Economic Valuation of Coral Reefs and Adjacent Habitats in American Samoa

Final Report

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Jacobs in association with:

- **MRAG Americas, Inc., USA**
- **National Institution of Water & Atmospheric Research, NZ**
- **Prof N Polunin (University of Newcastle, UK)**

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	Prepared by	Reviewed by	Approved by
DRAFT	NAME **James Spurgeon** **Toby Roxburgh** **Stefanie O' Gorman** **Robert Lindley*** **Doug Ramsey**** **Nick Polunin*****	NAME **Stephen Clamp**	NAME **Stephen Clamp**
DATE **10th June 2004**	SIGNATURE	SIGNATURE	SIGNATURE

* Marine Resources Assessment Group, USA
** National Institution of Water and Atmospheric Research, New Zealand
*** University of Newcastle-upon-Tyne, UK

FINAL	NAME **James Spurgeon** **Toby Roxburgh** **Stefanie O' Gorman** **Robert Lindley*** **Doug Ramsey**** **Nick Polunin*****	NAME **Stephen Clamp**	NAME **Stephen Clamp**
DATE 2nd November 2004	SIGNATURE	SIGNATURE	SIGNATURE

Executive summary

Introduction

The coral reefs of American Samoa are without doubt one of its most valuable assets, having provided benefits to generations of islanders. However, with one of the fastest population growth rates in the world and rapid economic and industrial development, over the last few decades the island's coral reefs have come under unprecedented pressure from habitat loss, over fishing and pollution.

The Department of Commerce (DOC) established the American Samoa Coastal Management Program (ASCMP) in 1980 to protect and preserve natural resources while attempting to balance and satisfy development needs of the people and Fa'asamoa (the Samoan way of life). Under the ASCMP, the Governor's Coral Reef Advisory Group (CRAG) identified resource economic valuation as an important tool to furthering coral reef management in the Territory. In particular, it was recognised that understanding the current and potential future economic value of reefs, can be an effective way of demonstrating the benefits of sustainable management to policy makers and the general public alike.

In December 2003, the DOC commissioned Jacobs to undertake an economic valuation of the coral reefs and adjacent habitats of American Samoa. This report provides the results of the study which, it is hoped, will assist in the overall policy decision-making and help to guide resource management for future generations.

Objectives

The overall aim of the study was to undertake an economic valuation of coral reefs and adjacent habitats in American Samoa, of sufficient quality and content, to guide future use of resources and management for the territory. In particular, the aim was to focus on current and potential values for corals and mangroves focussing on artisanal and subsistence fisheries, shoreline protection and recreation/tourism (eco-tourism).

In addition, it was agreed that an attempt should be made to estimate potential **non-use values** (i.e. the fact that people may have a value for maintaining coastal resources irrespective of their actual use of the resource). Such values predominantly relate to social, cultural and biodiversity aspects.

Methodology

A visit to American Samoa was undertaken in January and February 2004, during which three main data collection components were undertaken: Information review, village discussion meetings, and general public questionnaire survey.

The **information review** drew upon wide-ranging and highly dispersed sources of environmental, social and economic information, both published and unpublished, as well as anecdotal information obtained through interviews with key consultees.

Discussion meetings were held with representatives from four coastal villages in order to collect information on coral reef and mangrove benefits and discuss the design and implementation of the general public questionnaire. Villages were selected to represent areas with and without significant coral reefs, mangroves or MPAs. Meetings were conducted in Samoan and typically attended by the village mayor or member of the matai, and accompanied by a representative from the fishing community.

A **general public contingent valuation questionnaire** was designed and used to collect information about the use and importance of coral reefs and mangroves to the local residents on American Samoa. The main aim was to elicit a willingness to pay value covering use and non-use values (i.e. the fact that people may derive values.

The survey was initially piloted amongst a small sample (14) in January 2004 before being modified and conducted island wide in February 2004. Responses were obtained from 300 residents from 44 villages on Tutuila, Ofu and Olosega. Interview sampling locations and respondents were selected to be reasonably representative of population distribution (e.g. 90% in southern Tutuila) and socio-economic characteristics (e.g. gender, age, place of birth).

For both coral and mangrove benefits, estimates of current and potential future values have been made for each of the main benefit types. **Current values** are based on the situation in 2004. **Potential future values** were calculated based on two scenarios; a business as usual (BAU) scenario and an optimum sustainable management (OSM) scenario.

The business as usual (BAU) scenario represents a continuation of current trends and impacts affecting coastal resource quality, benefits and values. Although the scenario recognises that significant efforts are being made to improve the management of island resources, it assumes a slight continued decline in coral and mangrove resources predominantly due to continued coastal development and lack of adequate regulation enforcement.

The optimum sustainable management (OSM) scenario represents the potential values associated with an ideal situation. This assumes that the current management initiatives and other proposed mitigation and enhancement measures are fully implemented in an effective manner. Management actions therefore include those specific to the benefit in question (e.g. fisheries regulations or restrictions) and more generic coastal zone management actions (e.g. controlling coastal development and discharge of pollutants).

The study used a **GIS map-based economic model** for assessing the coral and mangrove values. The extent of coral reefs and mangroves was assessed using benthic habitat map data prepared by NOAA (2004). This approach provides significant advantages in that it highlights the potentially significant differences in values between different locations. This is because values at any given location are determined by a range of site-specific factors.

Key economic values

The coral reefs and mangroves of American Samoa both provide significant benefits to the territory and mainland US. A breakdown of the estimated annual values by type and stakeholder group is given in Tables 1 and 2.

Total benefits to American Samoa residents and visitors are estimated to be worth around US$ 5 million/year for coral reefs and US$ 0.7 million/year for mangroves. When potential non-use benefits accruing to US citizens are included, overall benefits could be in the order of at least US$ 10 million/year for coral reefs and US$ 1.5 million/year for mangroves.

Excluding US public non-use values, the combined annual coral and mangrove value is only around 1.2% of American Samoa's annual Gross Domestic Product (GDP). This is a small proportion due to the significant contribution of the current tuna canning export business.

The value of corals in American Samoa is also currently relatively low. This is because tourism and recreational access to corals is limited, extensive man-made shoreline defences have already been constructed (due to significant beach sand and rubble mining) and because there is a relatively small and poor population.

As present values (PV) (i.e. the total sum of future annual values over 100 years converted to current day values using a 3% discount rate), the annual values equate to around US$ 161 million for corals excluding US public values and US$ 318 million including potential US public values. For mangroves the values are around US$ 24 million and US$ 47 million respectively. Note that the true international non-use values could be significantly higher.

Table1 Current coral reef annual values (US$/year)

Type of benefit		Residents	Visitors	US public	Total
Use benefits	Direct subsistence fishery products	572,000	-	-	572,000
	Direct artisanal fishery products	44,000	-	-	44,000
	Direct subsistence fishing CS[1]	73,000	-	-	73,000
	Direct snorkelling/diving CS[1]	38,000	12,000	-	50,000
	Direct snorkel/dive expenditure[2]	17,000	7,000	-	23,000
	Indirect artisanal fishery products[3]	70,000	-	-	70,000
	Indirect shoreline protection	447,000	-	-	447,000
Non-use benefits		3,598,000	216,000	4,964,000	8,778,000
Total benefits		4,858,000	235,000	4,964,000	10,057,000

Note: 1 CS = Consumer Surplus
2 Visitor expenditures are actually a cost to visitors and a benefit to local businesses/residents
3 Offshore reef-associated bottomfish.

Table 2 Current mangrove annual values (US$/year)

Type of benefit		Residents	Visitors	US public	Total
Use benefits	Direct subsistence fishery products	29,000	-	-	29,000
	Direct subsistence fishing CS[1]	4,000	-	-	4,000
	Indirect fishery products[2]	13,000	-	-	13,000
	Indirect shoreline protection	135,000	-	-	13,5000
Non-use benefits		541,000	32,000	745,000	1,318,000
Total benefits		722,000	32,000	745,000	1,499,000

Note: 1 CS = Consumer Surplus
2 Component of the direct coral reef fishery (accounted for in Table 1)

It can be seen above that both coral reef and mangrove values are dominated by non-use benefits. With estimates of US public non-use values included, overall non-use values are around US$ 8.8 million/year (87%) and US$ 1.3 million/year (83%) respectively. Around 8% and 2% of coral reef and mangrove values relate to direct uses and 5% and 10% to indirect uses respectively.

Tables 1 and 2 also highlight that with US public non-use values included, around 50% of coral reef and mangrove values accrue to residents of American Samoa, equivalent to US$ 4.9 million/year and US$ 0.7 million/year respectively. Around 75% of the resident values are related to non-uses, which partly capture traditional and social values. However, of particular significance for residents are subsistence fishery catches (worth US$ 0.6 million/year), shoreline protection services (US$ 0.5 million/year) and subsistence consumer surplus, which represents part of the way of life (US$ 73,000/year).

The degree of uncertainty surrounding the resident and visitor non-use values is such that they could be underestimated by a factor of at least 10. It is not known whether the resident respondents fully understood the implications of the scenarios explained in the willingness to pay questionnaire survey.

The US public could be deriving around half the estimated total coral reef value solely in the form of non-use values at around US$ 5 million/year. However, due to the little know nature of this type of value and the fact that few socio-economic surveys have attempted to determine such values, it is felt that this value could be overestimated by a factor of 10, or more likely underestimated by a factor of possibly 20 to 50 or higher.

Given the uncertainty over the accuracy of the non-use values, Tables 3 and 4 below highlight the extent of values with and without different components of use, indirect and non-use values. Based on resident direct uses for coral reefs alone, the total PV is around US$24 million (US$0.11/m^2) and, including resident indirect uses, US$40 million (US$ 0.18/ m^2). However, by also including resident non-uses the PV becomes US$ 154 million (US$ 0.70/ m^2). With the further inclusion of visitor benefits and US public non-uses the total becomes US$ 318 million (US$ 1.43/ m^2).

Table 3 Cumulative values associated with American Samoa's coral reefs

Value	Cumulative annual value (US$/yr)	Cumulative total PV (US$; 3%)	Cumulative annual value per unit area (US$/yr/$m^2$)	Cumulative PV per unit area (US$/$m^2$; 3%)
Resident direct use value	762,000	24,076,000	0.003	0.11
Above + resident indirect use value	1,279,000	40,413,000	0.006	0.18
Above + resident non-use value	4,877,000	154,101,000	0.022	0.69
Above + visitor non-use value	5,093,000	160,939,000	0.023	0.72
Above + US general public non-use value	10,057,000	317,801,000	0.045	1.43

Table 4 Cumulative values associated with American Samoa's mangroves

Value	Cumulative annual value (US$/yr)	Cumulative total PV (US$; 3%)	Cumulative annual value per unit area (US$/yr/$m^2$)	Cumulative PV per unit area (US$/$m^2$; 3%)
Resident direct use value	33,000	1,034,000	0.07	2.15
Above + resident indirect use value	180,000	5,698,000	0.38	11.87
Above + resident non-use value	721,691	22,805,440	1.50	47.51
Above + visitor non-use value	754,148	23,831,072	1.57	49.65
Above + US general public non-use value	1,499,000	47,360,000	3.12	98.67

The study also revealed that the magnitude of each benefit is highly location specific, not only between region (islands), but within each region. Tables 5 and 6 give a summary of values in US$ per m^2 by type and region of American Samoa (shown as PV). For example, the direct fishery "added value" subsistence value for all American Samoa is 0.08/m^2/year, whereas for Ofu and Olosega the average is estimated at 0.69/m^2/year. The spatial economic model approach revealed that the best quality reefs with the best access within Ofu and Olosega could be worth around US$ 2.5/m^2/year. In other parts of American Samoa such as Pago Pago harbour, where pollution precludes most fishing, and other uninhabited islands, there is an assumed zero direct fishery "added value" subsistence value.

Table 5 Current coral reef present values (US$/m^2; discounted at 3% over 100 years)

Location	Use values								Non-use values				Total value
	Subsistence fishery		Artisanal fishery										
	Direct fishery added value (+multiplier effect)	Fishing consumer surplus	Direct fishery added value (+multiplier effect)	Indirect fishery added value (+multiplier effect)	Snorkelling / diving consumer surplus	Snorkelling / diving expenditure added value (+multiplier effect)	Shoreline protection value	Total use value	Resident non-use value	Visitor non-use value	US general public non-use value	Total non-use value	
Tutuila south shore	0.35	0.04	0.03	0.02	0.06	0.01	0.53	1.04	0.82	0.05	1.14	2.01	3.05
Pago Pago Harbour	-	-	-	0.02	0.08	0.02	0.36	0.48	0.07	0.004	0.10	0.17	0.65
Tutuila north shore	0.07	0.01	0.01	0.02	0.01	0.005	0.27	0.40	1.61	0.10	2.23	3.94	4.33
Aunu'u and inshore banks[1]	0.02	0.003	0.002	0.02	-	-	-	0.04	0.69	0.04	0.96	1.69	1.73
All Tutuila	0.20	0.03	0.02	0.02	0.03	0.004	0.34	0.64	0.97	0.06	1.33	2.36	2.99
Ofu & Olosega Islands	0.69	0.09	0.05	0.05	0.03	0.04	0.10	1.05	1.33	0.08	1.84	3.26	4.31
Ta'u Island	0.37	0.05	0.03	0.01	-	-	0.08	0.53	0.69	0.04	0.96	1.69	2.22
All Manu'a	0.55	0.07	0.04	0.03	0.02	0.03	0.09	0.83	1.07	0.06	1.47	2.60	3.44
Swains Island	0.10	0.01	-	-	-	-	-	0.11	0.69	0.04	0.96	1.69	1.80
Rose Atoll	-	-	-	-	-	-	-	-	6.92	0.42	9.55	16.89	16.89
Offshore banks[2]	-	-	-	0.005	-	-	-	0.005	0.07	0.004	0.10	0.17	0.17
All other areas	0.001	0.0002	-	0.005	-	-	-	0.01	0.35	0.02	0.48	0.85	0.86
All American Samoa	0.08	0.01	0.01	0.01	0.01	0.003	0.06	0.18	0.51	0.03	0.71	1.25	1.43

Note: 1 includes Taema and Nafanua banks.
2 includes South, and East Banks.

Table 6 Current mangrove present values (US$/m^2; discounted at 3% over 100 years)

Location	Use values							Non-use values[1]				Total value
	Subsistence fishery		Artisanal & subsistence fishery									
	Direct fishery added value (+multiplier effect)	Fishing consumer surplus	Indirect fishery added value (+multiplier effect)[2]	Recreation consumer surplus	Recreation expenditure added value (incl. multiplier effect)	Shoreline protection value	Total use value	Resident non-use value	Visitor non-use value	US general public non-use value	Total non-use value	
Pala lagoon	1.91	0.24	0.83	-	-	9.36	12.34	35.64	2.14	49.02	86.80	99.14
Leone	1.91	0.24	0.83	-	-	-	2.98	35.64	2.14	49.02	86.80	89.78
All mangroves	1.91	0.24	0.83	-	-	8.89	11.87	35.64	2.14	49.02	86.80	98.67

Note: 1 - Relative proportions for each stakeholder group based on coral reef non-use calculations.
2 - Direct coral reef fishery component - value also accounted for under coral reef summary.

The spatial economic model approach also highlighted that values at a given location can reach in excess of 130 times the territory average (e.g. coral reef snorkelling expenditure values at Ofu). This has major implications for the application of values at a micro-scale and clearly illustrates the importance in considering spatial variation as opposed to overall mean values.

With the exception of current fishery product values, the benefit estimates are approximate and should be considered in terms of their relative order of value only. More accurate estimates would require additional specific detailed and comprehensive questionnaire surveys and studies.

The values reported can generally be considered as minimum values. In particular, consumer surplus, non-use and future values may be significantly underestimated. As mentioned above, non-use values could be underestimated by as much as 10 to 20 times. All assumptions have been conservative and there are other benefits identified that have not been valued (e.g. provision of sand supply and genetic resources).

Other key observations arising from the valuation process

When considered at a macro-scale (e.g. the entire territory or an individual island etc), the total values appear reasonably large. For instance, the annual coral reef resident and visitor use and non-use values (US$ 5 million) outweigh the current coastal zone management expenditure of around US$ 2 million per year by two and a half times. Including non-use values for the US population, the total of US$10 million outweighs expenditure by five times. Without this management expenditure, the coral and mangrove values would rapidly decline to virtually zero.

On the other hand, when considered at a micro-scale, the values appear relatively small. The best estimate average PV of coral reefs per unit area is US$ 1.43/m^2. Whilst, this value does compare favourably to Cesar et al (2003) who estimated PVs of US$ 0.8/m^2 of corals for the Pacific and US$ 2.8/m^2 worldwide, it is considerably smaller than per unit area values used in claims for damages to coral reefs following ship groundings or pollution incidents (which range from tens of US$ to thousands per m^2). This has major implications for the use of the results (see recommendations below).

The results highlight that non-use values are of considerable importance when considering the value of coral reefs and other coastal resources. This is particularly true for resources with comparatively few or no human uses, where the value may be significantly underestimated if non-uses are ignored.

However, due to the number of assumptions involved, non-use value estimates are the least robust of all benefits examined. Actual values may be underestimated by orders of magnitude and must be considered as minimum values. Until specific comprehensive non-use value stated preference surveys (such as CVM or choice modelling) are undertaken, the magnitude of such values will remain unknown.

Mariculture could potentially generate considerable value given appropriate research, investment and management. However, due to physical and economic constraints, the future potential for the development of an aquarium trade is limited. Although coastal zone management activities have improved considerably in recent years, there is a great deal more to be done. In particular, there is an urgent need to: develop and implement a targeted integrated coastal management plan; strictly enforce, and where needed, enhance existing regulations; and encourage appropriate development of suitable facilities and training (e.g. relating to tourism and mariculture).

The activity of mining coral rubble and sand from the foreshore over the past few decades results in potential additional costs to the American Samoa economy of between US$ 0.5 to 2.3 million per year, at a value of between US$ 90-450 per cubic yard of material. This estimate excludes the considerable loss of beach recreation and tourism value, also potentially worth millions of dollars per year.

Comparison of alternative scenarios (potential values)

Under the **Business As Usual scenario**, over a 25 year period, total coral reef and mangrove **non-use values are likely to increase** relative to the current scenario whilst total **use value would decrease**. The net effect is an increase in the overall annual value to around **US$ 22.2 million per year** (up by around 92% over current value). This is mainly due to the non-use values increasing over time anyway as populations grow and conservation awareness improves. However, there is an expected significant decline in annual coral reef and mangrove use values to around US$ 0.9 million collectively (a reduction of around 39% below current value).

Under the **Optimum Sustainable Management scenario**, the total annual coral reef and mangrove values are estimated to be significantly higher than at present at a total **around US$ 61 million per year**; up by around 430% over current value. Again this change is driven strongly by **increased non-use value** (which increases to around US$ 58 million/year, up by 474%), due to both population growth and even more enhanced individual non-use value (associated with greater awareness of conservation issues). However, most significantly for residents and visitors, total annual **use value increases** dramatically under the OSM scenario to just under US$ 3.3 million (an increase of around 124% over current levels).

The expected significant decline in use coral reef and mangrove values under the BAU scenario represents a potentially major cause for concern for residents and visitors and highlights the importance of continuing and enhancing national ICZM strategy and actions.

Potential use of the results

This valuation study provides a powerful tool to assist in resource use planning and territory management. By understanding the relative value of different coastal resources, their different types of benefit and how the values vary spatially, future policy-making and resource management decisions can be better guided. The following are examples as to how the values could be used.

The examples include reference to several “market-based instruments” whereby conventional environmental “externality” values can effectively be “internalised” by creating market prices for them (e.g. user fees and fines).

Prioritisation of focus and expenditure: By examining the relative values of different benefits at different locations (e.g. fisheries, recreation and shoreline protection), priorities can be determined and specific locations can be targeted for special management attention (e.g. specific water catchments).

Enhancing decision-making: The values can be used to inform development decisions where the costs and benefits of alternative development options are being (or should be) explored. For example, the likely high non-use values of Ofu and its potential loss should be taken into account if considering further development of the island.

Justification for additional expenditures: By appreciating the value of what is being protected, and the potential benefit to be gained by improved management, the values can be used to justify additional expenditure. For example, management actions required for the OSM scenario are well justified in economic terms.

Natural resource damage assessments: By knowing the value of coastal resources one can determine appropriate levels of fines and compensation payments for damages caused to them. However, a review of ship grounding incidents (e.g. in Mexico, US, Pacific and Egypt) reveals that the average payment for damages to corals is in the order of US\$ 1000/m^2, predominantly based on restoration costs. The US adopts a habitat restoration approach to damage assessments guided by specific legislation rather than fines. So careful thought is needed as to how best to approach damage assessments in line with national US legislation.

Controlling use of resources: If prices are set appropriately, by charging people for use of coastal resources, numbers of users and quantities extracted can be controlled.

Raising revenues: By understanding the value that certain stakeholders enjoy from having free access to coastal resources, a range of different means of capturing that value can be developed. For example user fees can be established through, entrance fees, permits to undertake activities, concessions for private operators and royalties. Non-use values can be appropriated through innovative subscription, donation and voluntary work schemes.

Maximising benefits: By understanding what the current and potential benefits are, a more targeted approach can be achieved to develop or enhance certain types of benefit (e.g. marine eco-tourism and mariculture). Carefully designed and targeted public education and awareness campaigns can also increase both use and non-use values.

Minimising costs: By understanding better who benefits from use (and non-use) of coastal resources and by how much, one can elicit voluntary help to minimise management costs. The questionnaire survey results demonstrate significant potential support for coastal management activities by local residents.

However, there are two important caveats:

Although market-based instrument approaches are increasingly being used around the world for improved natural resource management, the ideas need to be implemented extremely carefully. Many complex issues can arise (e.g. stakeholder reactions and indirect impacts) that need to be thoroughly understood and dealt with appropriately.

The valuation exercise undertaken for this study has been relatively limited. More detailed and accurate estimates of some values (e.g. recreation and non-user willingness to pay) would be needed to appropriately undertake some of the above uses of environmental values. Project specific valuations and impact assessments may therefore be necessary in the case of planning major development or policy changes.

Recommendations

General use of the results

- The results should be used to guide future policy and project decision-making; help secure adequate coastal zone management funding; help target funding; and guide use of market-based instruments.

- The Government of American Samoa should consider incorporation of the results (or more accurate future estimates) into the national accounts.

Advice over specific use of the results

- Careful consideration should be given to application of the results. In particular it is strongly recommended that:

  - Both use and non-use values are considered when assessing the value of a given location (i.e. that the concept of total economic value is applied).
  - The spatial variation in results is considered. Based on average values alone, the value of a given location may be significantly underestimated (or overestimated). Detailed location specific values can be determined from Appendix D.
  - When considering the value for any given location, only those values that are relevant should be considered.

- However, where small-scale impacts are likely (e.g. direct destruction of corals from a ship grounding or landfill), the direct economic loss may not appear to be that large. It is thus worth considering other approaches to valuation and compensation, such as one based on restoration costs. Coral reef restoration costs can be in the order of US$ 1000/m^2.

General actions arising out of the valuation

- **Population growth.** The dramatic adverse implications of rapid and uncontrolled population growth are generally widely acknowledged. This issue must become a top Government priority if the American Samoa Coastal Management Program is to be able to successfully manage coral reefs and mangroves and maintain or enhance their values.

- **Coastal development.** Although coastal development itself is driven to extent by population growth, tackling coastal development impacts must be addressed urgently. The existing DOC Project Notification and Review System should be strengthened and should integrate the values and concepts in this report in all development decision-making.

Actions on fisheries management

- Better enforcement of existing fisheries regulations is needed.
- Community-based fisheries management should continue to be pursued.
- Measures should be taken now to plan for the likely cannery closure.
- Other sources of fish should be promoted for consumption.
- Fishery resource use taxes should be considered.
- Complete monitoring of the harvest of coral reef fish and invertebrates is needed.

Actions on recreation and tourism management

- A national study should be undertaken to investigate how best to develop marine eco-tourism.
- The introduction of user fees in parks should be considered.
- A basic guide to snorkelling and diving on American Samoa should be produced.
- Pilot studies should be carried out to encourage selected villages and suitable local entrepreneurs to enhance marine eco-tourism.
- The carrying capacity of popular and sensitive snorkelling areas and mangrove areas should be explored.

Actions on shoreline protection management

- Enforcement of sand and coral rubble mining regulations must become a top priority, with serious fines imposed for offenders.
- A more holistic territorial strategy to shoreline protection should be developed.

Enhancement of non-use value

- Non-use values should be enhanced through a carefully designed and targeted public awareness and education campaign aimed at residents, visitors and the US public.
- Alternative means of capturing local, visitor and US non-use values should be considered.

Other studies

- Further studies should be undertaken to explore in more detail the values not addressed in this study.

- In addition, other studies could be undertaken to examine the spatial distribution of parameters that affect key values.

Next steps

The following next steps are recommended:

- **The results of this study should be used to their fullest possible extent.** This for example should include promotion of the value of coastal resources to residents in American Samoa and policy-makers in the US.

- **A Territory wide integrated coastal zone management plan should be developed drawing closely upon the results of this study.** It is essential that this should influence broader policies regarding population growth, the economy and housing.

- **Additional studies should be undertaken to:**

  a. Assess the suitability and best means of introducing market-based instruments balanced with developing and enforcing regulations;

  b. Determine how best to manage and develop future artisanal, subsistence and mariculture fisheries;

  c. Assess how best to develop and manage future coastal resource based recreation and eco-tourism.

  d. Develop an holistic shoreline protection strategy;

  e. Enhance and capture the non-use values of American Samoa's coastal resources, and;

  f. Assess the extent and value of other coastal resource benefits such as education and research.

Abbreviations

ASCC	American Samoa Community College
ASCRAG	American Samoa Coral Reef Advisory Group
ASEPA	American Samoa Environmental Protection Agency
ASPA	American Samoa Power Authority
BAU	Business as Usual
BMUS	Bottomfish Management Unit Species
CBA	Cost Benefit Analysis
CBM	Community Based Management
CS	Consumer Surplus
CVM	Contingent Valuation Method
DMWR	Department of Marine and Wildlife Resources
DOC	Department of Commerce
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organisation (of the UN)
FBNMS	Fagatele Bay National Marine Sanctuary
FY	Financial Year
GATT	General Agreement on Tariffs and Trade
MPA	Marine Protected Area
NPSA/NPS	National Park of American Samoa/National Parks Service
NPV	Net Present Value
OSM	Optimum Sustainable Management
PNRS	Project Notification and Review System
TEV	Total Economic Value
US$	American Dollars
US(A)	United States (of America)
WTP	Willingness to pay

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1 Introduction

1.1 Background

The coral reefs of American Samoa are without doubt one of its most valuable assets, having provided benefits to generations of islanders. However, with one of the fastest population growth rates in the world and rapid economic and industrial development, over the last few decades the island's coral reefs have come under unprecedented pressure from habitat loss, over fishing and pollution.

The Department of Commerce (DOC) established the American Samoa Coastal Management Program (ASCMP) in 1980 to protect and preserve natural resources while attempting to balance and satisfy development needs of the people and Fa'asamoa (the Samoan way of life). Under the ASCMP, the Governor's Coral Reef Advisory Group (CRAG) identified resource economic valuation as an important tool to furthering coral reef management in the Territory. In particular, it was recognised that understanding the current and potential future economic value of reefs, can be an effective way of demonstrating the benefits of sustainable management to policy makers and the general public alike.

In December 2003, the DOC commissioned Jacobs to undertake an economic valuation of the coral reefs and adjacent habitats of American Samoa. This report provides the results of the study which, it is hoped, will assist in the overall policy decision-making and help to guide resource management for future generations.

1.2 Study objectives

According to the Request for Proposals (RFP), the overall aim of the study was to:

"undertake an economic valuation of coral reefs and adjacent habitats in American Samoa, of sufficient quality and content, to guide future use of resources and management for the territory".

As part of this, other objectives were to:

"Identify the major uses, users and threats focussing on (at least) the representative parts of the coral reef ecosystem outlined in the Scope of Works". In doing so, *"the study shall concentrate on selected areas (i.e. South Shore Tutuila Island (harbour and non-harbour areas) and Manu'a Islands) whilst remaining applicable to other parts of the Territory";*

"Provide a full accounting, to the extent possible, of the principal economic values of coral reefs and adjacent habitats based on a Total Economic Value (TEV) approach".

The RFP also suggested that the focus should be on the following values:

- *Shoreline subsistence fishery* (35% of effort)
- *Artisanal coral reef fishery* (20%)
- *Wetlands/mangroves* (15% - during the study it was agreed to omit the wetlands and focus on mangroves)

- *Coastal erosion protection* (10%)
- *Recreation/eco-tourism* (10%)
- *And other aspects* (*10% - e.g. aquaculture, aquarium trade and sand mining)*

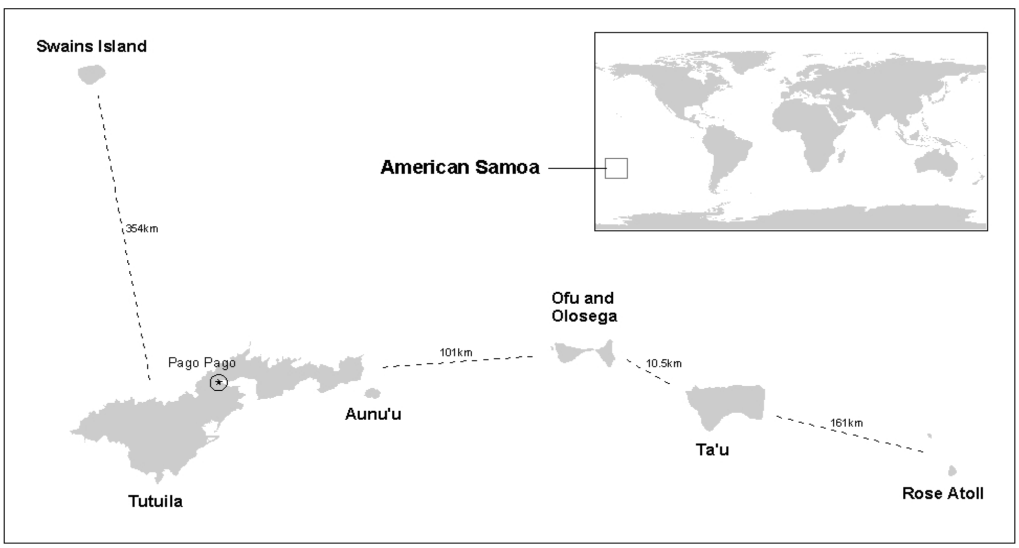
The RFP also suggested that the study should rely principally on existing **available information**, knowledge and data, although it suggested that some **primary data** should be collected for subsistence and artisanal fisheries. During the study, it was agreed that the primary collection should be in the form of a contingent valuation questionnaire focussing on use and non-use values for the general public.

The RFP also requested that estimates of economic values should focus on **gross values** rather than net (i.e. less costs incurred), and that qualitative **levels of confidence** of the values should be provided.

1.3 The islands of American Samoa

American Samoa is the only US Territory in the Southern Hemisphere. The territory consists of five rugged volcanic islands (Tutuila, Aunu'u, Ofu, Olosega and Ta'u) and two atolls (Swains Island and Rose Atoll) in the central South Pacific Ocean see Figure 1.1). The largest islands are the economic and government centre Tutuila and those of the Manu'a group (Ofu, Olosega and Ta'u Islands). The islands have a total area of 199 km^2, most of which is steep, forested and inaccessible.

Figure 1.1 The islands of American Samoa



Note distances between islands are not to same scale.
Source: based on NOAA (2004A).

The vast majority of the 66,000 residents live on the narrow coastal plain of southern Tutuila. The population is growing rapidly (about 2.1% per year between 1990-2000; DOC statistics, 2004) and is expected to continue rising due to high birth and immigration rates. Over recent decades, population expansion and a steady shift from a subsistence to a cash economy has led to major changes in land-use, increased urbanization and significant losses of coastal resource services and values. However, due to possible changes in import duty regulations in the USA, it should be noted that the island's tuna canneries may close in the near future which could lead to a population decline.

The coastal habitats considered in this study are coral reefs and mangroves. Other habitats, which are not the focus of this study, can also be valuable and we have briefly mentioned the significance of seagrass beds and beaches.

1.4 Coastal habitats of American Samoa

1.4.1 Coral reefs

The islands of American Samoa host extensive coral reefs (see Figures 1.2 and 1.3). The reefs tend to be fringing in character around the main islands of Tutuila, Aunu'u and those of the Manu'a group. Tutuila also has a number of submerged banks with reef formation (Taema and Nafanua Banks). Swains Island is a raised atoll whilst Rose Atoll is a typical atoll formation. Extensive reef areas are also believed to be located on several of the shallower offshore banks, though they are not well studied and the exact extent and status is uncertain.

Coral reef biodiversity is generally similar to those of other islands in this region of the South Pacific (e.g. Samoa) but less than those on reefs further west. In total, some 890 reef fish, 200 coral, 262 algae and 2 seagrass species have been recorded here (Spalding et al, 2001; Craig, 2002; Skelton 2003).

Estimates of reef area vary depending on the definition of coral reef habitat and the depth to which they are measured (see Table 1.1). For the purposes of this study, coral reefs were considered to a maximum depth of 30m, primarily to enable use of NOAA's (2004) benthic habitat mapping data (based on IKONOS imagery which has a depth penetration of ~30m). The biological basis for the 30m definition is that most hermatypic corals (those responsible for reef development) grow in waters of less than 25m because they require a light intensity of at least 1-2% of surface intensity (Nybakken, 1993). Coral reefs were also considered to include macroalgae and coralline algae (both of which are naturally occurring reef components) but to exclude areas of unconsolidated sediment (i.e. sand and mud).

Table 1.1 Coral reef area in American Samoa (km^2)

Island / Bank	<30m depth[1]	<50m depth[2]	<100m depth[2]
Tutuila	36.2	108	365.7
Ofu / Olosega	11.2	12.2	28.6
Ta'u	8.0	4.7[3]	22.7
Swains Island	2.1	3.4	5.0
Rose Atoll	6.6	9.9	11.6
Offshore banks	158.1[4]	340.6	461
Total	222.2	478.8	894.6

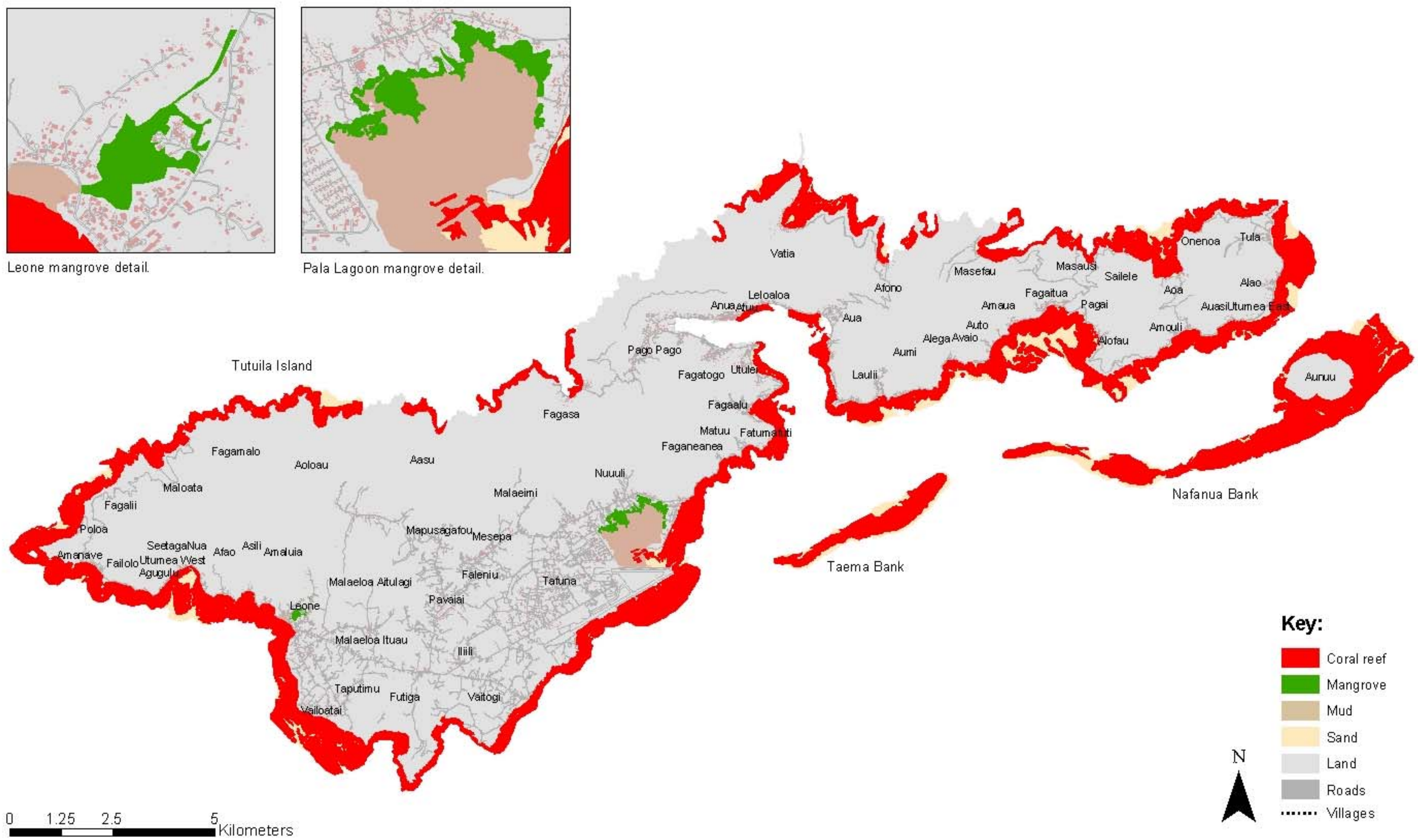
Notes: 1 Source: NOAA (2004a)
2 Source: Graves (2003)
3 Value smaller than that at 30m, assumed to be due to method of area estimation.
4 Not mapped by NOAA; value extrapolated based on mean difference between 30m and 100m total across all other areas.

Based on the above, total coral reef area in American Samoa (<30m) has been calculated to be around 222km^2 (see Table 1.1). This total is considerably lower than previously reported and has major implications for subsequent coral reef value estimates. However, this figure is identical to that reported in Spalding et al (2001) and is likely to be a truer representation of actual reef area than non GIS-based estimates. This represents about 7% of coral reefs in the US (including all territories) and less than 0.001% of coral reefs globally.

Figure 1.2

Distribution of coastal and marine habitats on Tutuila, Aunu'u, Taema and Nafanua Banks.

Note: Maps based on NOAA benthic habitat classification (NOAA, 2004).

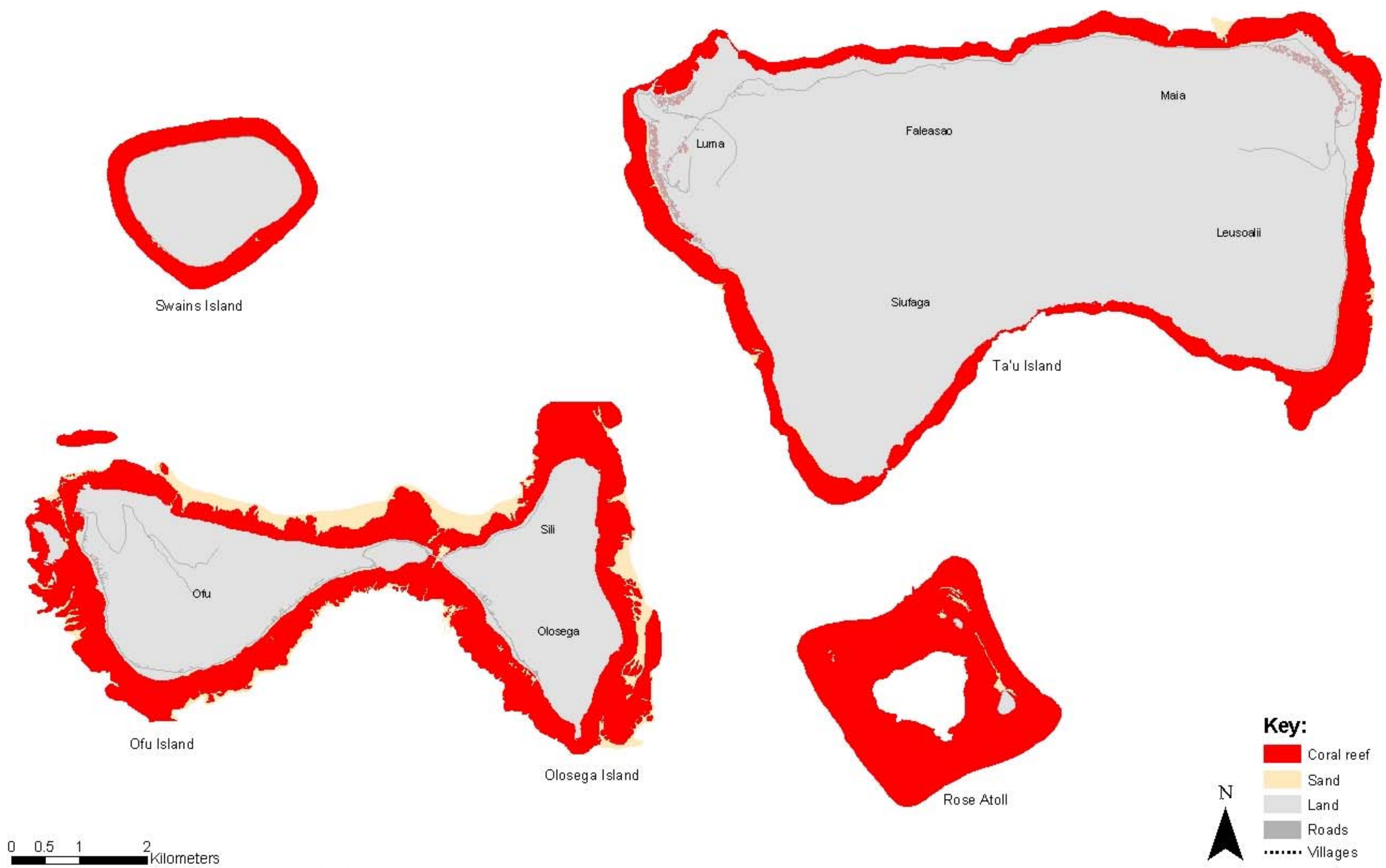


N.B. Scale refers to main map only; insets not to scale.

Figure 1.3

The coastal and marine habitats of Ofu, Olosega, Ta'u, Swains Island and Rose Atoll.

Note: Maps based on NOAA benthic habitat classification (NOAA, 2004).



N.B. All islands drawn to same scale but relative locations and distances between islands are not.

American Samoa's reefs have experienced a range of large-scale disturbances over the last few decades, particularly on Tutuila, where a crown-of-thorns outbreak in the late 1970s, two major hurricanes in 1990/1991 and a coral bleaching event in 1994 have taken their toll on coral health. Tutuila's reefs have also seen increasing pressure from human activities, particularly due to dredging and discharge from tuna canneries in Pago Pago Harbour. A number of studies report that by the early 1990s Tutuila's reefs were recovering well (e.g. Green 2002), most notably in Pago Pago harbour due to improved water quality. However, with the population of American Samoa expected to rise by another 20% by 2020 (see ASPA, 2003), human pressures on coral reefs can only increase.

The most pristine coral reefs are located within areas exposed to low human interference. On Tutuila, some of the most intact reefs are located on the inaccessible north coast (e.g. Vatia) and in relatively undeveloped watersheds of the south coast (e.g. the Fagatele Bay National Marine Sanctuary and Aunu'u island) (Green, 2002). However, another hurricane in 2004, just prior to this study, may have set recovery back in some areas on the north coast. Reefs in the more remote islands of the Manu'a Islands (Ofu, Olosega and Ta'u) are in even better condition, with far more live coral cover and species richness. Rose Atoll, located over 240 km east of Pago Pago, is one of the world's most isolated and least disturbed atolls (apart from a ship grounding in 1993).

1.4.2 Mangroves

American Samoa hosts three species of mangrove; red mangroves, oriental mangroves and puzzlenut trees (the latter of which is relatively rare). The largest remaining and most threatened area of mangrove in American Samoa is the mangrove at Nu'uuli Pala Lagoon in south-central Tutuila. The only other reasonably significant stand is in Leone, Tutuila (see Figure 1.2). Other very small stands are located at Masefau and Aoa on Tutuila, and in two places on Aunu'u (not mapped in Figure 1.2). Mangroves are absent from the Manu'a Islands

The total area of mangrove remaining in 1991 was estimated to be 0.53km^2 (Volk, 1991) some 95% of which was located in Pala lagoon. However, despite the fact that Leone and Pala lagoon mangroves were designated "Special Management Areas" under the Coastal Management Act of 1990, both continue to be cleared at a rapid rate, particularly for construction of homes, piggeries and commercial buildings (ASEPA, 2002). Assuming a net loss of 10% since 1991 (see Volk, 1991; ASEPA, 2002), the area remaining could be as little as 0.48km^2 in 2004.

1.4.3 Other habitats

(a) Seagrass beds

As with mangroves, with few sheltered lagoon formations with soft sediments, seagrass beds are extremely limited in extent in American Samoa. No information on the exact distribution and area of coverage is known to exist. The most important areas are thought to be in Pago Pago harbour (Fagaalu'u) and in Pala Lagoon (Craig, pers. comm.). Assuming that seagrass has only minor representation in American Samoa, the habitat is certainly less significant than in many other tropical locations (e.g. in terms of fisheries support, nutrient regulation and pollution absorption). As agreed with DOC at the start of the study, overall the habitat is considered a minor component of the coastal ecosystem and is not considered further in this study.

(b) Beaches

The islands are fringed in many places by narrow sand or coral rubble beaches, the finer material tending to have accumulated in more sheltered bays and in the lee of shallow reefs or offshore islets. Unfortunately, over the last few decades many beaches have noticeably declined in size. This is due to removal of beach material (sand and coral rubble) for construction and other uses, and due to the proliferation of seawalls (i.e. shoreline protection schemes). The need for the latter is exacerbated by the "sand mining" activities, and the installation of seawalls themselves leads to reduced replenishment of foreshore materials.

Beaches can be of immense value as a recreational resource for residents and visitors, and also for the natural shoreline protection function they serve. However, beaches, together with their sand and coral rubble, were agreed as being outside the terms of reference and are thus only briefly considered in this study.

2 Study approach and methodology

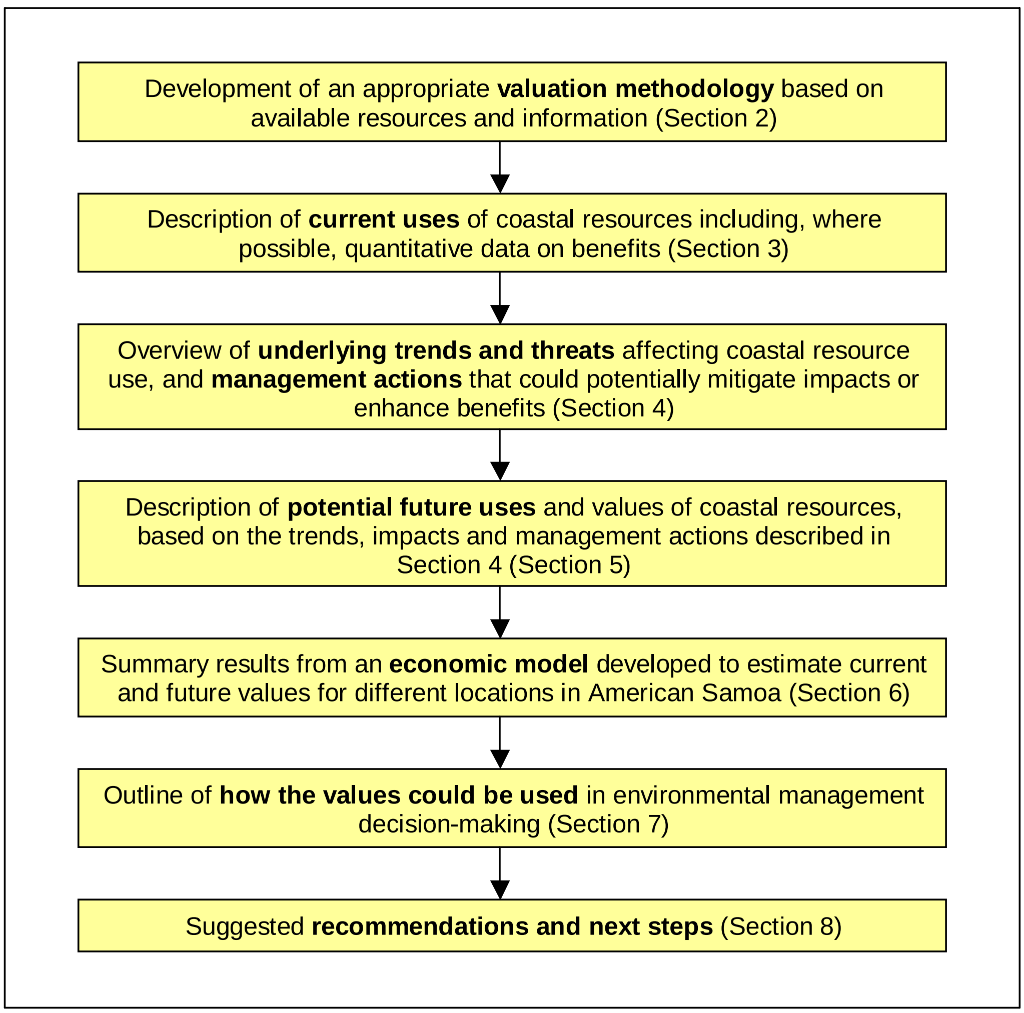
2.1 Introduction

This study has assessed the current and potential economic value of coastal resources in American Samoa, focussing principally on coral reefs and mangroves. Seagrass and beach habitat benefits are discussed briefly but not valued quantitatively. This section provides details on:

- *An overview of the general study approach*
- *An overview of economic valuation (including definitions etc)*
- *The Total Economic Value of American Samoa's corals and mangroves*
- *How the coastal resources have been valued in this study.*

2.2 Overview of General Study Approach

The overall study approach followed a logical, step-wise framework as follows:



2.3 Overview of Economic Valuation

Economic valuation of coastal resources such as corals and mangroves should be based on neoclassical economic welfare analysis (see Grigulas & Congar, 1995 and Dixon et al, 1997). As such, this approach enables the net economic benefits to society from schemes (e.g. park development) and policies (e.g. coastal zone management) to be determined. This is achieved through use of cost:benefit analysis, whereby total scheme costs and benefits are compared.

The costs and benefits should be converted to equivalent present day values by means of a discount rate, which takes into account people's time preference for money. For the purposes of this study a discount rate of 3% over 100 years has been assumed. This means that the equivalent value of US$ 1 today declines by 3% each year in the future over this period. A 3% real rate of discount is commonly used by NOAA in coral damage assessments and restorations in the US.

Economic valuation can also be used for assessing the economic losses associated with natural resource damage (e.g. from a ship grounding or oil spill). In addition, the overall economic value of an asset (its Total Economic Value – see below) may need to be assessed for national accounting purposes, or to determine how much it is worth spending on environmental protection.

2.3.1 Types of economic value

Economic costs and benefits should generally be measured in terms of:

- ***Willingness to pay (WTP):*** *the amount individuals are prepared to pay for goods and services.*

- ***Consumer surplus (CS):*** *the benefit an individual receives from utilising a resource over and above what they have to pay for it (usually measured in terms of "willingness to pay").*

- ***Producer surplus (PS):*** *the area above the supply curve (cost of production) and below the product price. This is effectively the profit that a producer makes from selling a product (i.e. the difference in the cost of producing the product and the market price). In this study we account for this value using the term* ***"added value",*** *whereby a ballpark estimate of production costs has been deducted from gross market revenues. For the purposes of this study, production costs are assumed to be 5% for the subsistence fishery, 40% for the artisanal fishery and 75% for tourism. The former figure is the authors' best guess; the latter two are based on Cesar (2002).*

- ***Opportunity cost:*** *the value of something in its next best alternative use.*

The economic benefit associated with using an environmental asset is known as **economic surplus,** which is a combination of CS and PS. Measuring the overall economic surplus is the focus of this study.

Economic impact analysis is a form of assessment that focuses on the overall contribution to local, regional & national economies. As such it uses data on gross expenditure, taking into account further related expenditure (indirect and induced impacts) using multipliers. The number of direct and indirect jobs provided is also of relevance.

The **multiplier effect** has been used to help determine the overall producer surplus or added values associated with coastal resource related expenditures (e.g. fishing and diving). A general expenditure multiplier effect of 1.25 has been assumed. This compares to one of 1.12 for Florida (Leeworthy, pers comm.) and 1.25 for the Hawaiian economy (Cesar, 2002).

Another type of assessment is known as **financial analysis**, which is used to determine the financial viability (profit/loss) of a scheme or organisation. It is based purely on monetary (cash) transactions in the market place. Converting economic values to financial values is important because organisations and individuals generally depend upon cash to operate effectively in modern life (increasingly the case in American Samoa). It is a useful approach to assess the financial viability of an operation (for example a National Park)

2.3.2 Total Economic Value

The most appropriate framework to assess the overall economic value of coastal habitats is that of Total Economic Value (TEV). This is based on the theory that environmental assets give rise to a range of economic goods and services (functions) that include direct use values, indirect use values and non-use values. The latter are also referred to as "passive-use" values, which comprise option, existence and bequest values. As based on World Bank definitions (Munasinghe, 1993):

- ***Direct use value*** *is determined by the contribution an environmental asset makes to current production or consumption through direct use of the site (e.g. recreation and fish harvesting).*

- ***Indirect use value*** *includes the benefits derived from functional services that the environment provides to support current production and consumption (e.g. coral reefs providing biological support to nearby bottom and pelagic fisheries, and a protection function to shoreline assets).*

- ***Option value*** *is the premium that consumers are willing to pay for an un-utilized asset, simply to avoid the risk of not having it available in the future. This is sometimes considered a non-use value because there is no current use of the resource.*

- ***Existence value*** *arises from the satisfaction of merely knowing that the asset exists, although the valuer has no intention of using it. Part of the motive can be for future generations, in which case that element of value is known as "bequest value". These non-use values also capture some of the biodiversity, social, heritage and cultural values associated with natural resources.*

2.3.3 Potential environmental valuation techniques

There are many techniques available to estimate the economic value of environmental goods and services. A summary is provided below in Table 2.1, which highlights the techniques potentially relevant to this study. Further details and guidance on how and when they should be applied can be found in Hufschmidt et al (1983), Barbier et al (1996), Dixon et al (1997), Bann (1997) and Bennett & Blamey (2001).

Table 2.1 Environmental Valuation Techniques

Category of technique	Name of Technique	Description of approach
Market price based	Market values	This approach is based on the assumption that the value of a good is based on its price in the market place. The value of the good is taken as the market price of a good, less the cost of production and any transfer payments made, such as taxes and subsides.
	Change in productivity	Changes in environmental quality can lead to changes in productivity and production costs, which in turn lead to changes in the volume and price of goods. For example, a decline in coral reef quality will lead to a decline in artisanal fishery catch and hence loss of market value.
	Damage costs avoided	Under this approach, the value of an environmental asset, such as coastal or flood protection, is taken to be represented by the saving made by avoiding damage to assets it protects. For example, the value of coastal defence provided by a beach would be considered to be equal to the cost of repairing or replacing infrastructure and building damaged by erosion and flooding.
	Substitute/ surrogate prices	The substitute or alternative cost approach values a particular environmental service or good according to the cost of available substitutes. If the two alternatives provide an identical service, the value of the environmental good is the saved cost of using the substitute. For example, fish consumed at a subsistence use level can be assumed to have the same value as similar fish sold in a nearby market.
	Defensive or preventative expenditure	Defensive expenditures, such as the provision of extra-filtration for purifying water, are considered as minimum estimates of the benefits of environmental improvements. Such an increase in quality must provide a benefit to the individual at least as great as the cost of the defensive equipment, because otherwise the individual would settle for lower quality and avoid spending the money.
	Expected values	Value is based on potential revenues (less potential production costs) multiplied by probability of occurrence.
Cost based	Replacement cost	The value of an environmental asset (or the function it performs) can be given a proxy value based on the cost of replacing the function with an alternative. For example, the value of a coral reef's shoreline protection function can be estimated based on the cost of providing an equivalent man-made shoreline protection scheme.
Revealed Preference/ Surrogate Market (uses market based information to infer a non-marketed value)	Travel cost method	This technique centers on the expenditure incurred by households or individuals in order to reach recreational sites, and uses these expenditures as a mean of measuring willingness to pay for the recreational activity. The sum of the cost of travelling, including the opportunity cost of time, and any entrance fee gives a proxy for market prices in estimating demand for the recreational opportunity provided by the site under investigation. By observing these costs and the number of trips that take place at each of the range of prices, it is possible to derive a demand curve and hence overall value for the particular site.

Category of technique	Name of Technique	Description of approach
	Hedonic price	This approach seeks to isolate the contribution that environmental quality makes to the total market value of an asset. For example, the proportion of the price differential between two otherwise identical houses accounted for by the change in the environmental quality characteristic reveals an individual purchaser's valuation of the importance of environmental quality.
Stated Preference/ Construed market approach (questionnaire surveys to ask people's direct willingness to pay)	Contingent valuation	This is a carefully constructed and analysed questionnaire survey technique asking a representative sample of respondents how much they are willing to pay (WTP) for an environmental benefit or what they are willing to accept (WTA) in compensation for a loss. The questionnaire format thus stimulates a hypothetical (contingent) market for a particular good.
	Choice experiments	As above, however, respondents are presented with several short descriptions of a composite good (a good composed of a number of valuable characteristics such as species number and price to pay). Each description is treated as a complete package and differs from the other packages in respect to one or more of the good's characteristics. Respondents then select their preferred package (pairwise comparison) based on their personal preferences. It is then possible to isolate the effects that variation in individual characteristics has on the price.
Transfer of Values	Benefit (Value) Transfer	This methodology uses the transfer of economic values estimated in one context and location in order to estimate values in a similar or different context and location. The values should ideally be adjusted based on key criteria and variations that apply in the different contexts and locations. This technique is used when it is not feasible to carry out primary data collection.

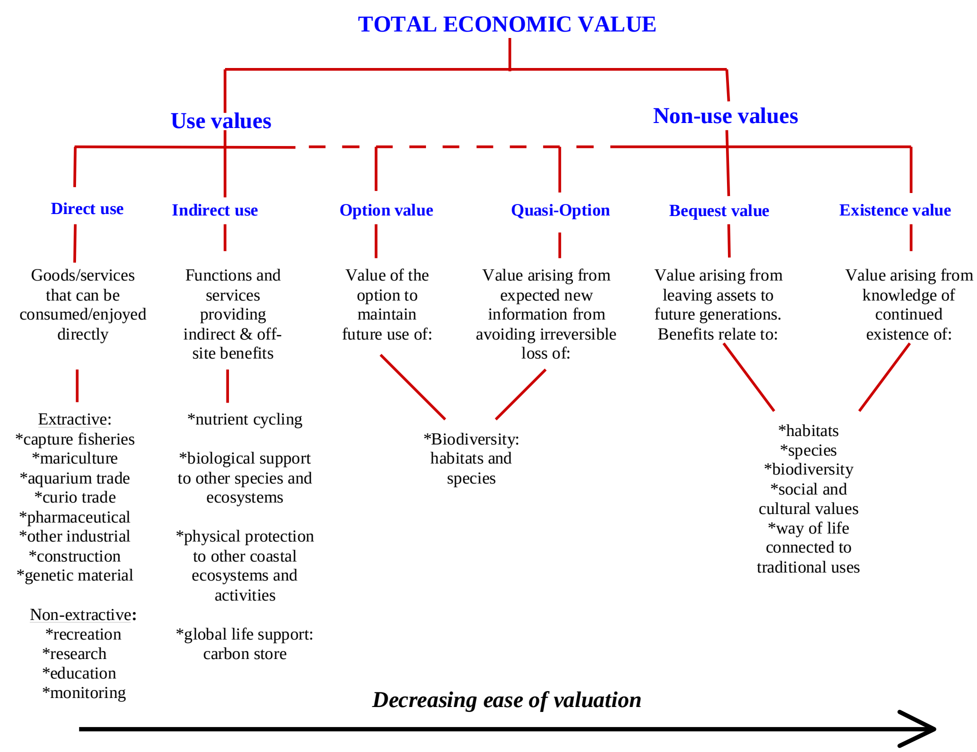
In environmental valuation it is important that the most appropriate technique is used to value each different type of good or service. Choice of valuation technique generally depends on the availability of resources, time and data for the study. In particular, it is essential not to double count benefits by valuing any type of benefit more than once.

2.4 The TEV of American Samoa's coastal resources

2.4.1 TEV of American Samoa's coral reefs

The TEV approach was used to help identify the potential coral reefs benefits on America Samoa (see Figure 2.1).

Figure 2.1 Potential Total Economic Value of coral reefs in American Samoa



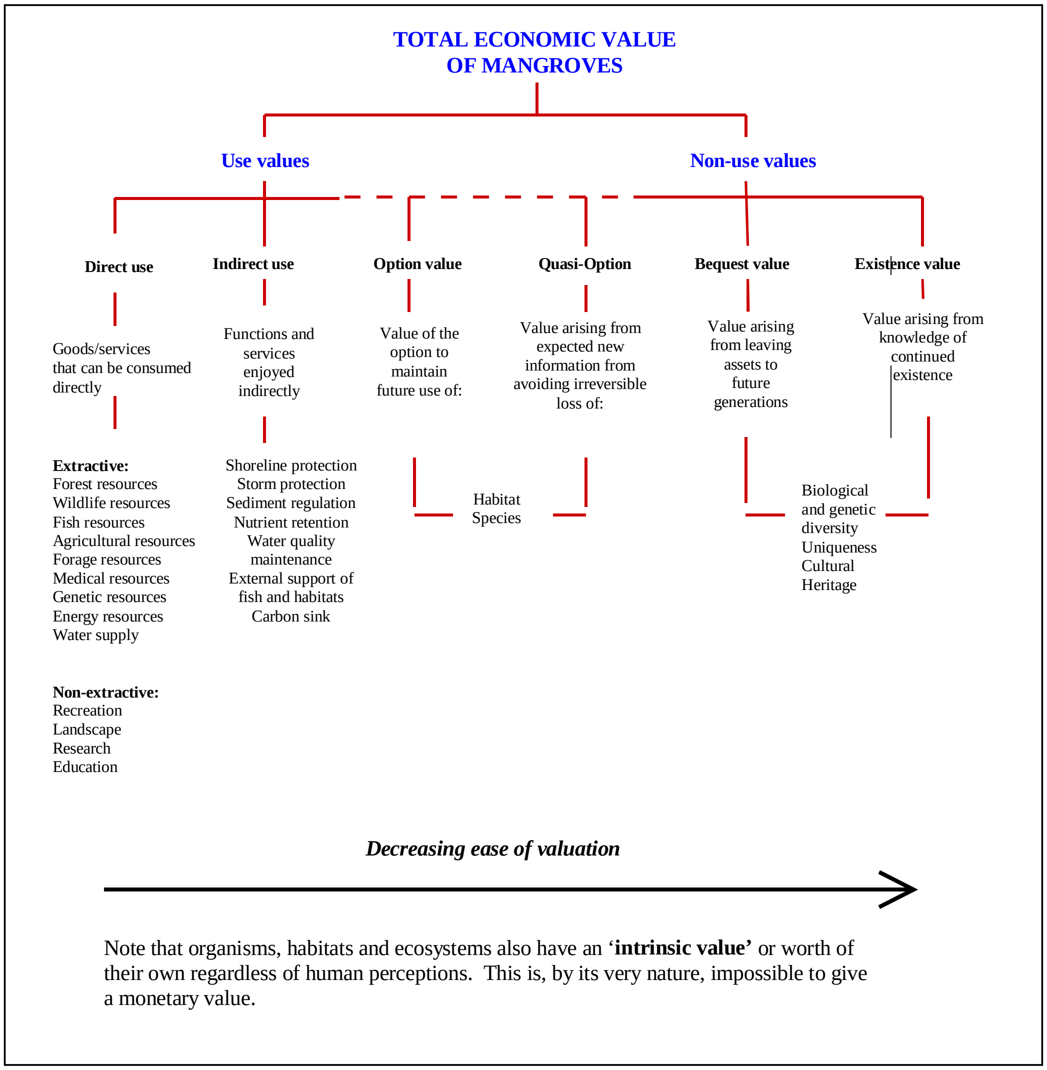
Note that organisms, habitats and ecosystems also have an '**intrinsic value'** or worth of their own regardless of human perceptions. This is, by its very nature, impossible to give a monetary value.

Based on Spurgeon (1992) and Barton (1994).

2.4.2 TEV of American Samoa's mangroves

Likewise, the TEV approach was also used to help identify the potential mangrove benefits on America Samoa (see Figure 2.2).

Figure 2.2 Potential Total Economic Value of mangroves in American Samoa



2.5 Benefits valued in this study

2.5.1 Overview of benefits addressed

Table 2.2 identifies the main coral reef and mangrove benefits that have been valued in this study. It also highlights the valuation technique used and the relative degree of accuracy of the estimated values for both the current and future values. The degree of accuracy is a function of the accuracy of the individual values (e.g. average US$ WTP value) and the populations (e.g. number of visits) over which they are aggregated. A description of each of the benefits is provided further below.

Table 2.2 Types of benefit valued in this study.

Category of benefit	Type of benefit	Valuation approach used in this study	Relative accuracy of current values[2]	Relative accuracy of future values[2]	Valued for coral reefs	Valued for mangroves
Direct	Subsistence fishery product value[1]	Market value/ substitute price	H	M	Yes	Yes
	Subsistence fishing consumer surplus	Benefit transfer	M	M	Yes	Yes
	Artisanal fishery product value[1]	Market value	H	L	Yes	No
	Recreation consumer surplus	Benefit transfer	M	M	Yes	Yes
	Recreation related expenditure[1]	Market value	M	L	Yes	Yes
Indirect	Artisanal fishery product value[1]	Change in productivity	L	L	Yes	No
	Coast (shoreline) protection value	Replacement cost	L	L	Yes	Yes
Non-use	Existence, option and bequest values (including elements of social and cultural value).	Contingent valuation	M for residents L for others	M for residents L for others	Yes	Yes

Notes:
1 - These are added values (producer surplus), calculated by deducting assumed production costs from full market benefits.
2 - The scale for the relative accuracy of values is as follows: H = high, M = medium, L = low

2.5.2 Description of benefits addressed

Direct benefits include:

- **Subsistence fishery product added value** – direct harvest of fishery products for personal consumption. Both coral reefs and mangroves provide subsistence fishery benefits.
- **Subsistence fishing consumer surplus** – the enjoyment gained (i.e. personal satisfaction) by fishers during their fishing trips.

- **Artisanal fishery product added value** – direct harvest of coral reef products for sale. Note that many people sell a proportion of their catch and people do not always fall neatly into either subsistence or artisanal categories.

- **Recreation consumer surplus** – the enjoyment gained during snorkels/dives on coral reefs or walks/canoe trips to the mangroves. Such values may either be by local residents (i.e. recreation) or visitors (i.e. tourism).

- **Recreation related expenditure added value** - the economic impacts of coral reef and mangrove recreation related expenditure. This may be direct (e.g. fees, gear) or indirect (e.g. accommodation and food).

Indirect benefits:

- **Artisanal fishery product added value** – refers to the harvest of "coral reef associated" bottomfish from offshore waters. The majority of such fish are assumed to be associated with coral reefs at some stage in their life history, usually for spawning or nursery grounds (hence "indirect" coral reef benefit).

- **Shoreline protection value** - the protection of shoreline resources and assets from erosion and flooding by waves and storm surges.

Non-use benefits:

- **Existence, option and bequest values** – values held by different stakeholder groups to maintain the quality of corals and mangroves despite potentially never using them. This may include simple altruistic reasons and social and cultural values. Values for local residents were assessed using a contingent valuation questionnaire. Values for visitors and the general public in the US were based on assumed benefit transfer values. It should be noted that non-use values are gaining increasing levels of importance in resource decision-making (Spurgeon, 2001).

2.5.3 Other benefits valued

In addition, current and potential aquaculture and mariculture benefits have been assessed. These have not been directly added to the coral and mangrove benefits, but are considered separately.

2.5.4 Other benefits not valued

Use of coral rubble and beach sand: These materials are indirect benefits of coral reefs, taking many years to build up. They have been used as a source of aggregates in American Samoa for many decades, particularly for use in building construction, spreading around houses to keep the area clean and free of weeds (which attract insects), and for traditional burial rituals. Such materials are preferred because of their accessibility and lower prices compared to commercially available alternatives. However, such beach mining is illegal (apart from small scale ritual use), and enforcement seems to be non-existent.

On the one hand, such material is a benefit; the value being the cost of providing equivalent material through quarrying or importing from sustainable sources elsewhere. However, on the other hand, there are significant shoreline protection costs associated with it as valued in Section 3.2.4. In addition, associated current and future loss of recreational beach use consumer surplus value could also be in the order of millions of US$ per year. The latter has not been estimated in this study.

Indirect biological support to other habitats: In theory some coral reefs "export" fish to other less productive locations. However, there is currently considerable debate about the spatial scale of marine larval dispersal and thus potential recruitment among coral reefs. Some species appear to disperse over many hundreds of kilometres, while for others there is evidence of local recruitment effects (Cowen, 2002). Particularly in a region as unexplored with respect to coastal oceanography as the Pacific, it is not possible to relate reef habitat status at particular locations with recruitment (and to an even lesser extent yield) of particular target fish species at another.

Genetic value and bio-prospecting: Although it was mentioned during the study that bio-prospecting for coral reef associated organisms may have some commercial potential, insufficient information was obtained on this aspect.

Other benefits: Benefits such as education and research are not included in this assessment, whereas social, cultural and heritage benefits may partly be captured by the non-use value. The value of sand generated by live corals has also not been assessed.

2.5.5 Other mangrove benefits not quantified

Indirect offshore fishery values: A proportion of coral reef fishery target species are also in some way "mangrove associated" at some point in their life history, and hence an indirect mangrove benefit. These values are already accounted for under direct coral reef benefits and have been excluded from the mangrove benefits.

Sedimentation control: The mangroves of Pala Lagoon and Leone provide an important function in terms of slowing down freshwater flows onto nearby coral reefs during and following storm events. This helps settle the sediments and reduce sedimentation, thereby protecting the reefs.

Mangrove products: The mangroves in Pala Lagoon provide a range of other cultural-ceremonial benefits including bark collection for dye making and wood posts for construction of fales and umus. Transitional areas of the Pala lagoon and Leone mangrove are also used for growing agricultural crops for ceremonies (fa'alavelave) (ASEPA, 2004). Insufficient information was available to value these aspects.

Other benefits: As highlighted in the mangrove TEV figure, mangroves provide a range of other benefits. In the overall scheme of things, these are not considered to be as significant as the benefits quantified, but may nevertheless be important.

2.6 The valuation approach

2.6.1 Data collection methods used

A visit to American Samoa was undertaken in January and February 2004, during which three main data collection components were undertaken: Information review, village discussion meetings, and general public questionnaire survey.

The **information review** drew upon wide-ranging and highly dispersed sources of environmental, social and economic information, both published and unpublished, as well as anecdotal information obtained through interviews with key consultees.

Discussion meetings were held with representatives from four coastal villages in order to collect information on coral reef and mangrove benefits and discuss the design and implementation of the general public questionnaire. Villages were selected to represent areas with and without significant coral reefs, mangroves or MPAs. Meetings were conducted in Samoan and typically attended by the village mayor or member of the matai, and accompanied by a representative from the fishing community. Meetings were organised through the Office of Samoan Affairs and promoted in both Samoan and English through television interviews and press releases.

A **general public contingent valuation questionnaire** was designed and used to collect information about the use and importance of coral reefs and mangroves to the local residents on American Samoa. The main aim was to elicit a willingness to pay value covering use and non-use values. However, due to problems with some of the responses relating to frequency of activities undertaken, only value estimates for the latter were feasible. Further details on the method and results are provided in Appendix B, with the questionnaire being reproduced in Appendix C.

The survey was initially piloted amongst a small sample (14) in January 2004 before being modified and conducted island wide in February 2004. Responses were obtained from 300 residents from 44 villages on Tutuila, Ofu and Olosega. Interview sampling locations and respondents were selected to be reasonably representative of population distribution (e.g. 90% in southern Tutuila) and socio-economic characteristics (e.g. gender, age, place of birth).

The interviews were carried out in Samoan and English by a team of survey assistants from a number of organisations in American Samoa. All assistants had a background in marine/environmental science or public surveying and were given additional prior training (covering study aims, the questionnaire design, interview technique and feedback on practice questionnaires).

2.6.2 Analysis of values

For both coral and mangrove benefits, estimates of current and future values have been made for each of the five main benefit types. **Current values** are based on the situation in 2004 and are detailed in Section 3.

Potential future values were calculated based on two scenarios; a **business as usual** (BAU) scenario and an **optimum sustainable management** (OSM) scenario. These scenarios are further detailed in Section 5.

As is explained in Section 2.6.3, all values have been estimated based on their specific location using a map-based approach. More detailed information regarding the valuation approaches and assumptions for the spatial model are provided in Appendices D and E.

2.6.3 The spatial economic model approach

The study used a GIS map-based economic model for assessing the coral and mangrove values. The extent of coral reefs and mangroves was assessed using benthic habitat map data prepared by NOAA (2004a). This approach provides significant advantages in that it highlights the potentially significant differences in values between different locations. This is because values at any given location are determined by a range of site-specific factors.

The overall results of the model are given in Section 6. The associated map-based outputs, (see figures 3.1 to 3.10) are a potentially powerful tool for the dissemination of study findings. This more accurate spatial approach to valuation can also be extremely important for decision-making purposes (see Section 7). Further details of the methodology and assumptions for each benefit are detailed in Appendices D and E. Appendix F provides more location specific estimates of values per unit area.

The process of calculating **coral reef values** was based on detailed spatial habitat maps. Initially, reefs were categorised using GIS (to ~30m, the approximate depth limit of IKONOS imagery) according to a range of factors based on the limited information available, and their significance as drivers of the major types of benefit.

Coral reef maps were produced for all islands/reef areas mapped by NOAA (2004a) with the exception of the offshore banks, for which no equivalent data was obtained. Total values and per unit area values were then calculated based on a series of simple models representing the five benefit types. The models split total benefits (e.g. fishery catches) and values (e.g. catch market values, recreational consumer surplus or non-use values) based on the area of different reef categories within each coastal unit.

Mangrove values were calculated based on the area of remaining habitat and a simple average value per unit area. There was insufficient data or maps to split the values at a more site-specific level. Values were determined for direct fisheries, indirect fisheries and non-use benefits. Mangrove habitat area data was derived from published figures.

The future values calculated for both scenarios are based on current reef category area data. The estimates represent what the values could be in 25 years time (ignoring inflation). Future values are not mapped, but total and per unit area values are given in table format (see Section 6).

3 Current coastal resource benefits

3.1 Introduction

The coastal resources of American Samoa are without doubt one of its most valuable natural assets and, as a small island territory, the great majority of the population interact with or depend on coastal resources in some way. The main current uses of the coral reefs and mangroves in 2004, and the basic values of the associated benefits, are discussed in this section. A summary table of current values can be found in Section 6.

3.2 Coral reefs

3.2.1 Direct subsistence fishery benefits

The subsistence fishery is a direct benefit as it principally targets the diverse array of fish and invertebrates that live on the shallow coral reefs around American Samoa. It is practiced mainly on foot from the shore or across exposed reef flats using a variety of methods including rod and reel, gleaning, snorkel diving and gill nets. The vast majority of catches (~90%) are retained for personal consumption (e.g. Wass 1980). The general public questionnaire survey also indicated that only 10% of respondents that catch fish usually do so to sell. Both the product value and enjoyment value are detailed below. Figures 3.1 and 3.2 show the relative importance of different direct coral reef fishery locations within Tutuila and the other islands. The greater the reef access and the higher the reef complexity, the greater the assumed value derived from the reefs (see Appendices D and E).

(a) Direct product added value

Fish species make up around 75% of the subsistence catch, the remainder being mostly invertebrates (see Saucerman, 1995). One of the most important fish species is the atule (*Selar crumenophtalmus*), a coastal migrant that typically accounts for a large proportion of overall catches (though proportions vary widely year to year). Other important fish species include jacks, surgeonfish, mullet, groupers, snappers, squirrelfish and parrotfish. Invertebrates include lobster, octopus, sea urchins, bivalves and various gastropods. Another unique species collected is the Palolo worm (*Eunice viridis*), a reef-burrowing polychaete that spawns once a year releasing swarms of epitokes (reproductive segments) that are collected in their 1000s by scoop net on the water's surface. Other edible products include *Euchemia*, a marine algal species.

The subsistence fishery catch has steadily decreased over the last two decades (Wass, 1980; Ponwith, 1992). The reduction in effort is primarily associated with a steady shift towards a cash economy on the islands (Coutures, 2003). The village discussion meetings confirmed that, whereas once people tended to rely heavily on the fishery for food, lifestyles and diet are changing and they now increasingly buy alternative products from the local store. Over collection of vulnerable species has also been reported as a major factor, with some sedentary species (such as clams) having almost disappeared. Annual variation in the Atule catch has also contributed towards reduced catches in recent years. Annual catch of Palolo also varies widely due to prevailing wind and tide conditions that concentrate the epitokes close to the shore (Craig et al, 1993).

Figure 3.1

Current direct coral reef fishery values (subsistence and artisanal) for Tutuila, Aunu'u and inshore banks (Taema and Nafanua).

Notes:
Refer to Box 6.1 for corresponding value for each category and location.
Maps based on NOAA benthic habitat classification (NOAA, 2004).

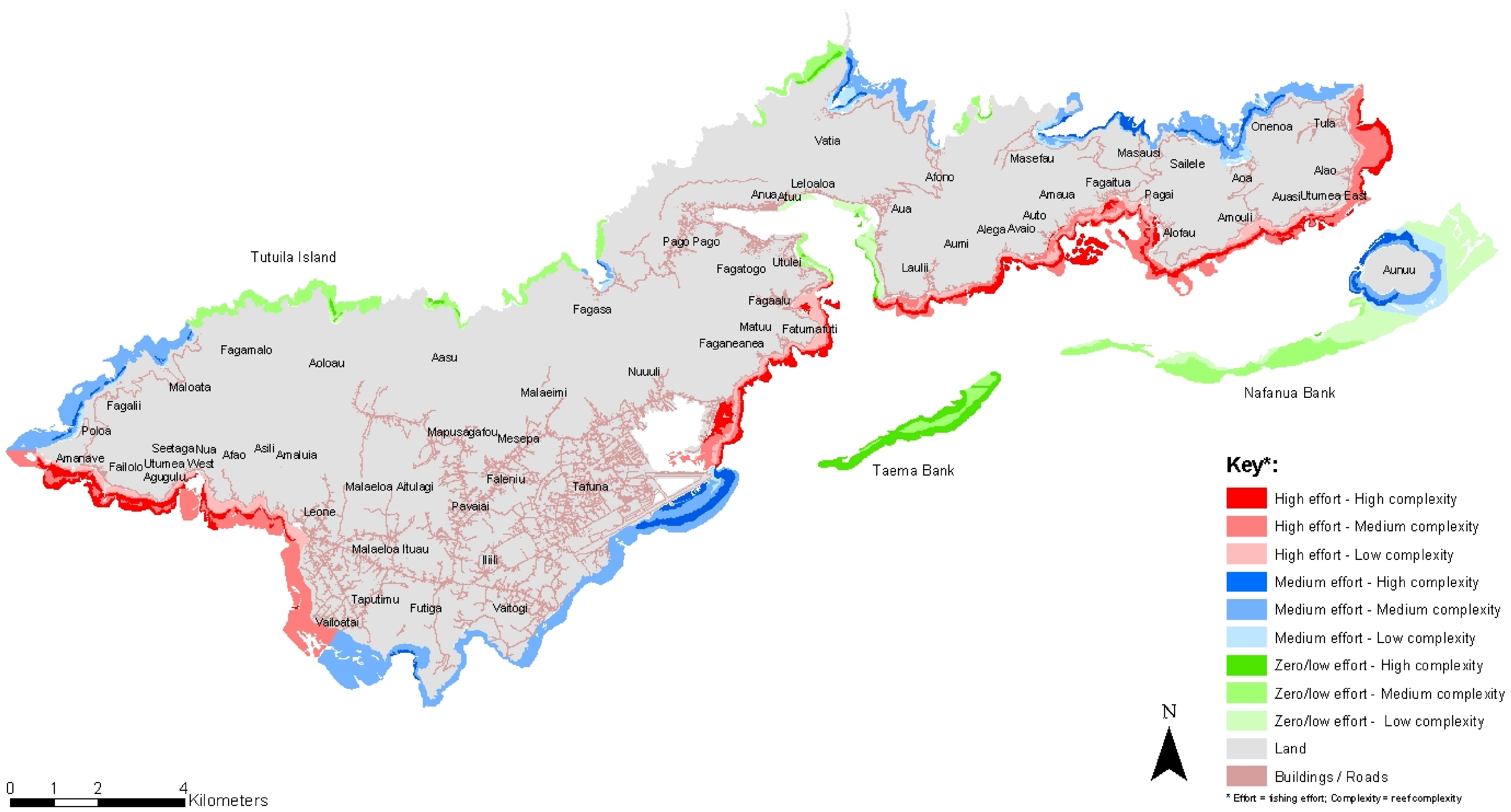
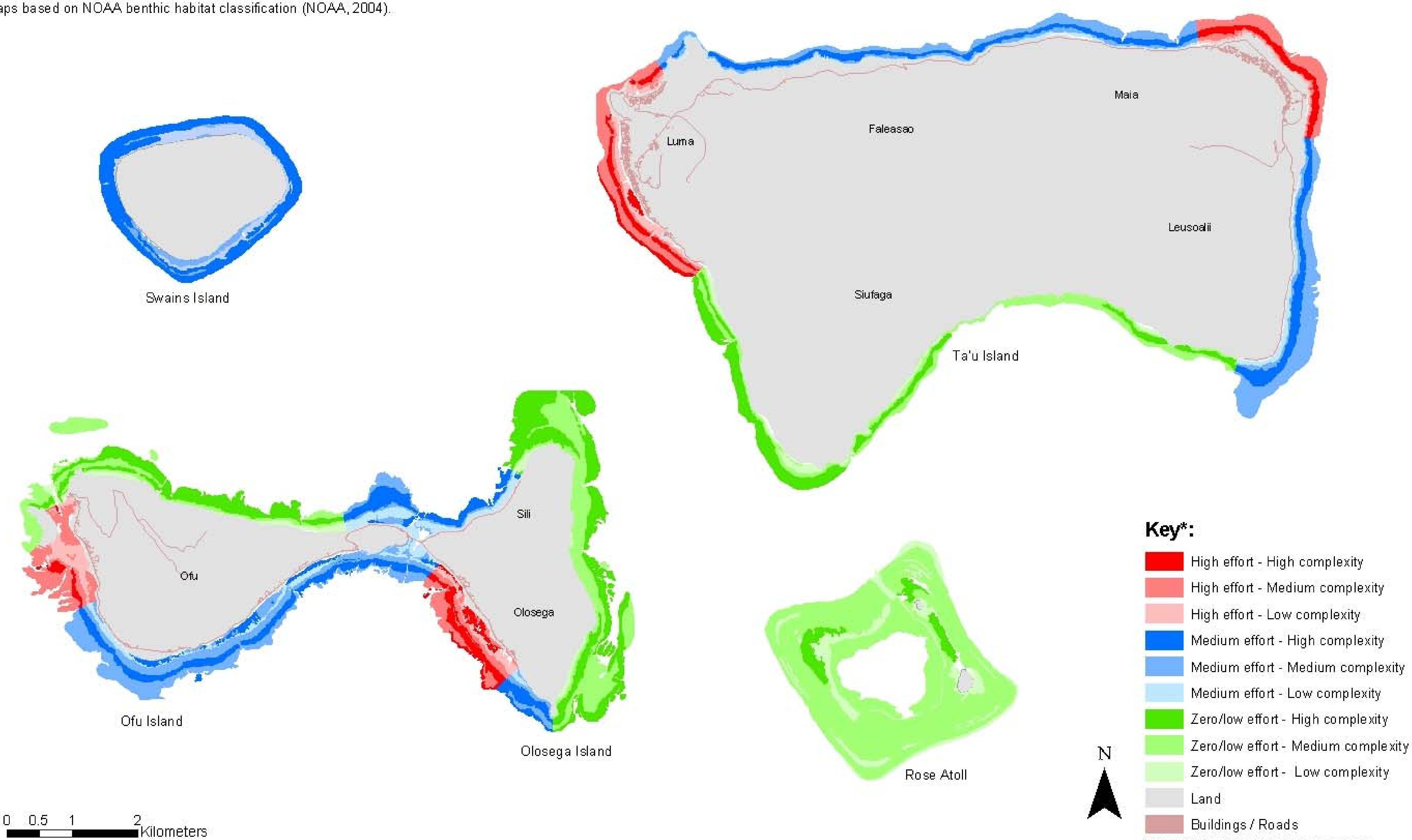


Figure 3.2

Current direct coral reef fishery values (subsistence and artisanal) for Ofu, Olosega, Ta'u, Swains Island and Rose Atoll.

Notes:
Refer to Box 6.1 for corresponding value for each category and location.
Maps based on NOAA benthic habitat classification (NOAA, 2004).



N.B. All islands drawn to same scale but relative locations and distances between islands are not.

Nevertheless, as was expressed by a number of respondents in the village discussion meetings, few families fish for a living anymore and is tending to become more of a leisure activity only (i.e. for personal enjoyment). Current generations tend to work in salaried employment and go fishing on weekends and public holidays. This recreational value represents an important subsistence fishery benefit and is captured as consumer surplus (see below).

In terms of fishery products, extrapolation from Coutures (2003) to account for incomplete sampling effort, the total subsistence catch for Tutuila in 2003 was estimated to be in the region of 41.5 tonnes/year (1.15 tonnes/km^2/year), including 1.6 tonnes/year of Palolo (0.04 tonnes/km^2/year) (Braun 2003).

Based on recent monitoring by the US National Parks Service (Craig, 2004; unpub.), the total subsistence catch for Ofu and Olosega Islands was estimated to be 44.4 tonnes/year (3.95 tonnes/km^2/year), including an estimated 1.3 tonnes/year (0.12 tonnes/km^2/year) of Palolo based on Coutures (2003) and Craig (2004, unpub.).

Extrapolation of this figure by population gives roughly 16.9 tonnes/year (2.1 tonnes/km^2/year) and 1.2 tonnes/year (0.6 tonnes/km^2/year) on Ta'u and Swains Island's respectively. No information on Palolo catches is available for these islands.

The value of the subsistence catch is based on the average retail market prices for similar fish traded in the market. Market prices at the time of the study visit (January 2004) were US$ 2.50/pound (US$ 5.51/kg) for locally caught reef fish and US$ 7.50/pound (US$ 16.54/kg) for lobster. Palolo catches were also valued at fish market prices although in reality they are generally not traded. All market prices were converted to producer surplus values or "added values" by subtracting the estimated costs of production (assumed for this study to be around 5% of market price for the subsistence fishery).

Based on the above, at 2004 market prices, the total current product added value of the direct coral reef subsistence fishery was estimated to be around US$ 544,000/year. Including additional indirect and induced expenditures associated with the multiplier effect (assumed to be 1.05 for the subsistence fishery), this equates to US$ 572,000/year.

(b) Direct fishing consumer surplus value

It is assumed that people undertaking subsistence fishing also do it for enjoyment. This fact clearly arose from the results of the general public questionnaire survey, with 46% doing it because they always or usually enjoy it.

Partly based on data in Coutures (2003), the number of subsistence fishing trips per year is estimated to be 52,000 based on the total fish catch of 104 tonnes/year (direct subsistence and artisanal combined) and an assumed catch of 2 kg/fishing trip. This is partly based on data in Coutures (2003). Consumer surplus is split between locations using same ratios as subsistence catches.

The direct fishery consumer surplus value was derived using a benefit transfer approach assuming a value of US$ 1.40/person/trip. This value was obtained by taking the average of two values adjusted from other sources. This included (a) US$ 8.32/person/day for resident coral reef fishing trips in southeast Florida (from NOAA, 2004c) adjusted to US$ 0.76/person/day based on differences in per capita GDP between the USA (US$ 30,200 in 2000) and American Samoa (US$ 2,600 in

2000), and (b) US$ 22/person/day for stream fishing in the USA of by Loomis & Crespi (1999) adjusted to US$ 2.00/person/day, also based on GDP differences.

This gives a total direct fishery consumer surplus value in the order of US$73,000/year.

3.2.2 Direct and indirect artisanal fishery benefits

The artisanal fishery includes both direct benefits and indirect benefits. Direct benefits refer to near shore catches of coral reef species that are traded in local markets. Indirect fishery benefits refer to catches of offshore bottom fish species, the majority of which are in some way "reef-associated" and thus an indirect reef benefit. Both are discussed separately below.

Note that the artisanal fishery also includes offshore trolling and long lining for deep-water pelagic species to supply the cannery. These benefits are not derived from coral reefs and are hence not included in this study. However, the offshore pelagic fishing effort does act to indirectly reduce offshore bottom fishing effort (and hence indirect catch benefits). In addition, by providing pelagic by-catch at a relatively cheap price the fishery may reduce fishing pressure on reef species.

Note also that between 1995-2002 the artisanal fishery also included SCUBA-assisted spear fishing. However, this practice was banned in 2002 due to major concern over impacts on reef fish populations (see ASEPA, 2002) and is also not discussed here.

(a) Direct artisanal fishery product value

The two main products derived in the direct artisanal fisheries are fish and lobster. Both are discussed below. Figures 3.1 and 3.2 show the relative importance of different direct coral reef fishery locations within Tutuila and the other islands.

Reef fish

Reef fish species caught on or in the vicinity of coral reefs are considered to be a **direct benefit**. Generally, the largest proportion is caught by spear or line from alia (catamaran) and is recorded in the artisanal creel survey. A small shore derived catch is sold, often on roadside "bush stores", and is included in the artisanal catch since it is covered by the DMWR creel surveys of landing and sales.

The amount of reef fish entering the marketplace has declined over recent years, from >30 tonnes to less than a third of this figure between 2001 and 2002. The main reason for the decline seems to have been the implementation on the ban of SCUBA spear fishing; though the shift of some vessels into the long lining industry accounts for some of the decline.

According to DMWR (2002) artisanal creel survey data, around 6.9 tonnes/year of reef fish and 0.4 tonnes/year of "other fish" were landed on Tutuila in 2002, totalling 7.3 tonnes/year, an average of 0.13 tonnes/km^2/year for Tutuila and the Manu'a Islands. However, for this study these benefits are split based on the ratio of subsistence catch in these locations.

The 2004 retail market price for locally caught fish products was used at US$ 2.50/pound (US$ 5.51/kg). This was converted into an "added value" or producer surplus value by subtracting the estimated costs of production (assumed to be 40% of market prices for the artisanal fishery to cover boat, equipment and wages etc).

Based on the above, at 2004 market prices the total current product added value of the direct coral reef artisanal fishery was estimated to be around US$ 24,000/year. Including additional indirect and induced expenditures associated with the multiplier effect (plus 25% in the artisanal fishery), this equates to US$30,000/year.

Lobsters

Lobsters are also collected by snorkel on reefs (predominantly *P.penicillatus*) and are considered a **direct benefit**. Locally caught lobster is sold whole in many of the restaurants and hotels on the island.

DMWR figures show that the lobster landings have varied greatly from month to month over the 20 years that data has been available. No definite trends in catch levels of time are discernable in this data.

Artisanal lobster catches on Tutuila in 2002/2003 were reported to be between 0.58 tonnes/year (Coutures, 2003) and 0.76 tonnes/year (DWMR, 2002). Neither estimate includes lobsters taken in the "recreational" fishery; these are assumed to be included under direct subsistence fishery benefits. The DMWR estimate includes some lobsters imported commercially from the Manu'a Islands. Since nobody knows the "recreational" catch it is assumed to be 50% of the commercial catch, giving a total catch of around 1.14 tonnes/year, an average of 0.02 tonnes/km^2/year for Tutuila and the Manu'a Islands. Note however that, as with reef fish, these benefits are split based on the ratio of subsistence catch in these locations.

The 2004 market price for lobster was used at around $5.50/pound ($16.54/kg). This was converted into an "added value" by subtracting the costs of production (assumed to be 40% of market price).

Based on the above, at 2004 market prices the total current product "added value" of the direct artisanal coral reef lobster fishery is in the region of US$ 11,000/year. Including additional indirect and induced expenditures associated with the multiplier effect (assumed to be 1.25 for the artisanal fishery), this equates to US$14,000/year.

(b) Indirect artisanal fishery product value

The majority of bottom fish species are assumed to be "reef-associated" and are therefore considered as an **indirect benefit**. For instance, in deeper areas the catch is exclusively Bottomfish Management Unit Species (BMUS) many of which inhabit shallow reef environments at some point in their life history (as juveniles). In shallower depths, species include many that are typically associated with shallow reef environments at any stage of their life history. From DMWR catch composition statistics, the reef-associated proportion (i.e. that considered to be an indirect benefit) was estimated at 85%. Figures 3.3 and 3.4 show the relative importance of coral reefs for indirect fishery values within Tutuila and the other islands. The higher the complexity the higher the assumed indirect fishery value (see Appendices D and E).

The bottom fishery typically operates using small, motorised catamarans (alia) and targets high value species at between 40-300m depth, using lines hauled by wooden hand reels. It is a method widely practiced throughout the Pacific Islands.

In 2003, there were 14 alias actively operating in the Territory, six located on Tutuila (Pago Pago), four on Aunu'u and four on the Manu'a Islands (DMWR statistics, 2002). Ownership of the boats is between around 10 owners, mostly of American Samoan or Samoan origin. Each boat is crewed by 4-5 people, drawn from a wide pool of available labour.

There has been a significant decline in the number of boats operating in the bottom fishery (and hence decline in catches). This reflects a trend in the loss of skilled and full-time commercial fishermen from the fishery, the gradual depletion of newly discovered banks, the shift into more profitable trolling and longlining. Recently exports of bottom fish to Hawaii and on to the US mainland have also stopped due to lack of volume and high airfreight prices.

In 2002, the total reef-associated bottom fish catch (85% of total catch) was 16.9 tonnes (DMWR survey data). This is likely to be an underestimate since creel survey effort is patchy. However, in the absence of information on which to base an adjustment the reported catch is used. Based on discussion with DMWR, it was assumed that the majority of bottom fishing takes place on the reefs of Tutuila, Ofu, Olosega and the offshore banks. It is also assumed that there is no transfer of indirect reef benefits or movement of bottom fishing boats between these locations (see Appendix D). Based on the above, the reef associated bottom fish catch derived from each location was assumed to be: Tutuila; 6 tonnes/year, Ofu and Olosega; 4 tonnes/year; Ta'u; 0.8 tonnes/year and Offshore Banks; 6 tonnes/year.

Again, a retail market price of US$ 2.50/pound (US$ 5.51/kg) for locally fish products was used and converted into an "added value" by deducting 40% of the market price to account for assumed fishery costs of production.

Based on the above, at 2004 market prices the total current product added value of the indirect artisanal coral reef associated bottom fishery is in the region of US$ 56,000/year. Including additional indirect and induced expenditures associated with the multiplier effect (assumed to be 1.25), this equates to US$70,000/year.

Figure 3.3

Current indirect coral reef fishery values (artisanal) for Tutuila, Aunu'u and inshore banks (Taema and Nafanua).

Notes:
Refer to Box 6.1 for corresponding value for each category and location.
Maps based on NOAA benthic habitat classification (NOAA, 2004).

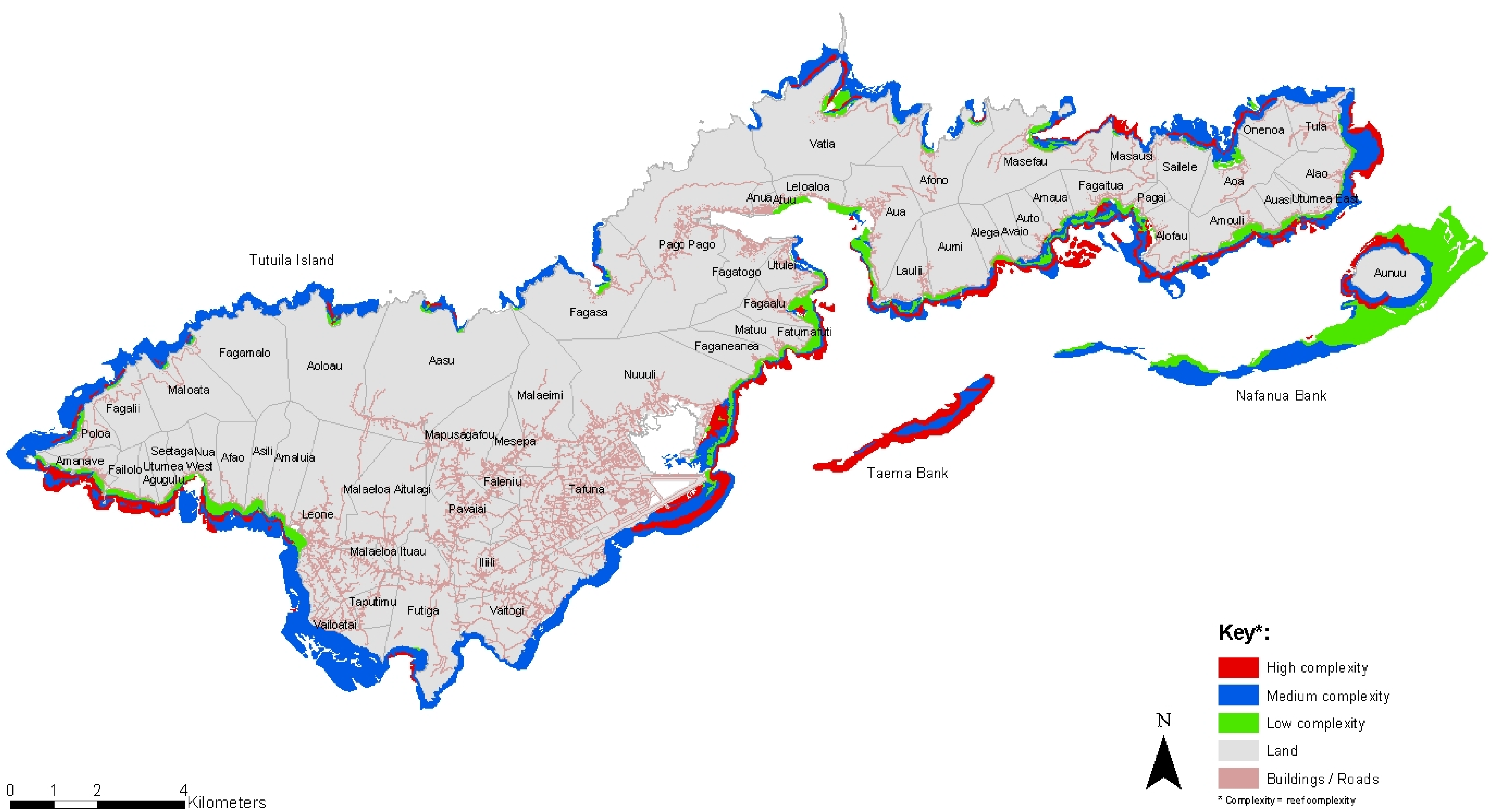
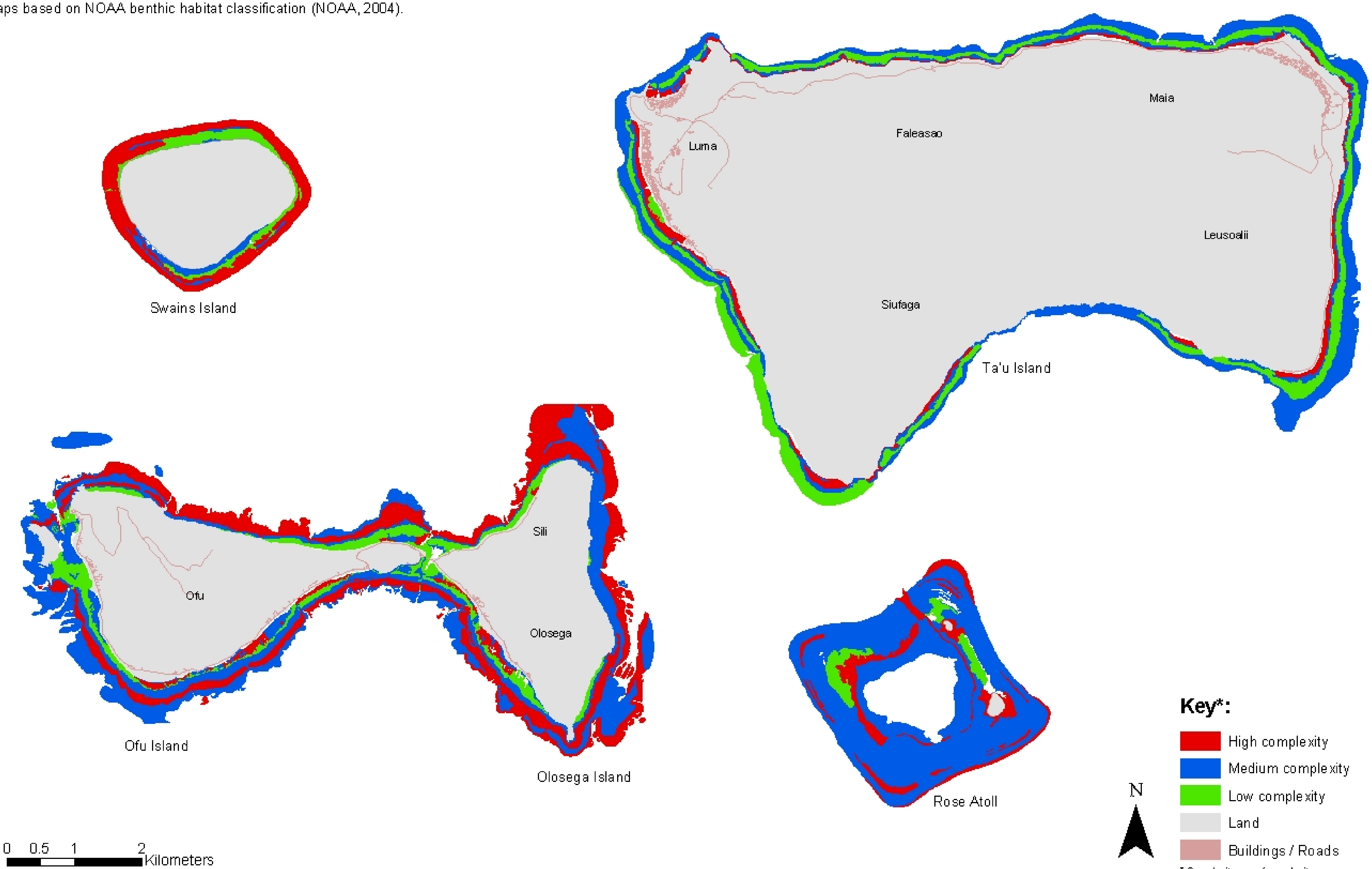


Figure 3.4

Current indirect coral reef fishery values (artisanal) for Ofu, Olosega, Ta'u, Swains Island and Rose Atoll.

Notes:
Refer to Box 6.1 for corresponding value for each category and location.
Maps based on NOAA benthic habitat classification (NOAA, 2004).



N.B. All islands drawn to same scale but relative locations and distances between islands are not.

3.2.3 Recreation and tourism benefits

American Samoa has seen a precipitous drop in the tourist arrivals since the 1970s when 35,000 people visited the Territory by plane and cruise ship. This is due to several factors, such as the loss of international airline service, the decline of the main hotel (the Rainmaker), inadequate infrastructure and intense competition from elsewhere in the Pacific. While the Territory has many of the support services in place, such as car rental and restaurants, the infrastructure is woefully inadequate to support large-scale tourism. The number of guest rooms in 2000 was approximately 312 (ASPA, 2003).

The number of tourist arrivals is currently around 6,000 a year (DOC, 2004), contributing around 7% to the economy. According to the latest Census (DOC, 2002), in 2000, there were 6,333 tourists, 10,099 business visitors and 27,726 people visiting relatives. The main tourists are Americans (58%, Australians/New Zealand 35% and Europeans 4%). However, there are an increasing number of cruise ships visiting American Samoa. In 1999, there were 10,000 passengers and the same number of crew. They tend to come onto the island just for the day and are not included in the tourist number, but as transits.

In terms of tourist benefits, it is unlikely that many visitors come specifically for the coral reefs (i.e. for snorkelling and diving), although they may play a small role. However, there are many residents (permanent and expatriates) that gain important recreational benefits from coral reefs, particularly snorkelling and to a lesser extent diving. Estimates of current snorkelling and dive related consumer surplus and expenditures are explored below.

(a) Snorkelling

Discussions in the village meetings clearly highlighted the fact that relatively few residents and visitors snorkel recreationally. This was in part due to difficulties in access to good snorkelling areas due to the nature of the fringing reefs, dangerous swimming conditions due to high wave action and rip currents, the fact that permission is needed by owners of the foreshore before one can swim, and the paucity of equipment, facilities and information about sites. Few American Samoans seem to venture out over the reef crest with snorkelling gear unless spear fishing or collecting.

However, a handful of coastal locations do provide the right combination of conditions (e.g. sheltered, good coral growth) and are popular for snorkelling. These include Alega beach, the deep lagoon south of the airport runway, Pago Harbour near the yacht club, Fagatele Bay National Marine Sanctuary and Ofu National Park. A very limited amount of snorkelling is assumed to occur in other locations. Figures 3.5 and 3.6 show the relative importance of different locations for snorkelling within Tutuila and the other islands.

No studies have been made of the number of recreational snorkels made per year nor for their consumer surplus and expenditures. Based on discussions with Pago Pago Yacht Club members and other individuals, a ballpark total of 2,750 snorkels per year was assumed in Tutuila. A figure of 500 was assumed for Ofu and Ta'u Island based on Craig & Basch (2001).

Figure 3.5

Current coral reef recreational snorkelling values for Tutuila, Aunu'u and inshore banks (Taema and Nafanua).

Notes:
Refer to Box 6.1 for corresponding value for each category and location.
Maps based on NOAA benthic habitat classification (NOAA, 2004).

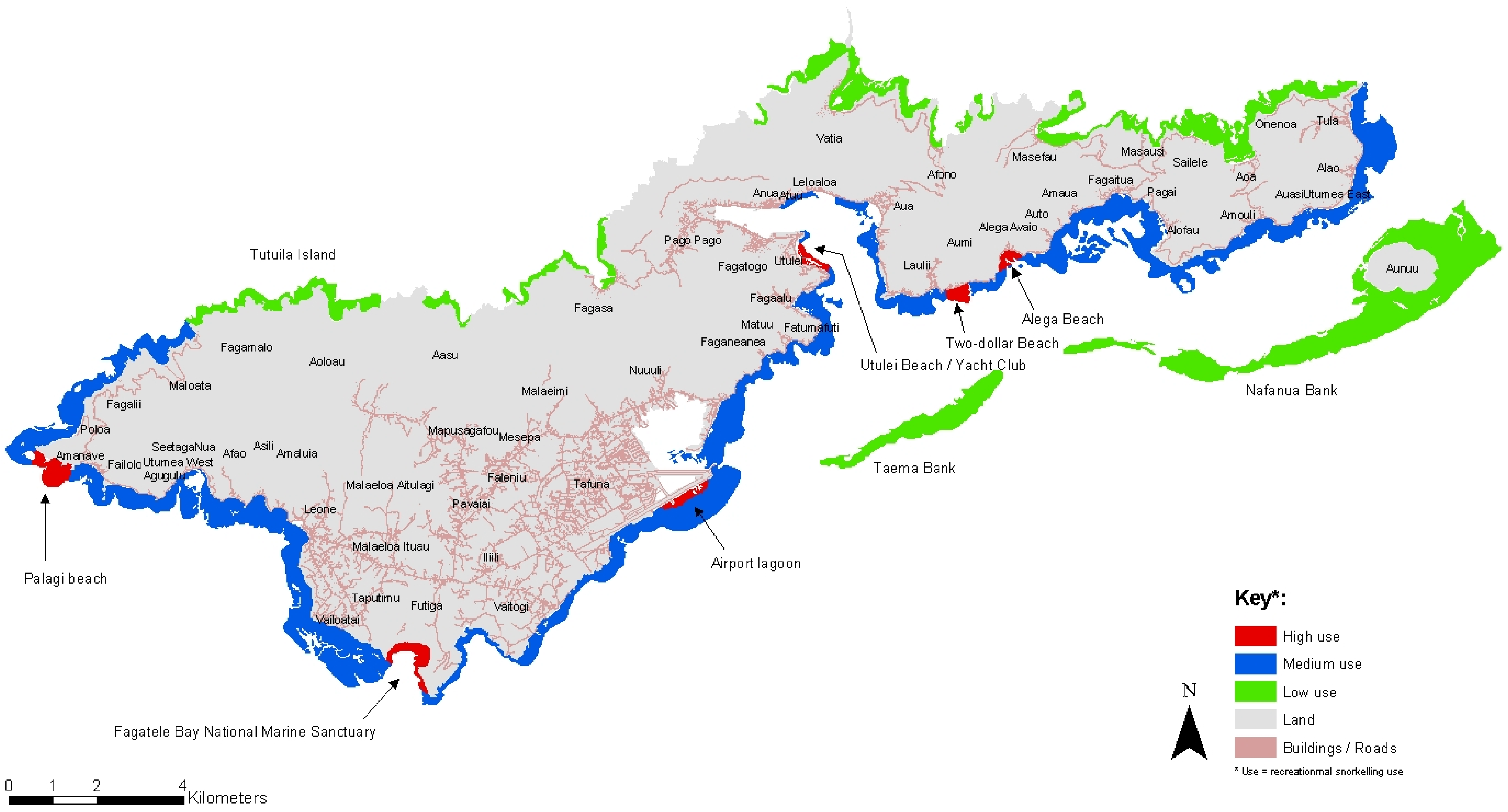
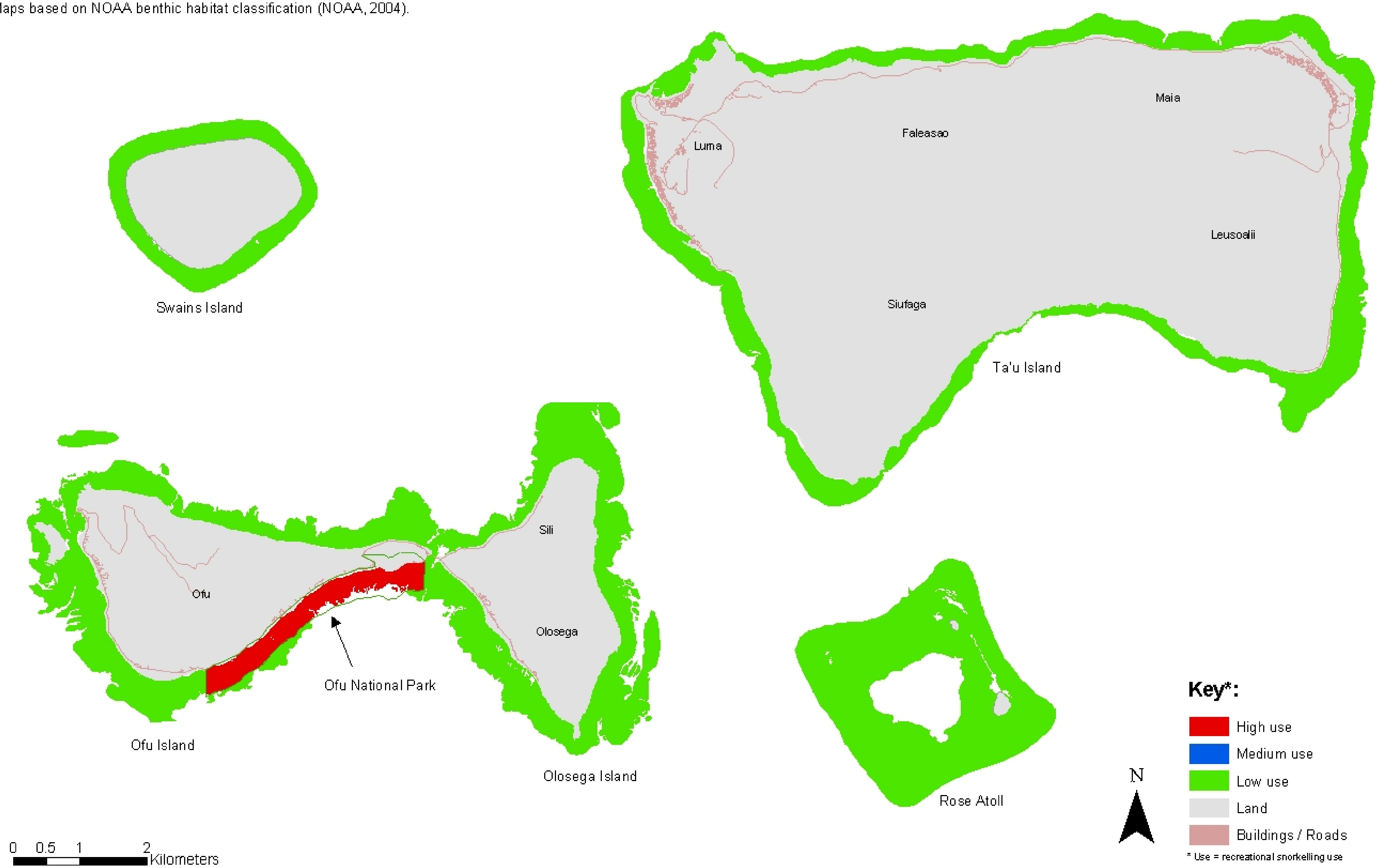


Figure 3.6

Current coral reef recreational snorkelling values for Ofu, Olosega, Ta'u, Swains Island and Rose Atoll.

Notes:
Refer to Box 6.1 for corresponding value for each category and location.
Maps based on NOAA benthic habitat classification (NOAA, 2004).



N.B. All islands drawn to same scale but relative locations and distances between islands are not.

Average consumer surplus values were based on adjusted benefit transfers for consumer surplus values from a number of other studies, as follows:

For visitor (i.e. non American Samoan) snorkel trips to Ofu, the most similar study was that in Palau by Graham et al (2000), which estimated a consumer surplus of US$ 26 visitor/trip. This was adjusted to US$ 24 person/trip for this study, based on Palau's more extensive coral reef recreational opportunities. For visitor snorkels in Tutuila, the most relevant estimates were considered to be those of US$17 visitor/trip in Florida (NOAA, 2004c) and US$ 9.59 in Hawaii (Cesar, 2002). For this study, based on additional discussions with local stakeholders, a mid-range value of US$ 12 person/trip was used (i.e. 50% of that used in Ofu).

For residents (i.e. American Samoans and Caucasians working in American Samoa), the best available estimate for snorkelling CS alone was considered to be US$0.75/trip for residents in southeast Florida (NOAA, 2004c). In this study, a higher value of US$ 4/person/trip was used for Tutuila due to the relative lack of substitute activities on America Samoa, and the fact that most resident snorkellers are Caucasians. For resident snorkels in Ofu, a value of US$ 8 per trip was used (as for visitors, this is double the assumed Tutuila value). Note that Cesar (2002) estimated a resident consumer surplus of US$ 8.93 resident/trip in Hawaii, however this also included CS for dive trips.

Based on the authors' experience and observations whilst visiting American Samoa, average snorkelling related expenditures on Tutuila is assumed to be US$ 10 for visitors and US$ 4 for residents, covering transport, food and travel. Expenditure per snorkel to Ofu by tourists and residents is assumed to be US$ 100, taking into account flights, accommodation and food, and assuming 1.5 snorkel visits per trip to the Islands. Expenditures were converted to expenditure "added values" by subtracting costs of production. The costs are assumed to be 75% of expenditures in the tourism sector, based on Cesar (2002).

Based on the above assumptions, total annual snorkelling consumer surplus and expenditures are estimated to be in the order of US$ 45,000/year and US$ 16,000/year respectively. With a multiplier effect of 1.25, this expenditure equates to US$20,000/year.

(b) SCUBA diving

With so few tourists travelling to American Samoa, there is very little recreational coral reef diving. Few if any visitors fly here specifically to dive. Due to the lack of demand there are only two commercial dive outlets, both of which receive most of their trade from visiting research scientists (however, these are not included in this assessment because they relate to management and research activities). The Pago Pago Yacht Club accounts for the majority of active local divers.

No studies have been made of the number of recreational dives made per year in American Samoa. Resident divers are estimated to do around 450 dives per year (around 15 active divers at an average of 30 dives each per year), visiting divers only accounting for around another 30 (Loftenses and Harrison, 2004. pers. comm.).

Perhaps 45% of all dives are performed off the north coast of Tutuila, and 45% off the south coast. The north coast is often first choice (weather permitting) since it has some of Tutuila's most pristine and spectacular coral reefs, although it takes much longer to get to. Some of the most popular dive sites on the south coast are found between Leone bay and Vailoatai, and to a lesser extent between Leone to

Poloa and off Fagatele bay. The remaining 10% of dives are within Pago Pago Harbour, which has a number of popular wall and seamount dives. Its sheltered aspect also makes it popular for dive training. There is assumed to be no recreational diving on other islands in American Samoa. Due to the low number of dives and the diverse range of very specific locations for diving, no current dive location maps have been produced for this study.

An average consumer surplus value of US$ 10 per dive is assumed for residents and US$ 20 for visitors. Note that Dixon et al (1993) estimated a diving consumer surplus value of almost US$ 30 per dive in Bonaire Marine Park in the Caribbean. However, a lower consumer surplus is assumed here for the residents because they do numerous dives each year, and for visitors because they have to pay a significant sum to go diving.

Average dive related expenditure, covering food, equipment and boat costs, is assumed to be US$ 10 for residents and US$ 90 for visitors (based on Harrison, 2004. pers. comm. and the authors' experience and observations). Expenditures were again converted to "added values" by subtracting an assumed 75% for costs of production.

Based on the above assumptions, total annual dive consumer surplus and recreational added value are estimated to be around US$ 5,000/year and US$ 2,000/year respectively. With a multiplier effect of 1.25, this expenditure equates to just under US$3,000/year.

3.2.4 Shoreline protection benefits

The existing fringing reefs surrounding American Samoa play an extremely important role in shoreline protection, helping to reduce erosion and flooding. Roberts et al (1992) summarized wave energy attenuation over the outer reef flat, measured on various Caribbean and Pacific reefs, of between 75% and 95%.

However, to understand the full extent of this function, it is essential to understand the oceanographic and geomorphological conditions. Current and future oceanographic conditions around America Samoa are provided in Appendix F. Some of the issues relating to both are discussed below.

The present day coastal margin of the islands of American Samoa are largely a relic feature attributable to the climatic conditions experienced over the last 1000 – 4000 years (as rapid sea levels rise stabilized to present day levels). Within the active beach system, in very general terms, modern day beach sediments also reflect this antecedent system with little present day fresh input to sediment budgets.

Carbonate sediment composition on the shoreface is typically dominated by sediments of between 500 and 2000 years of age, with more recently produced sediments generally forming a very small percentage of the overall composition. In part this is due to the relatively narrow fringing reefs that surround the various islands limiting the reef area available for carbonate sediment production.

American Samoa currently suffers from an extreme coastal erosion problem. On high Pacific Islands such as American Samoa, present day erosion is typically due to a combination of both human and natural factors, the overall rate of erosion and relative contribution of each of these factors depending on the particular location and setting. The most significant factors resulting in erosion in American Samoa include:

- A reduction in the carbonate productivity of reefs and reef flats relative to that occurring as the present day coastline formed as sea levels stabilized 4000 to 1000 years ago.

- Episodic typhoon and storm conditions, and inter-annual and annual variations in the easterly trade wind wave climate. The most recent typhoons in American Samoa occurred in 1981 (Esau), 1987 (Tusi), 1990 (Ofa), 1991 (Val) and most recently Heta (2004).

- Impacts on natural beach processes due to the construction of coastal protection and other structures, as attempts have been made to protect land, property and infrastructure. The high level of development and infrastructure that has occurred on the immediate backshore of the low lying coastal plains is in part due to the extremely steep inland topography of Tutuila and Manu'a islands, but also due to poor land use planning in allowing development to occur right to the coastal edge. This prevents beaches from responding to the natural variability of the forcing hydraulic processes.

- The continuous extraction over many decades of large volumes of sand and beach rubble from the foreshore (estimated at 100 cubic yards per week (Volk et al, 1992). Note that the cost of mining this coral rubble is estimated at US$ 470,000 to 2.3 million per year or between US$ 90 and 450 per cubic yard. This is based on the fact that if the coral and sand had been left to protect the coastline, installation of shoreline protection schemes costing on average around US$ 1 million per year for 25 years around the Islands could have been delayed by 10 to 20 years. The assumptions are based on a 5% and 10% discount rate respectively. The calculation also assumes rubble has been taken at the above rate for the past 50 years. Note the loss of recreation and tourism value that could be derived from the sandy beaches is not included in the valuation.

Given the highly variable nature of the morphological setting and hydraulic processes acting on the beaches of American Samoa and the various factors contributing to the present day rates of coastal erosion, ascertaining the relative magnitude of the effects of sand mining on the rate of beach erosion of the various coastal systems is not a straightforward task.

However, in the context of the present study the table below attempts to estimate a generalized rate of erosion for open coast (i.e. non harbour) settings, relative to the severity of sand mining activities within the particular coastal system. This is based on erosion information in the Shoreline Inventory Update II (Sea Engineering, Inc & Belt Collins, 1994), Richmond (1995) and from experience elsewhere in the Pacific.

Table 3.1 Estimated generalized rates of erosion relative to severity of sand mining

Severity of sand mining within beach unit	General long-term rate of landward retreat of the beach
No sand mining	0.2m / year
Low	0.4m / year
Moderate	0.8 m / year
Severe	1.2m / year

Although fringing reefs can assist in shoreline protection and in the provision of new beach material, their role appears to be overshadowed by the extensive removal of beach material. As a result, a considerable amount of money has already been spent on installing shoreline protection schemes.

There is no overall database of information on existing shoreline protection schemes. However, the Department for Public works and the Army Corps of Engineers did provide some useful information (Arewgoda and Nakaoka, 2004 pers. comm.). The data indicates that 22 shoreline schemes have been or will be installed between 1977 and 2007 with an overall cost potentially in the order of US$ 26 million along around 2.6 km of coast.

According to the Territorial General Plan (DOC, 2003) the list of needed shoreline protection and flood control projects increased from US$ 8.2 million to US$ 12.5 million. They predict that over the next few years shoreline protection needs will increase to US$ 15 million (excluding the impacts of Hurricane Heta). They also point out that insufficient funds are available to pay for the protection.

Based on the GIS map of America Samoa, this study has identified around 48 km of coastline potentially at risk from erosion where either property or roads are immediately adjacent to the shoreline. Around 64 km^2 of coral reefs are located immediately in front of the coast potentially at risk from erosion. Figures 3.7 and 3.8 show the relative importance of different locations for shoreline protection in Tutuila and the other islands.

Due to the nature of the Islands' terrain and the location of key roads and villages, where such key assets are at risk, there seems little alternative but to install shoreline protection schemes. The coastal roads are vital to the islands' economy, and relocation of villages is not really possible or desirable, especially given that family are often buried in garden plots on the shoreline.

It is likely that the wave attenuation function of the fringing reefs helps slow the rate at which new shoreline protection schemes need installing and existing schemes need replacing. Shoreline protection values are thus based on savings from delaying the:

i) Replacement of existing shoreline protection schemes;
ii) Installation of new shoreline protection schemes; and
iii) Replacement of new shoreline protection schemes.

Based on this approach and the assumptions and data in Appendix D, the overall benefit from coral reefs with respect to shoreline protection function may be in the order of $447,000/year. This value is relatively low compared to studies elsewhere, because it acknowledges that much of the shoreline protection function is provided by the solid limestone reef matrix laid down over thousands of years that, in many locations, has relatively low coral cover.

Figure 3.7

Current coral reef coast protection values for Tutuila, Aunu'u and inshore banks (Taema and Nafanua).

Notes:
Refer to Box 6.1 for corresponding value for each category and location.
Maps based on NOAA benthic habitat classification (NOAA, 2004).

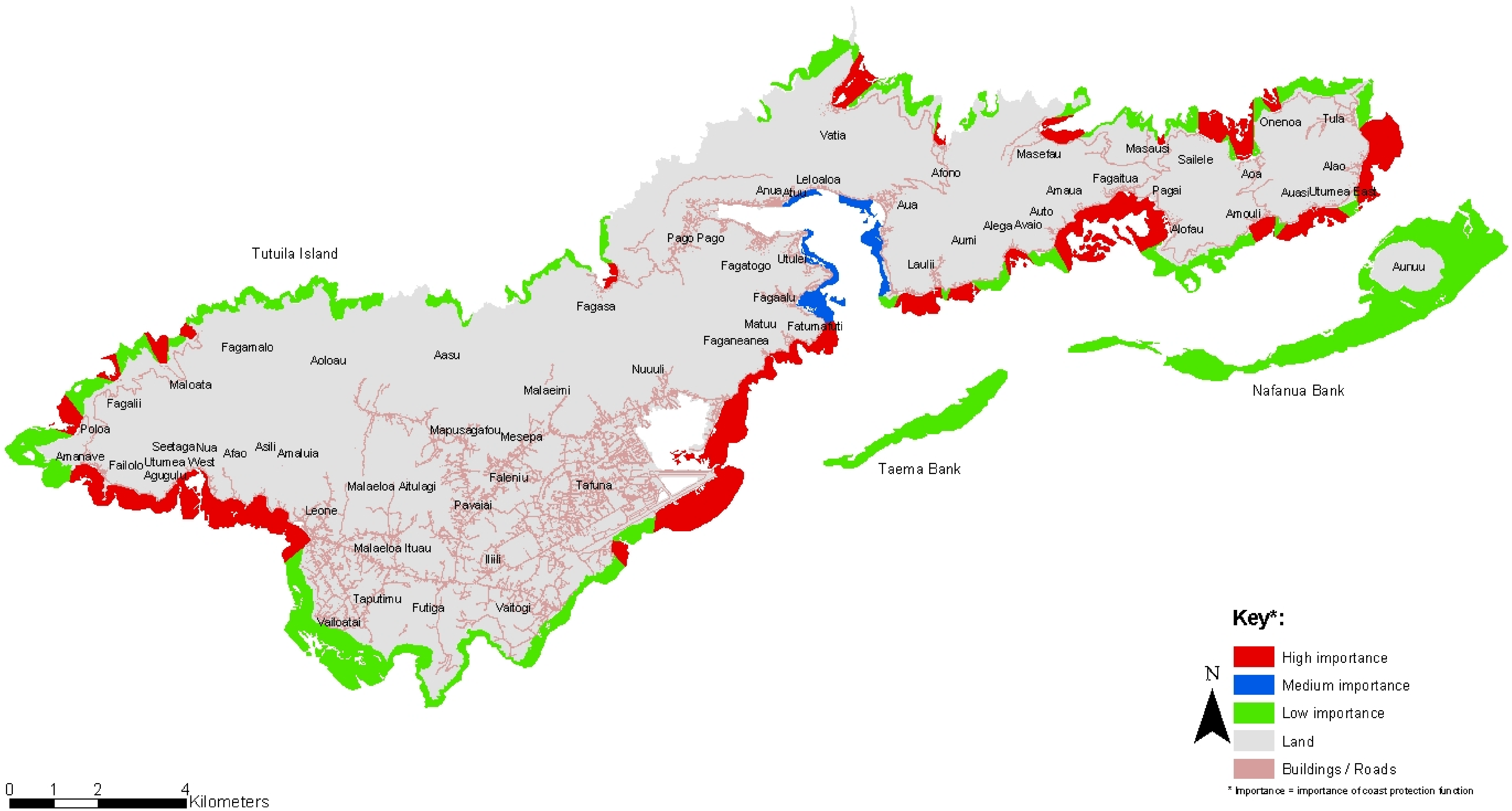
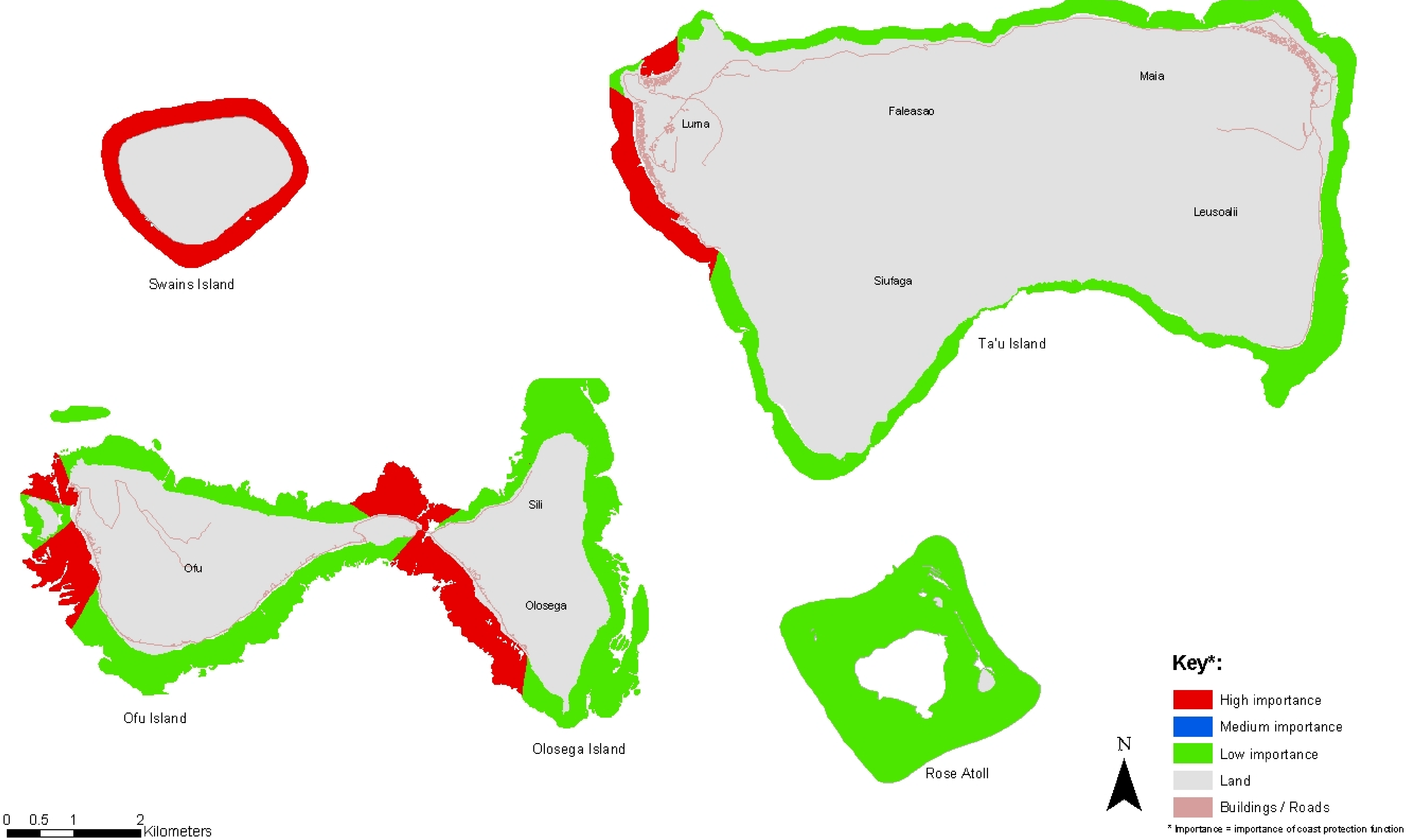


Figure 3.8

Current coral reef coast protection values for Ofu, Olosega, Ta'u, Swains Island and Rose Atoll.

Notes:
Refer to Box 6.1 for corresponding value for each category and location.
Maps based on NOAA benthic habitat classification (NOAA, 2004).



N.B. All islands drawn to same scale but relative locations and distances between islands are not.

3.2.5 Non-use benefits

Various stakeholder groups are likely to derive non-use values from knowing that American Samoa's coral reefs continue to exist in a healthy state. This can be because they consider that they may benefit from using the reefs at some time in the future (option value), or that future generations may benefit (bequest value) or from simply knowing that reef continue to exist with no planned use of them whatsoever (existence value). It is important to note that this non-use value excludes direct use value but may capture part of the social, cultural and historic value of corals.

American Samoa's reefs hold considerable social, cultural and historical significance. For instance, the village discussion meetings revealed that older islanders in particular, sometimes retain important memories of their own interaction with coral reefs during early life. Reef resources are also still used for various traditional food, medicine, cultural and religious customs. Several meeting attendees noted the importance of coral sand and gravel for use in traditional fales, decoration and for keeping weeds from gardens. Coral slabs are also reported to have been used for covering graves and for constructing star-mounds (tia seu lupe).

In addition, spiritual relationships to ancestors and gods are often renewed through experiencing natural phenomena at marine and coastal areas or through the offering of marine resources in religious ceremonies (Crosby et al, 2002). For instance, the collection of palolo and giant clams for use in ceremonial events (e.g. falavelave) was widely cited during village discussion meetings and stakeholder interviews. Coral reefs also feature in early Samoan creation legend, in which the god Tagaloa first created a rock, which he split into clay, coral, cliffs and stones (NPAS, 2004).

The concept of non-use value was raised at the village discussion meetings to mixed response. Some attendees felt it important that some areas of coral reef are set aside as MPAs with little or no human use (e.g. Rose Atoll). This suggests a clear understanding of and belief in existence values. However, others felt that such actions would be a waste of resources that could otherwise be put to good human use, suggesting the opposite. Other attendees felt strongly that coral reefs should be conserved for future generations (bequest values). In addition, support for MPAs was also justified by several attendees on the grounds that they may personally benefit in the future through enhanced fishery productivity.

To more distant populations, including those who are unlikely ever to visit the islands, existence values are likely to be more important. In particular, the general public of the US may hold relatively high non-use values because of the status of American Samoa as a US territory. They may hold high values for corals that are well preserved and used at subsistence levels by local populations.

The potential relative spatial importance of non-use values is shown on Figures 3.9 and 3.10. It highlights that higher values are likely to be associated with protected areas and better quality reefs.

Figure 3.9

Current coral reef non-use values for Tutuila, Aunu'u and inshore banks (Taema and Nafanua).

Notes:
Refer to Box 6.1 for corresponding value for each category and location.
Maps based on NOAA benthic habitat classification (NOAA, 2004).

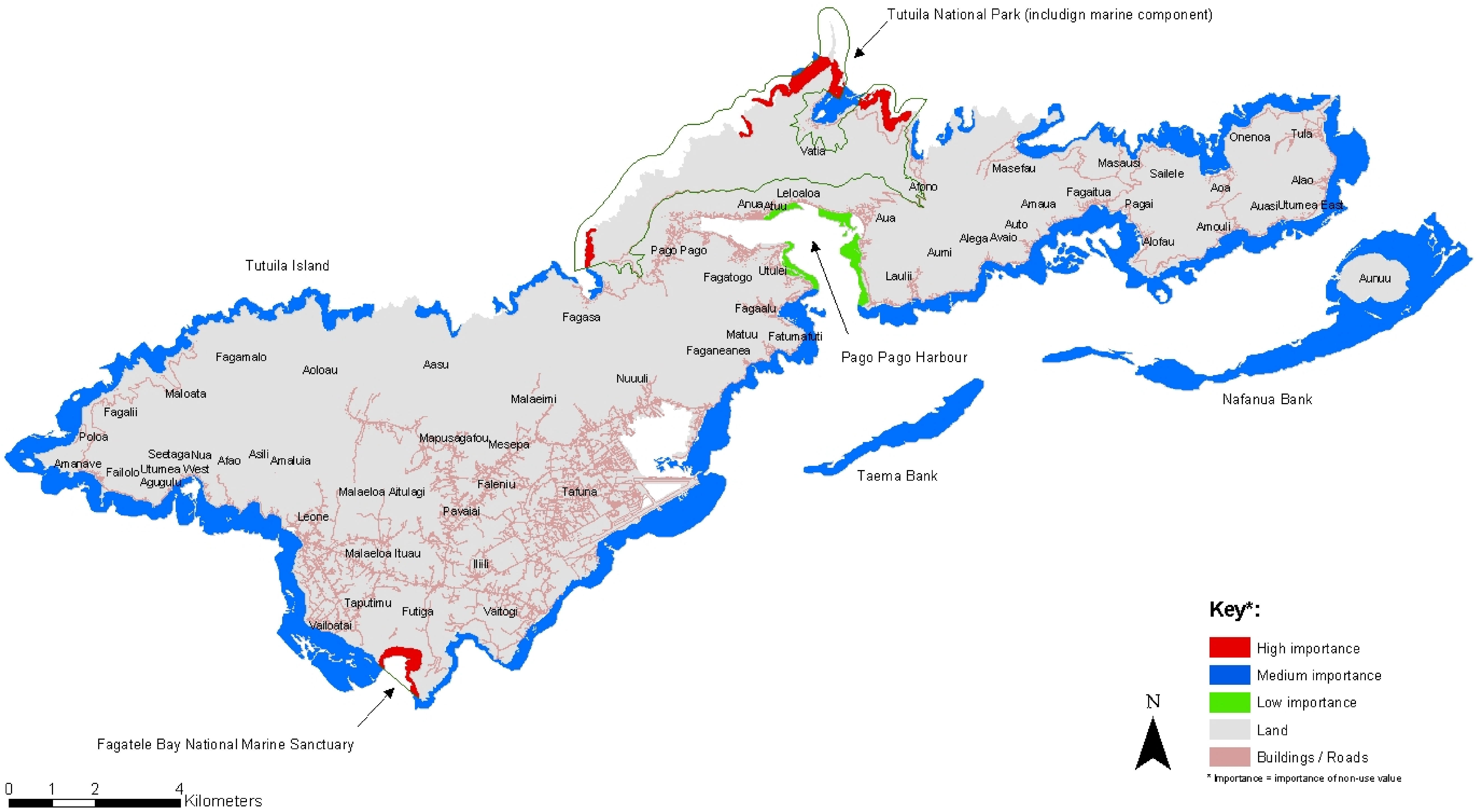
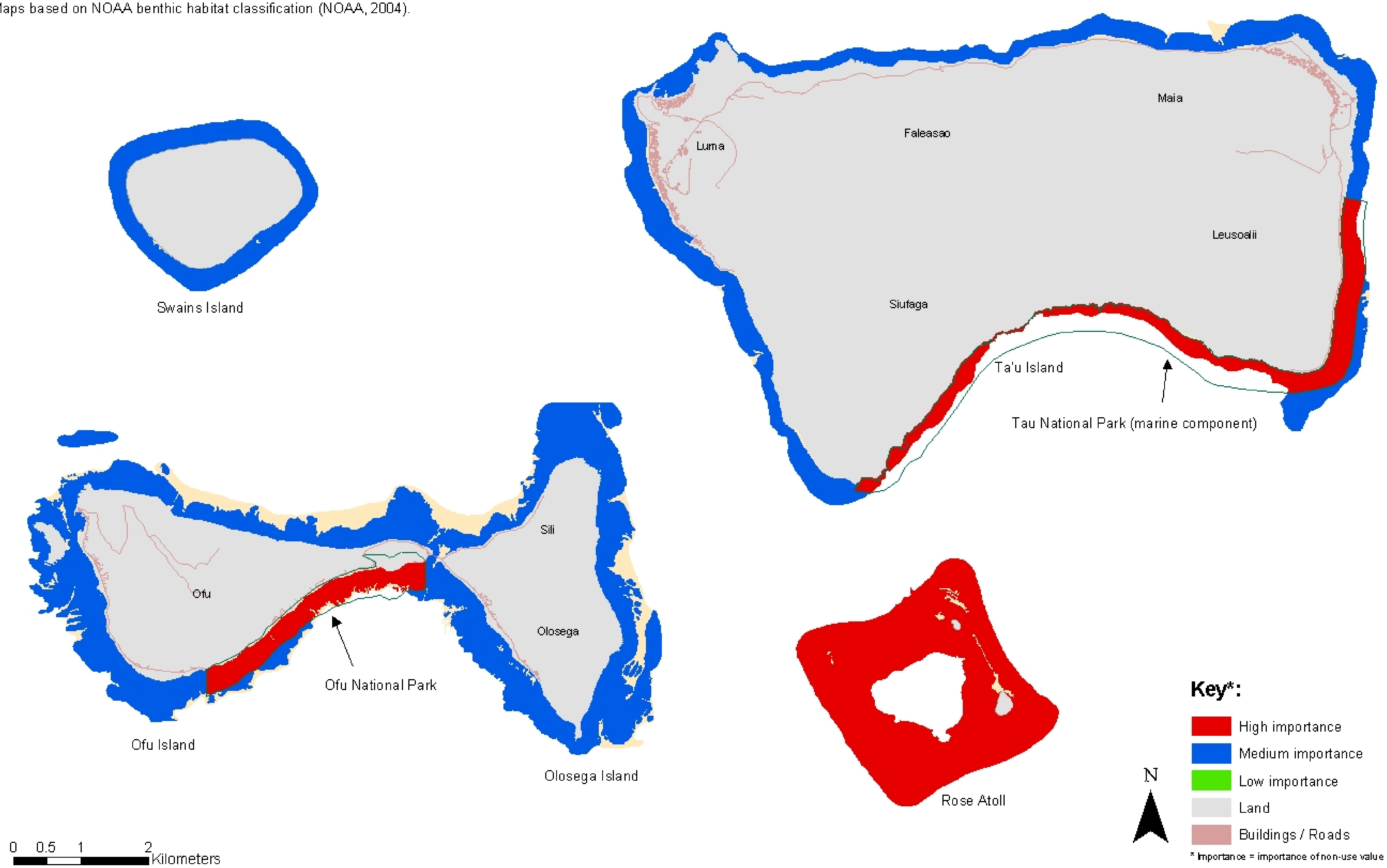


Figure 3.10

Current coral reef non-use values for Ofu, Olosega, Ta'u, Swains Island and Rose Atoll.

Notes:
Refer to Box 6.1 for corresponding value for each category and location.
Maps based on NOAA benthic habitat classification (NOAA, 2004).



N.B. All islands drawn to same scale but relative locations and distances between islands are not.

Based on the results of the general public questionnaire, the average adult (over 16) living in American Samoa was estimated to have a total non-use value of US$ 105/year for the protection of coastal resources (see Appendix B). Adult residents born in the USA, New Zealand and Australia (1,618) had the highest non-use value (US$ 207 per person per year) compared to US$ 131, US$ 89 and US$ 31 per year for those born elsewhere in the Pacific (11,328), in American Samoa (19,419) and in other locations (e.g. Asia) (2,141) respectively. Further details as to how non-use values were calculated are given in Appendix B.

The non-use WTP for coral reefs is assumed to be US$ 8.50 per visit for tourists and cruise passengers (16,000 people) and US$ 2.13 per visit for business visitors and those visiting relatives (38,000 people). These WTP values are simply assumed values based on Bann's (1999) CVM estimate of US$ 10 for international visitor non-use values for mangroves in Malaysia, split according to the ratio of 85:15 for corals and mangroves respectively. The ratio is based on Mohd-Sahwahid and McNally's (2001) CVM survey in Western Samoa, which identified coral reef and mangrove values in the ratio of 60:40, but adjusted to 85:15 for the purposes of this study. This is based on the understanding that mangroves in Western Samoa are likely to play a more significant role than in American Samoa. These assumptions give a ballpark WTP of around US$ 216,000/year.

For the purposes of this assessment, it is thought that the US general public could have a non-use WTP for coral reefs of around US$ 0.04 per household per year (i.e. say 10% of households have a WTP of US$ 0.50/year for American Samoa's coral reefs and mangroves, adjusted to 85% for coral reefs). There are no specifically relevant valuations that can be used for this benefit transfer, although Leeworthy and Wiley (2000) assume that 1% of the US population would have a willingness to pay of between US$ 3 and 10 for protecting Tortugas Ecological Reserve, in the US.

Assuming there are approximately 117 million households in the US, this gives a total ballpark non-use WTP of $5 million/year. However, given that American Samoa's reefs are 7% of those within US territorial waters, that Rose Atoll is amongst the least disturbed and that Ofu National Park is amongst the most breathtaking locations, the actual value may be significantly greater. It also excludes values held by people elsewhere in the world.

As an absolute minimum, non-use value for coral reefs could therefore be in the region of at least US$ 8.8 million/year. This is not unreasonable compared to non-use value estimates for other nationally important reefs. For example, a CVM study estimated a present value non-use value (of locals and visitors) of US$ 1 million/year (based on a present value of US$ 20 million and a discount rate of 5%) for protecting and improving coral reefs in a single bay (Montego Bay) in Jamaica (Spash et al, 1998). In Australia, non-use value held by Australians for protecting the Great Barrier Reef was estimated at US$ 80 million/year (1997 values based on Hundloe, 1990).

However, these are only ball-park estimates and actual values could differ by orders of magnitude. For instance, the resident and visitor non-use values may be underestimated by a factor of up to 10. Similarly, the US population values (which make up around 56% of the stated values) may be overestimated by a factor of 10, but more likely could be underestimated by as much as a factor of 20 to 50 or higher. In addition, only the general public in the US were considered in this study (because it is an American territory) however, other international non-users will also derive benefits.

3.2.6 Other benefits

(a) Mariculture

There is no mariculture presently being undertaken in American Samoa. To date, mariculture industries have concentrated on giant clams, which are a favorite food item in the Western Pacific and wild populations have been heavily over-collected in many reef areas. However, the mariculture facility in Tutuila is in disrepair and although there is a stock of clams available for spawning, these are not being used at present, and their numbers are declining due to theft. There have been no recent successful spawnings. The current value of reef-related mariculture is assumed to be zero.

(b) Aquarium trade

Currently there is no extraction of aquarium fishes, corals or other organisms from the reefs of American Samoa. Two licenses have been issued in the recent past but they are not now utilised. A major problem is the airfreight costs to the US mainland via Hawaii. The current value of reef-related aquarium trade is assumed to be zero.

3.3 Mangroves

3.3.1 Direct subsistence fishery product benefits

Mangroves provide direct fishery benefits in the form of catches of invertebrates, fish and other food products. The vast majority of the mangrove fishing effort takes place in Pala lagoon. Catches are considered to be primarily subsistence in nature though a small proportion may be sold.

Mangrove fishing effort has declined dramatically over recent years for the same reasons as the wider subsistence fishery. In addition, the environment of Pala Lagoon has deteriorated considerably due to mangrove clearance and pollution from piggeries and other sources (Yamasaki et al, 1995; ASEPA, 2004).

Based on the most recent mangrove fishery survey data (Ponwith, 1992), assuming a 55% reduction in catches as has been seen in the subsistence fishery island wide (Coutures, 2003), current mangrove catches are estimated to be in the region of 7 tonnes/year in Pala lagoon. Based on area, the catch in Leone lagoon was estimated to be 0.4 tonnes/year. Catch composition was assumed to be the same as 1992 (44% fish, 46% shell-on clams, 10% crabs and <1% miscellaneous). It was also assumed that 75% of invertebrates (clams, crabs and misc.) and 65% of fish caught were a direct mangrove benefit of the mangroves themselves.

Retail market prices used were US$ 2.50/pound (US$ 5.51/kg) for fish, US$ 7.50/pound (US$ 16.54/kg) for crabs and US$ 1.39/pound (US$ 3.06/kg) for shell-on clams. Market prices were converted to “added values” by subtracting costs of production (assumed at 5% of market prices in the subsistence fishery).

Based on the above, at 2004 market prices the total current product added value of the direct mangrove subsistence fishery was estimated to be around US$ 28,000/year. Including additional indirect and induced expenditures associated with the multiplier effect (assumed to be 1.05 for the subsistence fishery), this equates to US$ 29,000/year.

3.3.2 Direct subsistence consumer surplus benefits

Using a similar approach to valuing the enjoyment of coral reef related subsistence fishing, an overall estimate of mangrove fishing consumer surplus of US$ 4,000/year was estimated. This is based on an assumed WTP of US$ 1.40 per fishing trip and an average of 2kg fish caught per trip.

3.3.3 Indirect fishery benefits

Mangrove habitats typically provide a range of important indirect fishery benefits, particularly due to their role as spawning and nursery areas for many marine species (including those typically caught on coral reefs). However, there is little data on the role of Pacific mangroves in reef fisheries, and none related to those in American Samoa.

The closest studies (geographically) seem to be those conducted in Queensland, where Robertson and Duke (1987) documented numerous reef species more abundant as juveniles in mangroves. The relationship between mangroves and abundance of such species may be little based on food supply. Studies have shown for example that adults of penaeid shrimp which are associated with mangroves as juveniles and mature in the open sea do not apparently assimilate mangrove-derived carbon (Rodelli et al. 1984). This does not rule out mangroves being a source of food to resident juveniles (e.g. review of Fry & Ewel 2003) and these may also benefit through mangrove habitat acting as refuge from predation (e.g. Mumby et al. 2004).

There is also some evidence of mangrove detritus being taken up by consumer organisms at distances up to 3 km from mangroves (Hemminga et al. 1994). However, this still leaves open the question as to whether mangroves are conducive to adjacent reef-fisheries yield, and thus whether in areas such as Pala lagoon the presence of the extensive mangrove stands does enhance productivity of some target species. Debate about relationships between mangrove and reef fish is ongoing (e.g. Mumby et al. 2004) but there is currently no basis for predicting mangrove-influenced fishery yields at different distances from mangroves of varying sizes.

Ronnback (2001) highlights various studies where between 30% and 80% of nearshore fish catches are associated with mangroves. However, considering the limited extent of mangrove habitat in the Territory and the complete absence of mangroves on four of five islands, the relationship with total fisheries is likely to be far less strong. For the purposes of this study, 5% of the direct subsistence and artisanal reef catch on Tutuila is assumed to be associated with the mangroves (equivalent to 2 tonnes/year of fish and 23 kg/year of lobster).

Based on 2004 market prices for fish products, converted to “added values” by subtracting costs of production (assumed to be 5% of market price for the subsistence fishery), this gives an overall indirect fishery added value of around US$ 12,000/year. Including additional indirect and induced expenditures associated with the multiplier effect (assumed to be 1.05 in the subsistence fishery), this equates to just under US$ 13,000/year.

3.3.4 Shoreline protection benefits

In comparison to other tropical countries, mangroves do not appear to play a significant role in shoreline protection in American Samoa. The Pala lagoon mangrove (0.5km^2) is sheltered from cyclones from the northwest (usually between November-April), and oceanic swells generated by the southeast trades (May to December) are also unlikely to penetrate the narrow opening off Coconut point. However, with a fetch of some 1.25km across the lagoon, the mangrove will provide a degree of local protection from inundation during strong trades. By acting as a buffer between the land and sea this may provide protection to housing and commercial infrastructure situated close to the waters edge. Other small stands of mangrove in streams along other parts of the coast may also provide minor local protection during storms.

Using the replacement cost approach, the mangroves in Pala Lagoon provide an annual shoreline protection value of US$ 135,000/year. This is based on there being approximately 3km length of mangroves protecting properties, a cost of US$ 1500/m to provide equivalent protection, and a discount rate of 3%.

3.3.5 Recreation and tourism benefits

Although there is recreation within Pala lagoon, there is currently no direct mangrove related recreation in American Samoa. However, the size of the mangrove at Pala lagoon provides some opportunities for walking/hiking (ASEPA, 2004).

3.3.6 Non-use benefits

Like coral reefs, various stakeholder groups are likely to hold non-use benefits related to the mangroves, including the general public of American Samoa and further afield. For the purposes of this study, the same stakeholder populations are assumed as for coral reefs. The mangrove non-use WTP values are assumed to be 17.6% of those used for coral reef values (i.e. based on the ratio of 85:15 discussed for coral reefs).

This gives an overall non-use value for mangroves in Pala Lagoon and Leone of US$ 1.3 million/year.

Note however that as for corals, non-use values are ballpark estimates and actual values may vary by orders of magnitude.

4 Trends, threats and enhancement of coastal resources

4.1 Introduction

The value of American Samoa's coastal resources is being shaped by a wide range of environmental, social and economic trends, some global in scale (e.g. climate change and industrialisation) and others local (e.g. resource status and availability). These underlying trends give rise to a series of impacts that determine the status of resources and how society interacts with and values such resources.

The potential value of coastal resources is dependant on how both adverse and positive impacts are managed in the future. This section provides a summary of the key underlying driving force trends, ways in which these impacts can be mitigated and ways in which coastal resource benefits can be enhanced.

4.2 Key underlying trends

Some of the key trends affecting coastal resource values in American Samoa include:

Climate change: the anticipated increase in global temperature of 1.5-4.5^{o}C and consequent sea level rise of between 25-40cm by 2030 is expected to have significant effects on American Samoa (See Appendix F). For instance, the frequency and severity of tropical cyclone damage is expected to increase. Although a natural feature of many tropical regions, hurricanes can have rapid and dramatic and rapid environmental effects, particularly due to erosion of low-lying coastal areas and damage to fragile coral reefs. Since most people on Tutuila live on the narrow coastal strip, a significant proportion of the population may be affected.

Market competition: the value of goods and services provided by American Samoa's coast, such as tourism opportunities and fish products, are increasingly affected by competition from globalised markets. For instance, the Territory faces a stiff challenge in attracting tourists that may otherwise go to other Pacific islands (e.g. Western Samoa and Fiji). Similarly, American Samoa increasingly imports a range of fresh and preserved fish products that are sold to local markets thereby decreasing local market prices (though note that this has positive impacts, including alleviation of pressure on local stocks).

Increased conservation awareness: the gradual increase in the level of awareness related to marine and coral conservation issues is likely to continue. This will lead to an increase in the use and non-use values held by all stakeholder groups. The non-use values held could have significant implications for future management, for instance in terms of encouraging respectful use of resources and generating sources of finance.

Rapid population growth: population growth is high at around 2.1% (1990-2000) and predicted to reach over 76,000 by 2020 (ASPA, 2003). Most growth will occur by 2005 after which rates may slow down due to decline in fertility and lack of available development land. In addition, between 2006-2010 around 33% of the national workforce (about 5000 people) will lose their jobs if the Starkist cannery closes, as is predicted. Besides reduced local incomes, this will cause significant out-migration and is likely to slow down population growth for a period. However, population will certainly reach unprecedented level within the next decade potentially resulting in significant pressure to develop marginal lands, direct loss of coastal habitats, increased land run-off and pollution and overuse of coastal resources.

Development of the economy: over recent decades the islands have undergone a steady shift from subsistence to cash economy due to increasing influence of global market forces. As a result, fewer people rely directly on coastal resources for food and livelihood, and subsistence catches have declined significantly. The main island industry of canneries is likely to change more towards telecommunications and tourism in the future. However, the associated increase in urbanisation, development and waste is increasingly affecting the coast indirectly. In addition, commercial resource extraction has given rise to serious overuse in the recent past (e.g. the SCUBA fishery) and pressure to develop other similar industries to provide short-term profit will always be present.

Increased management effectiveness: Coastal management has progressed dramatically in American Samoa over the last few decades and is likely to continue to do so in the future. Significant achievements to date include: creation of an MPA network (now estimated to cover 5% of reefs), formation of the American Samoa Coral Reef Advisory Group (ASCRAG), implementation of a 5-year coral reef management plan, initiation of the community fishery management plan, banning of SCUBA fishing and a number of education and outreach programmes.

4.3 Threats to coastal resources

Table 4.1 lists the key current and potential threats that face the American Samoan coral reefs over the coming years (based on ASCRAG, 1999). The threats listed are either anthropocentric in origin or due to natural events. The table identifies the root cause or drivers for the threat and those individuals or groups that impact the reef system.

Both the direct and indirect consequences of the threat are listed, and some potential solutions are suggested. The threats are also given a priority, showing the need to address the root cause.

4.4 Enhancement of coastal resource values

Table 4.2 identifies a number of examples in which the value of the coastal resources in American Samoa may be increased. These methods vary from long-term strategies to one-off projects. For each action, details of the underlying principle, the beneficiaries and the possible benefits it might result in are listed. Where an action carries with it potential adverse impacts such as costs or restrictions these are also listed. Each action is given a priority rating based on the magnitude of benefit is might allow to be realised.

Table 4.1 ***Threats to coastal resources in American Samoa and solutions.***

Threat (harmful activity)	Root causes	Impactors	Direct impact to coastal resources	Indirect and other consequences	Potential solutions	Priority
Coastal development	• Rapid population growth • Increased need for housing and infrastructure • Lack of regulation enforcement	• Land owners • Developers • Development planners	• Habitat loss (e.g. coral reef, mangrove and beaches) • Loss of fish spawning grounds and turtle breeding sites	• Reduced shoreline protection and increased erosion • Reduced fishery support and catches • Reduced recreation opportunities	• Implementation of coastal zone management • Control population growth • Enforce planning regulations • Train planning staff	H
Clearance of coastal and upland forests	• Rapid population growth • Need for development / agricultural land • Need for wood products (e.g. umus, building etc) • Lack of regulatory enforcement	• General public • Builders and developers • New residents setting up new houses	• Loss of mangrove habitat • Increased sediment loads in coastal waters	• Loss of mangrove fishery support • Smothering of coral by sediment and associated loss of benefits • Reduced water visibility	• Control population growth • Avoid development of marginal land • Enforce regulations • Train planning staff • Encourage alternative building materials	H
Sand and coral rubble mining	• Increased demand for materials (e.g. construction / traditional uses) • Lack of available alternatives	• Construction firms • General public	• Loss of reef flat substrate • Loss of recreational beaches	• Increase in erosion • Need for costly coastal defences • Further loss of beaches	• Control population growth • Strictly enforce existing regulations • Impose fines • Provide alternative sources of material	H
Installation of new shoreline protection	• Sand and rubble mining • Global warming • Use of hard shoreline protection nearby • Need to protect coastal infrastructure	• People taking sand and rubble • Land owners • Developers • Development planners	• Loss of beach recreation • Further loss of beach material due to stopped erosion.	• Increased erosion nearby	• Minimise use of hard structures • Consider alternatives (e.g. beach replenishment/setback) • Enforce existing management plans	H
Over use of coastal resources	• Rapid population growth • Increased demand for food resources • Increased need for livelihoods • Lack of enforcement of management plans	• General public • Private boat owners • Export industries • Costal managers	• Reduced wild stocks • Local extinctions (e.g. giant clams) • Reduced biodiversity • Reduced reproductive viability of stocks (i.e. recruitment over fishing)	• Loss of fishery livelihoods • Reduced future fishing potential • Loss of amenity value of reefs (e.g. diving/snorkelling)	• Continue community fishery management • Enforce fishery management plans • Expand MPA network / enforce “no-take” status • Introduce fishery entrance controls • Develop alternative protein sources (e.g. mariculture)	H

Threat (harmful activity)	Root causes	Impactors	Direct impact to coastal resources	Indirect and other consequences	Potential solutions	Priority
Oil and waste spill in Pago Harbour and elsewhere	• Insufficient risk assessment and safety procedures • Accidents / carelessness • Lack of enforcement	• Shipping companies and boat owners • Port authorities	• Reduced water quality • Wildlife kills (birds, fish and invertebrates) • Habitat loss	• Closure of beaches / loss of recreation • Loss of food sources	• Enforce regulations • Mandatory checks on vessels using Territorial waters	H
Coral Bleaching	• Climate Change and resulting water temperature increases	• Global populations emitting greenhouse gases	• Reduction in coral cover and potential death of particular sections of reef	• Loss of coral benefits	• International commitment to reduce greenhouse gases	M
Dumping/ or Improper waste disposal (solid & chemical)	• Insufficient incentive not to dispose of waste properly • Inadequate waste disposal facilities and landfill design • Poor choice of landfill sites	• Canneries, factories and businesses • Local residents	• Coral loss • Loss of bathing recreation value	• Reduced aesthetic appeal of coastal resources and mangrove sites • Human health costs (illness, lost work)	• Improve overall waste management • Establish fining system for illegal or irresponsible disposal • Improve enforcement	M
Hurricanes	• Natural phenomenon • Climate Change	• Global populations emitting greenhouse gases	• Habitat loss	• Loss of coral benefits	• International commitment to reduce greenhouse gases	M
Eutrophication /nutrient loading in Pago Harbour and elsewhere	• Not all houses connected to sewerage • Poorly built and maintained septic tanks	• Residents in watershed • Illegally built new houses • Piggery operators	• Damage to corals • Loss of bathing recreation value • Oxygen depletion leading to fish kills in Pago Pago harbour and elsewhere	• Algal blooms in water • Health impacts (illness, time off work, and medical costs)	• Connect all houses to adequate sewerage system • Maintain septic tanks in better condition • Better management of waste from piggeries	M in Pago Pago L elsewhere
Debris from marine sources	• Lack of harbour waste facilities • Laziness of boat users	• Boat users	• Loss of aesthetic appeal of beaches • Suffocation of corals • Killing of turtles & dolphins	• Loss of associated benefits	• International awareness campaign • Improved provision of harbour waste collection facilities	L
Alien species (e.g. from ballast water)	• Increased marine transport • Transfer and disposal of ballast waters between locations	• Shipping operators	• Competition with native species • Species and habitat loss	• Potential increase in marine organism diseases	• Impose tighter controls /regulation on disposal of ballast waters	L
Crown of thorns (COT) starfish predation	• Over collection of the slow growing triton mollusc (sole predator of COTs)	• Local and non-local collectors (mainly historical)	• Loss of coral cover	• Loss of coral benefits	• Ban all collection of the triton mollusc • COTs removal during outbreaks	L
Coral diseases	• Increased vulnerability of coral due to external stresses	• Stakeholders causing stress to reef	• Loss of corals	• Loss of coral benefits	• Implementation of coastal zone management • Enforce regulations	L

Table 4.2 Enhancement of coastal resource values in American Samoa.

Value enhancing actions	Underlying principle	Beneficiaries	Potential benefits	Possible adverse impacts	Priority
Integrated Coastal Zone Management	• Full co-ordination and co-operation between different bodies with coastal related roles and responsibilities. • Will facilitate implementation of appropriate coastal management principles and policies to enhance overall integrity of coastal resources.	• General public • tourists	• General maintenance and improvement of coastal resources	• Cost of implementation • Friction between government departments	H
Marine Protected Areas (MPAs)	• Full protection of coastal marine and terrestrial locations and creation of Marine Parks to allow the control of potentially damaging activities and visitor numbers.	• General public • tourists	• Habitat and species protection.	• Restriction of activities, sometimes considered traditional ones.	H
Community MPAs	• As above but involving community development and management.	• Local communities, • general public • tourists	• Community involvement and participation along with habitat and species protection.	• Few	H
Public/tourist awareness campaign	• Information provision to educate local population on the benefits provided by the coastal resources, the activities that impact on the resources and ways of avoiding those impacts.	• General public • tourists	• Awareness and education, ideally leading eventually to a reduction in damaging activities and their impacts.	• Few	H
Improve access to beaches (e.g. have signs welcoming visitors)	• Improved access will hopefully lead to an increased desire to maintain such site/locations.	• Beach users (public and tourists)	• Allows for the full appreciation of the available coastal resources.	• Increased access could lead to a reduction in the quality of the habitat and local way of life.	H
Improve provision of marine recreational facilities (e.g. beach showers) and equipment (e.g. snorkel rental)	• To encourage the use of the coastal areas and to allow for further interpretation of the resources present.	• Beach users (public and tourists)	• Encourages users to certain locations.	• As above. • Initial outlay and maintenance requirements.	H
Increase tourist numbers on the Islands	• Revenue generation for management of the coastal environment.	• General public • Government	• Potentially increase the prosperity of the island's economy.	• Potentially disturb the tranquillity of Manu'a. • Further social and cultural impacts	H
Improve provision of beachside cafés, bars and restaurants	• To encourage appreciation of the coastal environment by the general public.	• General public • tourists	• Creation of business and job opportunities increasing indirect use of the coastal environment.	• Coastal land take can cause indirect impacts to habitats and species.	M

Value enhancing actions	Underlying principle	Beneficiaries	Potential benefits	Possible adverse impacts	Priority
Improve information on marine activities (e.g. places to snorkel, dive, rent gear etc)	• If people are better informed, more will undertake the activity	• General public • tourists	• Improved snorkelling and diving benefits	• Too much use could damage sensitive locations	M
Improve efficiency of reef fishing	• Provide alternative livelihood opportunities and source of protein	• Residents • Fishermen	• Additional incomes and employment opportunities	• Uncontrolled use could result in a decline in fishery yields.	M
Develop mariculture	• Provide alternative livelihood opportunities and source of protein	• Residents • Fishermen	• Additional incomes and employment opportunities	• Introduction of disease from imported livestock	M
Clean up water quality in Pago Pago Harbour	• To allow for the improvement of the resources in this location and ensure that this area provides benefits in terms of use and non-use values.	• General public • tourists	• Improved habitat for reef species potentially leading to an increased harvesting • Improved recreational use	• Tackling the cause of the poor water quality will carry with it additional costs and restrictions on activities.	M
Create more value added marine products (e.g. arts and crafts using marine products)	• Conflict with other mgt option, such as MPAs, collection and trade of natural products??	• Local communities	• Revenue generation and promotion of 'cottage industries'	• Illegal/ damaging collection of live animals /plants could lead to population reductions.	L

5 Potential Future Coastal Resource Benefits

5.1 Introduction

This section provides an estimate of potential future coral reef and mangrove benefits in twenty-five years time. Benefits are described under two different coastal management scenarios, as follows:

1. **Business as usual (BAU) scenario.** This represents a continuation of current trends and impacts affecting coastal resource quality, benefits and values. Although the scenario recognises that significant efforts are being made to improve the management of island resources, it assumes a slight continued decline in coral and mangrove resources predominantly due to continued coastal development and lack of adequate regulation enforcement. It also assumes relatively limited eco-tourism development.

2. **Optimum sustainable management (OSM) scenario.** This scenario represents the potential values associated with an ideal situation. One that assumes that the current management initiatives and the other proposed mitigation and enhancement measures identified in Section 4 are fully implemented in an effective manner. Management actions therefore include those specific to the benefit in question (e.g. fisheries regulations or restrictions) and more generic coastal zone management actions (e.g. controlling coastal development and discharge of pollutants). It therefore assumes that corals and mangroves remain in reasonably good condition, and that eco-tourism becomes well developed.

The purpose of the two scenarios is to demonstrate the potential additional benefits that could accrue through a successfully implemented ICZM initiative. It must be recognised that due to the many complex issues at hand, the accuracy of the scenarios is poor. However, they indicate useful potential orders of magnitude of value.

Potential future benefits under the BAU and OSM scenarios are described below for the five major categories of benefit. Others potential types of benefit are also discussed briefly.

It is worth noting here that many of the benefits outlined in this section are influenced by future population increase. Population growth is high at around 2.1% (1990-2000), however, due to decline in fertility, employment opportunities (e.g. closure of the tuna cannery) and lack of available development land, rates are expected to slow down in the future. ASPA (2003) suggest a moderate rate of growth up until 2020, at which the population would reach 76,530. For the purposes of this study, population is assumed to be 80,000 and 70,000 under the BAU and OSM 25 year scenarios respectively (i.e. in 2029).

Significant changes in visitor numbers are also assumed under the different scenarios.

5.2 Coral Reefs

5.2.1 Direct fishery benefits

(a) Business as usual scenario

Subsistence fishery

Despite population growth, subsistence catches on Tutuila have declined at around 3.75% per annum over the last few decades, from around 300 tonnes/year in 1980 (Ponwith, 1991) to around 42 tonnes/year in 2003 (DMWR, 2003). This decline is principally due to a reduction in fishing effort associated with a number of fundamental societal changes on Tutuila, such as a steady shift towards a cash economy, less leisure time and different dietary preferences and consumer habits (Volk et al, 1992). No long-term catch data are available for the Manu'a islands, though the subsistence fishery clearly remains more important to the local way of life than on Tutuila. There is no indication that these trends will be reversed.

A decline in fish abundance may have contributed to the decline in catches, particularly as a result of historical over fishing (especially by the artisanal SCUBA fishery). Evidence to support this conclusion includes a decrease in mean and maximum size of species, absence of mature individuals and a possible decrease in CPUE (ASEPA, 2002). No concerns have been raised by Manu'a island residents about declining fish stocks (Craig, 2004. pers. comm.), however, other studies have shown similar decline in reef stocks there (e.g. Green, 1996).

As a result, stocks around Tutuila do not appear to be recovering as fast as one would expect given the reduction in fishing pressure (per unit area effort on Tutuila is some 15% of the average for the Pacific; Adams et al, 1996). A possible explanation for this is that recruitment over fishing has occurred, where the size of the adult stock has been reduced to a point where production of larvae and subsequent recruitment are impaired (Craig, 2004, pers. comm.). However, recruitment failure may also be occurring due to a range of other factors about which little is known (e.g. changes in currents affecting larval drift or surface temperatures affecting larval survival).

In addition, continuing damage to reefs by non-fishery factors may also be affecting stock recovery. Saucerman (1995) cites changes in the species mix and abundance of some non-fishery species as possible evidence. Human induced impacts such as habitat loss, pollution and sediment may be mitigated in some areas in the future (e.g. south shore Tutuila and harbour area). However, this is considered to be a far less significant factor than overall fishing effort.

Climate related phenomena such as hurricanes and coral bleaching events have had serious impacts on coral reef fisheries in the past (by reducing reef complexity and hence fisheries productivity) but are beyond the control of reef managers. Reefs do appear to have improved in status since the mid-1990s, however, it seems more likely that over the long-term increased frequency and severity of climate related impacts should be expected.

Prediction of future BAU scenario values based on the above is difficult. Climatic effects aside, if reef fishing effort continues to decline (subsistence and artisanal), stocks on Tutuila may begin to recover naturally over time. Although total catches will decline, fishers may gradually see greater personal benefits as CPUE increases. However, following any closure of the cannery a proportion of employees are likely to return to the collection of reef resources for subsistence and for sale (in the region of 20% of the 5000 employees are expected to remain on American Samoa and will have no other source of income). If the fishery is pushed further towards or eventually over MSY, CPUE will quickly decrease over the longer term, as will total catch. In this situation, without intervention to control fishing effort, the fishery may never recover.

Non-fishery factors aside, the BAU scenario assumes a continued decline in subsistence catches of 3.75% per annum, stabilisation of catches following cannery closure (due to increased effort) followed after 5 years by a decline in catches due to the continued trend to a cash economy of 0.05% per annum. Under this scenario, total annual catch may stabilize in the region of 16.5 tonnes/year (0.29 tonnes/km2/year). Total catch includes fish, invertebrates and palolo. Areas fished are assumed to remain the same as current (i.e. Tutuila, including Taema and Nafanua Banks, the Manu'a Islands and Swains Island).

Based on the above, at 2004 market prices adjusted to reflect "added value" and the multiplier effect as under the current scenario, the direct subsistence coral reef fishery under the BAU scenario is assumed to be worth around US$ 91,000/year.

Based on the above and the same assumptions as in the current scenario regarding per trip catch and consumer surplus, the subsistence consumer surplus under BAU is estimated to be around US$12,000/year.

Artisanal reef fishery

Although artisanal catches of reef fish and invertebrates have also declined over the last two decades, the proportion of people relying on the sale of reef resources for income is likely to increase following closure of the tuna cannery as people seek alternative incomes. However, since demand will probably continue to decline, changes in total catches are likely to be negligible.

As with the subsistence fishery, prediction of future values based on the BAU scenario are difficult due to the multitude of factors involved. Taking a precautionary approach, artisanal reef fishery values are therefore based on the current effort, with annual catches of 8.4 tonnes/year (0.14 tonnes/km^2/year). The ratio of lobster and fish in this catch is assumed to be the same as current. Areas fished are assumed to remain the same as current (i.e. Tutuila, including Taema and Nafanua Banks, and the Manu'a Islands).

Based on the above, at 2004 market prices adjusted to reflect "added value" and the multiplier effect, as under the current scenario, the direct artisanal coral reef fishery under the BAU scenario is assumed to be worth around US$ 44,000/year.

(b) Optimum sustainable management scenario

The subsistence and artisanal reef fisheries rely on the same resource base, and sustainable management efforts are therefore closely related in both cases and are thus discussed together below. ASCRAG (1999) concludes that tackling over-fishing is one of the key requirements for sustainable coral reef fishery management. Actions recommended were as follows:

- Maintain a network of marine protected areas to allow fish to recover, reproduce and reseed the over fished areas;

- Community-based fisheries management, whereby villages determine how they will manage their own catches;
- Monitoring the complete harvest of coral reef fish and invertebrates, and;
- Better enforcement of existing fisheries regulations.

Other sources note that nothing short of a territory-wide reduction in catches over a significant period is required to ensure long-term sustainability of resource exploitation (Craig. 2004, pers. comm.). Additional actions that would help to achieve this, include:

- Promoting other sources of fish for consumption (such as the by catch of pelagic fish that is discarded by the domestic long-line fleet)
- Prohibiting export of all coral reef products;
- Proactively strengthening territorial fisheries regulations to prevent the introduction of overly destructive types of fishing gear and entrance to the various fisheries, and;
- Better co-operation and data transfer between all Government and Non-Government Organisations in the Territory and in the rest of the US; and also with Regional bodies; the aim being towards achieving common aims

ASCRAG (1999) also emphasised that land-based activities can have a direct impact on coral reefs and their fisheries and that an integrated approach is required between land and water management. A phased recovery plan is required that includes actions such as:

- Control of coastal development (e.g. construction, seawalls, filling, dredging);
- Reducing sedimentation from land development, mining and tree removal, and;
- Better waste treatment/disposal practices to reduce pollution in the harbour.

Assuming maintenance of fishing effort below MSY and gradual recovery of yields, coral reefs could provide significant subsistence and artisanal reef fishery benefits under the OSM scenario. For instance, according to Ponwith (1991) American Samoa's reef could potentially provide yields of 4-5 tonnes/km^2/year of fish. Adams et al (1996) suggests that based on figures from Fiji, yields of at least 10 tonnes/km^2/year are sustainable (depending on the health of the reef). Adams & Dalzell (1993) reported that MSY for lobster was at about 20 kg/km of reef face in other Pacific Island countries. Note that achieving these benefits would take a considerable period (i.e. upwards of ten years).

Applying a precautionary approach as recommended by FAO (1995), a sustainable reef fishery in American Samoa yielding in the region of 4 tonnes/km^2/year is assumed under the OSM scenario. Based on the current ratios of subsistence to artisanal reef fish catches (85:15), catches would be around 196 tonnes/year (3.4 tonnes/km^2/year) and 33 tonnes/year (0.6 tonnes/km^2/year) respectively. Areas fished on both cases are assumed to be the same as in the BAU scenario. The ratio of fish to lobster in the artisanal catch is assumed to be the same as current (86:14).

Based on the above, and 2004 market prices adjusted to reflect "added value" and the multiplier effect, the total value of all direct coral reef related fisheries under the BAU scenario (including both direct subsistence and artisanal components) is assumed to be around US$ 1.25 million/year.

Based on the above and the same assumptions as in the current scenario regarding per trip catch and consumer surplus, total subsistence consumer surplus under the OSM would be in the region of US$ 137,000/year.

5.2.2 Indirect fishery benefits

(a) Business as usual

Although artisanal bottom fishing effort has been declining sharply over recent years, following closure of the cannery it is likely to expand again for a number of reasons. Firstly, the cannery is the main purchaser of locally caught Tuna and its closure is likely to force many locally owned boats in the long-line fleet to convert back to bottom fishing (probably the majority of the foreign owned or operated boats would merely move away). Secondly, there will be a much larger pool of available labour to crew the bottom fishing boats.

Nevertheless, based on the currently available data the bottom fish fishery is considered to be good status (DMWR, 2002) and capable of absorbing extra fishing effort. For instance, current catches are at around half of the MSY, estimated to be 35 tonnes/year by (WPRFMC, 2002). In 2002, the total catch was only 50% of this figure and over the last 15 years the maximum reached has been only 60% (in 2001). In addition, CPUE over the past five years has not been less than 50% of the average aggregate for the first three years of available data, and this year's is the highest since 1990 (WPRFMC, 2002).

Assuming the MSY estimate is an accurate reflection of reality, bottom fish catches could in theory be increased by as much as 100% (equivalent to another 14 boats) with no long-term deleterious effects. However, considering that the numbers of locally based long-liners is around 35 (DMWR, 2001 figures) and many of these are capable of returning to or entering the fishery should the cannery close there is a considerable chance that MSY will be exceeded.

Assuming two thirds of local long-liners (23) begin bottom fishing on closure of the cannery, the total number of bottom fishing boats would increase to 37, a fleet that may be expected to land catches of around 53 tonnes/year (0.25 tonnes/km^2/year), or 150% of MSY. However, if effort was maintained at this level over MSY for any length of time, there is a very high probability that catches would crash rapidly to a low residual rate, perhaps to 5 tonnes/year 4-5 years after closure. The reason for such a rapid decline is that bottom fish are exceedingly long-lived and very susceptible to over fishing. Bottom fishing is also not particularly profitable and even small changes in CPUE (certainly a 50% drop), would make it uneconomical to fish, not because there is no fish at all but because there is no profit to be made in chasing the remaining fish.

Under the BAU scenario, assuming that two-thirds of long-liners enter the fishery upon cannery closure, indirect reef benefits (i.e. reef associated bottom fish) may be in the region of 5 tonnes/year (0.02 tonnes/km^2/year). It is assumed that these benefits are derived from the same reef areas (i.e. Tutuila, Offshore Banks and the Manu'a Islands) at the same ratios as current.

Based on the above, and 2004 market prices adjusted to reflect "added value" and the multiplier effect, the indirect coral reef fishery under the BAU scenario is assumed to be worth in the region of US$ 21,000/year.

(b) Optimum sustainable management scenario

The bottom fishery may serve as a valuable alternative occupation for those who livelihoods now depend on the tuna fishery. However, due to the risk of a rapid and unsustainable increase in effort, management controls should be introduced now to ensure that the means and legislative reinforcement is in place should it be needed to alleviate pressure on bottom fish stocks. For instance, mechanisms could be introduced to control or restrict entry to the deep bottom reef fisheries, possibly by setting realistic transferable quotas and allocating them in an equitable way to those already operating (but not making them available to new entrants). This may have to be coupled with a generous subsidy for scrapping surplus domestic boats made inactive by the closure of the canneries. The licensing system would have to include a mechanism to spread effort over the whole group of islands, and not concentrate quotas or vessels on Tutuila, or in Pago Pago itself.

Nevertheless, the fishery does appear to be under-utilised at the current level of effort. Assuming the above management controls are implemented and entry to the bottom fishery is restricted, the OSM scenario assumes a total bottom fish catch of 28 tonnes/year (131 tonnes/km^2/year) based on a precautionary approach of 80% MSY, equivalent to an increase in fleet size by a further 5-6 boats. In terms of the proportion of this catch indirectly derived from reefs (85%), this equates to a total catch of 23.8 tonnes/year (111 tonnes/km^2/year). Again, it is assumed that these benefits derived from the same reef areas (i.e. Tutuila, Offshore Banks and the Manu'a Islands) at the same ratios as current.

Based on the above, and 2004 market prices adjusted to reflect "added value" and the multiplier effect, the total indirect coral reef fishery under the OSM scenario is assumed to be worth in the region of US$ 98,000/year.

5.2.3 Recreation and tourism

(a) Business as usual scenario

Under the BAU scenario tourism arrivals will continue to be constrained by accommodation availability (Tourism Task Force, 1994). Over the next 20 years bed provision is likely to double resulting from an increase of around 3% per annum (DOC, 2004). This also concurs with ASPA's prediction of there being around 600 beds by 2020 (ASPA 2003). Based on the likelihood that there will be no change in the level of provision of airline services (e.g. see ASPA, 2003), tourist arrivals are simply assumed to double to 12,000 per year. Cruise ship visitors are assumed to remain the same at 10,000 per year. The number of business visitors and relatives is assumed to increase one and a half times to around 57,000 per year.

The proportion of visitors undertaking coral reef related recreation (snorkelling and diving) is unlikely to change significantly given the current trend of negligible promotion of the activity and investment in facilities.

Coral reef related recreation amongst local residents is assumed to double under the BAU scenario. This is due to a gradual increase in public interest in coral reefs and improved access to coral reefs (e.g. due to some improvements to water quality in the harbour).

The magnitude and quality of visitor and resident recreational benefits are likely to continue to be affected by environmental degradation under the BAU scenario, particularly due over fishing, beach erosion, water pollution and litter. Numbers of resident water users will continue to be restricted by the limited proportion of able swimmers.

Snorkelling

The number of visitor and resident snorkelling trips is assumed to double from current levels. Tutuila's south shore and Ofu Island (principally Ofu National park) are likely to remain the most popular sites due to ease of access, with a slight increase in use of Pago Pago harbour if water quality continues to improve. Consumer surplus and expenditure are assumed to remain constant for both visitors and locals.

The above assumptions result in BAU scenario estimates of total annual consumer surplus of US$ 93,000 and annual added value recreational expenditure of US$ 35,000.

Diving

Based on current trends, the proportion of visitors that dive during their trip is likely to remain small, perhaps tripling to say 90 dives a year. Most will be around Tutuila's north and south shores, though operators may begin to do a limited number of dives around Ofu and Olosega Islands.

Local resident diving activity is likely to remain predominantly amongst dive club members that own their own equipment. However, with the current increase in teaching of Scuba diving, the numbers of resident dives could easily double to around 900 per year. Consumer surplus and expenditure are assumed to remain constant for both visitors and locals.

These assumptions result in BAU scenario estimates of total annual consumer surplus of US$ 11,000 and added value expenditures of US$ 7,000.

(b) Optimum sustainable management scenario

In an ideal situation, American Samoa could successfully develop niche tourism markets such as historical, cultural and eco-tourism, and make the most of the cruise ship industry. Small-scale activities are more in keeping the aim of American Samoa to retain its rich Samoan culture and island life-style (fa'asamoa), as well as its natural resources. Eco-tourism initiatives could involve a significant marine-based element, including activities such as snorkeling, diving, sports fishing, and sightseeing in marine parks. Eco-tourism has been extremely successful in other Pacific Islands (e.g. Western Samoa).

Even a modest eco-tourism industry would require a considerable investment in the provision of sensitively designed small-scale accommodation. Visitors would require adequate facilities, equipment, training and organised trips to enable them to enjoy coral reef related activities. This would include transport to sites (e.g. by land and boat) and snorkel/dive training for the conditions in American Samoa. Good access to nearby shops and restaurants would also help to maximise expenditure into local economy. An appropriately designed international marketing campaign, perhaps coordinated with other US Pacific islands, would be essential to enable these islands to compete with others in the region. Assuming the current international terrorist situation continues, US visitors may be much more comfortable visiting American Samoa than other potential holiday destinations.

It is clearly difficult to accurately predict the total numbers of future visitors. For the purpose of this study it is assumed that annual tourist visitor numbers increase four-fold to 24,000 per year and cruise ship numbers increase one and a half times to 15,000 per year. Business and visiting relatives are assumed to double to a total of 76,000 per year.

The level of recreational use of reefs by local residents also has the potential to increase significantly but also requires investment in improving access for the general public. Management actions should concentrate on provision of training facilities for teaching swimming, snorkelling and diving, as well as enhancing the means and opportunity to use them (e.g. through subsidised courses for schools and clubs). In addition, the benefits of swimming, snorkelling and diving (i.e. recreation, education and health) need to be promoted at a national scale.

In addition, visitor and resident recreational values are also highly dependent on the quality of the coral resources, which under the OSM scenario are assumed to be reasonably well maintained.

Snorkeling

No studies have examined the carrying capacity of the islands for coral reef related recreation activities. However, based on information from key stakeholders it was assumed that the number of visitor and resident snorkels is increased to almost 25,000 per year (around seven and a half times the current number).

Most visitor and resident snorkels would be on Tutuila, including increased use of the north coast (with access through the NP) and Pago Pago Harbour (with improved water quality). The Manu'a islands may account for a larger proportion than currently as operators begin to service a small number of eco-tourism developments. If appropriate, a small number of trips could be run to Swains Island or Rose Atoll.

Average consumer surplus values are assumed to remain the same as current levels for residents and tourists. Expenditures are assumed to increase by 50% in all cases due to improved availability of facilities and services.

It is also assumed that 25% of the future tourist snorkeller visits may be specifically due to the presence of coral reefs on the islands, especially if promoted in the right way. Hence all their additional indirect expenditure in country, such as food and accommodation is assumed to be due to the corals. This could be around US$ 700/trip assuming 5 days spending US$ 140/day.

The above assumptions result in OSM scenario estimates of total annual consumer surplus of US$ 318,000 and recreational added value expenditure of US$ 361,000.

Diving

Visitor diving activity has the potential to increase significantly with appropriate investment in facilities, equipment and marketing. With two full-time dive operators, each taking 150 visitors on four trips per visit per year, the total number of visitor dives could be in the region of 1,200/year, a forty-fold increase.

With an increase in participation with PPYC dive activities and in the number of recreational boat owners, the total number of resident dives could be in the region of

1,800/year, a four-fold increase. American Samoans would account for a greater proportion of dives than current given adequate access to training.

As with snorkelling, most dives would be on Tutuila though access would improve in certain areas (e.g. Pago Pago) and other islands if appropriate (e.g. Manu'a islands, Swains Island and Rose Atoll).

Average consumer surplus values are assumed to remain constant for residents and tourists. Expenditures are assumed to remain the same as current on Tutuila, however, with new dive facilities and services on other islands, expenditures of around US$ 150 may be expected per visitor dive trip and US$ 100 for residents.

It is also assumed that 50 % of future tourist diving visits may be specifically due to the corals presence. Hence all their additional indirect expenditure in country, such as food and accommodation is assumed to be due to the corals. This could be around US$ 700/trip assuming 7 days spending US$ 100/day.

The above assumptions result in OSM scenario estimates of total annual consumer surplus of US$ 46,000 and added value expenditures of US$ 111,000.

5.2.4 Shoreline protection

(a) Business as usual scenario

Under current natural and management trends, overall quality of coral reefs may gradually decline, for example due to increased sedimentation, nutrient inputs and freshwater run-off. This would particularly be due to increased population growth and uncontrolled housing development in forested hillside areas. In addition, as outlined in Appendix F, sea levels are likely to rise (currently 1.78 mm/year), and there may be increasingly severe storms that result in reduced shoreline protection function of corals. Future costs of new shoreline protection schemes are assumed to increase by 30% above inflation as a result.

In order to focus on the value of corals in shoreline protection, beach mining of sand and rubble is assumed to have stopped completely.

Based on the assumptions for how much new shoreline protection is needed, and when existing schemes will need replacing (see Appendix D), the annual value of corals in 25 years time for delaying the need for shoreline protection costs may be in the order of US$ 440,000/year.

(b) Sustainable management scenario

Under improved management, the same sea level rise and storm intensity is assumed as the BAU, however, the condition of corals is assumed not to have got worse. This would be achieved by control and enforcement new developments and improving water quality and nutrient runoff. Again, it is assumed that sand and rubble mining has been stopped.

Based on the assumptions for how much new shoreline protection is needed, and when existing schemes will need replacing (see Appendix D), the annual coral reef shoreline protection function may be worth in the order of US$ 714,000 /year.

5.2.5 Non-use benefits

(a) Business as usual scenario

Assessing the changes in non-use values over time is extremely speculative because our understanding of non-use values is currently limited. However, it is worth noting a few possible changes that may affect the values.

In general, stakeholder populations are considered likely to increase over the next 25 years. As highlighted under the tourism section, visitor numbers (tourists, business and cruise visitors) are assumed to increase in total by 46%. The local population is assumed to increase to 80,000 residents, and the US population has been assumed to grow by 17%.

With respect to non-use values, on the one hand awareness and understanding of visitor, local resident and the US populations regarding American Samoan corals is likely to increase slowly over time. This is particularly the case with children being educated and informing their parents. However, on the other hand, the quality and condition of corals under the BAU is likely to fall. For the purposes of this study, average non-use values are thus assumed to increase by 25% under the BAU scenario.

Based on the above assumptions, the BAU scenario estimate of potential coral reef non-use value is around US$ 18 million/year.

(b) Optimum sustainable management scenario

Under the OSM scenario, tourist numbers are assumed to increase fourfold, cruise ship passengers by one and a half times, and relative and business visitor numbers are assumed to double. The local population is assumed to increase to only 70,000 residents, and the US population is assumed again to grow by 17%.

With respect to non-use values, there is assumed to be far greater emphasis on educating all visitors, local residents and even the general public in America with respect to the beauty and importance of coral reefs in American Samoa. In addition, the quality and condition of corals under the OSM is assumed to increase. For the purposes of this study, average non-use values are assumed to increase from current values by twofold for residents of American Samoa and fivefold for visitors and the US general public.

Based on these assumptions, total OSM scenario estimate of potential coral reef non-use value is assumed to be US$ 49 million per year.

5.2.6 Other quantified benefits

(a) Aquarium trade

(i) Business as usual scenario

There is currently a high value of aquarium fish, corals and “living rock” (a rock covered with coralline algae and invertebrate life such as anemones, sponges and tunicates), in the region of $500/kg, $7/kg and $2-$4/kilo respectively (see Wabnitz et al, 2003).

However, it is unlikely that the aquarium trade in America Samoa is likely to ever be viable due to current airfreight costs between American Samoa and the US, the main global market for aquarium ornamentals. In addition, there is a shortage of reef area suitable for collection. Most of the islands are surrounded by very narrow high wave energy reefs. Furthermore, there is intense market competition from the world biggest exporters of live fish; the Philippines and Indonesia.

To a lesser extent, the relatively low fish biodiversity in American Samoa also affects potential. However, note that Hawaii has far less fish species but has a viable industry predominantly based (78%) on a single species, the Yellow Tang (*Zebrasoma flavescens*). The trade there is estimated to be worth at least $1.8 million per year (Cesar et al, 2002).

In addition to the economic constraints, there are serious concerns about the harvest of both live coral and living rock, which has been blamed for considerable damage to the reefs in various areas such as Fiji and Tanzania where rugosity is seriously reduced. Collecting live corals is presently banned (since 2000) in American Samoa and it is unlikely that the DMWR would countenance permitting large scale coral or live rock collection from the wild for the aquarium trade (Mike King (DWMR), 2002, pers. comm.).

For the above reasons, it is assumed that likely future values under BAU will remain zero.

(ii) Optimum sustainable management scenario

For the reasons given above, it is also assumed under OSM that the aquarium trade value will remain zero. If a sustainable trade of any kind were to be developed, the value would probably be low, in the order of thousands of dollars at most.

(b) Mariculture

(i) Business as usual scenario

Lindsay (2001) assessed the potential for large mariculture enterprises in neighbouring Western Samoa and concluded that it was greatly inhibited by limited resources, economic potential and environmental concerns. The limitations imposed by lack of suitable development land, failure of community based management systems and economic constraints are even more acute in American Samoa.

American Samoa has attempted the production of giant clams for restocking of depleted wild stocks. However, attempts to form reproductive populations have not been successful as they are collected or stolen and eaten very quickly, being a delicacy in American Samoa. Until the social and management problems encountered in protecting the clam farms are overcome, it is unlikely under current circumstances that this type of mariculture will be successful in producing stocks suitable in size for either trade or consumption.

In addition, mariculture can be used to produce organisms for food or the aquarium trade. A number of NGOs in American Samoa are interested in the latter, including production of giant clams, corals and live rock for export. However, facilities have not yet been constructed, and the sources of supply of brood stock or imported supplies of seed stock for either clams or corals are not identified. Moreover, no market surveys have recently been done and there is a possibility that markets may be much smaller than envisaged, or that American Samoa has no competitive advantage over other sources of supply (e.g. other Pacific Island countries and Asia).

Overall, mariculture industries in American Samoa are expected to be at best of small scale. Values under the BAU scenario are thus assumed to be at most in the order of a few thousands of dollars.

However, despite the problems with establishing viable mariculture for restocking, such programmes can give rise to indirect benefits related to raising awareness of the marine environment. They can be used to initiate or boost the implementation and enhancement of MPA networks and traditional community based management systems (such as those presently being established in American Samoa). In other Pacific Islands, establishment of clam gardens, reseeding of reefs or the release of new commercial species have all proved to be very effective in raising awareness (Johannes & Hickey, 2002).

(ii) Optimum sustainable management scenario

If appropriate research, investment and management were in place, there is scope for developing a mariculture industry. The most significant potential in terms of commercial mariculture lies in on-growing and/or culture of larval fish, live corals, living rock and giant clams for the aquarium trade. Potential values are difficult to estimate, though examples are discussed briefly here.

Values for on-growing of larval aquarium fish is impossible to estimate at this stage, because the parameters of this type of enterprise: what species are suitable; what suitable species are available in American Samoa; production costs; and future values of cultured species are unknown. Culturing wild caught larvae for the aquarium trade is a nascent industry; and future research will prove its viability.

For clams and live rock, it may be possible to produce at least 10,000 aquarium sized giant clams per year in a hatchery and up to 20 tonnes of coral and “live rock”, if appropriate grow-out sites can be identified. Based on current values (clams for the aquarium are valued at about US$ 7 each and live corals and “living rock” at about US$ 5 a kilo), this gives a potential gross value of $70,000/year for giant clams and US$ 100,000/year for live corals.

Based on the above, total gross values of mariculture under the OSM scenario could potentially be in the order of a few hundred thousand US$.

5.3 Mangroves

5.3.1 General trends

The **BAU scenario** assumes that the mangroves will continue to decrease in area by 0.7% per year (i.e. a 17% loss over 25 years), based on Volk et al (1992) and ASEPA (2002). This gives 0.38 km^2 for Pala Lagoon and 0.02 km^2 for Leone mangroves. The population and visitor numbers are assumed to be the same as for the coral reef scenarios.

The **OSM scenario** assumes that the mangroves will be restored to their 1991 levels through mangrove restoration activities and that no more are lost (i.e. increase in area of 10% compared to 2004 areas) based on Volk et al (1992). This gives 0.5km^2 for Pala and 0.03km^2 for Leone mangroves. The population and visitor numbers are assumed to be the same as for the coral reef scenarios.

5.3.2 Direct fisheries benefits

The **BAU scenario** assumes that direct fishery catch from Pala lagoon will decline from current levels by 17% due to loss of mangrove habitat and by a further 60% (76% in total) due to changes in population and the level of dependence on subsistence fisheries (as was assumed for the direct subsistence coral reef fishery). Catch value is calculated in the same was as under the current scenario (e.g. same catch composition, market values, subsistence added value adjustment factor and subsistence expenditure multiplier). Consumer surplus assumptions remain the same as for the coral subsistence fishery (i.e. consumer surplus of US$ 1.40/trip and catch per trip of 2kg/trip).

Based on these assumptions, the BAU direct mangrove fishery product added value (including expenditure multiplier effect) is assumed to be US$ 17,000/year and the consumer surplus is just over US$ 2,000/year.

The **OSM scenario** does not assume an increase in catch over the current (since there are no data on maximum sustainable yield of the fishery) but is estimated based on an overall increase in yield pro rata with the 10% increase in area of mangrove habitat.

Based on these assumptions, the OSM direct fishery product added value (including expenditure multiplier effect) is assumed to be US$ 32,000 per year and the consumer surplus is US$ 4,000/year.

5.3.3 Indirect fisheries benefits

The **BAU and OSM mangrove scenarios** have the same assumptions regarding percentage (5%) of Tutuila's direct reef catches attributable to mangroves, market prices, subsistence added value adjustment factor and subsistence expenditure multiplier. The total catches used relate to the equivalent future direct coral reef fishery scenarios.

Based on the above, the total indirect fishery product values are estimated to be in the region of US$ 3,000/year and US$ 26,000/year under the BAU and the OSM scenarios respectively.

5.3.4 Shoreline protection benefits

The BAU scenario assumes a decrease in length of the shoreline protection function provided by the mangroves in Pala of 17%, with the OSM scenario assuming a 10% increase in length. No such protection function is assumed in Leone.

This gives a shoreline protection function value of around US$ 113,000/year and US$ 149,000/year under the BAU and OSM scenarios respectively.

5.3.5 Recreation and tourism benefits

Due to their limited extent, there is relatively little potential to increase the future recreation/tourism values of mangroves. However, with appropriate facilities on site (e.g. information boards and boardwalks) and cleanup of the areas, there is potential to develop small-scale guided visits by foot and or canoe. This may be part of an overall special tour of the island or part of the island.

Under the **BAU scenario**, it is assumed that 120 visits per year are made (83% in Pala Lagoon), with a consumer surplus of US$ 4 per trip and associated expenditure of US$ 10 per trip. This gives a total consumer surplus value of around US$ 480/year and gross expenditure added value of around US$ 1,200/year.

Under the **OSM scenario**, it is assumed that 2,400 visits per year are made, with the same other assumptions as above. This gives a total consumer surplus value of around US$ 10,000/year and gross expenditure added value of US$ 24,000/year.

As for coral reef related recreation, expenditure added values are actual expenditures, less 75% costs (for the tourism sector) and include a 1.25 multiplier.

5.3.6 Non-use benefits

Under the BAU and OSM scenarios, the same predicted change in population numbers (US population, visitors and residents) is used as in the equivalent coral reef future scenarios. The mangrove non-use WTP values are assumed to be 17.6% of the coral reef values (based on the same assumptions for the ratio of mangrove to coral reef non-use value as in the current scenario).

Based on these assumptions, the total non-use value for mangroves is estimated to be around US$ 3.2 million/year under the BAU scenario and US$ 8.7 million/year under the OSM. These are clearly very high ballpark values that predominantly comprise US population values.

6 Economic valuation model results

6.1 Introduction

This section draws upon the valuations of the various benefits developed in Sections 3 and 5 to provide a summary of current and potential future coral reef and mangrove values.

Coral reef and mangrove values are summarised and discussed in terms of both annual and present values. Annual values are converted to present day values by capitalizing the value over 100 years using a discount rate of 3% (equivalent to multiplying by a factor of 31.6).

6.2 Breakdown of current values by type and location

6.2.1 Summary

The coral reefs and mangroves of American Samoa both provide significant benefits to the territory and mainland US. In total, the value of all benefits identified is estimated to be in the order of US$ 6 million/year or US$ 190 million in terms of present value for residents and visitors to American Samoa. When the US general public non-use values are included, the values may be around US$ 11.5 million/year and US$ 365 million in terms of present value. Section 6.3 highlights how the key values vary between stakeholder groups.

However, the spatial economic model approach revealed that the magnitude of coral reef benefits is highly location specific, not only between region, but within each region.

Coral reef and mangrove values are presented by type and location for the current scenario in Boxes 6.1 and 6.2 respectively. The relative significance and spatial distribution of current coral reef benefits is also shown on maps in Section 3 (Figures 3.1 to 3.10). Further detailed calculations for both current and future values are provided in Appendix F.

6.2.2 Coral reefs

Box 6.1 overleaf highlights that coral reefs are estimated to currently be worth in the region of US$ 10 million/year (US$ 318 million in terms of PV). With an estimated 222km^2 of reefs in American Samoa, per unit area this value equates to an average of US$ 45,000/km^2/year or, in terms of PV, US$ 1.4 million/km^2 (US$ 1.43/m^2).

Coral reef values are dominated by non-use benefits at around US$ 8.8 million/year (87%). Around 8% of coral reef values relate to direct uses and 5% to indirect uses.

The largest proportion of this value (35%) may be accrued in the form of non-use values from the remote coral reefs of Rose Atoll (a total of around US$ 3.5 million/year or US$ 535,000/km^2/year). Tutuila and on Ofu and Olosega Islands also potentially provide considerable total non-use values. However, even those areas with the highest non-use value per unit area (e.g. north shore Tutuila) provides only around a quarter of this value.

Box 6.1

Current coral reef annual values (US$/yr)

Location	Use values								Non-use values				Total value	% of total
	Subsistence fishery		Artisanal fishery											
	Direct fishery added value (+multiplier effect)	Fishing consumer surplus	Direct fishery added value (+multiplier effect)	Indirect fishery added value (+multiplier effect)	Snorkelling / diving consumer surplus	Snorkelling / diving expenditure added value (+multiplier effect)	Shoreline protection value	Total use value	Resident non-use value	Visitor non-use value	US general public non-use value	Total non-use value		
Tutuila south shore	202,970	25,850	15,846	13,564	32,985	5,770	307,997	604,983	477,924	28,653	657,339	1,163,917	1,768,900	17.6
Pago Pago Harbour	-	-	-	418	2,160	523	9,556	12,658	1,846	111	2,539	4,495	17,153	0.2
Tutuila north shore	19,970	2,543	1,559	6,224	2,955	1,363	75,005	109,619	446,571	26,773	614,216	1,087,561	1,197,180	11.9
Aunu'u and inshore banks[1]	5,412	689	422	4,993	-	-	-	11,517	183,308	10,990	252,123	446,421	457,938	4.5
All Tutuila	228,352	29,083	17,827	25,200	38,100	7,656	392,559	738,777	1,109,649	66,527	1,526,217	2,702,393	3,441,171	34.2
Ofu & Olosega Islands	243,824	31,053	19,035	16,800	12,000	15,625	35,116	373,453	475,094	28,483	653,446	1,157,023	1,530,476	15.2
Ta'u Island	92,837	11,824	7,248	3,500	-	-	19,326	134,734	176,326	10,571	242,520	429,417	564,152	5.6
All Manu'a	336,660	42,877	26,283	20,300	12,000	15,625	54,442	508,187	651,420	39,055	895,966	1,586,440	2,094,628	20.8
Swains Island	6,595	840	-	-	-	-	-	7,435	45,792	2,745	62,983	111,520	118,955	1.2
Rose Atoll	-	-	-	-	-	-	-	-	1,454,805	87,220	2,000,945	3,542,971	3,542,971	35.2
Offshore banks[2]	-	-	-	24,500	-	-	-	24,500	347,454	20,831	477,889	846,174	870,674	8.6
All other areas	6,595	840	-	24,500	-	-	-	31,936	1,848,051	110,796	2,541,817	4,500,665	4,532,600	45.0
All American Samoa	571,607	72,800	44,111	70,000	50,100	23,281	447,001	1,278,900	3,609,120	216,378	4,964,000	8,789,498	10,068,399	100.0
% of total	5.7	0.7	0.4	0.7	0.5	0.2	4.4	12.7	35.8	2.1	49.3	87.3	100.0	-

Note: 1 - includes Taema and Nafanua banks.
2 - includes South, and East Banks.

Current coral reef present values (US$/m^2; 3%)

Location	Use values								Non-use values				Total value
	Subsistence fishery		Artisanal fishery										
	Direct fishery added value (+multiplier effect)	Fishing consumer surplus	Direct fishery added value (+multiplier effect)	Indirect fishery added value (+multiplier effect)	Snorkelling / diving consumer surplus	Snorkelling / diving expenditure added value (+multiplier effect)	Shoreline protection value	Total use value	Resident non-use value	Visitor non-use value	US general public non-use value	Total non-use value	
Tutuila south shore	0.35	0.04	0.03	0.02	0.06	0.01	0.53	1.04	0.83	0.05	1.14	2.01	3.06
Pago Pago Harbour	-	-	-	0.02	0.08	0.02	0.36	0.48	0.07	0.004	0.10	0.17	0.65
Tutuila north shore	0.07	0.01	0.01	0.02	0.01	0.005	0.27	0.40	1.62	0.10	2.23	3.94	4.34
Aunu'u and inshore banks[1]	0.02	0.003	0.002	0.02	-	-	-	0.04	0.69	0.04	0.96	1.69	1.73
All Tutuila	0.20	0.03	0.02	0.02	0.03	0.004	0.34	0.64	0.97	0.06	1.33	2.36	3.00
Ofu & Olosega Islands	0.69	0.09	0.05	0.05	0.03	0.04	0.10	1.05	1.34	0.08	1.84	3.26	4.31
Ta'u Island	0.37	0.05	0.03	0.01	-	-	0.08	0.53	0.69	0.04	0.96	1.69	2.22
All Manu'a	0.55	0.07	0.04	0.03	0.02	0.03	0.09	0.83	1.07	0.06	1.47	2.61	3.44
Swains Island	0.10	0.01	-	-	-	-	-	0.11	0.69	0.04	0.96	1.69	1.80
Rose Atoll	-	-	-	-	-	-	-	-	6.94	0.42	9.55	16.91	16.91
Offshore banks[2]	-	-	-	0.005	-	-	-	0.005	0.07	0.004	0.10	0.17	0.17
All other areas	0.001	0.0002	-	0.005	-	-	-	0.01	0.35	0.02	0.48	0.85	0.86
All American Samoa	0.08	0.01	0.01	0.01	0.01	0.003	0.06	0.18	0.51	0.03	0.71	1.25	1.43

Note: 1 includes Taema and Nafanua banks.
2 includes South, and East Banks.

Box 6.2

Current mangrove annual values (US$/yr)

Location	Use values							Non-use values[1]				Total value	% of total
	Subsistence fishery		Artisanal & subsistence fishery										
	Direct fishery added value (+multiplier effect)	Fishing consumer surplus	Indirect fishery added value (+multiplier effect)[2]	Recreation consumer surplus	Recreation expenditure added value (+multiplier effect)	Shoreline protection value	Total use value	Resident non-use value	Visitor non-use value	US general public non-use value	Total non-use value		
Pala lagoon	27,554	3,518	11,973	-	-	135,014	178,058	514,300	30,834	707,370	1,252,504	1,430,561	95.5
Leone	1,450	185	630	-	-	-	2,265	27,068	1,623	37,230	65,921	68,186	4.5
All mangroves	29,004	3,703	12,603	-	-	135,014	180,323	541,368	32,457	744,600	1,318,425	1,498,748	100.0
% of total	1.9	0.2	0.8	-	-	9.0	12.0	36.1	2.2	49.7	88.0	100.0	-

Note: 1 - Relative proportions for each stakeholder group based on coral reef non-use calculations.
2 - Direct coral reef fishery component - value also accounted for under coral reef summary.

Current mangrove present values (US$/m^2; 3%)

Location	Use values							Non-use values[1]				Total value
	Subsistence fishery		Artisanal & subsistence fishery									
	Direct fishery added value (+multiplier effect)	Fishing consumer surplus	Indirect fishery added value (+multiplier effect)[2]	Recreation consumer surplus	Recreation expenditure added value (incl. multiplier effect)	Shoreline protection value	Total use value	Resident non-use value	Visitor non-use value	US general public non-use value	Total non-use value	
Pala lagoon	1.91	0.24	0.83	-	-	9.36	12.34	35.64	2.14	49.02	86.80	99.14
Leone	1.91	0.24	0.83	-	-	-	2.98	35.64	2.14	49.02	86.80	89.78
All mangroves	1.91	0.24	0.83	-	-	8.89	11.87	35.64	2.14	49.02	86.80	98.67

Note: 1 - Relative proportions for each stakeholder group based on coral reef non-use calculations.
2 - Direct coral reef fishery component - value also accounted for under coral reef summary.

Direct fishery added value and indirect shoreline protection benefits are by far the most important use values accounting collectively for almost 80% of the total use value at around US$ 1 million/year (US$ 5,000/km^2/year). Other fishery benefits (i.e. fishing consumer surplus and indirect bottom-fishery added values) and recreational values account for relatively minor proportions.

Ofu and Olosega Islands provide the greatest proportion of total direct fishery added value at around US$ 244,000/year (US$ 22,000/km^2/year, the largest per unit area value for any single reef use benefit across the Territory). Tutuila's south shore provides a similar total value (US$ 203,000), but only half the value per unit area.

The reefs on the offshore banks were estimated to provide around the same total level of indirect fishery added value (worth around US$ 25,000/year) to the whole of Tutuila, though with a relatively low per unit area value due to their larger extent.

Shoreline protection represents around a third of all use values in American Samoa at US$ 447,000 /year (US$ 2,000/km^2/year). Due to the concentration of settlements and amount of shoreline infrastructure, the reefs along the south shore of Tutuila account for the vast majority of shoreline protection values, totalling around US$ 308,000 per annum (US$ 17,000/km^2/year).

At a more site-specific level (see Appendix D and Figure 3.7), the high-risk area of coral reef on south Tutuila (11.5 km^2) is worth US$ 27,000/km^2/year for coast erosion. Note that Cesar (1996) estimated a high shoreline protection function value of US$ 550,000/km^2 for Indonesia, or US$ 60,000 /km^2/year. Notably, the reefs of Pago Pago Harbour provide a similar value per unit area, mainly due to the protection they provide to key coastal infrastructure. The north shore of Tutuila is also important for shoreline protection, providing around US$ 75,000 /year (US$ 9,000/km^2/year, around half of that on the south shore).

For instance, values were orders of magnitude higher for reefs with better access and hence higher recreational use (e.g. Fagatele National Marine Sanctuary and Alega Beach). Overall, coral reef recreational snorkelling expenditure value showed the highest elevation above mean at around 130 times the territory average at US$ 14,000/km^2/year for the corals in Ofu Lagoon compared to US$ 92/km^2/year for all reefs (see Appendix D). To a lesser extent, reef value was also significantly higher in areas with (a) high coral rugosity (complexity of structure) and hence higher fishery productivity (e.g. parts of the south shore of Tutuila), and (c) provide locally significant coastal protection benefits to valuable and erosion prone coastline (e.g. parts of the north and south shores of Tutuila).

6.2.3 Mangroves

As can be seen in Box 6.2, mangroves are estimated to be currently worth in the region of US$ 1.5 million/year (US$ 47 million in terms of PV). With around 0.48 km^2 of mangrove habitat remaining on American Samoa, this equates to around US$ 3.1 million/km^2 or, in terms of PV, US$ 99 million/km^2 (US$ 99m^2). Almost all of this value is derived from the stand in Pala lagoon (around 95%).

Like corals, the vast majority of mangrove values (around 88%) are derived in the form of non-uses at a total of US$ 1.3 million/year. Around 2% of values relate to direct uses and 10% to indirect uses.

Provision of coast and flood protection benefits is the most significant use value provided by mangroves at a total of US$ 135,000/year. This represents around 75%

of total use values and equates to around US$ 296,000/km^2/year. All of this benefit is provided by Pala Lagoon mangrove, the stand at Leone being fully protected from open water.

Direct fishery product values are the next most important benefit generating around US$ 29,000/year in total. Fishery consumer surplus and indirect fishery product values (e.g. enhancement of other fisheries elsewhere through export of recruits) are comparatively small.

6.3 Breakdown of current results by stakeholder group

Tables 6.1 and 6.2 summarise coral reef values by stakeholder group respectively. It can be seen that 50% of coral reef and mangrove values accrue to residents of American Samoa, equivalent to US$ 4.9 million/year and US$ 0.7 million/year respectively. Around 75% of resident coral reef and mangrove values are related to non-uses, which partly capture traditional and social values.

However, of particular significance for local communities are coral reef subsistence fishery catches (worth US$ 0.6 million/year), shoreline protection services (US$ 0.5 million/year) and subsistence consumer surplus, which represents part of the way of life (US$ 73,000/year). The US public could be deriving just under half of total coral reef value solely in the form of non-use values at around US$ 5 million/year.

***Table 6.1** Current coral reef annual values (US$/year)*

Type of benefit		Residents	Visitors	US public	Total
Use benefits	Direct subsistence fishery products	572,000	-	-	572,000
	Direct artisanal fishery products	44,000	-	-	44,000
	Direct subsistence fishing CS[1]	73,000	-	-	73,000
	Direct snorkelling/diving CS[1]	38,000	12,000	-	50,000
	Direct snorkel/dive expenditure[2]	17,000	7,000	-	23,000
	Indirect artisanal fishery products[3]	70,000	-	-	70,000
	Indirect shoreline protection	447,000	-	-	447,000
Non-use benefits		3,598,000	216,000	4,964,000	8,778,000
Total benefits		4,858,000	235,000	4,964,000	10,057,000

Note: 1 CS = Consumer Surplus
2 Visitor expenditures are actually a cost to visitors and a benefit to local businesses/residents
3 Offshore reef-associated bottomfish.

***Table 6.2** Current mangrove annual values (US$/year)*

Type of benefit		Residents	Visitors	US public	Total
Use benefits	Direct subsistence fishery products	29,000	-	-	29,000
	Direct subsistence fishing CS[1]	4,000	-	-	4,000
	Indirect fishery products[2]	13,000	-	-	13,000
	Indirect shoreline protection	135,000	-	-	13,5000
Non-use benefits		541,000	32,000	745,000	1,318,000
Total benefits		722,000	32,000	745,000	1,499,000

Note: 1 CS = Consumer Surplus
2 Component of the direct coral reef fishery (accounted for in Table 1)

Tables 6.3 and 6.4 below show the extent to which the annual values per year and per m^2 vary depending upon which values are included.

Table 6.3 Cumulative values associated with American Samoa's coral reefs

Value	Cumulative annual value (US$/yr)	Cumulative total PV (US$; 3%)	Cumulative annual value per unit area (US$/yr/$m^2$)	Cumulative PV per unit area (US$/$m^2$; 3%)
Resident direct use value	762,000	24,076,000	0.003	0.11
Above + resident indirect use value	1,279,000	40,413,000	0.006	0.18
Above + resident non-use value	4,877,000	154,101,000	0.022	0.69
Above + visitor non-use value	5,093,000	160,939,000	0.023	0.72
Above + US general public non-use value	10,057,000	317,801,000	0.045	1.43

Table 6.4 Cumulative values associated with American Samoa's mangroves

Value	Cumulative annual value (US$/yr)	Cumulative total PV (US$; 3%)	Cumulative annual value per unit area (US$/yr/$m^2$)	Cumulative PV per unit area (US$/$m^2$; 3%)
Resident direct use value	33,000	1,034,000	0.07	2.15
Above + resident indirect use value	180,000	5,698,000	0.38	11.87
Above + resident non-use value	721,691	22,805,440	1.50	47.51
Above + visitor non-use value	754,148	23,831,072	1.57	49.65
Above + US general public non-use value	1,499,000	47,360,000	3.12	98.67

6.4 Future coral reef and mangrove values

6.4.1 Summary

Under the BAU scenario, total coral reef and mangrove non-use value increases relative to the current scenario whilst total use value decreases (see Boxes 6.3 and 6.5). The net effect is an increase in the overall annual value to around US$ 22.2 million per year (up by around 92% over current value). The main reasons for this are that non-use values are far larger than use values and the population of non-users is expected to grow significantly over the next 25 years particularly in the US (perhaps by around 111% overall). However, for American Samoan residents and visitors to the islands, the more significant change under the BAU scenario is the expected significant decline in annual coral reef and mangrove use values to around US$ 0.9 million collectively (a reduction of around 39% below current value).

Under the OSM scenario, the total annual coral reef and mangrove values are estimated to be significantly higher than at present at a total around US$ 61 million; up by around 430% over current value (see Boxes 6.4 and 6.6). Again this change is driven strongly by increased non-use value (which increases to around US$ 58 million/year, up by 474%), due in this case to both population growth and enhanced individual non-use value (associated with greater awareness of conservation issues). However, most significantly for residents and visitors, total annual use value increases dramatically under the OSM scenario to just under US$ 3.3 million (an increase of around 124% over current levels).

6.4.2 Coral reefs

(a) BAU scenario

As seen in Box 6.3, under the BAU scenario, coral reef value is estimated to increase to around US$ 19 million (up 88% on current levels). Non-uses would be expected to still account for the vast majority of this figure at just over US$ 18 million/year.

Snorkelling and diving related recreation benefits are the only type of use benefit to increase in value under the BAU scenario. However, in absolute terms the number of people deriving these benefits is likely to remain small and hence total recreational value still only accounts for 19% of all use value (US$ 147,000).

Most significantly for local residents, the total value of direct and indirect fisheries benefits is reduced to under a quarter of its current level to a total of US$ 167,000/year. By far the largest change is in the 84% reduction in direct subsistence catches and related consumer surplus, to a total of US$ 91,000/year and US$ 12,000/year respectively. As a result, per unit area values decrease by an order of magnitude in both cases. Indirect fishery values are also reduced by 70% to around US$ 21,000/year (US$ 93km^2/year).

Coral reef shoreline protection value decreases slightly due to the expected general decline in coral status due to coastal development, runoff and global warming. Note, however that, due to the significant decreases in fishery benefits under the BAU scenario, shoreline protection becomes by far the most significant of all use values accounting for 58% of the total (US$ 440,000, around US$ 2,000/km^2/year).

(b) OSM scenario

As seen in Box 6.4, under the OSM scenario, total coral reef value is estimated to increase to around US$ 52 million (up 461% over current levels). Non-use value may be expected to account for around US$ 49 million/year of this value, reaching per unit area values of as much as US$ 3 million/km^2/year (Rose Atoll).

Use values are expected to increase significantly under the OSM scenario (up 137% to a total of US$ 3 million/year). The most important are expected to be recreation values, particularly recreation related expenditure and direct fishery product added values, which could be expected to reach in the region of US$ 472 million/year and US$ 1.1 million/year respectively. The former represents a 2000% increase over current levels, indicating the significant potential for enhanced tourism related benefits.

Shoreline protection value is also expected to increase to over US$ 700,000 (up 60% over current levels), the greatest proportion of which is provided by reefs along Tutuila's south shore.

6.4.3 Mangroves

(a) BAU scenario

As seen in Box 6.5, under the BAU scenario, mangroves are estimated to increase in value to around US$ 3.3 million/year (an increase of 123% over current levels). As with coral reefs, this is primarily due to an increase in non-use values since use values are expected to decrease overall.

Due to a continued reduction in the importance of subsistence fisheries and continued loss of mangrove habitat, direct fishery product added value, consumer surplus and indirect fishery support added value are all expected to decrease (by around 41-76% each). Shoreline protection value is likely to be reduced by a smaller degree, but will account for the vast majority of use values at around US$ 113,000/year (83% of the total).

Mangroves may begin to provide some limited recreational use benefits under the BAU scenario, though probably still only accounting for less than a few thousand US$/year.

(b) OSM scenario

As seen in Box 6.6, under the OSM scenario, mangroves are estimated to increase in value to around US$ 9 million/year (an increase of 496% over current levels). Again, trends are similar to coral reefs, with continued increases in both non-use and use values of 560% and 27% respectively.

Direct fishery benefits (product added values and consumer surplus) are likely to see considerable increase as mangrove area increases, perhaps accounting for around 16% of total use values, a total of US$ 36,000/year.

Box 6.3

Future coral reef annual values (US$/yr) - BAU scenario

Location	Use values								Non-use values					
	Subsistence fishery		Artisanal fishery											
	Direct fishery added value (+multiplier effect)	Fishing consumer surplus	Direct fishery added value (+multiplier effect)	Indirect fishery added value (+multiplier effect)	Snorkelling / diving consumer surplus	Snorkelling / diving expenditure added value (+multiplier effect)	Shoreline protection value	Total use value	Resident non-use value	Visitor non-use value	US general public non-use value	Total non-use value	Total value	% of total
Tutuila south shore	32,293	4,113	15,846	4,004	64,320	12,297	294,749	427,621	1,385,069	55,900	959,947	2,400,916	2,828,537	15.0
Pago Pago Harbour	-	-	-	123	13,302	3,074	12,737	29,237	5,349	216	3,707	9,272	38,509	0.2
Tutuila north shore	3,177	405	1,559	1,837	7,320	3,153	79,804	97,255	1,294,205	52,233	896,972	2,243,409	2,340,664	12.4
Aunu'u and inshore banks[1]	861	110	422	1,474	858	187	-	3,912	531,244	21,440	368,188	920,872	924,784	4.9
All Tutuila	36,331	4,627	17,827	7,439	85,800	18,711	387,290	558,026	3,215,867	129,789	2,228,814	5,574,469	6,132,495	32.5
Ofu & Olosega Islands	38,793	4,941	19,035	4,959	18,040	23,555	35,888	145,211	1,376,866	55,569	954,261	2,386,695	2,531,906	13.4
Ta'u Island	14,771	1,881	7,248	1,033	360	469	16,769	42,531	511,010	20,624	354,164	885,798	928,329	4.9
All Manu'a	53,564	6,822	26,283	5,992	18,400	24,023	52,657	187,742	1,887,875	76,193	1,308,425	3,272,493	3,460,235	18.3
Swains Island	1,049	134	-	-	-	-	-	1,183	132,709	5,356	91,977	230,042	231,225	1.2
Rose Atoll	-	-	-	-	-	-	-	-	4,216,160	170,159	2,922,084	7,308,404	7,308,404	38.7
Offshore banks[2]	-	-	-	7,232	-	-	-	7,232	1,006,953	40,639	697,887	1,745,480	1,752,711	9.3
All other areas	1,049	134	-	7,232	-	-	-	8,415	5,355,823	216,155	3,711,948	9,283,925	9,292,340	49.2
All American Samoa	90,944	11,583	44,111	20,663	104,200	42,734	439,947	754,182	10,459,565	422,136	7,249,187	18,130,888	18,885,070	100.0
% of total	0.5	0.1	0.2	0.1	0.6	0.2	2.3	4.0	55.4	2.2	38.4	96.0	100.0	-

Note: 1 - includes Taema and Nafanua banks.
2 - includes South, and East Banks.

Future coral reef present values (US$/m^2; 3%) - BAU scenario

Location	Use values								Non-use values				
	Subsistence fishery		Artisanal fishery										
	Direct fishery added value (+multiplier effect)	Fishing consumer surplus	Direct fishery added value (+multiplier effect)	Indirect fishery added value (+multiplier effect)	Snorkelling / diving consumer surplus	Snorkelling / diving expenditure added value (+multiplier effect)	Shoreline protection value	Total use value	Resident non-use value	Visitor non-use value	US general public non-use value	Total non-use value	Total value
Tutuila south shore	0.06	0.01	0.03	0.01	0.11	0.02	0.51	0.74	2.39	0.10	1.66	4.15	4.89
Pago Pago Harbour	-	-	-	0.005	0.50	0.12	0.48	1.10	0.20	0.01	0.14	0.35	1.45
Tutuila north shore	0.01	0.00	0.01	0.01	0.03	0.01	0.29	0.35	4.69	0.19	3.25	8.13	8.48
Aunu'u and inshore banks[1]	0.003	0.0004	0.002	0.01	0.003	0.001	-	0.01	0.98	0.04	0.68	1.69	1.71
All Tutuila	0.03	0.004	0.02	0.01	0.07	0.02	0.34	0.49	2.81	0.11	1.95	4.87	5.36
Ofu & Olosega Islands	0.11	0.01	0.05	0.01	0.05	0.07	0.10	0.41	3.88	0.16	2.69	6.73	7.13
Ta'u Island	0.06	0.01	0.03	0.004	0.001	0.002	0.07	0.17	2.01	0.08	1.39	3.49	3.66
All Manu'a	0.09	0.01	0.04	0.01	0.03	0.04	0.09	0.31	3.10	0.13	2.15	5.38	5.68
Swains Island	0.02	0.00	-	-	-	-	-	0.02	2.01	0.08	1.39	3.49	3.51
Rose Atoll	-	-	-	-	-	-	-	-	20.13	0.81	13.95	34.89	34.89
Offshore banks[2]	-	-	-	0.001	-	-	-	0.001	0.20	0.01	0.14	0.35	0.35
All other areas	0.0002	0.00003	-	0.001	-	-	-	0.002	1.01	0.04	0.70	1.76	1.76
All American Samoa	0.01	0.002	0.01	0.003	0.01	0.01	0.06	0.11	1.49	0.06	1.03	2.58	2.69

Note: 1 - includes Taema and Nafanua banks.
2 - includes South, and East Banks.

Box 6.4

Future coral reef annual values (US$/yr) - OSM scenario

Location	Use values								Non-use values				Total value	% of total
	Subsistence fishery		Artisanal fishery											
	Direct fishery added value (+multiplier effect)	Fishing consumer surplus	Direct fishery added value (+multiplier effect)	Indirect fishery added value (+multiplier effect)	Snorkelling / diving consumer surplus	Snorkelling / diving expenditure added value (+multiplier effect)	Shoreline protection value	Total use value	Resident non-use value	Visitor non-use value	US general public non-use value	Total non-use value		
Tutuila south shore	381,678	48,611	62,810	19,059	183,900	187,852	474,638	1,358,547	1,939,097	751,677	3,839,787	6,530,561	7,889,107	15.1
Pago Pago Harbour	-	-	-	588	97,200	104,180	21,960	223,928	7,489	2,903	14,829	25,221	249,149	0.5
Tutuila north shore	37,552	4,783	6,180	8,745	37,980	48,480	132,780	276,500	1,811,887	702,365	3,587,887	6,102,139	6,378,639	12.2
Aunu'u and inshore banks[1]	10,176	1,296	1,675	7,016	4,920	6,754	-	31,837	743,741	288,306	1,472,752	2,504,799	2,536,636	4.8
All Tutuila	429,407	54,689	70,664	35,407	324,000	347,266	629,379	1,890,812	4,502,214	1,745,251	8,915,254	15,162,719	17,053,531	32.6
Ofu & Olosega Islands	458,501	58,395	75,452	23,605	35,348	106,113	59,006	816,420	1,927,612	747,225	3,817,044	6,491,881	7,308,301	14.0
Ta'u Island	174,576	22,234	28,729	4,918	3,120	13,594	26,086	273,256	715,414	277,325	1,416,657	2,409,396	2,682,651	5.1
All Manu'a	633,077	80,629	104,180	28,523	38,468	119,707	85,092	1,089,675	2,643,025	1,024,550	5,233,701	8,901,277	9,990,952	19.1
Swains Island	12,403	1,580	-	-	88	586	-	14,656	185,793	72,021	367,907	625,721	640,377	1.2
Rose Atoll	-	-	-	-	1,844	4,688	-	6,532	5,902,624	2,288,110	11,688,337	19,879,071	19,885,602	38.0
Offshore banks[2]	-	-	-	34,424	-	-	-	34,424	1,409,735	546,474	2,791,547	4,747,755	4,782,179	9.1
All other areas	12,403	1,580	-	34,424	1,932	5,273	-	55,611	7,498,152	2,906,605	14,847,791	25,252,547	25,308,159	48.3
All American Samoa	1,074,886	136,898	174,844	98,354	364,400	472,246	714,471	3,036,098	14,643,391	5,676,406	28,996,747	49,316,544	52,352,642	100.0
% of total	2.1	0.3	0.3	0.2	0.7	0.9	1.4	5.8	28.0	10.8	55.4	94.2	100.0	-

Note: 1 - includes Taema and Nafanua banks.
2 - includes South, and East Banks.

Future coral reef present values (US$/m^{2}; 3%) - OSM scenario

Location	Use values								Non-use values				Total value
	Subsistence fishery		Artisanal fishery										
	Direct fishery added value (+multiplier effect)	Fishing consumer surplus	Direct fishery added value (+multiplier effect)	Indirect fishery added value (+multiplier effect)	Snorkelling / diving consumer surplus	Snorkelling / diving expenditure added value (+multiplier effect)	Shoreline protection value	Total use value	Resident non-use value	Visitor non-use value	US general public non-use value	Total non-use value	
Tutuila south shore	0.66	0.08	0.11	0.03	0.32	0.32	0.82	2.35	3.35	1.30	6.63	11.28	13.63
Pago Pago Harbour	-	-	-	0.02	3.66	3.92	0.83	8.43	0.28	0.11	0.56	0.95	9.37
Tutuila north shore	0.14	0.02	0.02	0.03	0.14	0.18	0.48	1.00	6.57	2.55	13.00	22.11	23.11
Aunu'u and inshore banks[1]	0.04	0.005	0.01	0.03	0.02	0.03	-	0.12	2.82	1.09	5.58	9.49	9.61
All Tutuila	0.37	0.05	0.06	0.03	0.28	0.27	0.55	1.62	3.93	1.52	7.78	13.24	14.85
Ofu & Olosega Islands	1.29	0.16	0.21	0.07	0.10	0.25	0.17	2.25	5.43	2.11	10.76	18.29	20.55
Ta'u Island	0.69	0.09	0.11	0.02	0.01	0.02	0.10	1.05	2.82	1.09	5.58	9.49	10.54
All Manu'a	1.04	0.13	0.17	0.05	0.06	0.16	0.14	1.75	4.34	1.68	8.60	14.62	16.37
Swains Island	0.19	0.02	-	-	0.001	0.001	-	0.21	2.82	1.09	5.58	9.49	9.70
Rose Atoll	-	-	-	-	0.01	0.02	-	0.03	28.18	10.92	55.80	94.90	94.93
Offshore banks[2]	-	-	-	0.01	-	-	-	0.01	0.28	0.11	0.56	0.95	0.96
All other areas	0.002	0.0003	-	0.01	0.0004	0.001	-	0.01	1.42	0.55	2.81	4.78	4.79
All American Samoa	0.15	0.02	0.02	0.01	0.05	0.06	0.10	0.42	2.08	0.81	4.12	7.01	7.43

Note: 1 - includes Taema and Nafanua banks.
2 - includes South, and East Banks.

Box 6.5

Future mangrove annual values (US$/yr) - BAU scenario

Location	Use values							Non-use values[1]				Total value	% of total
	Subsistence fishery		Artisanal & subsistence fishery										
	Direct fishery added value (+multiplier effect)	Fishing consumer surplus	Indirect fishery added value (+multiplier effect)[2]	Recreation consumer surplus	Recreation expenditure added value (+multiplier effect)	Coast / flood protection value	Total use value	Resident non-use value	Visitor non-use value	US general public non-use value	Total non-use value		
Pala lagoon	16,304	2,077	2,852	400	313	112,511	134,457	1,732,566	70,770	1,215,836	3,039,590	3,174,047	95.2
Leone	815	104	150	80	63	-	1,212	91,188	3,725	63,991	159,978	161,190	4.8
All mangroves	17,120	2,180	3,002	480	375	112,511	135,668	1,823,754	74,495	1,279,827	3,199,568	3,335,237	100.0
% of total	0.5	0.1	0.1	0.0	0.0	3.4	4.1	54.7	2.2	38.4	95.9	100.0	-

Note: 1 - Relative proportions for each stakeholder group based on coral reef non-use calculations.
2 - Direct coral reef fishery component - value also accounted for under coral reef summary.

Future mangrove present values (US$/m^2; 3%) - BAU scenario

Location	Use values							Non-use values[1]				Total value
	Subsistence fishery		Artisanal & subsistence fishery									
	Direct fishery added value (+multiplier effect)	Fishing consumer surplus	Indirect fishery added value (+multiplier effect)[2]	Recreation consumer surplus	Recreation expenditure added value (incl. multiplier effect)	Coast / flood protection value	Total use value	Resident non-use value	Visitor non-use value	US general public non-use value	Total non-use value	
Pala lagoon	1.36	0.17	0.24	0.03	0.03	9.36	11.18	144.08	5.89	101.11	252.77	263.95
Leone	1.29	0.16	0.24	0.13	0.10	-	1.91	144.08	5.89	101.11	252.77	254.68
All mangroves	1.35	0.17	0.24	0.04	0.03	8.89	10.72	144.08	5.89	101.11	252.77	263.48

Note: 1 - Relative proportions for each stakeholder group based on coral reef non-use calculations.
2 - Direct coral reef fishery component - value also accounted for under coral reef summary.

Box 6.6

Future mangrove annual values (US$/yr) - OSM scenario

Location	Use values							Non-use values[1]				Total value	% of total
	Subsistence fishery		Artisanal & subsistence fishery										
	Direct fishery added value (+multiplier effect)	Fishing consumer surplus	Indirect fishery added value (+multiplier effect)[2]	Recreation consumer surplus	Recreation expenditure added value (incl. multiplier effect)	Shoreline protection value	Total use value	Resident non-use value	Visitor non-use value	US general public non-use value	Total non-use value		
Pala lagoon	30,498	3,884	24,861	8,000	6,250	149,077	222,571	2,480,332	951,633	4,877,986	8,267,773	8,490,344	95.1
Leone	1,525	194	1,308	1,600	1,250	-	5,878	130,544	50,086	256,736	435,146	441,024	4.9
All mangroves	32,023	4,078	26,169	9,600	7,500	149,077	228,448	2,610,876	1,001,719	5,134,722	8,702,919	8,931,368	100.0
% of total	0.4	0.0	0.3	0.1	0.1	1.7	2.6	29.2	11.2	57.5	97.4	100.0	-

Note: 1 - Relative proportions for each stakeholder group based on coral reef non-use calculations.
2 - Direct coral reef fishery component - value also accounted for under coral reef summary.

Future mangrove present values (US$/m^2; 3%) - OSM scenario

Location	Use values							Non-use values[1]				Total value
	Subsistence fishery		Artisanal & subsistence fishery									
	Direct fishery added value (+multiplier effect)	Fishing consumer surplus	Indirect fishery added value (+multiplier effect)[2]	Recreation consumer surplus	Recreation expenditure added value (incl. multiplier effect)	Shoreline protection value	Total use value	Resident non-use value	Visitor non-use value	US general public non-use value	Total non-use value	
Pala lagoon	1.91	0.24	1.56	0.5	0.39	9.36	13.97	155.67	59.73	306.15	518.89	532.86
Leone	1.82	0.23	1.56	1.91	1.49	-	7.01	155.67	59.73	306.15	518.89	525.90
All mangroves	1.91	0.24	1.56	0.57	0.45	8.89	13.62	155.67	59.73	306.15	518.89	532.51

Note: 1 - Relative proportions for each stakeholder group based on coral reef non-use calculations.
2 - Direct coral reef fishery component - value also accounted for under coral reef summary.

7 Conclusions and use of the results

7.1 Conclusions

The main conclusions drawn from the study are as follows:

Valuation

- Total benefits to American Samoa residents and visitors are estimated to be worth around US$ 5.1 million/year for coral reefs and US$ 0.75 million/year for mangroves.

- When potential non-use benefits accruing to US citizens are included, overall benefits could be in the order of US$ 10 million/year for coral reefs and US$ 1.5 million/year for mangroves. However, the values could be significantly higher, especially accounting for other international non-use values.

- Excluding US public non-use values, the combined annual coral and mangrove value is around 1.2% of American Samoa's annual Gross Domestic Product (GDP).

- The total present value of coral reefs is at a minimum worth US$ 318 million and US$ 47 million for the mangroves (assuming that current annual values are capitalized over 100 years using a 3% discount rate).

- Based on all values (i.e. including US public non-use values), coral reef and mangrove values are likely to be dominated by non-use benefits at around US$ 8.8 million/year (87%) and US$ 1.3 million/year (83%) respectively. Around 8% and 2% of coral reef and mangrove values relate to direct uses and 5% and 10% to indirect uses respectively.

- Around 50% of coral reef and mangrove values accrue to residents of American Samoa, equivalent to US$ 4.9 million/year and US$ 0.7 million/year respectively. Around 75% of resident values are related to non-uses, which partly capture traditional and social values.

- Of particular significance for residents are subsistence fishery catches (worth US$ 0.6 million/year), shoreline protection services (US$ 0.5 million/year) and subsistence consumer surplus, which represents part of the way of life (US$ 73,000/year).

- The shoreline protection value is relatively low due to the fact that beach sand and rubble mining has led to construction of extensive man-made structures along the coast.

- The US public could be deriving around half of total coral reef value solely in the form of non-use values at US$ 5 million/year.

- With the exception of current fishery product values, the benefit estimates are necessarily very approximate and should be considered in terms of their

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relative order of value. More accurate estimates would require additional detailed questionnaire surveys and studies.

- The values reported can generally be considered as minimum values. In particular, consumer surplus, non-use and future values may be significantly underestimated. All assumptions have been conservative and there are other key benefits identified that have not been valued.

Key observations arising from the valuation process:

- The magnitude of values is significantly affected by the types of benefit considered. Based on resident direct uses for coral reefs alone, the total PV is around US$24 million (US$0.11/m^2) and, including resident indirect uses, US$40 million (US$ 0.18/m^2). However, by also including resident non-uses the PV becomes US$ 154 million (US$ 0.70/m^2). With the further inclusion of visitor benefits PV becomes US$ 161 million (US$ 0.72/m^2), and with the US public non-uses the total becomes US$ 318 million (US$ 1.43/m^2).

- The magnitude of each benefit is highly location specific and varied by orders of magnitude between locations due to a range of factors. This has major implications for application of values, particularly at a micro-scale. For instance, when considering development impacts or management of any given reef area, be it for formulation of an Marine Protected Area (MPA) zoning strategy or identification of an appropriate permit fee to construct a seawall, the locally specific factors that affect values must be examined.

- The expected significant decline in use coral reef and mangrove values under the BAU scenario (39% overall) represents a potentially major cause for concern for residents and visitors and highlights the importance of continuing and enhancing national ICZM strategy and actions. If this course of action is pursued, the significant increases in both use and non-use values under the OSM scenario suggests that considerable benefits can be gained for future stakeholders, both on island and overseas.

- When considered at a macro-scale (e.g. the entire territory or an individual island etc), the total values appear reasonably large. For instance, the annual coral reef resident and visitor use and non-use values (just over US$ 5 million) outweigh the current coastal zone management expenditure of around US$ 2 million per year by 2.5 times. However, including non-use values for the US population, the total of US$10 million outweighs expenditure by five times. Without this management expenditure, the coral and mangrove values would rapidly decline to virtually zero.

- On the other hand, when considered at a micro-scale, the values appear relatively small. For instance, the best estimate average PV of coral reefs per unit area is US$ 1.43/m^2. Whilst this value does compare favourably to Cesar et al (2003) who estimated PVs of US$ 0.8/m^2 of corals for the Pacific and US$ 2.8/m^2 worldwide, it is considerably smaller than per unit area values used in claims for damages to coral reefs following ship groundings or pollution incidents (which can range from tens to thousands of US$ per m^2). Note here though that (as discussed in the results section) the non-use values were larger, coral reef value could be significantly greater (e.g. US$ 15/m^2). Though even this could be an underestimate for reefs in some areas because, as discussed above, values vary spatially. Nevertheless, when considered at the micro-scale, the relatively small per unit area values have major implications for the use of the results (see recommendations below).

- The results highlight that non-use values are of considerable importance when considering the value of coral reefs and other coastal resources. This is particularly true for resources with comparatively few or no human uses, where the value may be significantly underestimated if non-uses are ignored. For locations such as Rose Atoll and other uninhabited and pristine coral islands across the Pacific, consideration of their value only on the basis of human use would be unthinkable.

- However, due to the number of assumptions involved, non-use value estimates are the least robust of all benefits examined. Actual values may be underestimated by orders of magnitude and must be considered as minimum values. For instance, the resident and visitor non-use values may be underestimated by a factor of up to 10. Similarly, the US population values (which make up around 56% of coral reef values) may be overestimated by a factor of 10, but more likely could be underestimated by as much as a factor of 20 to 50 or higher. In addition, only the general public in the US were considered in this study (because it is an American territory) however, other international non-users may also derive benefits. Until specific comprehensive non-use value stated preference surveys (such as CVM or choice modelling) are undertaken, the magnitude of such values will remain unknown.

- Mariculture (i.e. farming of marine organisms) could potentially generate considerable value given appropriate research, investment and management. However, due to physical and economic constraints, the future potential for the development of an aquarium trade is limited.

- Although coastal zone management activities have improved considerably in recent years, there is a great deal more to be done. In particular, there is an urgent need to: develop and implement a targeted integrated coastal management plan; strictly enforce, and where needed, enhance existing regulations; and encourage appropriate development of suitable facilities and training (e.g. relating to tourism and mariculture).

- The activity of mining coral rubble and sand from the foreshore over the past few decades results in potential additional costs to the American Samoa economy of between US$ 0.5 to 2.3 million per year, at a value of between US$ 90-450 per cubic yard of material. This estimate excludes the considerable loss of beach recreation and tourism value, also potentially worth millions of dollars per year.

7.2 Potential use of the results

This valuation study provides a powerful tool to assist in resource use planning and territory management. By understanding the relative value of different coastal resources, their different types of benefit and how the values vary spatially, future policy-making and resource management decisions can be better guided. The following are examples as to how the values could be used.

The examples include reference to several “market-based instruments” whereby conventional environmental “externality” values can effectively be “internalised” by creating market prices for them (e.g. user fees and fines).

- **Prioritisation of focus and expenditure:** By examining the relative values of different benefits at different locations (e.g. fisheries, recreation and shoreline protection), priorities can be determined and specific locations can be targeted for special management attention (e.g. specific water catchments).

- **Enhancing decision-making:** The values can be used to inform development decisions where the costs and benefits of alternative development options are being (or should be) explored. For example the values can be used in cost:benefit analysis, such as in deciding whether to extend an airport runway or not, or to what extent Pago Pago Harbour should be cleaned up, or how best to develop tourism in Manu'a.

- **Justification for additional expenditures:** By appreciating the value of what is being protected, and the potential benefit to be gained by improved management, the values can be used to justify additional expenditure. For example, this could be to justify greater coastal zone management expenditure to ensure that the OSM scenario becomes reality.

- **Natural resource damage assessments:** By knowing the value of coastal resources one can determine appropriate levels of fines and compensation payments for damages caused to them. However, a review of ship grounding incidents (e.g. in Mexico, USA, Pacific and Egypt) reveals that the average payment for damages to corals is in the order of US$ 1000/m^2, predominantly based on restoration costs. A recent ship grounding in Yemen resulted in compensation being paid of US$ 1.9 million for damage to 2,350m^2 of relatively unused corals, averaging US$ 809/m^2 (K. Alwazir, pers comm. 2004).

  The USA actually adopts a habitat restoration approach to damage assessments rather than fines, based on the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980 and the Oil Pollution Act (OPA) of 1990. Careful thought is needed as to how best to approach damage assessments in line with national legislation.

- **Controlling use of resources:** If prices are set appropriately, by charging people for use of coastal resources, numbers of users and quantities extracted can be controlled. For example imposing an appropriate user fee in sensitive and popular national parks (such as at Ofu), user numbers can be better monitored and controlled.

- **Raising revenues:** By understanding the value that certain stakeholders enjoy from having free access to coastal resources, a range of different means of capturing that value can be developed. For example user fees can be established through, entrance fees, permits to undertake activities, concessions for private operators and royalties. Non-use values can be appropriated through innovative subscription, donation and voluntary work schemes. However, all such monies raised are best re-invested in conservation

- **Maximising benefits:** By understanding what the current and potential benefits are, a more targeted approach can be achieved to develop or enhance certain types of benefit (e.g. marine eco-tourism and mariculture).

Carefully designed and targeted public education and awareness campaigns can also increase both use and non-use values.

- **Minimising costs:** By understanding better who benefits from use (and non-use) of coastal resources and by how much, one can elicit voluntary help to minimise management costs. The questionnaire survey results demonstrate significant potential support for coastal management activities by local residents.

However, there are two important caveats:

- Although market-based instrument approaches are increasingly being used around the world for improved natural resource management, the ideas need to be implemented extremely carefully. Many complex issues can arise (e.g. stakeholder reactions and indirect impacts) that need to be thoroughly understood and dealt with appropriately.

- The valuation exercise undertaken for this study has been relatively limited. More detailed and accurate estimates of some values would be needed to appropriately undertake some of the above uses of environmental values. Project specific valuations and impact assessments may therefore be necessary in the case of planning major development or policy changes.

8 Recommendations and next steps

8.1 Recommendations

The terms of reference for the project are to provide an economic valuation which can be used as a tool. In Section 8.1.1 below we provide general guidance on the use of the results and in 8.1.2, further specific guidance on more detailed considerations. To add value to our study we have also drawn out some of the key recommended actions that have emerged from the valuation, these are presented in the subsequent sections.

8.1.1 General use of the results

- The results may be used as an aid to future policy and project decision-making.
- The results may be used to help secure and justify adequate funds for effective future coastal zone management in American Samoa.
- The results may be used to help ensure that future funds are appropriately targeted to provide the most benefit.
- The results may be used to decide what type of market-based instruments should be adopted and to guide associated price setting (e.g. sand mining fines and user fees).
- The Government of American Samoa should consider incorporation of the results (or more accurate future estimates) into the national accounts.

8.1.2 Advice over specific use of the results

- Careful consideration should be given to application of the results. In particular it is strongly recommended that:
  - Both use and non-use values are considered when assessing the value of a given location (i.e. that the concept of total economic value is applied). Based on use values only the values give a significant underestimation of the true value of the resource.
  - The spatial variation in results is considered. Based on average values alone, the value of a given location may be significantly underestimated (or overestimated). The extent to which this is undertaken may vary, however, any additional means by which a value can be refined beyond the average over a large area is beneficial. Location specific values can be determined from Appendix D.
- Similarly, when considering the value for any given location, only those values that are relevant should be considered. For instance, when assessing the value of a specific area of reef on the south shore of Tutuila (e.g. to assess the impacts of a proposed development), only those values generated by reefs there should be considered. This can be done using the maps in Figures 3.1 to 3.10 in conjunction with the value tables in Appendix

D. Alternatively, the mean value for the entire south shore can be read from Box 6.1 (PV of US$ 3.06/m^2).

- However, even if the above recommendations are adopted, where small-scale impacts are likely (e.g. direct destruction of corals from a ship grounding or landfill), the direct economic loss may not appear to be that large. It is thus worth considering other approaches to valuation and compensation. For example, it may be better to argue that all corals are integrally linked and represent a national treasure that must be maintained, and hence pursue restoration of an equivalent area of corals (and gaining compensation for the loss of services until the corals are fully replaced). Under such circumstances it is often better to carefully consider each incident on a case-by-case basis. Coral reef restoration costs can be in the order of US$ 1000/m^2.

8.1.3 General actions arising out of the valuation

- **Population growth.** The dramatic adverse implications of rapid and uncontrolled population growth are generally widely acknowledged (e.g. see Governors Task Force on Population Growth, 2000). This issue must become a top Government priority if the American Samoa Coastal Management Program is to be able to successfully manage coral reefs and mangroves and maintain or enhance their values.

- **Coastal development.** Although coastal development itself is driven to extent by population growth, tackling coastal development impacts must be addressed urgently. The existing DOC Project Notification and Review System (PNRS) should be strengthened or enhanced if needed and should integrate the values and concepts in this report in all development decision-making.

8.1.4 Actions on fisheries management

- **Better enforcement of existing fisheries regulations is needed.** This is particularly relevant in MPAs where poaching is a problem. Measures should include: night-time patrols; strict control on export of all coral reef products; proactively strengthening territorial fisheries regulations to prevent the introduction of overly destructive types of fishing gear; and improved legislation to control entrance to commercial fishery sectors.

- **Community-based fisheries management should continue to be pursued.** It may not seem to yield direct benefits initially, but it helps indirectly by raising awareness of conservation issues amongst the general public and encouraging sustainable coastal resource use. In the long-term, as the role of the community is encouraged and strengthened, it is likely to form a central component in the CZM tool-kit and will significantly help to enhance benefits for local resource users.

- **Measures should be taken now to plan for the likely cannery closure.** Measures could include: development of a more comprehensive fishery monitoring network (to identify changes in fishing effort), establishing the legislative means to control fishing effort if needed in the future (particularly bottom fishing); and investigation of alternative employment opportunities, particularly mariculture and tourism related.

- **Other sources of fish should be promoted for consumption.** This should include the by-catch of pelagic fish currently discarded by domestic long-liners.

- **Fishery resource use taxes should be considered.** For example commercial fishing industries such as the export of high-value bottom-fish products overseas could be targeted.

- **Complete monitoring of the harvest of coral reef fish and invertebrates is needed**. In particular, direct subsistence and artisanal catches should be covered to enable early detection of trends.

8.1.5 Actions on recreation and tourism management

- **A national study should be undertaken to investigate how best to develop marine eco-tourism.** This should be integrated with more general eco-tourism development within the Territory.

- **The introduction of user fees in parks should be considered.** However, this may be best left until eco-tourism is better developed in the Territories.

- **A basic guide to snorkelling and diving on American Samoa should be produced.** This should highlight the best locations, safety issues, what to see and where facilities and equipment can be bought and rented, and where people can learn.

- **Pilot studies should be carried out to encourage selected villages and suitable local entrepreneurs to enhance marine eco-tourism.** This would include provision of improved beach access, welcoming signs, facilities etc and creation of a range of commercially organised day trips (especially for Cruise passengers).

- **The carrying capacity of popular and sensitive snorkelling areas and mangrove areas should be explored.** The potential for limited tourism on Rose Atoll and Swains Island could also be considered.

8.1.6 Actions on shoreline protection management

- **Enforcement of sand and coral rubble mining must become a top priority.** Significant fines should be implemented for non-compliance. Alternative sources of sand and rubble materials for local residents should also be investigated.

- **A more holistic national strategy to shoreline protection should be developed.** This should include consideration of softer alternative forms of shoreline protection (e.g. setback and beach nourishment) compared to hard structures.

8.1.7 Enhancement of non-use value

- **Non-use values should be enhanced through a carefully designed and targeted public awareness and education campaign.** This should target citizens and visitors of American Samoa and citizens of the US (through a combined approach with other Pacific US Territories).

- **Alternative means of capturing non-use values should be considered.** This could include use of trust-funds, sponsorship and voluntary work opportunities.

8.1.8 Other studies

- **Further studies should be undertaken to explore in more detail the values not addressed in this study.** These include, in particular, education, research, and bio-prospecting.

- **In addition, other studies could be undertaken to examine the spatial distribution of parameters that affect key values.** In particular, there is considerable uncertainty about factors affecting the spatial variation in non-use values.

8.2 Next steps

The following next steps are recommended:

- **The results of this study should be used to their fullest possible extent.** This for example should include promotion of the value of coastal resources to residents in American Samoa and policy-makers in the US.

- **A Territory wide integrated coastal zone management plan should be developed drawing closely upon the results of this study.** It is essential that this should influence broader national policies regarding population growth, the economy and housing.

- **Additional studies should be undertaken to:**

  a. Assess the suitability and best means of introducing market-based instruments balanced with developing and enforcing regulations;

  b. Determine how best to manage and develop future artisanal, subsistence and mariculture fisheries;

  c. Assess how best to develop and manage future coastal resource based recreation and eco-tourism.

  d. Develop an holistic shoreline protection strategy;

  e. Enhance and capture the non-use values of American Samoa’s coastal resources, and;

  f. Assess the extent and value of other coastal resource benefits such as education and research.

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