey around Tutuila Island, American Samoa. Manuscript.

Whistler, W.A. (1983). Vegetation and flora of the Aleipata Islands, Western Samoa. Pacific Science 37: 227-249.

Witzell, W.N. and A.C. Banner. (1980). The hawksbill turtle (*Eretmochelys imbricata*) in Western Samoa. Bulletin of Marine Science 30 (3): 571-579.

Zann, L.P., L. Bell and T. Sua. (1984). A preliminary survey of the inshore fisheries of Upolu Island, Western Samoa. USP/IMR Technical Report 100. 10 pages.

12. Appendices

Appendix 1. Fish species list with Samoan names

Scientific name	Common anglo name	Local Samoan name
Family Carcharhinidae	Reef sharks	Malie
Family Myliobatidae	Rays	
Aetobatus narinari	Eagle ray	
Dasyatis sp.		Fai
Family Muraenidae	Moray Eels	Pusi
Gymnothorax fimbriatus		Pusi
Family Coryhaenidae		
Coryphaena hippurus	Dolphinfish	Masi masi
Family Thunnidae	Tuna	
Thunnus albacares	Yellow-fin tuna	Asiasi
Family Scombridae	Skipjack	
Katsuwonus pelamis	Bonito	Atu
Family Theraponidae	Tigerperches	
Terapon jarbua	Crescent perch	Avaava
Family Gerreidae	Mojarras	
Gerres sp.		Matu
Family Chanidae	Milkfish	
Chanos chanos		Ava
Family Nemipteridae	Threadfin bream	
Scolopsis sp.		Tivao
Family Kyphosidae	Seachubs	
Kyphosus cinerasens		Gague
Family Holocentridae	Soldierfish	
Myripristis berndti	Berndts soldierfish	
Myripristis kuntee	Black-tip soldierfish	
Myripristis violaceus		Malau
Flammeo sammara	Bloched soldier-fish	
Flammeo opercularis	Banded soldier-fish	

Family Aulostomidae	Trumpetfish	
Aulostomus chinensis		Taotaoama
Family Scorpaenidae	Butterfly cod	
Pterois antennata	Zebrafish	
Pterois volitans	Butterfly cod	
Family Serranidae	Groupers	
Epinephelus sp.		Ata'ata
Epinephelus hexagonatus	Rock cod	
Epinephelus merra	Honeycomb rock cod	Gatala
Epinephelus maculatus		
Cephalopholis argus		
Cephalopholis urodelus		
Variola louti	Coronation trout	
Plectropomus leopardus	Coral trout	
Plectropomus laevis	Footballer trout	
Family Apogonidae		
Apogon sp.		
Family Carangidae	Trevally	
Caranx melampygus		
Caranx ignobilis		Malauli
Elagatis bipinnulatus	Rainbow runner	Samani
Selar crumenopthalus	Silver scad	Atule
Family Caesionidae	Fusiliers	
Caesio xanthonotus		
Caesio caerulaureus		
Pterocaesio diagramma		
Pteriocaesio tile	Tricoloured fuslier	
Family Lutjanidae	Snappers	
Apharus furcatus		
Aprion virescens	Grey jobfish	Utu
Lutjanus bohar	Red bass	
Lutjanus gibbus	Paddle tail	Malai
Lutjanus kasmira	Blue-lined sea perch	
Macolor niger		
Etelis carbunculus	Red snapper	Palumalau
Family Lethrinidae	Emperors or sweet-lips	
Gnathodentex aureolineatus	Golden-lined sea perch	
Lethrinus harak	Sweet-lip	
Lethrinus variegatus	Variegated emperor	Mata eleale
Lethrinus elongatus	Long-nosed emperor	Filoa

Family Mullidae	Goatfish	
Mulloidichthys flavolineatus		Vete
Mulloidichthys vanicolensis	Non-spotted goatfish	
Parupeneus chryserydros		Taulaia
Upeneus tragula		
Upeneus vittatus	Yellow-stripped goatfish	Ulualoa
Family Kyphosidae	Rudderfish	
Kyphosus cinerascens		
Family Chaetodontidae	Butterflyfish	Tifitifi
Forcipiger flavissimus		
Forcipiger longirostris		
Heniochus varius		
Heniochus monoceros		
Heniochus acuminatus		
Chaetodon reticulatus		
Chaetodon ephippium		
Chaetodon auriga		
Chaetodon unimaculatus		
Chaetodon trifasciatus		
Chaetodon ornatissimus		
Chaetodon quadrimaculatus		
Chaetodon citrinellus		
Chaetodon vagabundus		
Chaetodon pelewensis		
Chaetodon ulietensis		
Chaetodon trifascialus		
Family Pomacanthidae	Angelfish	
Pomancanthus imperator	Emperor anglefish	
Centropyge flavissimus	Lemon-peel anglefish	
Centropyge bicolor		
Centropyge bispinosus		
Pygolplites diacanthus		
Family Pomacentridae	Damselfish	
Dascyllus aruanuas		
Abudefduf sexfasciatus		
Plectroglyphidodon johstonianus		
Plectroglyphidodon dickii		
Plectroglyphidodon lacrymatus		
Pomacentrus vaiuli		
Pomacentrus pavo		
Pomacentrus melanopterus		
Chromis margaritifer		
Chromis iomelas		
Amphiprion perideraion		
Amphiprion chrysterus		
Amphiprion sandaracions		
Amphriprion clarkii		
Stegastes nigricans		

Family Cirrhitidae		
Parracirrhites arcatus	Stripped hand-fish	
Parracirrhites fosteri		
Parracirrhites hemistictus	Multicoloured hand-fish	
Family Mugildae	Mullet	Mata pona
Liza vaigiensis		Afa
Mugil cephalus	Sea mullet	Anae
Family Spayraenidae	Barracuda	
Sphyraena barracuda		
Sphraena quenie		
Sphraena forsteri		Sapatu
Family Labridae	Wrasses	
Bodianus axillaris		
Bodianus loxozonus		
Labriodes bicolor	Cleaner wrasse	
Labroides dimidiatus	" "	
Labroides rubrolabiatus	" "	
Cheilinus undulatus	Moari wrasse	Lalafi
Novaculichthys taeniourus		
Thalassoma lutescens		
Thalassoma hardwickei	Six-barred wrasse	
Gomphosus varius		
Coris gaimard		
Halichoeres trimaculatus		
Hemigymnus fasciatus		
Cheilio inermis		Mo'o
Family Scaridae	Parrotfish	Galo
		Laea
		Fuga'usi
Scarus sordidus		
Scarus dimidiatus		
Scarus schlegeli		
Scarus gibbus		
Scarus laltipinnis		
Scarus ghobban	Banded parrotfish	Fuga

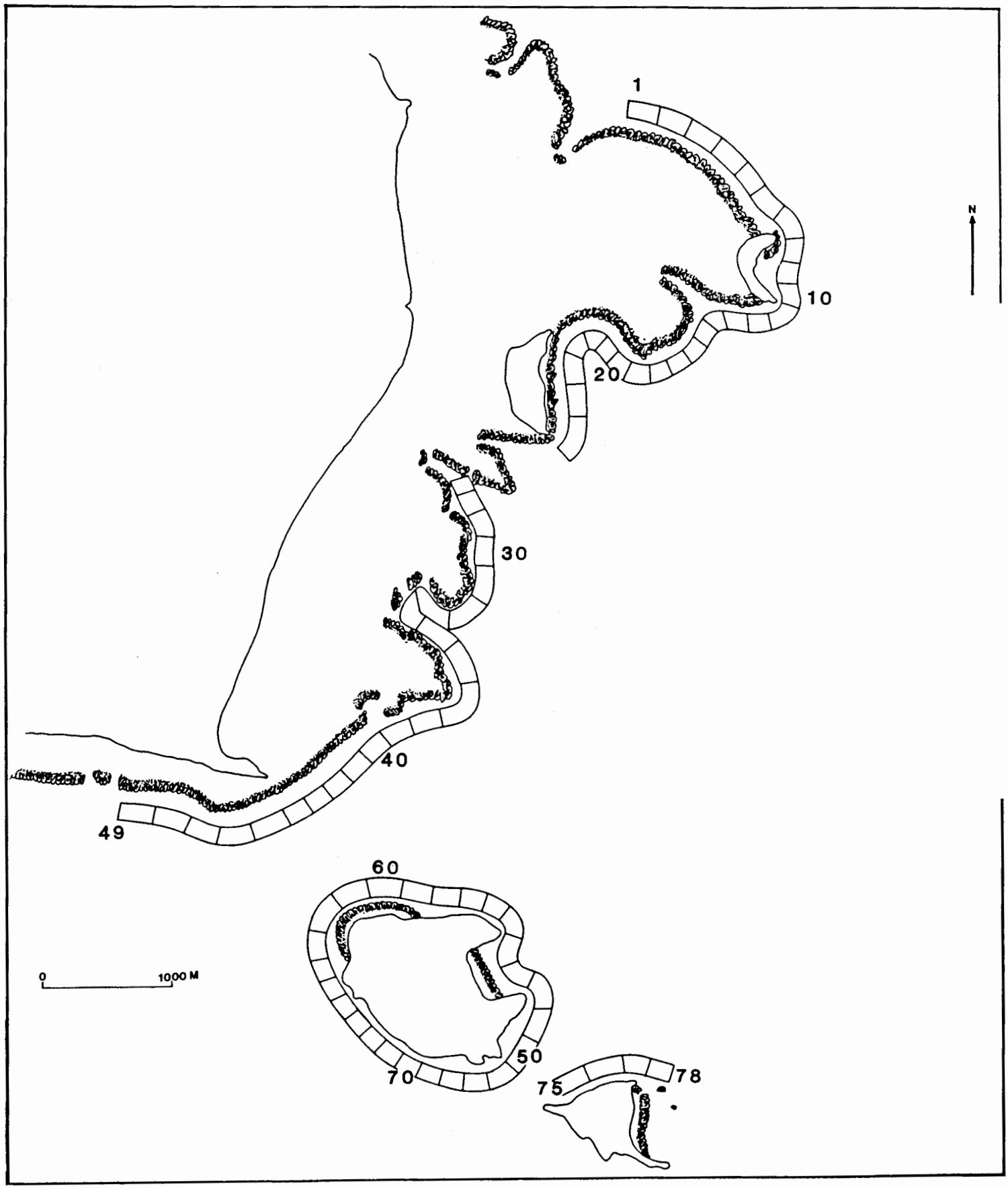
Family Acanthuridae	Surgeonfish	Palaia- baby surgeonfish
Acanthurus triostegus	Convict surgeon	Manini
Acanthurus guttatus	Spotted surgeonfish	
Acanthurus achilles	Red-spotted surgeonfish	
Acanthurus glaucopareius		
Acanthurus olivaceus		
Acanthurus lineatus	Zebra surgeonfish	Alugo
Ctenochaetus striatus	Bristle-toothed surgeonfish	Pone
Zebrasoma scopas	Brown tang	
Naso lituratus	Smooth-head unicornfish	
Naso tuberosus		
Family Zanclidae	Moorish idols	
Zanclus cornutus		
Family Siganidae	Rabbitfish	
Siganus spinus		
Siganus argenteus		
Siganus vermiculatus	Spinefish rabbitfish	Lo
Family Balistidae-Monocanthidae	Triggerfish	
Rhinecanthus aculeatus	Picasso triggerfish	
Sufflamen bursa	Keel trigerfish	
Balistoides conspicillum		
Balistapus undulatus	Oranged-lined triggerfish	Sumu
Family Tylosuridae	Needlefish	
Tylosurus sp.		A'u
Family Albulidae	Bonefish	
Albula vulpes		I'usila
Family Pleuronectidae	Flounder	
Bothus sp.		Ali
Family Fistularidae	Trumpetfish	
Aulostumus chinensis		Taotaoama

Appendix 2. Invertebrate food resources

Samoan name	Common name	Scientific name
Tupa	Land crab	*Cardisoma sp.*
Ula sami	Golden rock lobster	*Panulisus penicillatus*
Aliao	Trochus	*Trochus niloticus*
Alili	Turban shell	*Turbo chrysostomus*
Faisua	Rugose giant clam	*Tridacna maxima*
Fee	Octopus	
Mama'o	Red surf fish	*Actinopyga mauritiana*
Loli	Lollyfish	*Holothuria atra*
Fa'atafa	Prickly redfish	*Thelenota ananas*
Sea	Curryfish	*Holothurian*
Fugafuga	Brown sandfish	*Bohadschia sp.*
Alu'alu	Upside-down jellyfish	*Cassiopea sp.*
Tuitui	Sea urchin	*Echinometra sp.*
Savae	Sea urchin	*Tripneustes gratilla*
Ipu	Peanut worm	*Siphonosoma australe*
Vaga	Sea urchin	?
Gau	Green sea hare	*Dolabella auricularia*
Pala'au		*Lambis lambis*
Fole	Razor clam	*Pinna sp.*
Other and uncertain foods:		
Limu	Sea-weed (macroalgae)	
Pu	Either the giant triton	or *Cassis cornuta*
Tapumiti		*Tripneustes sp.*?

Appendix 3. Raw manta tow data

(Numbers correspond to the computer data base record and not to the tow number from field data).



RECORD NO.	TOW NO.	HARD CORAL	SOFT CORAL	DEAD CORAL	MACRO ALGAE	DIVERSITY	SIZE
1	26	3	1	2	1	2	2
2	25	2	1	1	1	2	1
3	24	2	2	2	2	1	2
4	23	1	1	1	1	1	1
5	22	2	1	1	1	2	1
6	21	2	2	1	1	2	1
7	20	1	1	1	1	1	1
8	19	1	2	1	1	1	1
9	18	1	2	1	2	1	1
10	17	1	1	2	2	2	1
11	16	1	2	2	2	2	2
12	15	1	3	1	2	2	2
13	14	1	3	1	2	2	2
14	13	2	2	1	2	2	2
15	12	2	2	1	2	2	2
16	11	1	1	1	2	2	2
17	10	1	1	1	2	2	2
18	9	1	1	1	2	2	2
19	8	1	3	1	2	2	2
20	7	2	3	1	2	2	2
21	6	2	2	1	2	2	2
22	5	1	3	1	2	2	2
23	4	1	3	1	2	2	2
24	3	2	2	1	2	2	2
25	2	1	3	1	2	1	2
26	1	1	2	1	2	1	2
27	1	1	0	0	4	1	2
28	2	1	0	0	3	1	2
29	3	1	0	1	3	1	2
30	4	1	1	1	3	1	2
31	5	3	1	1	2	2	2
32	6	3	1	1	2	3	2
33	7	1	1	1	3	1	2
34	8	1	1	1	2	1	2
35	9	1	1	1	2	1	2
36	10	1	1	1	2	1	2
37	11	1	1	1	2	1	2
38	12	1	2	1	2	1	2

39	13	2	3	1	2	1	2
40	1	3	1	1	1	2	2
41	2	2	1	1	1	1	2
42	3	3	1	1	1	2	2
43	4	3	1	1	1	2	1
44	5	2	1	1	1	1	1
45	6	1	1	1	1	1	1
46	7	2	1	1	1	1	1
47	8	3	2	1	1	2	2
48	9	4	2	1	1	3	3
49	10	4	2	1	1	3	3
50	5	0	1	0	1	0	0
51	4	1	1	0	1	2	1
52	3	1	3	1	1	2	3
53	2	2	1	1	0	2	2
54	1	3	2	1	1	2	2
55	1	1	2	1	2	2	2
56	2	1	2	1	2	2	2
57	3	1	2	1	2	2	2
58	4	1	2	1	2	3	2
59	5	3	1	2	2	2	2
60	6	2	1	1	1	2	2
61	7	4	1	1	1	2	2
62	8	4	1	1	1	3	1
63	9	3	1	1	1	3	2
64	1	2	2	1	1	2	2
65	2	3	2	1	1	2	2
66	3	4	1	1	1	2	2
67	4	4	2	1	1	2	2
68	5	1	4	1	1	2	2
69	6	3	3	1	1	2	2
70	7	1	3	1	1	2	2
71	8	1	2	1	1	2	2
72	9	1	2	1	2	2	2
73	10	1	2	1	1	2	3
74	11	1	1	0	1	1	1
75	1	3	1	1	1	2	3
76	2	4	1	1	1	2	3
77	3	4	1	1	1	2	3
78	4	4	1	1	1	2	3

Appendix 4. Resource use survey questionnaire

GENERAL INFORMATION

NAME: DATE:

AGE: LOCATION:

VILLAGE: INTERVIEWER:

LOCATION	METHOD	TIMES/WK	SEASON	NUMBER	SIZE	TARGET
A	GILL NETTING					
B 1	BAIT-CAST					
2	SEIN					
C	LAMA					
D 1	LINE-SHALLOW					
2	DEEP					
E	TROLLING					
F	FISH DRIVES					
G	FISH TRAPS					
H	SPEAR FISHING					

BOAT/USAGE

VILLAGE FISHERIES

NO. OF FISHERMAN

FULL-TIME
PART-TIME

NO. OF BOATS/VILLAGE

ALAI
CANOE

ACCESS/RIGHTS

GENERAL COMMENTS

HABITAT INFORMATION

FISH	LOCATION	TIME/SEASON	DEGRADATION OF SITE
SPAWNING			
AGGREGATION			

HABITAT	LOCATION/AREA	TIME/SEASON	DURATION

DESTRUCTIVE FISHING	LOCATION	TIME/SEASON	TARGET
DYNAMITE			
POISON			

GENERAL COMMENTS

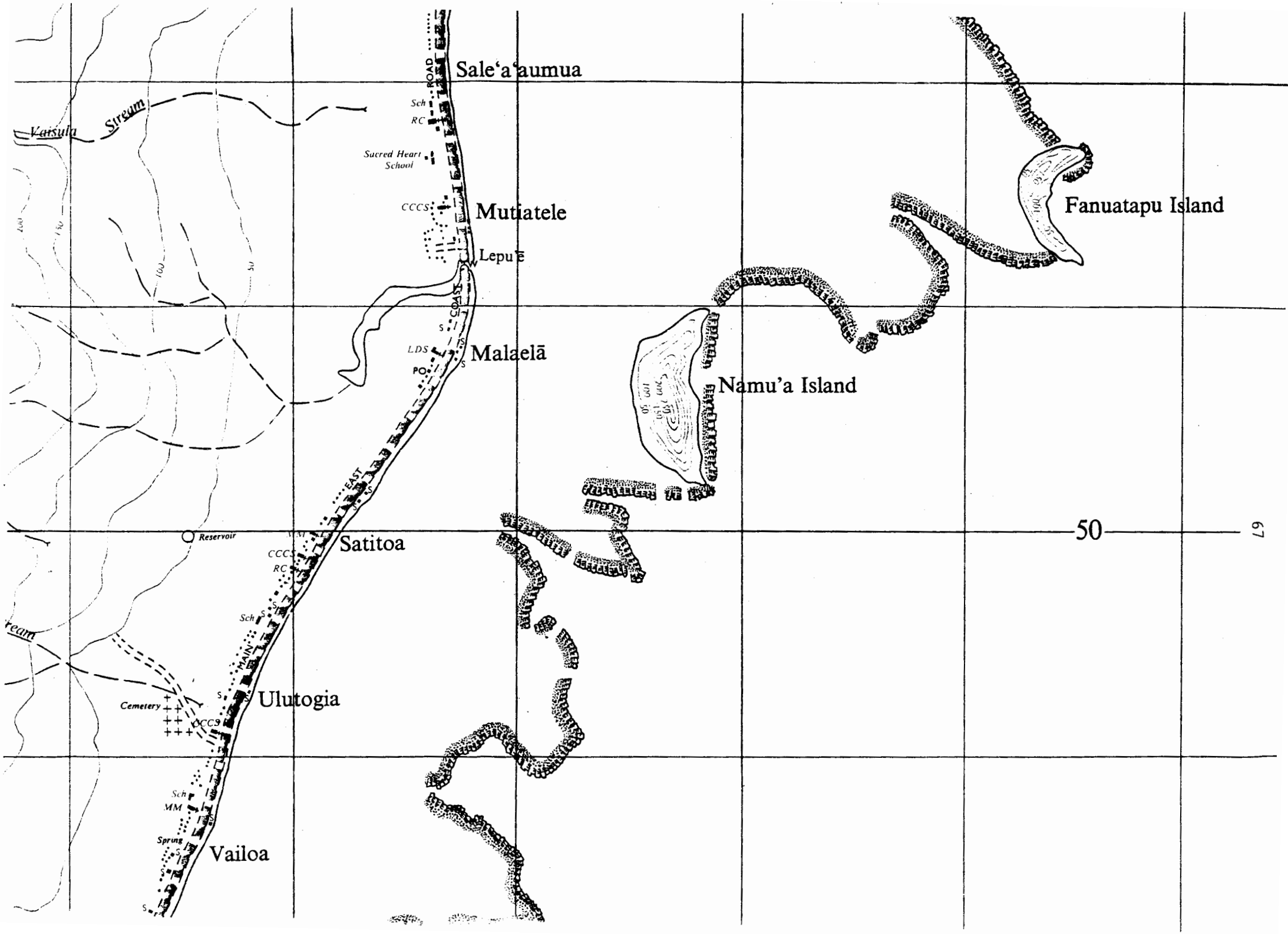
OCEANOGRAPHY	DIRECTION	SEASON	STRENGTH
CURRENTS			
WAVES			
STORMS			

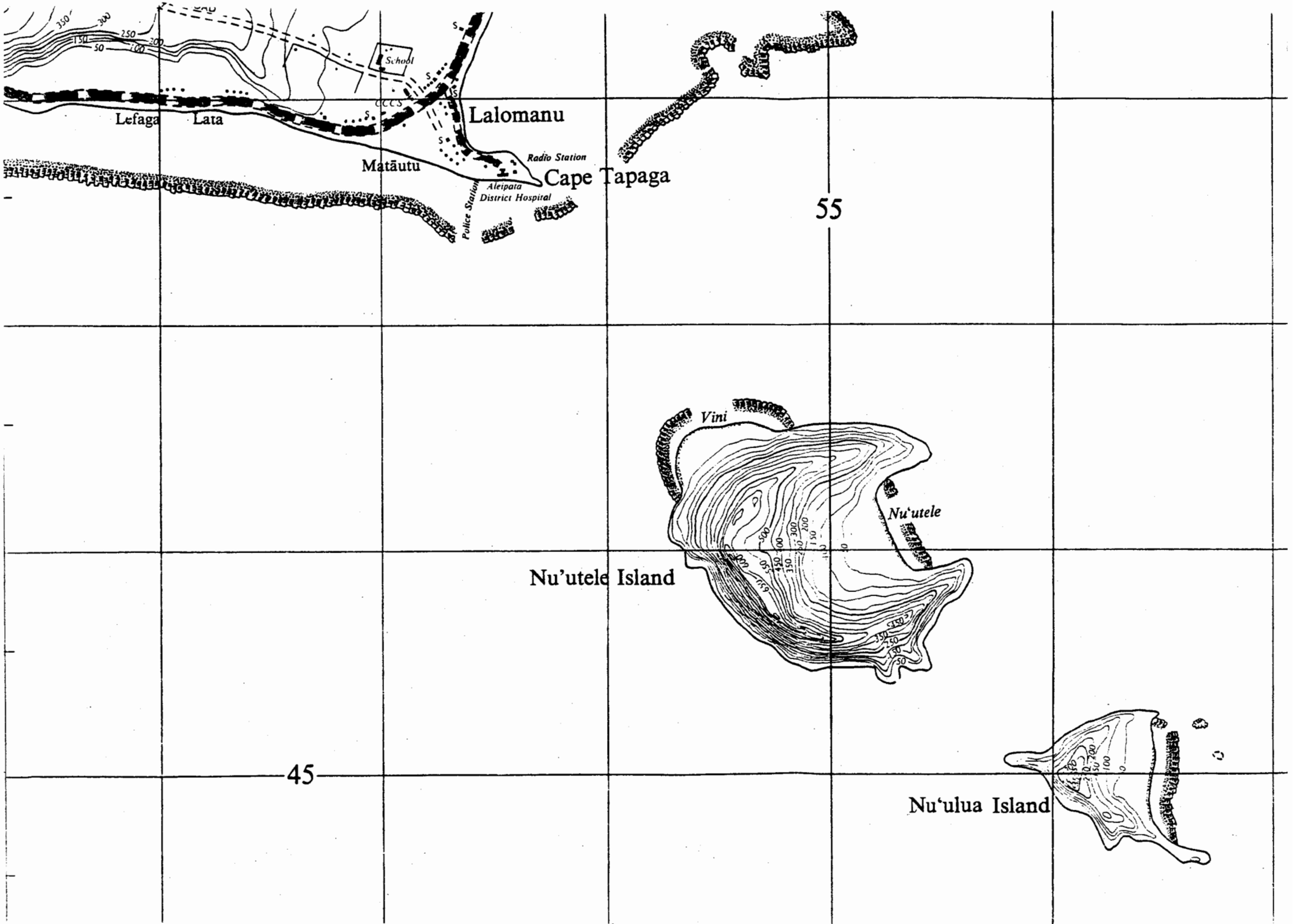
OTHER COMMENTS

REEF GLEENING

LOCATION	TIMES/WK/MTH	SEASON	NUMBER	SIZE	DIST. CATCH
1. U'a					
2. Poatinago					
3. Kuku					
4. Tupa					
5. Ula Vai					
6. Ula Sami					
7. Papata					
8. Valo					
9. Aliao					
10. Panea					
11. Pae					
12. Alili					
13. Asi					
14. Fatuaua					
15. Faisua					
16. Tupane					
17. Tio					
18. Li					
19. Fee					
20. Mama'o					
21. Loli					
22. Faatafa					
23. Sea					
24. Fugafuga					
25. Alu'alu					
26. Tuitui					
27. Savae					
28. Ipo					
29. Aau					
30. Limu					
31. Vaga					
32. Satula					

OTHER COMMENTS


Sale'a'aumua
Vaisula Stream
Sacred Heart School
Mutiatele
Lepu'e
Malaelā
Namu'a Island
Fanuatapu Island
Satitoa
Reservoir
Ulutogia
Cemetery
Vailoa
ROAD
EAST
MAIN
Sch
RC
CCCS
LDS
PO
Spring
MM
50
67


School
Lefaga
Lata
Lalomanu
Matāutu
Radio Station
Cape Tapaga
Police Station
Aleipata
District Hospital
55
Vini
Nu'utele
Nu'utele Island
45
Nu'ulua Island