A Comprehensive Strategy for Wildlife Conservation in American Samoa

2nd Edition (2016)

Department of Marine and Wildlife Resources
American Samoa Government

December 2016
Revised March 2018

This page was intentionally left blank.

A MESSAGE FROM THE DIRECTOR

American Samoa's natural resources have long sustained the lives of our people for many generations. These resources and their associated habitats make up our island's unique and diverse ecosystems ranging from the mountains to the sea. However, in this new era, the challenges impacting these resources are rapidly increasing at an alarming rate. The demand for development to accommodate population growth is threatening native habitats. Invasive species introductions, diseases and over-exploitation of resources compete with the natural ability of species to become resilient. Moreover, climate change creates a new facet of challenges for species and conservation management.

The American Samoa Department of Marine and Wildlife Resources conducts scientific research on these important resources through support of the United States Fish and Wildlife Service Sportfish and Wildlife Restoration program. Despite these efforts, there is still a wealth of information to be collected and questions to be answered in order to better understand the dynamics occurring in our island's ecosystem. From this, we are able to develop effective management regimes that ensure conservation and resilience of wildlife populations and habitat.

The Comprehensive Strategy for Wildlife Conservation in American Samoa 2nd Edition was written to identify strategies and develop conservation priorities to address some of the marine and wildlife conservation challenges our island is currently facing. It describes species of concern and proposes ways to improve their populations, natural habitats, and address conservation challenges while recognizing potential biological and socioeconomic impacts. The plan also proposes management alternatives based on the best available scientific information to allow island ecosystems and wildlife populations to become more resilient to changing environmental conditions. More importantly, it now encompasses the marine species of concern and marine habitats, something that was not incorporated in the previous comprehensive wildlife strategy.

Today we are faced with numerous challenges threatening our small island and the natural resources we depend on. I am convinced that this plan will move us forward with the conservation of our livelihood for our children and our future.

Soifua,
Va'amua Henry Sesepasara
Director
Department of Marine and Wildlife Resources
American Samoa Government
March 2018

LIST OF ACRONYMS

Several acronyms are used repeatedly in the text. To avoid repetitious explanation, their definitions are presented here:

ASAC	American Samoa Administrative Code
ASCA	American Samoa Code Annotated
ASCC	The American Samoa Community College
ASCMP	American Samoa Coastal Management Program
ASEPA	American Samoa Environmental Protection Agency
ASG	The American Samoa Government
ASIST	American Samoa Invasive Species Team
ASNMS	American Samoa National Marine Sanctuaries
CRAG	American Samoa Coral Reef Advisory Group
CWCS	Comprehensive Wildlife Conservation Strategy
DMWR	The Department of Marine and Wildlife Resources of the American Samoa Government
DOA	Department of Agriculture
DOC	Department of Commerce
FBNMS	Fagatele Bay National Marine Sanctuary
NMFS	National Marine Fisheries Service
NOAA-NCCOS	National Oceanographic and Atmospheric Administration-National Centers for Coastal Ocean Science
NPAS	The National Park of American Samoa
PNRS	Permit and Notification Review System
SPC	Secretariat of the Pacific Community
SPREP	The Secretariat of the Pacific Regional Environment Programme
SWCDB	Soil and Water Conservation District Board
SWG	State Wildlife Grants
WCPFC	Western and Central Pacific Fisheries Commission
WPFMC	Western Pacific Regional Fisheries Management Council

ACKNOWLEDGMENTS

The American Samoa CWCS 2015 Revision benefitted greatly from the suggestions, recommendations, contributions of information, and section revisions from the following individuals, as well as others not listed:

Marine Section Revisions
Dr. Douglas Fenner
Dr. Mareike Sudek
Alice Lawrence
Dr. Wendy Cover
Mia Comeros-Raynal
Jeremy Raynal
Tepora Lavatai

Wildlife Section Revisions
Dr. Edward Webb
Dr. Jooke Robbins
Dr. Mark Schmeadick
Roger Meyer
Mark Macdonald
Kim Kayano

We also acknowledge the inputs and comments of the members of the Fono, heads and representative of various government agencies, and village and district leaders through their participation in the various consultative dialogues held as part of the CWCS Revision process.

The planning and consultative discussions would not have been as fruitful, informative, and effective if not for the able language translation and technical support provided by the staff of the Wildlife Division and Fisheries Division of DMWR.

Finally, our deepest *fa'afetai* and *fa'amalo* to R Utzurrum and EF Curren, of the Hawaii Office of the FWS Federal Assistance (Region 1), for aiding us through the CWCS Revision process, and to DMWR Director Dr. Ruth Matagi-Tofiga, and DMWR Deputy Director Selaina Tuimavave for their support and active participation in all the consultative workshops throughout the development of this CWCS.

DMWR CWCS 2015 Revision Team:

Adam Miles, Chief Wildlife Biologist

Domingo Ochavillo, PhD, Chief Fisheries Biologist

Cover photos by M. MacDonald.

Suggested Citation: Department of Marine and Wildlife Resources. 2016. A comprehensive strategy for wildlife conservation in American Samoa 2nd Edition (AC Miles, DO Ochavillo, authors, 1st Edition: RCB Utzurrum, JO Seamon, & K Schletz Saili, authors). DMWR, Pago Pago.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 EXECUTIVE SUMMARY

The wildlife resources of American Samoa are distributed among five volcanic islands (Aunu'u, Ofu, Olosega, Ta'u, and Tutuila) and two atolls (Swains and Rose), the insular shelves and seaward up to 200 nm as part of the Territory's Exclusive Economic Zone). Highly migratory marine species such as tunas, sharks, marine turtles and marine mammals are the obvious components of the oceanic marine fauna. Coral reefs and associated fish and invertebrates constitute the components of the marine fauna insular shelves. Between the insular shelves and the 200-nautical mile limit are the seamounts and mesophotic reefs that contain deepwater fishes like snappers, emperors and groupers. For the terrestrial fauna, land birds and fruit bats are the most conspicuous components. Most of the taxonomic groups are relatively depauperate for both terrestrial and the marine fauna. Most of these groups are found on the fringes of their geographic distribution with few species unique to American Samoa, with the exception of the gastropods. Land snails, in particular, are represented by numerous species, a high proportion of which are endemic to the Samoan archipelago.

The combination of small land mass, isolation from other faunal communities, occurrence of catastrophic natural forces, and a burgeoning human population render the islands' wildlife particularly vulnerable to the effects of shrinking habitat, novel and emergent diseases, minimal dispersal (movement of animals between islands), and drastic declines in abundances. The impacts of global climate change are increasingly important and its impact needs to be assessed in terms of the vulnerabilities of terrestrial and marine wildlife. For these reasons, it is imperative that resources for wildlife conservation be used for collecting the best scientific information for the timely institution of conservation and management tools to ensure the viability of: 1) its native wildlife populations for future enjoyment and for cultural uses; and 2) the biotic interactions that help sustain the islands' natural habitat.

The Comprehensive Wildlife Conservation Strategy presented here provides guidance for the allocation of resources and efforts to those **species that for reasons of lack of information, low or declining abundances, highly localized or restricted distributions, great vulnerability to threats and more importantly not covered under any program** and therefore considered deserving priority conservation attention. Among these are select species of terrestrial invertebrates (coconut crab, a *Papilio* butterfly, and endemic terrestrial snails) and vertebrates (Pacific boa, 2 species of skinks, green and hawksbill turtles, rare and poorly known species of land birds, ground-nesting sea birds, the sheath-tailed bat). The status of these species are described to the extent possible with available information, and priority conservation actions for each are defined (Section 5:

SPECIES OF GREATEST CONSERVATION CONCERN). For the marine species, the select species of concern are the sea cucumbers, giant clams, mesophotic reef fishes and the coral reefs as a habitat due to threats such as increased levels of harvest and the impacts of predators. The expanding human population coupled with the lack of land use guidelines in the Territory make it imperative to develop and implement a wildlife habitat plan as a strategy necessary for the conservation of most terrestrial species (Section 6: PROTECTION OF NATIVE HABITATS AS A STRATEGY FOR WILDLIFE CONSERVATION & Section 8: STATUTORY AND REGULATORY ASPECTS OF CONSERVATION). When implemented with local and regional partners, in full consideration of the traditional and cultural sensitivities of the local community (Section 7: WILDLIFE IN THE SAMOAN CULTURE: ANCHORING CONSERVATION TO TRADITIONS AS A STRATEGY), the strategies identified should improve information on the status of species, their ecological needs, vulnerability to threats, resiliency to disturbance, and prospects for maintaining viable populations through the future (Section 9: SUMMARY OF STRATEGIES AND MECHANISMS FOR IMPLEMENTATION).

2 INTRODUCTION

2.1 FOCUS AND SCOPE

The American Samoa Comprehensive Wildlife Conservation Strategy (CWCS) is the Territory's's blueprint for conservation. It embodies the Territory's vision and the roadmap of wildlife conservation for the next 10 years. This document is mandated by US Congress and is the source document for funding under the Fish and Wildlife Service. This is the second edition and this document is reviewed every 10 years or earlier if deemed necessary by the American Samoa Department of Marine and Wildlife Resources which has the mandate to preserve and manage the terrestrial and the marine resources.

The first American Samoa CWCS in 2005, except for the marine mammals and sea turtles, covered only the terrestrial fauna. For this revised CWCS, we have included the marine fauna. Since this is the Territory's blueprint for conservation, it is deemed important to include the marine realm of American Samoa. American Samoa is surrounded by waters, has actually more water than land (99.5% is water) and the Samoan culture is centered around the ocean. In addition, the State Wildlife Program provides DMWR with the conservation and management opportunity to include those species that, for reasons of lack of funding, have been largely excluded in previous research, monitoring, and conservation programs. There are already several research and management initiatives implemented by DMWR, the National Parks Service, the National Marine Sanctuaries and by various programs by National Oceanographic and Atmospheric Administration and Department of Interior for the conservation and management of the marine environment as noted in the first edition. However, recent threats to coral reefs such as the predation by the crown-of-thorn starfish have stymied the department's efforts in eradicating this coral reef threat because of funding limitations by current grants. The department's major grant for conservation and management of the marine environment covers only finned-fish. This basically excludes the other important fisheries of lobsters, sea cucumbers, crabs, and giant clams. The first edition also stated that the exclusion of marine organisms in no way precludes their consideration in later revisions or updates of this Plan, should it be warranted.

For this revised edition, we consulted with local experts, and the assessments and protocols by the NOAA Endangered Species Act and the IUCN Red List Assessment in prioritizing marine species for conservation in the Territory. This has strategically narrowed down the process of prioritizing species of concern. We developed conservation actions for these species of concern. We further narrowed down to priority species of greatest concern using the following classification in order of importance: (1) Conservation Class; (2) Data Reliability; (3) Abundance (with priority for rare and uncommon); and (4) Distribution (see Appendix 2 and 3 legends for definitions of these classifications). Unlike the terrestrial fauna, the marine fauna is more biologically diverse. So for the marine species of greatest concern, there is sufficient data and information available to support their prioritization. For the terrestrial fauna, most of the species are covered to various degrees in this plan. Information on species or species groups for which sufficient data are available, and/or for which there is significant biodiversity or cultural interest are summarized. In general, the vertebrate taxa are better known, particularly the avifauna and mammals. The invertebrate taxa, on the other hand, remains poorly studied with the exception of a few groups or species, such as land snails.

Introductory accounts on taxonomic groups of the marine and terrestrial fauna covered in this plan are presented in Section 3 (THE FAUNA). These accounts provide an overview of the diversity within groups and the general state of knowledge available on the priority taxa. Where information is inadequate for detailed treatment, or for taxonomic groups accorded lower conservation priority statuses, threats and recommended priority actions are incorporated in the general taxonomic accounts presented in Section 3. For example, a more detailed treatment of insects and other arthropods is precluded by the general lack of information of this group. Entomological studies in the Territory have focused largely on those species of economic importance as agricultural pests, pathogens, or beneficial symbiotic interactors (M. Schmaedick, pers. comm.). For this reason, with the exception of *Papilio godeffroyi*, the group has not been considered for detailed treatment in Section 5 (SPECIES OF GREATEST CONSERVATION CONCERN). However, some of the possible threats to the fauna are discussed in the overview (Section 3.2.1) as is a short list of identified conservation priorities. Other taxa similarly treated are crustaceans and the herpetofauna. **The conservation priority actions were basically based the following criteria: (1) coverage by existing initiatives or programs; (2) cost-benefit analysis; and (3) probability of success.**

Taxa assessed as species or species groups of priority concern are described in greater detail in Section 5 (SPECIES OF GREATEST CONSERVATION CONCERN). The detailed accounts provide more specific information on abundance, distribution, habitat, and threats to the extent that data are available. Priority conservation actions specific to the species or species groups are provided.

It has long been recognized that adequate habitat (quality and quantity) are necessary for the health and stability of wildlife populations, particularly on small isolated islands. This plan brings into focus the status of the habitat (Section 4: AN OVERVIEW OF THE HABITAT) by illustrating in detail qualitative trajectories of projected landscape changes (Figure 3) and actual land cover trends for the islands of Tutuila and Manu’a (Figure 4). Threats to the habitat are elucidated in Section 6 (PROTECTION OF NATIVE HABITATS AS

A STRATEGY FOR WILDLIFE CONSERVATION), priority actions deemed critical for addressing these threats are identified (see Section 6.1.3 and 6.2.3), and attendant regulatory and statutory measures in support of habitat conservation are discussed in Section 8 (STATUTORY AND REGULATORY ASPECTS OF CONSERVATION; see Sections 8.2.1 & 8.3.1, in particular). For this revised American Samoa CWCS, there was a deliberate effort to adhere to the form and structure of the previous edition for consistency.

2.2 DEVELOPING A COMPREHENSIVE STRATEGY

2.2.1 THE PROCESS

The Department of Marine and Wildlife Resources, as the Territorial agency vested with the mandate to "manage, protect, preserve and perpetuate the marine and wildlife resources in the Territory" (Section 24.0304 of Chapter 3 of the American Samoa Code Annotated), undertook the sole responsibility of developing the first and now the second Comprehensive Wildlife Conservation Strategy (CWCS) for American Samoa. The blueprint for both plannings have two components: 1) targeted TECHNICAL REVIEWS & CONSULTATIONS; and 2) interactive CONSULTATIVE DIALOGUES with various sectors of the government and the community (Figure 1).

The reviews and expert consultations completed Phase I of the process, and produced a provisional list of conservation priorities based on the best scientific information available. For the marine fauna, a draft list was generated from the NOAA ESA and IUCN assessments. The list was later modified based on the informed opinion of local experts during a combined intra- and inter-agency meeting held on July 13, 2015. Subsequent communications were conducted for expert opinion and knowledge for those who could not attend the meeting. The final list was developed from the classification indicated in Appendix 2 and 3. Among the contributing agencies outside of DMWR were ASCC- Land Grant, the Department of Commerce/ASCMP, the American Samoa Environment Protection Agency, the National Park of American Samoa (NPAS) and the National Marine Sanctuaries of American Samoa. Intra-agency opinions were provided by staff who have significant field experience and knowledge in the marine fauna (Dr. Domingo Ochavillo, Alice Lawrence and Sean Felise for marine fishes; and Dr. Mareike Sudek for corals). For the inter-agency consultations, Dr. Wendy Cover (NMS) provided expert opinion on the marine fauna and species priorities through correspondence and separate meetings. Dr. Doug Fenner, who worked in DMWR for 8 years and who is the NOAA Protected Species Division local technical support provider for the ESA listing of 5 corals in the Territory, provided knowledge and informed opinions on coral diversity, abundance and distribution. Dr. Fenner also gave background knowledge and process of the NOAA ESA listing. Mia Comeros-Raynal (ASEPA) gave extensive background on the IUCN assessment process given her significant experience in this field.

For the terrestrial fauna, the expert consultations were previously sought in the first CWCS edition on specific issues, among others on land snails (R. Cowie), freshwater snails (D. Vargo), arthropods (M. Schmaedick), marine mammals (L. Dolar), regional birds (D. Watling), vegetation (E. Webb, A. Whistler), invasive species (E. Hanson, T. Togia), and protective legislation (M. McCarthy). For the revised 2nd edition we reviewed and updated each section based on new available information that has become available over the last 10 years. For a subset of taxon for which DMWR had significant local expertise we mainly reviewed the sections internally (A Miles – bats, K. Kayano and M. MacDonald – birds, M. MacDonald – turtles, M MacDonald - reptiles). For taxon for which DMWR did not have expertise, we had experts review and revise sections, many of whom have been doing considerable work in American Samoa for the last 10 years. This included review, consultation, and revision of sections for arthropods and butterfly (M. Schmaedick), marine mammals (J. Robbins), terrestrial habitats (R. Meyer), and habitat protection (E. Webb). The Overview of Habitat Section (4) was improved by the inclusion of the Mapping of Wildlife Habitat in American Samoa Section (4.1.3) and associated habitat maps (Appendix 4) which was a priority of the 1st CWCS Edition and was work conducted by R. Meyer at DMWR over the last 6 years.

The 1st CWCS Phase 2 consisted of various initiatives of consultation and public review. Two consultative dialogues were held with the available members of the Fono (Legislature); Executive Branch with all its various departments; Local Government (*pulenu'u*s [village mayors], *fa'alupega*s [county chiefs], district governors, and other traditional community leaders under the Office of the Samoan Affairs. Members of the first three sectors were recognized as the critical leaders able to capture the sentiments and priorities of the community and, in turn, communicate to their constituents the various aspects of the proposed conservation program presented for review. Our approach for the CWCS Revision was similar. We conducted two public review and consultation sessions in October 2015 where we presented each section and requested either oral or written comments from attendees. As in the 1st CWCS, these sessions were attended by members of the general public, Fono, Local and Federal Government Agencies, and village leaders.

The decision to combine consultations and the review process in a single exercise was predicated on the need to: 1) capture a more varied representation from the community than could have been achieved if the plan was simply left out for review at the public's leisure; 2) target sectors and agencies whose cooperation and support are, in effect, requisites to the effective coupling of proposed actions with the community; and, 3) achieve an atmosphere of interactive dialogue facilitated by Samoan staff of DMWR to a) provide instantaneous translations of technical material, b) solicit responses in a language that participants would be most comfortable with (Samoan), and, most importantly, c) ensure that the proper cultural and traditional protocols for discourse were observed.

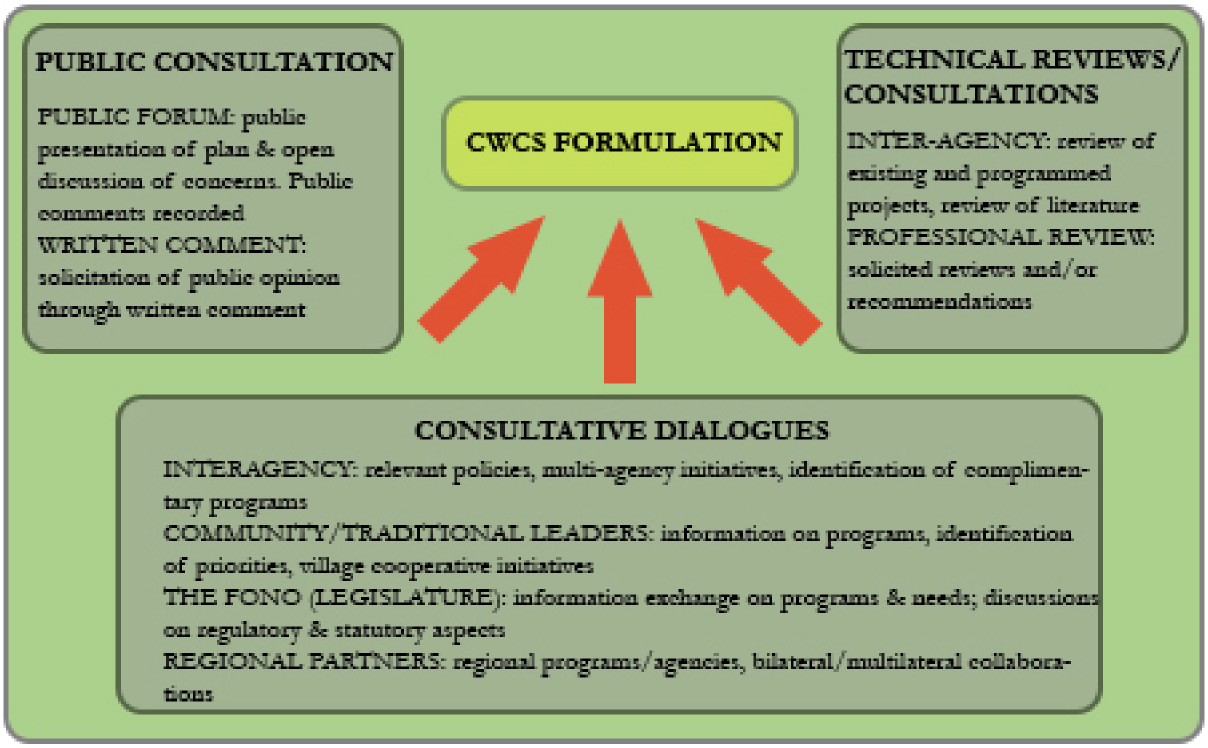


FIGURE 1. PROCEDURAL BLUEPRINT FOR THE DEVELOPMENT OF AMERICAN SAMOA'S CWCS.

2.2.2 CWCS R E V I S I O N

DMWR views the CWCS as a living document which will be continually updated as new information becomes available, studies and species assesements are completed, and emerging threats are identified. Formal reviews of the CWCS with major revisions will be conducted every 10 years in consultation with the USFWS and include consultations with local and regional partners and include public review. DMWR informal reviews will be conducted as necessary to ensure that the CWCS remains up to date with the latest information available. Attendance at local and regional meetings and sypmposia will ensure the CWCS remains current, and presentations to the public through outreach efforts will allow for continual public involvement in the process. Informal reviews and minor updates will be executed yearly, as project reports from ongoing conservation efforts are generated. Any changes to the CWCS will be tracked and logged in order present changes to the USFWS in the form of a "road map" during the formal review process. DWMR may also publish sections of the plan online, which will be frequently updated as individual studies and species assesments are completed.

2.3 DEFINING SPECIES OF GREATEST CONSERVATION NEED

Assignment of priority ratings to species, at the very least, should take into consideration information on taxonomic status (Is the species endemic or unique to the area?), abundance (Are local populations in decline, increasing, or stable), distribution (How geographically widespread is the species? How restricted are distributions within sites of occurrences?), and threats (What are the threats and how severe are the threats?). These types of information may not be available, or may only be partially available, for a number of species found in American Samoa. Thus, the rankings assigned to species examined were reached to the extent possible with available data, published and unpublished (including those from on-going projects). The significance of species to the local culture was also considered in the evaluations.

Following these guidelines, five levels or classes of conservation rankings were developed. **Class I** species are those for which insufficient data are available. Such data include the minimum required to make informed decisions on spatial patterns or trends in abundance, and the extent of distributional restrictions or among-population movements. **Class II** species are those for which baseline data exists to at least tentatively identify threats or guide focused research on variables of concern. These data might suggest a direct threat to survival (e.g., from introduced predators or disease), an indirect threat through destruction of critical habitat, or possible genetic bottlenecks due to very restricted population sizes. Species near range boundaries are predicted to be more sensitive to habitat loss, and species with broad diets and habitat breadth less so (Swihart et al. 2003). **Class III** species are those of conservation interest due to rarity, uniqueness, or cultural importance, but for which there are already ongoing monitoring and research programs. **Class IV** species are indigenous species of interest as components of natural communities, but which are known to be abundant. **Class V** species are exotics or invasive, and for which population control or reduction would be encouraged where feasible.

For the marine fauna, there was no attempt to classify all the marine faunal components of the wildlife resources in American Samoa into these classes of conservation. Unlike the terrestrial fauna, the marine fauna has high species diversity. Instead, the marine species prioritization was based on the NOAA ESA and Species of Concern list and then the IUCN red list species assessments. We also reviewed the analysis of both these assessments for coral reef fishes conducted by Zgliczynski et al. (2013) focusing on the US Pacific Islands including American Samoa. We also reviewed the stock assessments for highly exploited tunas conducted by the Western and Central Pacific Fisheries Commission through the

Secretariat of the Pacific Community. The IUCN assessments are usually global and regional (in this case Oceania that includes American Samoa) in coverage. From the IUCN red list species assessments, we only focused on those threatened species (vulnerable, endangered, and critically endangered). The application of these assessments was a strategic way to narrow down the list of species of concern. The resultant list of priority species for conservation was reviewed and modified through expert consultations with scientists and the community. The final list of species of greatest concern was developed using the categories used for terrestrial wildlife (Appendix 2 and 3) and in order of priority included those species with high reliable data (first criterion) and identified as Conservation Class I and II (second criterion). Conservation Class II includes species that are high priority with available data that identifies threats or known with low population estimates. Conservation Class I includes species that are high priority but have insufficient data to make informed assessment of conservation status. We then narrowed down these species to abundance categories (third criterion) those who are moderately common, uncommon, rare and with with very rare abundance as top priority) and whose distributions (fourth criterion) with very restricted distribution as top priority. The list of species of greatest concern includes the three species of giant clams, three species of sea cucumbers, the five hard corals and three species of mesophotic coral reef fishes. See Appendix 2 for a list of terrestrial vertebrate species and Appendix 3 for a list of marine species.

2.4 AMERICAN SAMOA: GEOGRAPHIC AND SOCIO-CULTURAL BACKDROP

2.4.1 G E O G R A P H Y

American Samoa is an unincorporated, unorganized territory of the United States, and is located approximately between 167 ^{o} to 172 ^{o} W (longitude) and 11^{o} to 15 ^{o} S (latitude) in the southwestern Pacific (Figure 2). Five of the seven islands comprising the Territory are volcanic in origin – Tutuila, Ta'u, Ofu, Olosega, and Aunu'u. Ta'u, Ofu, and Olosega islands are collectively referred to as Manu'a. The other two islands, Swains and Rose, are coral atolls.

The islands and atolls in American Samoa are part of the larger Samoan Archipelago, a remote chain of 13 islands of varying sizes and an atoll, located 140 south of the equator near the International Date Line. This archipelago is approximately 4,200 km south of Hawai'i, in the central South Pacific Ocean. The independent Samoa has two large islands (Upolu and Savaii) and eight islets.

The Samoan Archipelago sits on the northern end of the Tongan Trench. It is at the southwestern end of the Polynesian Triangle, 550 km west of the Cook Islands. The archipelago spans about 520 km east to west. The Samoa archipelago was formed by a series of volcanic eruptions from the “Samoan hotspot” (Hart et al. 2000). The islands in the archipelago rest on a portion of the Earth’s crust known as the Pacific Plate. This plate is drifting westward at a rate of ~ 7 cm per year (McDougall 1985). Most of the islands were formed by volcanic eruptions when a portion of the plate they are resting passed over a thermal plume in the Earth’s mantle. Based on the classic hotspot model, Savaii Island (the westernmost) in Samoa would be the oldest and Tau island (the easternmost) in American Samoa the youngest of the islands in the archipelago. Geological data indicate that Savaii is about 4-5 million years old, Upolu about 2-3 million years old, Tutuila about 1.5 million years old, Ofu-Olosega about 300,000 years old and Tau about 100,000 years old. Swains and Rose are built on much older volcanoes but not part of the Samoan volcanic chain. There are various banks (submarine platforms of various origins, i.e. submerged barrier reefs and seamounts) found in the Archipelago and these also have various geological originations (Hart et al. 2004).

Tutuila island and the adjacent much smaller Aunu’ u island are highly eroded volcanic structures bounded by very narrow reef flats, and narrow and steep fore-reef slopes. Tutuila has been exposed to significant erosion and consequently has an insular shelf that is 4 km wide on average and 320 km^2 of coral reef ecosystem. Tutuila is also the largest and most populated island in American Samoa. Its northern and southern sections are exposed to varying levels of wave intensity from swells generated by the trade winds.

Ofu and Olosega are twin volcanic islands separated by the Asaga Strait, a shallow, narrow break in the reef flat between the islands. These two islands are located in the westernmost part of the Manu’a Islands group, approximately 100 km northeast of Tutuila Island. The islands are formed by two eroded, coalescing basaltic shield volcanoes whose slopes dip to the east and west. Steep cliffs are located on both the northern and southern sides of the two islands. Ofu and Olosega have a narrow shelf that is ~1 km wide and banks eroded in several corners of the islands extending ~2 km offshore. Ta’u Island, the third island of the Manu’a, is approximately 10 km to the southeast with a narrower insular shelf, and no shelf at all on the south and eastern parts of the island. In some areas its insular shelf is a few hundred meters and extends ~1 km offshore along the western half of the northshore.

Rose is an uninhabited atoll located at the far eastern end of American Samoa, approximately 300 km east of Tutuila. This easternmost part of the territory has the coolest, most vertically stratified and most variable temperature profile in the upper 30 m of the water column. Swains is the northernmost island of American Samoa and approximately 350 km north of Tutuila. Geologically, it is not part of the Samoan hotspot track, but part instead of the Tokelau volcanic chain. Based on oceanographic and water quality data, Swains islands is located in an outlier characterized by significantly different physical water environment. As the northern and most isolated island of the group, it had the warmest, least vertically stratified and least variable temperature profile.

Tutuila, the largest of the seven islands and with Mt. Matafao as its highest point, accounts for approximately 72% of the Territory's total land area (Table1). With the exception of the two atolls, the islands are topographically steep and rugged, particularly along the northern shores. Flat plains and areas less than 30 ^{o} in slope that are suitable for agriculture, settlement, and development are limited.

TABLE 1. *ISLAND CHARACTERISTICS IN AMERICAN SAMOA (HUNTER 1995, WHISTLER 2002).*

Island/Bank	Island Type	Area (km^2)	Highest Point (m)	Coral Reef Area (km^2)	Reef Type
Tutuila	Volcanic	143.2	650	243.0	Fringing, non-structured
Aunu'u	Volcanic	1.6	88	0.5	Fringing
Ofu	Volcanic	7.5	495	3.2	Fringing
Olosega	Volcanic	5.4	640	2.0	Fringing
Tau	Volcanic	45.7	930	1.7	Fringing, non-structured
Swains	Atoll	0.1	5	3.3	Atoll
Rose	Atoll	0.1	5	3.0	Atoll
Nafanua Bank		N/A	N/A	6.0	Submerged bank/shoal
Taema Bank		N/A	N/A	4.0	Submerged bank/shoal
Outer Banks		N/A	N/A	25.0	Submerged bank/shoal

2.4.2 THE CLIMATE AND THE MARINE ENVIRONMENT

American Samoa is in a tropical environment with mild temperature the whole year round. Mean daily temperature varies between 22^{0}C and 30^{0}C with December to April, the warmest months. The relative humidity is high with a daily range of 70 to 90%. The territory experiences persistent easterly or northeasterly tradewinds. Because most mountains in the islands are oriented in an east-west direction there is no pronounced rain shadow, and all areas receive more than 2,000 mm of rain per year (Whistler 1980). Annual rainfall is high with an average of >3,000 mm that varies with topography. The tops of the higher mountains may receive more than 8,000 mm of rain per year (Whistler 1980). The eastern part of Tutuila and the Tafuna plains are the drier parts of the island and receive 318 mm of rain a year. The mountains and Pago Harbor receive 500 to over 600 mm rains a year. December through March are the wettest months and also the time when devastating cyclones occur (Craig et al. 1994).

The winds are mostly 40% easterly with speeds varying from 2 to 20 mph. The average highest wind speeds occur in July and the lowest average wind speed in March. The months from June to October have the mostly easterly winds. A major atmospheric feature that affects the Samoan climate is the South Pacific Convergence Zone (SPCZ) where the trade winds converge at the surface. This area of convergence results to heightened rainfall during the summer months. The SPCZ undergoes changes in position and intensity when it crosses the Territory twice a year. It crosses the archipelago during summer and moves northward in winter causing stronger winds and lower rainfall (Alory and Delcroix 1999).

Tropical cyclone is a recurrent natural disturbance in American Samoa. The Samoan EEZs lie along the eastern edge of a region conducive to development of cyclonic storms in the South Pacific (Craig 2009). Cyclones occur at an interval of 1-13 years and there have been six major ones in the last 30 years. Two cyclones in 2004 and 2005 caused substantial damage. Tsunamis occur on average of one every 50 years. The recent tsunami in 2009 caused extensive damage to coastal communities but its impact on the coral reef ecosystem was minimal (Fenner et al. unpublished).

The Samoan Archipelago lies along the northern edge of the South Pacific Gyre, a series of connected ocean currents with a counter-clockwise flow (Alory and Delcroix 1999, Tomczak and Godfrey 2003, McClain et al. 2004, Craig 2009) (Figure 2.3). There are 2 major surface currents affecting the archipelago (Qiu and Chen 2004): (1) the westward flowing South Equatorial Current (SEC), and (2) the eastward flowing South Equatorial Counter Current (SECC) (Figure 2.3). The intensity of these currents in Samoan waters is variable among seasons and years. Regional current patterns is most probably a major determinant in larval transport and connectivity among islands in the archipelago.

Wave power exposures are typically highest on the eastern and southern facing coasts of Samoan islands but can vary seasonally and among years (Barstow and Haug 1994). The wave climate can be split into two main components, short period (~2-10 seconds) “wind seas” that result from local forces such as the easterly trade winds versus long period (~10-20 seconds) “ocean swells” that originate from storms many of which are far south of the archipelago (Barstow and Haug 1994). Ocean swells from the south and wave power are generally highest during May-September (2-3 m wave height is common) with the increased intensity of the trade winds and frequency of swell producing storms at higher latitudes (Barstow and Haug 1994, Brainard et al. 2008). November through March is a period often characterized by shorter period waves, lower wave heights (~2 m), and more variable directionality (Brainard et al. 2008).

2.4.3 SOCIO-CULTURAL PROFILE

The earliest settlement in the Samoan Archipelaho is 3,000 bp in Ofu island. The Polynesians have been hypothesized to originate from the people grouped as the Lapita Complex characterized by the distinct markings on their pottery. The **Lapita culture** or tradition was a prehistoric Pacific Ocean people from c. 1600 BCE to c. 500 BCE. Archaeologists believe that the Lapita is the ancestor of historic cultures in Polynesia, Micronesia, and some coastal areas of Melanesia. The Lapita people were expert in seamanship and navigation, reaching out and finding islands separated from each other by hundreds of miles of empty ocean. Their descendants, the Polynesians, would populate islands from Hawaii to Easter Island, possibly even reaching the South American continent. They domesticated pigs, dogs and chicken. They also grew taro, yam, coconuts, bananas and breadfruits. They spoke proto-Oceanic language, a precursor of the Oceanic branch of Austronesian. It is estimated that pre-Western contact population was about 30,000 people in the whole Samoan archipelago. The population slightly dipped after the Western contact due to disease exposure.

Western contact started in the early 18th century that included a battle between French explorers and islanders in Tutuila Island. Missionary work started in late 1830's. By the late 19th century, French, British, German, and American vessels routinely stopped at Pago Pago Harbor for refueling for coal-fired shipping and whaling. The international rivalries at the turn of the 20th century were settled by the 1899 Tripartite Convention in which Germany and the United States partitioned the Samoan Islands into two parts:[6] the eastern island group became a territory of the United States (the Tutuila Islands in 1900 and officially Manu'a in 1904) and is today known as American Samoa.

The population in the Territory has steadily increased through centuries although it has been in decline in the last 10 years. As of the April 2002 census, the population in the Territory was estimated at slightly less than 60,000, 97% of whom reside in Tutuila (Department of Commerce Statistics Division 2005). With an average annual growth rate of 2.0% (between 1990-2000), the population is estimated to have exceeded 60,000 by the end of 2005. Approximately 48% of this population is under 40 years of age, and the median age of 21 is at least 10 years younger than that of the continental US. The highest recorded rates of growth in population is in western side of Tutuila Island, particularly in the Tualauta county. The Manu'a islands exhibited negative growth rates (-2.2%), perhaps, as a result of immigration from the islands from lack of opportunities for employment and economic development (Department of Commerce 2003).

Although American Samoa, undeniably, has the trappings of western developed countries, tradition and religion continue to permeate the fiber of the society. The "*aiga*," or extended family is the core structure of the society and all matters of family life (from administration of communal lands to handling of weddings and funerals) are typically run by the senior *matai* (chief) and subordinate *matais*. The running of customary village affairs generally resides in the traditional leaders, such as the village council of chiefs. Although the Governor, Lt. Governor, and representatives to the lower house of the legislature, or Fono, are duly elected by qualified residents, members of the Senate are selected by councils from among the titled traditional leaders. The understanding of this integration of traditional and western modes of governances and life styles are considered crucial for successful implementation of any program in the Territory. Indeed, the traditional heirarchical structure of the society acts as a pre-existing network by which outreach and public participation may be pursued. In addition, the village church is also a significant stakeholder similar to many south Pacific countries.

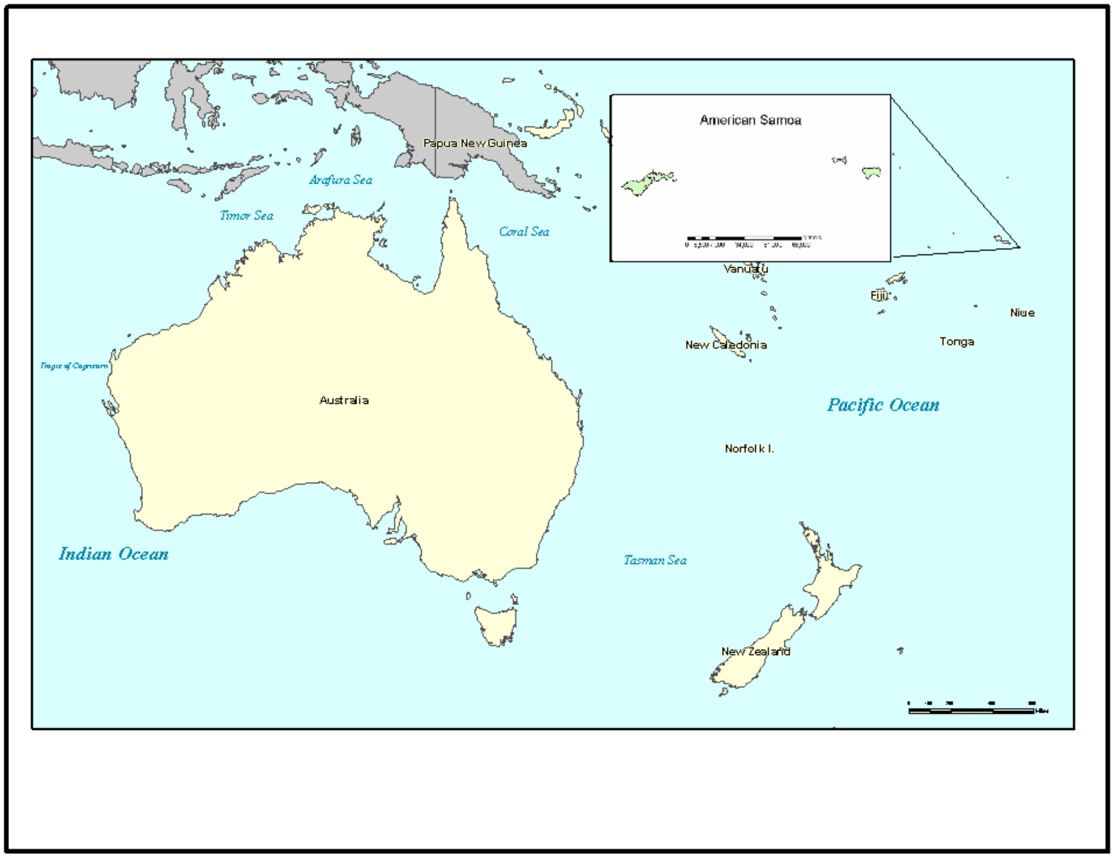


FIGURE 2. REGIONAL MAP SHOWING LOCATION OF AMERICAN SAMOA ISLANDS (area with Tutuila and Manu'a enlarged in the inset).

3 THE FAUNA: AN OVERVIEW OF THE CONSERVATION THREATS AND THE IMPACTS ON WILDLIFE

American Samoa's marine fauna is grouped within the Central Polynesia ecoregion, the ecoregion that includes the Line Islands, Phoenix Island, Tokelau, Northern Cook Islands and the Samoan Islands (Spalding et al. 2007). A marine ecoregion is defined as areas of relatively homogeneous species composition that is clearly distinct from adjacent systems. The terrestrial ecoregion is grouped under the Samoan tropical moist forests based on the vegetation types. While van Balgooy et al (1996) considers Tonga and Samoa as one unit with respect to floristic affinities, Allison treats the Tongan and Samoan archipelagos as separate units with respect to herpetofauna. The Samoan Islands are delineated as an Endemic Bird Area due to the presence of 11 endemic bird species.

3.1 MARINE CONSERVATION THREATS

There is evidence that fishing has caused the decline of fish stocks in American Samoa. In a regional-scale comparison of its surveys, the NOAA CRED data showed that the total fish biomass in the populated areas in the Territory is only 50% of the total fish biomass at the unpopulated islands of the Mariana Archipelago and as low as 20% of fish biomass of the Northwestern Hawaiian Islands and the Pacific Remote Island Areas. The lack of large-bodied fishes (≥ 50 cm in total length) contributed to these differences in total biomass. Fishing typically targets large fishes resulting in declines in target species size, density and biomass. Larger-bodied species are the most vulnerable to fishing since they have, in general, slower growth rates, lower abundance and lower recruitment rates. It has been noted that productivity in terms of chlorophyll *a* concentration is higher in the Pacific Remote Island Areas to account for differences in fish biomass. However, the impact of human populations on the reduction of large-fish biomass is more significant. In subsequent studies, Nadon et al. (2012) used models and re-created shark populations in the absence of human populations. Their analyses showed that sharks declined by 3 to 10% in American Samoa. In similar analyses, Williams et al. (2015) showed that human impact depleted reef fish biomass by 21 to 56% in the Territory.

The loss of coral reef habitats and decline in habitat quality pose another threat to the nearshore marine life in American Samoa. Coral mortality and reef loss has been attributed to sedimentation, severe storms, predation and global climate change. Habitat degradation brought about by anthropogenic inputs into the coral reef system are of particular concern due to increases in land-based sources of pollution and added nutrients to the coral reef system from the proliferation of piggeries, increased sediment and nutrient loading, especially in reef areas near highly populated villages. The effects of these inputs, especially on reef flats, mangroves and seagrass beds are of obvious concern. These habitats are already restricted and are supplementary nursery habitat for the recruitment and juvenile development of some reef fish.

There are limited studies on sedimentation impact in the Territory's coral reefs. However, current studies indicate that sedimentation due to terrestrial run-off has led to coral mortalities in Fagaalu. The high coastal development in Pago Pago and decline in water quality have resulted to coral mortality and small-scale loss of coral reefs. Algal blooms are also a regular occurrence in Pago Pago Harbor, indicating problems with nutrient run-off. Finally, it has been estimated that the Samoan Archipelago has lost 80% of its original forest cover in the last 3,000 years. Such degree of environmental change has been implicated in the significant loss of coral reefs in other parts of the world (e.g. Caribbean).

Outbreaks of Crown-Of-Thorn Starfish (COTS) can also cause massive damage to reefs through loss of corals. One such outbreak occurred in American Samoa in 1978/1979 resulting in a significant reduction in live coral cover, with losses of up to 90% being recorded at some sites. Coral reef mortality has also been attributed to some extent to periodic hurricanes, damage from the 2009 tsunami, and very low tide events related to El Nino Southern Oscillations.

There is an increasing concern on the predicted impacts of global climate change on the marine environment in the tropical Pacific. The accumulation of greenhouse gases and the continued uptake of extra heat by the ocean has wide-ranging implications for marine resources. Thermal expansion of the ocean and melting land ice is resulting in rising sea levels and higher levels in the future. Increases in ocean temperatures are also changing the strength and direction of currents. In the tropical Pacific, greater evaporation and moisture availability are expected. There is also the possibility that warmer conditions may result in more intense cyclones and storms, more powerful waves and greater physical disturbance of coastal environments. Changes in the frequency and strength of El Nino Southern Oscillation has already been shown to change ocean-wide oceanographic patterns and the movement and availability of tuna. Nearshore, ENSO will impact coral reefs with predicted drastic lowering of tidal cycles and increased frequency of bleaching events. In effect, the predicted global changes in climate will lead to drastic physical and chemical changes especially in the coastal marine environment to conditions the species were not originally adapted to. These changes will impact thermal tolerance of different life stages of marine organisms and their distribution. For skeleton-building corals and other invertebrates, increased CO_2 absorption by the ocean will decrease carbonate accretion rates leading to weak skeletons. The general end result of these predicted changes is loss of coral reefs and decreased availability of fisheries. There will be regional and geographic variations of global climate change impacts based on reef types, island size and reef development. This underlines the need for area- and American Samoa-specific vulnerability assessment of climate change impacts. There has been no formal vunerability assessment of the Territory's coral reefs to global climate change nor predictive studies on the impact of such changes and this is a priority research area that is highlighted in this document. These general threats to the marine fauna are more detailed for the respective species of greatest concern. The terrestrial taxonomic groups in the Territory are much more limited than the marine fauna. Consequently, the threats to terrestrial wildlife are discussed for every species or species group and therefore their discussions are incorporated with their faunal descriptions.

The results of rankings based on guidelines expounded on in Section 2.3 for terrestrial vertebrate species and marine species are summarized in Appendix 2 and 3. Classes I, II, and III are three main classes of species that warrant particular concern. Very few terrestrial invertebrate species have sufficient data for ranking. Hence, although some are identified as high priority species (see subsections 3.1, 5.1, 5.2, & 5.3) their few numbers did not warrant inclusion in the Table.

3.2 THE TERRESTRIAL FAUNA AND CONSERVATION THREATS

3.2.1 INVERTEBRATES

3.2.1.1 INSECTS AND SIMILAR ARTHROPODS

There have been significant collections of insects in American Samoa, most of which have been summarized in Kami & Miller (1998). They found records of over 2500 species in the Samoan archipelago, of which a large subset occur in American Samoa, but of course these numbers almost certainly underestimate total diversity. For example, even limited trapping on Tutuila can result in the capture of at least one heretofore undescribed species (M. Schmaedick, ASCC Land Grant, *pers. comm.*). The level of diversity and endemism in American Samoa is depauperate by insect standards (Wilson & Taylor 1967, Adler & Dudley 1994, Bickel 1996, de Boer & Duffels 1996, Miller 1996, Morrison 1997). Nonetheless it is a daunting task to ascertain detailed habitat requirement, abundance or distribution data on a single species, let alone a substantial subset of the fauna (*cf.* Holloway [1996] for a summary of habitat association studies from a different island ecosystem, and Levings & Windsor [1982] for an example of seasonal and temporal fluctuations in populations). Recent work in American Samoa has focused on collections on Swains Island and Rose Atoll (DMWR *unpub. data* Peck et al. 2014), ants (Wetterer and Vargo 2003, Peck and Banko 2015), dragonflies (Marinov et al. 2015), butterflies (Patrick et al. 2010), and soil communities (Vargo 2000).

Perhaps because of their conspicuousness, Lepidoptera have been one of the better-studied groups in the territory, including data on habitat requirements and ecology (Swezey 1921, Hopkins 1927, Swezey 1942, Comstock 1966). There are also numerous endemic but somewhat cryptic moth species (Munroe 1996). Although most of the butterfly fauna in American Samoa consists of widespread species (Dudley & Adler 1996, Munroe 1996), there are several known endemic species, including the conspicuous (but seemingly not abundant, M. Schmaedick *pers. obs.*) *Papilio godeffroyi*. It is important not to neglect rare species, since they often have unique intrinsic characteristics that may affect their responses to conservation measures (Kunin & Gaston 1993).

Threats to insects and similar arthropods

Although there is no direct evidence on the current status of most insect species in American Samoa, there are several reasons to be cautiously optimistic. First, there remain significant areas of native habitats in the territory, so habitat specialists are unlikely to be threatened strictly due to habitat loss (*cf.* Raghu et al. 2000). Second, although there is local application of insecticides on agricultural crops, the areas devoted to this land use are still relatively limited, and there is active monitoring of pesticide usage by the American Samoa Environmental Protection Agency. Third, there is no timber industry, so there has been no recent broad-scale or aerial applications of pesticides. Fourth, many of the species on a remote archipelago such as American Samoa are expected to be generalists, which are in turn expected to represent the most abundant component of the insect fauna (Kitihara & Fujii 1994).

However, there are at least three significant threats to subsets of the insect fauna. The first are introduced and invasive ant species, which are well known as important drivers of ecosystem change (Madeiros et al 1986, Jourdan 1997). Since 2011 ASCC Land Grant and AS Department of Agriculture have conducted ongoing surveys for exotic invasive ants in areas at high risk for accidental introductions on the five high islands. These surveys have documented spread of the tropical fire ant (*Solenopsis geminata*) to all five islands and recent introductions of three additional *Monomorium* spp. on Tutuila. In other surveys, the litter dweller *Strumigenys eggersi* was detected for the first time (M. Schmaedick unpublished data, Peck et al. 2015) and found to be already widespread on Tutuila and Ta'u islands. It is possible other invasive insects may also have deleterious effects on the native insect fauna, although introduced insects do not necessarily cause declines even in closely related native species (Roubik & Wolda 2001). The second is the possible impact of the introduced toad *Rhinella marina* on ground arthropod species. This amphibian is currently widespread and very abundant on Tutuila, less abundant or absent from the other islands. However, since the current terrestrial arthropod fauna has already been subject to waves of invasive ant species, it may already consist primarily of a robust generalist fauna (Vargo 2000). Third, there is the threat of unintended consequences of insect species introduced as biological controls (Howarth 1991, Louda et al. 2003), a number of which have been introduced on various islands in American Samoa to control invasive plants or insects. There is particular reason to be concerned about the impact of such agents on butterfly species (Nafus 1992).

Conservation priorities for insects and similar arthropods

Given their conspicuousness and endemic status we classify *Papilio godeffroyi* as a high priority species and feature it in greater detail in subsection 5.1. Recommended actions for arthropods as a group are:

1. *Continue to develop a list of research priorities* on diversity, distributions, and conservation status assessments in collaboration with ASCC-Land Grant and the Department of Agriculture for consideration in subsequent revisions of this Strategy.

2. *Document the distribution of invasive ant species* in the territory, in part to locate potential refugia from these highly adaptable species (Tsutsui & Suarez 2003).

3. *Conduct insect surveys in selected habitats*, to ascertain the presence of potential habitat specialists that might also be imperiled by reductions in these habitats, and which might be expected to be rarer even within preferred habitats (Kitihara & Fujii 1994), and to generate predictive maps to guide further efforts to locate rare species (Wang et al. 2003). Also conduct surveys in areas targeted for conservation interventions, such as Swains Island (for possible rat eradication), to help document intervention outcomes.

3.2.1.2 CRUSTACEANS

Terrestrial and freshwater stream crustaceans are a conspicuous part of the fauna of oceanic islands such as American Samoa (Burggren & McMahon 1988, Cook 2004). Land crabs in particular may be key components of tropical terrestrial ecosystems (O'Dowd & Lake 1991, Green et al. 1997, Sherman 2002). On other islands land crabs have been the focus of intensive research (Hicks 1985, Lee 1985, Louda & Zedler 1985, O'Dowd & Lake 1990, Jimenez et al. 1994, Green 1997), but we were able to locate no published studies that had been conducted on this fauna in American Samoa (Knudsen et al. 1992).

Threats to terrestrial and freshwater crustaceans

Biological information of terrestrial and freshwater crustaceans is very limited. For this reason, it is impossible to pinpoint threats to the species other than those associated with human activities. The potential for overharvesting is high in those species that are edible and conspicuous, such as the coconut crab (*Birgus latro*). Pollution from waste water from piggeries and sewer systems, toxic (pesticide) runoff from farms, and improperly disposed solid waste compromise water quality and, therefore, the habitat of native freshwater fauna (such as crayfish). Recently discussed ideas for fresh-water shrimp farming in the Territory may also pose a threat to the native fauna if a) new (exotic) species are introduced, b) streams are modified for irrigation of pens or farms, and/or c) vegetative modification of streams are undertaken to increase food material for aquaculture.

Conservation priorities for terrestrial and freshwater crustaceans

Because of its large size (Burggren & McMahon 1988), potential ecological impact (Sherman 2002), cultural importance, history of overexploitation in other parts of its range (Chauvet & Kadiri-Jan 1999), commercial potential (priced at $25 each in local markets), and apparent rarity in American Samoa, we initially focus our conservation priorities on the coconut crab, *Birgus latro* (see subsection 5.2). With this exception, the following actions are recommended to address the preliminary conservation needs of crustaceans as a group:

1. *Develop research priorities* in collaboration with pertinent agencies and experts (such as ASCC-Land Grant) to facilitate development of a conservation plan for the taxonomic group. At the minimum, a thorough inventory of stream fauna (thus, also covering other faunal groups inhabiting streams such as freshwater fishes, eels, and snails), in the context of their basic ecology (e.g., physico-chemical parameters, zonation) must be conducted; and

2. *Rigorously review any proposal to set-up aquaculture projects* for itspossible impact on native fauna and the quality of the environment they inhabit.Additionally, DMWR should continue to provide technical advice and cooperative support to agencies tasked with minimizing pollution of freshwater bodies in the Territory, such as ASEPA and the NRCS/SWCDB.

3.2.1.3 GASTROPODS

In spite of its small land area, American Samoa has a diverse gastropod fauna in both freshwater streams and terrestrial habitats (Haynes 1990, Miller 1993, Cowie 1998). The land snail fauna includes a significant number of species endemic to the Samoan Archipelago (~42 of ~58 total species), several of which were newly discovered in American Samoa (Cowie 2001a). The diversity in freshwater gastropods is lower (at least 13 species known from Tutuila), none of which are unique to American Samoa (Haynes 1990).

A comparative analysis of information from various surveys spanning from the 1920s to the late 1990s show an alarming declining trend in populations of native species in contrast with generally increasing trends in populations of exotic species of land snails (Cowie 2001a). Several of the identified threats to the species are present in American Samoa, including the predatory snail, *Euglandina rosea*, and commensal rats; a predatory flatworm, *Platydemus manokwari*, has recently been introduced to Samoa and may find its way into American Samoa through (among others) imported agricultural products.[1] If these, and other threats, are not addressed, the potential loss in diversity will be great. Hence, endemic land snails (including arboreal species) are among the taxa of priority conservation concern (see subsection 5.3).

3.2.2 VERTEBRATES

3.2.2.1 HERPETOFAUNA: AMPHIBIANS, LIZARDS, AND SNAKES

The herpetofauna of American Samoa is relatively depauperate and consists largely of widespread and introduced or commensal species (Table 2; Allison 1996). It includes one introduced amphibian species, at least 13 species of terrestrial reptiles, and breeding populations of two marine turtle species. There are also pelagic records of at least two other marine turtle species: the leatherback (*Dermochelys coriacea*) and the Olive ridley (*Lepidochelys olivacea*) (Grant 1994; Utzurrum 2002). Amphibians, lizards, and snakes are profiled in the succeeding sections. The paucity of information on terrestrial species precludes a more specific description of status and threats to the three species of high conservation concern (see Table 1) in Section 5 (SPECIES OF GREATEST CONSERVATION CONCERN). In lieu of this, priority actions recommended for their conservation are incorporated in this section (see 3.2.1.5 below). The two breeding species of marine turtles are discussed in greater detail in Section 5.4 as species of priority concern: *Chelonia mydas* (green turtle) and *Eretmochelys imbricata* (hawksbill turtle) are listed Endangered under the US Endangered Species program.

Amphibians

There are no native amphibians in American Samoa. The introduced toad *Bufo marinus* is widespread and abundant on Tutuila, including on high ridges covered in native forest, but is absent or as yet uncommon in Manu'a, and absent from the two atolls. Although studies of the diet of this species in the territory suggest a significant arthropod component in the diet (Grant 1996; ASCC Land Grant, *unpub. data*), there is no data from American Samoa on the possible impact of this predation on the net abundances of the native arthropod fauna.

---

[1] R. Cowie (pers. comm.) was uncertain as to the source of recent information that *P. manokwari* is already in American Samoa (see Cowie 2005). However, P. Craig (*pers. comm.*) reported personally finding flatworms identified as *P. manokwari* in Tutuila Island (see also Cowie 2005). It is clear that additional confirmatory information or documentation is needed.

Snakes

Only one species of native snake occurs in American Samoa, the Pacific Boa *Candoia bibroni*. Although widespread and occasionally common elsewhere in the region (e.g., Fiji, *pers. obs*), in American Samoa this species is very infrequently encountered, is apparently rare, and is currently known only from Ta'u island (Amerson et al. 1982b). Although there are no recently developing threats to the species on Ta'u, which is still almost entirely covered in native vegetation, the restricted distribution and lack of detailed data on its distribution and abundance on Ta'u argue for further study of this species. There is the possibility that the Ta'u form represents a distinct subspecies, since all individuals collected have been extremely melanistic (Amerson et al. 1982b); genetic studies may be warranted in the future to explore this possibility. The soil snake *Ramphotyphlops brahminus* is a recent introduction to the territory, and is currently common and (based on anecdotal evidence) expanding its range on Tutuila.

Lizards

The most recent and exhaustive distributional surveys of geckos and skinks was conducted in American Samoa by Amerson et al. (1982a, 1982b). Schwaner (1980) determined life history information for several species, and a recent summary of the relationship between the fauna in American Samoa and elsewhere in Oceania is found in Allison (1996). Species present include five geckos, all of which are widespread in the region: *Gehyra mutilata*, *G. oceanica*, *Hemidactylus frenatus*, *Lepidodactylus lugubris*, and *Nactus pelagicus*. The skink fauna includes *Cryptoblepharus poeciloplurus*, *Emoia adspersa*, *E. cyanura*, *E. lawesi*, *E. nigra*, *E. samoense*, and *Lipinia noctua*. The only endemic species is *E. samoense*, a common and widespread species on Ta'u and Tutuila (Amerson et al. 1982b). The species with the most restricted distribution within the territory appear to be *E. adspersa*, which is apparently confined to Swains island, and *C. poeciloplurus*, which is known from very few specimens. Both of these species occur elsewhere in the region, and it is possible their distributions may be constrained by competition with other lizard species (Case & Bolger 1991).

Threats to the herpetofauna

The greatest threat to the native herpetofauna of the territory is likely to be loss of habitat. Although there remains a substantial area of native lowland forest in the territory, coastal forests, particularly those on Tutuila, are under significant pressure from human activities and habitat modification. Although most of the species found in American Samoa are good dispersers and can presumably recover from local habitat loss, even these generalist species can be constrained in their ability to rapidly colonize new areas (e.g., Cook et al.

2001). A number of the skink species are restricted to or prefer coastal habitats, including *C. poeciloplurus* and *E. lawesi,* making them susceptible to hurricanes and potentially less well-adapted to their local surroundings (Calsbeek & Smith 2004). Introduced predators are also a potential threat, but both cats and rats have been present in most of the territory for a significant time, and their impacts on the herpetofauna are unlikely to significantly increase. The exception is Swains Island, where cats have been introduced to control rats (W. Jennings, *pers. comm.*) since the surveys conducted by Amerson et al (1982a).

General Conservation Priorities

The lack of known, imminent threats on most islands downgrades the overall priority level of herpetofaunal studies. There are, however, three species that warrant priority attention, and the following actions are recommended to facilitate future conservation planning for this group:

1. *Update the status of the three high priority species*: *Candoia bibroni* (Pacific Boa), *Cryptoblepharus poeciloplurus* (Snake-eyed Skink), and *Emoia adspersa* (Micronesian Skink)

The severe damage to the forest habitat in Ta'u brought on by Hurricane Olaf (February 2005) may have had an impact on the Pacific Boa. Both species of skinks were noted as rare and/or of restricted distribution during previous surveys (Amerson et al 1982a).

2. *Re-assess the status of the Swains island herpetofauna*

Swains Island represents the last known habitat for rare and/or coastal species of skinks (Amerson et al 1982a). The introduction of cats to the island since the last previous surveys may have had adverse effects on the herpetofauna of the island.

3. *Prevent spread of introduced species, or new introductions*

Strict quarantine measures must be applied to prevent the spread of *Bufo marinus* to the Manua islands, and the introduction of the Brown Tree Snake (*Boiga irregularis*) to the Territory.

3.2.2.2 THE AVIFAUNA

Avifaunal diversity in American Samoa is depauperate by tropical standards (Diamond 1984, Keast 1996), but includes potentially endemic land bird (sub)species, a number of species found nowhere else in the territories of the USA, and potentially important breeding areas for certain widespread seabird species (Table 1). There are also a small number of migratory species that occur in the territory, including some shorebirds, seabirds and *Eudynamys taitensis*. Due to low numbers observed, strictly pelagic occurrence patterns, and/or the limited habitats available for these species in American Samoa, they are omitted from priority consideration. For consistency, where possible all taxonomic affiliations follow those used in Handbooks of the Birds of the World: del Hoyo et al. (1992), Gochfeld & Berger (1996), Taylor (1996), Baptista et al. (1997), Collar (1997), Chantler (1999), Bruce (1999) and Woodall (2001).

A number of studies and surveys have been conducted on the resident avifauna of American Samoa. Results of early collecting trips by the Whitney South Sea Expedition and others are summarized in Banks (1984). Baseline distributional and abundance information is presented in Amerson et al (1982a, 1982b), Engbring & Ramsey (1989), Pyle et al. (1990), and Trail et al. (1992). More recent survey results can be found in Freifeld (1999), Utzurrum & Seamon (2001), O'Connor & Rauzon (2003), and Freifeld et al. (2004). Regional distribution data were determined from species accounts in Harrison (1983), Pratt et al. (1987), Stattersfield et al (1998), Watling (2001), and US Fish & Wildlife Service (2005).

There are numerous ongoing studies of the American Samoan avifauna, particularly on land bird species. Distributions and abundance estimates have been obtained in several ways. DMWR has been conducting DISTANCE-based VCP transects for forest bird species for more than 25 years and these data provide a reliable baseline for detecting any long-term or climate-related trends in abundances of the Passerine species in the territory (Freifeld et al. 2004). DISTANCE-based point surveys have also been conducted, which were designed to survey Columbiform and other highly mobile frugivorous species. Recent mark- recapture studies have greatly enhanced our knowledge of the distributions and abundances of the Manu'a forest avifauna, particularly *C. vitiensis*, *G. stairii*, and *V. australis*, as well as documenting long-term survival patterns on Tutuila (*unpub. DMWR data*). These methods may also provide a basis for detecting possible shifts in habitat associations over time (O'Connor 1986), a not unexpected pattern when major changes in bird abundance are caused by catastrophic disturbances such as hurricanes.

The Tropical Monitoring of Avian Productivity and Survivorship (TMAPS) program in collaboration with the Institute for Bird Populations, was initiated on Tutuila Island in 2012 in order to fill knowledge gaps on the ecology, population status, and conservation needs of landbirds in American Samoa. The project was expanded to Ta'u Island in 2013, and to Ofu and Olosega islands in 2015-2016, and aims to provide annual estimates of adult population size, survival, post-fledging productivity, and recruitment. The project also aims to relate avian demographic data to weather and habitat. The TMAPS program, which applies standardized, constant-effort mist netting and modern capture-recapture analytical techniques, has filled substantial information gaps about the basic biology of Pacific island landbirds, particularly relating to their life-histories, molt strategies, age/sex-determination criteria, and nesting phenology. For example, we found that annual adult survival rates using transient and non-transient models were relatively high (i.e. 0.625 for Pacific Kingfisher, 0.655 for Polynesian Wattled Honeyeater) compared to survivorship estimates among comparable MAPS stations in North America (which vary between 0.40 and 0.55 for most species). Higher survival rates are to be expected among resident tropical species that do not have to migrate and generally are subject to stable climate and food resources. Data collected has also resulted in a publication (Pyle et al. 2016) and manual that may be used by future studies and researchers on how to accurately age and sex individuals in the field.

A corollary goal of the establishment of the new stations on Ofu-Olosega was to gather information on the small population of shy ground doves residing on these islands. Our capture of 17 individuals and one additional recapture has enabled us to confirm age and sex criteria for this species in American Samoa, and has provided critical information on breeding condition, biometrics, and weights, which will allow us to undertake further studies on this population during future seasons. Our current goal is to collect feather, blood, and swab samples from shy ground doves during the 2017 season to investigate genetic differentiation, pathogens, and diet, to use playback experimentation to help monitor populations, and to apply tracking devices in order to better understand home-range sizes, movement patterns, population size, and nesting behavior. This information will be applied to the management of this population, which was listed as Endangered in October of 2016.

A number of the bird species that occur in American Samoa are widely distributed or have congeners throughout the Pacific region. In many cases, data obtained elsewhere or on closely related taxa may well be generalizable to American Samoan populations. Examples of such recent studies include those on foraging ecology (Surman & Wooller 2003), movements (Day et al. 2003), abundances (Bull et al. 2002), physiology (Schleucher & Withers 2002), habitat use (Craig & Beal 2001) and distributions within archipelagos (Freifeld et al. 2001). However, continued studies on the landbirds in American Samoa is needed to monitor population trends. Birds are sensitive indicators of environmental quality and ecosystem health (Morrison 1986, Hutto 1998). Most broad-scale bird monitoring has involved counts of birds to index abundance and estimate trends (Bart 2005), but monitoring of demographic rates (including productivity, recruitment, and survival) is needed to infer actual causes of population changes (DeSante et al. 2005). Because demographic rates are directly affected by environmental stressors or management actions, they can more-accurately reflect short-term and local environmental changes (Temple and Wiens 1989, DeSante and George 1994). The need for such approaches is pressing given the many potential threats to the persistence of Pacific insular populations such as habitat loss, avian disease, and exotic predators.

DMWR studies completed in the last 10 years

Short- and Long-term Resource Use by the Pacific Imperial-Pigeon

Seamon, J. O., V. Vaivai, A. Tualaulel'ei, and R. C. B. Utzurrum. Short-and-long term resource use by a generalist frugivore, the pacific imperial-pigeon. 2010. DRAFT1 ASG-DMWR Report #56665-2010-1.

A long term study was conducted in order to systematically document resource use by the pacific imperial pigeon (*Ducula Pacifica)* over ten years at six different sites throughout the Island of Tutuila. This project assessed the potential role of the pacific imperial-pigeon in structuring the plant communities in Tutuila by 1) visually collecting data on plant resource use over a decade and 2) examining short-term resource use by comparing gastro-intestinal contents from 26 birds collected over two days with two independent measures of concurrent resource availability. The study documented use of at least 29 plant species, including flowers and leaves and results suggest that the pacific imperial-pigeon is important for dispersal for many native and introduces species.

Coexistence and Long-term Population Dynamics of Three Frugivorous Birds

Seamon, J. O., R. C. B. Utzurrum, A. Tualaulelei, S. Fa'aumu, V. Vaivai, and R. Meyer. 2010. Coexistence and long-term population dynamics of three frugivorous birds. DRAFT2 ASG-DMWR Report #56665-2010-2.

Three frugivorous bird species (Many-colored Fruit Dove, Pacific Imperial Pigeon, and Samoan Starling) were studied utilizing monthly data taken over a decade across six survey sites on Tutuila. Densities for each species were estimated using distance methods, and abundances by using GIS to determine sampled areas. Temporal dynamics in abundances were modeled using time series methods and forecasts were created to predict abundances. The study found that Many-Colored Fruit Dove was not abundant even at sites where it regularly occurred, and was unsuitable for abundance estimation using Distance methods. There was significant variation in long-term mean abundances of the three species among the six sites (Leone, Nuuuli, Amalau, Malaeimi, Masausi, Maloata).

Effects of Climate and Land Use on Diversity, Prevalence, and Seasonal Transmission of Avian Hematoza in American Samoa

Atkinson, C. T., R. B. Utzurrum, J. O. Seamon, M. A. Schmaedick, D. A. LaPointe, C. Apelgren, A. N. Egan, and W. Watcher-Weathermax. 2016. Effects of climate and land use on diversity, prevalence, and seasonal transmission of avian hematozoa in American Samoa. Technical Report HCSU-072. Hawai`i Cooperative Studies Unit University of Hawai`i at Hilo.

The study documented diversity of vector borne parasites on Tutuila and Ta'u Islands over a 10-year period to expand earlier observations of *Plasmodium*, *Trypanosoma*, and filarial parasites, to provide better parasite identifications, and to create a better baseline for detecting new parasite introductions. They also identified potential mosquito vectors of avian *Plasmodium* and *Trypanosoma*, determined whether land clearing and habitat alterations associated with subsistence farming within the National Park of American Samoa can influence parasite prevalence, and determined whether parasite prevalence is correlated with seasonal changes in rainfall, temperature and wind speed.

Three taxonomically distinct lineages of *Plasmodium* were identified from mosquito vectors and forest birds based on partial sequence data from parasite mitochondrial genes. All three have been described from passerine and galliform birds in Australasia. Two lineages, SCEDEN01 and ORW1, had elongate gametocytes and large schizonts that were consistent with species of *Plasmodium* in the subgenus *Giavannolaia*, but were taxonomically distinct from known morphological species of *Plasmodium* based on a Bayesian phylogenetic analysis of a 478 bp region of the parasite cytochrome b gene. Both are candidates for description as new species. The third lineage (GALLUS02) was detected only in mosquito vectors on Tutuila and was similar in cytochrome b sequence to *P. juxtanucleare*, a pathogenic species of *Plasmodium* from chickens and other galliform birds from Australasia, Africa, and South America. *Plasmodium relictum*, the malarial parasite that has had such a devastating impact on Hawaiian forest birds, was not detected. They observed large, striated trypanosomes in avian hosts from both Tutuila and Ta'u Islands that fell within the same taxonomic clade as *T. corvi* and *T. culicavium* based on 18S ribosomal DNA sequence. They also observed sheathed microfilariae with pointed tails that had some morphological similarities to microfilaria from species of *Pelecitus, Struthiofilaria and Eulimdana*, but identification will require recovery and examination of adult filarial worms from the connective tissue or body cavities of infected birds. They also observed one or more species of *haemococcidians* (Isospora , synonym = Atoxoplasma) within circulating lymphocytes from multiple avian host species.

Overall prevalence of *Plasmodium* was higher on Ta'u (22%, 75/341) than Tutuila (9.2%, 27/294), with most infections occurring in Polynesian starlings, Samoan starlings, Wattled honeyeaters, and Cardinal honeyeaters. Prevalence was relatively constant from year to year and between seasons at individual study sites, but varied among study sites, with highest rates of infection in areas with agricultural activity at Faleasao (37.4%, 73/195, Taʻu Island) and Amalau Valley (9.7%, 21/216, Tutuila Island). Prevalence in more remote areas of the National Park of American Samoa was lower, ranging from 1.4% (2/146) at Laufuti and Luatele on Taʻu to 7.7% (6/78) at Olo Ridge on Tutuila. Similar trends were evident for infections with *Trypanosoma* and filarial worms. Overall prevalence was not influenced significantly by warmer, wet (summer) or cooler, dry (winter) season.

They detected Plasmodium infections in *Culex sitiens* and *C. quinquefasciatus* through either salivary gland and midgut dissections or PCR amplification of parasite cytochrome b genes in pooled or individual samples of mosquitoes that were collected on Tutuila. Pooled or individual *Aedes oceanicus, A. polynesiensis, A. tutuilae, A. upolensis, A. nocturnus, Aedes* (Finlaya) (mixed pools of *A. samoanus, A. oceanicus, A. tutuilae*), *Aedes (S. tegomyia*) (mixed pools of *A. aegypti, A. upolensis, A. polynesiensis*), and *C. annulirostris* were negative for *Plasmodium* , but they detected infections with *Trypanosoma* through midgut and salivary gland dissections in a single *C. sitiens* from Amalau Valley, Tutuila and three *A. oceanicus* from Faleasao, Taʻu. Two of the *A. oceanicus* from Faleasao amplified successfully with *Trypanosoma* primers, but sequences were distinctly different from those obtained from avian hosts.

The project found a strong association between land use and prevalence of mosquito-transmitted parasites on Taʻu Island with odds of being infected more than 20 times greater in agricultural plots than more remote native forest. This relationship was evident on Tutuila Island but not statistically significant because of the close proximity of study sites and observed movement of birds between native forest and agricultural land. Our data support previous studies that have suggested that *Plasmodium* and other vector-borne parasites are part of the indigenous parasite fauna in American Samoa. Transmission dynamics appear to be affected by environmental changes associated with land use practices.

Evolutionary Origins of the Samoan Avifauna

Modak, T. 2011. Evolutionary origins of the Samoan avifauna. MA Thesis. Boston University.

This study used DNA sequences of the mitochondrial ND2 gene to reconstruct the phylogenetic relationships of common Samoan land bird species (starlings, shrikebills, fantails, honeyeaters, kingfishers, whistlers, white-eyes) along with closely related taxa in American Samoa and neighboring islands. All but one, Samoan Fantail (Rhipidura nebulosi), of the Samoan populations sampled forms a genetically distinct, monophyletic lineage. For example, wattled honeyeaters (Foulehaio carunculata) in Samoa are 4.8% divergent in ND2 sequence from wattled honeyeaters in Vanua Levu, Fiji, suggesting long-term isolation and independent evolution. While nine of the ten Samoan populations sampled are genetically distinct, the depth of historical divergence from the most closely related population elsewhere varies greatly among taxa. In addition, tree topologies for different taxa do not conform to a common evolutionary or biogeographic history, although birds from nearby Fiji are often the closest relatives of Samoan birds. These results suggest that each lineage has had its own idiosyncratic history and that the assembly of the Samoan avifauna has proceeded gradually over time. The genetic distinctiveness of Samoan species warrants a reevaluation of their taxonomy and heightens concerns for their conservation. The comparative phylogenetic analyses showed that the Samoan birds lack a common evolutionary and biogeographic history. Multiple colonization events over an extended period of time from various sources likely led to the assembly of the current diversity of avian species in the Samoan Islands. These results are consistent with the theory of island biogeography, which envisions the accumulation of species on oceanic islands as a stochastic process that continues over time and eventually leads to ongoing turnover as old species go extinct and new species arrive.

3.2.2.3 MAMMALS

Terrestrial mammals

Discounting domestic animals, there are eight species of terrestrial mammals present in islands of American Samoa. Of these, three are indigenous bats, four are exotic murids (*Mus musculus*, *Rattus exulans*, *R. norvegicus*, and *R. rattus*), and one is a feral pig (*Sus scrofa*) that is considered to be a Polynesian introduction.

The three native mammals are all members of the Order Chiroptera: *Emballonura semicaudata semicaudata* (Family Emballonuridae), and *Pteropus samoensis* and *P. tonganus* (Family Pteropodidae). All three species are considered of conservation concern, with *E. semicaudata, which was listed as Endangered under the ESA in September 2016,* possibly extinct in the Territory and deserving the highest priority action.

The introduced species, on the other hand, are of concern due to their potential impact on native species or the habitat. Introduced rats may prey on most ground nesting birds, and recent works have documented their presence in high elevation areas where native species-of-concern (sea birds and the spotless crake) are known to occur and/or nest. The impact of feral pigs on forest regeneration and seedling survivorship in native habitats, added to the possibility that they may facilitate dispersal of invasive plants, has led the NPAS to conduct regular removal trapping in Park areas in the past (R. Cook, *pers. comm.*). The degree of threat or impact of these introduced species should be determined so that appropriate control or mitigation may be established.

Marine mammals

The dearth in scientific information on species and abundances of marine mammal species occurring in American Samoa in the face of: a) global concerns for the status of marine mammals; b) efforts to establish regional conservation and protection programs particularly for migratory species (SPREP, 2005); and c) a local initiative declaring Territorial waters as marine mammal and turtle sanctuaries (American Samoa Government Executive Order No. 005-2003) has elevated this group into the American Samoa's list of Species of Conservation Concern (see Subsection 5.10). Following is an overview of the diversity in the region, in general, and in waters surrounding American Samoa, in particular, as excerpted from the Dolar (2005) report commissioned by DMWR:

"To date, 33 marine mammal species have been reported to occur in the tropical South Pacific either as resident, seasonal migrant or occasional visitor. The list includes 30 species of cetaceans, one sirenian and two species of pinnipeds (Reeves et al., 1999). Most populations of the commercially important large whales have been greatly reduced by whaling, and hunting of medium-sized and small cetaceans still occurs in some areas in the South Pacific Ocean (*e.g*. the Solomon Islands) (Reeves, et al. 1999, Dawbin, 1984; Kahn, 2004).

Of the 33 species of marine mammals recorded present in the region, thirteen have been confirmed from the waters surrounding the islands of American Samoa. Two of these are mysticetes: minke whale (*Balaenoptera acutorostrata or B. bonaerensis*), and the humpback whale (*Megaptera novaeangliae*)*;* the remaining eleven are odontocetes: sperm whale (*Physeter macrocephalus*), short-finned pilot whale (*Globicephala macrorhynchus*), killer whale (*Orcinus orca*), common bottlenose dolphin (*Tursiops truncates, Tursiops aduncus),* pantropical spotted dolphin (*Stenella attenuata*), spinner dolphin (*Stenella longirostris)* (Reeves et al., 1999), striped dolphin (*Stenella coeruleoalba*) rough-toothed dolphin (*Steno bredanensis*), Cuvier's beaked whale (*Ziphius cavirostris)* (Utzurrum pers, comm.; Craig, 2005) and false killer whale (*Pseudorca crassidens*) (Craig, 2005).

3.3 THE MARINE FAUNA AND CONSERVATION PRIORITIES

3.3.1 THE MARINE INVERTEBRATES

Various marine invertebrates are fished for both subsistence and commercial fisheries. Marine invertebrates threatened by habitat degradation, predation and global climate change impacts. The species of greatest concern are two species of giant clams, three holothurians or sea cucumbers and the 5 hard corals now listed as threated under the Endangered Species Act.

There are three native species of giant clams ('faisua'): *Tridacna maxima*, *T. squamosa* and *Hippopus hippopus*. *Tridacna derasa* was introduced to the Territory during a giant clam mariculture project in the 1980's. '*Faisua*' is a delicacy in Samoan culture and they are highly exploited. Giant clams owing to their photosynthetic symbionts are mostly found in coral reefs that receive adequate sunlight. Radtke (1985) estimated the population size and density, age structure, growth rate, maturity and mortality of *T. maxima* in Rose Atoll. Green and Craig (1999) surveyed *T. maxima* in six islands including Rose Atoll. The NOAA CRED conducted macroinvertebrate surveys that included giant clams in 2002, 2004, and 2006. Green and Craig (1999) and Radtke (1985) showed that *T. maxima* populations have slow turn-over rate and clams have slow individual growths. Both studies showed that Rose Atoll has relatively high densities. The NOAA CRED data showed that Tau had the highest densities in 2002, 2004 and 2006. The inner lagoon of Rose Atoll also had high densities of giant clams. Most of the recorded clams were *T. maxima*. *T. squamosa* are occasionally recorded in the commercial spearfisheries. *Hippopus hippopus* abundance is very low based on anecdotes of a few shells found in the Territory.

There are 9 species of holothurians recorded in American Samoa. Lawrence (2014, unpublished) reported that four species, namely, *Holothuria whitmaei*, *Actinopyga mauritiana*, *Stichopus chloronotus*, *Holothuria atra*, were harvested commercially in the last 2 years. Holothurians are found in various habitats in coral reefs. The governor passed an executive order banning the commercial harvest of holothurians. There have been reports of continued violations and it is suspected that the trade has gone underground. The species of greatest concern are *Holothuria fuscogilva*, *Holothuria whitmaei*, and *Actinopyga mauritiana*, all of which have been listed as threatened by IUCN.

Dr. Douglas Fenner has recorded over 200 species of corals in American Samoa. The six hard corals that have been listed as threatened under the Endangered Species Act are: *Acropora globiceps*, *Acropora speciosa*, *Acropora retusa*, *Isopora crateriformis*, *Euphyllia paradivisa* and *Pavona diffluens*. All of these corals have been deduced to have declined in abundance for the last 50 to 100 years although no species-specific information are available.

Acropora globiceps is a digitate coral that is known to occur on upper reef slopes, reef flats and adjacent habitats from 0 to 8 m in water depth. This coral is fairly common in American Samoa. Its morphology is similar to 6 other species, taxonomy being an underlying issue in corals. *Acropora speciosa* has a morphology described as thick cushions or bottlebrush branches. It is known to occur on lower reef slopes and walls. It has been observed to be similar in appearance to two other corals. Its depth range is 12 to 40 meters, and has been found in mesophotic (>100 m depth) habitats. *Isopora crateriformis* form encrusting plates to over a meter in diameter. There is a moderate level of taxonomic uncertainty for this coral. Veron (2014) stated that *I. crateriformis* can be easily confused with *I. cuneata*. This coral is commonly in shallow, high-wave energy environments, from low tide to at least 12 meters deep, and has been reported from mesophotic depths. *I. crateriformis* is one of the most common species on upper reef slopes of southwest Tutuila Island. Both *E. paradivisa* and *P. diffluens* are very rare in the Territory. *E. paradivisa* is a sub-massive coral and its habitat is shallow or mid-slope reef environments protected from wave action, from five to 20 meters depth. *P. diffluens* is a sub-massive coral that looks similar to two other species of *Pavona*. It is known to occur in upper reef slopes, mid-slopes, lower reef crests, reef flats, and lagoons, in depths ranging from five to at least 20 m. Colonies of *Acropora retusa* are flat plates with short, thick finger-like branches, with the branches appearing rough and spiky because its radial corallites are variable in length. Colonies are typically brown or green in color. This coral is a hermaphrodite, containing both male and female gametes. *Acropora retusa* occurs in shallow reef slope and back-reef areas, such as upper reef slopes, reef flats, and shallow lagoons, and its depth range is 0 to 5 meters. It is a rare coral.

Threats to marine invertebrates

Overexploitation is the main threat to the giant clams and sea cucumbers in the Territory. Other threats include habitat degradation, sedimentation and global climate change. Giant clams thrive in clear, oceanic waters that can be negatively impacted by high sedimentation with run-offs from high-islands like Tutuila Island. Giant clams also harbor photosynthetic symbiotic zooxanthellae that are expelled when stressed during bleaching events triggered by increased water temperature.

The commercial fishery of the holothurians has spread from the Southeast Asian region to remote Pacific areas like American Samoa and Hawaii. This indicates a trend of overexploitation fishery expansion to countries that are remote from the main Chinese market and areas with no historic commercial fishery of sea cucumbers.

The ESA-listed threatened corals have been deduced to be vulnerable to ocean warming, disease, ocean acidification, trophic effects of fishing, nutrients, and predation, sedimentation, sea-level rise, and collection and trade. In American Samoa, predation by crown-of-thorns starfish, sedimentation and sea-level rise are probably the biggest short-term threats.

Marine invertebrates' general conservation priorities

1. We propose ***to conduct active coral reef restoration methods*** to mitigate the impacts of marine threats. The coral reef restoration should include restocking and development of hatcheries. For example, hatcheries for giant clams have been developed in several sites in the Pacific and re-stocking of hatchery-produced giant clams have been successful. We also propose to develop ocean nurseries for corals where we will re-grow colonies from fragments. These re-grown colonies will subsequently be transplanted to denuded reefs. We have already adapted this technology to a limited extent in the Territory and propose to expand the implementation.

2. We propose ***to conduct vulnerability assessment of islands and coral reefs and predict area-specific impacts of global climate change*** in the Territory. This assessment will help identify resilient areas and prioritize areas of conservation. In addition, this plan will continue to support an ecosystem or ridge-to-reef approach to conservation and management of marine protected areas that are already in place in the Territory.

3. We propose ***to develop a program to eradicate coral reef predators***. The Territory has been hit by an outbreak of the crown-of-thorns starfish for the last four years. We will conduct the eradication in collaboration with various government agencies. The proposed program will also involve the AS Environmental Protection Agency as COTS outbreaks have been hypothesized to result from significant nutrient influx to coral reefs.

4. There is a need ***to conduct basic life history research*** on these invertebrates of concern. Basic research on growth rate, longevity, reproduction, recruitment, population structure and distribution are critical to our understanding of ther biology and the threats they are facing.

3.3.2 THE MARINE FISHES

3.3.2.1 OCEANIC FISHES

Wass (1984) recorded 991 fish species in American Samoa, 45 of which are considered pelagic surface fishes. The Pelagic Fisheries Ecosystem Plan by the Western Pacific Regional Fisheries Management Council lists 30 pelagic species as management units: 7 tuna and tuna-relative species, six billfishes, 9 sharks, three squids, dolphinfish, moonfish, wahoo, oilfish and pomphret. Their designation as management units reflect their status as important to the pelagic fisheries. The species of concern are the big-eye tuna *Thunnus obesus*, the striped marlin *Kajikia audax*, the silky shark *Carcarhinus falciformis* and the oceanic white tip *Carcarhinus longimanus*. Both the big-eye tuna and the striped marlin constitute minor contributions to the longline fishery based in American Samoa that mainly targets the Southern Pacific albacore *Thunnus alalunga*. The silky shark and the oceanic white tip shark are by-catches of the longline fishery. There is currently a zero-retention for sharks in the US fleets of longline and purse seine fisheries. These sharks, however, are targeted by the pelagic fisheries in other countries. The current stock assessments by the Science Committee of the Western and Central Pacific Fisheries Commission for the big-eye tuna, the striped marlin, the silky shark and the oceanic white tip shark indicate that these stocks are overfished and experiencing overfishing.

The big-eye tuna (BET) has similar latitudinal distributions with the yellow-fin tuna (YFT). BET, however, has evolved to exploit cooler, deeper and more oxygen poor waters and when compared to YFT is pointed as an example of adaptive niche partitioning. This has been accomplished through a combination of physiological and behavioral thermoregulation and other anatomical adaptations (Lowe et al. 2000; Fritsches and Warrant 2001). The BET has life history traits characterized by rapid growth during the juvenile stage, movements between temperate and tropical waters to feed and spawn, equatorial spawning with high fecundity, preference for cool water foraging and a protracted maturity schedule, an extended life span and the potential for broad spatial movements.

Maximum fork length of BET is about 200 cm. The growth of juveniles appears to depart somewhat from von Bertalanffy type growth with the growth rate slowing between about 40 and 70 cm FL (Lehodey et al. 1999). BET becomes reproductively mature at 100 cm (around 3 years old) and 100% of individuals >120 cm are sexually mature. As with other tunas, sex ratio changes at sexual maturity with more males at larger sizes. Spawning occurs throughout the Pacific the whole year in tropical waters with water temperatures above 24°C and seasonally at higher latitudes (Kume 1967; Miyabe 1994). The highest reproductive potential was considered to be in the EPO based on size frequencies and catch per unit of effort inferred abundance (Kikawa 1966). It has been suggested that sexual maturity, or more accurately, the development into active spawning condition appears to be linked to mixed layer water temperatures above 26E C (Mohri 1998). Hisada (1979) reported that BET require a mixed layer depth of at least 50 m with a sea surface temperature (SST) of at least 24°C. Estimates of natural mortality for bigeye tuna is 0.5 yr^{-1} for >40 cm FL (Hampton 2000). Maximum age is around 16 years.

Analysis of mtDNA and microsatellites did not reveal significant genetic differentiation in the Pacific Ocean (Grewe and Hampton 1998). This is consistent with taggin experiments, some of tagged bigeye tuna traveled 4,000 miles. However, majority of those tagged were recaptured much closer to their release points (Schaefer and Fuller 2002; Hampton and Williams 2005). It is hypothesised that while bigeye tuna in the far eastern and western Pacific may have relatively little exchange, those in the central part of the Pacific between about 180° and 120°W may mix more rapidly over distances of 1,000 – 3,000 nautical miles. Like many tunas, BET exists as 'semi-discrete' stocks with most fish tending to stay close around islands, atolls and seamounts with some fish moving wider distances. The combination of relative site-fidelity, longer lifespan, slow growth, bigger sizes at sexual maturity, and fishing pressure makes big-eye tuna more vulnerable than yellow-fin tuna.

The striped marlin *Kajikia audax* has a distribution extending through equatorial to temperate waters with highest catch rates within subequatorial and subtropical areas in the Pacific Ocean (Nakamura 1985). Most catches of striped marlin have been reported from surface waters less than 100 m deep (Brill et al. 1993, Domeier et al. 2003). The striped marlin is vulnerable to surface fisheries (longline, recreational and purse seine method fisheries) from a relatively young age. There is little data on the biology and ecology of striped marlin as a result of their relatively low abundances, low catch rates, highly mobile nature and low priority for research funding.

Based on the observed distribution of larval striped marlin, spawning occurs between November and December in the southwest Pacific Ocean (10–30ºS) (Nakamura 1985). Striped marlin displays very high initial growth rates, attaining up to 45% of their maximum size in the first year of life (Melo-Barrera et al. 2003) and perhaps 70-75% of their maximum size by the second year of life (Kopf et al. 2009, 2011). Growth rates slows down following the onset of maturity (Melo-Barrera et al. 2003, Kopf 2009) at around 140–180 cm fork length, 27–40 kg weight and at approximately 2 years of age (Skillman and Yong 1976, Nakamura 1985, Kopf 2011). Sexual differences in growth rates have been reported, and females tend to be heavier than males (Kopf et al. 2011). Striped marlin live for at least 10–12 years (Melo-Barrera et al. 2003, Kopf et al. 2005, 2011) and can exceed more than 300 cm (lower jaw–fork length, LJFL) and 240 kg. Estimated natural mortality rates (M) vary between sexes, being lower in males (0.57–0.79 year-1) than females (0.82–1.33 year-1) (Boggs 1989, Hinton and Bayliff 2002). Large striped marlin tends to move further into temperate regions on a seasonal basis. However, current tag-recapture data suggest some level of broader sub-regional fidelity (Bromhead et al. 2004).

The silky shark *Carcarhinus falciformis* is a circumtropical species found in tropical waters of the Pacific Ocean. It is found in the coastal and oceanic waters of the Western and Central Pacific Ocean and one of the most commonly caught sharks in the tropical tuna fisheries

(Clarke et al. 2011a). There is limited data on the biology, ecology and movement patterns of silky sharks (Bonfil 2008). Available data indicates that silky sharks show a preference for warmer tropical waters above 23˚C (Last and Stevens 1994). For the first few years of its life, silky sharks in the Pacific Ocean lead demersal/semipelagic lifestyles usually associated with reefs and deeper parts of the continental and insular shelves before moving to more offshore and pelagic environments as sub-adults (Bonfil (2008). Silky sharks then switch to a more oceanic habitat at around 130 cm in total length, where they often join schools of large pelagic fish (such as tuna) and may disperse seasonally from the equator to higher latitudes (Strasburg 1958, Bonfil 2008). Adult silky sharks are known to return seasonally to feed and reproduce in shelf waters although near term pregnant females and neonates are also found in oceanic waters (Bonfil 2008). The silky white shark is viviparous with placental embryonic development with 8-10 pups per litter and a 9-12 month gestation period with pups with a sex ratio of 1:1 (Oshitani et al. (2003). Newborn silky sharks size at birth is 63.5 cm (Joung et al. 2008). Spawning season in the Pacific spans over much of the year (February- August) (Branstetter 1987, Bonfil et al. 1993; Bonfil 2008). There is a positive correlation between maternal size and litter size (Cadena-Cárdenas 2001, Oshitani et al. 2003). Estimated sizes at 50% maturity for silky sharks in the western Pacific are 212.5 cm TL for males and 210-220 cm TL for females (Joung et al. 2008). The Von Bertalanffy growth coefficient (k) ranges from 0.08 to 0.15 with a longevity of 36 years for females. The population intrinsic rate of increase and natural mortality are 0.102 and 0.17-0.21 respectively (Cortés, 2002).

The oceanic whitetip shark *Carcarhinus longimanus* is a circumtropical species found in tropical waters of the Pacific Ocean. This shark was once considered one of the most common sharks in all tropical oceans of the world (Bonfil et al. 2008). It is frequently caught in commercial fisheries and their fins command high commercial value (Bonfil et al. 2008; Clarke et al. 2005, 2006). The oceanic whitetip shark is truly oceanic and show a clear preference for the open ocean water between 10˚S and 10˚N, but can be found in decreasing numbers out to latitudes of 30˚N and 30˚S with decreasing abundance with increasing proximity to continental shelves (Backus et al. 1956, Strasburg, 1958; Compango, 1984, Bonfil et al. 2008). Little is known about possible migration paths for oceanic whitetips in the Pacific although tagging studies in the Atlantic ocean indicate movement along the equator and from southern latitudes (off Brazil) to the equator (Kohler et al. 1998, Bonfil et al. 2008). The oceanic whitetip is viviparous with placental embryonic development, an average fecundity of 6 pups per female and a 9-12 month gestation period (Seki et al. (1998). Estimated sizes at maturity are 168-196 cm for males and 175-189 cm TL for females. Seki et al. (1998) found a weak positive correlation between maternal size and litter size. Seki et al. (1998) estimated a growth coefficient of k=0.103 corresponding to a theoretical $L\infty$ of approximately 340 cm (TL) which corresponds to an age of approximately 36 years. Oceanic whitetip growth rate is considered slow compared to other pelagic sharks, namely blue, mako, and silky (Branstetter, 1990). In the Pacific, oceanic white tips reach sexual maturity after about between 4-7 years (170-200 cm). Estimates of the intrinsic rates of increase range from 0.081 to 0.11 (Smith et al. 1998, Cortés, 2002). Overall the biology of oceanic white tip, indicates a species with low resilience to fishing – even among shark species - and minimal capacity for compensation.

3.3.2.2 CORAL REEF AND NEARSHORE FISHES

Out of the 991 fish species by Wass (1984), 890 are considered shallow-water or reef inhabiting fish. The fish species of concern are:

1.) The humphead wrasse *Cheilinus undulatus* is the largest member of the wrasses family Labridae. It attains a maximum size of over 200 cm. It is usually not common in coral reefs, even relatively rare in undisturbed habitats. It is a protogynous hermaphrodite fish and forms pair-spawning and aggregations. It attains sexual maturity at 5 to 7 years of age and males live up to 25 years and females up to 30 years. So unlike many other coral reef fishes, the humphead wrasse attains sexual maturity at 20% of its maximum size. Juveniles are mostly found in high coral reef cover. Growth is very rapid and indeterminate among males. Growth in females seem to asymptote around 15 years. Because of its naturally low abundance, aggregative spawning behavior and relative slow sexual maturity, it is sensitive to even slight fishing pressure. Life history data has been limited and Choat et al. (2006) suggested additional and more detailed analysis of demographic and abundance in other areas.

2.) The bumphead parrotfish *Bolbometopon muricatum* is the largest member of the parrotfishes (family Scaridae) growing up to 130 cm and weighing 46 kg. Adults develop a bulbous forehead and their teeth plates are exposed, partly covered by fleshy lips). Owing to its corallivorous diet, it is an important coral reef bioeroder and species of ecological significance on ecosystem resilience (Bellwood et al. 2003). Each fish is estimated to ingest 5 tons of reef carbonates in a year. There is limited life history data for this large parrotfish. Size-at-age data is limited to a few samples and only in the Great Barrier Reef. Maximum age is around 33 years and growth rate is relatively slow. There is generally low recruitment and perhaps owing to its diet, this fish is mostly found in coral reef habitats. (Choat and Robertson 2002, Hamilton 2003). Juveniles are mostly found in seagrass beds and adults in lagoons and reef slopes. Adults usually rove and sleep in groups (Myers 1999) making this species highly vulnerable to fishing. Although this species has a very wide range, population sizes have been declining. It is rarely encountered at a few islands of American Samoa during intensive diver surveys on research cruises by NMFS Pacific Islands Fisheries Science Center.

3.) *Plectropomus areolatus* and *Plectropomus Laevis*. *P. areolatus* inhabits lagoon and seaward reefs rich with coral growth. It feeds exclusively on fishes and may be ciguatoxic in some areas. This grouper forms spawning aggregations in association with specific lunar phases, with variable seasonality and lunar cycle associated with spawning by locale. It commonly co-aggregates with the camouflage grouper, *Epinephelus polyphekadion*, and brown-marbled grouper, *E. fuscoguttatus* throughout its range. The IUCN assessment stated that although *P. areolatus* is heavily fished and is hence declining at a rate of at least 30% over the last 20 to 30 years. The species is particularly vulnerable due to fishing targeted at spawning aggregations (Pet et al. 2005) and larger size at sex change observed with very low proportion of males. Size-at-age data indicated that *P. areolatus* is a fast-growing, early maturing and relatively short-lived aggregation-spawning grouper (Rhodes et al. 2013). Females and males sexually mature at 2 and 3 years, respectively, suggesting protogynous hermaphroditism. Mature females ranged from 318-469 cm SL, while males were found between 390-570 cm SL. Both sexes reach 90% of asymptotic length by age 3 years. Maximum age is around 12 years.

The related grouper *P. laevis* is a widespread species in the Indo-Pacific but naturally uncommon (average of less than 1 individual per 1000 sq m). It is a monandric protogynous hermaphrodite and is conspicuous on outer coral reef slopes occurring in depths between 4 and 90 m (Heemstra and Randall 1993). However, this grouper has very few sightings in American Samoa. *P. laevis* appears to be a relatively fast-growing species and reaches 50 cm in less than four years; females achieve maturity in under three years (Davies et al. 2006). Growth parameters based on the von Bertalanffy model ranged from $K = 0.14$ to 0.19 year^{-1} (Davies et al. 2006, Grandcourt 2005). Maximum age is about 16 years, and age at first maturity around 1 year with the size range over which sex change occurs.

4.) *Epinephelus lanceolatus* is the largest grouper and reef-dwelling fish in the world (Gomon et al. 1994) and is much sought after by line and spearfishers. It is also the mostly widely distributed grouper being found throughtout the Indo-Pacific from the Red Sea to Pitcairn islands (Sadovy and Cornish 2000). It tends to be solitary and inhabits lagoon and seaward reefs at a depth up to 100 m. Large individuals often home in specific sites in which they frequently stay (Myers 1991). Being such a large predator, it is rare even in areas unexploited by fishing (Randall and Heemstra 1991) and it has nearly been extirpated in areas where it has been heavily fished especially for the live reef food-fish trade (Lieske and Myers 1994). Very little is known about the life history of the giant grouper in addition to the information that grows up to 2 meters and over 450 kgs. in weight. The estimated size of sexual maturation for *E. lanceolatus* is 105–110 cm TL, which means that all individuals are collected in the live fish trade before they reach sexual maturity.

5.) Several sharks are species of concern: (a) the scalloped hammerhead shark *Spyrna lewini*; (b) the whale shark *Rhincodon typus*; (c) the tawny nurse shark *Nebrius ferrugineus*; (d) the zebra shark *Stegostoma fasciatum*; (e) the sicklefin lemon shark *Negaprion acutidens*; (f) the grey reef shark *Carcarhinus amblyrhynchos*; (g) the black tip shark *Carcarhinus melanopterus*; and (h) the white tip shark *Triaenodon obesus*. These sharks have traits that are a combination of low in abundance and with a life history characterized by slow growth, late maturing, low fecundity (or high mortality during the early stages), site fidelity and long life. The late age of maturity and the high maximum age are apparently the two life history traits that make sharks susceptible to fishing. It has been hypothesized that both historical and current overfishing have cause the decline in their abundance (Nadon et al. 2010). In addition, the populations of these fish probably encompass various island countries and territories in the south Pacific where fishing regulations are ineffective or lacking.

(a) The scalloped hammerhead shark *S. lewini* is a circumglobal species found in coastal warm temperate and tropical seas, from intertidal and surface up to 275 m in depth (Compagno 1984). It is a highly mobile and partly migratory (Maguire et al. 2006). It is a viviparous shark and parturition occurs in coastal waters where the young tend to stay in up to 2 years before moving to oceanic habitats as it grows older. Maximum size ranged from 219-340 cm TL for males and 296-346 cm for females. Males mature between 140-198 cm TL and females at around 210-250 cm TL (Miller et al. 2014). The scalloped hammerhead shark is considered long-lived (20 to 30 years) and late maturing (10 to 15 years). and slow growing (k <0.1 per year).

(b) The Whale Shark (*Rhincodon typus*), the world's largest living fish, is a cosmopolitan tropical and warm temperate species. It is found in both coastal and oceanic habitats but spends the majority of time in the epipelagic zone. The largest recorded whale shark was approximately 20 m TL and 42 t in mass was reported from Taiwan. Length at first maturity ranges from 7 to 10 m TL. It is an ovoviviparous shark and the smallest free-swimming neonate found in the wild, from the Philippines, was 46 cm TL. Whale Sharks are highly mobile, with mean daily movement rates of 24–28 km. Two major subpopulations exist, in the Atlantic Ocean and Indo-Pacific, respectively. Age and growth data on whale shark are sparse. Growth band deposition estimated that male sharks begin maturing at ~17 years and females at 19–22 years. Generation time is about 25 years (reviewed in Pierce and Norman 2016)

(c) The tawny shark *N. ferrugineus* is widely distributed in the continental and insular shelves of the Indian, west and central Pacific Oceans. It is found in the shallows water habitat (5 to 30 m) such as lagoons, channels, outer edges of coral and rocky reefs, in areas with seagrass and sand on reefs, sandy areas near reef and off sandy beaches. It also prefers crevices and caves. Although the young tawny shark prefers shallow lagoons, adults are more wide ranging. There is very limited life history data available for the tawny nurse shark. The maximum size is 320 cm TL. Size of male maturity is 250 cm TL and size of female maturity ranges from 230 to 290 cm TL. There are no data on growth rates (reviewed in Pillans 2003).

(d) The zebra shark *Stegostoma fasciatum* is a broadly distributed in the continental and insular shelves of the Indian, west and central Pacific Oceans. It is found from the intertidal zone to a depth of 62 m over the continental and insular shelves. They are frequently found in coral reefs. Compared to other sharks, they have limited movement (<140 km). The zebra shark attains maximum size at 235 cm TL. It is an oviparous species and hatchlings measure 20 to 36 cm. Sexual maturity is around ranges from 147 to 183 cm TL for males and 169 to 171 cm TL for females. Maximum age is around 25-30 years. (reviewed in Pillans and Simpfendorfer 2003).

(e) The sicklefin lemon shark *Negaprion acutidens* is widely distributed in the tropical Indo-west and central Pacific. It is usually associated with waters with limited visibility in coral reefs, lagoons and mangrove estuaries and insular shelves up to 92 m. It attains maximum size at 300 cm. Size of male and female sexual maturity is 220 cm TL. It is a viviparous shark. Size at birth is 60 cm TL and growth rate in juveniles is 12.5 to 15.5 cm per year. Tagging experiments showed limited movement with individual movements averaging 1.3 km and maximum distance 5 km. (reviewed in Pillans 2003).

(f) The grey reef shark *C. amblyrhynchos* is a widespread species occurring in the central Pacific and westwards to the eastern Indian Ocean. It is social species usually common in clear, tropical, coastal waters and oceanic atolls. Its restricted habitat, site fidelity, inshore distribution, small litter size, and relatively late age at maturity, along with increasing fishing pressure suggests that this species may be under threat. The species is found in clear tropical waters from 10 m to more than 50 m around coral reefs, particularly near drop-offs and passes of fringing reefs. It is more common at ancient atolls, and less common at high profile islands with extensive human habitation, or in turbid continental waters. Males mature at 120-140 cm total length (TL) and attain a size of 185 cm; females mature at about 125 cm TL and attain 190 cm at about seven years. Litters are small, up to six embryos (reviewed in Smale 2009).

(g) The blacktip reef shark *C. melanopterus* is a common and wide-ranging species, regularly caught by inshore fisheries. This shark range from 30-50 cm at birth. Adults reach total lengths of up to 180 cm and mature between 90-110 cm. Due to small litter sizes (2-4 pups) and long gestation periods (10-16 months), the blacktip reef shark is vulnerable to depletion (reviewed in Heupel 2009).

(h) The whitetip reef shark *Triaenodon obesus* is closely associated with coral reefs in clear, tropical waters within 10-40 m depth. Primarily nocturnal, they shelter in caves by day, often communally. Maturity is attained at about 105 cm, and pups are born at 52-60 cm after a gestation period of at least five months. Litter size is from 1-5. Growth is slow at 2.1-4.2 cm year-1, sexual maturity at eight to nine years and life span of 16 years. Maximum size is around 200 cm TL but adults are very rare over 160 cm (reviewed in Smale 2009).

6.) Three rays are species of concern: the black-blotched stingray *Taeniura meyeni*; the thorny stingray *Urogymnus asperrimus*, and; the reef manta ray *Manta alfredi*. These fishes share similar life history characteristics and threats with sharks.

(a) The black-blotched stingray *T. meyeni* is one of the largest stingrays and can attain a size of up to 180 cm disk diameter. Little is known of its biology. It is generally nocturnal, bottom-dwelling and found close to shore and up to 20-60 m in depth. It is viviparous and pups measure around 30 cm in disk diameter. Males attain sexual maturity around 100 to 110 cm. The maturity size of females is unknown (reviewed in Kyne and White 2015).

(b) The thorny stingray *U. asperimus* is a bottom-dweller found in sand, coral rubble and seagrass habitats in inshore waters up to a depth of 30 m. It is wide ranging in its distribution but relatively uncommon compared to other stingrays. It attains maximum size of 120 to150 cm disk diameter. It is viviparous and juveniles are found in mangrove areas. Juveniles seem to be site-attached. Sexual maturity is attained at 90 cm diameter size for males and 100 cm diameter sixe for females. Most of its life history data is unknown. Longevity may be 21.5 years based on a related stingray (reviewed in Chin and Compagno 2016).

(c) The reef manta ray *M. alfredi* is the second-largest ray known with a maximum known size at 480 disc width. It is found in shallow, coastal habitats in the tropical and sub-tropical regions of the Pacific, Indian and Atlantic Oceans. They are often encountered feeding and traveling in schools.This manta ray been documented to travel distances of up to 500 km. Although it is wide ranging, populations are sparse and highly fragmented with seemingly low inter-population movement. This species has an extremely low reproductive output. Females bear on average a single pup every 2–3 years. This ray is ovoviviparous and the pup is about 150 cm in disc width staying in a shallow-water environment for a few years. The reef manta seems to be relatively long-lived, living up to 30 years. Female mantas sexually mature around 8 to 10 years and may live up to 40 years. Females mature at 400 cm disc width and males at 300 disc width. Fecundity is very low with one pup per gestation with an annual reproductive cycle (reviewed in Marshall et al. 2011).

3.3.2.3 MESOPHOTIC REEF FISHES

Wass (1984) listed 56 deep-bottom fish species that are found in 60 to 500 m deep in American Samoa. Several of these fishes are targeted by bottomfishing fishermen. This fishery is characterized by a few commercial boats and numerous unaccounted recreational and subsistence fishery. In Aunuu Island, a few alia bottomfish catch deep-water fish mostly for family social events or *fa'alavelave*. Life histories of most deep-water fishes are characterised by extended longevities, slow growth, late maturity, and low fecundity, indicating low production potential and resilience (Koslow et al. 2000). These deep-water fishes are, therefore, vulnerable to even low levels of fishing. The species of great concern are the ruby snapper *Etelis carbunculus*, the flame snapper *Etelis coruscans* and the pink snapper *Pristopomoides filamentosus*. This group, also known as eteline snappers, inhabits steep coral and rock reefs, residing at depths usually exceeding 100 m, and can attain sizes exceeding 100 cm (Parrish1987). Their geographic range extends throughout the tropical and subtropical Indo-Pacific from the Hawaiian Archipelago and the central western Pacific Ocean to the western Indian Ocean and south along northwestern and northeastern Australia (Allen 1985; Kramer et al. 1994; Newman 2006). There is no data on the life-history of these species in the Territory. There are some data collected in other parts of the south Pacific such as Australia, the Marianas and Hawaii. The available data provides a growing evidence of geographic differences in life history traits for these snappers (Andrews et al. 2012). There is also wide concern that available data for deep-water snappers underestimate longevity and that length and age are probably decoupled. Data on size-at-maturity, maximum age and size-at-age are critical for stock assessment and sustainable exploitation of these deep-water fishes.

Threats to marine fishes

Over-exploitation is the major threat to these fish species of concern. Some of the fishes such as *Cheilinus undulatus* and *Bolbometopon muricatum* are already uncommon so they are susceptible to even low levels of exploitation. Other life history traits such as site fidelity, relatively high maximum age (>30 years), slow growth, relatively late sex maturity, and low fecundity exacerbate the impacts of fishing making the populations of these fishes less resilient.

There are no formal assessment of these fishes' vulnerability to climate change. We hypothesize that shallow coral reef fishes may be more susceptible to changes in the climate. Sea-level rise and mortality of corals due to bleaching are expected to affect the habitats of *C. undulatus* and *B. muricatum*. These fishes are mostly found in reefs with high coral cover so increased coral mortality associated with bleaching events is expected to lead to declines in fish abundance. Habitat degradation due to increased sedimentation rates with high rainfall, sea level rise and stronger hurricanes and storms will exacerbate coral reef loss.

Marine fish general conservation priorities

1. The development of scientific framework for catch limits and its implementation will support sustainable exploitation of these highly exploited fish. Such frameworks are being implemented by Regional Fisheries Management Organizations such as the Western and Central Pacific Fisheries Commission and the Western Pacific Regional Fishery Management Council. We propose ***to collect life history data such as length-at-first maturity, size-at-age, maximum age, movement and population structure critical for stock assessment models that develop biological reference points for sustainable fisheries***. For fishes with no or extremely low sightings, species prohibitions should be considered. In addition, we propose ***to conduct population genetic connectivities for various species among the islands in the Samoan Archipelago***. Data on the genetic structure would complement life history in delineating fish populations and stocks for fisheries management and conservation.

2. We propose ***to support an ecosystem and integrated approach to conservation using ridge-to-reef framework*** as variously implemented in the Territory by the National Park System, the National Marine Sanctuaries and the Community-Based Fisheries Management Project under the Department of Marine and Wildlife Resources. Such approach is appropriate given that various factors are important in sustaining healthy fish populations. In addition, there is a need ***to conduct formal climate change vulnerability assessment for coral reefs will help identify priority sites for conservation***.

4 AN OVERVIEW OF THE HABITATS

4.1 TERRESTRIAL HABITATS

4.1.1 VEGETATION TYPES

Whistler (2002) recognized six main categories of plant communities, of which five can be found on the high volcanic islands in American Samoa: littoral, wetland, upland scrub, disturbed, and rainforest vegetation. Although American Samoa is subject to relatively frequent hurricanes, vegetation patterns suggest these disturbances do not typically affect large areas of forest (Mueller-Dombois & Fosberg 1998, but *cf.* Webb & Fa'aumu 1999). The most extensive natural terrestrial habitat in American Samoa is lowland tropical rainforest (Whistler 1992). Due to the presence of few permanent streams and lakes, wetland habitats are the least extensive. There is significant heterogeneity within these broad habitat categories, which can be differentiated into a large number of habitat subtypes (Whistler 1980; also see Mueller- Dombois & Fosberg for a discussion on habitat subtypes). However, the flora of American Samoa has very low rates of endemism (van Balgooy et al. 1996). The two atolls in the territory are dominated by agroforest with remnants of littoral species (Swains Island; Whistler 1983) or by natural littoral communities (Rose Atoll; Whistler 2002).

4.1.2 HABITAT STATUS AND PROGNOSIS

The current extent of native habitats in American Samoa compares favorably with the situation found in most tropical countries. However, there is increasing pressure on forest habitats, especially on Tutuila. The pattern of conversion of habitats into types less suited for wildlife is best modeled in Figure 3, and actual documented changes are illustrated in Figures 4a and b. **The general net trend is toward decreasing habitat quality**. Except in parts of the Tafuna Plain, much of the land converted was previously classed as an agroforest type (Cole et al. 1988). Human population growth and economic development are important drivers in the pattern of land use conversion (American Samoa Government 2002; Department of Commerce 2003), as is the resurgent production of highly profitable, blight-resistant taro (*Colocasia esculenta*) and various leafy vegetables such as *Brassica rapa*.

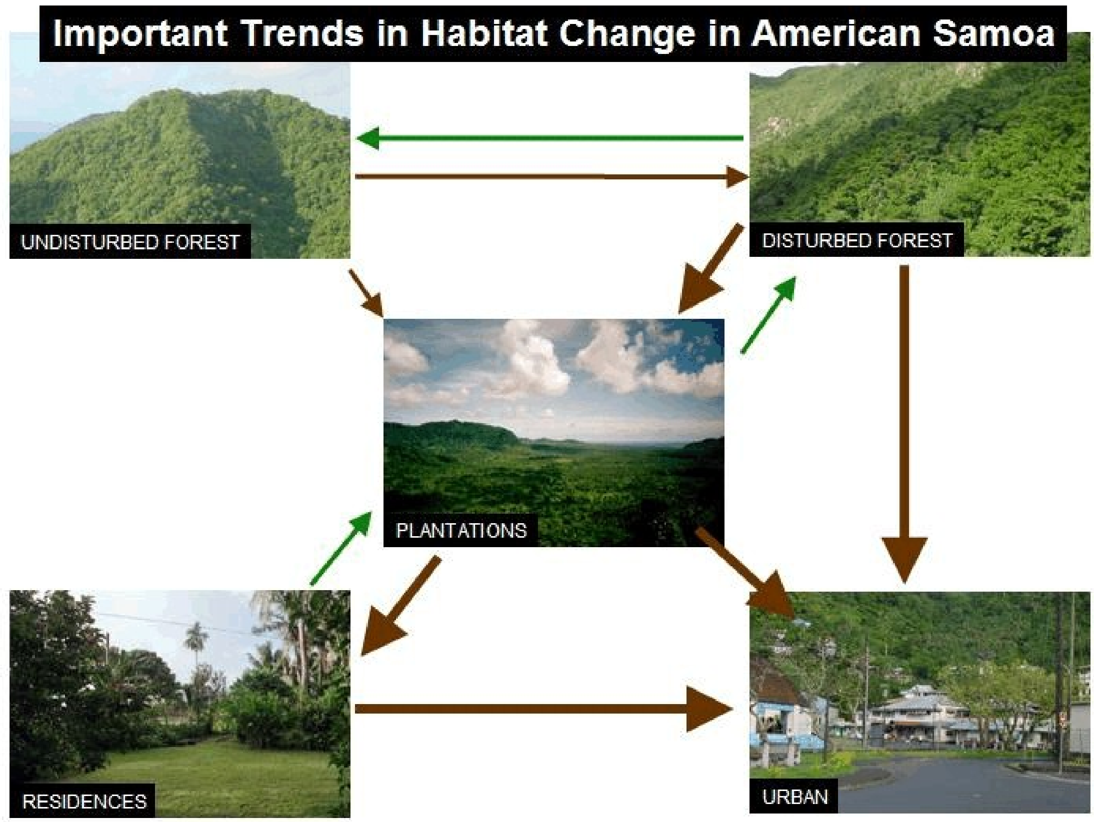


FIGURE 3. PROJECTED LANDSCAPE CHANGES BASED ON OBSERVED PATTERNS OF LAND USE (Green arrow projects a positive reversal to higher quality habitat; brown arrow represents a loss in habitat quality. Difference in line thickness reflect differential rates of conversion between types of habitat with rates proportional to thickness.)

A comparison of satellite and aerial images indicate that rainforest areas remain largely intact (Figure 4). Given that approximately 40% of the land area are characterized by slopes 30º or greater, a significant portion of the island remains forested and is projected to remain forested through the foreseeable future. Under a 50-year lease agreement between local villages and the federal government, a combined total of approximately 3,240 ha. of select forested tracts on Tutuila and Ta'u were established as the National Park of American Samoa. A significant portion of areas with slopes less than 30º consist of tracts of agriculture intermixed with forest patches or tree species (Department of Commerce 2003) and remain suitable habitat for a wide array of vertebrate and invertebrate species. In Manu'a (particularly Ta'u Island), areas of previously cultivated land have been left to fallow and are reverting to natural vegetation (Figure 4b).

FIGURE 4. MAPS OF TUTUILA (A) AND MANU'A (B) SHOWING ACTUAL LAND COVER TRENDS IN AMERICAN SAMOA OVER THE PAST THREE DECADES. The upper map in each figure shows land cover classes in 1984 as mapped by Cole et al. (1988). The dark green areas represent native vegetation types, the lighter green areas are disturbed and agroforest areas, while the beige areas are built up or urbanized habitats. The lower map in each figure shows an Ikonos (Space Imaging Systems LLC) satellite image from 2001, partially obscured by scattered clouds. The green cross-hatched areas indicate Cole et al. (1988) habitat classes that have experienced a significant reversion toward native types. The pink cross-hatching indicates approximate areas of habitat classes that experienced significant decrease in suitability or quality for wildlife. These changes are not specific to any one habitat type. For example, native habitat can experience a decrease in suitability by being converted to agroforest, while agroforest can become less suitable by being converted to more residential areas (see Figure 3). Numbers refer to Priority Habitat Preservation Areas in the following Table:

NUMBER	TYPE	DESCRIPTION/EXAMPLES (Species Benefitted)
1	Refugia	Known refuges from hurricanes, introduced predators, human disturbance, e.g., volcanic craters (*P. tonganus*), offshore islets (*P. tonganus*, land snails)
2	Critically threatened habitats	Habitats with very limited distributions, high uniqueness, rare plants, or high rates of loss, e.g., Tava-mamala (Tafuna Lowland) rainforest (native birds, bats), mangrove/estuarine areas (Pacific black duck)
3	Habitat for rare wildlife	Areas determined to have significant remnants of rare or declining wildlife, e.g., Manu'a wooded talus slopes (Shy ground-dove), Mt. Lata montane scrub forest (Spotless crakes and ground-nesting seabirds)
4	Contiguous expanses of habitat	Large remaining areas of native habitat, e.g., Mt. Leaeno & Mt. Leele (snails, insects, Pacific imperial-pigeon)

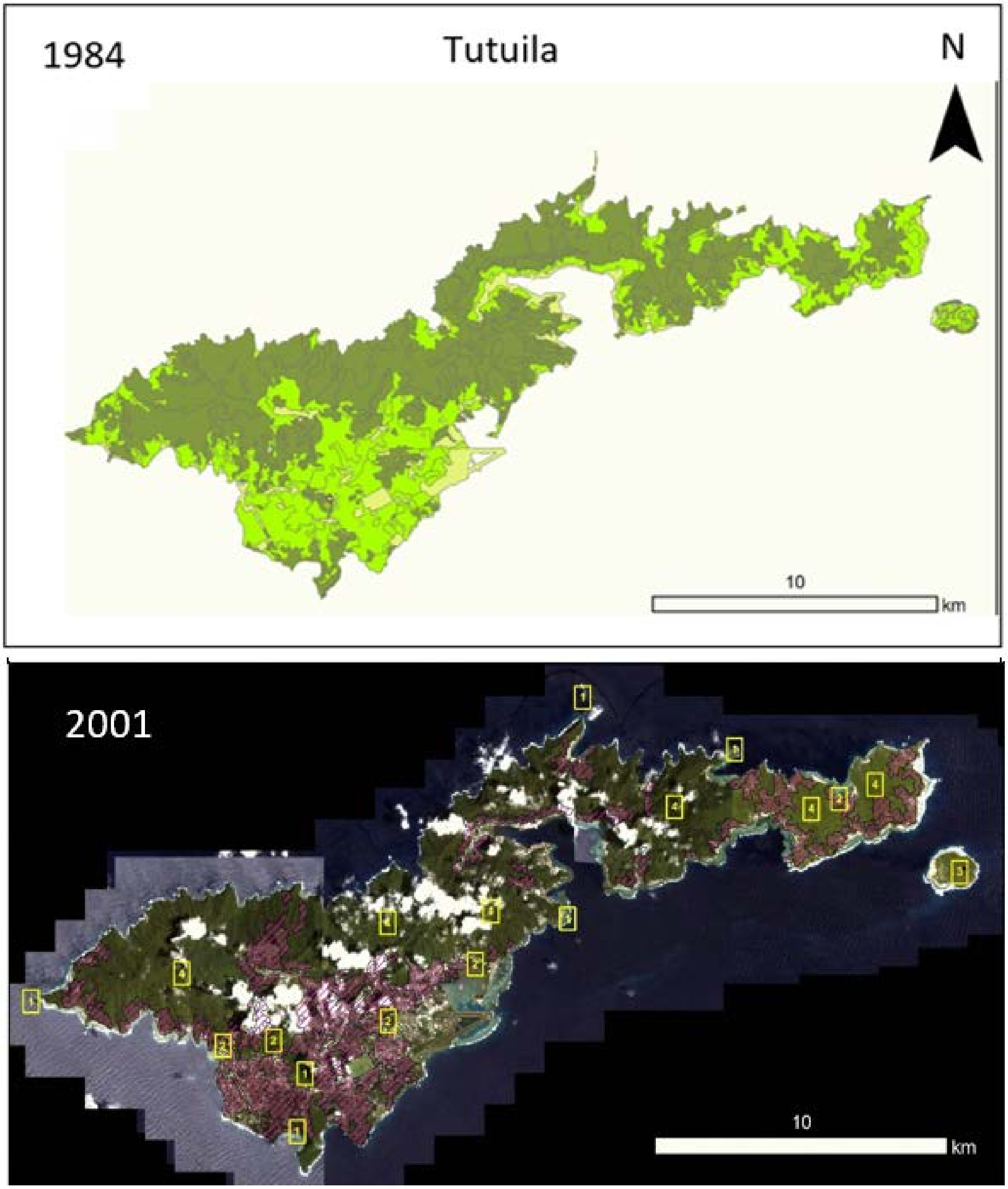


Figure 4a

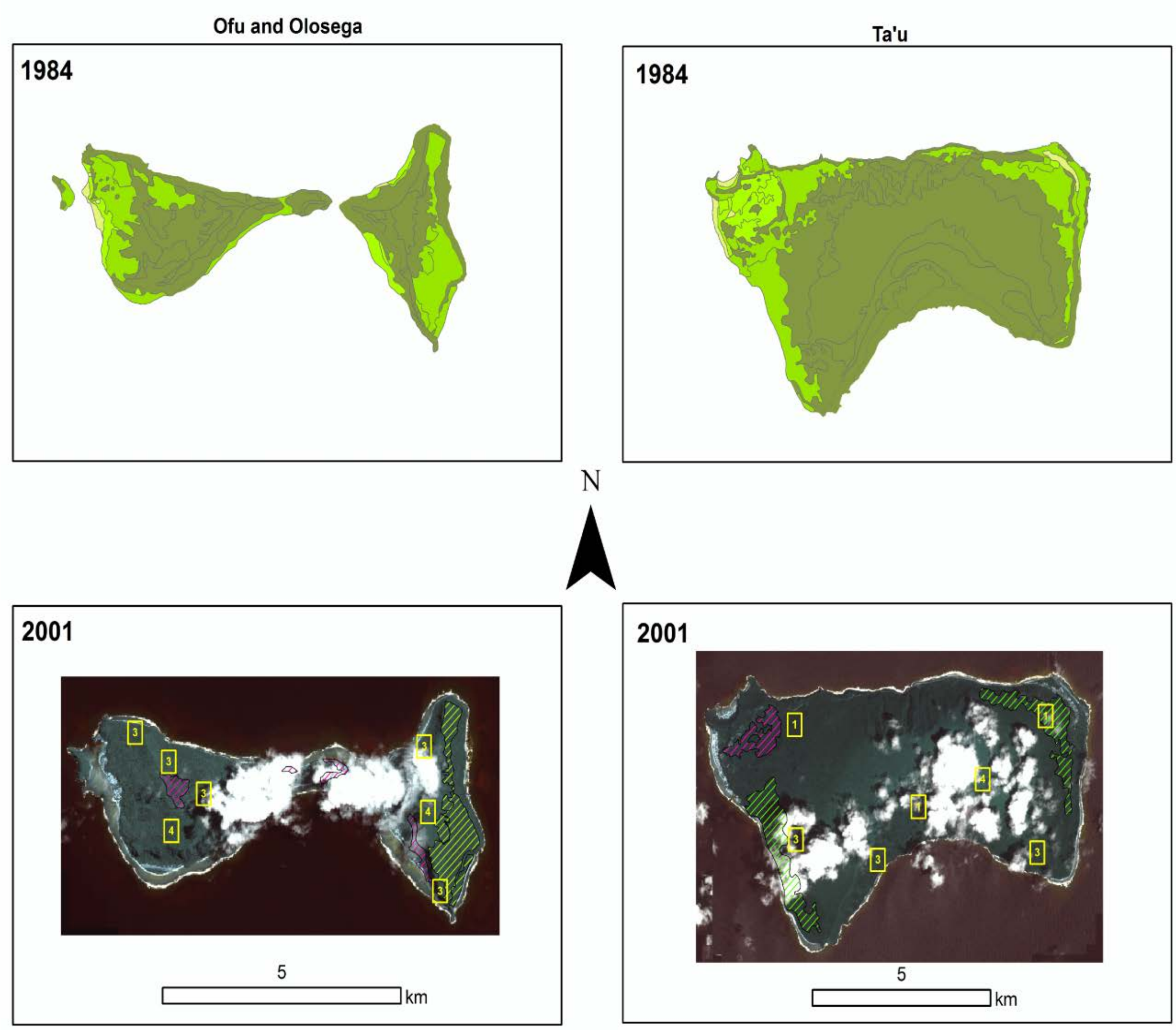


Figure 4b

Wetland and riparian habitats have experienced the most severe declines in coverage. It is estimated that at least 48% of the original wetlands has been degraded, and that approximately 450 acres of wetland habitat remains, largely in the Nu'uuli Pala, Leone Pala, and in Aunu'u (Department of Commerce 2003). There are anecdotes that the Aunu'u pala is being degraded by rising sea levels. Of these tracts, the Nu'uuli Pala and Leone wetlands are declared Special Management Areas and as such are afforded protection under the Territorial Coastal Zone Management Plan.

Littoral vegetation remains largely in stable and good condition in most islands other than Tutuila. On Tutuila, recent development in Fogagogo and Vaitogi have resulted in removal of significant areas of *Pandanus*, *Barringtonia*, and *Callophyllum* (pers. obs.). Still, a significant portion of remaining littoral vegetation on Tutuila are along steep coastal slopes, and it is unlikely that development and urban growth in the near future will result affect these areas (although see Section 5.4.4 regarding threats to beaches).

Current administrative provisions aimed at slowing down decline in habitat quality, or outright loss of native vegetation cover are inadequate (see subsections 8.2.1 & 8.2.2 for a thorough discussion). Yet it is recognized that the protection and conservation of the Territory's natural vegetation landscape is integral to the conservation of its wildlife populations (see subsection 4.3 below). For this reason, this plan highlights the protection of native habitats, through research & outreach (subsection 6.3), and through legal means (subsection 8.3), as a critical strategy for conservation. In particular, four critical habitat types are defined and designated priority conservation areas fitting these habitat types are indicated in Figure 4.

4.1.3 MAPPING OF WILDLIFE HABITAT IN AMERICAN SAMOA

Habitat maps offer many benefits to natural resource managers and wildlife biologists in managing wildlife species and their habitat. Habitat maps provide biologists with the ability to spatially quantify wildlife habitat, and to monitor habitat quality and land use change. Further, they can facilitate the inventory and monitoring of wildlife species and provide an important variable for use in habitat suitability and species distribution modeling.

Historically, the available aerial and satellite imagery for the American Samoa islands have been highly inadequate for delineation of the extent of the vegetation categories defined by Whistler (2002). Past efforts to generate a land cover map by the Pacific Northwest Research Station Forest Inventory and Analysis (FIA) Program resulted in portions of disturbed vegetation (*sensu* Whistler 2002) characterized as managed lands (agroforest and coconut plantations) and were lumped together with other forest types (undisturbed, disturbed secondary, etc) as part of the "forest" coverage (Donnegan et al. 2004). Consequently, assessments of the status and prognosis of habitats across the seven islands of American Samoa was limited by the then available information and focused largely on wetlands and rainforests (collectively lowland, montane, cloud forests [including upland scrub]; undisturbed and disturbed). In 2009, DMWR initiated an effort to map wildlife habitat on the islands of American Samoa. The impetus for this effort originated as a result of the findings of the 2005 CWCS for American Samoa which identified a deficiency in updated and detailed habitat maps for the islands (Utzurrum et al. 2006). Although the vegetation of American Samoa has been extensively mapped over the past 30 years (Whitesell et al. 1988, Donnegan et al. 2004, Liu et al. 2011) these products are either outdated or too generalized to meet the needs of local wildlife biologists. The goal was to produce detailed and accurate habitat maps using a habitat classification scheme specific to American Samoa that would provide a useful management tool for wildlife biologists.

Habitat mapping based on traditional ground surveys typically require time and cost intensive efforts, especially when mapping large areas. Remote sensing data provides an efficient and cost effective method to map large geographical areas (Wulder et al. 2004). Recent advances in remote sensing sensors and technology are producing imagery with higher spatial and spectral resolutions, providing the ability to map land features with more detail and spatial accuracy. Also, LIDAR (light detection and ranging) is an emerging technology that has been demonstrated to be an effective tool in ecological studies for measuring topography and vegetation height, structure, and cover (Lefsky et al. 2004). Very high resolution (VHR) orthoimagery and LIDAR data were made available for Tutuila and the Manua Islands in August of 2012. The availability of this high quality remote sensing data provided the opportunity to investigate the synergistic effect of LIDAR and VHR imagery on the ability to produce accurate and detailed habitat maps for the islands. It was anticipated that the incorporation of LIDAR derivatives would improve the ability to map habitats in the classification scheme developed for the project which is largely based on vegetation lifeform and successional stages. The habitat classification scheme combines and integrates remote sensing based classification schemes (Anderson et al. 1976, Dobson et al. 1995) with Whistler's (Whistler 2002) classification of Samoan Rainforest. Habitats were first divided into 8 major life forms which can be extracted from the remote sensing data: developed land, barren land, grassland/herbaceous, shrub/scrub land, forest, water, wetlands and cultivated land. Subsequent levels of the scheme further divide habitats into subtypes based on land use, successional stage, and plant community associations. Table 1 provides the classes defined in the scheme for the habitat mapping project.

TABLE 2. *HIERARCHICAL HABITAT CLASSIFICATION SCHEME FOR AMERICAN SAMOA.*

1000 - Developed Land
- 1100 - Open Space
- 1200 - Cultivated Woodland
- 1300 - Residential Buildings
- 1400 - Secondary Roads
- 1500 - Major Roads
- 1600 - Commercial/Industrial Buildings
- 1700 - Impervious Surfaces
- 1800 - Landfill
- 1900 - Quarries and Gravel Pits

2000 - Barren Land
- 2100 - Unconsolidated Shore
- 2200 - Exposed Lava Rock
- 2300 - Landslips/Clearcuts

3000 - Forest Land
- 3100 - Lowland Rainforest
  - 3110 – Primary Rainforest
    - 3111 - Ridge Forest
    - 3112 - Valley Forest
    - 3113 - Lavaflow Forest
    - 3114 - Slope Forest
  - 3120 – Secondary Rainforest
    - 3121 - Mature Secondary Forest
    - 3122 - Intermediate Secondary Forest
    - 3123 - Young Secondary Forest
    - 3124 - *Hibiscus* Thicket
- 3200 - Montane Forest
- 3300 - Coastal Forest
  - 3310 - *Barringtonia* association
  - 3320 - *Tournefortia* association
  - 3330 - *Calophyllum* association
  - 3340 - *Pisonia* association
  - 3350 - *Diospyros* association
  - 3360 - Mixed Coastal Forest
  - 3370 - *Hernandia* association
  - 3380 - *Pandanus* association
- 3400 - Agroforest
  - 3410 - Coconut Agroforest
  - 3420 - Coconut Plantation
  - 3430 - Mango Agroforest
  - 3440 - Mixed Agroforest
  - 3450 - Breadfruit Agroforest

4000 – Shrub/Scrub Land
- 4100 - Upland Scrub
  - 4110 - Summit Scrub
  - 4120 - Montane Trachyte Scrub
  - 4130 - Montane Forest Scrub
- 4200 - Coastal Scrub
  - 4210 - *Scaevola* Coastal Scrub
  - 4220 - *Wollastonia* Coastal Scrub
  - 4230 - *Pandanus* Coastal Scrub
  - 4240 - Mixed Coastal Scrub
- 4300 - Successional Scrub Vegetation

5000 - Grassland/Herbaceous Land
- 5100 - Coastal Herbaceous Strand
- 5200 - Grassland/Herbaceous
- 5300 - Fernlands

6000 - Cultivated Land
- 6100 - Banana Plantation
- 6200 - Wetland Taro Plantation
- 6300 - Upland Taro Plantation
- 6400 - Mixed Cultivated Plantation
- 6500 - Row Crops
- 6600 - Papaya Plantation

7000 - Wetlands
- 7100 - Marsh
  - 7110 - *Eleocharis* Marsh
  - 7120 - *Acrostichum* Coastal Marsh
  - 7130 - *Paspalum* Salt Marsh
  - 7140 - Mixed Marsh Vegetation
- 7200 - Mangrove
  - 7210 - *Rhizophora* Mangrove Scrub
  - 7220 - *Bruguiera* Mangrove Forest
  - 7230 - *Xylocarpus* Mangrove Forest
  - 7240 - Mixed Mangrove Forest
- 7300 - Freshwater Swamp
  - 7310 - *Hibiscus* Swamp Forest
  - 7320 - *Inocarpus* Swamp Forest
  - 7330 - *Erythrina* Swamp Forest
  - 7340 - Mixed Swamp Forest

8000 - Open Water
- 8100 - Lake/Pond
- 8200 - Ocean

Processing methods for producing the habitat maps integrated LIDAR derivatives and VHR orthoimagery (Figures 5 and 6) using image segmentation and object based image analysis (OBIA). Automated classification of image objects using classification tree analysis (CTA) was supplemented with visual interpretation of the imagery to overcome limitations of the remote sensing data and to map habitat classes at a greater level of detail. As part of the mapping effort, ground truth data was collected for training and accuracy assessment purposes. Given the difficulties working on remote islands and the steep, often inaccessible terrain of American Samoa, an attempt was made to create a sample design which minimized sampling effort but adequately sampled the variation in habitats across the islands of American Samoa. A point centered quarter method with a 10m circular plot was used for collection of canopy, subcanopy and ground cover vegetation metrics. Three general components of the biotic and physical environment were assessed at each ground truth site: forest tree density, habitat composition, and microhabitat characteristics. Approximately 727 ground truth sites across the islands of American Samoa were validated (Figure 7). The ground truth data collected for the project represents one of the largest samples of vegetation collected for the American Samoa islands and will provide biologists with an additional tool for inventory and monitoring of wildlife species, and the ability to minimize sampling effort for rare, threatened or endangered species.

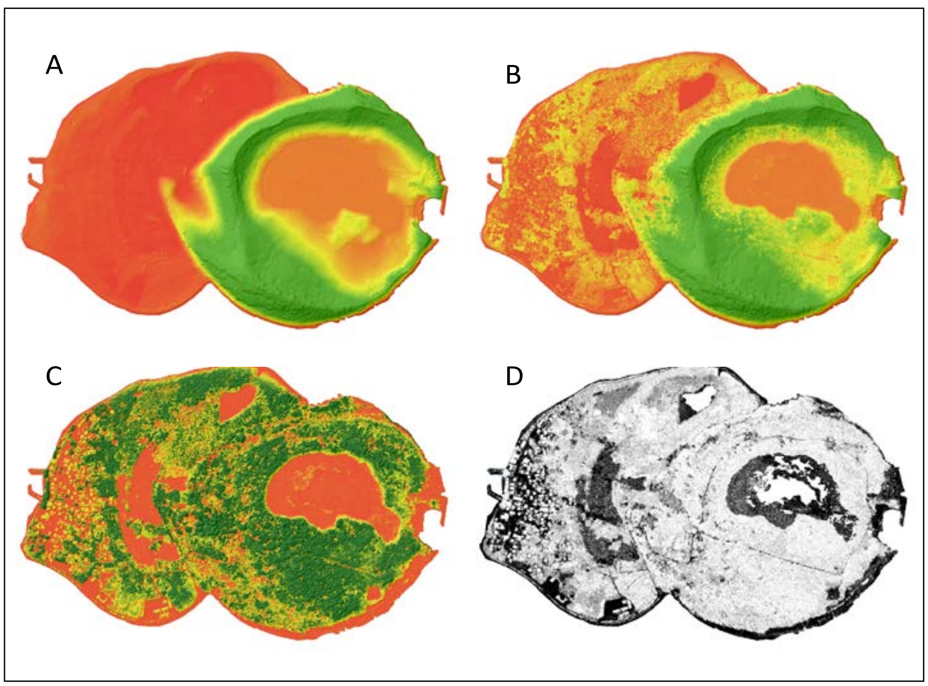


FIGURE 5. EXAMPLES OF LIDAR DERIVATIVES, ANUU'U ISLAND. (A) digital elevation model (B) digital surface model (C) normalized digital surface model (D) surface density model.

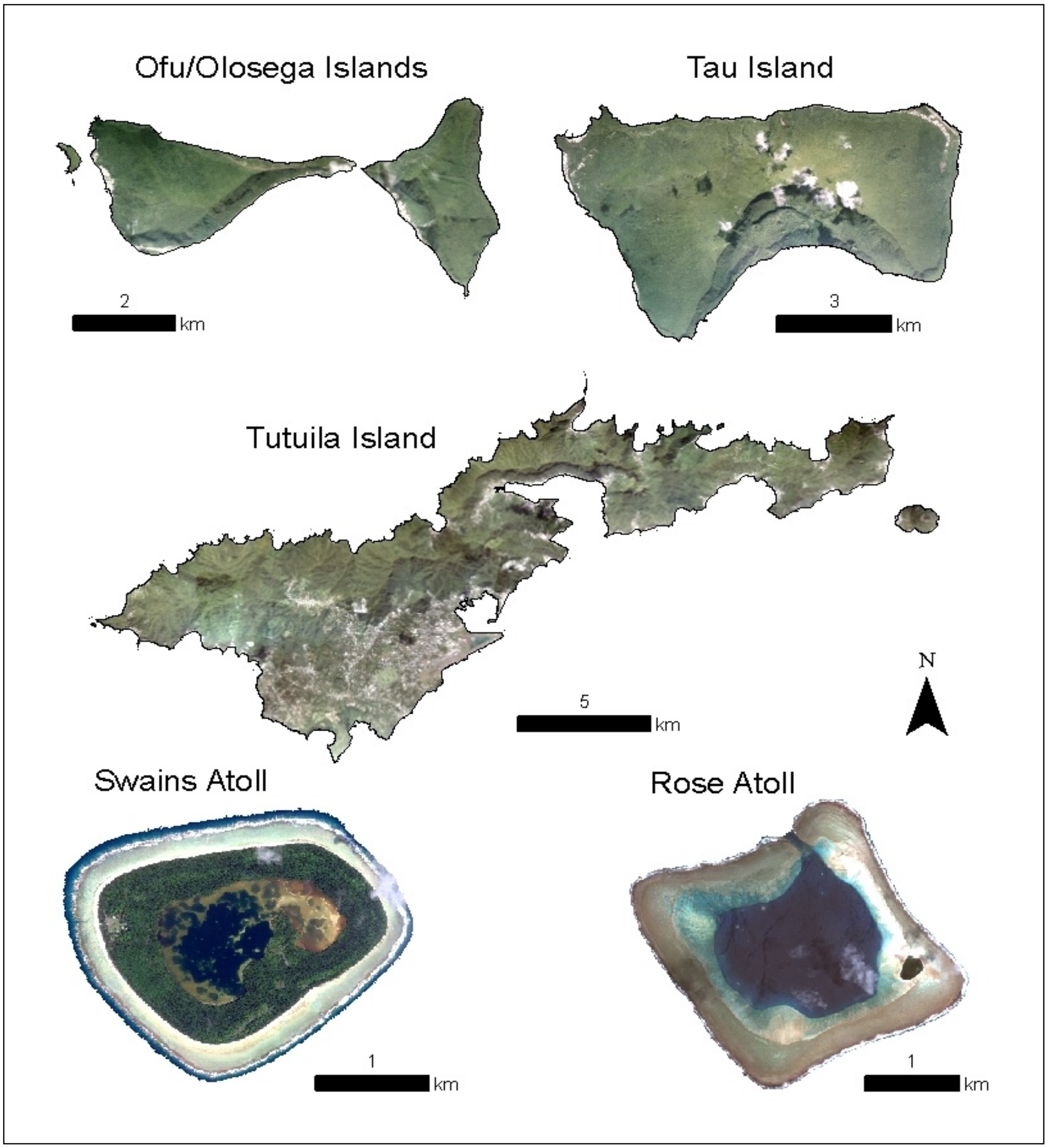


FIGURE 6. TRUE COLOR COMPOSITE SATELLITE AND AERIAL ORTHOIMAGES USED FOR MAPPING.

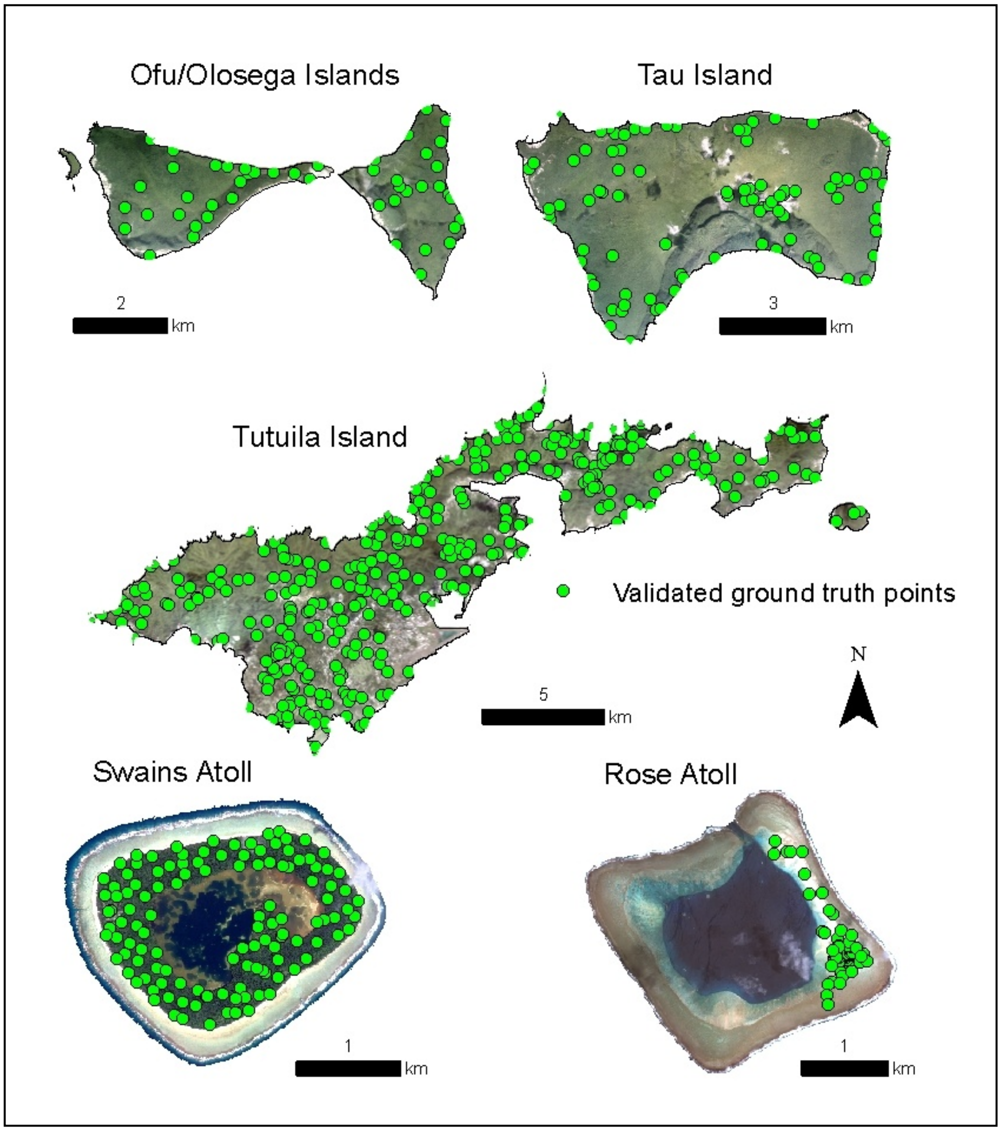


FIGURE 7. GEOGRAPHIC DISTRIBUTION OF VALIDATED GROUND TRUTH SAMPLES IN AMERICAN SAMOA.

The terrestrial habitat mapping project was completed in September 2017. Updated habitat maps for all islands of American Samoa are provided in Appendix 4 (A-F). The completed technical report, GIS data coverages, and associated meta-data is available through DMWR. The report is cited as:

Roger Meyer, Joshua Seamon, Siaifoi Fa'aumu, and Iofi Lalogafuafua. Classification and Mapping of Wildlife Habitat in American Samoa: An object-oriented approach using high resolution orthoimagery and LIDAR remote sensing data. *Department of Marine and Wildlife Resources Technical Report.* American Samoa (2017).

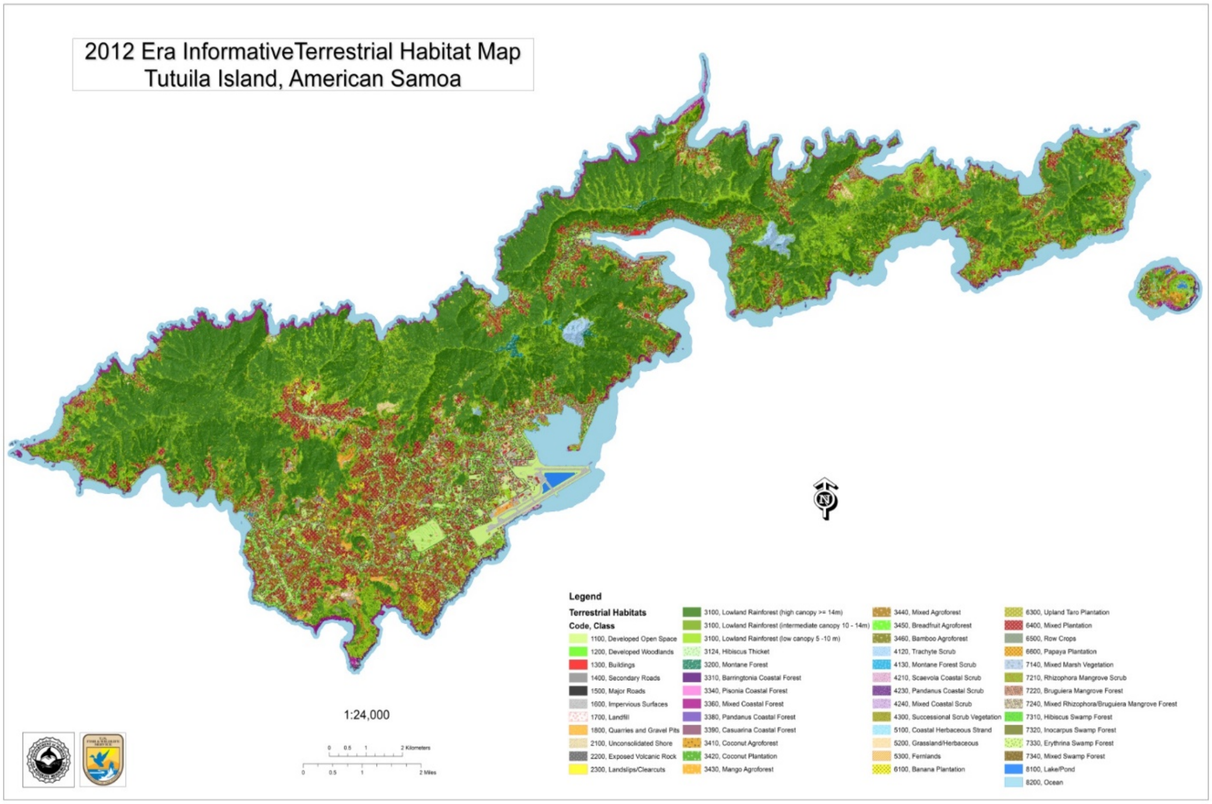


FIGURE 8. EXAMPLE OF THE TUTUILA HABITAT MAPPING PRODUCT CREATED BY THE HABITAT MAPPING PROJECT. SEE APPENDIX 4 (A-F).

4.1.4 HABITAT AND WILDLIFE: INTERDEPENDENT SYSTEMS

For many vertebrate species in American Samoa, agricultural crops can be an important resource. Cultivation of traditional plants such as coconut (*Cocos nucifera*), breadfruit (*Artocarpus altilis*), papaya (*Carica papaya*), nonu (*Morinda citrifolia*) and banana (*Musa spp.*) may potentially have increased some wildlife populations, especially bats, nectarivorous birds, and *Aplonis atrifusca* (Utzurrum & Seamon 2001). Clearing for plantations has traditionally occurred in a shifting or rotational scheme, primarily in secondary or disturbed forests (Nunn 2001, Myllyntaus et al. 2002). After initial intensive production, areas cleared for agriculture become fallow and regenerate into heterogeneous forests initially characterized by colonizing species such as *Macaranga harveyana* and *Pipturus argenteus*.

Taro and vegetable cultivation, in contrast, is often monocultural and may create areas that are both of little use to wildlife and prone to erosion (*pers. obs.*). Although even extensively cleared areas will regenerate (e.g., Elmqvist et al. 2001), the absence of other species (such as coconut or remnant native trees) in taro plantations presumably reduces visits by disperser species, slowing regeneration. Likewise, although residential areas can in theory provide valuable resources for many birds and bats (Rudd et al. 2002, Ricketts & Imhoff 2003), many of the trees planted near dwellings are exotic species of little use to wildlife (*unpub. DMWR data*).

However, in spite of the utility of agricultural areas to some wildlife species, there can be no substitute for maintaining extensive areas of native forests. This is particularly true for those species with somewhat narrow niches (Swihart et al. 2003). Even generalist species, such as many of American Samoa's native birds, are significantly more abundant in undisturbed native forests (Freifeld 1999), and the extent of deforestation has been shown to be crucial in predicting overall species richness (Steadman et al. 1999). Fruiting and flowering episodes in native species may also cause temporal shifts in animal movements (Webb et al. 1999).

Conversely, wildlife are equally important to native habitats and plant species. For example, Rainey et al. (1995) found that interactions among pollinators and plants may structure plant pollination and seed dispersal systems. Although the interactions between plants and animals have been the subject of numerous studies (e.g., see Howe & Westley 1988, Hunter et al. 1992, Fenner 2000 and Levey et al. 2001 for numerous examples from various ecosystems), there may be salient differences in plant-animal interactions between island systems such as American Samoa and more continental systems (Rainey et al. 1995).

For example, more than half of the native floras of Samoa are species dispersed by birds (Carlquist 1996). Many of the frugivores in American Samoa are generalist consumers of native fruits (e.g., Trail 1994, Webb et al. 1999), and elsewhere birds and bats have been shown to be instrumental in colonizing new islands (Shanahan et al. 2001). The conservation of this native fauna was predicted by Webb & Fa'aumu (1999) to be "essential in retaining the potential for regeneration of native forest after large- scale disturbance." Recent studies have indeed shown the crucial importance of wildlife in facilitating regeneration from the catastrophic disturbances that characterize this ecosystem (Elmqvist et al. 2001, Hjerpe et al. 2001).

These crucial interdependencies between plants and animals must therefore guide our approach to conservation in the territory. In most cases, we have attempted a two-tiered approach to conservation, focusing both on characteristics of the species of interest, and on its habitat associations. Only by obtaining adequate information on both aspects of a species ecology can we make truly informed management decisions.

4.2 MARINE HABITATS

American Samoa has a land area of 197 km^2 distributed among 5 islands and 434,503 km^2 of EEZ (0-200 nm shoreward). The ratio of land to sea is 0.045% so over 99% of the Territory is oceanic water. This emphasizes the importance of the marine habitats in American Samoa. Fringing the islands is an estimated 291.7 km^2 of coral reef area. Most of these reef ecosystem is located in Tutuila Island (243 km^2 or 83%). The banks have at least 35 km^2 of reef area. The reef area has been estimated by both satellite image analyses and is limited only up to 30 m water depth resolution. Mesophotic reefs occur in 30 to 150 m water depths so reef areas are underestimated. The underestimation must be significant. For instance, the submerged shelf around Tutuila covers an area of 358 km^2, but 86% of this shelf is at depths below 30 m. The Manua Islands have much smaller seafloor area from 30 to 150 m depth: 23 km^2 for Ofu-Olosega (66%) and 10 km^2 in Tau (50%).

4.2.1 SHALLOW-WATER CORAL REEFS

The status of the coral reefs in the Territory have been monitored by the NOAA Coral Reef Division since 2004. The data collected are percent cover of hard corals, frondose algae, and crustose coralline algae. The analyses indicated relatively stable cover of these benthic groups from 2004 to 2010 with surveys conducted every two years (PIFSC 2011). Hard coral cover ranged from 20 to 30% with the following overall-ranking: Swains (31%)> Tutuila (21%) = Tau (21%) > Ofu & Olosega (20%) > Rose (14%). These values are within the average to the upper range of percent hard coral cover published in the south Pacific (Doug Fenner, pers comm.). There was a reported moderate increase in live coral cover in Tutuila, Ofu and Olosega from 2004 to 2010. These increases have been attributed to coral cover recovery after various disturbances such as bleaching events in 2002 and 2003 and tropical storms.

Changes in the cover of the frondose algae and crustose corraline algae are relatively faster compared to live coral cover. Algae are some of the fastest growing organisms that can quickly track changes in the environment perhaps owing to their non-mineralized structures. Changes in algal cover have been attributed to changes in temperature, wave energy, nutrient availability, herbivore grazing pressure and also allelopathy (interactions with other sessile organisms). For instance, there were sharp declines recorded for the cover of the macroalgae, turf algae and crustose coralline algae in response to the severe and widespread outbreak of a tunicate that affected Swains coral reef (Vargas-Angel et al. 2009). Frondose algae and crustose coralline algae later recovered after the tunicate cover declined.

Rose Atoll is an isolated and unique coral reef ecosystem because it is geomorphologically distinct from the other volcanic islands in the archipelago. The coral reef benthos in the forereef slopes are dominated by the encrusting coralline red algae. Crustose coralline algae cover is twice the hard coral cover and has been relatively stable across years.

Coral diversity is high with more than 300 species recorded belonging to 60 scleractinian and hydrozoan genera (Birkeland et al. 1987, Green et al. 1999, DiDonato et al. 2005). There was a positive correlation between the number of coral genera and the size of the island consistent with the theory of island biogeography (MacArthur and Wilson 1967).

4.2.2 MESOPHOTIC REEFS

Deep, zooxanthellate, scleractinian coral reefs have been documented in both the Pacific and Atlantic Oceans and often occur around islands in clear tropical oceanic waters (Lang 1974; Fricke and Meischner 1985; Reed 1985; Kahng and Maragos 2006). These mesophotic coral ecosystems are found at depths of 30 to 40 m up to 150 m and have been exploited by bottomfishing fishermen mainly targeting snappers and emperors. Fishermen have reported catching eteline snappers up to 300 m depth. These ecosystems have been previously unstudied as they were beyond the capacity of regular scientific scuba diving. But the recent availability of new technology and equipment such as drop cameras, remotely operated vehicles, autonomous underwater vehicles, submersibles, and advancements in technical scuba diving practices, have opened up these previously inaccessible depths to study these deeper zooxanthellate reefs (Menza et al. 2007).

Some surveys conducted in in Tutuila Island have shown evidence of flourishing coral reefs in mesophotic depths. Most of these mesophotic coral reef ecosystems are found on mid-shelf patch reefs and on banks around the periphery of the shelf. Coral cover was highest at 30-40 m depths and declined with increasing depths. Corals were observed as deep as 102 m. There were patterns of changes in the morphology across the surveyed depth ranges. Encrusting and massive corals were dominant in 30-40 m depths while plate-like and branching corals were dominant in 40-90 m depths. An understanding of mesophotic reefs is important since these ecosystems may serve as refugia and larval source for the shallow ecosystems (Glynn 1996; Reigl and Piller 2003). Mesophotic coral reefs will probably not experience sedimentation, eutrophication, heat-related bleaching events nor tropical storms and cyclones to the level and extent that impact shallow coral reef ecosystems.

4.2.3 OCEANIC REALM

Pelagic species are closely associated with their physical and chemical environments. The physical environment depends on gradients in temperature, oxygen, or salinity, all of which are influenced by oceanic conditions on various scales. Isotherm and isohaline boundaries often determine whether the surrounding water mass is suitable for pelagic fish. Fronts and eddies are important areas of congregation for different trophic levels for foraging, migration, and reproduction for many species (Bakun 1996).

Skipjack, yellowfin tuna and blue marlin prefer warm surface layers, where the water is well mixed by surface winds and is relatively uniform in temperature and salinity. Albacore, bigeye tuna, striped marlin, and swordfish, prefer cooler, more temperate waters, in higher latitudes or greater depths. Preferred water temperature often varies with the size and maturity of pelagic fish, and adults usually have a wider temperature tolerance than subadults. During spawning, adults of many pelagic species usually move to warmer waters, the preferred habitat of their larval and juvenile stages.

Large-scale oceanographic events (such as El Niño) change the characteristics of water temperature and productivity across the Pacific, and these events have a significant effect on the habitat range and movements of pelagic species. Tuna are commonly most concentrated near islands and seamounts that create divergences and convergences, which concentrate forage species, and also near upwelling zones along ocean current boundaries and along gradients in temperature, oxygen, and salinity. Swordfish and numerous other pelagic species tend to concentrate along food-rich temperature fronts between cold upwelled water and warmer oceanic water masses (NMFS 2001). For instance, Domokos et al. (2007) showed that south Pacific albacore catch rates in longlines were higher in boundaries of mesoscale eddies caused by the South Equatorial Current and South Equatorial Countercurrent. These areas of higher horizontal shears are associated with higher micronekton abundance and thus constitute as significant foraging areas of the south Pacific albacore.

5 SPECIES OF GREATEST CONSERVATION CONCERN

For the terrestrial wildlife, native species 1) whose conservation status are unknown (Conservation Class I), 2) known to the extent that they are considered to be of concern by virtue of threat and/or small population sizes (Conservation Class II), or 3) considered high priority in the past and are currently the focus of on-going research, conservation, & management efforts (Conservation Class III) include several invertebrates (a butterfly, a land crab, and endemic terrestrial snails), five reptiles (2 marine turtles, a snake, and 2 skinks), nine birds, and a variety of mammals (3 bats, and cetaceans) (see Table 2 for a listing). For the marine species, we prioritized species of greatest conservation concern only classified under Conservation Class I and II, with high data reliability and low abundance. These species included three giant clams, three sea cucumbers (holothurians), six hard corals, and three eteline snappers. With the exception of a few that are largely unknown, these species or species groups are presented in this Section in greater detail. Abundances, distribution, and threats to each are provided to the extent that data are available. Priority actions deemed essential for the conservation or future conservation planning are enumerated at the end of each descriptive subsection. The conservation needs of those poorly known species excluded from this Section but deserving priority attention have been outlined in the overviews presented in Section 3.

5.1 *Papilio godeffroyi*

Local common name: Unknown

Distribution: endemic to Samoan Archipelago

Abundance: uncommon to moderately common

Laboratory-hatched *P. godeffroyi*
(M. Schmaedick, ASCC/Land Grant)

The Samoan swallowtail butterfly, *Papilio godeffroyi*, appears to be a single-island endemic on Tutuila Island, reduced from its former range which included Upolu and Savai'i. Despite its conspicuous appearance, the butterfly has remained largely unnoticed in the Territory. Larvae occur on *Micromelum minutum* (N. Gurr, *pers. comm.*), a relatively common plant species in secondary forest understory. It is possible that other species in the Rutaceae are also food plants for the larvae but this has not been studied in American Samoa (M. Schmaedick, *pers. comm.*). A research collaboration between DMWR, NPS, USGS, and ASCC Land Grant evaluated parasitism on *P. godeffroyi* immature stages and documented habitat variables at field sites on Tutuila Island (R. Peck et al. unpublished data). The butterfly was found to be not rare, but present at low densities at secondary forest sites in the east, west, and central areas of the island, both inside and outside the National Park. Although analysis continues, eggs were found to be attacked at a rather high rate by an undescribed parasitoid species. The parasitoid may be native, as early reports from the 1800s also noted high egg parasitism of *P. godeffroyi.*

5.1.1 THREATS

Specific threats are difficult to identify owing to the lack of information on the butterfly's biology in the Territory. It is unlikely that food is a limiting factor given the abundance of potential food plants. It is unclear whether parasitism is a threat or perhaps even plays a stabilizing role by preventing overexploitation of host plants. The most immediate threats might be overcollecting for the lucrative price the butterfly may fetch in the collectors' market and/or possibly predators such as introduced exotic ants.

5.1.2 CONSERVATION PRIORITIES

The dearth of information on the species requires that priorities be set to:

1. *continue to document distribution* among and within islands of the Territory, including any information on habitat-specificity;

2. *develop and implement a monitoring protocol*

3. *develop a captive rearing capacity locally to facilitate research on predation and host preferences and to prepare for possible re-introduction into areas of Upolu and Savai'i where it has gone extinct*

4. *continue to assess natural threats*, such as predators and parasitoids on Tutuila Island and on Upolu and Savai'i if the butterfly is re-introduced there.

When sufficient baseline information on numbers, distribution, and basic biological needs and threats shall have been collected, a species-specific conservation plan should be developed given the potential commercial interest in the species.

5.2 THE COCONUT CRAB, *Birgus latro*

Coconut crab for sale at the Fagatogo market
(Photo by DF Nyhagen)

Local common name: u'u

Distribution: widespread in Oceania & within American Samoa

Abundance: common (immature) to uncommon

(adults)

Status: not federally listed; locally protected

The coconut crab, *Birgus latro*, has been a particularly frequent subject of study elsewhere in Oceania (Fletcher et al. 1990, Kadiri-Jan & Chauvet 1998, Chauvet & Kadiri-Jan 1999, Brown & Fielder 1991). It is found on all the islands of American Samoa (except Rose Atoll), but is abundant primarily on Swains island (*pers. obs.*). Despite its cultural importance as a food resource, there have been no studies conducted on the local species, and estimates of their numbers and information on the extent of their distributional (habitat) range in the Territory are lacking.

5.2.1 THREATS

Specific threats to the long-term health and viability of populations of coconut crabs in the Territory are unknown due to the lack of studies on the species. The most logical threats to the species are unregulated harvesting and loss of habitat, and these factors should be investigated. Subsistence and low-level commercial harvest pose a threat to the species, particularly when harvest is biased towards reproductive adults. Although existing regulations limit the harvest of crabs by size and reproductive condition (American Samoa Administrative Code Title 24, Chapter 09), it is suspected that a substantial amount of crabs harvested for subsistence and informal sale may violate restrictions.

Anecdotal information from locals who habitually hunt consistently report rocky coastal areas as likely areas for finding coconut crabs. In Tutuila, rocky coastal plains, particularly in the Tafuna area, are increasingly being bulldozed for housing and other developments. If, in fact, this type of substrate is important habitat for the species, then continuing developments may have a significant impact on the species, or a developmental stage of the species.

5.2.2 CONSERVATION PRIORITIES

Based on the minimum information available on the status of and threats to the species, the following priority actions are recommended to enable better conservation planning for species:

1) *assessment of the population and distributional status* in American Samoa

Measures are in place to regulate the take of *B. latro* throughout the Territory, including a prohibition against the take of gravid females. However, we have insufficient evidence to determine if these regulations are adequate to maintain a healthy population of crabs, or to determine trajectories in abundances through time. Once initial estimates of population abundance and distributional data become available, it will be possible to derive specific hypotheses pertinent to management decisions. For example, it might be important to determine which possible causative factors predict heterogeneity in spatial patterns of *B. latro* abundance;

2) *research the reproductive ecology of the species*, and

3) *conduct a feasibility study on subsistence and commercial farming* of cococutcrabs

Information on the species' ecological requirements, particularly for successful reproduction is vital for management of the species. Given the cultural interest in the species as a food item, farming of the crabs (whether for subsistence or commercial use) may alleviate pressure on populations in the wild.

As supporting information, it will be beneficial to *systematically compile harvest information* in cooperation with villages. The information can be used to develop a profile on levels of take, sizes taken, and areas of collection. Information on methods used for harvest could also be useful when developing a management plan.

5.3 ENDEMIC TERRESTRIAL SNAILS

Eua sp. and *Trochomorpha apia*
(Photo used with permission from R. Cowie)

Local common name: sisi

Distribution: endemic to Samoan

Archipelago

Abundance: deemed rare

Status: ESA Endangered Species

Two species of terrestrial gastropods are currently listed as endangered under the US Endangered Species Act: *Eua zebrina* and *Ostodes strigatus*. Six others are categorized as species of concern: *Diastole matafaoi*, *D. schmeltziana*, *Samoana abbreviata, S. conica*, *S. thurstoni* and *Trochomorpha apia*.

The snail fauna of the Pacific has been well-studied (Cowie 1996 and references therein), but primarily with a view to documenting distributions and diversity from given islands or archipelagos, rather than providing a basis for monitoring and conservation (e.g., Cowie & Cook 1998, Cowie & Rundell 2002, Cowie et al. 2002). However, these data have been sufficient to detect significant long-term declines in many species (Cowie 2001a, Cowie & Cook 2001).

5.3.1 THREATS

By far the most significant threat to native snail faunas is posed by introduced species of snails (Cowie 2001b). Although the efficacy of predatory species for the biocontrol of previously introduced deleterious species such as the African snail *(Achatina fullica*) was largely undocumented, several species have been introduced to the Samoan Archipelago precisely for this reason (see Lydeard et al. 2004). The most significant introduced predatory snail may be *Euglandina rosea*, but there are at least 25 other introduced species that may be important predators or competitors (Cowie 2001b). The predatory flatworm *Platydemus manokwari* could also be disastrous for native species (Cowie & Robinson 2002). The flatworm was introduced to Samoa to control introduced predatory snails, but itself has become a threat to the native snails. It is reported that this flatworm is now common on Tutuila, although it has not been reported from other American Samoa islands (Cowie 2005; P. Craig pers. comm.). Finally, for snail species with critically restricted distributions (e.g., *S. abbreviata*, Cowie & Cook 2001), even small-scale habitat loss is a potential problem.

5.3.2 CONSERVATION PRIORITIES

Due to the many threats faced by the remaining native snails in the territory, our immediate priorities are:

1) *exhaustively document the within-island distributions* of the snails within and among habitats;

2) *identify critical ecological linkages between species and habitat factors* (e.g. microclimate; substrate, plant species); and

3) *develop and implement a monitoring program* to determine population performance and trends through time.

Accurate distribution maps would allow focused conservation efforts within small but critically important areas, perhaps by the exclusion of introduced species. It would also determine the presence of any refugia within which some or all invasives are absent. Again, measures could then be taken to reduce the chance of immigration in to these refugi by known invasives. The monitoring program should be designed within an ecological framework. This would enable identification of factors that may be impacting the species.

The second major priority is to **improve quarantine methods**, both between American Samoa and Samoa to its west, and within American Samoa between Tutuila and the more pristine Manu'a islands to the east. It is imperative that *P. manokwari* not be introduced from Samoa, and the frequent shipment of root crops such as taro greatly increases the risk of such an accidental introduction. If indeed *P. manokwari* is already in Tutuila, it is imperative that quarantine measures are observed to precent its spread to other islands. Likewise, it is critically important that *E. rosea* not be introduced into Manu'a.

These priorities echo a few of the conservation actions outlined in Cowie (2004), and should set the stage for more in-depth treatment in subsequent updates of this strategy.

5.4 MARINE TURTLES


Green turtle. Photo by M.A. MacDonald

Local common name: laumei

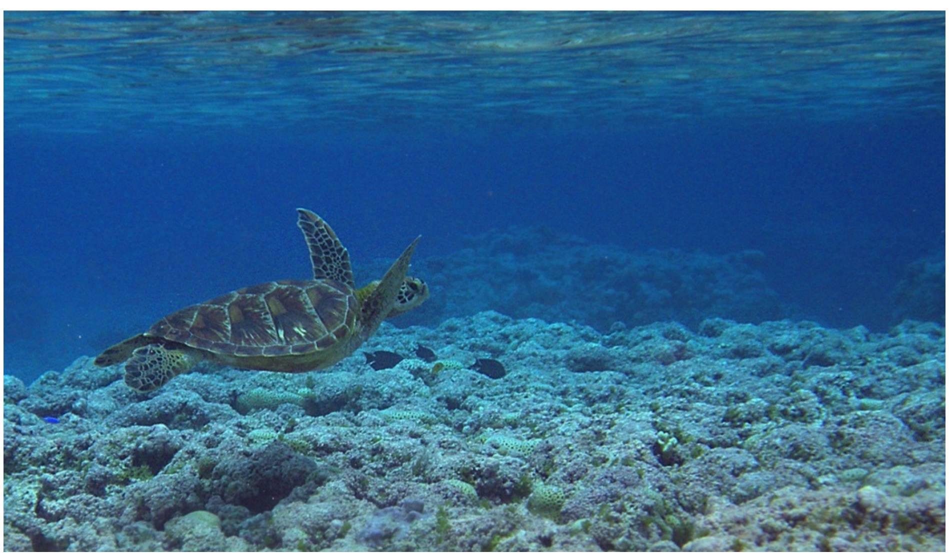
Distribution: throughout the Pacific

Abundance: uncommon in American Samoa Status:

E. imbricata – ESA Endangered Species;

C. mydas – ESA Endangered Species

Two species of marine turtle, the federally endangered hawksbill turtle (*Eretmochelys imbricata*) and the federally endangered green turtle (*Chelonia mydas*), are known to nest on American Samoan beaches and regularly occur on the inshore reefs in the territory (Tuato'o-Bartley et al. 1993). Territorial beaches are known nesting areas for both of these species (MacDonald 2015) and juvenile hawksbills and greens are frequently observed in coastal waters where they forage (Grant et al. 1997a). Serious declines in Pacific populations of sea turtles and a lack of basic biological information on turtles in our region make marine turtle conservation a top priority (Craig 2002). The protection of sea turtles and their habitats (i.e., nesting beaches and foraging areas) is critical to the preservation of populations inhabiting the territory and also forestalling the global extinction of these two species.



Green turtle on reef at Swain's Island, American Samoa. Photo by M.A. MacDonald.

5.4.1 ABUNDANCE

Abundance estimates of American Samoa's sea turtle populations are difficult to make due to a dearth of data for the territory. Ofu-Olosega have been monitored extensively since 2013 yielding avg estimates of ~10 breeding hawksbills and <5 breeding greens (MacDonald 2015). Continued monitoring over the next several years will be essential in refining these number to better describe the situation in Ofu-Olosega but these preliminary estimates show the breeding populations of both species to be extremely low. A comprehensive nesting beach monitoring programme for Tutuila is not feasible given the spread out nature of the beaches and low activity observed. Nest estimates for these beaches, obtained through detailed interviews and reports from the villages, suggest each beach only sees 1-2 nesters a season. A conservative estimate for Tutuila nesters, therefore, can be put at somewhere < 50.

5.4.2 DISTRIBUTION

Sea turtles have been reported in coastal waters and on beaches of all islands in American Samoa, with most reports coming from the most populous island, Tutuila (Utzurrum 2002). On Tutuila, the majority of sea turtle sightings occur in Pala Lagoon (Lion's Park), Faga'alu Park, and Gataivai although high densities of juvenile recruits can be found on nearly any of the island’s reefs (DMWR data). Figure 9 shows the locations at which turtle sightings were reported during the first eight months of 2005.

Beaches with nesting potential (i.e., sandy areas not inundated by high tide) occur on all aspects of Tutuila and on at least one beach of every island in the territory. Most of the 11 beaches on Tutuila for which nesting activity has been reported arelocated on the eastern half of the island (DMWR data) (Figure 9). Ofu-Olosega have several confirmed nesting beaches for both greens and hawkbills with the heaviest activity located on Ofu Island (MacDonald 2015). Ta’u has confirmed nesting for hawksbill turtles on the eastern beach although no formal surveying has been done to date. Rose Atoll is a confirmed green turtle nesting site with relatively high nesting activity as well on Swain’s Island (Craig et al. 2004).

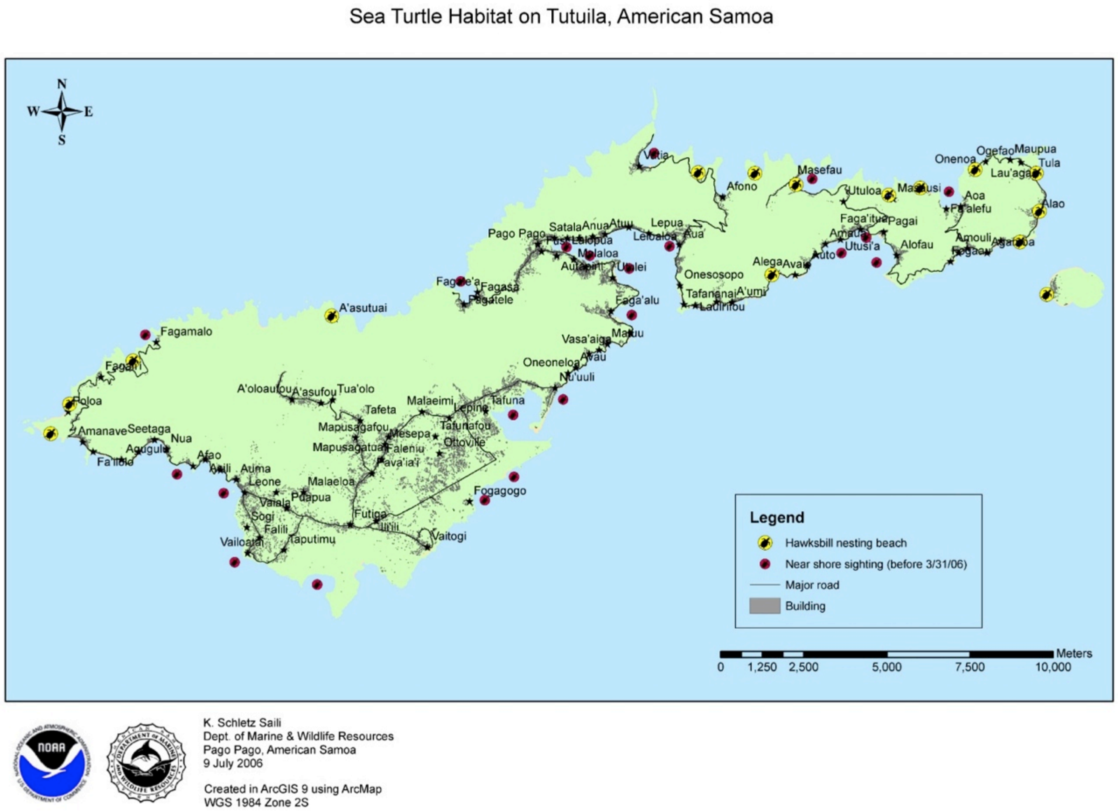


FIGURE 9. MARINE TURTLE HABITAT ON TUTUILA ISLAND.

5.4.3 KEY HABITATS

Key habitat for sea turtles includes both potential foraging areas as well as known or potential nesting beaches. In addition to confirmed hawksbill nesting beaches on Tutuila, several potential nesting beaches where extensive sandy areas are not inundated by high tide waters are available (DMWR data). Although it appears that the selection of nesting beaches may have a geographical basis (i.e., areas at the eastern side of Tutuila) in the territory, further research is needed to determine which beach characteristics affect nesting beach selection. The limited number of confirmed and potential nesting beaches on Tutuila necessitates extensive protection of all remaining undisturbed habitat to unsure continued breeding on the island.

Based on dietary habits, near shore areas with high coral and seagrass cover are the most probable foraging grounds for hawksbill and green turtles. Limited data from in-water surveys and incidental sightings, however, indicate that hawksbills are present throughout the surrounding waters of Tutuila Is. (Figure 9). An in-water programme is needed to determine whether certain areas are preferred over others and enable designation of select sectors for management as critical foraging areas.

An analysis of migratory patterns for Manu’a hawksbills and green turtles was undertaken during the 2014/2015 nesting season. Three hawksbill turtles and two greens were tagged on Ofu Island in the early months of 2015. Results indicate that green turtle migratory routes from Manu’a to the foraging grounds follow closely those previously recorded from Rose Atoll although the Great Barrier reef as a foraging ground is a new observation. Hawksbill turtles from Ofu were shown to have radically different migration patterns from those of greens and an increased deployment of tags is required to better identify routes and foraging grounds.

Deployment of a satellite tag on a female Green Turtle. Toaga beach, Ofu Island, American Samoa, Feb.-2015. Photo by M.A. MacDonald.

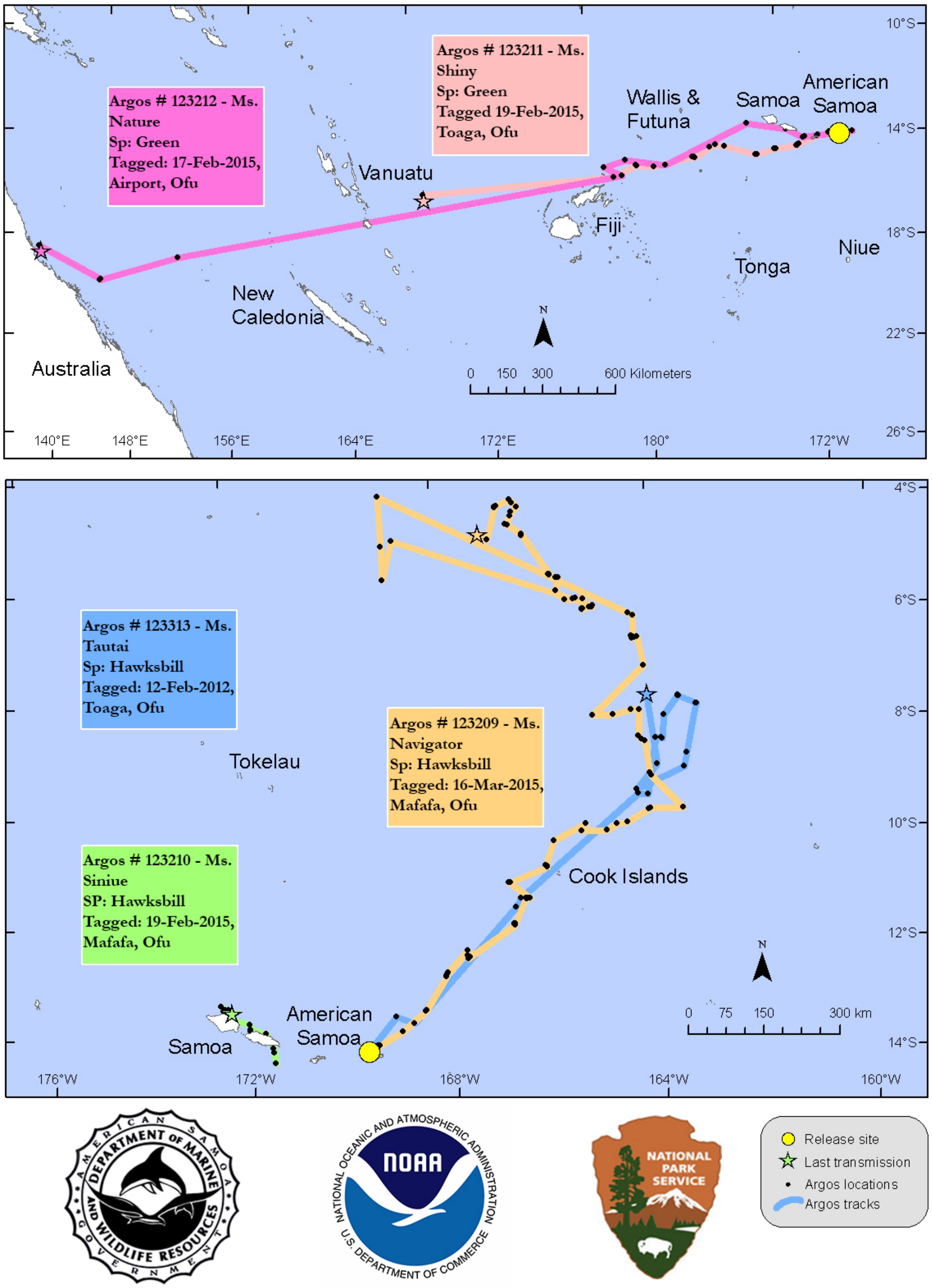


FIGURE 10. THE MIGRATION ROUTES OF 4 TURTLES SATELLITE TAGGED ON OFU.

5.4.4 THREATS

The construction of seawalls for protection of coastal roads and village infrastructure is a major threat to potential nesting beaches. Majority of these structures were installed following extensive damages to coastal roads in the aftermath of Hurricanes Ofa and Val in 1991 and 1992, respectively. Additional construction followed hurricanes in 2004 and 2005. The areas under increasing threat are confined to portions of the islands were villages and coastal infrastructures are found in Tutuila and Manu'a. In Tutuila, any future road development and shoreline revetment (such as a seawall) particularly along the southeastern sector of the island must be reviewed closely as these are areas of known nesting beaches.

Other, more insidious threats to the habitat itself include sand-mining and associated construction projects, inundation with freshwater runoff during floods, and pollution (Witherington 1999). Shoreline activities may also degrade foraging habitats by indirectly altering the seafloor composition and available food items at those sites (Gibson & Smith 1999).

Direct threats to nesting turtles and hatchlings include light pollution, traffic on roads accessible to turtles, predation, and poaching of eggs and adults (Boulon 1999). Turtles frequenting territorial waters (both coastal and pelagic) are at greatest risk from poachers and incidental catch in longline fisheries (Craig 2002). Although the harvest of eggs and turtles are illegal under Territorial and federal laws occasional reports of poaching are not uncommon (DMWR Enforcement/Conservation logs).

Derelict fishing gear has been shown to pose a significant threat to resident turtles on the reefs of Tutuila (MacDonald 2015). A full 25% of all stranding responses to dead turtles found the cause of death to be related to hooks and monofilament entanglement making this issue the number one threat faced by turtles foraging on reef flats around the island. American Samoa is fortunate not to be plagued by the ghost gear from industrial fishing seen elsewhere yet the risk of entanglement from derelict line from local fishers needs to be addressed. Direct hooking of turtles appears to be rare. Rather, line and hook cut after becoming snagged on the reef are those that are responsible for the majority of entanglements observed. A programme to reduce the amount of these types of materials left on the reef is critical.

Satellite tracking of green and hawksbill turtles nesting in Ofu Island and Rose Atoll demonstrates that these threats are not limited to American Samoa. The migratory habit of these animals expose them to predation by humans in other countries where regulations and restrictions on takes are not as stringent as in American Samoa. Indeed, the transnational habits of sea turtles necessitate the immediate implementation of a regional recovery plan (Craig 2002).

5.4.5 CONSERVATION PRIORITIES

A territorial sea turtle recovery plan was drafted in 1999 (AS Sea Turtle Recovery Team 1999) followed by an executive order from American Samoa's governor establishing the territorial waters as sanctuary for sea turtles and marine mammals in 2003 (American Samoa Government 2003: Executive Order 005-2003). These documents in addition to the USFWS recovery plans for Pacific populations of both green sea turtles and hawksbill sea turtles (NMFS 1998) outline American Samoa's sea trtle research needs. DMWR along with other local recovery team members has initiated a sea turtle research program aimed at implementing the needs identified in the draft recovery plan.

Among the identified conservation needs being acted upon are: 1) *mapping local distributions*; 2) *physical characterization of documented and potential nesting beaches* to be used in the mitigation of threats to nesting sea turtles, nests, and hatchlings; 3) *determination of genetic stocks* to aid in transboundary management; 4) *documentation of migration routes* (with focus on the hawksbill sea turtle); 5) *identification of key foraging areas*; and 6) *increasing public awareness on conservation issues* affecting local populations of sea turtles (NOAA Unallied Management Grants to DMWR: 2004 to present).

Future research will be needed to establish reliable estimates of population size and long-term data sets from which population trends can be determined. Also, the American Samoa Sea Turtle Recovery Team need to revisit the draft conservation strategy for the territory, assess what objectives have been accomplished, and identify pragmatic means by which unaccomplished priority objectives can be accomplished.

Although a regional conservation strategy has apparently been drafted (Craig 2002; SPREP Marine Turtle Conservation Action Plan 2002-2007), its implementation appears to be behind schedule. Communication networks must be re-established in order to implement a regional conservation plan. The celebration of the Year of the Sea Turtle in 2006 provides an excellent impetus to reestablish communication lines among nations and readdress the implementation of a regional conservation strategy.

5.5 TERRESTRIAL REPTILES OF CONCERN

Candoia bibroni (Pacific Boa)
Local common name: gata
Distribution: throughout the region; restricted in American Samoa
Abundance: rare
Status: unknown, but maybe in decline; locally protected

Photo by Mark Macdonald

Cryptoblepharus poeciloplurus and *Emoia lawesi*
(Snake-eyed and Lawes skinks)
Local common name: pili and pili oua'
Distribution: restricted in American Samoa
Abundance: presumed rare
Status: unknown; locally protected

Three species of reptiles are deserving attention and very little is known of their current status in American Samoa except that they are rare and of restricted distribution. These are the Pacific boa (*Candoia bibroni*) and two species of skinks (*Cryptoblepharus poeciloplurus* and *Emoia lawesi*). The Pacific Boa is currently known only in Ta'u, although there is fossil evidence of its occurrence in Tutuila (Steadman and Pregill 2004). A brief summary of threats to these species, and of baseline actions that can enable a preliminary assessment of their statuses are presented in this section.

5.5.1 THREATS

Major threats to the Pacific boa and the two skinks (Snake-eyed and Lawes) are likely to be loss of habitat and predation. The Pacific boa is presently known only from the island of Ta'u. Ta'u remains largely covered with forest and a substantial area of which is protected under the National Park lease agreement with the local villages. Frequent sightings are reported to DMWR by residents of the villages of Ta'u and Faga.A major threat to the Pacific boa is being killed by local villagers when found in their plantations due to the false believe the snake is dangerous. The population may be reduced to critically low numbers requiring active intervention aimed at increasing numbers.

The Snake-eyed Skink (*C. poeciloplurus*) and Lawes Skink (*E. lawesi*) are restricted to or known to prefer coastal habitats, thus making them susceptible to hurricanes, and susceptible to introduced predators. Both cats and rats have been present in most of the territory for a significant time, and their impacts on the herpetofauna are unlikely to significantly increase. The exception is Swains island, where cats have been introduced to control rats (W. Jennings, *pers. comm.*) since the surveys conducted by Amerson et al. (1982a).

5.5.2 CONSERVATION PRIORITIES

Although the lack of known, imminent threats on most islands downgrades the overall priority level of herpetofaunal studies, there are at least three areas that warrant attention:

1. *Update the status of the Pacific Boa in Ta'u*. Local villagers report frequent sightings in Ta'u village and Faga (on Ta'u) to DMWR Wildlife Division staff and a live snake was delivered to DMWR Wildlife Division staff in November 2015 while they were on Ta'u conducting bird surveys. The snake was used as a presentation tool to local school children and villagers in order to educate them on the importance of the snake, and demonstrate that they are not dangerous to the public. Additional, systematic surveys are needed in order to document distribution and population size on the Island of Ta'u.

Conducting boa public outreach through KVZK news.

2. *Update the status of the Swains island herpetofauna*, given previousrecords of uncommon species from the island and the introduction of cats (to the island) since the previous surveys.

3. *Update the status of the Snake-eyed skink*, since this species was noted as rare during previous surveys.

5.6 NATIVE LAND BIRDS

A number of land birds are of conservation concern by virtue of their status, distribution, abundance, susceptibility to threats, and/or cultural importance (Table 1).Several of these species are restricted to the Western Polynesian region, while others are more geographically widespread. Out of 18 species that occur/occured in American Samoa, only two are endemic to the SamoanArchipelago, the Samoan Starling (*Aplonis atrifusca*) and the Ma'oma'o (*Gymnomyza samoensis)*. The Ma'oma'o has been extirpated from American Samoa, though it continues in low numbers in Western Samoa. Five subspecies are endemic to American Samoa, the Collared Kingfisher of Tutuila (*Todiramphus chloris pealei*), the Collared Kingfisher of Manu'a (*Todiramphus chloris manuae*), the Polynesian Starling of Tutuila (*Aplonis tabuensis tutuilae)*, the Polynesian Starling of Manu'a (*Aplonis tabuensis manuae)*, and the Lesser [Fiji/Samoan] Shrikebill of Manu'a (*Clytorhynchus vitiensis powelli*)..

Following are brief descriptions of threats to the species. Information on distribution and abundances, and general assessment of status are summarized in Table 1 and cited in Subsection 3.2.2. Gaps in information and priority actions pertinent to their conservation are identified in theaccounts.

5.6.1 SPECIES ACCOUNTS

Baseline data remains patchy for most terrestrial bird species found in American Samoa. Surveys conducted over the past decade may give indication of relative abundance and population trends but not of population size. Among these species this information gap is particularly apparent in the Shy [friendly] Ground-dove (*Alopecoenas* stairi), Many-coloured Fruit-dove (*Ptilinopus* perousii), Pacific Black [Grey] Duck (*Anas superciliosa*), Purple Swamphen (*Porphyrio porphyrio*), and Spotless Crake (*Porzana tabuensis*). Less is known of populations in the Manu'a islands due to the difficulty in maintaining continuous monitoring in these more remote locations. Ten species are featured below as deserving priority attention, and if available, includes such information as habitat, distribution, abundance and threats.

5.6.1.1 Purple Swamphen (manuali'i)

Porphyrio porphyrio

The Purple Swamphen is widespread and likely has never been abundant in American Samoa. Their low numbers are an expected result of habitat restrictions, as it relies on agroforests and wetland areas. In American Samoa, it occurs on all islands except Rose Atoll (Amerson et al. 1982a) and Swains Island. This species is of cultural significance, as its Samoan name *manuali'i* translates to "bird of chiefs." However, it is also perceived as an agricultural pest to crops such as banana (*Musa spp.*) and taro (*Colocaia sp.)*. Because of this, it isoccasionally killed by farmers. This species may be inherently vulnerable due to its habitat restrictions. Wetlands in American Samoa are few, and these limited areas may continue to decrease and degrade as the island becomes more developed. Swamphens may also be vulnerable to the changes in agricultural lands that result from farming practices converting to modern, more intensive methods as mixed, traditional methods are left behind (Hole et al. 2002). Its diet elsewhere in its range is omnivorous, and thus, it may be beneficial in agricultural settings if it also consumes snails or other agricultural pests. It is therefore important to accurately determine the abundance and distribution of this species, and to determine its actual dietary preferences and habits. Such distribution and density data would allow for the construction of detailed maps to identify and protect the most suitable habitats for *P. porphyrio*, a method successfully used in other study systems (Li et al. 2002).

5.6.1.2 Spotless Crake

Zapornia tabuensis

The Spotless Crake remains a high priority species due to its low abundance and extreme geographical restriction. It is thought to have once occurred on Tutuila but no recent sightings have been noted, and it is presumed to have been extirpated from the island. The only stronghold remaining to this species is Ta'u island; it is found nowhere else in American Samoa. The Spotless Crake was first discovered on Ta'u in the 1920s and had been thought extirpated until one specimen was rediscovered near Ta'u village in the 1980s. It was not recorded again on Ta'u until 2001 when one bird was briefly observed in dense montane scrub at the summit of Mt. Lata. In 2011, one was caught incidentally via a live trap during a rat sampling expedition at the summit of Mt. Lata. It should be noted that during this sampling period, no rats were captured at or near the summit of Mt. Lata while, during the same sampling period, both Polynesian (*Rattus exulans*) and Norway rats (*R.*

norvegicus) were frequently captured at forested lowland and mid-elevation sites on Ta'u. In May – September 2013 surveys were undertaken on Ta'u in order to help describe the distribution, habitat preference, and population of the Spotless Crake. The Crake is currently thought to be restricted to an area within the National Park of American Samoa on Ta'u island, and although formerly reported from lowland wetlands thereon, recent records are exclusively from dense montane scrub habitats near the summit of Mt. Lata (~1000 m elevation). It is known to be associated with ephemeral upland stream habitats in Western Samoa (*pers. comm.*), and the most recent surveys have indicated that they are closely tied to wetland habitat on Ta'u. Intensive follow up surveys targeting the Spotless Crake are crucial to augmenting the current knowledge of this species on Ta'u, as well as to closely monitor for sudden declines in numbers. We are only beginning to understand its status and it is recommended that transects establishedin 2013 continue to be surveyed for the presence of Crake. Other survey sites should also be added to include the Liu area, which is very similar and geographically near to the area in which Crakes were detected. Efforts should be made to survey the northwestern foothills of Mt. Lata, as well as the extreme southwestern side of Ta'u island, as these areas were not covered by past sampling efforts. It appears that the major threat to the persistence of this species in American Samoa is the presence of introduced rats. Rat trapping on Ta'u has documented the presence of Norway rats (*Rattus norvegicus*) in both lowland agroforest and summit montane scrub habitats, while Polynesian rats (*R. exulans*) occupy forested habitats on the north side of the island (O'Connor & Rauzon 2003, DMWR *unpub. data*). These surveys found lower rat abundance on the south side of the island where, as suggested then, a refuge for the Crake was discovered in the Laufuti area. The well-documented propensity for flightlessness of insular rails in this genus (Slikaset al. 2002) makes them particularly susceptible to within-island threats. Other threats may include feral cats, habitat destruction and modification by feral pigs and cattle, and increased subsistence farming resulting in habitat loss. It is highly likely that this species will become extinct in the foreseeable future without active conservation efforts.

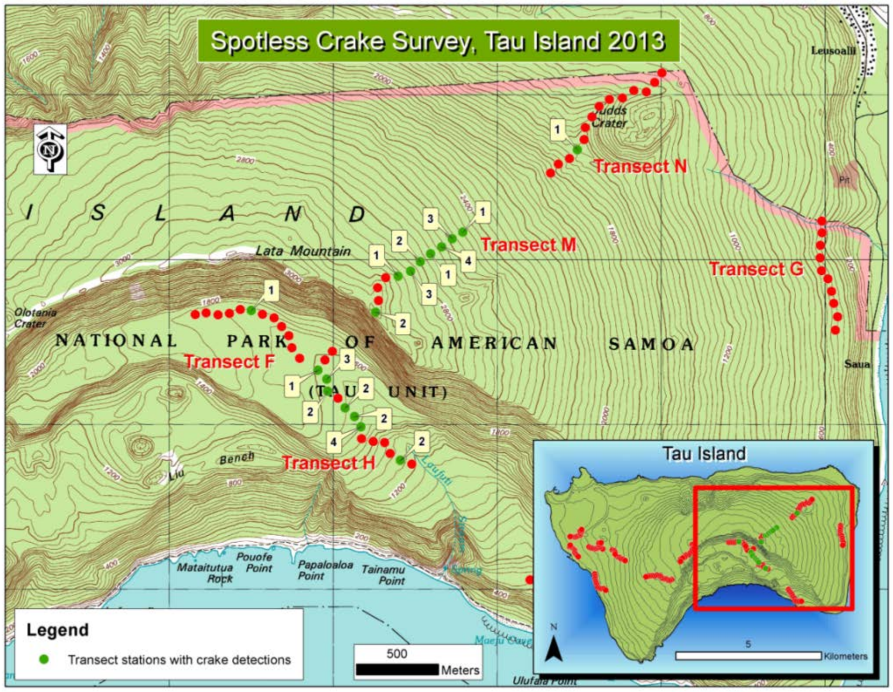


FIGURE 11. SPOTLESS CRAKE TRANSECT SURVEYS CONDUCTED IN 2013.

5.6.1.3 Samoan Starling (fuia)
Aplonis atrifusca

One of six Class III terrestrial bird species listed in Table 2 is the Samoan archipelago endemic, the Samoan Starling (*Aplonis atrifusca*). Survey data suggests reasonably abundant populations of this species, which occurs on all islands of American Samoa except for Rose Atoll and Swains Island. It is a habitat generalist, and is not subject to significant human predation. Highest densities occur in Manua's agro-forest edges (*pers. obs.*), where it is commonly seen feeding on crop fruits such as papaya (*Carica* papaya). It is listed as a priority species due to its endemism (restricted globally to the Samoan archipelago), its significantly high loads of endoparasites (Atkinson et al. 2006), and because of its cavity nesting habit which may pose a vulnerability to the burgeoning Tutuila populations of introduced myna species (*Acridotheres sp.*). Continued surveys suggest stable populations, though a thorough analysis of existing data is necessary to detect finer trends. Intensive mark-recapture surveys targeting forest bird species have resulted in additional baseline data for this species. New ageing and sexing criteria have been developed so as birds can be accurately aged and sexed in hand (Pyle et al. in review). With this, data is available to begin constructing demographic makeup of the populations and analysis will likely begin in 2016. Moulting appeared to be protracted in this species, and began June – August and completed in December – March. One female in definitive plumage was captured undergoing staffelmauser-like replacement of primary feathers. If such proves to be the case, it would be the first documented passerine showing such a feather replacement pattern. This data, along with those of Banks (1984), suggests a primary breeding season of May – November with lower-level breeding in December – April.

5.6.1.4 Polynesian Starling (miti vao)

Aplonis tabuensis tutuilae

Aplonis tabuensis manuae

The Polynesian Starling is listed as a priority species. Unlike its endemic congener, the Samoan Starling, the Polynesian Starling has a much wider range and is found in Fiji, Tonga, Niue, and the Samoan archipelago. Two subspecies of the Polynesian Starling, which can be visually separated, however, are endemic to American Samoa (*A. t. tutuilae and A. t. manuae*). The Polynesian Starling appears to be less common than the Samoan Starling and is restricted to native forest habitat; rarely seen in urbanized areas such as plantations and villages. They appear to be more common in Maloata on the west end of the island, between Afono and Vatia on the north side, and along the Mt. Alava Road. The Polynesian Starling is also a cavity nester, but because of a demarcated habitat preference, it may be less impacted by the presence of the introduced Common Myna (*Acridotheres tristis*) which may compete with Samoan Starlings over nesting spaces. However, the introduced Jungle Myna (*Acridotheres fuscus*) has been seen in forest habitat bordering urban areas and may potentially compete with Polynesian Starlings if its range continues to expand into native forested areas. Mark-recapture surveys have resulted in sufficient data to develop aging and sexing criteria for this species (Pyle et al. in review), though likely not enough individuals were captured to give a good indication of the demographic makeup of the population. This may be resultant of the natural low densities of the species and more intensive sampling methods may be necessary to gather baseline demographic trends.

5.6.1.5 Lesser [Fiji] Shrikebill (sega o le vau)

Clytorhynchus vitiensis powelli

Lesser Shrikebill in American Samoa are currently listed as being an endemic subspecies, but this subspecies is a candidate for elevation to full species status (Pratt 2010 and Andersen 2015). Already, it is considered a separate species, Samoan Shrikebill (*Clytorhynchus powelli*) to the Fiji/Lesser Shrikebill (*Clytorhynchus vitiensis*), by some authors (Pyle et al. in review). More data is needed for the status change, but the Samoan subspecies is morphologically distinguishable from populations found in Fiji and Tonga. Once it is officially elevated to full species, it will be the only bird endemic to American Samoa (the Samoan Starling is endemic to the Samoan archipelago). The Shrikebills in American Samoa arerestricted to the Manu'a island group where they are locally abundant in suitable habitat, though uncommon throughout the territory. In Ta'u they are restricted to mid-elevation mature native forest, and are rarely seen in lower elevations. This habitat specificity makes this species more vulnerable to population decline; this is particularly the case in American Samoa where hurricanes cause large scale habitat destruction (hurricane Heta in January 2004, and Olaf in February 2005). Continued monitoring of this species before, and after such events should be a high priority to ensure subsistence of the population. Bird banding data has resulted in criteria to accurately age and sex individuals in the hand. These data indicate that breeding probably occurs primarily in November – January, followed by moulting of feathers.

5.6.1.6 Pacific Imperial-pigeon (lupe)

Ducula pacifica

The Pacific Pigeon ranges from the islands north of New Guinea east through Fiji, Tonga, Samoa, Niue, and the Cook Islands. Throughout its range, it is usually found on small islands and atolls, and rarely on large ‘high islands’ where it is replaced by a different species of pigeon. Its natural habitats are tropical moist lowland forests on smaller islands and tropical moist montane forest on larger islands. The Pacific Pigeon is the largest forest bird found in American Samoa, and as a fructivor, it likely plays an important role in dispersing the largest seeds of native trees. They have been observed carrying nesting material during the months of January – September. A pair will lay one egg, which is incubated by both parents. The hatched chick will be fed by both parents for close to a month while in the nest. Timing suggests that this species could nest more than once a year, but because most young birds are seen from July – August, it is likely that nesting occurs just once during each year. This points towards a low reproductive rate, in particular because one chick needs two adults to successfully care and rear for it. In event of a population crash this strategy would make population growth and recovery a slow process. Such sharp declines in populations have occurred after hurricanes. While some mortality may occur directly as a result of the hurricane itself, evidence suggests that much mortality is due to increased hunting vulnerability after such an event. When the native forest is stripped of leaves and fruit, birds must forage widely and in open habitats. In response to the hurricanes in the 1990s, both Western and American Samoa imposed a hunting ban to allow the species time to recover. Unfortunately, hunting still occurs in American Samoa, and the ban is not being effectively enforced. Populations on Tutuila apparently reached moderately stable levels approximately 7 years after the major hurricanes of 1991 and 1992 (Hurricanes Ofa and Val) (Utzurrum & Seamon 2001) although the numbers observed are a fraction of those reported in earlier studies (Amerson et al. 1982b). With the advent of more exploitive hunting using modern methods (Craig et al. 1994), hunting pressure will increasingly effect populations at low densities. Pigeons are still hunted for ceremonial purposes or for consumption during certain holidays such as Easter and White Sunday, though customs such as these are probably practiced less frequently due to a dwindling population. Perhaps more than any other species, the *Lupe* is of irreplaceable importance to Samoa; both because of its natural role in spreading rainforest seeds, and its cultural role in the stories, proverbs, and heritage of the Samoan people. Early missionary accounts tell of whole villages spending weeks in the forest around the *tia seulupe* (pigeon catching huts upon star mounds) during pigeon catching season, and that this was a time of feasting. Lupe once must have been very abundant to support such a cultural activity. The rainforest that once covered the Tafuna plain is now gone, likely taking away with it the best habitat available for the Pacific Pigeon in American Samoa. Conserving remaining lowland rainforest habitat, and either enforcing the hunting ban or implementing bag limits is needful for the protection of this species.

a(Photo by RCB Utzurrum)

5.6.1.7 Shy [Friendly] Ground-dove (tuaimeo)

Alopecoenas stairi

ESA endangered species

The Shy Ground-Dove, formerly of the genus Gallicolumba (del Hoyo et al. 2014), has a discontinuous and poorly documented distribution across central Polynesia. This species has been extirpated throughout much of its range and the small and fragmented population that remains is suspected to be declining. The IUCN lists this species as vulnerable worldwide, meaning that the best available evidence indicates that it is facing a high risk of extinction in the wild. In American Samoa, the population is restricted to the islands of Ofu and Olosega where it appears to occupy low to mid-elevation forest. Low population sizes in Manu'a may be a natural phenomenon, since it apparently prefers steep but forested slopes in close proximity to exposed or talus substrates. Observations from a decade ago suggest that the largest population occurred on Olosega, particularly in areas that were ravaged by Hurricane Heta (2004). It feeds on seeds, fruit, buds, young leaves, snails, insects and caterpillars on the forest floor and in the undergrowth (Watling 1982 and Cluine 1984). The Shy Ground-Dove appears particularly sensitive to human disturbance, usually leaving areas with logging or planting activities within days of occurrence, and not re-inhabiting even five years after the cessation of human activity (Kretzschmar 2000). The reasons for this may relate to change in forest characteristics (e.g. leaf-litter, food resources), structure (e.g. openness) or invasion by ground predators. The major threat to the small Western Samoan population of Shy Ground-Doves is predation by Polynesian rats (*Rattus exulans*) (Roberts 2009). There is almost no information available about the population in Ofu-Olosega, much of what exists being anecdotal. It is essential to gather baseline data by conducting surveys to assess this species' distribution, population numbers and conservation requirements. Data to age and sex birds accurately should also be established in order to acquire an understanding of the demographic makeup of the population. Timing for breeding and molting cycles should be documented in order to identify important periods of the year.

5.6.1.8 Many-colored Fruit-dove (manuma)

Pilinopus perousii

Male P. perousii (Photo by M. MacDonald)

The Manuma (Many-colored Fruit Dove) *Ptilinopus perousii* is a species that is found in Fiji, Tonga, Samoa with an endemic subspecies in American Samoa (*P. p. perousii*). The IUCN has classified this species as Least Concern because of its wide distribution but it has also indicated that its population has been in decline. The Manuma is considered rare and local over much of its range.

Manuma were not considered rare on Tutuila in the 19th and early 20th centuries. The first systematic bird surveys were done in the mid-1970s recorded only a small number of Manuma. In a follow up survey done in mid-1980s the population on Tutuila was estimated at 80 birds (Craig 2009). The Manuma has also declined in Tonga. The island of Tongatapu, which is the largest island in the Tongan archipelago, no longer supports Manuma.

Habitat loss and hunting have been the primary causes of decline (Craig 2009). The Manuma shows a strong preference for Aoa (*Ficus prolixa* and *F. obliqua*) and are usually seen in associate with these two species of trees. Birds will congregate on the trees when eating, but Manuma have also been seen aggressively fighting other Manuma to keep them out of the tree and protect the food resource. Since the Manuma feed almost exclusively on *Ficus prolixa* and *F. obliqua* their population size is directly related to status of these two species of trees.

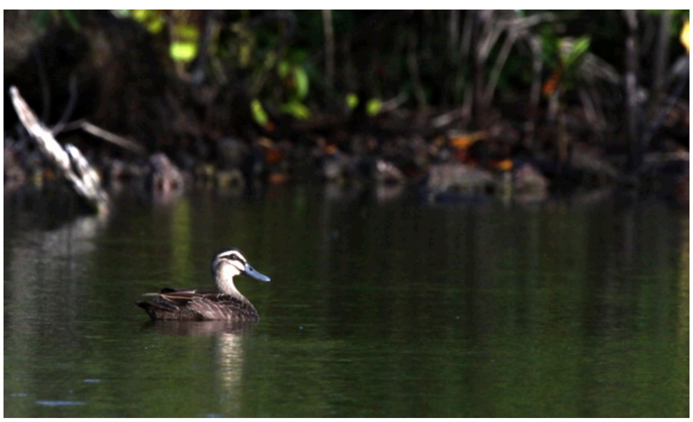
The relatively low population size of Manuma in American Samoa make them particularly vulnerable to catastrophic weather events or other population level disturbances. A restricted diet may also make this bird more difficult to manage in rehabilitation and recovery situations which necessitates the development of protocols that will aid DMWR in Manuma conservation.

5.6.1.9 Blue-crowned Lory (segaula)

Vini australis

(Photo by RCB Utzurrum)

American Samoa's only parrot, the Blue-crowned Lory is another culturally important species. Its bright feathers were used in traditional headgear and used as decorations within woven mats. This species is restricted to Manu'a, and appears to be more abundant on Ta'u. Post-hurricane records of them exist from Tutuila but strangely, they have not become established on the larger island, and there are no historical records of them ever being a resident on Tutuila. Although the populations appear to be stable, they are known from elsewhere in their range to be vulnerable to both introduced rats and introduced cavity nesting birds, such as the common myna. Detailed life-history studies, as well asstudies of seasonal shifts in resource usage, are priorities for this species.



5.6.1.10 Pacific Black [Gray] Duck (toloa)

Anas superciliosa

(Photo M. MacDonald)

The Pacific Black Duck is a rare sighting on the wetlands of Tutuila and is only seen regularly on the small nearshore island of Aunu'u. The number of ducks appear to be low even on Aunu'u, with maximum recorded counts of 20-25 individuals (DMWR unpubl. data) per survey. Periodic counts of the Aunu'u population indicate numbers are low and stable at best (i.e., there are no indications that numbers are increasing). Its appearance in many Samoan proverbs speaks to its cultural significance. Due to the population's isolation from regular enforcement activities, there exists a significant potential for poaching. Demographic and ecological studies are needed to better understand the status of the species and to determine whether management actions are appropriate or if their low abundance is a natural phenomenon. It is likely that their decline over the decades ties into the loss of appropriate wetland habitats within the territory.

5.6.1.10 Ma'oma'o (toloa)

Gymnomyza samoensis

ESA endangered species

The Ma'oma'o or Mao (*Gymnomyza samoansis*) honeyeater is endemic to the Samoan archipelago. It is currently listed as endangered by the IUCN red list and endangered under a 2016 ESA ruling. Though the Ma'oma'o species previously occurred on Tutuila, American Samoa it is now presumed to be locally extinct and currently is only found in declining numbers on the largest islands on Upolu and Savaii in Samoa (Olson, and Butler 2006). Museum specimens of this species in Tutuila were last collected in the 1800's and the last confirmed sightings were in the 1920's (Craig 2009).

The decline of the Mao in Samoa is linked to habitat loss and the associated increase in black rat abundance. Research in Samoa suggests that the species has a wide diet and is found both in the uplands of Savaii and at low elevation in areas with some larger tree canopy cover. It is not found in areas which have been logged or been burnt suggesting it requires forest with some canopy cover. Recent cyclones in Upolu appear to have impacted the remaining population and reduced the amount of canopy forest even further.

The reasons for the Mao's local extinction in American Samoa are unclear as the same suite of introduced predators exists in Samoa as American Samoa and, furthermore, habitat loss in American Samoa has been minimal compared with Samoa. It is possible that a combined effect of a disease, cyclonic damage affected the survival rates. Though we are never likely to know why this species has disappeared from American Samoa its reintroduction to American Samoa is likely to be a critical component towards its continual survival since forest loss in Samoa continues to increase making populations more susceptible to the effects of cyclones (due to even further fragmentation). Furthermore the Mao is an important pollinator and seed disperser in Samoa and its reintroduction to American Samoa may be important for a number of plant species.

5.6.2 SUMMARY OF THREATS TO THE AVIFAUNA

Threats to birds vary from species to species (see above) but fall into five general classes. The first is the threat of **predation**, typically from introduced rats but also from cats or humans. This applies not only to ground nesting species, but also to cavity nesters such as *V. australis*. The second is **loss of habitat**, whether of particular plant species such as *Ficus prolixa* or of entire habitat types such as wetlands. The third is **catastrophic declines**, especially in species with very small populations, due to natural occurrences such as hurricanes. The fourth threat is that of **disease**. Although most indigenous diseases do not appear to be major threats, new or emergent diseases such as West Nile Virus are a significant concern. The fifth threat is that from **introduced species**, including introduced birds already present in the territory.

5.6.3 CONSERVATION STRATEGIES

The data suggest several broad strategies are required to meet the conservation needs of the avifauna of the territory.

1. *Protect the Manu'a islands from introduced species* and *prevent the entry of new threats* (such as the brown tree snake) into the Territory.

Enhance quarantine procedures, as well as post-introduction emergency eradication efforts, since there is frequent shipping between Tutuila and Manu'a. The Manu'a islands contain 16 of the 17 species of conservation concern. A number of these are known to be vulnerable to introduced species, particularly *Rattus rattus*.

2. Initiate extensive surveys to *determine distributions and habitat requirements of poorly known species.* Among the priority species are *A. superciliosa, C. vitiensis, G. stairi, P. porphyrio*, and *P. tabuensis*.

3. Employ well-designed surveys to *derive robust population estimates, and monitor at intervals sufficient to allow detection of multi-annual trends in abundances*.

4. *Determine detailed demographic data for species of concern, since even reliable abundance estimates are often insufficient to determine factors responsible for* dynamics of populations.

5. *Create a territorial habitat management plan*.

6. *Develop mechanisms for emergency response to threats of emergent infections*, such as West Nile Virus.

5.7 SEA BIRDS

Tahiti Petrel (*Pseudobulweria rostrata*) (Photo by RCB Utzurrum)

5.7.1 CLASSIFICATION

Six sea bird species (Polynesian Storm-petrel *Nesofregetta fuliginosa*, Bridled tern *Sterna anaethaetus*, Collared Petrel *Pterodroma leucoptera brevipes*, Herald Petrel *P. arminjoniana heraldica, Christmas shearwater Puffinus nativitatus*, and Wedge-tailed Shearwater *P. pacificus*) are grouped as Class I due to little, if any information on their breeding populations (Table 2). These species have a potential to be breeders on American Samoa but no studies have been conducted in order to determine their status. All but the Bridled tern (*S. anaethaetus)* are expected to be found in remote and difficult to access locations, primarily the montane scrub summits of mountains. The remoteness of breeding areas has restricted the collection of incidental data on these species during the course of previous studies. Bridled terns (*S. anaethaetus)* have been seen in the vicinity of Tutuila island(*unpub. DMWR data*), but surveys have not been systematic enough to derive robust estimates of their abundance.

Two other seabird species (Tahiti Petrel *Pseudobulweria rostrata* and Tropical Shearwater *Puffinus bailloni*) are listed as Class II species (Table 2). Their breeding sites are well documented, and their presence has been repeatedly confirmed, but abundance estimates are not robust and they are potentially threatened by a known population of *Rattus norvegicus* in the most important breeding area at the summit of Mt. Lata, Ta'u.

5.7.2 PREVIOUS STUDIES

5.7.2.1 TUTUILA, TA'U, OFU, OLOSEGA ISLANDS SEABIRD MONITORING

Baseline data on seabirds in American Samoa is patchy and incomplete. This results from the difficulties in establishing regular access to known seabird areas, which frequently require boat access. As such, studies have been sporadic over the years and much of the data has been collected incidentally. Most of the seabird species found on Tutuila Island inhabit the north shore, which is less accessible to people and is important nesting habitat for coastal cliff nesting birds (O'Conner and Rauzon 2004).

In 2012, DMWR undertook a pilot study to inventory and monitor seabirds in American Samoa and to develop protocols for more regular seabird surveys around the islands. The pilot study had three objectives; 1) To design a survey to estimate annual baseline estimate of population sizes of seabirds in American Samoa and to implement the surveys annually; 2) Determine locations of nesting sites and habitats of various resident seabird species; 3) Document new species records in American Samoa. Tutuila island, Ta'u island, and Swains island were visited for these surveys.

During September 2012, surveys for Swains island of species observed at sea included white tern, sooty tern, brown noddy, black noddy, brown noddy, red-footed booby, and white-tailed tropicbird. Seabird numbers were generally low over pelagic areas with increased abundance around Tutuila.

Seabird numbers indicated highest abundance over the north-east corner of Swains island and the species found were the same as those found by Amerson et al. during their 1976 visit to Swains. Roosting and nesting seabirds were identified to primarily use pockets of mixed *Pisonia* forest that are surrounded by dense coconut palms. Only red-footed booby, brown noddy, black noddy, and white tern were observed either roosting or nesting, indicating that some of the less common species (white-tailed tropicbird, greater frigatebird, lesser frigatebird, brown booby, sooty tern) may not be breeding on the island, or not enough transects were performed to adequately sample these species. Time limitations due to length of visit to Swains island and time of day restrictions in sampling may also have been a factor. Breeding phenology of many of these species on equatorial islands is poorly understood and thus the timing of the visit to the island may have affected the results.

In July 2013, surveys were conducted on Tutuila and Ta'u islands in order to evaluate and identify potential sites for seabird population monitoring and for initial assessments of seabird abundance and distribution. 8 sites (both shoreline lookouts close to seabird roosts and flyways as well as high lookouts, which gave a good view of entire colony areas) were identified on Tutuila. On Ta'u island, much of the accessible shoreline was also investigated in order to identify areas important for seabirds as well as potential habitat and flyways for petrels and shearwaters. Overall seabird abundance on Ta'u seems low, likely due to the absence of offshore island and rocky cliff areas that can provide refuge for seabirds. However, three key areas were identified that contained seabird populations which should be monitored. All four monitoring locations were easy to access, either on a road or within a short hike in order to make continued monitoring as easy as possible (Figure 2). Using these observations we are developing standardized protocols which can be used to effectively monitor birds from locations around the islands. The next step of the project would be to attempt to visit and evaluate sites on the islands of Ofu and Olosega.

FIGURE 12. MAP OF TUTUILA SHOWING THE IDENTIFIED SEABIRD COLONY LOCATIONS (red) and additional high lookouts (yellow).

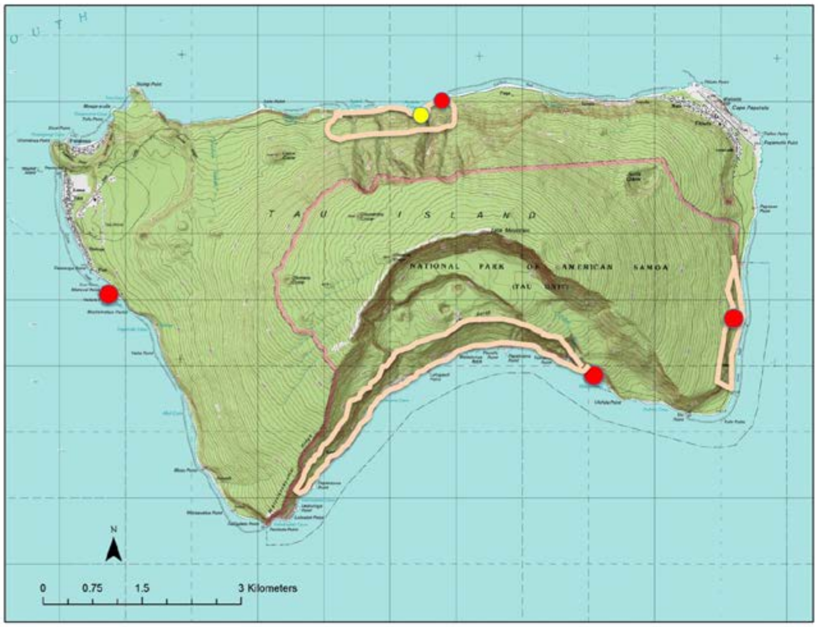


FIGURE 13. MAP OF TA'U ISLAND SHOWING MONITORING LOOKOUT LOCATIONS (red) as well as approximate extent of seabird colony areas (beige lines). Additionally, the location of the only sighting of a Tahiti petrel transiting to the Ta'u summit is shown (yellow).

5.7.2.2 ROSE ATOLL

Rose Atoll is an important seabird breeding site in American Samoa as many ground nesting colony species utilize the island. It is also the only island in American Samoa that is free of rats and year-round human habitation.

Rose Atoll was visited in March 2013, and again in September 2016 to conduct seabird and shorebird surveys as well as to assist USFWS in other biological monitoring and conservation activities. In 2013, all seabird nests were censused by Mark MacDonald and Frank Pendleton on Mar. 17th and 19th along twelve transects laid out in an east – west orientation across the island at 30m spacing. In 2016, the same surveys were attempted by Kim Kayano and Brian Peck on 31st August, and 1st September. One observer walked the transect line while a second walked an intermediate transect ~ 15m to the north. Visibility varied greatly across the island and care was taken in the more open areas to ensure double counting did not occur. Breeding activity was relatively low during the 2013 visit which made it easy to mitigate double counting. During the 2016 surveys much of the island was colonized by nesting sooty terns which made transect surveys difficult. Much of the established transects were not walked in a straight line in order to minimize disturbance to nesting birds. Location of the transects are presented in Figure 1.

In addition to basic counts, notes on phenology were also taken with stage of breeding, incubation, and chick development all noted. Areas where the potential for disturbance to nesting birds was unacceptably high were not covered. During the 2013 survey, the eastern clearing (visible in Figure 1) was the only area where access was restricted due to easily flushed nesting Brown Booby. During the 2016 survey, sooty terns were nesting around the entire perimeter of the island leaving only a small area in the center that was not used for breeding.

Evidence of potential burrow nesting activity was sought out during daytime activities and areas of interest revisited at night for thorough checks for birds. The vegetation perimeter was walked in the hours following sunset to listen for calls and a few key areas were searched for birds on the ground. An evening spotting scope scan of the horizon was also completed in an attempt to spot shearwaters or petrels coming in at dusk but no individuals were observed.

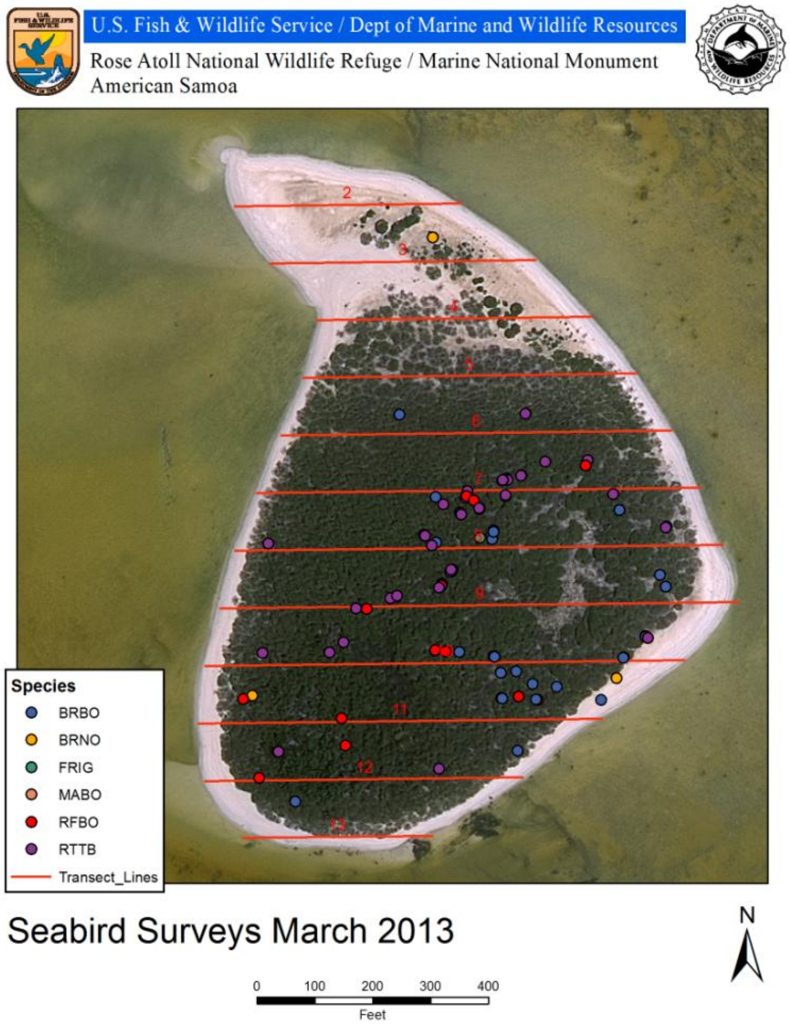


FIGURE 14. RESULTS OF SEABIRD SURVEYS CONDUCTED MARCH 17TH – 19TH, 2013 ON ROSE ATOLL.

5.7.2.3 TAHITI PETREL

Little is known about the biology of the Tahiti petrel generally, and within American Samoa we lack knowledge of the species population size, distribution, and susceptibility to predation (O'Connor and Rauzon 2004). Due to its small and declining population size, the Tahiti petrel has been identified as a species of conservation concern, and estimating the abundance and distribution, and understanding the threats to this species has been identified as a priority in the comprehensive strategy for wildlife conservation in American Samoa (Department of Marine and Wildlife Resources 2006). In order to identify best conservation practices to stop the decline of this species, more information about its biology, distribution, and potential threats is needed.

In January and February 2014, a preliminary survey was conducted on Tutuila and Ta'u in order to develop methods for remote monitoring for abundance, distribution, and predations risk for Tahiti petrel (*Pseuobulweria rostrata*) and other procellariiform seabirds, such as Herald petrel (*Pterodroma heraldic*) and Tropical shearwater (*Puffinus balloni*). The primary purpose was to deploy acoustic monitoring devices within the summit area of Ta'u Island, which is recognized potentially as a globally important breeding ground for Tahiti petrel. Eight Song Meter acoustic recorders were deployed around the summit area of Mt. Lata, Ta'u. During this visit two active Tahiti petrel burrows were located. In 2015, researchers revisited the Song Meters to replace batteries in order to continue data collection throughout the year.

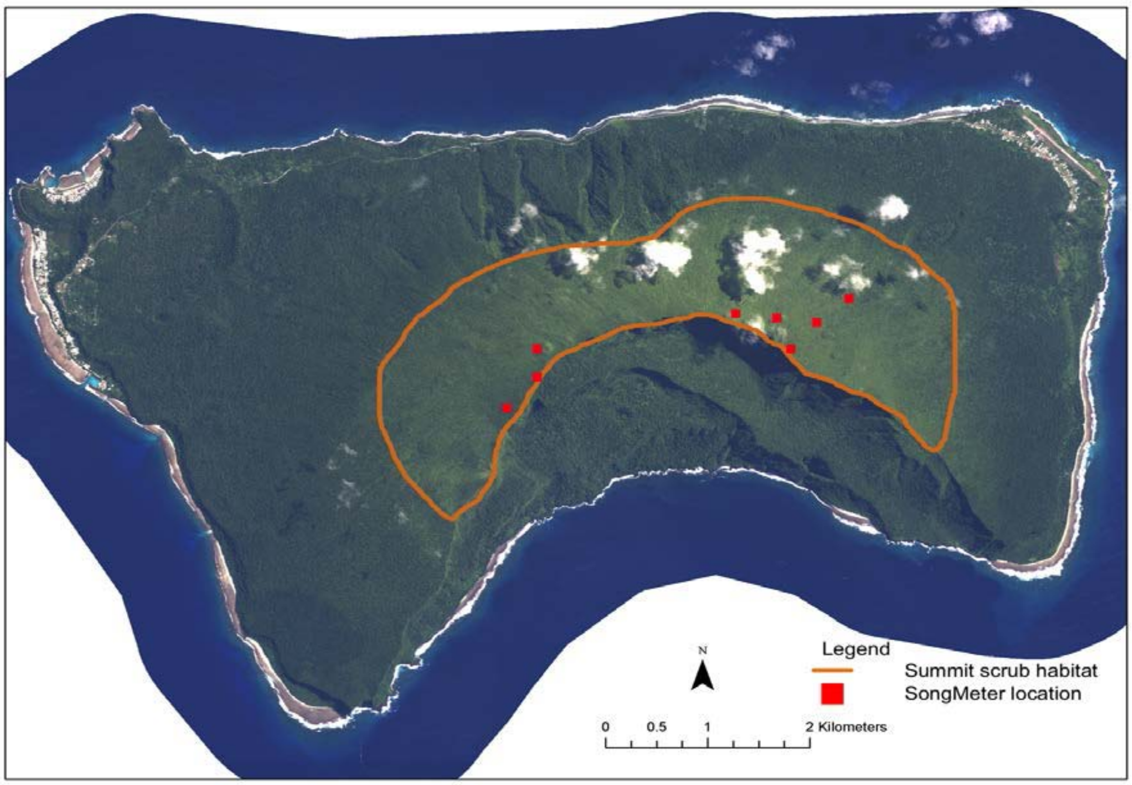


FIGURE 15. MAP OF TA`U ISLAND SHOWING THE TOTAL EXTENT OF THE SUMMIT SCRUB HABITAT (ORANGE LINE) AS WELL AS THE PLACEMENT LOCATIONS OF THE EIGHT REMOTE ACOUSTIC MONITORING DEVICES (RED SQUARES). Note the two clusters of recording units centered around the ends of the two trails which access the summit region.

5.7.3 THREATS

Threats are largely unknown. However, predation by introduced rats is the most likely threat to ground-nesting species. Rodent trapping undertaken on Mount Lata, Ta'u confirmed the presence of Norway Rats in areas where Tahiti Petrels are known to nest.

However, their impact on the petrels has yet to be documented. Since most nesting areas are either in isolated islets, inaccessible cliffs on north-facing slopes of the islands, and/or remote montane to mossy tops of mountains disturbance by humans and potential for habitat loss are not seen as imminent threats to the species. However, as human population on American Samoa continues to rise, the potential for habitat loss and the resultant spread of invasive plant and animal species increases as well. Predation and disturbance by feral cats, wild pigs, and dogs has been identified as a threat at breeding sites outside of American Samoa (BirdLife International 2014). Subsistence hunting is not a major factor affecting seabird populations in American Samoa, though occasional birds are taken for food, sport, or are accidentally caught during fishing operations. Another potential threat to seabird species is the potential depletion of food resources at sea as fishing methods and technology continue to improve. It has been reported previously that fledgling petrel chicks have been grounded on Tutuila due to urban lights (personal communication from J. Seamon noted in O'Connor and Rauzon 2004). Additionally injured adult Tahiti petrels and grounded fledglings have been turned in to the DMWR during July and November during recent years. An emerging threat to sea birds is the planned introduction of wind power development to the territory. Since many species use the ridges proposed for wind turbines as flyways to access nesting grounds, we anticipate that there will be mortality associated with wind power developments.

5.7.4 FUTURE STUDIES/CONSERVATIONS STRATEGIES

1) Obtain updated estimates of abundances and distributions of priority species. Systematic surveys encompassing the range and breeding periods would alleviate the information gap on most species. A survey of Bridled tern (*S. anaethaetus)* would also improve the accuracy of population estimates available for other diurnal species.

2) Determine if and to what degree rat predation is a threat to ground-nesting species.

3) Continual surveys on Tutuila and Manu'a islands in order to track population trends for all species.

4) Restoration of Swain's Island to improve sea bird nesting habitat. This includes eradication of non-native mammalian predators (rats, cats) and restoration of coconut plantation to native forest.

5) Conduct investigations on the potential impacts of wind power developments on all islands in American Samoa. Develop guidelines for developments to reduce the impacts on seabird populations.

5.8 SHEATH-TAILED BAT

Em*ballonura semicaudata semicaudata*

Local common name: pe'ape'a vai

Distribution: throughout Oceania

Abundance: unknown

Status: possibly extinct in American Samoa; ESA Endangered Species

E. semicaudata from Fiji
(Photo by J. Palmeirim)

5.8.1 DISTRIBUTION

Emballonura semicaudata semicaudata is a regional subspecies of an insectivorous bat geographically widespread throughout Oceania (Hutson et al. 2001). Its historical distribution includes Fiji, the Samoan Archipelago, Tonga, and Vanuatu. Three other recognized subspecies occur north of the equator in Chuuk andPohnpei (*E. s. sulcata*), the Mariana Islands (*E. s. rotensis*), and Palau (*E. s. palauensis*) (Flannery 1995; Koopman 1997).

In American Samoa, historical records confirm their occurrence in all the main islands, except Rose Atoll and Swains (Amerson, et al., 1982). Voucher specimens have been collected from Ta'u (Sanborn 1931: AMNH) and Tutuila (Amerson et al. 1982b & Pacific Ocean Biological Survey Program in 1966: USMNH) (in Amerson et al.1982b).

5.8.2 ABUNDANCE

Previously estimated in the 10,000s, no more than 2 individuals of this species were last sighted in 1998, in the same shallow coastal cave in Afono (Tutuila Is.) where the largest colonies were reported from in the mid-1970s (Amerson et al. 1982b, R. Utzurrum unpubl. DMWR data). An estimated 100-200 individuals were reported from this Afono cave by Knowles (1988) and subsequent visits in 1990, 1992, and 1993 yielded similar results, i.e., bats were either absent or were present in very low numbers of 2-3 individuals (Grant et al. 1994). On-going systematic acoustic (for free-ranging bats) and cave surveys (for roosting individuals) in the four main islands of Tutuila and Manu'a have failed to detect the presence of the species (DMWR WCRP R- 1-R-0 *E. semicaudata* assessment project: 2002-present).

Aggregations in the 10,000s are highly uncharacteristic of the genus *Emballonura*, and estimated aggregates of 15-20 or up to 100 individuals may be more typical of the species (Nowak 1994, Flannery 1995, Wiles et al. 1997). With this in mind, the sporadic surveys conducted between 1975 and the present strongly indicate that *E. semicaudata* may be near extinct (if not already extinct) in American Samoa. Reports from Fiji and Samoa indicate that populations of *E. s. semicaudata* are in decline or have been extirpated elsewhere in the region (FIJI: Hutson et al. 2001, C. Morley [University of the South Pacific, Suva] pers. comm.; SAMOA: Lovegrove et al. 1992, Park et al. 1992, Tarburton 2002, R.C.B. Utzurrum unpub. data on random acoustic surveys in 2004 in Upolu and Savai'i islands). There is very little known of the status of populations in Tonga and Vanuatu, but the bats are thought to be rare in Tonga (Koopman and Steadman 1995).

Although populations of the subspecies *E. s. rotensis* appear to be healthy in Aguiguan, it is now absent from four other Mariana islands they previously were recorded from (Esselstyn et al. 2004). The subspecies *E. s. sulcata* and *E. s. palauensis* persist within their historical range and populations are reportedly stable (Hutson et al. 2001).

5.8.3 HABITAT

E. semicaudata typically roost in caves, although they may possibly use rockfalls on cliff faces or hollows of large trees (such as banyans), and even man-made structures such as under bridges (Lemke 1986, Grant 1993, Grant et al. 1994, Hutson et al. 2001, Esselstyn et al. 2004). The bats were often found to co-habit the caves with swiftlets (in American Samoa, *Aerodramus spodiopygius*). There are no systematic studies on the types of habitats free-ranging and foraging individuals frequent. Estimates of densities provided by Amerson et al. (1982a: Table 29) indicate their presence in a range of natural and disturbed habitats, from littoral and mangove forests to ridge forest, and in plantations and villages. A recent study of sheath-tailed bats in Aguiguan, Mariana Islands indicate that the species prefer forest over non-forest areas (Esselstyn et al. 2004).

5.8.4 THREATS

Direct threats are largely unknown but it is assumed that the lack of suitable safe roosting habitats contributed to the vulnerability of the species, or their possible decline or extirpation from American Samoa islands. In American Samoa, most caves are small, shallow, and along coastal areas (Amerson et al. 1982, unpubl. DMWR records). Tidal surges and strong winds would easily inundate these caves during hurricanes, as evidenced by the appearance of the Afono cave following Hurricane Ofa in 1990 (Grant et al. 1994). Inland caves are largely unknown but they may represent the last holdout of these species in American Samoa. Recently, in the fall of 2015, two cave systems were discovered on Ta'u. The system on the west was discovered by A. Miles during DMWR wildlife surveys, and the system on the east by a National Park Service crew. Both systems are upland, deep, with large openings and appear to be the best potential roosting caves in American Samoa.

While use of pesticides have been implicated in the decline of insectivorous bats worldwide, and of *E. semicaudata* in the Mariana Islands, in particular (Rainey 1998), the level of chemical use in the Territory is minimal due to a relatively low intensity agricultural production requiring its application. Moreover, widespread aerial spraying for mosquitoes and other pests is not practiced. Destruction and disturbance of caves have been also been implicated in the decline and extirpation of the species from islands in the Mariana chain (Rainey 1998). Again, these impacts were not associated with decline of the populations in American Samoa (Grant et al. 1994), and, indeed, white-rumped swiftlets (*Aerodramus spodiopygius*) persist in relatively large numbers in the same caves once co-habited by the bats (R. Utzurrum pers. obs).

Steadman and Pregill (2004) found numerous *E. semicaudata* bones in prehistoric material from a cave in Tutuila, indicating that the species have been present in the islands for centuries before the arrival of Polynesians. Hence, it cannot be inferred that their possible extinction represents a case of an unsuccessful colonization by a recent arrival. Indeed, it was suggested that predation by the barn owl (*Tyto alba*) may account for most of the vertebrate bones in the cave deposits (Steadman and Pregill 2004). Whether such predation can satisfactorily account for the severe decline or extinction of the species may be addressed through a more thorough archaelogical analysis of deposits in other caves in the Territory.

5.8.5 CONSERVATION PRIORITIES

Subspecies *E. s. semicaudata* is possibly locally extinct in American Samoa and is in decline elsewhere in the region. It is a candidate for listing in the US Endangered Species list. The priority actions recommended in this strategy are intended to reach a final determination of its status and, if warranted, trigger development and implementation of a recovery plan.

1) *Assessment of local status*

Complete systematic visual and acoustic surveys in Aunu'u, Manu'a, and Tutuila in American Samoa, with simultaneous collection of ecological variables from areas surveyed.

Investigate the newly discovered cave systems on Ta'u for evidence of sheath-tailed bats through both visual and acoustic monitoring. Continue the ongoing effort to locate additional caves which could be potential roosting sites for the species.

2) *Assessment of regional status*

Develop cooperative studies with regional partners to document changes in numbers and conduct ecological and toxicological studies that may help determine causes of population declines. This may be achieved through cooperative efforts under the Memorandum of Understanding between DMWR and the Ministry of Natural Resources and Environment (Government of Samoa) signed in 2004, and in collaboration with colleagues at the University of the South Pacific in Suva, Fiji (C. Morley and M. Tuiwawa).

3) *Evaluate foraging and roosting habitat*

Characterize the foraging and roosting habitat needs of the species in order to evaluate the potential for species reintroduction if necessary. Especially important is evaluating the cave specifications needed by characterizing currently occupied caves in the South Pacific and comparing those characteristics (thermal, depth, light, moisture) to the historically occupied caves on Tutuila and the newly discovered caves on Ta'u.

4) *Species restoration*

If found to be extant, development and implementation of a Species Recovery Plan (possibly involving captive breeding and reintroduction) should be a priority under SWG regardless of the status of the populations in American Samoa, a regional species recovery plan should also be developed in collaboration with partner agencies to stave off any further declines in populations elsewhere in the South Pacific. If determined to be locally extinct, develop a captive rearing system with partner agencies for possible future reintroduction to the territory.

5.9 THE FLYING FOXES

Pteropus samoensis

Local common name: pe'a vao

Distribution: restricted to Samoan Archipelago and Fiji

Abundance: moderately uncommon

Status: populations locally stable; locally protected

Pteropus tonganus

Local common name: pe'a fanua

Distribution: widespread in the South Pacific

Abundance: common

Status: populations relatively stable; locally protected

P. samoensis (top) and *P. tonganus*
(Photo by RCB Utzurrum)

The two species of flying foxes are by far among the best known wildlife in the Territory. In addition to general accounts on the species (*P. samoensis*: Banack 2001; *P. tonganus*: Miller and Wilson 1997), numerous studies on various aspects of the biology of both species have been published, with in-depth investigations on a number of these aspects continuing on. These include estimates of abundances (Amerson et al. 1982a, 1982b, Wilson and Engbring 1992, Brooke 1997, 2001, Utzurrum and Seamon 2001, Utzurrum et al. 2003), assessments of impacts of hurricanes and hunting (Daschbach 1990, Craig and Syron 1992, Craig et al. 1994a, 1994b, Morrell and Craig 1995, Grant et al. 1997b, Pierson et al. 1996), and studies on feeding ecology and physiology (Cox et al. 1992, Elmqvist et al. 1992, Banack 1996, 1998, Nelson et al. 2000a, 2000b, Nelson 2003), habitat use (Banack and Grant 2003b, Richmond et al. 1998, Brooke 2001, Nelson 2003), pollination and seed dispersal ecology (Cox et al. 1991, Rainey et al. 1995), patterns of activity and behavior (Cox 1983, Banack 1996, Thomson et al. 1998, Brooke et al. 2000, Norberg et al. 2000, Brooke 2001), and reproduction (Grant and Banack 1999, Banack and Grant 2003a). In addition to these, recent projects focused on genetics of populations (both inter- and intra-population patterns) and diseases were recently completed by DMWR and partner organizations (Utzurrum per com, DMWR Wildlife Investigations: W-1-R Program). Findings from these and other studies support the continued placement of the flying foxes among the species of conservation concern particularly because of their vulnerability to anthropogenic activities.

5.9.1 DISTRIBUTION

Pteropus samoensis is extant only in the islands of Fiji and the Samoan Archipelago. Fossil bones found in a cave in ‘Eua were the last indications that the species may have occurred once in Tonga (Koopman and Steadman 1995). Populations in the Fiji Archipelago are recognized as the subspecies *P. s. naiwensis*, while those occurring the Samoan islands are designated as *P.s. samoensis* (Wodzicki and Felten 1975).

Pteropus tonganus, on the other hand, is the most geographically widespread species in the genus (Mickleburgh et al. 1992, Koopman and Steadman 1995). Three subspecies are recognized: *P. t. basiliscus* is found in small islands northeast of Papua New Guinea to the Solomons; *P. t. geddiei* occurs in Vanuatu and New Caledonia; and *P. t. tonganus* range from Fiji east to the Cook Islands (Wodzicki and Felten 1975, Hill and Beckon 1978, Koopman 1979, Wodzicki and Felten 1981, Koopman 1993).

In American Samoa, both species are confirmed from Aunu’u, Manu’a, and Tutuila (Amerson et al. 1982a, 1982b, Wilson and Engbring 1992), where the largest and most stable populations occur.

5.9.2 ABUNDANCE

Populations of both species have been surveyed since the late 1980's in Tutuila (Craig and Syron 1992, Wilson and Engbring 1992, Craig et al. 1994, Brooke 2001, Utzurrum and Seamon 2001, Utzurrum et al. 2003). The current population estimate of *P. tonganus* on Tutuila is in excess of 50,000, with multiple roost colonies numbering over 5,000 individuals. Estimates of *P. samoensis* are more difficult to obtain due to its largely solitary nature. However, daytime visual counts of the species estimate numbers in Tutuila at 1,000 - 1,500 individuals (Craig et al. 1994, Brooke 1997, 2001, Utzurrum et al. 2003). The sizes of the populations in Manu’a are less known due to logistical challenges of conducting regular systematic surveys in the islands. While linear surveys conducted by Amerson et al. (1982) found higher abundances of fruit bats (lumped as a single species) in each of the Manu’a islands compared with Tutuila, data from periodic surveys since 1995 clearly show that in recent years populations of both species are considerably lower in those islands than on Tutuila (Brooke 1997, DMWR unpubl. data from 1997-2004).

Trends show that the species are impacted by hunting (Craig and Syron 1992, Craig et al. 1994a, 1994b), even when hunting was regulated and conducted only on a seasonal basis (Utzurrum and Seamon 2001). When populations suffered substantial reductions of up to 80% in the aftermath of two successive hurricanes in the early 1990s, an executive order for a total ban on the hunting of the fruit bats was called in 1992 and subsequently encoded in 1995 (American Samoa Administrative Code Title 24 Chapter 8). Since then populations have rebounded (Brooke 1997, 2001, Utzurrum and Seamon 2001, Utzurrum et al. 2003). However, hurricanes in 2004 and 2005 temporarily may have set back the populations, but they have since recovered.

5.9.3 HABITAT

Both species prefer forest habitats, particularly low elevation forests, but, *P. tonganus*, in particular, may be seen foraging close to habitations where agricultural fruits (such as breadfruit and mango) and flowers (banana flowers) are available (Banack 1996, Richmond et al. 1998, Brooke 2001, Banack and Grant 2003b, Nelson 2003).

Roosting groups of *P. tonganus* (a colonial species), while confined to forested areas when the populations were lower, are currently located throughout the island, including developed areas such as Pago Pago (>800), Aua (>300) and Ottoville Lowland Forest in the center of Tafuna (>5000). *P. samoensis* (generally a solitary species) remain largely confined to forested areas, in locations that often are removed from houses (Brooke et al. 2000).

5.9.4 THREATS

Flying foxes are without any significant natural predators in American Samoa, although predation by barn owls have been reported in the past (Amerson et al. 1982, Engbring and Ramsey 1989, Grant and Banack 1995). **Hunting** (currently banned, although low level poaching is assumed), and increased predation (from domestic and feral cats and dogs), physical and physiological impacts, and malicious harm (by humans) in the aftermath of **hurricanes** are the main documented sources of mortality and population declines (Daschbach 1990, Craig et al. 1994b, Pierson et al. 1996, R. Utzurrum unpub. obs. from 2004 hurricane). Along with (Western) Samoa, American Samoa were the principal sources of bat exports to Guam in the mid-1980s (Wiles and Payne 1986, Wiles 1992, Craig et al. 1994a), and this period coincided with reports of declines in numbers of bats (Craig and Syron 1992, Craig et al. 1994b). Simulations of population trends indicate that even low levels of exploitation will result in declines and retard recoveries from natural disasters (Pierson and Rainey 1992, Craig et al. 1994b). Thus, any proposals to re-open the populations for hunting should be given very careful consideration.

A potential negative consequence of the recovery in fruit bat populations is the increase in man-bat conflicts stemming from use of orchard and cultivated fruits. If these conflicts were to escalate, the perception of bats as pests is likely to intensify and substantiate arguments calling for the culling or eradication of populations. Any management program should take this issue into consideration and develop proactive provisions that could mitigate impact of fruit bats on fruit resources for human consumption.

Scattered reports of epidemic-related mortalities, particularly in the genus *Pteropus*, (summarized in Rainey 1998) demonstrate the potential threat of **diseases** to bat populations. Malarial infection has recently been documented in both *P. samoensis* and *P. tonganus* in American Samoa, Samoa, and Fiji (DMWR Wildlife Investigations W-1-R project), with nycteribiid flies as a likely vector (H. Klompen [Ohio State University], pers. comm.). Results indicated a differential rate of infection between the two species and it remains to be established whether the infection has any impact on the demographics (reproduction, survivorship, mortality) of both species.

A new emerging threat to the bats of American Samoa is the potential impacts of wind power developments currently planned for the territory. Numerous studies throughout North America, Hawaii, and Europe have demonstrated that wind farms cause bat and bird fatalities. Current estimates are that between 651,000 and 888,000 insectivorous bats have been killed in the United States in 2012 (Smallwood 2013). Very little information exists on the mortality caused by wind farms on the types of bats present in American Samoa. Email communication with experts worldwide resulted in no identified studies on mortality rates of *Pteropus* fruit bats in relation to wind farms or wind power production.

5.9.5 OTHER BIOLOGICAL CONSIDERATIONS

Fruit bats (Family Pteropodidae), in general, have low reproductive rates. *Pteropus samoensis* and *P. tonganus* most likely bear no more than one young per year, although birth intervals of 9 months have been proposed for *P. tonganus* (Grant and Banack 1999). This limits their ability to recover from population declines (see Pierson and Rainey 1992, Craig et al. 1994, and Brooke 1997 for discussions on recovery time). Serious consideration should also be given to the genetic characteristics of these two species. On-going analyses of populations across the south-central Pacific indicate substantial genetic structuring in one of the species among islands (DMWR W- 1-R project). This indicates poor movement among islands (hence, low expectation of emigration as a means for repopulation) and argues for independent conservation/protection of geographically-separate populations to maintain the genetic distinctions.

5.9.6 CONSERVATION PRIORITIES

Local populations of both flying foxes are generally stable, but declines have been recorded following hurricanes, and in relation to hunting. The species may be threatened elsewhere in its distribution. Locally, both are under full legal protection, are protected from international commercial trade per listing under CITES Appendix 1, and *P. samoensis*, in particular, is designated as a Species of Concern in the US Endangered Species list. Local populations are in no imminent danger and resiliency to effects of hurricanes is evidenced by persistence of the species. However, populations elsewhere in the region are hunted at various levels and shrinking forest habitats may decrease carrying capacities for the species in the various islands where they occur, including those in American Samoa. Given that unpredictable natural disasters and exploitation by humans are a major threat to the populations, development and institution of management measures should be of high priority in on-going conservation programs for the species.

In particular, provisions should be made to:

1) continue *population monitoring*, with increased effort to determine specific demographic parameters critical in projecting models for achieving population stability or recovery under scenarios of take and no take, and use new technologies to improve reliability of population estimates;

2) *develop a rescue and rehabilitation program* to minimize morbidity and mortality brought on by hurricanes;

3) *secure adequate critical habitat* for foraging, roosting, and reproduction to sustain viable populations;

4) *determine threats to the population from diseases and wind power developments*;

5) *establish management guidelines to minimize potential conflicts with humans* arising from consumption of fruits (agricultural and orchard) by bats and *risks to public health* from (bat) diseases.

Extensive studies on diseases and bats were undertaken by Dr. Ruth Utzurrum, DMWR Chief Wildlife Biologist, in DMWR's 2006-2010 Wildlife Restoration program, in collaboration with USGS/BRD/PIERC (C.T. Atkinson: malaria study), Ohio State University (H. Klompen: molecular analysis of vector transmission of malaria), and CDC (T. Kziasek: viral infection study). Population monitoring, rescue and rehabilitation, movement ecology, and investigating the threats of wind power production are currently being undertaken in DMWR's ongoing Wildlife Restoration program.

5.10 MARINE MAMMALS

5.10.1 INTRODUCTION

Relatively little is known about the historical distribution and abundance of most marine mammals in the South Pacific Ocean (Reeves et al. 1999). Most populations of large whales were greatly reduced by whaling, and hunting of odontocetes still occurs in some areas in the South Pacific (*e.g*. the Solomon Islands, Reeves, et al. 1999, Dawbin, 1984; Kahn, 2004). Historic information comes based on whaling records (Townsend 1935) and associated scientific efforts such as the "Discovery tag" program carried out between 1932 and 1984 (Dawbin 1959). Most modern research in the region has been devoted to humpback whales. Coordinated photo-identification and genetic studies carried out across Oceania by members of the South Pacific Whale Research Consortium have produced considerable information on humpback whale abundance, interchange and stock identity. In recent years, the Southern Ocean Research Partnership has worked to better establish links between the South Pacific and high latitude humpback whale feeding areas[2]. Humpback whale research has also yielded opportunistic data on other marine mammal species, but dedicated, regional studies (e.g., aPOD, led by Oregon State University) are beginning to emerge to improve understanding of odonotcetes. Nevertheless, information on the distribution and ecology of small whales and dolphins in the tropical South Pacific remains more limited.

Understanding marine mammal occurrence and abundance at American Samoa is important in the face of: a) global concerns for the status of marine mammals; b) efforts to establish regional conservation and protection programs particularly for migratory species (SPREP 2012); c) the recent delisting of humpback whales under the U.S. Endangered Species Act and post-delisting monitoring requirements; and d) a local initiative declaring Territorial waters as marine mammal and turtle sanctuaries (American Samoa Government Executive Order No. 005-2003) that has elevated this group into the American Samoa's list of Species of Conservation Concern (see Subsection 5.10).

Due to a lack of specific information on some cetacean species, including their diversity and status in the Territory, it has been necessary to treat these species as a group. With the exception of THREATS and STATUS subsections, the summary on distribution and conservation needs presented in this section are partially based on a review commissioned as part of the SWG planning process (Dolar 2005).

[2] http://www.marinemammals.gov.au/sorp/movements-and-mixing-of-humpback-whales-around-antarctica

5.10.2 SPECIES SUMMARY

A total of 33 marine mammal species have been reported in the tropical South Pacific (Reeves et al. 1999, Miller 2009), of which thirteen (all cetaceans) have been reported or confirmed in the waters of American Samoa. As shown in Table 1, these include two baleen whale species (humpback and minke whales) and eleven odontocetes. There is considerable local knowledge about humpback whales from an established research program. Local understanding of the remaining species is more limited, based on some field research (Johnston et al. 2008, Robbins and Mattila, unpublished data), stranding records (DMWR, unpublished data) and literature reviews (Reeves et al. 1999, Dolar 2005, Craig 2009). Despite limited local understanding, available evidence suggests that odontocete diversity at American Samoa is similar to other areas in Oceania where surveys have been done, for example at Samoa and the Solomon Islands (Johnston et al. 2008).

Humpback whales are seasonal migrants that breed at low latitudes in winter and feed at mid- to high-latitudes in summer. American Samoa is one of several humpback whale breeding sites in the South Pacific. This species was initially studied at American Samoa by Kaufman (1983). Since 2003, population studies have since been conducted annually in September and October in the shelf waters of Tutuila (Robbins & Mattila 2006).

American Samoa is a low density humpback whale habitat, with an average of 5.5 individuals encountered per day at the peak of the season (Robbins & Mattila 2006). It exhibits all of the characteristics of a breeding population, including mating behavior and the presences of young calves (Robbins & Mattila 2006). Passive acoustic monitoring at Tutuila and Rose Atoll indicated the presence of breeding-related acoustic displays from mid-July through November (Munger et al. 2012). Those results also suggested a greater density of whales at the Tutuila site, and a peak season beginning in late August (Munger et al. 2012). Habitat use around Tutuila is consistent with other oceanic breeding grounds, with sightings in all surveyed areas of the shelf (Robbins & Mattila 2006). However, shallow water is the best spatial predictor of habitat use by mothers and certain seafloor characteristics best predict the specific location of acoustic breeding displays by males (Lindsay et al. 2016).

TABLE 3. *MARINE MAMMAL SPECIES CONFIRMED IN AMERICAN SAMOA AND THEIR MANAGEMENT STATUS*		
Common name	**Scientific name**	**Status**
Humpback whale	*Megaptera novaeangliae*	ESA:Delisted in 2016 (Oceania DPS) IUCN:Endangered (Oceania subpopulation)
Minke whale, (Dwarf/Antarctic)	*Balaenoptera acutorostrata/ Balaenoptera bonaerensis*	ESA-Not listed, IUCN-Least Concern/ ESA-Not listed, IUCN-Data Deficient
Sperm whale	*Physeter macrocephalus*	ESA: Endangered, IUCN-Vulnerable
Dwarf sperm whale	*Kogia sima*	ESA: Not listed, IUCN-Data deficient
Killer whale	*Orcinus orca*	ESA: Not listed, IUCN-Data Deficient
False killer whale	*Pseudorca crassidens*	ESA: Not listed, IUCN-Data Deficient
Short-finned pilot whale	*Globicephala macrorhynchus*	ESA: Not listed, IUCN-Data Deficient
Bottlenose dolphin	*Tursiops truncatus /* *Tursiops aduncus*	ESA: Not listed, IUCN-Least Concern ESA: Not listed, IUCN-Data Deficient
Spinner dolphin	*Stenella longirostris longirostris)*	ESA: Not listed, IUCN-Data Deficient
Striped dolphin	*Stenella coeruleoalba*	ESA-Not listed, IUCN-Least Concern
Pantropic spotted dolphin	*Stenella attenuata*	ESA-Not listed, IUCN-Least Concern
Rough-toothed dolphin	*Steno bredanensis*	ESA-Not listed, IUCN-Least Concern
Cuvier's beaked whale	*Ziphius cavirostris*	ESA-Not listed, IUCN-Least Concern

Humpback whales can be individually-identified on the basis of their ventral fluke patterns (Katona & Whitehead 1981). Approximately 350 unique individuals have been identified at Tutuila through 2016, and 23 have been re-sighted in multiple years (Robbins and Mattila, unpublished data). Humpback whales at American Samoa are part of a larger breeding population within the South Pacific. Individual exchange has been confirmed with Western Samoa during the breeding season, although humpback whales occur in the latter area in comparatively lower numbers (Noad et al. 2006, Robbins & Mattila 2006). Exchange has also been confirmed with more remote sites in Oceania and western South America, including: New Caledonia, Tonga, the Kermadec Islands, the Cook Islands, French Polynesia and Columbia (Robbins & Mattila 2006, Garrigue et al. 2011a, Robbins et al. unpublished data). Research further confirms cultural exchange of humpback whale acoustic displays across the South Pacific (Garland et al. 2011, Garland et al. 2013). However, no matches have been made between American Samoa and areas used by humpback whales that breed off East Australia (Garrigue et al. 2011b, Steel et al. 2011, Franklin et al. 2012, Constantine et al. 2014, Franklin et al. 2014). Furthermore, photo-identification, genetic analyses and acoustic data continue to suggest some level of population sub-structuring within Oceania (Garrigue et al. 2002, Olavarria et al. 2007, Garland et al. 2015).

Two humpback whales have been matched between American Samoa and feeding grounds at the Antarctic Peninsula (Robbins et al. 2011). Their minimum round-trip movement of 18,840 km, spanning 108 longitudinal degrees, was once considered the longest distance movement by a mammal (Robbins et al. 2011). Genetic analysis suggest that although the Antarctic Peninsula is one feeding site for whales that breed at American Samoa, it is likely not the predominant one (Albertson et al. 2015, Albertson et al. In review). No matches have been made between American Samoa and primary Antarctic feeding grounds used by Australian whales (Garrigue et al. 2011b, Steel et al. 2011, Franklin et al. 2012, Constantine et al. 2014, Franklin et al. 2014). Satellite tagging research has recently been undertaken at the Kermadec Islands (Constantine et al., unpublished data) that will further clarify the high latitude migratory destination of whales that breed in Oceania, including those at American Samoa.

Spinner dolphins at American Samoa are the more typically patterned form known as Gray's spinner dolphin (S. longirostris longirostris). This species has a widespread distribution in the South Pacific (Reeves et al. 1999, SPWRC 2004). Spinner dolphins were the most frequently encountered odontocete during cetacean surveys at American Samoa and seen more nearshore and in shallower water than other odontocetes (Johnston et al. 2008). These habitat preferences within the Territory appear to be consistent with observations in other parts of their range (Johnston et al. 2008). Photo-identification studies of distinctive individuals has revealed high re-encounter rates, suggesting individual fidelity to specific sites around Tutuila (Johnston et al. 2008). Molecular genetic studies have revealed high diversity among spinner dolphins at American Samoa, which indicate that they are not reproductively isolated from other sites in the South Pacific (Johnston et al. 2008). They are, nevertheless, genetically distinct from spinner dolphins in Hawaii (Johnston et al. 2008). This is similar to findings of high genetic diversity but also genetic distinctiveness among island communities of spinner dolphins in French Polynesia (Oremus et al. 2007). The tendency of spinner dolphins to frequent near-shore waters can place them at risk of targeted human activities, such as whale watching (Norris et al. 1994) or drive fisheries (Oremus et al. 2015b).

Rough-toothed dolphins are found in tropical and subtropical waters, rarely ranging north or south of 40°. This species often inhabits deep oceanic waters, although recent work suggests site fidelity to South Pacific Islands (Oremus et al. 2012, Oremus et al. 2015b), including at American Samoa (Johnston et al. 2008). Rough-toothed dolphins are the second most commonly encountered odontocete species in the coastal waters of the Territory (Johnston et al. 2008). This species has been observed in shelf waters around Tutuila, but typically in slightly deeper water (123 meters on average) than spinner dolphins. Rough-toothed dolphins at American Samoa are sometimes observed in association with humpback whales in the austral winter (Robbins and Mattila, unpublished data). Some individuals photographed at Tutuila exhibit notches in their jaws that may be the result of fisheries interactions (Robbins and Mattila, unpublished data). As in the case of spinner dolphins, re-sightings of distinctive individuals through photo-identification indicate site fidelity within the Territory (Johnston et al. 2008). A recent genetic study in the South Pacific, including samples from the Samoan archipelago, confirmed multiple insular populations as well as island-specific genetic isolation within archipelagos (Albertson et al. 2016).

Other cetaceans:

Minke whale species (Dwarf minke whale and Antarctic minke whale) overlap in the Southern Hemisphere and tend to be poorly differentiated. Either species can potentially occur in the South Pacific. Minke whales are most abundant in the South Pacific during the austral winter (October-December, Kasamatsu et al. 1995). At least some of these individuals likely migrate south to feed in the Southern Ocean during the austral summer. Sighting surveys conducted across the South Pacific from 1976 to 1987 detected winter densities in the general vicinity of American Samoa (i.e., 10-20°S, 150- 170°W) that were suggestive of a breeding ground (Kasamatsu et al. 1995). However, no minke whales have been documented during 105 coastal surveys conducted at Tutuila in the austral winter from 2003-2016 (Robbins and Mattila, unpublished data).

Sperm whales are found in all oceans of the world and were one of the major targets of 19th and 20th century British and American whalers. This species was hunted in Samoan waters during the 1820's to the late 1840's (Richards 1992 in Reeves et al. 1999). Whaling of animals thought to belong to the same stock as those in the tropical South Pacific continued off Australia and in the Antarctic until 1980, when whaling in most of the Southern Hemisphere was banned by the International Whaling Commission (Reeves et al. 1999). Sperm whales are a deep water species and modern sightings at American Samoa tend to occur in deeper water (averaging 907 meters) than any other odontocete (Johnston et al. 2008). Sightings off Rose Atoll and Swains Island have occurred in 4,055m (Johnston et al. 2008). The most recent sperm whale sighting occurred off Tutuila in October 2016 (Robbins and Mattila, unpublished data).

Dwarf sperm whales are small, toothed whales found worldwide in temperate and tropical waters (Willis & Baird 1998). They appear to forage over the continental shelf or slope (Berta 2015), feeding on cephalopods, crustaceans and fish (Nagorsen 1985). Because of the elusive behavior of this species, little is known about its behavior or distribution (Willis & Baird 1998, Berta 2015), and most knowledge is derived from stranding records (Reeves et al. 2003). In the South Pacific, specimens have been reported from the Galapagos Islands (Muñoz-Hincapié et al. 1998), the mainland of Chile (Crovetto & Torro 1983, Van Waerebeek et al. 1987) and Peru (Reyes & Van Waerebeek 1992), the mainland of Australia (Aitken 1971, Bannister et al. 1996), Tasmania (Bannister et al. 1996, Van Waerebeek et al. 2004), New Zealand (Baker & Van Helden 1991, Brabyn 1991, Van Waerebeek et al. 2004) and New Caledonia (Robineau & Rancurel 1981, Borsa 2006). There have been at-sea observations of dwarf sperm whales in the northeastern tropical Pacific (Wade & Gerrodette 1993), French Polynesia (Gannier 2000, SPWRC 2004) and New Caledonia (SPWRC 2004). To date, there has been a single sighting of a dwarf sperm whale at American Samoa (Johnston et al. 2008).

Killer whales have a cosmopolitan distribution. In the tropical South Pacific. Sightings been reported in the vicinity of the Phoenix Islands, north of the Northern Marianas Islands, between the Phoenix and Tonga Islands, in the vicinity of the "Cook-Society-Austral islands triangle", around Samoa (Miyashita et al. 1995 in Reeves et al. 1999) Guam, Palau, New Guinea, Solomon Islands (Reeves et al. 1999) as well as New Caledonia, French Polynesia and Fiji (SPWRC 2004). Although reportedly seen on occasion off American Samoa (R. Volk cited in Reeves et al. 1999), no killer whales have been observed during 105 cetacean surveys conducted around Tutuila since 2003.

False killer whales typically inhabit deep offshore waters. They are found in tropical and warm temperate waters no further than 50^{o} north and 50^{o} south and believed to be present throughout the tropical South Pacific Ocean (Reeves et al. 1999). They have been confirmed at a range of sites, including: New Caledonia, Fiji, Tonga, Samoa and French Polynesia (SPWRC 2004). Sightings of false killer whales at American Samoa have been limited to three encounters during austral winter surveys around Tutuila (Johnston et al. 2008). These sightings tended to occur in deep water around Tutuila (229 meters on average, Johnston et al. 2008). Molecular genetic analyses indicate that false killer whales at American Samoa are genetically distinct from the endangered Main Hawaiian Islands Insular population at Hawaii (Chivers et al. 2010, Martien et al. 2014).

Short-finned pilot whales are widely distributed in warm temperate and tropical waters worldwide. Areas of distribution in the tropical South Pacific include Guam (where it is the most frequently observed cetacean), Micronesia, Northern Marianas, Fiji, Tonga, Solomon Islands, New Guinea, Loyalty Islands, northern Line Islands, Cook Islands, French Polynesia, Samoa, Palau, Gambier and Society Islands, Pitcairn group, Marquesas and Vanuatu (Reeves et al. 1999, SPWRC 2004). Evidence of this species at American Samoa includes the three skulls collected from a stranding near Sita Bay northeast of Tutuila Island (currently stored at the office of the National Park of American Samoa). There has also been one live sighting off the nearshore waters of the Manuʻa Islands in 375m deep waters (Johnston et al. 2008).

Bottlenose dolphins are reportedly common across the South Pacific (Reeves et al. 1999). They include the common bottlenose dolphin (*Tursiops truncatus*) and the Indo-Pacific bottlenose dolphin (*Tursiops aduncus*), which differ both in form and habitat preferences (Hale et al. 2000). In the South Pacific, they have been reported at sites such as the Solomon Islands, where they are hunted (Oremus et al. 2015a, Oremus et al. 2015b), as well as in New Caledonia, Tonga, Samoa, the Cook Islands and French Polynesia (SPWRC 2004). Molecular genetic work suggests differential genetic diversity of *T. aduncus* at different South Pacific sites (Oremus et al. 2015a). Bottlenose dolphins are reportedly common in American Samoa (R. Volk in Reeves et al. 1999), but have been encountered on only three occasions since 2003.

Striped dolphins, named for a unique pattern of stripes on their flanks, are found in temperate to tropical regions worldwide (Archer & Perrin 1999, Reeves et al. 1999). They are found in deep waters where they feed on fish and cephalopods at depths of up to 700 m (Archer & Perrin 1999). Their distribution extends mainly over the continental slope and open ocean, and where deep water is found near-shore (Van Waerebeek et al. 1998, Hammond et al. 2008). In the South Pacific, striped dolphin sightings are typically concentrated in areas with high search effort; mainly in the far east and west (Perrin et al. 1985). In the western South Pacific, reports of stranded or museum specimen and live sightings exist over a wide range of latitudes ranging from New Guinea and the Solomon Islands to Australia and New Zealand (Wilson et al. 1987). The South Pacific Whale

Research Consortium reported no instances of striped dolphins in their research across Oceania (SPWRC 2004). Evidence of this species in the Territory is based on one stranding in 2007 (DMWR, unpublished data).

Pantropical spotted dolphins have been described as common in American Samoa (R. Volk in Reeves et al. 1999) and recorded in many areas in the tropical South Pacific such as New Caledonia, Vanuatu, Fiji, Cook Islands, French Polynesia, Solomon Islands, Marquesas, and New Guinea (Reeves et al. 1999, SPWRC 2004). The pantropical spotted dolphin is also the predominantly species still hunted in the Solomon Islands (Oremus et al. 2015b). Only one sighting of spotted dolphins has been made during 105 marine mammal surveys conducted around Tutuila (Robbins and Mattila, unpublished data). Recent studies of spotted dolphins in Hawaii suggest a high level of island based differentiation, which is likely to also occur in the South Pacific (Courbis et al. 2014).

Cuvier's beaked whales are widely distributed in all oceans. This species can reach up to 7.5 m and weigh up to 3,000 kg. It is not considered common in the tropical South Pacific, but has been documented at Micronesia, Sydney Island,Phoenix Island, New Britain, Nauru and Manua Islands, the Cook Islands and French Polynesia (Reeves et al. 1999, Gannier 2000, SPWRC 2004). The first record of this species at American Samoa was based on a stranding on June 3, 2002 (R. Utzurrum pers comm.) in Pago Pago harbor.

5.10.3 THREATS TO MARINE MAMMALS

American Samoa, as a territory affiliated with the United States, is obligated to enforce the provisions of the Marine Mammal Act; hence, intentional takes of any form are illegal in the Territory. However, hunting of small cetaceans continues in areas of the South Pacific (Oremus et al. 2015b) and therefore remains a potential threat to marine mammal populations in the region. Additionally, it is conceivable that lethal takes in more remote areas, such as Antarctic minke whales taken by Japan under special permit whaling, may impact Territory populations. However, better understanding of species distribution and stock structure is needed to assess those threats.

Other human-caused threats to locally occurring cetaceans include fisheries interactions and vessel strikes. An observer program was established in 2006 to document marine mammal interactions with the commercial longline industry operating from American Samoa, and interactions have been reported with false killer whales, short-finned pilot whales, Cuvier's beaked whales and rough-toothed dolphins, with up to 24 estimated interactions in 2011 and 13 estimated interactions in 2013[3] (Aylesworth 2009). Rough-

[33] NOAA U.S. National Bycatch Report First Edition Update 2: http://www.st.nmfs.noaa.gov/observer-home/first-edition-update-2

toothed dolphins around Tutuila have been documented with injuries that may have resulted from fisheries interactions (Robbins and Mattila, unpublished data) and depredation is known to occur in these species (Johnston et al. 2008). Scar-based assessment methods (Robbins 2012) are currently underway to assess the frequency of non-lethal entanglement injuries among humpback whales at American Samoa. The incidence of vessel strike injuries is also unknown, but injury based assessments (Hill et al. In press) may also help clarify this threat in the future. Whale watching has been identified as a potential source of disturbance for marine mammals, but no such industry yet exists at American Samoa. Finally, possible indirect future threats to cetaceans in the Territory include climate change and habitat degradation (including chemical and noise pollution).

Marine mammals in the Territory are also vulnerable to natural impacts, such as predation and disease. Live humpback whales at American Samoa frequently exhibit injuries inferred to be from cookie cutter sharks (Robbins and Mattila, unpublished data). Healed rake marks consistent with killer whale attacks have also been observed (Robbins and Mattila, unpublished data). Humpback whales at American Samoa have been shown to exhibit a higher frequency of ovoid skin lesions than other oceanic populations, and the cause of these lesions is not yet known (Mattila & Robbins 2008).

5.10.4 SPECIES STATUS

There are no robust local estimates of abundance of marine mammal species at American Samoa. Of the thirteen marine mammal species known to occur in Territorial waters, only one (the sperm whale) is currently listed as Endangered under the Endangered Species Act (Table 1). The most recent Federal Stock Assessment of humpback whales at American Samoa (last updated in 2009) indicated a minimum local population size of 150 individuals based on photo-identification work conducted at that time (Carretta et al. 2016). The maximum number of allowable human induced serious injuries and mortalities (i.e., Potential Biological Removal) was set at 0.4 whales per year, but no takes were known to have occurred during the prior five year window (Carretta et al. 2016). Humpback whales at American Samoa are part of the Oceania distinct population segment (DPS) which was recently removed from the Endangered Species List. The most recent estimate of abundance in Oceania was 4,329 whales (3345–5313) in 2005 (Constantine et al. 2012), which is the smallest humpback whale stock in the Southern Hemisphere. The International Whaling Commission recently completed a comprehensive assessment of the current status of humpback whales in Oceania. The results indicated recovery of 37% in 2012, versus 64% and 99% in adjacent populations off Australia (IWC 2015). Humpback whales in Oceania are still listed as Endangered by the IUCN.

U.S. stock assessments also exist for spinner dolphins and false killer whales, but there are no local assessments of population size or trend.

At present, all marine mammal species are protected within the 3-mile limit of Territorial waters by virtue of Executive Order No. 005-2003 (American Samoa Government 2003), a layer of protection that has been added to that afforded to the species group under the US Marine Mammal Protection Act.

5.10.5 MARINE MAMMAL CONSERVATION PRIORITIES

1. *Continue to inventory and study marine mammal fauna*

Understanding species diversity and habitat requirements depends on systematic efforts to document their presence. To date, the majority of the marine mammal research at American Samoa has focused on humpback whales at the peak of their breeding season. Further research is needed to detect and characterize other marine mammals in Territory waters. In addition to on-water surveys, passive acoustic monitoring may provide lower cost options for acquiring occurrence and seasonality data.

Continued research is also needed to understand humpback whales within Territorial waters. This is a low density breeding site and so consistent annual effort is required to achieve the sample sizes needed for abundance and trend estimates. This will be particularly important in light of the recent delisting of the Oceania DPS and post-delisting monitoring requirements. In addition to continued research at the peak season, it would be valuable to extend the research season to better characterize breeding season duration. Surveys to date have been limited to the waters around Tutuila, but could be expanded to include other parts of the Territory.

Understanding of local populations would continue to benefit from comparative studies. For example, humpback whales at American Samoa are one of several populations for which age structure is being estimated by new epigenetic techniques (Polanowski et al. 2014). These results, in comparison to other areas, will help to clarify population composition and status. Studies of skin-associated bacteria on humpback whales at American Samoa and other populations are leading to a better understanding of their biology as well as possible health indicators (Apprill et al. 2014). As previously noted, current understanding of the genetic diversity and stock structure of false killer whales and spinner dolphins at American Samoa has been facilitated by comparisons to other oceanic populations.

2. *Continue to develop local expertise in marine mammal research*

Capacity building should be continued and enhanced at American Samoa by maintaining on-going partnerships with external collaborators and providing training to local personnel. Local expertise has been facilitated by having local biologists/technicians assist visiting scientists in the course of their field work and surveys.

3. *Assess and prevent impacts from human activities*

Fishing interactions are currently the only confirmed source of human interaction with cetaceans in the Territory. Increasing the amount of observer coverage may improve estimates of fishery-related mortality from the commercial longline industry (Aylesworth 2009). However, photographic studies can also be used to estimate the frequency of cetaceans with peduncle injuries, jaw notches and other indicators of fisheries interactions. Such studies can also be used to evaluate the frequency of non-lethal vessel strikes affecting cetaceans that inhabit Territory waters.

There is currently no commercial nor significant recreational whale watching in Territorial waters. This, combined with near-shore distribution of some species, offers a unique opportunity to establish population and behavioral baselines before such development occurs. Baseline research can also potentially be undertaken from shore stations where controlled vessel approach experiments can be studied. Regional best practices for whale watching should be developed at American Samoa now, before any commercial development occurs.

4. *Identify cetacean stocks and their range of distribution*

Tissue samples obtained during vessel surveys and strandings have already been included in molecular genetic studies to determine stock structure and diversity of some marine mammal species. To date, such work has focused on humpback whales (e.g., Constantine et al. 2012), spinner dolphins (Johnston et al. 2008) and false killer whales (Chivers et al. 2010). Another priority species would include the bottlenose dolphin in light of uncertainty as to whether the species found at American Samoa is*T. truncatus* or *T. aduncus or both*.

Satellite tagging could also be performed to better understand the geographic range and migratory movements of marine mammal species, such as humpback whales. Work undertaken in other parts of Oceania have improved understanding of humpback whale connectivity in Oceania and migratory destinations. Participation in regional collaborations are also essential to understanding range and connectivity, as outlined under Item 6, below.

5. *Enhance stranding response capability*

Stranding response capability can be enhanced with the cooperation of local territorial government, NOAA-OLE, and villages. An MOU between DMWR and NOAA was signed in 2015 to designate DMWR as the lead Terrirtorial Agency on Marine Mammal Stranding response. A Marine Mammal Stranding Response team was organized with David Schoefield of NOAA in the Summer 2015, in order address a response plan. A Marine Mammal Response Plan is currently in development to help coordinate response and leadership roles for stranding events. Stranding events provide the opportunity for collection of vital scientific information, especially for rare Marine Mammals, and data collection is coordinated with the Marine Mammal Stranding Network in Hawaii. Samples are stored both at DMWR in American Samoa, and shipped to Hawaii for analysis. Currently, DMWR has supplies on hand to respond to strandings and collect vital scientific information. Additional funding needs to be secured to ensure that a rapid response to strandings can be accomplished and vital scientific information is not lost due to response delays.

6. *Develop/strengthen linkages with other South Pacific countries and territories and other relevant programs and agencies*

Cetaceans are highly mobile animals without political boundaries. Thus, collaboration with neighboring countries and territories is essential for attaining meaningful research results and effective conservation strategies. Such collaboration may also help defray costs involved in research and training. DMWR works in partnership with marine mammal scientists who are members of the South Pacific Whale Research Consortium and the Southern Ocean Research Partnership. Data from the humpback whale studies project are shared with regional catalogs, including the Antarctic Catalog, and with geneticists who hold large-scale tissue archives. Other opportunities for collaboration include greater integration with the Secretariat of the Pacific Regional Environmental Program (SPREP) and the program of research on marine mammals being organized at the Pacific Islands Fisheries Science Center in Honolulu,Hawaii.

5.11 THE MARINE INVERTEBRATES AND FISH

5.11.1 GIANT CLAMS

Tridacna maxima, and *Tridacna squamosa*

Local common name: faisua

Distribution: Widely distributed

Abundance: Uncommon

Status: Size limits, collection prohibited in the National Marine Sanctuaries

DISTRIBUTION

Giant clams are marine bivalve mollusks that inhabit the shallow coral reefs of the Indo-West Pacific (Harzhauser et al. 2008) in the area bounded by southern Africa, the Red Sea, Japan, and Polynesia (excluding New Zealand and Hawaii) (bin Othman et al. 2010). They live in symbiotic relationship with photosynthetic dinoflagellate (*Symbiodinium*) that grow in their mantle tissues. This relationship restricts the distribution of giant clams in clear tropical waters. Adult clams get most (70-100%) of their nutrients from this symbiotic relationship and the rest from filter feeding. The largest living marine bivalve mollusk is the giant clam *Tridacna gigas*, reaching 120 cm in length and over 200 kg in weight. There are 13 extant giant clam species and four of them are found in American Samoa (*Tridacna derasa, Tridacna maxima, Tridacna squamosa, and Hippopus hippopus*). Three are native species of giant clams. *Tridacna derasa* was introduced to the Territory during a giant clam mariculture project in the 1980's. *Hipopus hippopus* is so rare that its existence is only known from a few found empty shells.

Tridacna maxima is the most widely distributed giant clam, found in the waters of East Africa, India, China, Australia, Southeast Asia, and the south Pacific from Solomon Islands to French Polynesia and Pitcairn Island. It is the most abundant giant clam in American Samoa and is also known as the small giant clam as it is relatively smaller than the other clams in the family. It is distinguished by its close-set scutes and it tends to bore partially into reef substrates. It is much sought after in the aquarium trade because of its mantle color and its manageable size.

Tridacna squamosa is identified by its large, well-spaced scutes. It is also widely-distributed like *T. maxima*, found from the Red Sea and East African Coast across the Indo-Pacific to Pitcairn Islands. It is also a popular food item in many Pacific island people. Maximum shell size is 45 cm. As a male, age and size at first sexual maturity is 4 years and 6 cm, respectively. As a hermaphrodite, age and size at first sexual matuiry is 6 years and 16 cm, respectively.

ABUNDANCE

The Rose Atoll Fish and Wildlife Refuge has the highest number of giant clams (mostly *T. maxima*) in the Territory owing perhaps to its protected status and its relatively significant lagoon area. Radtke (1985) first estimated the population size and density, age structure, growth rate, maturity and mortality of *T. maxima* in Rose Atoll in 1984 and 1985. Radtke (1995) surveyed three habitats: patch reefs, coral patches and lagoons. Estimated maximum density was 6, 3, and 5 individuals per m^2 in patch reefs, coral patches and lagoons, respectively. These densities translated to between 900,000 and 1.7 million *T. maxima* in Rose Atoll. For the both years, size frequency distribution was strongly bi-modal with 2-7 cm-sized clams dominant. Maximum age was estimated 18 years based on 'annual' rings in the shells. Growth rate was low at k = 0.065, and maximum size at 29.4 cm. *T. maxima* does not typically exceed 20 cm in length but sizes of up to 35-40 cm have been recorded. Size at first sexual maturity is around 2 years. It is a protandrous hermaphrodite and the transition to the female sex is at 9 cm (around 9-10 years). Instantaneous mortality (Z) was 0.154.

Green and Craig (1999) surveyed *T. maxima* in six islands including Rose Atoll. The data showed that 97% of the recorded giant clams were in Rose Atoll and the atoll lagoon, especially the base of the pinnacles, had the highest densities. Twenty-four percent of the *T. maxima* recorded in Rose Atoll were sexually mature sizes (≥ 12 cm). Maximum recorded size was 25 cm and estimated instantaneous mortality rate was low (Z = 0.3). The size distribution and the population parameters (L_{max}, L_∞ and total mortality Z) have been relatively stable for at least 14 years up to 1999 in Rose Atoll. This indicates that the population of *T. maxima* has been relatively 'undisturbed' in Rose Atoll. The NOAA CRED data showed that Tau had the highest densities (7 to 18 *T. maxima* per hectare) in 2002, 2004 and 2006 with very low densities in Rose. However, the surveys only covered the forereef slope data for inter-island comparisons. *Tridacna squamosa* are occasionally recorded in the commercial spearfisheries but never recorded in surveys. *Hippopus hippopus* abundance is very rare.

HABITAT

Radtke (1985) noted that *T. maxima* were found throughout the shallow areas of the lagoon in Rose Atoll. Radtke (1985)) also claimed that *T. maxima* is the only giant clam found in Rose Atoll. Radtke (1985) found the highest densities of *T. maxima* in the patch reefs and lagoon substrate in the Atoll. Green and Craig (1999) also found the highest densities of *T. maxima* in the Rose Atoll lagoon, an area of low wave exposuere, especially around the bases of the pinnacles. These pinnacles rise steeply from the lagoon floor to sea level and are encrusted by coralline algae and a variety of hard and soft corals. The patterns of habitat use of *T. maxima* in Rose Atoll is similar to other areas in the Central and Eastern Pacific (McKoy 1980, Richard 1978). In contrast, this giant clam is more abundant in reef flat or reef front in the Western Pacific (McMichael 1975, Hardy and Hardy 1969, Hester and Jones 1974). *T. squamosa* appears to favour fairly sheltered lagoon environments adjacent to high islands but apparently excluded by *T. maxima* in the lagoons of French Polynesia.

THREATS

Giant clams are traditionally harvested in the Indo-Pacific and is a delicacy in American Samoa. Their accessibility in terms of their lagoonal habitats and being sessile make them vulnerable to over-harvesting. Certain aspects of the giant clams' life history compound this vunerability. Growth is slow owing perhaps to shell calcification making population turn-over low. As broadcast spawners, low population turn-over is exacerbated by low recruitment in areas of low densities of sexually mature giant clams.

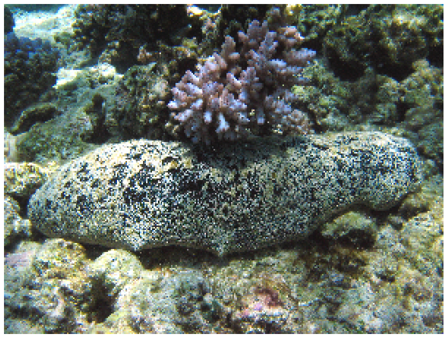
Habitat degradation is another major threat to giant clams. High water clarity has been shown to be important for giant clam growth due to their photosynthetic symbionts. Therefore, low water clarity caused by sediment run-off would be detrimental for giant clams. This result is consistent with the natural distribution of the species, *T. maxima* is generally more abundant in open, clear waters. Giant clams are also vulnerable of rising sea-surface temperatures and have been known to bleach with increased temperatures.

CONSERVATION STRATEGY

1. Given its already depleted state, we propose to conduct **an active population restoration program for giant clams that includes population restocking, and development of hatcheries.** Hatcheries have been successfully developed in other parts of the world and restocking implemented. The program would also include regular monitoring of stocks in the wild and the status of giant clams in protected areas (e.g. Rose Atoll), mapping of their distribution and an education and outeach component for fisheries regulation compliance.

2. We also propose to conduct **basic scientific research on the demography of giant clams on growth rate, reproduction and longevity and population genetic connectivity in the Samoan Archipelago**.

*5.11.2 **SEA CUCUMBERS***

Holothuria fuscogilva, *Holothuria whitmaei*, *Actinopyga mauritiania*

Local common name: mamao, susu valu pe'ape'a, paulu

Distribution: Widely distributed

Abundance: Uncommon

Status: Commercial collection prohibited

DISTRIBUTION

Sea cucumbers are echinoderms under the class Holothuroidea. They comprise a large group of marine animals that include sea stars and sea urchins. Sea cucumbers or holothurians don't look like echinoderms because they do not possess the five-fold symmetry but instead look tubular. At the anterior end is the mouth that is usually surrounded by a ring of tentacles.

Sea cucumbers are conspicuous components in shallow water coral reef ecosystems. They are also actually found on seafloors worldwide from shallow coral reefs to deep seafloors up to 9 km where they can make up 90% of the macrofaunal biomass. In fact, sea cucumbers seem best adapted to extreme depths as various species have been recorded from 5,000 to 10,000 m deep. They scavenge while moving slow through the seafloors taking in sand with dead animal and plant materials and other debris. The dead materials are ingested while the sand is expelled. A single sea cucumber can swallow more than 45 kg of sediment a year, and their excellent digestive capacities allow them to reject a finer, purer and homogeneous sediment. Therefore, sea cucumbers play a major role in the biological processing of the sea bed (bioturbation, purge, homogenization of the substratum etc.). In addition, sea cucumbers are important in recycling nutrients and breaking down waste matter.

Holothuria fuscogilva, also known as white teatfish, is the most highly prized sea cucumber. It widely is distributed throughout the Indian and Pacific Oceans from South Africa, north to the Red Sea and Egypt, east to India and to Australia, north to China and Japan, and east to Easter Island, including Pacific Islands. *Holothuria whitmaei* is found only in the Pacific, from Australia and the Philippines to Guam and Samoa, and to Hawaii and Johnston Island. *Actinopyga mauritiana* is found throughout the central Pacific and Indian Oceans. It occurs from eastern Africa and the Red Sea in the west, to Hawaii, and the Solomon Islands in the southeast.

HABITAT

Holothuria fuscogilva is found in waters from 0 – 40 m, but is mostly encountered between 15 and 30 m, and may occur occur in deeper waters. In the Western Central Pacific, *H. fuscogilva* inhabits outer barrier reefs and passes and shallow seagrass beds between 0 and 40 m. In the African Indian Ocean region, it prefers slopes and lagoons over sandy bottoms from 10 -50 m. The juveniles can occur in much shallower waters. In Fiji, it recruits in shallow seagrass beds and then moves to deeper waters. Sexual maturity is reached at 1.2 kg (Conand 1989), slower to compared to other *Holothuria* spp. This species only reproduces once or twice a year. In New Caledonia, *H. fuscogilva* is known to spawn from December to March and in Solomon Islands from August to October. It has a maximum size of 60 cm, with an average weight of 2.4 kg. Generation length is unknown for this species. Body size is not a good indicator of age or longevity (reviewed in Conand et al. 2013).

Holothuria whitmaei is found along slopes and passes within reef zones. In the Western Central Pacific, this species can also be found in reef flats, slopes and shallow seagrass beds between 0 and 20 m. This species has been observed at 30 m, but may possibly occur in deeper waters to about 50 m. In New Caledonia, *H. whitmaei* spawns between June and

August. Genetic studies on the Australian east coast suggested that recruitment to populations of this species occurs from a wide geographic range. Growth of this species is slow, between 80-170 g*yr-1, and large animals can shrink during certain periods. This species may live at least 12 years (reviewed in Conand et al. 2013).

Actinopyga mauritiana prefers outer reef flats and fringing reefs, mostly in the surf zone between 0-20 m as part of the medio-littoral reef community in the Western Central Pacific Region. It holds on to the hard bottom when exposed to wave action. In Solomon Islands, adults are commonly found around solid reef rock and scattered tables of the coral *Acropora* sp. This species has a high fecundity and early sexual maturity, around 350 g weight in New Caledonia. In the Africa and Indian Ocean region, this species reaches sexual maturity at 23 cm TL. The peak reproductive activity is between December and January in New Caledonia and from October until January in the Solomon Islands and the cycle relates to ambient ocean temperature and photoperiod (reviewed in Conand et al. 2013).

THREATS

H. fuscogilva has been depleted in parts of the South Pacific (approximately 30% of the range). Depletion refers to commercially unviable collection, and estimated to represent an approximately 60-80% loss or greater, with some refuge for this species in deeper water. Shallow waters are more heavily impacted. In areas where it is considered overexploited, harvests have declined.

H. whitmaei is commercially exploited throughout its range for its high value as beche-de-mer to supply the Asian consumers around the world. Based on a number of quantitative and qualitative studies, populations are estimated to be depleted and have declined by more than 60-90% in the majority of its range (at least 70%). It is considered overexploited in other parts of its range.

A. mauritiana is harvested both commercially as well as in subsistence fisheries throughout its distribution. In many countries of the Western Central Pacific region, *A. mauritiana* is consumed as bêche-de-mer or their instestines and/or gonads are consumed as delicacies or as the protein component in traditional diets. *A. mauritiana* is among the top three species for local subsistence consumption (Kinch et al. 2008). Although heavily targeted, *Actinopyga mauritiana* is difficult to fish because it is found on the exposed reef crest, and is somewhat cryptic (found in crevices).

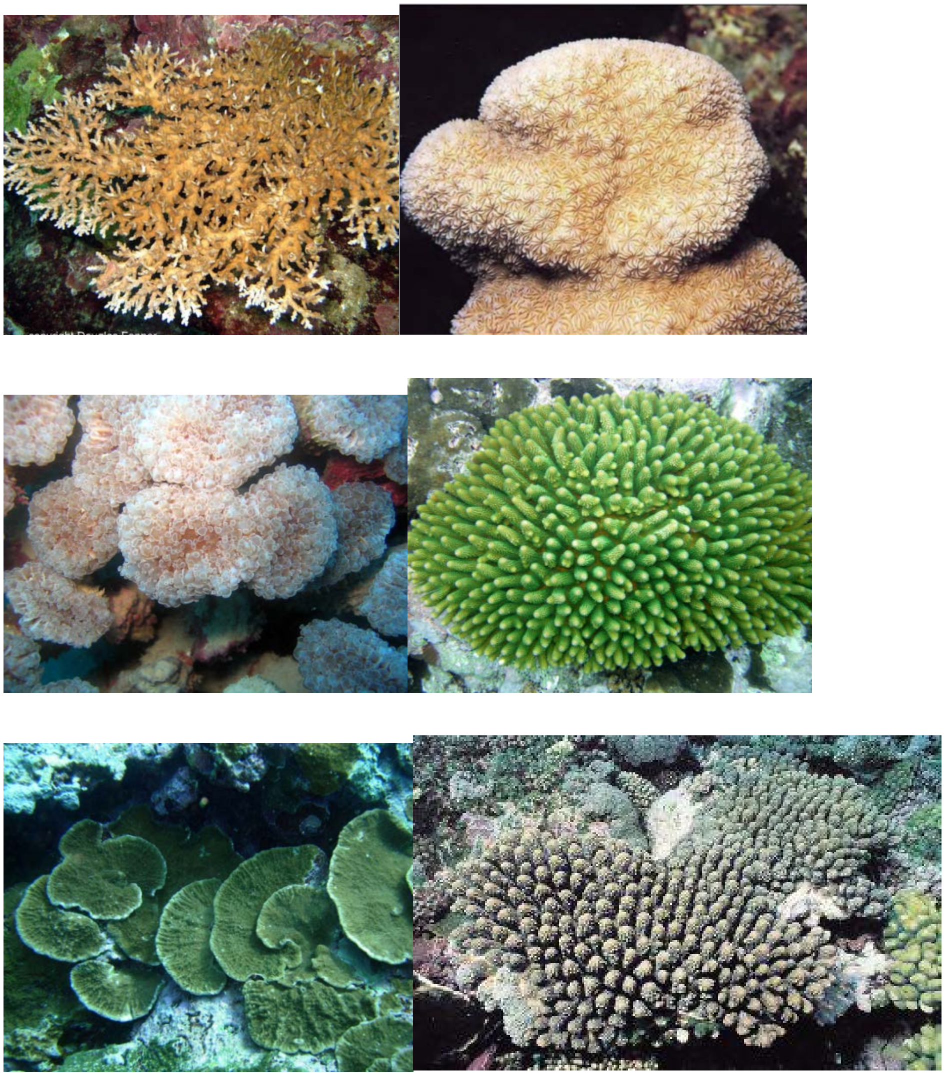
CONSERVATION STRATEGY

1. We propose **to develop a management plan for the harvest of these sea cucumbers**. The management plan would include the **development of sea cucumber**

hatcheries in collaboration with regional partners such as the Secretariat of the Pacific Community. The plan would also include **regular monitoring of stocks in the wild, mapping of their distribution and an education and outreach component for fisheries regulation compliance**.

2. We also propose to conduct **basic scientific research on the growth rate, longevity and reproduction of these sea cucumbers and their population genetic connectivity in the Samoan Archipelago**.

5.11.3 ***HARD CORALS***



Acropora speciosa, Pavona diffluens, Euphyllia paradivisa, Acropora globiceps, Isopora crateriformis, Acropora retusa

Local common name: samu

Distribution: Widely distributed

Abundance: Rare to moderately common

Status: listed as threatened under the Endangered Species Act

DISTRIBUTION

Acropora retusa is found in the south-west and northern Indian Ocean, the central Indo-Pacific, the Solomons, the oceanic west Pacific, and the central Pacific and in the Pitcairn Islands.

Acropora speciosa is found in the central Indo-Pacific, the oceanic west Pacific, and the central Pacific. It is distributed from Indonesia to the Marshall Islands in the western and central Pacific, in the Maldives in the Indian Ocean and at least one site in French Polynesia.

Acropora globiceps is distributed from the central Indo-Pacific, oceanic west Pacific to the central Pacific as far east as the Pitcairn Islands.

Euphyllia paradivisa is distributed mostly in the Coral Triangle area (the Philippines to Timor Leste and east to the Solomon Islands).

Isopora crateriformis is distributed within the Coral Triangle area (the Philippines to Timor Leste and east to the Solomon Islands), plus some of the western Pacific too, including New Caledonia, the Samoas, and the Marshall Islands.

Pavona diffluens is distributed along part of the east African coast, the Red Sea, and the northwestern Indian Ocean.

These corals are purportedly found in American Samoa but there are no published information in their distribution.

HABITAT

Acropora retusa is a hermaphroditic spawner (contains both male and female gametes). Its colonies are flat plates with short, thick, finger-like branches. Its radial corallites vary in length giving the branches 'rough' and spiky appearance. *Acropora retusa* is found in shallow reef slope and back-reef areas, such as upper reef slopes, reef flats, and shallow lagoons, from 0 to 5 meters in depth.

Like other species of *Acropora*, *Acropora speciosa* is likely to be hermaphroditic (having both male and female gametes) spawners. Its colonies form thick cushions or bottlebrush branches and are cream or light brown in color with delicately colored branch tips. *Acropora speciosa* occurs on lower reef slopes and walls, in reefs characterized by clear water from 12 to 40 meters in depth.

Acropora globiceps form colonies that have finger-like branches. The branches are always closely compacted although the size and appearance of branches depend on degree of exposure to wave action. Colonies exposed to strong wave action have pyramid-shaped branchlets. Colonies can be uniform blue, purple, cream, brown, or fluorescent green in color. *Acropora globiceps* is also likely to be hermaphroditic (having both male and female gametes) spawners. It occurs on upper reef slopes, reef flats, and adjacent habitats in depths ranging from 0 to 8 meters.

Euphyllia paradivisa is found in environments sheltered from wave, on the upper reef slopes, mid-slope terraces, and lagoons from 2 to 25 meters in depth. It is made up of separate and branching corallites and polyps have branching tentacles. Color is pale greenish-grey or pink (in rare instances) with lighter tentacle tips.

Isopora crateriformis is mostly found in shallow, high-wave energy environments, including reef flats and lower reef crests, and upper reef slopes. It has been reported from low tide to at least 12 meters deep, and may occur in mesophotic depths (<50 meters). It forms colonies of flat, solid encrusting plates. Colonies are usually brown in color and can sometimes be over 1 meter in diameter. When a colony occurs on a slope, the lower edge is usually lifted as a plate.

Pavona diffluens forms sub-massive and tan-colored colonies. It occurs in upper reef slopes, mid-slopes, lower reef crests, reef flats, and lagoons in depths of 5 to at least 20 meters. *Pavona* species are known to be gonochoristic (individual colonies have either male or female gametes, not both) broadcast spawners.

The age of first maturity of most reef building corals is typically three to eight years (Wallace 1999) and therefore we assume that average age of mature individuals is greater than eight years. Furthermore, based on average sizes and growth rates, we assume that average generation length is 10 years, unless otherwise stated. Total longevity is not known, but likely to be more than ten years. However, most corals are also capable of asexual reproduction through fragmentation so longevity can be indeterminate.

THREATS

Several of the most important threats contributing to the extinction risk of corals are related to global climate change. The main concerns are regarding the impacts of the magnitude and the rapid increase in greenhouse gas concentrations and atmospheric warming. These changes are increasing the warming of the global climate system and changing the carbonate chemistry of the ocean (ocean acidification), which affects a number of biological processes in corals, including secretion of their skeletons. Higher atmospheric CO^2 results in: Ocean warming via the greenhouse effect, ocean acidification via oceanic uptake of CO^2, and rising sea levels via ice melting and thermal expansion. Latest studies also indicate that El Nino events facilitate the increase of atmospheric CO^2.

Based on current models, global annual mean ocean surface temperatures will likely increase by approximately 0.4-1 °C by 2030, approximately 0.7-2 °C by 2060, and approximately 2-5 °C by 2081-2100 (IPCC, 2013). The models also indicate that mean surface pH in the tropics (20 °N to 20 °S) is projected to decline from the current pH of approximately 8.05 to approximately 7.95 by 2050, and to approximately 7.75 by 2100, or a reduction of 0.31 by 2100 (IPCC, 2013), with a subsequent large decline in aragonite saturation state in surface tropical waters, exacerbating the impacts of ocean acidification on reef-building corals.

Bleaching is the primary observable coral response to ocean warming, wherein corals turn white as they expel their symbiotic zooxanthellae in response to thermal stress. For many corals, an episodic increase of only 1 °C-2 °C above the normal local seasonal maximum ocean temperature can induce bleaching. Corals can withstand mild to moderate bleaching but severe or prolonged bleaching can lead to colony death. In addition to coral bleaching, ocean warming has been documented to lead to impaired fertilization, developmental abnormalities, mortality, impaired settlement success, and impaired calcification of early life phases.

The impact of ocean warming is expected to variably affect corals in various spatial scales. Exposure to increased sea surface water temperature will depend on colony location (e.g., latitude, depth, bathymetry, habitat type, etc.) and physical processes that affect seawater temperature and its effects on coral colonies (e.g., winds, currents, upwelling shading, tides, etc.). Colonies in higher latitudes and/or deeper areas are usually less affected by warming events. Coral in deeper areas are generally less affected typically because lower irradiance reduces the likelihood of warming-induced bleaching. Also, some locations are blocked from warm currents by bathymetric features, and some habitat types reduce the effects of warm water.

Physical processes can also moderate exposure of colonies of the species to ocean warming in many ways, including processes that increase mixing (e.g., wind, currents, tides), reduce seawater temperature (e.g., upwelling, runoff), or increase shading (e.g. turbidity, cloud cover). While exposure of colonies of a species to ocean warming will likely vary annually and decadally, while increasing over time, ocean warming is predicted to substantially increase by 2100. These projected changes will likely decrease the environmental suitability for shallow coral reef habitats across the equatorial western Pacific and on the Indo-Pacific (Couce et al. 2013). However, these declines in habitat suitability will vary since seawater temperatures are moderated by physical factors such as higher latitudes or upwelling and aragonite saturation states. However, severe coral bleaching events will likely start to occur annually (van Hooidonk et al. 2014)

Projecting species-specific responses to global threats is complicated by several physical and biological factors: (1) model uncertainty (emissions assumptions, strength of the climate's response to increased temperature, and large natural variations); (2) spatial variability in projected environmental conditions across the ranges of the species; and (3) species-specific responses depend on many biological characteristics, including, at a minimum, distribution, abundance, life history, susceptibility to threats, and capacity for acclimatization.

Finally, warming will cause increased stratification of the upper ocean because water density decreases with increasing temperature. Increased stratification results in decreased vertical mixing, leaving surface waters warmer and nutrient-poor. Consequently, increased water vertical stratification will decrease the overall net productivity of coral reef ecosystems (e.g., fewer nutrients) and probably negatively impact coastal and oceanic fisheries.

The impact of global warming is likely to be compounded by increasing coral disease, trophic effects of fishing, land-based sources of pollution, and other threats to corals. Increased seawater temperature can lower resistance to coral diseases and reduce coral health and survivorship. Coral disease outbreaks often have either accompanied or immediately followed bleaching events, and also follow seasonal patterns of high seawater temperatures. Fortunately, the incidence of coral disease in American Samoa is still relatively low. Sedimentation is considered a medium and limited to some watersheds in the Territory. However, its impact cannot be downplayed. High sediment loading can induce sublethal effects, such as reductions in tissue thickness, polyp swelling, zooxanthellae loss, and excess mucus production. Increased suspended sediment can also reduce the amount of light in the water column, making less energy available for coral photosynthesis and growth. Sedimentation also impedes fertilization of spawned gametes and reduces larval settlement and survival of recruits and juveniles.

Eutrophication is becoming a problem in American Samoa due to untreated sewage water. Nutrient can affect corals through direct impact on coral physiology and indirect effects through nutrient-stimulation of other community components (e.g., macroalgal turfs and seaweeds, and filter feeders) that compete with corals for space on the reef. The main vectors of anthropogenic nutrients are point-source discharges (such as rivers or sewage outfalls) and surface runoff from modified watersheds.

CONSERVATION STRATEGY

1. We propose to enhance the development of **active coral reef restoration program that includes ocean nurseries** that can regrow coral fragments to colonies for

transplanting to denuded reefs. This is not limited to the corals already listed as threatened under the Endangered Species Act. This active restoration program would also include basic **research on various aspects of coral demography such as growth rates, recruitment, reproductive biology, and distribution** that still remain as knowledge gaps in American Samoa. Finally, we propose to put in place a **long-term program to eradicate coral predation** in American Samoa by crown-of-thorns starfish among other threats.

5.11.4 MESOPHOTIC CORAL REEF FISHES

Etelis carbunculus, Etelis coruscans and Pristipimoides filamentosus

Local common name: Palu-malau (for *E. carbunculus* and *E. coruscans*), Palu-sina (for *P. filamentosus*); Palu-atu and Palu-loa (for *E. coruscans*); Palu-ena'ena and Palu-pa'epa'e (for *P. filamentosus*)

Distribution: Widely distributed but restricted to deepwater coral reefs

Abundance: Moderately common

Status: Not listed under the Endangered Species Act

DISTRIBUTION

The ruby snapper *Etelis carbunculus* and the flame snapper *Etelis coruscans* are deep-water fish of the subfamily Etelinae (Lutjanidae) that generally inhabit waters between 100 m and 500 m depth (Carpenter and Niem 2001). The Ruby Snapper, *E. carbunculus*, is found throughout the Indian and Pacific Oceans. It is known from the coast of East Africa to the

Persian Gulf and Red Sea, across the Indo-pacific, north to Japan and south to Australia. It is distributed from 30^0 N and 25^0 S in the tropical and subtropical waters of the Pacific Ocean. In the Pacific, its range extends to Hawaii, including French Polynesia. It has also been recorded from northern New Zealand (Fry and Newman 2010) and out to both Christmas and Cocos Islands. The flame snapper *E. coruscans* is distributed from East Africa up to the Bashee River 32°S, eastward to the Hawaiian Islands, north to southern Japan, south to Australia (Queensland and New South Wales) and Lord Howe Island.

Pristipomoides filamentosus is another eteline snapper of major fishery importance. Its geographic range extends throughout the tropical and subtropical Indo-Pacific from the Hawaiian Archipelago and the central western Pacific Ocean to the western Indian Ocean and south along northwestern and northeastern Australia (Allen 1985; Kramer et al. 1994; Newman 2006).

HABITAT AND ECOLOGY

E. carbunculus is a demersal species that inhabits rocky bottoms on the continental shelf from a depth range of 90-400 m. It feeds on fishes and large invertebrates such as squids, shrimps and crabs and on planktonic organisms (Fry and Newman 2010). This demersal species is known to occur in aggregations. At Vanuatu (New Hebrides) spawning occurs throughout much of the year, with a peak in activity around November (Allen 1985).

Previous studies reported varying estimates of the longevity of snappers from <15 to >30 years with *Etelis* on the younger range (10 to 15 years) (Ralston and Williams 1988, Smith and Kostlan 1991). Smith and Kostlan (1991) estimated the maximum age of *E. carbunculus* in Vanuatu to be <10 years. Williams et al. (2013) examined sectioned otoliths and estimated maximum age of *E. carbunculus* as 21 years based on ring counts. Fry et al. (2006) made the highest estimate at 28 years age for a 760 mm SL *E. carbunculus*. Recent methodology using bomb carbon dating indicated that *E. carbunculus* can live up to 35-39 years (Andrews et al. 2011). This has significantly extended the longevity of this deep-water snapper and suggests that natural mortality rate is much lower. Bomb carbon dating has not been conducted for *E. coruscans*. Maximum age for *E. coruscans* from otolith ring counts has been estimated to be 18 years.

As is usually the case with the other eteline snappers, many of the life history characteristics of *P. filamentosus* are unknown or incompletely described (Moffitt 2006). Earlier estimates of the maximum age of *P. filamentosus* ranged from 5 to almost 17 years (Uchiyama and Tagami 1984, Ralston and Miyamoto 1983, Radtke 1987, Ralston and Williams 1988, Fry et al. 2006). Bomb radiocarbon dating has now extended estimates of maximum age for *P. filamentosus* to more than 40 years (Andrews et al. 2012). However, there seems to be geographic differences in maximum age as its estimates for *P. filamentosus* in the Mariana Islands is 27 years. The growth rate (k) estimated from bomb radiocarbon dating indicated that *P. filamentosus* is a slow-growing fish with *k* equal to 0.24. Using otolith increment data, Williams et al. (2013) also showed slow growth rates for *E. carbunculus* (k = 0.28) and *E. coruscans* (k = 0.32).

THREATS

Overfishing is the main threat to these mesophotic eteline snappers. The relatively high longevity and slow growth for these fishes suggest low natural mortality, low population turn-over and in turn, low production potential. These are all life history characteristics for a fish that is highly vulnerable to even low levels fo fishing. Williams et al. (2013) suggested that a fishing mortality of $F < 0.1$ is necessary to achieve stock persistence. In many other fast-growing fishes, $F = 0.5$ is a reference point for sustainable fishing.

CONSERVATION STRATEGY

1. We propose to support and conduct **basic research on the life history of these eteline snappers** in the Territory. Scientific research should include growth rates, longevity, population genetics, reproduction and spatial distribution. These information will be critical in conducting stock assessment and developing fisheries management policies for these fishes.

6 PROTECTION OF NATIVE HABITATS AS A STRATEGY FOR WILDLIFE CONSERVATION

6.1 TERRESTRIAL HABITATS

6.1.1 STATE OF KNOWLEDGE

The forested habitats of American Samoa have been and continue to be the focus of scientific study. The composition and structure of natural habitats, as well as the factors responsible for spatial patterns in these variables, has been extensively documented (Whistler 1980, Amerson et al. 1982b, Webb et al. 1999, Webb et al. 2005, 2006). Muller-Dombois & Fosberg (1998) identified forest dynamics in Samoa as little studied, but recent efforts have made important advancements to the understanding about the dynamics of wildlife habitat. In addition to Whistler's (1995) eight 0.1 ha plots in the NPAS Tutuila unit (now largely defunct owing to small size and inconsistent survey methodology, DMWR has installed four 1.0 ha Long-Term Monitoring Plots (LTMPs) to monitor forest dynamics on Tutuila (Webb & Fa'aumu 1999). In addition, NPAS in collaboration with DMWR installed four LTMPs on Ta'u, totaling 6 ha (Webb et al. 2006). And the US Forest Service Plots installed 30 plots (ASCC Land Grant *unpub data*). Studies on forest phenology, recruitment, and survivorship studies from these plots and elsewhere in American Samoa have been conducted (Trail 1994, Seamon et al. 2006, E. Webb *unpub data*). Recent research on forest recruitment demonstrates extremely high rates of annual seedling turnover, with mortality rates exceeding 20% (E. Webb, *unpub data*). LTMPs on Tutuila have documented the inter-cyclone habitat dynamics, demonstrating that even under periods of low cyclone activity the forest habitat of American Samoa have high rates of mortality and recruitment (Webb et al. 2014), indicating wide spatiotemporal variability in resource streams for wildlife. LTMPs on Ta'u provided opportunity to monitor habitat reorganization after Cyclone Olaf (Category 5), which struck the island in 2005. Monitoring post-cyclone habitat recovery is revealing the importance of species traits in survival and resilience of wildlife-relevant tree species (Webb et al. 2015), and is documenting ecosystem-level outcomes, with high relevance to wildlife as resource availability (species composition) changes over time (Webb et al. *unpub data*). Other potential contributors to habitat dynamics such as disease have also been well-documented (Grandison 1996, McKenzie 1996, Brooks 2000, Brooks 2002, Brooks 2004).

The spatial distributions of habitat classes were mapped in the mid-1980s by Cole et al. (1988). Aerial photos of subsets of the island are available at scattered times (ASG *unpub.photos*), while satellite images are available from 2001 (IKONOS, Space Imaging Systems) and 2004 (QuikBird). Such remote-sensing methods have been used elsewhere to map habitat modifications (e.g., Estreguil & Lambin 1996, Comber et al. 2003). In 2009, DMWR initiated an effort to map wildlife habitat on the islands of American Samoa. The impetus for this effort originated as a result of the findings of the 2005 CWCS for American Samoa which identified a deficiency in updated and detailed habitat maps for the islands (Utzurrum et al. 2006). Although the vegetation of American Samoa has been extensively mapped over the past 30 years (Whitesell et al. 1988, Donnegan et al. 2004, Liu et al. 2011) these products are either outdated or too generalized to meet the needs of local wildlife biologists. The goal was to produce detailed and accurate habitat maps using a habitat classification scheme specific to American Samoa that would provide a useful management tool for wildlife biologists (see section 4.3 Mapping of Wildlife Habitat in American Samoa).

6.1.2 THREATS

The main threats to wildlife habitat in American Samoa are categorized under the umbrella terms “deforestation” or “degradation”. Deforestation refers to the process of habitat conversion from forest (or other native habitat) to another land use; in American Samoa conversion is most frequently to agriculture or urbanization. Deforestation results in the immediate and short- to long-term loss of all resources to wildlife. Degradation refers to the loss of habitat quality, ecological linkages or structure that may have cascading effects on wildlife through alterations in resource availability. Specific actions creating these threats, which DMWR prioritizes, are: land clearing, invasive species, and habitat disturbances. Degradation is the second principle threat to wildlife habitat in American Samoa.

Land clearing: immediate and significant loss of resources for wildlife

Land clearing and conversion to unsuitable habitat types is a growing threat to native habitat as the human population,especially on Tutuila, continues to grow and traditional agricultural methods are utilized to supplement livelihoods. The native habitats of American Samoa have evolved in a disturbance-prone ecosystem, and are well-adapted to withstand and recover from hurricanes (Shanahan et al. 2001, Webb et al. 2015); these characteristics have in the past buffered the wildlife and habitats of the territory from many of the changes wrought by humans. However, land clearing for agricultural expansion exceeds the short-term resilience of habitat, although recovery can occur if agriculture is abandoned and left fallow, albeit regeneration that is severely impacted by invasive species (see below). Unfortunately, there is likely to be a point at which the extent of clearing exceeds the rate of regeneration, potentially causing a cascade of other ecological effects such as depletion.

Clearing habitat for agriculture and urbanization is an essential component of development in American Samoa, however it is essential that decisions to clear land are informed by adequate land use planning and habitat management legislation (Department of Commerce 2003; McCarthy 2005). ASG has a Project Notification and Review System (PNRS), a multi- agency system of approval for which all development projects must pass. In theory such a system could suffice, but as currently implemented it has a number of significant weaknesses.

1) PNRS applies only to actual development, not clearing of habitats for agriculture. This has prompted the practice of clearing land for putative 'agricultural' purposes, but then shortly thereafter submitting a proposal to PNRS for development of the now-cleared land. This skirts the PNRS requirements of mitigation for clearing of forested areas.

2) The strength of a system such as PNRS could be that it is a collective decision-making body. However, as currently implemented, enforcement and decisions on approval are placed solely on individual member agencies. This greatly exacerbates the problem of political, cultural or other pressure being brought to bear on single agencies.

3) There is not a clear habitat management plan and attendant authority for the territory. DMWR has legal authority to manage habitats in the context of wildlife management, but there are numerous gaps and vagaries in the attendant legislation (McCarthy 2005), making enforcement of difficult cases particularly problematic.

4) There is unequal implementation of the PNRS system. In particular, ASG agencies themselves frequently skip PNRS review of their own projects. Besides the ecological damage directly caused by these projects, there is an attendant backlash in the public, who question the government's commitment to the principles purportedly promoted by PNRS.

5) The zoning process, as implemented in practice by the zoning board, has no significant environmental or ecological requirement in its decisions.

Weaknesses in the PNRS system leave native habitat potentially vulnerable to clearing, whether or not the land is eventually converted to an active land use.

Invasive species: modifying and degrading critical wildlife habitat

There are a host of invasive species already well established, and expanding, in the territory. The PIER (Pacific Island Ecosystems at Risk project) lists approximately 285 invasive species in the territory, among all life forms (trees, shrubs, herbs, vines, grasses, ferns). Some of the most common and aggressive invasive species include *Abizzia falcataria*, *Adenanthera pavonina*, *Cinnamomum verum*, *Clidemia hirta*, *Leucaena leucocephala*, *Merremia peltata*, and *Mikania micrantha*. These species significantly alter wildlife habitat by arresting regeneration (Elmqvist et al. 1994) and outcompeting native trees for space. Arrested succession by vines significantly reduces the quality of resources available to wildlife, as the regeneration of plants that feed wildlife is reduced or prevented. The establishment and expansion of invasive tree species into native forest reduces the availability of fruit resources available to frugivores.

Habitat disturbances: enhancing the negative consequences of invasive species

While invasive species may under some circumstances establish in intact, mature habitat, disturbances are required for invasion of many species. Land clearing, as described above, reduces competition and will create greater opportunities for non-native species to invade. Cyclones, by removing canopy and killing mature trees, creates similar, but less extensive, conditions. Small-scale disturbances by people, such as the creation of small parcels of agricultural land, result in similar patterns of invasion. Therefore, the degradation of wildlife habitat, as well as its management and conservation, must be viewed in terms of not only invasive species, but also in terms of habitat characteristics and disturbance regimes.

6.1.3 CONSERVATION PRIORITIES

Our habitat protection priorities are to: 1) *obtain frequent, detailed, and accurate maps or images of land use patterns* in the territory, 2) use these data to *identify priority sites for conservation or land-use modifications*, 3) *implement measures and activities to improve habitat quality, expand the extent of native habitats, reduce the threat of invasive species, and protect endangered or critical habitats*, 4) *establish appropriate legal authority* to institute and implement regulatory and statutory guidelines *for habitat conservation* (see Section 9), and 5) establish wildlife reserves through land acquisition or long term conservation leasing of critical or rare wildlife habitats.

DMWR has made significant strides in several of these priorities. A very high resolution habitat map of the territory has been produced. This map serves as a foundation for subsequent mapping efforts to evaluate changes to wildlife habitat extent, and for higher-order investigations and actions to enhance and protect critical wildlife habitat.

Efforts to encourage the use of native species in urban and residential landscapes also have significant promise, and preliminary studies of propagation have been conducted for some tree species (Hanson et al. 2005). Under DMWR's Wildlife Restoration Program (FY2006-2010) the development and publication of the territory's first guide to native ornamental trees has been published, entitled "A guide to the native ornamental trees of American Samoa". This handbook has been translated into Samoan and has been published with the title "Tusi Ta'iala mo La'au Teuteu Fanua o Amerika Samoa".

Efforts to control identified invasive species has been undertaken with the American Samoa Invasive Species Team (ASIST), a cooperative working group among local and federal governmental agencies. In the context of the high resolution habitat map recently finalized, DMWR can now work to evaluate how invasive species interact with habitat type in order to inform its intervention strategies, making them more streamlined and efficient.

A critically important prerequisite for the implementation of habitat management and regulation of habitat alteration is the legal mandate to do so. To this end, our highest priority is to pass legislation that would formalize the idea of habitat preservation and management in the territory. Additionally, the creation of wildlife reserves through land acquisition or long-term conservation leases has been explored in order to protect critical wildlife habitat. DMWR is currently working with the land owners of the Naumati Forest and Olovalu Crater for long term protection of these critica wildlife habitat resources. We feel that with proper implementation of these plans, the wildlife resources of the territory could be managed in such a way as to promote both economic growth and development, as well as provide adequate protection for native plants and wildlife.

6.2 MARINE HABITATS

6.2.1 STATE OF KNOWLEDGE

The focus of our habitat conservation priorities is on the shallow-water coral reef ecosystems and the mesophotic coral ecosystem. We recognize the importance of these habitats for the various species of greatest concern. We have included the mangrove ecosystem since there are numerous studies that show the its linkage with the coral reef ecosystem. Several snapper species, for instance, have been known to use mangroves as nursery habitats with an ontogenetic shift to coral ecosystems as adults. There are already several studies and on-going programs on coral reef ecosystems that include satellite image analyses of their distribution and surveys on their status. On the other hand, the study of the mesophotic coral ecosystems in the Territory is still very limited but NOAA has previously conducted a survey of these deep-water reefs using remotely-operated video cameras.

6.2.2 THREATS

We have previously identified the main threats to coral reefs and various marine species in the Territory:

(1) Coral mortality and reef loss due to sedimentation, severe storms, predation and global climate change. Habitat degradation brought about by anthropogenic inputs into the coral reef system are of particular concern due to increases in land-based sources of pollution

and added nutrients to the coral reef system from the proliferation of piggeries, increased sediment and nutrient loading, especially in reef areas near highly populated villages.

(2) The predation by the crown-of-thorn starfish has historically and currently caused damage to reefs in the Territory. The extent of coral disease and coralline-algal diseases is relatively recent but this has given us a general picture of their impacts. The NOAA CRED surveys have shown that diseases were observed in 25 scleractinian coral genera. The most abundant genera and families seem to be disproportionately susceptible to disease: Acropopridae, Faviidae and Poritidae. These families accounted for 75% of all cases detected and all the disease categories. Five coralline-algal diseases were recorded around American Samoa. Ofu & Olosega and Swains had elevated site-specific occurrences. However, estimates of occurrence of coralline-algal diseases still remains low compared to other areas in the Pacific (Vargas-Angel 2010) and with no active outbreaks known.

(3) There is an increasing concern on the general predicted impacts of global climate change on the coral reefs in the Territory. It is highly predicted that sea-surface temperature will rise, the intensity and frequency of days with extreme heat and extreme rainfall will increase. The already increasing sea levels will definitely impact growth rates of coral reefs. The predicted changes in the frequency and strength of El Nino Southern Oscillation will impact coral reefs with predicted drastic lowering of tidal cycles and increased frequency of bleaching events. There are no data available to predict the impact of these threats to the mesophotic coral ecosystems.

6.2.3 CONSERVATION PRIORITIES

There are already several initiatives that protect the coral reef habitats in the Territory in the form of managed areas. Marine protected area programs include the Department of Commerce Special Management Areas (Leone Pala, Nuuuli Pala and the Pago Pago Harbor); Department of Marine and Wildlife Resources Community-Based Fisheries Management Program and No-Take Program; the National Marine Sanctuaries; the National Parks; and the National Wildlife Refuge and Marine National Monuments. A special mention is the ridge-to-reef initiative in the Fagaalu village that is being implemented by the NOAA Coral Reef Conservation Program. *Our conservation priority is* ***to support these marine protected area programs, and ecosystem-based and ridge-to-reef management approaches*** in recognition to the integrity of the reef and the terrestrial to marine linkages. This conservation approach is highly appropriate in addressing the listing of several corals under the Endangered Species Act.

Given the current threats to coral reef reefs, *our conservation priority is* ***to develop a program that responds to coral reef disaster or predation outbreaks***. This would include a program on coral threat/predator eradication/removal to address the crown-of-thorns starfish outbreaks. Coral and coralline-algal disease, although still low, is part of this disaster response program.

It is important to identify coral reef ecosystems resilient to current and predicted threats. *Our conservation priority is* ***to conduct and support various climate change vulnerability assessments to identify resilient and vulnerable areas***. This would identify priority areas of conservation and management.

Given the chronic threats to coral reef ecosystems, *our conservation priority is* ***to develop an active restoration program to enhance the recovery of these ecosystems***. This restoration program will cover developing coral nurseries for collected coral fragments and recruits developed from collected coral gametes.

7 WILDLIFE IN THE CULTURE: ANCHORING CONSERVATION TO TRADITION AS A STRATEGY

The successful implementation of this conservation strategy will depend largely upon the support it receives from the local community, a community in which all aspects of life are influenced by Samoan culture (*fa'asamoa*). Incorporation of Samoan culture, with emphasis on wildlife's role in the culture, into the conservation strategy can therefore help elicit support through the fostering of a local, culture-based conservation ethic. Although not exhaustive, this synopsis covers published accounts of wildlife in ancient Samoan culture and can be used as a source in the development of programs designed to foster a conservation ethic in American Samoa. The marine and terrestrial world are featured in all of the following aspects of ancient Samoan culture: cultural practices, oral tradition, artistic designs, cultural items, hunting and fishing, and religion.

The ocean is integral to the Samoan culture and cultural practices. Fish were traditionally eaten every day in the Samoan household although some species of fish were not eaten due to being poisonous or unpalatable or because they were deified (Watters 1958, Krämer 1995). As a result, fishing activities stood in high esteem in traditional Samoan culture, fishing skill brought high social status, and fishing activities figured importantly in mythology. Since social reciprocity is a distinct cultural practice, fish and other fishery resources (e.g. *palolo* worm or *Palolo viridis*) were and still are part of customary exchanges.

Since fish and fishing is part of everyday life, Samoans have intimate knowledge of the ocean so that related words are parts of phrases. For example, the phrase '*Ua a'e le tai lo or taivale*', translates as a poor season when fish are scarce (Milner 1966). *Vaipalolo* was the period of the wet season, beginning with the rise of the *palolo* in October or November. During the *palolo* season when the epitoke of *Palolo viridis* are released as swarms in the ocean at night, special festivities are organized the night before the harvest. When the signs of the *palolo* swarm are apparent, food and *ava* (drink extract from the local plant) are prepared by the village *taupou* (virgin). Food is accumulated and feasting and amusements occurred before the harvest of *palolo* swarm on the final night of the harvest. Palolo has been culturally considered as a visitor so that Samoans traditionally wore *mosoi* (a local tree) flowers to welcome this visitor during its swarms. Like the *palolo*, *atule* (the fish *Selar crumenopthalmus*) harvest is associated with ceremonies, division of labor and legends. Samoans used 'sacred' stones as lures for *atule* and these undergo ritual washing.

Supernatural influences, deities and taboos (*tapu*) were important in pre-historic Samoan political and social systems. Turner (1989) provides many examples of fish and sea creatures that were considered sacred in various districts and villages and well as sanctions associated with violating taboos. For example, the month of May was sacred to the deity incarnate in *fe'e* or octopus. During this period which can be three months in other districts, no traveller was allowed to pass through the village by public road nor was any canoe allowed in the lagoon off that part of the settlement. Violators could be beaten, if not killed, for insulting the god.

In Samoan legends, Sina was known to have brought the red-lipped mullet from Fiji and that the family of Toaloa in Puapua Savai'i has the right to rule over the fishing arrangements for her mullet (Hiroa 1930). Pre-historic Samoan culture had numerous deities both terrestrial and marine animals. The deities from the sea included: (1) Faamalu (Shade) and Taapai, separate deities represented by a trumpet shell or a fish; (2) Fuai Lagi (Beginner of Heavens) represented by the eel Maraena; (3) Nonia as incarnated in a cockle; (4) Limulimuta incarnate in the seaweed; (5) Tuialii (King of Chiefs) variously incarnated as mullet, eel and octopus.

In pre-historic Samoan culture, a species of shark called naiufi was regarded as the king of sharks and treated with ceremonial respect. It was considered a great honor to kill a naiufi. As the canoe came in with a naiufi, the shell trumpet was sounded and the canoe paraded before the village. The owner met his canoe at the landing with a fine mat and touched the head of the shark with it. The mat was given to the *tautai* (the village head fisherman) and the shark was given to the canoe owner and the village chiefs, where it was ceremonially divided among them. The shark, like the bonito, was cut into ceremonial divisions, with certain parts to certain people. The stomach and intestines of the shark were regarded as the best parts of the fish and were distributed to the talking chief and the head fisherman (Hiroa 1930).

Bonito fishing was regarded as the most elegant sport in Samoan culture and was practiced with various ceremonies from canoe-building associated with mats, food and gifts. Canoes were often decorated with ovula (*Ovula ovum*) shells and associated with social status and distinction. Bonito fishing was so special that there were many taboos, or restrictions, associated with it. Bonito was considered a fish for chiefs, and even the supreme god, Tagaloa, wanted a bonito. There are many other special terms and phrases related to bonito. For example, the first bonito in a new canoe is called *o le i'a a Tagaloa* (Tagaloa's fish) (Krämer 1995). In Manu'a, the families of the crews and boat owners were forbidden to do any work while the fleet was out fishing for bonitoes. They were expected to remain idle and pray to Tuiatua, patron saint of fishing (Holmes 1974). In distributing the cut bonito, the loin of its back including the head is especially given to the chief. The bonito hook was very important in fishing so that it was made by a specialist and it was important to tie the hook correctly. Samoan fish-hooks, in general, were thought to have divine origins because the shell that was used was said to have been brought down from heaven (Krämer 1995).

Oral tradition in the form of legends and proverbs was the means by which Samoa's history and culture was preserved and passed through generations prior to the arrival of Europeans (Lotu-Drabble 2000). A few of the most well-known **legends** that feature wild animals as key characters are "The Origin of the Earth and People" in which Tuli (golden plover) is the assistant of the supreme god, Tagaloaalagi (Steubel et al. 1976), "The Birds Conference" (Muse & Muse 1982), "The Title (ao) Tonumaipe'a" featuring fruit bats as a woman's rescuers (Kramer 1902-1903), "The Story of the Sega" (Kramer 1902-1903), and "The Wailing Turtle" (Anonymous 2001).

Proverbs, many of which were taken from legends, comprise a second component of Samoan oral tradition. In the book, Proverbs of Samoa compiled by N.M.M. Saipele (2002), approximately 25% of the listed proverbs deal with wild animals in some way. A large percentage of these center around the ancient sport of lupe (pigeon) hunting. Some of the other wild animals featured in this book are *manutagi* (purple-capped fruit dove), *toloa* (wild duck), *fuia* (Samoan starling), *pe'a* (fruit bat), and *sega* (blue-crowned lorikeet). Examples of some of the many proverbs relevant to conservation are "*E le togia Fuia aua o Moso*," which means do not throw stones at the *fuia* because it is actually the feared god, Moso (Saipele, No Date) and "*Ua maua ula futifuti*," which refers to the shredding of rare lorikeet feathers and means "to be careless and wasteful" (Schultz 1980).

There are countless Samoan proverbs associated with fishing showing indeed how the sea is intimate with everyday life. Selected proverbs and their meanings are:

Va lelei. To keep up friendly relations with one's neighbour.

Upu fa'amaulalo: Obedience.

O le va'a si'I vale la'u lauga nei. My speech is like a canoe launched without a sufficient reason.

Faiva o Fiti ia lililo. Let the Fijian method of fishing remain a secret.

Ia o gatasi le futia ma le umele. The sinnet ring and the stand for the fishing rod must be equally strong.

To'ai fa'a ia a po. To come like a fish in the night.

Talanoa atu, ‘ae le talanoa manu. The bonitos swim about thoughtlessly, but the seagulls are on the alert.

Tau ina uia o le ala o le atu. Let it go the way of the bonito.

Ia moe le ufu, to’a le paipai. An admonition to live in peace and harmony.

Avatu ni lo, aumai ni lo. Tit for tat.

O le vaivai o le fe’e. Despite its soft body, the octopus is a powerful ‘fish’.

Upu alofa, fa’aulaula or fa’anoanoa. The chiefs and orators make the decisions, but the common people (tagatalautele) must carry them into effect and suffer all the consequent hurt and damage, e.g., after a declaration of war.

Song can be considered a third component of Samoan oral tradition because it is the mode by which many legends are preserved (Lutu-Drabble 2000). One of the best anthologies of old Samoan songs can be found in the book entitled “Tusi PeseFatuga Tuai a Samoa - A Songbook of Popular Old Songs, Photographs, and Proverbs of Samoa” by T.C. Lutu-Drabble. By just scanning the table of contents, one can find 15 song titles with references to animals such as the *laumei* (turtle), *lupe*, *manu* (bird), and *isumu* (rat). These songs express everything from naturalistic observations of honeyeaters sipping flowers to frustration with and aversion towards rats. Although most of American Samoa's wildlife species are mentioned at some point in legends, proverbs, and songs, only a limited number of them appeared as designs in art or provided raw materials for cultural items.

Artistic designs can be found on *siapo* (bark cloth) and in the *tatau* (tattoo). Apparently, two of the prominent designs used in decorating siapo represented the *pe'a* (fruit bat) and the *pe'ape'a* (sheath-tailed bat) (Kramer 1902-1903). The men's *tatau*, also known as a "*pe'a*," gets its name from the shape it forms on the lower back. Perhaps the more significant connection of a wild animal to the *tatau* is the fact that part of the comb used in tattooing was made of tortoiseshell (Mallon 2002).

*Other cultural items that were made with wild animal parts are whale-tooth necklaces, tu'iga (*headdresses), and *'ietoga* (fine mats). Because Samoans did not hunt whales, they procured their whale teeth from beached whales (Kramer 1902-1903). *Tu'iga* and *'ietoga* were both decorated with red feathers plucked from the *sega* (Kramer 1902-1903). Although family heirlooms may retain their original *sega* feathers, dyed chicken feathers are used in making these articles today (Sowell 2000). In contrast to raising live *sega* for their feathers, ancient Samoans captured *lupe* for sport.

The **lupe hunt** was not only a form of recreation, but also "served as an arena for chiefly competition for prestige, status, and power" (Mallon 2002). Apparently, in ancient times the *lupe* was not eaten "for it was considered sacred," although it had become a popular food by the late 19th century (Kramer 1902-1903). Kramer also wrote that the sport (as practiced in ancient times) had been abandoned due mostly to the introduction of guns which "decimated" pigeon populations.

Other birds "hunted" (not necessarily eaten) in addition to lupe were *manutagi*, *manuali'i* (swamp hen), *ve'a* (banded rail), *tava'e* (tropicbird), *gogo* (noddy), and some other seabirds (Saipele 2002). The *manuali'i* (also called *manusa*, meaning sacred bird), was "a chief's bird" which was caught and tamed (Kramer 1902-1903). In addition to birds, bats were apparently eaten, but more as a delicacy than a daily food source (Sinavaiana & Enright 1992). Another animal eaten more often than bats was the sea turtle, also known as the *i'a sa* (sacred fish). This marine reptile was captured with coconut fiber nets, prepared for consumption according to strict rules, and served to the highest-ranking villagers, with the head going to the high chiefs (Kramer 1902-1903).

As noted above, there were several sacred wild animals in ancient Samoan culture. In many instances, this sacred status was due to the association of an animal with one of the many gods of the ancient religion (Mallon 2002). In addition to the *laumei* and *manuali'i*, other "holy animals of godly origin" were *tuli*, *sega fiti* (Fijian lorikeet), *sega*, *pe'a, fuia, ma'oma'o* (a bird), *pili* (lizard), and *lulu* (owl) (Mallon 2002). The *lulu*, specifically, was "often seen as an incarnation of a god consequently, a dead owl was usually buried quite ceremoniously" (Kramer 1902-1903).

By comparing the literature on ancient Samoa to American Samoa as it is today, one can see that most aspects of the culture have endured in spite of heavy outside influences. It is this fact that makes a culture-based conservation feasible and more appropriate for the territory. Whereas some conservation-related aspects of the ancient culture seem to have disappeared (e.g., deification of birds), other practices have been adapted in favor of conservation (e.g., substituting chicken feathers for sega feathers in *'ietoga*), and still others have simply been forgotten (e.g., the idea that *lupe* were not originally hunted for food).

The Dept. of Marine and Wildlife Resources, in collaboration with local agencies such as the "Ofisa o le Failautusi Aoao" (language preservation office), is in a position to help communities in American Samoa remember that wildlife has always been an integral part of the culture and that the preservation of wildlife is, in fact, integral to the preservation of the *fa'asamoa* for generations to come.

8 STATUTORY AND REGULATORY ASPECTS OF CONSERVATION

The need for enabling statutory and regulatory provisions that provide the legal basis for effecting conservation, particularly with respect to habitat management, has long been recognized by staff of DMWR, the PNRS, and the Department of Legal Affairs (Attorney General's Office). This section is an updated review by internal staff to that previously conducted by McCarthy (2005) on existing provisions with the view of developing approaches that could address this particular gap. The review of the Territory's statutory and regulatory aspects of conservation was further threshed out during recent consultations with the Fono (Legislature).

8.1 EXECUTIVE SUMMARY

The Department of Marine and Wildlife Resources ("DMWR") has often expressed a need for improved management and protection of terrestrial and marine wildlife in American Samoa. Threats to conservation previously identified in the last CWCS were rapidly increasing population, limited land area, encroachment by development, and international travel and trade. As the Territorial agency responsible for managing and perpetuating wildlife resources, DMWR has identified seven areas of immediate concern:1) protection and preservation of terrestrial and marine wildlife habitat; 2) management of endangered and/or threatened species; 3) habitat degradation due to invasive or injurious species, pollution and development; 4) the world-wide problem of species "bioprospecting"; (5) size and catch limits for fish and shellfish not currently covered by existing prohibitions; (6) the perennial problem of effective enforcement; and finally (7) potential impacts of global climate change. There are similarities and shades of differences of the issues on marine and terrestrial conservation. The latest revision of the CWCS is an opportunity to re-asses the effectiveness of the existing legal and regulatory frameworks and recommend strategies and directions for improvement in American Samoa. A review of the fisheries regulations is also an opportunity to compare and contrast the issues being faced by the terrestrial and marine wildlife.

First, the legal and regulatory regimes for protection and management of wildlife habitat in American Samoa are still inadequate in addressing some issues. The previous review rightfully stated that statutory authority for the DMWR, A.S.C.A. Title 24, Chapter 03, speaks directly to the management and conservation of marine and wildlife resources. However, it was not explicit in recognizing that habitats are also critical on the preservation and protection of wildlife. There was already a previous consensus among regulators and legislators to expand the authority of the DMWR under existing law to manage and protect wildlife habitat independently of the land use permit review system. There has not been much progress for the terrestrial habitat protection on this issue most probably due to the unique land ownership issues in the Territory. Most of the land is still communal. A habitat approach to conservation has only taken traction in the management of marine life in the forms of community-based marine protected areas and the declaration of special management areas in Leone and Nuuuli Pala. The first form is a co-management between the department and several villages while the second is a form of unilateral declaration by the local government. There is no analogous form in the terrestrial wildlife conservation and management. The co-management framework for managing forests and its wildlife is a form the department may pursue since this has showed success for the marine conservation and several models already exist in other areas in the world. The lease arrangement undertaken by the National Park System in American Samoa with various families is also another successful model, and DMWR is currently exploring options for leasing or purchasing vital wildlife habitat, including the Ottoville Lowland Rainforest and Olovalu Crater on Tutuila.

In September 2016, the first terrestrial endangered species in American Samoa were listed by the USFWS. The territorial Endangered Species Act (ESA), A.S.C.A. Title 24, chapter 07, provides for appointment of a Commission with authority to nominate endangered or threatened species but the provision provides no role for DMWR in the listing process, and no authority by which to manage and conserve habitat once a species is listed. Therefore, the Territroial ESA has been determined by the USFWS as inadequate to allow the Terririory to manage and conserve ESA listed species. There is an ongoing effort to draft a new ESA that adequately protects both species and habitat within 2017.

Third, invasive or injurious species of animals and plants are not addressed in existing statutes or rules, except to the extent a plant may be designated as a "noxious weed" harmful to agricultural crops or where animals are banned as "exotic" or "miscellaneous pets" by the territorial Department of Agriculture (DOA). Accordingly, suggested statute revisions are provided to enable the creation of an injurious species regulatory program within DMWR. Existing DOA authorities are also expanded to give DMWR a role in the quarantine, eradication or confiscations of injurious species of plants or animals. Although invasive species is a particularly relevant issue for the terrestrial wildlife, provisions needs to be incorporated to address potential marine invasive species.

Fourth, American Samoa currently lacks any system for controlling, monitoring or protecting the public inventory of biological resources from the "bioprospecting" or mining of commercially valuable species of plants and animals. A new statutory provision has therefore needs to be created to address bioprospecting, to control the activities of species hunters, and to guarantee that a portion of any profits derived from bioprospecting are reserved to the communities from whose land species were harvested.

Fifth, there is no provision on fish size and limited implementation of catch limits. There needs to be a formal assessment whether there is growth overfishing for various fish stocks. Scientific frameworks already exist for this type of assessment. Size limits established by the Secretariat of the Pacific Community have already been adapted by various countries in the region. There is a need to re-assess this framework and its applicability to the Territory's fisheries. The department needs to collaborate with the appropriate federal agencies on the implementation of catch limits in the Territory's fisheries. The re-authorized Magnuson-Stevens Act has provided a legal basis for the establishment of catch limits. Based on this authority, the Western Pacific Regional Fishery Management Council is developing a scientific framework to establish catch limits. Catch limits are annually established but the implementation is non-existent.

Finally, there is a need to conduct a vulnerability assessment of the Territory to global climate change and perhaps to draft appropriate legislations. There is a working framework for climate change for the Territory under the Coral Reef Advisory Group but related liegislations have not been enacted. As an archipelagic territory, American Samoa is particularly vunerable to changes in climate and its impacts to its wildlife and exploitable resources. A vulnerability assessment of wildlife and habitats will also help identify resilient areas and prioritize these areas for protection. There is a need to incorporate the importance of the impact of global climate change in the Territory's statutes and regulations that pertain to marine and terrestrial wildlife.

This report suggests modifications to existing statutes and regulations to improve enforcement, including providing DMWR with express administrative enforcement authority and the power to issue district court citations to enforce envisioned wildlife habitat protection requirements. As a whole, the recommended statutory changes provide a blueprint for improved protection of American Samoa's wildlife resources and the habitats upon which they depend.

8.2 ANALYSIS OF EXISTING REGULATORY REGIMES

The following discussion provides a brief analysis of existing statutes and regulations and identifies gaps or deficiencies in regulatory protections. Part III provides suggestions for filling the gaps and providing improved protections for wildlife and wildlife habitat.

8.2.1 PROTECTION FOR WILDLIFE HABITATS

The legal authorities for providing protection of diminishing wildlife habitats in American Samoa are twofold. First, there is the DMWR enabling statute set forth under Title 24, Chapter 03, of the ASCA. While this statute does not directly reference wildlife habitat protection or conservation, the DMWR is empowered to adopt regulations and to prepare and develop comprehensive plans for the management and protection of wildlife resources (ASCA 24.0304(2)). Arguably, a critical component for perpetuating wildlife is protection of wildlife habitat, but DMWR has never tested the limits of its authority by promulgating habitat protection regulations. Instead, DMWR has adopted Hunting Regulations[4] that control the taking of various wildlife species, including fruit bats and native birds.

A separate statute, ASCA 24.2305, provides the DMWR with authority to designate for conservation bat roosts and "areas of importance" to viable bat populations. Habitat protection for these species is therefore impliedly, but such protections require study, delineation, and the adoption of plans and maps via the rulemaking process. As of this time, no rules have been adopted relating to the preservation or protection of specific bat habitats.

Another source for regulatory authority relating to habitat conservation is the territorial Coastal Management Act.[5] This law establishes a land use permit (LUP)system for nearly all developments taking place in the territory, and further allows for the designation of Special Management Areas (SMA) through a delineation and nomination process to be approved by the Governor. However, it is important to note that a finalized SMA designation could take years for each area of concern, might be ultimately rejected by the sitting governor, and once designated would not necessarily preclude all development within its borders. Thus, the SMA process is both an uncertain and inadequate means for protecting areas deemed important to ensure the viability of wildlife. Finally, the SMA process has no clear definition of governance of these SMAs and its implementation.

The regulations adopted under the Coastal Management Act statute (ASCMA) attempt to circumvent this limitation, by providing that critical habitat(s) will be protected and preserved where they are "essential to productivity of plant or animal species" or are listed as threatened or endangered under territorial (or federal) laws.[6] (A.S.A.C. § 26.0220.I.2). This is potent language, but the standard of proof for "critical habitat" may not always be possibly met, particularly on smaller properties or on properties which have already been significantly degraded. Further, some common activities in the territory such as land clearing for agriculture or traditional Samoan uses do not require a LUP. These activities will not, therefore, receive scrutiny under the coastal management rules relating to critical habitat. Still other common uses, such as construction of single family residences, require only "minor" permit program review. The minor LUP review process involves an

[4] Hunting Regulations are set forth at Title 24, Chapter 08 of the American Samoa Administrative Code (ASAC).
[5] ASCA §§ 24.0501 et seq. and regulations at ASAC 26.0201 et seq.
[6] This provision (ASAC 26.0220.I.2) itself may also be inadequately authorized by the ASCMA because it effectively replaces the Special Management Area (SMA) public notice, participation and approval provisions with case by case decision-making. It also lacks any connection to the presence of endangered or threatened species and their critical habitat.

abbreviated in-house analysis and approval by the Department of Commerce, normally without referral to the PNRS Board or to the DMWR for consideration of wildlife conservation concerns. Accordingly, issuance of minor permits can result in significant loss of wildlife habitat, as permits will in most cases be approved without the involvement of the DMWR.

In conclusion, general authority exists under current territorial laws to protect individual species as well as wildlife habitats including "critical habitat." However, these authorities have either not been fully exercised, or existing authorities contain gaps through which many development activities can slip without meaningful review to the degradation of wildlife resources and their habitats.

8.2.2 ENDANGERED SPECIES AND CRITICAL HABITAT

The designation of species as endangered or threatened can also provide an effective means to protect critical habitat for species as well as habitat for other wildlife. Under federal as well as state laws, a listing of a species as threatened or endangered triggers protection for not only that species but also the geographic areas deemed to be "critical habitat" necessary for the survival and propagation of that species. Unfortunately, the existing territorial Endangered Species Act (ESA), A.S.C.A.24.0701 et seq., fails to provide authority to designate critical habitat for any species listed as endangered or threatened pursuant to the Act. Nor has the Endangered Species Commission taken steps to make any territorial listings or designations. Therefore, a new Territorial ESA is currently being drafted by DMWR with assistance of the Attorney General's Office and the USFWS.

8.2.3 INJURIOUS OR INVASIVE SPECIES AND "BIOPROSPECTING"

The world-wide phenomenon of invasive or introduced non-native species and the damage they cause to island wildlife and their habitats are well documented. Yet territorial legal authorities to deal with this problem remain underdeveloped or unutilized. Currently, the DMWR has authority under section 24.0304(2) of its enabling statute to adopt regulations addressing this problem. Because this authority has not been tested or utilized through regulations, the DMWR has striven to improve relations with the quarantine branch of the Department of Agriculture (DOA). The quarantine branch is tasked with inspecting and prohibiting entry to the territory of "noxious weeds" and undesirable domestic pets and other animals. Even if this cooperative approach were effective, the DOA derives its quarantine authority from a pair of statutes which do not go far enough to protect the territory's wildlife from non-native species.

Under ASCA Title 24, chapter 08, the DOA has the authority to ban, confiscate and destroy species of plants harmful to the agricultural economy. Over time, this authority was expanded by executive regulation so that the governor can ban the use or importation of any plant (See ASCA § 24.0801). A permit from the director of the DOA is likewise required before plants may be imported to American Samoa (See ASAC § 24.0328). These regulations[7], however, are promulgated without consultation with the DMWR, and their focus is tuned to agricultural pests. Therefore, some plant imports may be unwittingly permitted by the DOA which could prove harmful to native flora, fauna and the delicate ecology of American Samoa.

Similarly, under ASCA Title 24, chapter 06, the director of DOA has the authority to promulgate agriculture quarantine restrictions concerning animals. Using this authority, the DOA has restricted the importation of insects, farm animals, and "domestic pets," including exotic animals, to entry by permit only (See ASAC § 24.0305 et seq.). Yet these restrictions do not expressly extend to all non-domesticated animals, nor does the DMWR have any consultative role in restricting entry of animals (or plants) harmful to wildlife or native flora. Accordingly, existing statutes and regulations leave a great deal of discretion to the DOA, which may have neither the motivation nor the expertise to block the entry of animals harmful to native wildlife and the territory's ecology.

Perhaps not surprisingly, the statutes in American Samoa are also silent regarding the growing world-wide practice of bioprospecting. Persons engaged in bioprospecting seek animals and plants whose chemical or biological properties may have commercial value for consumer products or pharmaceuticals. The territorial "fishing regulations" require a scientific collection permit (ASAC 24.0938), but these rules apply to aquatic collections, and collectors are not required to reserve a portion of any profit derived from their discoveries to the territorial government. Suggested approaches to cope with bioprospecting are addressed in Part IV of McCarthy (2005).

8.2.4 ENFORCEMENT

Enforcement of DMWR statutes and regulations is authorized under the provisions of ASCA 24.0312. This section allows the department to confiscate unlawful catches of marine and wildlife resources, including any equipment used in unlawful catches or takes, and to prosecute violators through the issuance of fine-citations in district court. The hunting and fishing regulations include a fine schedule setting forth the amounts violators will be penalized for violations of each regulatory provision.

[7] The DOA regulations are located under Title 24, chapter 03, A.S. Administrative Code (ASAC).

There are, however no DMWR penalties or prohibitions concerning wildlife habitat, except insofar as bat roosts are protected from disturbance under the hunting regulations. In addition, the DMWR director has the authority to issue administrative orders (See ASCA 24.0304(8)). Arguably, this authority has also been under-utilized as no administrative procedure governs the issuance of agency orders. Even if there were, no penalty is included for failure to obey an order relating to the unlawful taking of marine or wildlife resources or destruction of their habitat.

Conversely, the "critical habitat" conservation regulations under the Coastal Management Program are enforceable by administrative Stop Orders, injunctive relief, and civil penalties from the High Court. These habitat protection provisions, however, are not currently enforceable by district court fine-citation.[8] Thus, under the coastal management program, wildlife habitat can only beprotected to the extent it qualifies as "critical habitat," and only to the extent that the activity taking place on the property is covered by the land use permit process or discovered by enforcement agents.

For plants and animals currently designated as "noxious weeds" or domestic animals, all statutes and regulations of the DOA are enforced by DOA officers and agents. Violations of these provisions are subject to penalties ranging from confiscation of contraband plants and animals to misdemeanor criminal prosecution in the district court. Arguably, any DMWR regulations relating to injurious species--if adopted to complement existing DOA restrictions-- could be enforced by district court fine-citation in accordance with 24.0312 ASCA.

Finally, there are no prohibitions of any kind included in the territorial ESA and no species are listed under it; hence, there are no violations or penalty provisions for terrestrial species of wildlife or ther habitats under the ESA.

8.3 RECOMMENDED STATUTORY CHANGES AND REGULATIONS

From the foregoing it is evident that the statutes and regulations governing wildlife and their habitats are insufficiently protective to ensure the viability of the territory's wildlife resources. Accordingly, this Part discusses possible approaches to improve the coverage of statutes and regulations for each of the major concerns set forth in Part I (of McCarthy 2005).

---

[8] Though the coastal management program regulations (ASAC Title 26, chapter 02) contain rules allowing enforcement by fine-citation in the district court, this enforcement method is not authorized by the territorial Coastal Management Act and is therefore not in use due to the prevailing opinion from the Attorney General's Office that the district court lacks jurisdiction to hear controversies relating to land unless that authority is expressly provided by statute, not by administrative regulation.

8.3.1 IMPROVING PROTECTIONS FOR WILDLIFE AND WILDLIFE HABITAT

The workshops previously conducted by DMWR with legislators and Fono leaders revealed significant support for amendments to existing territorial conservation statutes. In those consultations, legislators and policy makers were not inclined to craft new laws to address the problem of managing and protecting wildlife habitat. Therefore, the following amendments were suggested for the DMWR enabling statute under Title 24, Chapter 03. So far, the suggested amendments have not been implemented.

First, this statute should be amended to make clear that DMWR has the authority to manage and conserve not only wildlife resources but also the habitat upon which wildlife species depend. Once the general authorization is in place, two or more statutory provisions can be added to "enable" wildlife habitat management regulations. These sections are necessary to ensure that sufficient guidance is provided by the legislature to the agency in order to withstand a legal challenge that the agency's rules are in fact impermissible agency "legislation" rather than *execution* of legislative mandates. Accordingly, the first provision could indicate that the agency may manage and regulate wildlife habitat by means of a habitat removal permit program. It is suggested that the statute restrict habitats to be regulated to those *necessary* to support and propagate healthy wildlife populations. It is further suggested that permits be granted to applicants whose activities will not sufficiently degrade habitat or where applicants are willing to perform significant mitigation or replacement of habitat. The specifics of these permit requirements can be worked out later in regulations crafted by the department.

An additional statutory provision could allow villages, communities, or large land-holders to develop a habitat management plan with DMWR in lieu of seeking individual permits for each development activity. California has adopted such a voluntary program pursuant to the mandates of its state Endangered Species Act for the purpose of improving cost and efficiency of the development process while ostensibly preserving "critical habitat" for endangered species.[9]

The local statutes should include, at minimum, provisions outlining the goals of the program as well as general requirements for participation in the program and the content of the implementation agreements with community stakeholders. Suggested statutory language for each of these wildlife habitat management provisions is provided in Part IV below. In addition, the framework and the approach used by the community-based fisheries management program to manage village coral reefs should be examined for its applicability to the terrestrial wildlife.

---

[9] A similar cooperative regulatory approach is already in use by the DMWR to establish marine protected areas and community-based fisheries management programs.

By adding these provisions to the DMWR wildlife resources statute, the foundation will be laid for crafting habitat management and protection implementation regulations. These regulations will need to define the nature and extent of the habitats to be managed, and include appropriate provisions relating to permit review and approvals. The wildlife habitat permit review process could be merged with the existing Land Use Permit (LUP) approval process of the Department of Commerce (DOC), or could function independently, provided that DMWR would utilize its PNRS Board veto authority if any applicant failed to apply for and receive the wildlife habitat removal permit (when required).

Reference to the DOC's PNRS review process, however, raises the question, why not utilize the Coastal Management Program to manage wildlife habitat? Answer: there is no conclusive reason why the existing PNRS framework cannot be so used. After all, the public is already familiar with this process and DMWR works closely with the DOC to review and approve land use permit applications. Moreover, unlike the DMWR statute the Coastal Act statute primarily governs land-use statute activities such as the management and preservation of important physical features like habitat.

The DMWR could, therefore, dispense with revising its enabling statute and instead assist the DOC with regulations to be adopted and enforced under the Coastal Management Program. This approach has a simple elegance about it, when in fact it would confer actual enforcement authority on the Department of Commerce under the enforcement provisions of the Coastal Act. It would also limit wildlife habitat regulation to land use activities over which the DOC and PNRS have jurisdiction. Accordingly, there is the risk that some land use activities would slip through unregulated[10] and the primary enforcement responsibility would remain with DOC rather than wildlife officers of the DMWR.

8.3.2 PROTECTING WILDLIFE HABITAT UNDER THE ESA

American Samoa received the first federal terrestrial ESA listings in September 2016, when 2 snails, 2 birds, and 1 bat were listed as endangered by the USFWS. In order to enter into a Section 6 Management Agreement with the Secretary of the Department of Interior, the American Samoa ESA must be completely revised and enacted by the Fono in order to be accordance with the US ESA act. The US ESA states:

In order for a State program to be deemed an adequate and active program for the conservation of endangered species and threatened species, the Secretary must find, and annually thereafter reconfirm such finding, that under the State program — (A) authority resides in the State agency to conserve resident species of fish or wildlife determined by the State agency or the Secretary to be endangered or threatened; (B) the State agency has established acceptable conservation programs, consistent with

[10] Some activities, such as traditional Samoan uses, guest falles, and most plantation activities are exempt from the PNRS review process under the CZM regulations at ASAC § 26.0208

the purposes and policies of this Act, for all resident species of fish or wildlife in the State which are deemed by the Secretary to be endangered or threatened, and has furnished a copy of such plan and program together with all pertinent details, information, and data requested to the Secretary; (C) the State agency is authorized to conduct investigations to determine the status and requirements for survival of resident species of fish and wildlife; (D) the State agency is authorized to establish programs, including the acquisition of land or aquatic habitat or interests therein, for the conservation of resident endangered or threatened species of fish or wildlife; and (E) provision is made for public participation in designating resident species of fish or wildlife as endangered or threatened; or that under the State program

DMWR, with the assistance of the AS Attorney General's Office and the USFWS, is currently drafting a revised Territorial ESA which will meet these requirements. The new act is modeled after other states and territories, including Hawaii, Guam, CNMI, and California. The new ESA will include provisions for designation of critical habitat, incidental take, and enforcement. We expect the legislation to be completed and introduced by the Natural Resource Committee Chair during the 2017 legislative session.

8.3.3 PROTECTING WILDLIFE FROM INJURIOUS ALIEN SPECIES

The previously suggested statutory revisions in Part IV below take a two-pronged approach to controlling the problem of introduced and/or propagating injurious alien species of plants and animals. First, the DMWR enabling statute is amended to provide the department with express authority to create a regulatory program to authorize the seizure, eradication, or ban of any species deemed "injurious" by the department. Next, the existing DOA statutes are revised to expand the scope of animals and plants subject to quarantine and seizure protocols, and to provide DMWR with a "say" in determining which species of plants and animals should be subject to these restrictions.

Once these provisions become law, it will be up to the DMWR to follow through by working closely with the DOA to expand the listings under DOA regulations to include species harmful to territorial wildlife or wildlife habitats. The DMWR may then create a regulatory program of its own to work in tandem with the DOA regulations.

This cooperative relationship is in use in Hawaii, for example, where the DOA quarantine division takes responsibility for policing port-of-entry facilities, while the Dept. of Natural Resources takes responsibility for controlling or eradicating species that have already become established. A similar division of responsibility could be achieved in American Samoa by allowing the DMWR to seize, eradicate or destroy alien species harmful to marine and wildlife resources and habitats, while allowing the DOA to police the ports of entry for species controlled under either DOA statutes and regulations or those of the DMWR. Care should be taken to ensure that any import permit granted by the DOA cannot be validated if the same species is regulated or banned pursuant to DMWR wildlife regulations.

Finally, the statutory amendments in Part IV include a provision to address the problem of species bioprospecting. (See proposed ASCA section 24.0314). This new statute would provide a framework for DMWR regulations limiting bioprospecting to permitted activity, and would require prospectors to consent to a profit sharing arrangement with territorial landowners when profits are realized. The statute also provides requirements relating to various permit restrictions, including time, place, manner and species to be collected, subject to the discretion and expertise of the DMWR. Under this permit regime, DMWR will be able to track and control bioprospectors in the territory and the public will be protected against exploitation of its marine and wildlife resources.

8.3.4 IMPROVING ENFORCEMENT OF TERRITORIAL STATUTES AND REGULATIONS

The most significant suggested changes pertaining to enforcement are set forth in the DMWR enabling statute and in the proposed changes to the territorial ESA. The DMWR statute is amended to provide DMWR with authority to issue administrative orders (See sections 24.0304 and 24.0315). Administrative orders are useful in the habitat management context because they allow the director to require that persons cease and desist from harmful activity or that they take affirmative action to safeguard wildlife resources. The suggested statutory revision would also allow the DMWR to enforce an administrative order by means of a ticket-citation in district court (ASCA 24.0315). Accordingly, any failure or refusal to obey an order could be followed up with a citation for each consecutive day in which the order was disobeyed. Here again, the habitat management regulations should spell-out procedures for issuance and appeal of administrative orders, perhaps by reference to the existing Coastal Management Program “stop order” procedures, or through use of the Office of the Administrative Law Judge. The advice of the Attorney General’s Office will be required to ensure that “due process” requirements are properly followed.

Finally, under the territorial ESA, provisions are included to allow the DMWR to take the lead in enforcing the “no take” prohibitions and the species recovery plans. DMWR would be free to do so by administrative order, through issuance of district court citations, or any other manner authorized under proposed ASCA section 24.0315. Having acquired such broad enforcement authority, DMWR will then be empowered to enforce habitat management provisions for both endangered/threatened species as well as any other necessary wildlife habitats defined pursuant to agency regulations.

9 SUMMARY OF STRATEGIES AND MECHANISMS FOR IMPLEMENTATION

9.1 THE "WHAT" OF CONSERVATION: CATEGORIES OF IDENTIFIED STRATEGIES

Strategies for addressing various conservation needs of species, both specific (particularly Sections 3-6) and broad-based (Sections 7 & 8) were elucidated in preceding sections. To recapitulate, the identified priorities fall under one of the following strategic categories:

1) INVENTORY AND MONITORING

Inventories are particularly recommended for species groups for which information on diversity and baseline abundance are lacking or insufficient, such as sea birds, terrestrial snails, and marine mammals.

Monitoring, as a means for evaluating population performances and assessing the efficacy of targeted conservation or management initiatives, will continue for those species or species groups already under implementation (fruit bats, select terrestrial avifauna, and native forest tree species, and various marine fishes) and instituted for those species or species groups not covered under current programs (rare terrestrial birds, sea birds, marine mammals, select reptiles, endemic terrestrial snails, coconut crab, and the *Papilio* butterfly, sea cucumbers, giant clams).

With support from the Wildlife Restoration Program, systematic monitoring of populations of land birds and fruit bats have been on-going since the early 1990s. Monitoring protocols for these species are under review and are expected to be revised to improve accuracy and rigor of abundance estimation. New monitoring programs are being developed for other species under DMWR's SWG Program.

For the marine species, monitoring programs both under territorial and federal are in already place. However, there are limitations only to finfish therefore monitoring programs for marine invertebrates need to be developed and implemented. In addition, such programs should include marine organisms considered as threats such as predators, parasites and diseases.

As with current monitoring, new programs will be designed for detection of acute (as in following natural catastrophes) and long-term changes in the population. In so doing, conservation and management measures may be instituted as an emergency response or revised to accommodate multiannual trends.

2) SCIENTIFIC RESEARCH

The collection of scientific information on the biology of species should be the backbone of any conservation and management program. Information on the ecological requirements of species help define needs such as critical habitat and identify some of the threats to species. Information on such aspects as reproduction, survivorship, and mortality are necessary for determining the innate capacities for or, conversely, limitations to recovery. Determining the genetic basis for conservation and management, including decisions on reintroduction of extirpated or decimated populations are a must. Obviously, these actions need to be prioritized, as has been indicated in the preceding accounts. To date, ecological studies (such as on food habits, habitat use and determination of home ranges through radiotelemetry), analysis of intra- and inter-population levels of genetic variation and relatedness of populations, and disease studies are being conducted on fruit bats and select species of birds. With funds from SWG, additional species will be added to these studies, such as snails , butterflies, and marine invertebrates. Other studies covering additional species will be proposed for funding under SWG (based on priorities identified in Section 5).

3) MANAGEMENT AND PROTECTION

In some cases, conservation will require intervention and protection. The control or eradication of exotic species that may pose a threat to native populations (such as the mynas, commensal rats, invasive plants that threaten the quality of the natural habitat) have been initiated. As examples, feasibility studies are being conducted for control and eradication of mynas (under SWG), eradication of non-native mammalian predators on Swain's Island, and interagency efforts to control invasive plants through ASIST and the new Territorial Invasive Species Council.

Procurement of tracts of good quality natural habitats for protection is a major challenge in American Samoa, where a large proportion of the land are under customary communal holdings and conditions that permit transactions for land easements are largely absent. The NPAS system was successfully negotiated as a long-term lease from villages. This is an approach that DMWR can take and will attempt to pursue in the near future to secure the protection of critical wildlife habitat in Olavalu Crater and the Ottoville Lowland Rainforest in Tutuila. Other recommended habitat preservation areas are indicated in Figure 4.

Revisions to DMWR's enabling legislation and judicious exercise of the agency's regulatory authority are critical particularly for protection of wildlife habitat. As recommended, statutory changes will not only strengthen DMWR's regulatory authority to conserve and protect its wildlife resources and habitat, but will also clarify implementation guidelines for the fair exercise of regulatory authority.

4) COMMUNITY OUTREACH AND EDUCATION

Presentations on project and project outcomes made during the SWG consultations with the Fono, government agency representatives, and village leaders were consistently met with the same response – why does not DMWR package these information for public broadcast? Indeed, one asset that can aid DMWR in reaching the community is the government-run (public) television, KVZK-TV. DMWR plans on producting 30-minute video programs on American Samoa's wildlife and detailing DMWR conservation projects. Depending on the responses from the community, this video production of wildlife programs will be continued under WR and SWG, and will focus on the new species listed under Section 5 of this strategy to broaden people's understanding and appreciation of these species.

The proposed expansion of programs for inventory, monitoring, and scientific investigations will also significantly improve knowledge and understanding of the factors critical for the maintenance of populations of species that have long-been poorly known. These new body of information will enable DMWR provide better technical advise and assistance to the community, the local government, and other (federal and regional) institutions/agencies on issues pertinent to the health of the Territory's wildlife resources.

5) CAPACITY BUILDING

Although not specified in the detailed accounts of conservation strategies for species of concern, the technical expertise required to implement the various programs (both on-going and projected in the near future) were also reviewed during the planning process. In particular, the reliance on outside expertise for conduct of scientific studies can slow down implementation and achievement of project goals. Additionally, periodic changes in contractual personnel can compromise continuity of data necessary for long-term serial analysis of trends and population performances. Thus, it is very important that provisions be made for the continued training of the local technical support staff in techniques and methods necessary to continue collection of reliable data. Additionally, an initiative to develop a curriculum for wildlife biology should be discussed with the ASCC faculty.

9.2 THE "HOW" OF CONSERVATION: CATEGORIES OF MECHANISMS FOR EFFECTING IDENTIFIED STRATEGIES

The primary responsibility for ensuring that priority conservation actions identified in this document are implemented resides with DMWR, as mandated under its enabling statute. It is recognized, however, that DMWR cannot unilaterally put all identified priorities into effect, and that auxiliary mechanisms are necessary for strategies to be fully implemented. To this end, three ancillary implementation approaches should be seriously explored and tapped.

1) LOCAL AND REGIONAL COOPERATIVE INITIATIVES

DMWR currently participates in a number of Territorial multi-agency boards and committees, such as the PNRS, the Soil and Water Conservation District Board, ASIST, ASCC-Land Grant's Forest Stewardship Program, and the local action strategies on Fisheries, Land-Based of Pollution and Climate Change. Through these interagency panels, DMWR is able to provide technical inputs on programs being developed or instituted by the respective parent agencies, as well as develop collaborative projects with any of these groups. The dearth in conservation organizations (particularly NGOs) and limited expertise on wildlife studies in the Territory necessitates that DMWR assume a significant role in implementing inventory, monitoring, and biological studies. However, the NPAS is instituting an inventory and monitoring program for areas within the National Park, and the FWS Remote Islands office in Hawaii is also expected to continue monitoring of wildlife resources in the Rose Atoll National Wildlife Refuge (RANWR). Management of both these entities (NPAS and RANWR) are not totally independent of the Territorial Government (through terms of the lease agreement for the Park and a co-management provision for Rose Atoll). Thus, information on the resources in these protected areas and any conservation recommendations from the NPAS and FWS as a result of their respective monitoring and biological studies will be given due consideration in any planning, program revisions, and implementation actions undertaken by the Territorial Government (primarily through DMWR). Several on-going wildlife investigation projects based at DMWR are being conducted in collaboration with federal agencies or academic institutions in the US. This collaborative approach is particularly useful for projects requiring technical facilities for processing of samples or data (such as genetic analysis and disease studies). The expansion of the conservation programs to cover additional taxa (as specified in Section 5) will render this collaborative approach even more important. Already, collaborative arrangements are being developed with NOAA-PIRO for the establishment of a marine mammal stranding response network and the development of a monitoring program for marine mammals.

On a regional scale, DMWR participates in relevant activities of SPREP, such as the recent initiative to develop a regional MOU for the protection and conservation of migratory marine mammals, and with SPC. As mentioned, an MOU between DMWR and its counterpart agency in (Independent) Samoa has been in effect since 2004. Regional linkages and participatory mechanisms will be particularly germane for conduct of scientific studies, monitoring programs, and protection of species that are common among countries (e.g., shared species of birds and fruit bats) or are migratory in the region (such as sea turtles and marine mammals). A cooperative approach will enable collaborating agencies to pool their limited resources, make available to each other technical expertise, and assist in capacity building.

2) REGULATORY AND STATUTORY MECHANISMS

A number of strategies will require complementary legal backing for successful implementation, such as the conservation of critical habitat. Section 8 (particularly 8.3.1) of this Strategy provides very concrete approaches that can be explored to further conservation of wildlife and wildlife habitat. To achieve this, DMWR (through the Executive Branch) should continue to work closely with the Fono.

3) INTEGRATING TRADITIONAL/CULTURAL MECHANISMS

Elements of the Samoan socio-cultural structure lend themselves to conduct of outreach and consultations necessary to gain support for and participation in wildlife conservation programs. The embodiment of wildlife in traditional practices and cultural heritage provides a mechanism for fostering strong conservation ethic in the community. Suggestions to recover and restore this component of Samoa's cultural identity were voiced during SWG consultations. In recognition of the significance of the integration of nature and culture, DMWR has made the retrieval, documentation, and preservation of these traditions a priority under the SWG program, in collaboration with the American Samoa Historic Preservation Office.

Proposed elements to a recommended wildlife habitat protection program are also anchored to the concept of traditional exercise of responsibility over communal lands. In considering the concept of cooperative habitat management plans, DMWR acknowledges an inherent efficacy in the application of protective regulation through a cultural institutional framework.

10 PROGRAM EVALUATION AND ADAPTIVE MANAGEMENT

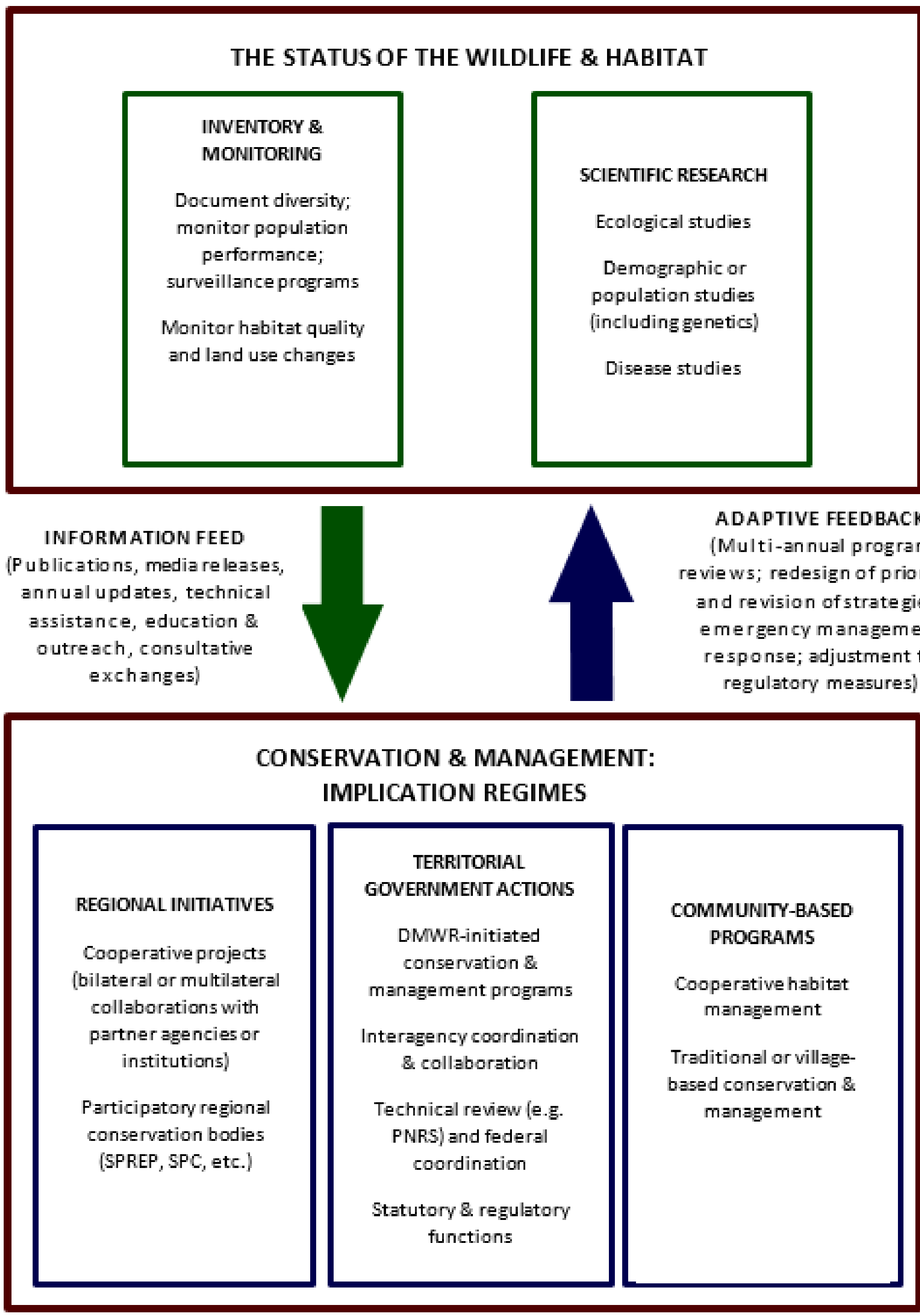
The development and implementation of a comprehensive conservation program for American Samoa's wildlife and wildlife habitat is predicated on the accumulation of sound biological information. In order to identify priority conservation actions and, correspondingly, determine the efficacy of conservation and management programs, information on the status of its diversity (through inventory), the health of populations (through monitoring), and the ecological, demographic (including genetic), and threats such as disease, predators and other factors and processes influencing populations (through scientific studies) must be obtained. Thus, Inventory, Monitoring, and Scientific Studies are considered critical elements of an **information matrix** for the determination of the state of the Territory's wildlife resources and habitats (upper box of Figure 16).

Through inventory, monitoring, and scientific studies, information pertinent to the development of appropriate conservation and management actions can be fed (green arrow in Figure 6) into an **implementation matrix** (lower box of Figure 16) consisting of three components deemed complementary for effective achievement of conservation goals (i.e., the maintenance of diversity and stable populations of wildlife). The components of this implementation matrix are the Territorial Government, Regional Entities, and Traditional Institutions. Priority measures developed based on the information matrix shall be put into effect through specific actions undertaken by government agencies (foremost of which is DMWR) and the legislature, collaborative or participatory initiatives with local and regional partners, and community-based cooperative conservation. Specific examples of measures or programs identified in this CWCS are indicated under each element or component (Figure 16).

The specifics of the various implementation measures undertaken by each component are responsive to the information flow from the status matrix. Thus, as information on population and habitat statuses are updated, conservation priorities may be revised, and implementation (conservation and management) measures may be modified accordingly. Conversely, the impact or efficacy of the implementation actions are expected to be reflected in the status of the wildlife and their habitat, and adjustments to conservation priorities should be instituted so implementation measures may be modified accordingly. Periodic (multi-annual) reviews of programs to be undertaken in-house and in consultation with various local entities (patterned after Figure 1) will permit adjustments to conservation priorities based on the efficacy and adequacy of implementation actions as reflected in the statuses of populations and the habitat (blue arrow in Figure 16). In addition, an emergency response management program will facilitate institution of immediate conservation measures (primarily through governmental and community-based actions) in the event of natural catastrophes (such as hurricanes and emergent infectious diseases).

As an example, the hunting, export, and import of the Pacific Imperial Pigeon are currently prohibited under AS Administrative Code Title 24 Chapter 08. Under the administrative rule, a hunt may be declared by the Director of DMWR, and it is implicit that such a declaration will be based on biological information that pigeon populations are, in fact, able to sustain takes. Pigeon populations have been monitored in the Territory since the ban was put into effect in 1991 following decline in numbers as a result of a hurricane. A 10-year data series from the monitoring program showed recovery in numbers and indicated the possibility of re-instituting a hunt of the species. Thus, DMWR conducted an experimental hunt in 2003, an exercise that was closely coordinated with villages (through the Office of Samoan Affairs) to ensure that hunting guidelines were observed. In the end, DMWR biologists recommended against the re- institution of pigeon hunts when populations were found to be impacted by a hurricane that befell the Territory in 2004. The ban continues to be in effect until such time when information from the monitoring program indicates re-evaluation of this particular management measure.

FIGURE 16. A BLUEPRINT FOR CONSERVATION IMPLEMENTATION, PROGRAM EVALUATION AND ADAPTIVE MEASURES



11 LITERATURE CITED

Adler, G.H. and R. Dudley. 1994. Butterfly biogeography and endemism on tropical Pacific islands. Biological Journal of the Linnean Society 51:151-162.

Aitken, P.F. 1971. Whales from the coast of South Australia. Transactions of the Royal Society of South Australia 95:95-103.

Albertson, G.R., R.W. Baird, M. Oremus, M.M. Poole, K.K. Martien, and C.S. Baker. 2016. Staying close to home? Genetic differentiation of rough-toothed dolphins near oceanic islands in the central Pacific Ocean. Conservation Genetics:1-19.

Albertson, G.R., A.S. Friedlaender, D.J. Steel, S.L. Bonatto, R. Constantine, A.L. Cypriano-Souza, M.H. Engel, C. Garrigue, L. Flórez-González, D.W. Johnston, D.P. Nowacek, C. Olavarría, M.M. Poole, A.J. Read, J. Robbins, and C.S. Baker. 2015 Genetic identification, temporal and mixed-stock analyses of humpback whales (Megaptera novaeangliae) in the nearshore waters of western Antarctic Peninsula from 2014. Unpublished report to the Scientific Committee of the International Whaling Commission.

Albertson, R., J. Robbins. (In review) Temporal stability and mixed-stock analyses of humpback whales (Megaptera novaeangliae) in the nearshore waters of the Western Antarctic Peninsula. Polar Biology.

Allen, G. R. 1985. FAO species catalogue. Snappers of the world. An annotated and illustrated catalogue of lutjanid species known to date. FAO Fisheries Synopsis 125, vol. 6, 208 pp. FAO, Rome.

Allen, H., J. Stephen. Newman, and M. Justine. Johnston. 2011. Bomb radiocarbon dating of three important reef-fish species using Indo-Pacific D14C chronologies. Marine and Freshwater Research, 2011, 62, 1259–1269.

Allison, A. 1996. Zoogeography of amphibians and reptiles of New Guinea and the Pacific region. pp 407-436 in A. Keast and SE Miller (eds), The origin and evolution of Pacific island biotas, New Guinea to eastern Polynesia: patterns and processes. SPB Academic Pub., Amsterdam, The Netherlands.

Alory, G., and T. Delcroix. 1999. Climatic variability in the vicinity of Wallis, Futuna, and Samoa islands (13°-15° S, 180°170° W). Oceanologica Acta 22: 249-263.

American Samoa Code Annotated. 1995. A.S.C.A. 24.08, A rule to regulate hunting by adding Chapter 08 to Title 24 of the American Samoa Administrative Code. Pago Pago, American Samoa.

American Samoa Government. 2002. Territory of American Samoa - state of the environment report. ASEPA, Pago Pago AS.

American Samoa Government. 2003. Executive Order No. 005-2003, An Order Establishing the Territorial Waters of American Samoa as a Sanctuary for Sea Turtles and Marine Mammals. Office of the Governor. Pago Pago. American Samoa.

Amerson, A.B. Jr., W.A. Whistler, and TD Schwaner. 1982a. Wildlife and wildlife habitat of American Samoa. I. Environment and ecology. DOI-USFWS, Washington DC.

Amerson, A.B. Jr., W.A. Whistler, and T.D. Schwaner. 1982b. Wildlife and wildlife habitat of American Samoa. II. Accounts of flora and fauna. DOI-USFWS, Washington DC.

Anderson, J.R., E.E. Hardy, J.T. Roach, and R.E.A. Witmer. 1976. Land use and land cover classification system for use with remote sensor data. U.S. Geological Survey Professional Paper, No. 964. USGS, Washington, D.C.

Andrews, AH, EE DeMartini, J Brodziak, RS Nichols, and RL Humphreys. 2012. A long-lived life history for a tropical, deepwater snapper (Pristipomoides filamentosus): bomb radiocarbon and lead–radium dating as extensions of daily increment analyses in otoliths. Can. J. Fish. Aquat. Sci. 69: 1850–1869.

Anonymous.1998-1999. Samoa Nei Galo Volume 1 (Second Edition). Commercial Printers and Co. Ltd., Apia. Anonymous. 2001. Samoa Nei Galo Volume 3. Malua Printing Press. Apia.

Apprill, A., J. Robbins, A.M. Eren, A.A. Pack, J. Reveillaud, D.K. Mattila, M.N. Moore, K.M., T. Moore, T.J. Miner. 2014 Humpback whale populations share a core skin microbiome: towards a health index for marine mammals. PLOS One 9:e90785.

Archer, F.I., and W.F. Perrin. 1999 Stenella coeruleoalba. Mammalian Species 603:1-9.

AS Sea Turtle Recovery Team. 1999. Sea Turtle Recovery Plan: Participation Plan for Sea Turtle Recovery in American Samoa – draft prepared for NMFS. Pago Pago, American Samoa.

Asner, G.P., M. Palace, M. Keller, R. Pereira Jr., J.N.M. Silva, and J.C. Zweede. 2002. Estimating canopy structure in an Amazon forest from laser range finder and IKONOS satellite observations. Biotropica 34:483-492.

Atkinson, C.T., R.C. Utzurrum, J.O. Seamon, A.F. Savage, and D.A. LaPointe. 2006. Hematozoa of forest birds in American Samoa - evidence for a diverse, indigenous parasite fauna from the south Pacific. Pacific Conservation Biology 12:229-237.

Atkinson, C. T., R. B. Utzurrum, J. O. Seamon, M. A. Schmaedick, D. A. LaPointe, C. Apelgren, A. N. Egan, and W. Watcher-Weathermax. 2016. Effects of climate and land use on diversity, prevalence, and seasonal transmission of avian hematozoa in American Samoa. Technical Report HCSU-072. Hawai`i Cooperative Studies Unit University of Hawai`i at Hilo.

Aylesworth, L. 2009 Pacific Island Fisheries and Interactions with Marine Mammals, Seabirds and Sea Turtles: Oceania Regional Assessment. M.S., Duke University.

Backus, R. H., S. Springer, and E.L.J. Arnold. 1956 A contribution to the natural history of the white-tip shark, Pterolamiops longimanus (Poey). Deep Sea Research 3, 178–188.

Baker, A.N., and A.L. Van Helden. 1991 First record of the dwarf sperm whale, Kogia simus (Owen) from New Zealand. National Museum of New Zealand Records 312:125-130.

Baker, C.S. 2000. New evidence for stock boundaries of humpback whales in the proposed South Pacific Whale Sanctuary. IWC/SC/52/IA20.

Bakun, A. 1996. Patterns in the ocean. La Jolla, CA: California Sea Grant.

Banack, S.A. 1996. Flying foxes, genus Pteropus, in the Samoan islands: interactions with forest communities. PhD dissertation, University of California, Berkeley, 281 pp.

Banack, S.A. 1998. Diet selection and resource use by flying foxes (Genus Pteropus). Ecology 79:1949-1967. Banack, SA. 2001. Pteropus samoensis. Mammalian Species 661:1-4.Banks, RC. 1984. Bird specimens from American Samoa. Pacific Science 38:150-169.

Banack, S.A., and G.S. Grant. 2003a. Reproduction and behaviour of the Samoan flying fox, Pteropus samoansis (Chiroptera, Pteropodidae). Mammalia 67:419-437.

Banack, S.A., and G.S. Grant. 2003b. Spatial and temporal movement patterns of the flying fox, Pteropus tonganus, in American Samoa. Journal of Wildlife Management 66:1154-1163.

Bannister, J.L., C.M. Kemper, and R. Warneke. 1996 The action plan for Australian cetaceans. Australian Nature Conservation Agency, Canberra, Australia.

Baptista, L.F., P.W. Trail, and H.M. Horblit. 1997. Columbidae. pp.185-230 in J del Hoyo, A Elliott and J Sargatal (eds), Handbook of the Birds of the World, Volume 4 - Sandgrouse to Cuckoos. Lynx Edicions , Barcelona, Spain.

Barstow, S.F., and O. Haug. 1994. The wave climate of Western Samoa. SOPAC Technical Report 204. 34 pp.

Bart, J. 2005. Monitoring the abundance of bird populations. Auk 122:15-25.

Bates, J.M. 2002. The genetic effects of forest fragmentation on five species of Amazonian birds. Journal of Avian Biology 33:276-294.

Bearhop, S., S. Waldron, S.C. Votier, and R.W. Furness. 2002. Factors that influence assimilation rates and fractionation of nitrogen and carbon stable isotopes in avian blood and feathers. Physiological and Biochemical Zoology 75:451-458.

Beau, A.G. 1970. The mollusk of the genus Charonia (Family Cymatiidae). Transactions of the Royal Society of New Zealand, Biological Series 11(16): 205-223.

Berta, A. 2015 Whales, Dolphins and Porpoises: A Natural History and Species Guide. University of Chicago Press.

Bickel, D.J. 1996. Restricted and widespread taxa in the Pacific: biogeographic processes in the fly family Dolichopodidae (Diptera). pp. 331-346 in A. Keast and SE Miller (eds), The origin and evolution of Pacific island biotas, New Guinea to eastern Polynesia: patterns and processes. SPB Academic Pub., Amsterdam, The Netherlands.

bin Othman, A.S., G.H.S. Goh, P.A. Todd. 2010. The distribution and status of giant clams (family Tridacnidae) – a short review. Raffles Bull. Zool. 58, 103–111.

Bonfil, R. 2008. "The Biology and Ecology of the Silky Shark, Carcharhinus falciformis". In Camhi, M., Pikitch, E.K. and Babcock, E.A.. Sharks of the Open Ocean: Biology, Fisheries and Conservation. Blackwell Science. pp. 114–127.

Bonfil, R., R. Mena, and D. de Anda. 1993 Biological parameters of commercially exploited silky sharks, Carcharhinus falciformis, from the Campeche Bank, México. In: Conservation Biology of Elasmobranchs (ed. S. Branstetter). NOAA Technical Report NMFS 115. NOAA/NMFS, Silver Spring, MD, pp. 73–86.

Borsa, P. 2006 Marine mammal strandings in the New Caledonia region, Southwest Pacific. Comptes Rendus Biologies 329:277-288.

Boulon, R.H. Jr. 1999. Reducing threats to eggs and hatchlings: in situ protection. pp. 169-174 in KL Eckert, KA Bjorndal, FA Abreu-Grobois and M Donnelly (eds) IUCN/SSC Marine Turtle Specialist Group Publication No. 4, 1999.

Brabyn, M.W. 1991 An analysis of the New Zealand whale stranding record. Head Office, Department of Conservation, P O Box 10-420, Wellington, New Zealand.

Brainard, R., and 25 others. 2008. Coral reef ecosystem monitoring report for American Samoa: 2002-2006. NOAA Special Report NMFS PIFSC. 472 pp.

Branstetter, S. 1987 Age, growth and reproductive biology of the silky shark, Carcharhinus falciformis, and the scalloped hammerhead, Sphyrna lewini, from the northwestern Gulf of Mexico. Environmental Biology of Fishes 19, 161–173.

Brill, R. W., D.B. Holts, R.K.C. Chang, R.K.S. Sullivan, H. Dewar, and F.G. Carey. 1993. Vertical and horizontal movement of striped marlin (Tetrapturus audax) near the Hawaiian Islands, determined by ultrasonic telemetry, with simultaneous measurement of oceanic currents. Marine Biology. 117: 567– 574.

Brooke, A.P. 1997. Fruit bat studies: Pteropus samoensis and Pteropus tonganus, 1995-1996. Biological Report. Department of Marine and Wildlife Resources, Pago Pago, American Samoa.

Brooke, A.P. 2001. Population status and behaviours of the Samoan flying fox (Pteropus samoensis) on Tutuila Island, American Samoa. Journal of Zoology, London, 254:309-319.

Brooke, A.P., C. Solek, and A. Tualaulelei. 2000. Roosting behavior of colonial and solitary flying foxes in American Samoa (Chirotera: Pteropodidae). Biotropica 32:338-350.

Brooks, F.E. 2000. List of plant diseases in American Samoa. Land Grant Technical Report No. 31, ASCC, Pago Pago AS.

Brooks, F.E. 2002. Brown root rot disease in American Samoa's tropical rain forests. Pacific Science 56:4:377-387.

Brooks, F.E. 2004. Plant-parasitic algae (Chlorophyta: Trentepohliales) in American Samoa. Pacific Science 3:419-428.

Brown, I.W., and D.R. Fielder. 1991. The coconut crab: aspects of Birgus latro biology and ecology in Vanuatu. ACIARMonograph 8, Canberra AUS.

Bruce, M.D. 1999. Tytonidae. pp. 71-72 in del Hoyo, A Elliott and J Sargatal (eds), Handbook of the Birds of the World, Volume 5 - Barn-owls to Hummingbirds. Lynx Edicions , Barcelona, Spain.

Bull, L.S., K.R. McConkey, and F. Tonga. 2002. Abundance and breeding habitat of noddies and white terns on a relatively unmodified island in the kingdom of Tonga. Emu 102:373-376.

Burggren, W.W., and B.R. McMahon. 1988. Biology of the land crabs. Cambridge Univ. Press, Cambridge, UK.

Cadena-Cárdenas, L. 2001 Biología reproductiva Carcharhinus falciformis (Chondrichthyes Carcharhiniformes: Carcharhinidae), en el Golfo de California. Bachelor's thesis, Departamento de Biología Marina, Universidad Autónoma de Baja California Sur, La Paz, Mexico, 66 pp.

Callaway, R.M., G.C. Thelen, A. Rodriguez, and W.M. Holben. 2004. Soil biota and exotic plant invasion. Nature 427:731- 733.

Calsbeek, R., and T.B. Smith. 2003. Ocean currents mediate evolution in island lizards. Nature 426:552-555.

Carlquist, S. 1996. Plant dispersal and the origin of Pacific island floras. pp 153-164 in A. Keast and SE Miller (eds), The origin and evolution of Pacific island biotas, New Guinea to eastern Polynesia: patterns and processes. SPB Academic Pub., Amsterdam, The Netherlands.

Carpenter, K. E. and V.H. Niem. 2001: FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific. Vol. 5. Bony Fishes, part 3 (Menidae to Pomacanthridae). FAO, Rome, pp. 2791–3380.

Carretta, J.V., E. Oleson, J. Baker, D.W. Weller, A.R. Lang, K.A. Forney, M.M. Muto, B. Hanson, A.J. Orr, H. Huber, M.S. Lowry, J. Barlow, J.E. Moore, D. Lynch, L. Carswell, and R.L. Brownell Jr. 2016 U.S. Pacific Marine Mammal Stock Assessments: 2015.

Case, T.J., and D.T. Bolger. 1991. The role of interspecific competition in the biogeography of island lizards. Trends in Ecology and Evolution 6(4):5 pp.

Chantler, P. 1999. Apodidae. pp.418-419 in J del Hoyo, A Elliott and J Sargatal (eds), Handbook of the Birds of the World, Volume 5 - Barn-owls to Hummingbirds. Lynx Edicions, Barcelona, Spain.

Chauvet, C., and T. Kadiri-Jan. 1999. Assessment of an unexploited population of coconut crabs, Birgus latro (Linne, 1767) on Taiaro atoll (Tuamoto archipelago, French Polynesia). Coral Reefs 18;297-299.

Chin, A., and L.J.V.Compagno. 2016. Urogymnus asperrimus. The IUCN Red List of Threatened Species 2016: e.T39413A68648645.

Chivers, S.J., R.W. Baird, K.M. Martien, B.L. Taylor, E. Archer, A.M. Gorgone, B.L. Hancock, N.M. Hedrick, D. Mattila, D.J. McSweeney, E.M. Oleson, C.L. Palmer, V. Pease, K.M. Robertson, J. Robbins, J.C. Salinas, G.S. Schorr, M. Schultz, J.L. Thieleking, and D.L. Webster. 2010 Evidence of genetic differentiation for Hawai'i insular false killer whales (Pseudorca crassidens). In: Commerce USDo (ed) NOAA Technical Memorandum NMFS.

Choat, J.H., C.R. Davies, J.L. Ackerman, and B.D. Mapstone. 2006. Age structure and growth in a large teleost, Cheilinus undulatus, with a review of size distribution in labrid fishes. Mar. Ecol. Prog. Ser. 318: 237–246.

Choat, J.H., and D.R. Robertson. 2002. Age-based studies on coral reef fishes. In Sale, P.F. (ed) Coral reef fishes: Dynamics and diversity in a complex ecosystem. Academic Press, San Diego, pp. 57-80.

Clarke, S.C., S. Harley, S. Hoyle, J. Rice. (2011a) An Indicator based analysis of key shark species based on data held by SPC-OFP. WCPFC-SC7-EB –WP-04.

Clarke, S.C., J. E. Magnusson, D. L. Abercrombie, M. McAllister, and M.S. Shivji. 2006 Identification of shark species composition and proportion in the Hong Kong shark fin market based on molecular genetics and trade records. Conservation Biology 20, 201–211.

Clarke, S. C., McAllister, M. K., and C. G. J. Michielsens. 2005 Estimates of shark species composition and numbers associated with the shark fin trade based on Hong Kong auction data. Journal of Northwest Atlantic Fishery Science 35, 453–465.

Cole, T.G., C.D. Whitesell, WA Whistler, N McKay and AA Ambacher. 1988. Vegetation survey and forest inventory, American Samoa. USDA Pacific Southwest Forest and Range Experiment Station, Resource Bulletin PSW-25.

Collar, N.J. 1997. Psittacidae. pp.353 in del Hoyo, A Elliott and J Sargatal (eds), Handbook of the Birds of the World, Volume 4 - Sandgrouse to Cuckoos. Lynx Edicions , Barcelona, Spain.

Comber, A.J., R.V. Birnie, and M. Hodgson. 2003. A retrospective analysis of land cover change using a polygon shape index. Global Ecology and Biogeography 12:207-215.

Compagno, L.J.V.. 1984 FAO Species Catalogue. Vol. 4. Sharks of the World: An Annotated and Illustrated Catalogue of Shark Species Known to Date. Parts 1 and 2. FAO Fisheries Synopsis No. 125. FAO, Rome, Italy, 655pp.

Comstock, J.A. 1966. Lepidoptera of American Samoa with particular reference to biology and ecology. Pacific Insects Monographs 11:1-74.

Conand, C., R. Gamboa, S. Purcell, and T-G Toral-Granda. 2013. Holothuria whitmaei. The IUCN Red List of Threatened Species 2013: e.T180440A1630988.

Conand, C., S. Purcell, and R. Gamboa. 2013. Holothuria fuscogilva. The IUCN Red List of Threatened Species 2013: e.T200715A2681354.

Constantine, R., J.A. Jackson, D. Steel, C.S. Baker, L. Brooks, D. Burns, P. Clapham, N. Hauser, B. Madon, D. Mattila, M. Oremus, M. Poole, J. Robbins, K. Thompson, and C. Garrigue. 2012 Abundance of humpback whales in Oceania using photo-identification and microsatellite genotyping. Mar Ecol Prog Ser 453:249-261.

Constantine, R., D. Steel, J. Allen, M. Anderson, O. Andrews, C. Baker, P. Beeman, D. Burns, J-B Charrassin, S. Childerhouse, M. Double, P. Ensor, T. Franklin, W. Franklin, N. Gales, C. Garrigue, N. Gibbs, P. Harrison, N. Hauser, A. Hutsel, C. Jenner, M. Jenner-N, G. Kaufman, A. Macie, D. Mattila, C. Olavarria, A. Oosterman, D. Paton, M. Poole, J. Robbins, N. Schmitt, P. Stevick, A. Tagarino, K. Thompson, and J. Ward. 2014 Remote Antarctic feeding ground important for east Australian humpback whales. Mar Biol 5:1087-1093.

Cook, R.P. 2004. Macrofauna of Laufuti stream, Ta'u, American Samoa, and the role of physiography in its zonation. Pacific Science 58:7-21.

Cook, S., R. Singidan, and I.W.B. Thornton. 2001. Colonization of an island volcano, Long island, Papua, New Guinea, and an emergent island, Motmot, in its caldera lake. IV. Colonization by non-avian vertebrates. Journal of Biogeography 28:1353-1363.

Cortés, E. 2002 Incorporating uncertainty into demographic modelling: Application to shark populations and their conservation. Conservation Biology 16, 1048–1062.

Couce, E., A. Ridgwell, and E. J. Hendy. 2013b. Future habitat suitability for coral reef ecosystems under global warming and ocean acidification. Global Change Biology.

Courbis, S., R.W. Baird, F. Cipriano, and D. Duffield. 2014 Multiple Populations of Pantropical Spotted Dolphins in Hawaiian Waters. J Hered 105:627-641.

Cowie, R.H. 1996. Pacific island land snails: relationships, origins and determinants of diversity. pp. 347-372 in A. Keast and SE Miller (eds), The origin and evolution of Pacific island biotas, New Guinea to eastern Polynesia: patterns and processes. SPB Academic Pub., Amsterdam, The Netherlands.

Cowie, R.H. 1998. Catalog of the nonmarine snails and slugs of the Samoan islands. Bishop Museum Bulletins in Zoology 3, Bishop Museum Press, Honolulu HI.

Cowie, R.H. 2001a. Decline and homogenization of Pacific faunas: the land snails of American Samoa. Biological Conservation 99:207-222.

Cowie, R.H. 2001b. Invertebrate invasions on Pacific islands and the replacement of unique native faunas: a synthesis of the land and freshwater snails. Biological Invasions 3:119-136.

Cowie, RH. 2004. Disappearing snails and alien invasions: the biodiversity/conservation interface in the Pacific. Journal of Conchology, Special Publication 3:23-37.

Cowie, R.H. 2005. Disappearing land snails. Pp 56-57, in P. Craig (ed.), Natural History Guide to American Samoa, 2nd edition. National Park of American Samoa and Dept. of Marine and Wildlife Resources, Pago, Pago, American Samoa.

Cowie, R.H., and R.P. Cook. 1998. Partulid and other land snails of the national park of American Samoa. Tentacle 8:14-15.

Cowie, R.H., and R.P. Cook. 2001. Extinction or survival: partulid tree snails in American Samoa. Biodiversity and Conservation 10:143-159.

Cowie, R.H., and A.C. Robinson. 2002. The decline of native Pacific island faunas: changes in status of the land snails of Samoa through the 20th century. Biological Conservation 110:55-65.

Cowie, R.H., and R.J. Rundell. 2002. The land snails of a small tropical Pacific island, Aunu'u, American Samoa. Pacific Science 56:143-147.

Cowie, R.H., R.J. Rundell, F. Mika, and P. Setu. 2002. The endangered partulid tree snail Samoana thurstoni (Cooke and Crampton, 1930) on Olosega and the land snail diversity of the Manu'a islands, American Samoa. American Malacological Bulletin 17:37-43.

Cox, P.A. 1983. Observations on the natural history of Samoan bats. Mammalia 47:519-523. Cox, PA. 1984. Flying fox nearly extinct in Samoa. Bats 1:1-2.

Cox, P.A., and T. Elmqvist. 2000. Pollinator extinction in the Pacific islands. Conservation Biology 14:1237-1239. Craig, P. 1995. Whales ho! Pp. 30-32 in American Samoa: Natural History and Conservation Topics. Vol.2. Department of Marine and Wildlife Resources.

Cox, P.A., T. Elmqvist, E.D. Pierson, and W.E. Rainey. 1991. Flying foxes as strong interactors in South Pacific island ecosystems: a conservation hypothesis. Conservation Biology 5:448-454.

Cox, P.A., T. Elmqvist, E.D. Pierson, and W.E. Rainey. 1992. Flying foxes as pollinators and seed dispersers in Pacific island ecosystems. pp 18-23, in DE Wilson and GL Graham (eds), Pacific island flying foxes: proceedings of an international conservation conference. US Fish and Wildlife Service Biological Report 90(23), Washington, DC.

Craig, P. 2002. Rapidly approaching extinction: sea turtles in the central South Pacific. Western Pacific Sea Turtle Cooperative Research and Management Workshop. Honolulu. 5-8Feb. 2002. Western Pacific Regional Fisheries Management Council, Honolulu.

Craig, P. 2005. Natural History Guide to American Samoa. National Park of American Samoa and Dept. of Marine and Wildlife Resources, Pago, Pago, American Samoa.

Craig, P. 2009 Natural history guide to American Samoa. National Park Service.

Craig, P. 2009. The Natural History Guide of American Samoa. 3rd Edition. National Park of American Samoa, Department of Marine and Wildlife Resources, and American Samoa Community College. Pago Pago, American Samoa. 131 pp.

Craig, R.J., and K.G. Beal. 2001. Microhabitat partitioning among small passerines in a Pacific island bird community. Wilson Bulletin 113:317-326.

Craig, P., T.E. Morrell, and K. So'oto. 1994. Subsistence harvest of birds, fruit bats, and other game in American Samoa, 1990-1991. Pacific Science 48:344-352.

Craig, P., D. Parker, R. Brainard, M. Rice, and G. Balazs. 2004. Migrations of green turtles in the central South Pacific. Biological Conservation 116:433-438.

Craig, P., P.W. Trail, and T.E. Morrel. 1994. The decline of fruit bats in American Samoa due to hurricanes and overhunting. Biological Conservation 69:261-266.

Craig, P., and W. Syron. 1992. Fruit bats in American Samoa: their status and future. pp. 145-149, in DE Wilson and GL Graham (eds), Pacific Island flying foxes: proceedings of an international conservation conference. US Fish and Wildlife Service Biological Report 90(3):1-76.

Crovetto, A., and F. Torro. 1983 Présence de Kogia simus (Cetacea, Physeteridae) dans les eaux chiliennes. Mammalia 47:591-593.

Daschbach, N. 1990. After the hurricane. Bats 8(3):14-15.

Davies, C. R., A.J. Williams, B.D. Mapstone, J. Benzie, L. van Herwerden, and J.H. Choat , S. Adams, C. D. Murchie, K. Bean, G. Carlos, A. Tobin, and J. Ackerman. 2006. Stock structure and regional variation in population dynamics of the Red Throat Emperor and other target species of the Queensland tropical reef line fishery. In CRC Reef Research Centre 694 Technical Report No. 61. Townsville: CRC Reef Research Centre.

Dawbin, W.H. 1959 New Zealand and South Pacific whale marking and recoveries to the end of 1958. Norsk Hvalfangsttid 5:213-238.

Day, R.H., B.A. Cooper, and R.J. Blaha. 2003. Movement patterns of Hawaiian petrels and Newell's shearwaters on the island of Hawai'i. Pacific Science 57:147-159.

de Boer, A.J., and J.P. Duffels. 1996. Biogeography of Indo-pacific cicadas east of Wallace's Line. pp 297-330 in A. Keast and SE Miller (eds), The origin and evolution of Pacific island biotas, New Guinea to eastern Polynesia: patterns and processes. SPB Academic Pub., Amsterdam, The Netherlands.

del Hoyo, J., A. Elliott, and J. Sargatal. 1992. Ostriches to Auks. Volume 1 of The Handbook of the Birds of the World. Lynx Edicions, Barcelona, Spain.

Department of Commerce Statistics Division. 2005. American Samoa Statistical Yearbook 2002. DOC Statistical Division, American Samoa Government, Pago Pago, AS. 191 pp.

Department of Commerce/American Samoa Government. 2003. Territorial General Plan, April 2003 version.

Department of Marine and Wildlife Resources. A comprehensive strategy for wildlife conservation in American Samoa (RCB Utzurrum, JO Seamon, and K Schletz Saili, authors). 2006.

DeSante, D.F., and T.L. George. 1994. Population trends in the landbirds of western North America. Pages 173-190 in J. R. Jehl, Jr. and N. K. Johnson (eds.), A century of avifaunal change in North America, Studies in Avian Biology No 15, Cooper Ornithological Society.

DeSante, D.F., M.P. Nott, and D.R. Kaschube. 2005. Monitoring, modeling, and management: Why base avian monitoring on vital rates and how should it be done? Pages 795-804 in C. J. Ralph and T. D. Rich, editors. Bird Conservation Implementation and Integration in the Americas. U.S. Forest Service General Technical Report PSW-GTR-191.

Diamond, J. 1984. Biogeographic mosaics in the Pacific. pp. 1-14 in FJ Radovsky, PH Raven and SH Sohmer (eds), Biogeography of the tropical Pacific. ASC and Bishop Museum Special Publication No. 72, Lawrence KS.

Dobson, J., E. Bright, and R. Ferguson. NOAA Coastal Change Analysis Program (C-CAP): guidance for regional implementation. 1995.

Dolar, M.L.L. 2005. Cetceans of American Samoa, a report submitted to the Department of Marine and Wildlife Resources, American Samoa. 24 pp.

Domeier, M. L., H. Dewar, and N. Nasby-Lucas. 2003. Mortality rate of striped marlin (Tetrapturus audax) caught with recreational tackle. Marine and Freshwater Research. 54, 435–445.

Domokos, R.K., M. Seki, J. Polovina, and D. Hawn. 2007. Oceanographic investigation of the American Samoa albacore (Thunnus alalunga) habitat and longline fishing grounds. Fish. Oceanogr. 16:6, 555–572.

Donnegan, J.A., S.S. Mann, S.L. Butler, and B.A. Hiserote. 2004. American Samoa's forest resources, 2001. Resour. Bull. PNW-RB-244. Portland, OR: US Department of Agriculture, Forest Service, Pacific Northwest Research Station. 32 pp.

Dudley, R., and G.H. Adler. 1996. Biogeography of milkweed butterflies (Nymphalidae: Danainae) and mimetic patterns on tropical pacific archipelagos. Biological journal of the Linnean Society 57:317-326.

Elmqvist, T., P.A. Cox, W.E. Rainey, and E.D. Pierson. 1992. Restricted pollination on oceanic islands - pollination of Ceiba pentandra by flying foxes in Samoa. Biotropica 24:15-23.

Elmqvist, T., W.E. Rainey, E.D. Pierson, and P.A. Cox. 1994. Effects of tropical cyclones Ofa and Val on the structure of a Samoan lowalnd rain forest. Biotropica 26:384-391.

Elmqvist, T., M. Wall, A. Berggren, L. Blix, A. Fritioff, and U. Rinman. 2001. Tropical forest reorganization after cyclone and fire disturbance in Samoa: remnant trees as biological legacies. Conservation Ecology 5:10[online].

Endean, R. 1969. Report on the investigations made into aspects of the current Acanthaster planci (Crown-of-thorns) infestations of certain reefs of the Great Barrier Reef. Qld. Dept. Prim. Ind. Fish. Branch, Brisbane, 30 pp.

Engbring, J., and F.L. Ramsey. 1989. A 1986 survey of the forest birds of American Samoa. DOI-USFWS, Honolulu HI.

Esselstyn, J.A., G.J. Wiles, and A. Amar. 2004. Habitat use of the Pacific sheath-tailed bat (Emballonura semicaudata) on Aguiguan, Mariana Islands. Acta Chiropterologica 6:303-308.

Estreguil, C., and E.F. Lambin. 1996. Mapping forest-cover disturbances in Papua New Guinea with AVHRR data. Journal of Biogeography 23:757-773.

Evans, S.M., G. Knowles, C. Pye-Smith, and R. Scott. 1977. Conserving shells in Kenya. Oryx 13 (5):480-485.

Fenner, M. 2000. Seeds - the ecology of regeneration in plant communities. CABI Publishing, Oxon, UK. Flannery, TF. 1995. Mammals of the southwest Pacific and Mollucan islands. Cornell University Press, Ithaca. 646 pp.

Fletcher, W.J., I.W. Brown, and D.R. Fielder. 1990. Movement of coconut crabs (Birgus latro) in a rain forest habitat in Vanuatu. Pacific Science 44:407-416.

Franklin, W., T. Franklin, L. Brooks, N. Gibbs, S. Childerhouse, F. Smith, D. Burns, D. Paton, C. Garrigue, R. Constantine, M. Poole, N. Hauser, M. Donoghue, K. Russell, D.K. Mattila, J. Robbins, A. Oosterman, R. Leaper, P. Harrison, S. Baker, and P. Clapham. 2012 Antarctic waters (Area V) near the Balleny Islands are a summer feeding area for some Eastern Australian (E(i) breeding group) humpback whales (Megaptera novaeangliae). J Cetacean Res Manage 12:321-327.

Franklin, W., T. Franklin, N. Gibbs, S. Childerhouse, C. Garrigue, R. Constantine, L. Brooks, D. Burns, D. Paton, M.H. Poole, M. Donoghue, K. Russell, D. Mattila, J. Robbins, M. Anderson, C. Olavarria, J. Jackson, M. Noad, P. Harrison, P. Baverstock, R. Leaper, S. Baker, and P. Clapham 2014 Photo-identification confirms that humpback whales (Megaptera novaeangliae) from eastern Australia migrate past New Zealand but indicates low levels of interchange with breeding grounds of Oceania. J Cetacean Res Manage 14:133-140.

Freifeld, H.B. 1999. Habitat relationships of forest birds on Tutuila island, American Samoa. Journal of Biogeography 26:1191-1213.

Freifeld, H.B., and D.W. Steadman. 2001. Landbirds on offshore islands in Samoa. Journal of Field Ornithology 72:72-85.

Freifeld, H.B., C. Solek. and A. Tualaulelei. 2004. Temporal variation in forest bird survey data from Tutuila island, American Samoa. Pacific Science 58:99-117.

Fricke, H., and D. Meischner. 1985 Depth limits of Bermudan scleractinian corals: a submersible survey. Mar Biol 88:175–187.

Fritsches, K.A., and E.J. Warrant. 2001. New discoveries in visual performance of pelagic fishers. PFRP Newsletter, Vol. 6, No. 3. 1-3.

Fry, G.C., D.T. Brewer., and W.N. Venables. 2006. Vulnerability of deepwater demersal fishes to commercial fishing: evidence from a study around a tropical volcanic seamount in Papua New Guinea. Fisheries Research 81, 126–141. doi:10.1016/J.FISHRES.2006.08.002.

Fry, G. and S. Newman. 2010. Etelis carbunculus. The IUCN Red List of Threatened Species 2010. e.T154999A4688739.

Gannier, A. 2000 Distribution of cetaceans off the Society Islands (French Polynesia) as obtained from dedicated surveys. Aquatic Mammals 26:111-126.

Garland, E.C., A.W. Goldizen, M.L. Rekdahl, R. Constantine, C. Garrigue, N. Hauser, M.M. Poole, J. Robbins, and M.J. Noad. 2011. Dynamic horizontal cultural transmission of humpback whale song at the ocean basin scale. Current Biology 21:687–691.

Garland, E.C., A.W. Goldizen, M.S. Lilley, M.L. Rekdahl, C. Garrigue, R. Constantine, N.D. Hauser, M.M. Poole, J. Robbins, and M.J. Noad. 2015. Population structure of humpback whales in the western and central South Pacific Ocean determined by vocal cultural exchange. Conservation Biology 29:1198-1207.

Garland, E., M. Noad, A. Goldizen, M. Lilley, M. Rekdahl, C. Garrigue, R. Constantine, N.D. Hauser, M.M. Poole, and J. Robbins 2013. Quantifying humpback whale song sequences to understand the dynamics of song exchange at the ocean basin scale. Journal of the Acoustical Society of America 133:560-569.

Garnnier, A., S. Bourreau, and C. Casacci. 2000. Preliminary results on the distribution of wintering humpback whales (Megaptera novaeangliae) in French Polynesia 1997-1999. IWC/SC/52/IA9.

Garrigue, C., A. Aguayo, V.L.U. Amante-Helwig, C.S. Baker, S. Caballero, P. Clapham, R. Constantine, J. Denkinger, M. Donoghue, L. Florez-Gonzales, J. Greaves, N. Hauser, C. Olavarria, C. Pairoa, H. Peckham, and M. Poole. 2002. Movements of humpback whales in Oceania, South Pacific. Journal of Cetacean Research and Management 4:255-260.

Garrigue, C., R. Constantine, M. Poole, N. Hauser, P. Clapham, M. Donoghue, K. Russell, D. Paton, D.K. Mattila, J. Robbins, and C.S. Baker. 2011a Movement of individual humpback whales between wintering grounds of Oceania (South Pacific), 1999 to 2004. Journal of Cetacean Research and Management (Special Issue) 3:275-281.

Garrigue, C., T. Franklin, K. Russel, D. Burns, M. Poole, D. Paton, N. Hauser, M. Oremus, R. Constantine, S. Childerhouse, D.K. Mattila, N. Gibbs, W. Franklin, J. Robbins, P. Clapham, and C.S. Baker. 2011b. First assessment of interchange of humpback whales between Oceania and east coast of Australia. Journal of Cetacean Research and Management (Special Issue) 3:269-274.

Garrigue, C., K. Russell, and R. Dodemont. 2004. A preliminary survey of humpback whales and other cetaceans in Vanuatu, South-West Pacific. A contribution to the South Pacific Whale Research Corsortium. IWC SC/56/SH18.

Gibson, J., and G. Smith. 1999. Reducing threats to foraging habitats: in situ protection. pp. 184-188 in KL Eckert, KA Bjorndal, FA Abreu-Grobois and M Donnelly (eds), IUCN/SSC Marine Turtle Specialist Group Publication No. 4, 1999.

Gill, P.C., E.J. Eyre, C. Garrigue, and W.H. Dawbin. 1995. Observations of humpback whales (Megaptera novaeangliae) on cruise to New Caledonia and the Chesterfield Reefs. Memoirs of the Queensland Museum 38(2): 505-511. Glynn PW. 1996 Coral reef bleaching: facts, hypotheses and implications. Global Change Biol 2:495–509.

Gochfeld, M., and J. Berger. 1996. Sternidae. pp 664-667 in J del Hoyo, A Elliott and J Sargatal (eds), Handbook of the Birds of the World, Volume 3 - Hoatzin to Auks. Lynx Edicions , Barcelona, Spain.

Gomon, M.F., J.C.M. Glover, and R.H. Kuiter. 1994: The fishes of Australia's south coast. Adelaide. State Print. 992 pp.

Grandcourt, E.M. 2005. Demographic characteristics of selected epinepheline groupers (Family Serranidae; Subfamily Epinephelinae) from Aldabra Atoll, Seychelles. Atoll Res Bull. 539:201-216.

Grandison, G.S. 1996. Plant-parasitic nematodes of American Samoa, Technical Paper No. 205. South Pacific Commission, Noumea, New Caledonia.

Grant, G.A. 1994. Juvenile leatherback caught by longline fishing in American Samoa. Marine Turtle Newsletter 66:3- 5.

Grant, G.S. 1996. Prey of the introduced Bufo marinus on American Samoa. Herpetological Review 27:67-69.

Grant, G.S, and S.A. Banack. 1995. Predation on Pteropus tonganus by a barn owl in American Samoa. Australian Mammalogy 18:77-78.

Grant, G.S., and S.A. Banack. 1999. Harem structure and reproductive behaviour of Pteropus tonganus in American Samoa. Australian Mammalogy 21:111-120.

Grant, G.S., S.A. Banack, and P. Trail. 1994. Decline of the sheth-tailed bat Emballonura semicaudata (Chiroptera: Emballonuridae) on American Samoa. Micronesica 27:133-137.

Grant, G.S., P. Craig, and G.H. Balazs. 1997a. Notes on juvenile hawksbill and green turtles in American Samoa. Pacific Science 51(1): 48-53.

Grant, G.S., P. Craig, and P. Trail. 1997b. Cyclone induced shift in foraging behavior of flying foxes in American Samoa. Biotropica 29:224-228.

Green, A., and P. Craig. 1999. Population size and structure of giant clams at Rose Atoll, an important refuge in the Samoan Archipelago. Coral Reefs 18: 205-211.

Green, P.T. 1997. Red crabs in rain forest on Christmas island, Indian ocean: activity, density and biomass. Journal of Tropical Ecology 13:17-38.

Green, P.T., D.J. O'Dowd, and P.S. Lake. 1997. Control of seedling recruitment by land crabs in rain forest on a remote oceanic island. Ecology 78:2174-2186.

Grewe, P.M., and J. Hampton. 1998. An assessment of bigeye (Thunnus obesus) population structure in the Pacific Ocean based on mitochondrial DNA and DNA microsatellite analysis. SOEST 98-05, JIMAR Contribution 98-330.

Hale, P.T., A.S. Barreto, G.J.B. Ross. 2000 Comparative morphology and distribution of the aduncus and trucatus forms of bottlenose dolphin Tursiops in the Indian and Western Pacific Oceans. Aquatic Mammals 26:101-110.

Hamilton, R.J. 2003. The Role of indigenous knowledge in depleting a limited resource - A case study of the bumphead parrotfish (Bolbometopon muricatum) artisanal fishery in Roviana Lagoon, Western Province, Solomon Islands. Putting Fishers' Knowledge to Work: Conference Proceedings. pp. 68-77.

Hammond, P.S., G. Bearzi, A. Bjørge, K. Forney, L. Karczmarski, T. Kasuya, W.F. Perrin, M.D. Scott, J.Y. Wang, R.S. Wells, and B. Wilson. 2008 Stenella coeruleoalba. The IUCN Red List of Threatened Species 2008: eT20731A9223182 http://dxdoiorg/102305/IUCNUK2008RLTST20731A9223182en Downloaded on 09 November 2016.

Hampton, J. 2000. Natural mortality rates in tropical tunas: size really does matter. Can. J. Fish. Aquat. Sci. 57: 1002−1010.

Hampton, J., and P. Williams. 2005. A description of tag-recapture data for bigeye tuna in the western and central Pacific Ocean. SCRS 2004/058. Col. Vol. Sci. Pap. ICCAT, 57(2), 85-93.

Hanson, D.E., J.D. Nichols, and O.C. Steele. 2005. Propagation methods for some important Samoan timber tree species. Journal of Tropical Forest Science 17:315-318.

Hardy, J.T., and S.A. Hardy. 1969 Ecology of Tridncna in Palau. Pac Sci 23:467-472.

Harrison, P. 1983. Seabirds, an identification guide. Houghton-Mifflin, Boston MA.

Hart, S.R., M. Coetzee, R.K. Workman, J. Blusztajn, K.T.M. Johnson, and J.M. Sinton. 2004 Genesis of the Western Samoa seamount province: age, geochemical fingerprint and tectonics, Earth. Planet. Sci. Lett. 227:37–56.

Hart, S.R., H. Staudigel, A.A.P. Koppers, J. Blusztajn, E.T. Baker, and R. Workman. 2000. Vailulu'u undersea volcano: the New Samoa, Geochem. Geophys. Geosys. 1: 12.

Harzhauser, M., O. Mandic, W.E. Piller, M. Reuter, A. Kroh. 2008. Tracing back the origin of the Indo-Pacific mollusc fauna: basal Tridacninae from the Oligocene and Miocene of the Sultanate of Oman. Palaeontology 51, 199–213.

Hauser, N., P. Hoyt, and P. Clapham. 2000. Humpback whales in the Southern Cook Islands. South Pacific Journal of Cetacean Research and Management. 3:159-164.

Haynes, A. 1990. The numbers of freshwater gastropods on Pacific islands and the theory of island biogeography. Malacologia 31:237-248.

Hedlund, S.E. 1977. The extent of coral, shell and algal harvesting in Guam waters. Sea Grant Publication UGSG-77-10, University of Guam Marine Laboratory Technical Report No. 37.

Heemstra, P.C., and J.E. Randall, 1993. FAO Species Catalogue. Vol. 16. Groupers of the world (family Serranidae, subfamily Epinephelinae). An annotated and illustrated catalogue of the grouper, rockcod, hind, coral grouper and lyretail species known to date. Rome: FAO. FAO Fish. Synop. 125(16):382 pp.

Hester, F.J., and E.C. Jones. 1974 A survey of giant clams, Tridacnidae, on Helen Reef, a western Pacific atoll. Mar Fish Rev 36(7):17-22.

Heupel, M. 2009. Carcharhinus melanopterus. The IUCN Red List of Threatened Species 2009: e.T39375A10219032.

Hicks, J.W. 1985. The breeding behavior and migrations of the terrestrial crab Gecarcoidea natalis (Decapoda: Brachyura). Australian Journal of Zoology 33:127-142.

Hill, A., C. Karniski, J. Robbins, T. Pitchford, S. Todd, and R. Asmutis-Silvia. (In press) Vessel collision injuries on live humpback whales, Megaptera novaeangliae, in the southern Gulf of Maine.

Hinton, M. G., and W. Bayliff. 2002. Status of striped marlin in the Eastern Tropical Pacific Ocean in 2001 and outlook for 2002. Working paper BBRG-1. 15th Meeting of the Standing Committee on Tuna and Billfish, Honolulu, Hawaii, United States of America, 22-27 July 2002.

Hiroa, T. R. 1930 Samoan Material Culture, Bernice P. Bishop Museum Bulletin 75. Honolulu: Bishop Museum Press.

Hjerpe, J., H. Hedenas, and T. Elmqvist. 2001. Tropical rain forest recovery from cyclone damage and fire in Samoa. Biotropica 33:249-259.

Hole, D.G., M.J. Whittingham, R.B. Bradbury, G.Q.A. Anderson, P.L.M. Lee, J.D. Wilson, and J.R. Krebs. 2002. Widespread local house-sparrow extinctions. Nature 418:931-932.

Holloway, J.D. 1996. The lepidoptera of Norfolk Island, actual and potential, their origins and dynamics. pp.123-151 in A. Keast and SE Miller (eds), The origin and evolution of Pacific island biotas, New Guinea to eastern Polynesia: patterns and processes. SPB Academic Pub., Amsterdam, The Netherlands.

Hopkins, G.H.E. 1927. Butterflies of Samoa and some neighboring island groups. pp. 1-64 in Insects of Samoa and other terrestrial arthropods, Brit. Museum of Nat. Hist., London UK.

Howarth, F.G. 1991. Environmental impacts of classical biological control. Annual Review of Entomology 36:485-509.

Howe, H.F., and L.C. Westley. 1988. Ecological relationships of plants and animals. Oxford University Press, New York NY.

Hughey, K.F.D., R. Cullen, and E. Moran. 2003. Integrating economics into priority setting and evaluation in conservation management. Conservation Biology 17:93-103.

Hunter, M.D., T. Ohgushi, and P.W. Price. 1992. Effects of resource distribution on animal-plant interactions. Academic Press Inc., San Diego CA.

Hutson, A.M., S.P. Mickleburgh, and P.A. Racey. 2001. Microchiropteran bats: global status survey and conservation action plan. IUCN/SSC Chiroptera Specialist Group, International Union for the Conservation of Nature and Natural Resources, Gland. 259 pp.

Hutto, R.L. 1998. Using landbirds as an indicator species group. Pages 75-92 in J. M. Marzluff and R. Sallabanks, editors. Avian Conservation: Research and Management. Island Press, Washington, D.C., USA.

IPCC. 2013. Climate Change 2013: The Physical Science Basis. Working Group I Contribution to the IPCC 5th Assessment Report.

IWC/C/56/SH7. 2004. Report of the Annual Meeting of the South Pacific Whale Research Consortium: 2-6 April, 2004 in Byron Bay, NSW, Australia.

IWC. 2015 Report of the Scientific Committee. J Cetacean Res Manage 16.

Jarvi, S.I., M.E.M. Farias, H. Baker, H.B. Freifeld, P.E. Baker, E. Van Gelder, J.G. Massey, and C.T. Atkinson. 2003. Detection of avian malaria (Plasmodium spp.) in native land birds of American Samoa. Conservation Genetics 5:1-9.

Jenkins, M., R.E. Green, and J. Madden. 2003. The challenge of measuring global change in wild nature: are things getting better or worse? Conservation Biology 17:20-23.

Jimenez, C., A. Ortega-Rubio, S. Alvarez-Cardenas, and G. Arnaud. 1994. Ecological aspects of the land crab Gecarcinus planatus (Decapoda: Gecarcinidae) in Socorro island, Mexico. Biological Conservation 69:9-13.

Johnston, D.W., J. Robbins, M.E. Chapla, D.K. Mattila, and K.R. Andrews. 2008 Diversity, relative abundance and stock structure of odontocete cetaceans in the waters of American Samoa, 2003-2006. J Cetacean Res Manage 10:59-66.

Joung, S.-J., C.T. Chen, H.H. Lee, K.-M. Liu. 2008 Age, growth, and reproduction of silky sharks, Carcharhinus falciformis, in northeastern Taiwan waters. Fisheries Research, 90 (1-3): 78-85.

Jourdan, H. 1997. Threats on Pacific islands: the spread of the tramp ant Wasmannia auropunctata (Hymenoptera: Formicidae). Pacific Conservation Biology 3:61-64.

Judge, S. W., R. J. Camp, V. Vaivai, and P. J. Hart. 2013. Pacific Island landbird monitoring annual report, National Park of American Samoa, Taʻu and Tutuila Units, 2011. Natural Resource Technical Report NPS/PACN/NRTR—2013/666. National Park Service, Fort Collins, Colorado.

Kadiri-Jan, T., and C. Chauvet. 1998.Distribution of the juvenile coconut crab, Birgus latro (L.), on the island of Lifou, New Caledonia. Ecoscience 5:275-278.

Kahn, B. 2004. (Unpublished) Technical report prepared for the Solomon Islands Marine Assessment Coordinating Committee (SIMACC).

Kahng, S.E., and J.E. Maragos. 2006 The deepest, zooxanthellate scleractinian corals in the world? Coral Reefs 25:254.

Kami, K.S., and S.E. Miller. 1998. Samoan insects and related arthropods: checklist and bibliography. Bishop Museum Technical Report No. 13, Honolulu HI.

Kasamatsu, F., S. Nishiwaki, and H. Ishikawa. 1995 Breeding areas and southbound migrations of southern minke whales Balaenoptera acutorostrata. Mar Ecol Prog Ser 119:1-10

Katona, S.K., and H.P. Whitehead. 1981 Identifying humpback whales using their natural markings. Polar Rec 20:439-444.

Kaufman, G. 1983. Ecology of Humpback whales in American Samoa. Society for Marine Mammalogy 5th Biennial Conference, Biology of Marine Mammals. New England Aquarium, Boston, Massachusetts, 27 Nov.-1 Dec., 1983. Abstract.

Keast. A. 1996. Avian geography: New Guinea to the eastern Pacific. pp 373-398 in A. Keast and SE Miller (eds), The origin and evolution of Pacific island biotas, New Guinea to eastern Polynesia: patterns and processes. SPB Academic Pub., Amsterdam, The Netherlands.

Kitihara, M., and K. Fujii. 1994. Biodiversity and community structure of temperate butterfly species within a gradient of human disturbance: an analysis based on the concept of generalist vs. specialist strategies. Researches in Population Ecology 36:187-199.

Knowles, C. 1988. The status of the wildlife and wildlife habitats in American Samoa. DMWR Annual Report. Department of Marine and Wildlife Resources, Pago Pago, American Samoa.

Knudsen, P.A., K.D. Kluge, and R.D. Volk. 1992. American Samoa resource management bibliography. Le Vaomatua Pub, Pago Pago AS.

Kohler, N. E., J. G. Casey, and P. A. Turner. 1998 NMFS cooperative shark tagging program, 1962–93: An atlas of shark tag and recapture data. Marine Fisheries Review 60(2):87.

Koopman, K.F. 1979. Zoogeography of mammals from islands off the northeastern coast of New Guinea. American Museum Novitates 2690:1-17.

Koopman, K.F. 1993. Chiroptera. pp. 151, in DE Wilson and DM Reeder (eds), Mammal species of the world, second ed. Smithsonian Institution Press, Washington, DC. 1,206 pp.

Koopman, K.F. 1997. The subspecies of Emballonura semicaudata (Chiroptera: Emballonuridae). Journal of Mammalogy 78:358-360.

Koopman, K.F., and D.W. Steadman. 1995. Extinction and biogeography of bats on ʻEau, Kingdom of Tonga. American Museum Novitates 3125:1-3.

Kopf, R. K., P.S. Davie, D. Bromhead, and J. Pepperell. 2011. Age and growth of striped marlin (Kajikia audax) in the Southwest Pacific Ocean. ICES Journal of Marine Science; doi:10.1093/icesjms/fsr110.

Kopf, R. K., J. Pepperell, and P.S. Davie. 2009. A preliminary report on age, growth, and reproductive dynamics of striped marlin (Kajikia audax) in the southwest Pacific Ocean. WCPFC-SC5-BI-WP-01.

Koslow, J. A., G. W. Boehlert, J. D. M. Gordon, R. L. Haedrich, P. Lorance, and N. Parin. 2000: Continental slope and deep-sea fisheries: implications for a fragile ecosystem. ICES J. Mar. Sci. 57, 548–557.

Krämer, A. 1994-1995 The Samoa Islands: An Outline of a Monograph with Particular Consideration of German Samoa, Vol. I (1994; orig. 1901) and Vol. II (1995; orig.1903). Honolulu: University of Hawaiʻi Press.

Kramer, A.F. 1902-1903. Die Samoa Inseln, 2 vols. B. Schweitzerbart, Stuttgart. Germany.

Kramer, S.H., S.H. Kramer, and S.J. Newman. 1994. New deepwater fish records from the Great Barrier Reef, Australia. Pac. Sci. 48(1): 70–79.

Kume, S. 1967. Distribution and migration of bigeye tuna in the Pacific Ocean. Rep Nankai Reg Fish Res Lab 25:75–80.

Kunin, W.E., and K.J. Gaston. 1993. The biology of rarity: patterns, causes and consequences. Trends in Ecology and Evolution 8:298-301.

Kyne, P.M., and W.T. White. 2015. Taeniurops meyeni. The IUCN Red List of Threatened Species 2015: e.T60162A68646736.

Lang, JC. 1974 Biological zonation at the base of a reef. Am Sci 62:272–281.

Last, P. R. and Stevens, J. D. 1994 Sharks and Rays of Australia. CSIRO, Collingwood, Victoria, Australia.

Lawrence, A. 2014. American Samoa Sea Cucumber Fishery Health Assessment. Department of Marine and Wildlife Resources. 33 pp.

Lee, M.A.B. 1985. The dispersal of Pandanus tectorius by the land crab Cardisoma carnifex. Oikos 45:169-173.

Lefsky, M.A., W.B. Cohen, G.G. Parker, and D. H. Lidar. Remote Sensing for Ecosystem Studies.

Lehodey, P., J. Hampton, and B. Leroy. 1999. Preliminary results on age and growth of bigeye tuna (Thunnus obesus) from the western and central Pacific Ocean as indicated by daily growth increments and tagging data. Working Paper BET-2, SCTB 12, Papeete, French Polynesia, 16−23 June 1999.

Lemke, T.O. 1986. Distribution and status of the sheath-tailed bat (Emballonura semicaudata) in the Mariana Islands. Journal of Mammalogy 67:743-746.

Levey, D.J., W.R. Silva and M. Galetti. 2002. Seed dispersal and frugivory: ecology, evolution and conservation. CABI Publishing, Oxon UK.

Levings, S.C., and D.M. Windsor. 1982. Seasonal and annual variation in litter arthropod populations. pp. 355-387 in EG Leigh Jr, AS Rand, and DM Windsor (eds) The ecology of a tropical forest - seasonal rhythms and long-term changes. Smithsonian Inst. Press, Washington DC.

Liu, Z., N. Gurr, M. Schmaedick, , W. Whistler, and L. Fischer. 2011 Vegetation Mapping of American Samoa.

Li, X., D. Li, Y. Li, Z. Ma, and T. Zhai. 2002. Habitat evaluation for crested ibis: a GIS-based approach. Ecological Research 17:565-573.

Lieske, E., and R. Myers, 1994. Collins Pocket Guide. Coral reef fishes. Indo-Pacific and Caribbean including the Red Sea. Haper Collins Publishers, 400 pp.

Lindsay, R., R. Constantine, J. Robbins, D.K. Mattila, A. Tagarino, and T.E. Dennis. 2016 Characterising essential breeding habitat for whales informs the development of large-scale Marine Protected Areas in the South Pacific. Mar Ecol Prog Ser 548:263–275.

Lott, C.A., T.D. Meehan, and J.A. Heath. 2003. Estimating the latitudinal origins of migratory birds using hydrogen and sulfur stable isotopes in feathers: influence of marine prey base. Oecologia 134:505-510.

Louda, S.M., A.E. Arnett, T.A. Rand, and F.L. Russell. Invasiveness of some biological control insects and adequacy of their ecological risk assessment and regulation. Conservation Biology 17:73-82.

Louda, S.M., and P.H. Zedler. 1985. Predation in insular plant dynamics: an experimental assessment of postdispersal fruit and seed survival, Enewetak Atoll, Marshall Islands. American Journal of Botany 72:438-445.

Louda, S.M., A.E. Arnett, T.A. Rand, and F.L. Russell. Invasiveness of some biological control insects and adequacy of their ecological risk assessment and regulation. Conservation Biology 17:73-82.

Lovegrove, T., B. Bell, and R. Hay. 1992. The indigenous wildlife of Western Samoa: impacts of cyclone Val and a recovery and management strategy. New Zealand Department of Conservation. 61 pp.

Lowe, T.E., R.W. Brill, and K.L. Cousins. 2000. Blood oxygen-binding characteristics of bigeye tuna (Thunnus obesus), a high-energy-demand teleost that is tolerant of low ambient oxygen. Mar. Biol.136: 1087-1098.

Lutu-Drabble. 2000. Tusi Pese Fatuga Tuai a Samoa A Songbook of Popular Old Songs, Photographs and Proverbs of Samoa. Brebner Print. Auckland.

Lydeard, C, R.H. Cowie, W.F. Ponder, A.E. Bogan, P. Bouchet, S.A. Clark, K.S. Cummings, T.J. Frest, O. Gargominy, D.G. Herbert, R. Hershler, K.E. Perez, B. Roth, M. Seddon, E.E. Strong, and F.G. Thompson. 2004. The global decline of nonmarine mollusks. Bioscience 54:321-330.

Macguire, J.J., M.P. Sissenwine, J. Csirke, R.J.R. Grainger, and S.M. Garcia. 2006. The state of world highly migratory, straddling and other high seas fishery resources and associated species. FAO FISHERIES TECHNICAL PAPER 495. FAO, Rome. 84 pp.

Madeiros, A.C., L.L. Loope, and F.R. Cole. 1986. Distribution of ants and their effects on endemic biota of Haleakala and Hawaii volcanoes national parks: a preliiminary assessment. pp. 39-52 in Proceedings, 6th Hawaii Volcanoes Science Conference, CNPRSU, University of Hawaii Manoa, HI.

Mallon, S. 2002. Samoan Art and Artists - O Measina a Samoa. Craig Potton Publishing. Nelson, New Zealand.

Marinov, M., M. Schmaedick, D. Polhemus, R. L. Stirnemann, F. Enoka, P. S. Fa'aumu, and M. Uili 2015. Faunistic and taxonomic investigations on the Odonata fauna of the Samoan archipelago with particular focus on taxonomic ambiguities in the Íschnurine complex". Journal of the International Dragonfly Fund 91: 1-56.

Marshall, A., T. Kashiwagi, M.B. Bennett, M. Deakos, G. Stevens, F. McGregor, T. Clark, H. Ishihara, and K. Sato, 2011. Manta alfredi. The IUCN Red List of Threatened Species 2011: e.T195459A8969079.

Martien, K.K., S.J. Chivers, R.W. Baird, F.I. Archer, A.M. Gorgone, B.L. Hancock-Hanser, D. Mattila, D.J. McSweeney, E.M. Oleson, C. Palmer, V.L. Pease, K.M. Robertson, G.S. Schorr, M.B. Schultz, D.L. Webster, and B.L. Taylor. 2014 Nuclear and mitochondrial pattersn of population structure in North Pacific false killer whales (Pseudorca crassidens). The Journal of Heredity 105.

Mattila, D.K., and J. Robbins. 2008 Incidence of raised and depressed ovoid skin lesions on humpback whales of American Samoa. Report SC/60/DW3 submitted to the 60th annual meeting of the Scientific Committee.

Mauffrey, J-F., and F. Catzeflis. 2003. Ecological and isotopic discrimination of syntopic rodents in a neotropical rain forest of French Guiana. Journal of Tropical Ecology 19:209-214.

McCarthy, M. 2005. Wildlife habitat planning and protection in American Samoa: analysis and suggested approaches. Report Submitted to DMWR as part of the SWG Planning, Pago Pago, American Samoa. 19 pp. + Appendix A, 10 pp.

McClain, C.R., S.R. Signorini, and J.R. Christian. 2004. Subtropical gyre variability observed by ocean-color satellites. Deep-Sea Research Part II 51: 281–301.

McKenzie, E.H.C. 1996. Fungi, bacteria and pathogenic algae on plants in American Samoa. Technical Paper No. 206, South Pacific Commission, Noumea, New Caledonia.

McKoy, J.L. 1980 Biology, exploitation and management of giant clams (Tridacnidae) in the Kingdom of Tonga. Fish Bull 1, Fish Div Tonga, pp 1-61.

McMichael, D.F. 1975 Growth rate, population size and mantle coloration in the small giant clam Tridacna maxima (Roding), at One Tree Island, Capricorn Group, Queensland. Proc 2""nt Coral Reef Symp 1: 241-254.

Melo-Barrera, F. N., R. Félix-Uraqa, and C. Quiñónez-Velázquez. 2003. Growth and length-weight relationship of the striped marlin, Tetrapturus audax (Pisces: Istiophoridae), in Cabo San Lucas, Baja California Sur, Mexico. Ciencias marinas. 29: 305–313.

Menza, C., M. Kendall, C. Rogers, and J. Miller. 2007 A deep reef in deep trouble. Cont Shelf Res 27:2224–2230.

Mickleburgh, S.P., A.M. Hutson, and P.A. Racey. 1992. Old Word fruit bats: an action plan for their conservation. IUCN/SSC Chiroptera Specialist Group, International Union for Conservation of Nature, Gland, Switzerland.

Miller, C. 2009 Current state of knowledge of cetacean threats, diversity and habitat in the Pacific Islands Region. Meeting document UNEP/CMS/PIC2/Inf.6-01 submitted to 2nd Meeting of the Parties for the Convention of Migratory Species Memorandum of Understanding for the Conservation of Cetaceans and their Habitats in the Pacific Islands Region, Auckland, New Zealand.

Miller, C.A., and D.E. Wilson. 1997. Pteropus tonganus. Mammalian Species 552:1-6.

Miller, S.E. 1993. Final report on surveys of the arboreal and terrestrial snail fauna of American Samoa. Internal Report, Submitted to US Fish and Wildlife Service, Honolulu HI.

Miller, S.E. 1996. Biogeography of Pacific insects and other terrestrial invertebrates: a status report. pp. 463-475 in A. Keast and SE Miller (eds), The origin and evolution of Pacific island biotas, New Guinea to eastern Polynesia: patterns and processes. SPB Academic Pub., Amsterdam, The Netherlands.

Milner, G. B. 1966. Samoan Dictionary London: Oxford University Press.

Modak, T. 2011. Evolutionary origins of the Samoan avifauna. MA Thesis. Boston University.

Moffitt, R.B., and F.A. Parrish. 1996. Habitat and life history of juvenile Hawaiian pink snapper, Pristipomoides filamentosus. Pac. Sci. 50(4): 371–381.

Mohri, M. 1998. Correlation between sexual maturity of bigeye tuna and water temperatura in the Indian Ocean. Journal of the National Fisheries University. 46(4) 175-181.

Morrell, T.E., and P. Craig. 1995. Temporal variation in fruit bats observed during daytime surveys in American Samoa. Wildlife Society Bulletin 23:36-40.

Morrison, L.W. 1997. Polynesian ant (Hymenoptera: Formicidae) species richness and distribution: a regional survey. Acta OEcologica 18:685-695.

Morrison, M.J. 1986. Bird populations as indicators of environmental change. Current Ornithology 3:429-451.

Mueller-Dombois, D., and F.R. Fosberg. 1998. Vegetation of the tropical Pacific islands. Springer-Verlag, New York NY.

Munger, L.A., M. Lammers, P. Fisher-Pool, and K. Wong. 2012 Humpback whale (Megaptera novaeangliae) song occurrence at American Samoa in long-term passive acoustic recordings, 2008-2009. J Acoustic Soc Am 132:2265-2272.

Muñoz-Hincapié M.F., Mora-DM Pinto, D.M. Palacios, E.R. Secchi, and A.A. Mignucci-Giannoni. 1998 First osteological record of the dwarf sperm whale in Colombia, with notes on the zoogeography of Kogia in South America. . Revista de la Academia de Ciencias Exactas, Físicas y Naturales 22:433-444.

Munroe, E. 1996. Distributional patterns of lepidoptera in the Pacific islands. pp. 275-295 in A. Keast and SE Miller (eds), The origin and evolution of Pacific island biotas, New Guinea to eastern Polynesia: patterns and processes. SPB Academic Pub., Amsterdam, The Netherlands.

Muse, C. and S. Muse. 1982. The Birds and Birdlore of Samoa O Manu ma Tala'aga o Manu o Samoa. Pioneer Press. Walla Walla, WA.

Myers, R.F. 1991. Micronesian reef fishes. Coral Graphics, Guam.

Myllyntaus, T., M. Hares, and J. Kunnas. 2002. Sustainability in danger? Slash-and-burn cultivation in nineteenth century Finland and twentieth-century southeast Asia. Environmental History 7:267-302.

Nadon, M.O., J.K. Baum, I.D. Williams, McPherson, B.J. Zgliczynski, B.L. Richards, R.E. Schroederand R.E. Brainard. 2012. Re-Creating Missing Population Baselines for Pacific Reef Sharks. Conservation Biology 26:493-503.

Nafus, D.M. 1992. Impact of intentionally and accidentally introduced biological control agents on unintended hosts, Hypolimnas anomala and H. bolina (Lepidoptera: Nymphalidae), on Guam. Pacific Science 46:394-395.

Nagorsen, D. 1985 Kogia simus. Mammalian species 239:1-6.

Nakamura, I. 1985. FAO species catalogue. Volume 5. Billfishes of the World. An annotated and illustrated catalogue of marlins, sailfishes, spearfishes and swordfishes known to date. Volume 5. FAO Fisheries Synopsis. No. 125 (5), 65 pp.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 1998. Recovery plan for U.S. Pacific populations of the green turtle (Chelonia mydas). National Marine Fisheries Service, Silver Spring, MD.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 1998. Recovery plan for U.S. Pacific populations of the hawksbill turtle (Eretmochelys imbricata). National Marine Fisheries Service, Silver Spring, MD.

Nelson, S.L. 2003. Nutritional ecology of Old-world fruit bats: a test of the calcium-constraint hypothesis. PhD dissertation, University of Florida, FL. 139 pp.

Nelson, S.L., M.A. Miller, E.J. Heske, and G.C. Fahey, Jr. 2000a. Nutritional consequences of a change in diet from native to agricultural fruits for the Samoan fruit bat. Ecography 23:393-401.

Nelson, S.L., M.A. Miller, E.J. Heske, and G.C. Fahey, Jr. 2000b. Nutritional quality of leaves and unripe fruit consumed as famine foods by the flying foxes of Samoa. Pacific Science 54:301-311.

Newman, S.J. 2006. Research and management systems from tropical deepwater demersal fish resources—a case study from northwestern Australia. In Deep Sea 2003: Conference on the Governance and Management of Deep-Sea Fisheries. Part 2: Conference reports. Queenstown, New Zealand, 1–5 December 2003. FAO Proceedings. No. 3/2. Edited by R. Shotton. FAO, Rome, Italy. pp. 221–233.

NMFS (National Marine Fisheries Service). 2001. Final Environmental Impact Statement for the Fishery Management Plan for Pelagic Fisheries of the Western Pacific Region.

NOAA-NCCOS. 2005. Atlas of the shallow water benthic habitats of American Samoa, Guam, and the Commonwealth of Northern Marianas. NOAA Technical Memorandum NOS-NCCOS 8, Biogeographic Team. Silver Spring, MD.

Noad, M.J., D.A. Paton, N.J. Gibbs, and S.J. Childerhouse. 2006 A combined visual and acoustic survey of humpback whales and other cetaceans of Samoa.

Norberg, U., A.P. Brooke, and W.J. Trewhella. 2000. Soaring and non-soaring bats of the family Pteropodidae (flying foxes, Pteropus sp.): wing morphology and flight performance. Journal of Experimental Biology 203:651-664.

Norris, K.S., B. Würsig, R.S. Wells, M. Würsig. 1994 The Hawaiian Spinner Dolphin. University of California Press, Berkeley, California.

Nunn, P.D. 2001. Ecological crises or marginal disruptions: the effects of the first humans on Pacific islands. New Zealand geographer 57:11-20.

O'Connor, R.J. 1986. Dynamical aspects of avian habitat use. pp. 235-239 in J Verner, ML Morrison and CJ Ralph (eds) Wildlife 2000: modelling habitat relationships of terrestrial vertebrates. University of Wisconsin Press, WI.

O'Connor, P.J., and M.J. Rauzon. 2003. Inventory and monitoring of seabirds in national park of American Samoa. National Park of American Samoa Technical Report 132.

O'Dowd, D.J., and P.S. Lake. 1990. Red crabs in rain forest, Christmas island: differential herbivory of seedlings. Oikos 58:289-292.

O'Dowd, D.J., and P.S. Lake. 1991. Red crabs in rain forest, Christmas island: removal and fate of fruits and seeds. Journal of Tropical Ecology 7:113-122.

Olavarria, C., C.S. Baker, M. Poole, N. Hauser, S. Caballero, L. Flórez-González, M. Brasseur, J. Bannister, P. Capella, R. Clapham, M. Dodemont, C.J. Donoghue, M-N. Jenner, D. Moro, M. Oremus, D. Paton, H. Rosenbaum, and K. Russell. 2007 Population structure of South Pacific humpback whales and the origin of the eastern Polynesian breeding grounds. Mar Ecol Prog Ser 330:257-268.

Oremus, M., C. Garrigue, Tezanos-G Pinto, and C.S. Baker. 2015a. Phylogenetic identification and population differentiation of bottlenose dolphins (Tursiops spp.) in Melanesia, as revealed by mitochondrial DNA. Mar Mamm Sci 31:1035-1056.

Oremus, M., J. Leqata, and C.S. Baker. 2015b. Resumption of traditional drive hunting of dolphins in the Solomon Islands in 2013. Royal Society open science 2:140524-140524.

Oremus, M., M.M. Poole, G.R. Albertson, and C.S. Baker. 2012 Pelagic or insular? Genetic differentiation of rough-toothed dolphins in the Society Islands, French Polynesia. Journal of Experimental Marine Biology and Ecology 432:37-46.

Oremus, M., M.M. Poole, D. Steel, and C.S. Baker. 2007 Isolation and interchange among insular spinner dolphin communities in the South Pacific revealed by individual identification and genetic diversity. Mar Ecol Prog Ser 336:275-289.

Oshitani, S., H. Nakano, S. Tanaka. 2003 Age and growth of the silky shark Carcharhinus falciformis from the Pacific Ocean. Fisheries Research 69: 456-464.

Pacific Islands Fisheries Science Center. 2011 Coral reef ecosystems of American Samoa: a 2002–2010 overview. NOAA Fisheries Pacific Islands Fisheries Science Center, PIFSC Special Publication, SP-11-02, 48 pp.

Park, G., R. Hay, A. Whistler, and T. Lovegrove. 1992. The national ecological survey of Western Samoa: the conservation of biological diversity in the coastal lowlands of Western Samoa. New Zealand Department of Conservation. 205 pp.

Parrish, J.D. 1987. The trophic biology of snappers and groupers. In Tropical snappers and groupers: biology and fisheries management. Edited by J.J. Polovina and S. Ralston. Frederick A. Praeger (publisher), Boulder, Colo. pp. 405–463.

Patrick, B., E. Edwards, and H. Patrick. 2010. Butterflies of the Samoan Archipelago. Butterflies (Teinopalpus) 54: 13-26.

Peck, R. W., and P. C. Banko 2015. Ants of the National Park of American Samoa. Technical report HCSU-061. University of Hawai'i Hawai'i Cooperative Studies Unit, Hilo, HI. 42 pp.

Peck, R., P. Banko, F. Pendleton, M. Schmaedick, and K. Ernsberger 2014. Arthropods of Rose Atoll with special reference to ants and Pulvinaria urbicola scales (Hemiptera: Coccidae) on Pisonia grandis trees. University of Hawai'i Hawai'i Cooperative Studies Unit, Hilo, HI. 22 pp.

Perrin, W.F. 2002. Spinner dolphin. In Perrin, W.F., Würsig, B., Thewissen, J.G.M. Encyclopedia of Marine Mammals. Academic Press. San Diego, pp.1174-1178.

Perrin, W.F., M.D. Scott, G.J. Walker, and W.L. Cass. 1985 Review of Geographical Stocks of Tropical Dolphins (Stenella spp. and Delphinus delphis) in the Eastern Pacific. NOAA NMFS Tech Mem. 28, 28pp.

Peta, J.S., P.J. Mousa, A.H. Muljadia, Y.J. Sadovy, and L. Squire. 2005. Aggregations of Plectropomus areolatus and Epinephelus fuscoguttatus (groupers, Serranidae) in the Komodo National Park, Indonesia: monitoring and implications for management. Environmental Biology of Fishes (2005) 74:209–218.

Pierce, S.J., and B. Norman. 2016. Rhincodon typus. The IUCN Red List of Threatened Species 2016: e.T19488A2365291.

Pierson, E.D., T. Elmqvist, W.E. Rainey, and P.A. Cox. 1996. Effects of tropical cyclonic storms on flying foxes on the South Pacific islands of Samoa. Conservation Biology 10:438-451.

Pierson, E.D., and W.E. Rainey. 1992. The biology of flying foxes of the genus Pteropus: a review. pp. 1-17, in DE Wilson and GL Graham (eds), Pacific Island flying foxes: proceedings of an international conservation conference. US Fish and Wildlife Service Biological Report 90(3):1-76.

Pillans, R. (SSG Australia and Oceania Regional Workshop, March 2003). 2003. Nebrius ferrugineus. The IUCN Red List of Threatened Species 2003: e.T41835A10576661.

Pillans, R. (SSG Australia and Oceania Regional Workshop, March 2003). 2003. Negaprion acutidens. The IUCN Red List of Threatened Species 2003: e.T41836A10576957.

Pillans, R., and C. Simpfendorfer. (SSG Australia and Oceania Regional Workshop, March 2003). 2003. Stegostoma fasciatum. The IUCN Red List of Threatened Species 2003: e.T41878A10564988.

Polanowski, A.A., J. Robbins, D. Chandler, and S.N. Jarman. 2014 Epigenetic estimation of age in humpback whales. Molecular Ecology Resources 14:976–987.

Pratt, H.D., P.L. Bruner, and D.G. Barrett. 1987. A field guide to the birds of Hawaii and the tropical Pacific. Princeton Univ. Press, NJ.

Pyle, P., K. Kayano, K. Murphy, A. J. Pate, M. Soderbergh, C. Taft, N. Weyandt, B. Wilcox, D. Kaschube, and L. Helton. 2016. The Tropical Monitoring Avian Productivity and Survivorship (TMAPS) Program in American Samoa: 2016 Report. The Institute for Bird Populations, Point Reyes Station, CA.

Pyle, P., L. Spear, and J. Engbring. 1990. A previously unreported population of herald petrel on Ta'u island, American Samoa. Colonial Waterbirds 13:136-138.

Qiu, B., and S. Chen. 2004. Seasonal modulations in the eddy field of the South Pacific Ocean. Journal of Physical Oceanography 34: 1515-1527.

Radtke, R.L. 1985. Population dynamics of the giant clam, Tridacna maxima, at Rose Atoll. Hawaii Institute of Marine Biology.

Radtke, R.L. 1987. Age and growth information available from the otoliths of the Hawaiian snapper, Pristipomoides filamentosus. Coral Reefs, 6(1): 19–25. doi:10.1007/BF00302208.

Raghu, S., A.R. Clarke, R.A.I. Drew, and K. Hulsman. 2000. Impact of habitat modification on the distribution and abundance of fruit flies (Diptera: Tephritidae) in southeast Queensland. Population Ecology 42:153-160.

Rainey, W.E. 1990. The flying fox trade: becoming a rare commodity. Bats 8:6-9.

Rainey, W.E. 1998. Conservation of bats in remote Indo-Pacific islands. pp. 326-341, in TH Kunz and PA Racey (eds), Bat biology and conservation. Smithsonian Institution Press, Washington, DC. 365 pp.

Rainey, W.E., E.D. Pierson, T. Elmqvist, and P.A. Cox. 1995. The role of flying ofxes (Pteropodidae) in oceanic island ecosystems of the Pacific. Symposia of the Zoological Society of London 67:47-62.

Ralston, S.V., and G.T. Miyamoto. 1983. Analyzing the width of daily otolith increments to age the Hawaiian snapper, Pristipomoides filamentosus. Fish. Bull. (Wash., D.C.), 81: 523–535.

Ralston, S.V., and H.A. Williams. 1988. Depth distributions, growth, and mortality of deep slope fishes from the Marianan Archipeligo [online]. NOAA-TM-NMFS-SWFSC-113. Available from http:// www.pifsc.noaa.gov/library/pubs/tech/NOAA_Tech_Memo_113.

Randall, J.E., and P.C. Heemstra, 1991. Revision of Indo-Pacific groupers (Perciformes: Serranidae: Epinephelinae), with descriptions of five new species. Indo-Pac. Fish. (20):332 pp.

Reed, J.K. 1985 Deepest distribution of Atlantic hermatypic corals discovered in the Bahamas. Proc 5th Int Coral Reef Symp 6:249–254.

Reeves, R.R., S. Leatherwood, G.S. Stone, and L.G. Eldredge. 1999 Marine mammals in the area served by South Pacific Regional Environment Programme. South Pacific Regional Environment Programme.

Reeves, R.R., S. Leatherwood, G.S. Stone, S. Gregory, and L.G. Eldredge. 1999. Marine Mammals in the area served by the South Pacific Regional Environment Programme (SPREP). SPREP, Apia, Samoa.

Reeves, R.R., B.D. Smith, E.S. Crespo, and G. Notarbartolo di Sciara. 2003 Dolphins, whales and porpoises: 2002-2010 Conservation Action Plan for the World's Cetaceans. IUCN/SSC, Gland, Switzerland, 139 pp.

Reigl, B., W.E. Piller. 2003 Possible refugia for reefs in times of environmental stress. Int J Earth Sci 92:520–531.

Reyes, J.C., and K. Van Waerebeek. 1992 Nuevos Registros del Genero Kogia en Perú, in: Operto, J.A. et al. (Ed.) Anales de la III Reunión de Trabajo de Especialistas en Mamíferos Acuáticos de América del Sur: Montevideo, Uruguay, 25-30 de Julio de 1988. pp. 54-61.

Rhodes K.L., B. M. Taylor, C. B. Wichilmel, E. Joseph, R. J. Hamilton and G. R. Almany. 2013. Reproductive biology of squaretail coral grouper Plectropomus areolatus using age-based techniques. Journal of Fish Biology (2013) 82, 1333–1350.

Richard, G. 1978 Quantitative balance and production of Tridacna maxima in the Takapoto lagoon (French Polynesia). Proc 3rd Int Coral Reef Symp 1: 599-605.

Richmond, J.Q., S.A. Banack, and G.S. Grant. 1998. Comparative analysis of wing flight behaviour, and habitat use in flying foxes (Genus Pteropus). Australian Journal of Zoology 46:283-289.

Ricketts, T., and M. Imhoff. 2003. Biodiversity, urban areas, and agriculture: locating priority ecoregions for conservation. Conservation Ecology 8:1[online].

Robbins, J. 2012 Scar-based inference into Gulf of Maine humpback whale entanglement: 2010. Report to the National Marine Fisheries Service. Order number EA133F09CN0253.

Robbins, J., L. Dalla Rosa, J.M. Allen, D.K. Mattila, E.R. Secchi, A.S. Friedlaender, P.T. Stevick, D.P. Nowacek, and D. Steel. 2011 Return movement of a humpback whale between the Antarctic Peninsula and American Samoa: a seasonal migration record. Endangered Species Research 13:117-121.

Robbins, J., and D.K. Mattila. 2006 Summary of humpback whale research at American Samoa, 2003-2005.

Robineau, D., and P. Rancurel. 1981 Sur deux spécimens du genre Kogia (Cetacea, Physeteridae) en Nouvelle-Calédonie. Zeitschrift fuer Saeugetierkunde 46:56-58.

Roubik, D.W., and H. Wolda. 2001. Do competing honey bees matter? Dynamics and abundance of native bees before and after honey bee invasions. Population Ecology 43:53-62.

Rudd H., J. Vala, and V. Schaefer. 2002. Importance of backyard habitat in a comprehensive biodiversity conservation strategy: a connectivity analysis of urban green spaces. Restoration Ecology 10:368-375.

Sabater, M.G., and S.B. Tofaeiono. In Press. Effects of scale and benthic composition on biomass and trophic group distribution of reef fishes in American Samoa. Pacific Science.

Sadovy, Y., and A.S. Cornish. 2000. Reef fishes of Hong Kong. Hong Kong University Press, Hong Kong. 321 pp.

Saipele, N.M.M. No Date. Proverbs of Samoa. Australian High Commission for Western Samoa. Wellington, New Zealand.

Schaefer, K.M., and D.W. Fuller. 2002. Movements, behavior, and habitat selection of bigeye tuna (Thunnus obesus) in the eastern equatorial Pacific, ascertained through archival tags. Fish. Bull. 100: 765−788.

Schleucher, E., and P.C. Withers. 2002. Metabolic and thermal physiology of pigeons and doves. Physiol Biochem Zool.: 75(5):439-50.

Schultz. 1980. Samoan Proverbial Expressions. Polynesian Press. New Zealand.

Schwaner, T.D. 1980. Reproductive biology of lizards on the American Samoan islands. Occ. Papers, Museum of Natural History, Univ. of Kansas 86:1-53.

Seamon, J. O. 2011. The potential use of satellite transmitters for toloa (Pacific Black Duck, Anas superciliosa) investigations in American Samoa. ASG_DMWR_Report #56665-2011-2.

Seamon, J.O., S.S. Mann, O.C. Steele, and R.C.B. Utzurrum. 2006.The conservation value of remnant forest patches: tree composition, spatial patterns and recruitment in the Ottoville lowland forest, American Samoa. Pacific Science 60:319-332.

Seamon, J. O., R. C. B. Utzurrum, A. Tualaulelei, S. Fa'aumu, V. Vaivai, and R. Meyer. 2010. Coexistence and long-term population dynamics of three frugivorous birds. DRAFT2 ASG-DMWR Report #56665-2010-2.

Seamon, J. O., V. Vaivai, A. Tualaulel'ei, and R. C. B. Utzurrum. Short-and-long term resource use by a generalist frugivore, the pacific imperial-pigeon. 2010. DRAFT1 ASG-DMWR Report #56665-2010-1.

Seki, T., T. Taniuchi, H. Nakano, and M. Shimizu. 1998 Age, growth and reproduction of the oceanic whitetip shark from the Pacific Ocean. Fisheries Science 64, 14–20.

Shanahan, M., R.D. Harrison, R. Yamuna, W. Boen, and I.W.B. Thornton. 2001. Colonization of an island volcano, Long island, Papua New Guinea, and an emergent island, Motmot, in its caldera lake. V. Colonization by figs (Ficus spp.), their dispersers and pollinators. Journal of Biogeography 28:1367-1377.

Sherman, P.M. 2002. Effects of land crabs on seedling densities and distributions in a mainland neotropical rain forest. Journal of Tropical Ecology 18:67-89.

Simberloff, D. How much information on population biology is needed to manage introduced species? Conservation Biology 17:83-92.

Sinavaiana, C. and J. Enright. 1992. The Cultural Significance of the Flying Fox in Samoa: A Legendary View. In D.E. Wilson and G.L. Graham (Eds.). Pacific Island Flying Foxes: Proceedings of an International Conservation Conference. Pp. 36-38. USFWS Biological report 90(23). USFWS, Washington D.C.

Skillman, R. A., and M. Y. Y. Yong. 1976. Von Bertalanffy growth curves for striped marlin, Tetrapturus audax, and blue marlin, Makaira nigricans, in the central north Pacific Ocean. Fishery Bulletin. 74: 5353–566.

Slikas. B., S.L. Olson, and R.C. Fleischer. 2002. Rapid, independent evolution of flightlessness in four species of Pacific island rails (Rallidae): an analysis based on mitochondrial sequence data. Journal of Avian Biology 33:5-14.

Smallwood, K.S. 2013. Comparing bird and bat fatality-rate estimates among North American wind-energy projects. Wildlife Society Bulletin 37:19-33.

Smale, M.J. 2009. Carcharhinus amblyrhynchos. The IUCN Red List of Threatened Species 2009: e.T39365A10216946.

Smith, M. K., E. Kostlan. 1991: Estimates of age and growth of ehu Etelis carbunculus in four regions of the Pacific from density of daily increments in otoliths. Fish. Bull. 89, 461–472.

Smith, S. E., D.W. Au, and, C. Show. 1998 Intrinsic rebound potentials of 26 species of Pacific sharks. Marine and Freshwater Research 49, 663–678.

Sowell, T.L. 2000. Worn with Pride   Celebrating Samoan Artistic Heritage. Oceanside Museum of Art.

Spalding, M.D., H.E. Fox, G.R. Allen, N. Davidson, Z.A. Ferdaña, M. Finlayson, B.S. Halpern, M.A. Jorge, A. Lombana, S.A. Lourie, K.D. Martin, E. McManus, J. Molnar, C.A. Recchia, and J. Robertson. 2007. Marine Ecoregions of the World: a bioregionalization of coast and shelf areas. BioScience 57: 573-583.

SPREP. 2012 Pacific Islands Regional Marine Species Programme 2013-2017. Secretariat of the Pacific Regional Environment Programme, P.O. Box 240, Apia, Samoa.

SPREP/CMS. 2005. Memorandum of understanding for the conservation of cetaceans and their habitats in the Pacific Island Region – A proposal of the formal meeting of the Drafting Group on the Memorandum of Understanding. Third Meeting on the CMS and Marine Mammal Conservation, 5-7 July 2005, Nadi, Fiji.

SPWRC. 2004 Report of the Annual Meeting of the South Pacific Whale Research Consortium: 2-6 April 2004, Byron Bay, NWS, Australia. Unpublished report to the Scientific Committee of the International Whaling Commission. SC/55/SH7.

Stattersfield, A.J., M.J. Crosby, A.J. Long, and D.C. Wege. 1998. Endemic bird atlas of the world - priorities for conservation. Birdlife Intl., Cambridge UK.

Steadman, D.W., J. Franklin, D.R. Drake, H.B. Freifeld, L.A. Bolick, D.S. Smith, and T.J. Motley. 1999. Conservation status of forests and vertebrate communities in the Vava'u island group, Tonga. Pacific Conservation Biology 5:191-207.

Steadman, D.W., and G.K. Pregill. 2004. A pre-historic, noncultural vertebrate assemblage from Tutuila, American Samoa. Pacific Science 58:615-624.

Steel, D., N. Schmitt, M. Anderson, D. Burns, S. Childerhouse, R. Constantine, T. Franklin, W. Franklin, N. Gales, C. Garrigue, N. Gibb, N. Hauser, D. Mattila, C. Olavarria, D. Paton, M. Poole, J. Robbins, J. Ward, P. Harrison, P. Baverstock, M. Double, C.S. Baker. 2011 Initial genotype matching of humpback whales from the 2010 Australia/New Zealand Antarctic Whale Expedition (Area V) to Australia and the South Pacific.

Steubel, C., A. Kramer, and B. Herman. 1976. Tala o le Vavau - The Myths, Legends, and Customs of Old Samoa. Pacifika Press. Auckland, New Zealand.

Strasburg, D.W. 1958 Distribution, abundance and habits of pelagic sharks in the central Pacific Ocean. Fishery Bulletin 59, 335-361.

Surman, C.A. and R.D. Wooller. 2003. Comparative foraging ecology of five sympatric terns at a sub-tropical island in the eastern Indian ocean. Journal of Zoology, London 259:219-230.

Swezey, O.H. 1921. The butterflies of the Samoan islands. Proceedings of the Hawaiian Entomological Society 4: 601- 605.

Swezey, O.H. 1942. Notes on food habits of Lepidoptera in Samoa. Proceedings of the Hawaiian Entomological Society 11:202-216.

Swihart, R.K., T.M. Gehring, M.B. Kolozsvary, and T.E. Nupp. 2003. Responses of 'resistant' vertebrates to habitat loss and fragmentation: the importance of niche breadth and range boundaries. Diversity and Distributions 9:1-18.

Tarburton, M.K. 2002. Demise of the Polynesian sheath-tailed bat Emballonura semicaudata in Samoa. Micronesica 34:105-108.

Taylor, P.B. 1996. Rallidae. pp. 163-197 in J del Hoyo, A Elliott and J Sargatal (eds), Handbook of the Birds of the World, Volume 3 - Hoatzin to Auks. Lynx Edicions , Barcelona, Spain.

Temple, S.A., and J.A. Wiens. 1989. Bird populations and environmental changes: can birds be bio-indicators? American Birds 43:260-270.

Thomson, S.D., A.P. Brooke, and J.R. Speakman. 1998. Diurnal activity in the Samoan flying fox, Pteropus samoensis. Philosophical Transactions of the Royal Society of London, Series B 353:1595-1606.

Tomczak, M. and J.S. Godfrey. 2003. Regional Oceanography: an Introduction. 2nd improved edition. Daya Publishing House, Delhi. 390 pp.

Townsend, C.H. 1935 The distribution of certain whales as shown by logbook records of American whaleships. Zoologica: scientific contributions of the New York Zoological Society 19:1-50.

Townsend, C.H. 1935. The distribution of certain whales as shown by logbook records of American whaleships. Zoologica 19: 1-50 + maps.

Trail, P.W. 1994. The phenology of rainforest plants in Tutuila, American Samoa. DMWR Biological Report Series No. 58.

Trail, P.W., T. Morrell and A. Tualaulelei. 1992. Declines in land bird populations on Tutuila island, American Samoa, 1986-1992. DMWR Biological Report Series, No. 32.

Tsutsui, N.D., and A.V. Suarez. 2003. The colony structure and population biology of invasive ants. Conservation Biology 17:48-58.

Tuato'o-Bartley, N., T.E. Morrell, and P. Craig. 1993. Status of sea turtles in American Samoa in 1991. Pacific Science 47(3): 215-221.

Turner, G. 1989 [1884]. Samoa: a Hundred Years Ago and Long Before. Suva, Fiji: Institute of Pacific Studies, University of the South Pacific.

Uchiyama, J.H., and D.T. Tagami. 1984. Life history, distribution, and abundance of bottomfishes in the northwestern Hawaiian Islands. In Proceedings of the Second Symposium on Resource Investigations in the Northwestern Hawaiian Islands. Edited by R.W. Grigg and K.Y. Tanoue. UNIHI-SeaGrant-MR-84-01. pp. 229–247.

US Fish and Wildlife Service. 2005. Regional seabird conservation plan, Pacific region. USFandWS Migratory Birds and Habitat Program, Portland OR.

Utzurrum, R.C.B. 2002. Sea turtle conservation in American Samoa. pp. 33-36, in I Kinan (ed), Proceedings of the western Pacific sea turtle cooperative research and management workshop. Western Pacific Regional Fishery Management Council, Honolulu.

Utzurrum, R.C.B., G.J. Wiles, A.P. Brooke, and D.J. Worthington. 2003. Count methods and population trends in Pacific Island flying foxes. pp. 49-61, in TJ O'Shea and MA Bogan (eds), Monitoring trends in bat populations of the United States and Territories: problems and prospects. US Geological Survey, Biological Resources Discipline, Information and Technology Report, USGS/BRD/ITR–2003-0003. 274 pp.

Utzurrum, R.C., and J.O. Seamon. 2001. Monitoring for conservation and management: some empirical and theoretical approaches. Sylvatrop: The Tech. Journal of Phil. Ecosys. and Nat. Res. 10:88-105.

van Balgooy, M.M.J., P.H. Hovenkamp and P.C. van Welzen. 1996. Phytogeography of the Pacific - floristic and historical distribution patterns in plants. pp.191-213 in A. Keast and SE Miller (eds), The origin and evolution of Pacific island biotas, New Guinea to eastern Polynesia: patterns and processes. SPB Academic Pub., Amsterdam, The Netherlands.

van Hooidonk, R., J. A. Maynard, D. Manzello, and S. Planes. 2014. Opposite latitudinal gradients in projected ocean acidification and bleaching impacts on coral reefs. Global Change Biology 20:103–112.

Van Waerebeek, K., F. Fernando, B. Haase, D.M. Palacios, D.M. Mora- Pinto, and M. Munoz-Hincapie. 1998 Inshore Records of the Striped Dolphin, Stenella coeruleoalba, from the Pacific Coast of South America. Rep Int Whal Commn 48:525-532.

Van Waerebeek, K., R. Leaper, A.N. Baker, V. Papastavrou, and D. Thiele. 2004 Odontocetes of the Southern Ocean Sanctuary. Paper SC/56/SOS1 presented to the IWC Scientific Committee, July 2004, Sorrento, Italy(unpublished). 35 pp.

Van Waerebeek, K., J.C. Reyes, and B.A. Luscombe. 1987 A second record of the Pygmy sperm whale Kogia breviceps (de Blainville, 1838) (Cetacea, Physeteridae) from the Peruvian coast. Zeitschrift fuer Saeugetierkunde 52:192-194

Vargas-Ángel, B., S.L. Godwin, J. Asher, and R.E. Brainard. 2009. Invasive colonial tunicate spreading across coral reefs at remote Swains Island, American Sāmoa, South Pacific. Coral Reefs 28:53.

Vargo, D. 2000. Soil invertebrates of American Samoa. Micronesica 33:1-10.

Veron, J. E. N. 2014. Results of an update of the Corals of the World Information Base for the Listing Determination of 66 Coral Species under the Endangered Species Act. Report to the Western Pacific Regional Fishery Management Council, Honolulu.

Wade, P.R., and T. Gerrodette. 1993. Estimates of Ceteacean Abundance and Distribution in the Eastern Tropical Pacific. Reports of the International Whaling Commission. 43: 477-494. SC/44/O18.

Wang, H.G., R.D. Owen, C. Sanchez-Hernandez, and M.D.L. Romero-Almaraz. 2003. Ecological characterization of bat species distributions in Michoacan, Mexico, using a geographic information system. Global Ecology and Biogeography 12:65-85.

Wass, R.C. 1984. An annotated checklist of the fishes of Samoa. NOAA Technical Report SSRF-781.

Watling, D. 2001. A guide to the birds of Fiji and western Polynesia. Environmental Consultants Ltd., Suva Fiji.

Webb, E.L., M. van de Bult, W. Chutipong, and M.E. Kabir. 2006. Composition and structure of lowland rainforest tree communities on Ta'u, American Samoa. Pacific Science 60(3): 333-354.

Webb, E.L., M. van de Bult, W. Chutipong, and M.E. Kabir. In Prep. Composition and structure of lowland rainforest tree communities on Ta'u, American Samoa.

Webb, E.L., and S. Fa'aumu. 1999. Diversity and structure of tropical rain forest of Tutuila, American samoa: effects of site age and substrate. Plant Ecology 144:257-274.

Webb, E.L., B.J. Stanfield, and M.L. Jensen. 1999. Effects of topography on rainforest tree community structure and diversity in American Samoa, and implications for frugivore and nectarivore populations. Journal of Biogeography 26:887-897.

Wells, S.M., R.M. Pyle, and N.M. Collins. The IUCN Invertebrate Red Data Book. IUCN, Gland, Switzerland.

Wetterer, J.K., and D. L. Vargo 2003. Ants (Hymenoptera: Formicidae) of Samoa. Pacific science 57: 409-419.

Whistler, W.A. 1980. The vegetation of eastern Samoa. Allertonia 2:45-190.

Whistler, W.A. 1983. The flora and vegetation of Swains island. Atoll Research Bulletin 262:1-25. Whistler, W.A. 1992. Vegetation of Samoa and Tonga. Pacific Science 46:159-178.

Whistler, W.A. 1995. Permanent forest plot data from the National Park of American Samoa. Cooperative National Park Resources Study Unit, Honolulu, HI, Technical Report 98.

Whistler, W.A. 2002. The Samoan rainforest - A guide to the vegetation of the Samoan archipelago. Isle Botanica, Honolulu HI.

Whitesell, T. G., W. A. Whistler, and N. M. Ambacher. Vegetation survey and forest inventory, American Samoa. (1988).

Wiles, G.J. 1992. Recent trends in th fruit bat trade on Guam. pp. 53-60, in D.E. Wilson, and G.L. Graham (eds), Pacific Island flying foxes: proceedings of an international conservation conference. US Fish and Wildlife Service Biological Report 90(3):1-76.

Wiles, G.J., J. Engbring, and D. Otobed. 1997. Abundance, biology, and human exploitation of bats in the Palau islands. Journal of Zoology, London, 241:203-227.

Wiles, G.J., and N.H. Payne. 1986. The trade in fruit bats, Pteropus spp., on Guam and other Pacific islands. Biological Conservation 38:143-161.

Williams, A.J., K. Loeun, S. J. Nicol, P. Chavance, M. Ducrocq, S. J. Harley, G. M. Pilling, V. Allain, C. Mellin, and C. J. A. Bradshaw. 2013. Population biology and vulnerability to fishing of deep-water Eteline snappers. J. Appl. Ichthyol. 29, 395–403.

Williams I.D., Baum, J.K. Heenan, A. Hanson, K.M. Nadon, and M.O. Brainard. 2015. Human, Oceanographic and Habitat Drivers of Central and Western Pacific Coral Reef Fish Assemblages. PLoS ONE 10 (4): 1-19.

Willis, P.M., and R.W. Baird. 1998 Status of the Dwarf Sperm Whale, Kogia simus, with special reference to Canada. Canadian Field-Naturalist 112:114-125.

Wilson, C.E., W.F. Perrin, J.W. Gilpatrick Jr., and S. Leatherwood. 1987 Summary of Worldwide Locality Records of the Striped Dolphin, Stenella coeruleoalba. NOAA NMFS, SWFC Tech. Mem. 90, 65 pp.

Wilson, D.E., and J. Engbring. 1992. The flying foxes, Pteropus samoensis and Pteropus tonganus: status in Fiji and Samoa. pp. 74-101, in DE Wilson and GL Graham (eds), Pacific Island flying foxes: proceedings of an international conservation conference. US Fish and Wildlife Service Biological Report 90(3):1-76.

Wilson, E.O., and R.W., Taylor. 1967. The ants of Polynesia. Pacific Insects Monographs 14:1-109.

Witherington, B.E., 1999. Reducing threats to nesting habitat: in situ protection. pp. 179-183 in KL Eckert, KA Bjorndal, FA Abreu-Grobois and M Donnelly (eds), IUCN/SSC Marine Turtle Specialist Group Publication No. 4, 1999.

Wittmann, F., D. Anhuf, and W.J. Junk. 2002. Tree species distribution and community structure of of central Amazonian varzea forests by remote-sensing techniques. Journal of Tropical Ecology 18:805-820.

Wodzecki, K., and H. Felton. 1975. The peka, or fruit bat (Pteropus tonganus tonganus) (Mammalia, Chiroptera), of Niue Island, South Pacific. Pacific Science 29:131-138.

Wodzecki, K., and H. Felten. 1981. Fruit bats of the genus Pteropus from the islands Rarotonga and Mangaia, Cook Islands, Pacific Ocean (Mammalia: Chiroptera). Senckenbergiana Biologica 61:143-151.

Woodall, P. 2001. Alcedinidae. pp. 219-22 in del Hoyo, A. Elliott, and J. Sargatal (eds), Handbook of the Birds of the World, Volume 6 - Mousebirds to Hornbills. Lynx Edicions, Barcelona, Spain.

Wulder, M.A., R.J. Hall, N.C. Coops, and S.E. Franklin. High spatial resolution remotely sensed data for ecosystem characterization. Bioscience 54, 511–521. 2004.

Zgliczynski, B., J.I.D. Williams, R.E. Schroeder, M.O. Nadon, B.L. Richards, and S.A. Sandin. 2013. The IUCN Red List of Threatened Species: an assessment of coral reef fishes in the US Pacific Islands. Coral Reefs 32: 637-650.

APPENDIX 1. A GUIDE TO THE EIGHT REQUIRED ELEMENTS AS FULFILLED IN AMERICAN SAMOA'S CWCS

ELEMENT No.	**DESCRIPTION**	APPLICABLE SECTIONS
1	**Information on the distribution and abundance of species**	Sections 3 & 5
2	**Descriptions of locations and relative condition of key habitats and community types**	Section 4 & 6 Figures 3, 4a & 4b, Appendix 4
3	**Description of problems, and priority research and survey efforts**	Sections 3, 4, 5, 6; also see Section 9
4	**Description of conservation actions**	Detailed descriptions in Sections 3, 5, & 6 (subheading Conservation Priorities); also see Section 7 (Cultural Approach) & Section 8 (Statutory and Regulatory Approaches). General action categories summarized in Section 9
5	**Proposed plans for monitoring & Adaptive management**	See Sections 9 & 10; also Sections 3 & 5 for wildlife species; Section 6 for habitat; Figure 16
6	**Descriptions of procedures to review the strategy**	See Section 2.2.2. Informal review ongoing, formal review every 10 years; also Section 10
7	**Plans for coordinating the development, implementation, review, and revision of the plan with Federal, State, and local agencies**	See Section 2.2, with appropriate agencies; also see Sections 9 & 10
8	**Public participation**	See Section 2.2.1, Figure 1.

APPENDIX 2. TERRESTRIAL VERTEBRATE SPECIES AND MARINE TURTLES KNOWN OR THOUGHT TO HAVE HAD RESIDENT BREEDING POPULATIONS IN THE TERRITORY OF AMERICAN SAMOA. Species highlighted in bold are priority species for new studies.

Species	Common Name	Taxonomic Status	Abundance	Distribution	Threat	Conservation Class	Data
HERPETOFAUNA							
Geckos:							
Gehyra mutilata	Stump-toed Gecko	I	M	M	L	IV	L
Gehyra oceanica	Polynesian Gecko	I	A	G	L	IV	M
Hemidactylus frenatus	House Gecko	C	A	G	L	IV	M
Lepidodactylus lugubris	Mourning Gecko	C	A	G	L	IV	M
Nactus pelagicus	Pelagic Gecko	I	M	M	H	IV	L
Skinks:							
Cryptoblepharus poecioplurus	Snake-eyed Skink	I	R	V	H,S	II	L
Emoia adspersa	Micronesian Skink	I	M	R	P	II	L
Emoia cyanura	Azure-tailed Skink	I	A	G	L	IV	M
Emoia lawesi	Lawes Skink	I	U	M	H	IV	L
Emoia nigra	Black Skink	I	A	G	L	IV	M
Emoia samoensis	Samoan Skink	E	M	G	L	IV	M
Lipinia noctua	Moth Skink	I	M	G	L	IV	L
Snakes:							
Candoia bibroni	Pacific Boa	I	R	V	P,S	I	L

Ramphotyphlops brahminus	Soil Snake	C	M	R	-	V	M
Marine Turtles:							
Chelonia mydas	Green turtle	I	U	R	H,P,S	II	M
Erytmochelys imbricata	Hawksbill	I	U	R	H,P,S	II	M
AVIFAUNA							
Sea birds:							
Anous m. minutus	Black Noddy	I	M	M	L	IV	H
Anous stolidus pileatus	Brown Noddy	I	A	G	L	IV	M
Gygis a. alba	White Tern	I	A	G	L	IV	H
Nesofregetta fuliginosa	Polynesian Storm-petrel	I	?	?	P	I	L
Fregata a. ariel	Lesser Frigatebird	I	M	G	L	IV	M
Fregata minor palmerstoni	Great Frigatebird	I	M	G	L	IV	M
Sterna anaethaetus	Bridled Tern	I	U	R	L	I	L
Sterna fuscata oahuensis	Sooty Tern	I	M	R	L	IV	H
Sterna lunata	Grey-backed Tern	I	U	R	L	IV	H
Sula dactylatra personata	Masked Booby	I	U	R	L	IV	H
Sula leucogaster plotus	Brown Booby	I	M	G	L	IV	M
Sula sula rubripes	Red-footed Booby	I	M	G	L	IV	H
Phaethon lepturus	White-tailed Tropicbird	I	A	G	L	IV	M
Phaethon rubricauda	Red-tailed Tropicbird	I	M	R	L	IV	H
Procelsterna cerulea nebouxi	Blue-grey Noddy	I	U	W	L	IV	M

Pseudobulweria rostrata	Tahiti Petrel	U	M	M	P	II	M
Pterodroma arminjoniana heraldica	Herald Petrel	U	U	R	P	I	M
Pterodroma leucoptera brevipes	Collared Petrel	I	?	?	P	I	L
Puffinus lherminieri dichrous	Audobon's Shearwater	I	U	M	P	II	M
Puffinus nativitatus	Christmas Shearwater	I	?	?	P	I	L
Puffinus pacificus	Wedge-tailed Shearwater	I	?	R	P	I	L
Land birds:							
Acridotheres fuscus	Common Myna	C	A	R		V	H
Acridotheres tristis	Jungle Myna	C	A	R	-	V	H
Aerodramus s. spodiopygius	White-rumped Swiftlet	I	A	G	H	IV	H
Anas superciliosa pelewensis	Pacific black Duck	I	R	R	H,P	I	L
Aplonis atrifusca	Samoan Starling	E	A	G	D,I	III	H
Aplonis tabuensis m anuae/tutuilae	Polynesian Starling	E	U	G	I,S	III	H
Clytorhynchus vitiensis powelli	Lesser Shrikebill	E	U	M	H,S	III	H
Ducula p. pacifica	Pacific Imperial-pigeon	U	M	G	P	III	H
Foulehaio c. carunculata	Wattled Honeyeater	U	A	G	D	IV	H
Gallicolumba s. stairi	Shy Ground-dove	U	R	R	H,S	III	H
Gallirallus philippensis goodsoni	Banded Rail	I	A	G	P	IV	H
Gymnomyza samoensis	Ma'oma'o	E	V	V	C,H,I	II	H
Egretta s. sacra	Pacific Reef Egret	I	M	G	L	IV	M
Myzomela cardinalis	Cardinal Honeyeater	U	M	R	D	IV	H

Porphyrio porphyrio sam oensis	Purple Swamphen	I	U	M	P	I	L
Porzana t. tabuensis	Spotless Crake	I	V	V	H,P,S	II	M
Ptilinopus s p. perousii	Many-colored Fruit-dove	U	R	M	C,H,S	III	H
Ptilinopus porphyraceus fasciatus	Purple-capped Fruit-dove	U	M	G	C	IV	H
Pycnonotus cafer	Red-vented Bulbul	C	A	R	-	V	H
Todiramphus chloris m anuae/pealei	Collared Kingfisher	I	M	G	H,I	IV	H
Tyto alba delicatula	Common Barn-owl	I	M	G	H	IV	M
Vini australis	Blue-crowned Lory	U	U	R	I,P	III	H
MAMMALS							
Terrestrial mammals:							
Emballonura semicaudata	Sheath-tailed bat	I	V	G	C,S	I	H
Mus musculus	House mouse	C	?	?	-	V	L
Pteropus s. samoensis	Samoan flying fox	E	U	M	C,D,H,P	II	H
Pteropus t. tonganus	Insular or Tongan flying fox	U	A	G	C,P	III	H
Rattus exulans	Polynesian Rat	C	A	G	-	V	H
Rattus norvegicus	Norway rat	C	A	G	-	V	H
Rattus rattus	Roof rat	C	?	G	-	V	L
Sus scrofa	Domestic Pig	C	M	G	-	V	M

Taxonomic Status: **U** - Unique to American Samoa in the USA, **E** - species or subspecies globally endemic to the Samoan islands, **I** - indigenous but occurs elsewhere in the USA, **C** - commensal with man, exotic or introduced, **W** - geographically widespread, some migratory

Abundance (known or inferred abundance *in the territory* where the species occurs, and scaled for expected values for the species): **V** - very rare, **R** - rare, **U** - uncommon, **M** - moderately common, **A** - abundant, **?** - data deficient

Distribution (known or inferred spatial distribution *in the territory*): **V** - very restricted, occurs on a single island and is not widespread thereon,

R - restricted to a single island, or to rare habitats on several islands, **M** - restricted to specific habitats that are not rare on more than one island, or to a subset of islands, **G** - occurs in many habitats, or on most or all islands, **?** - data deficient.

Threat (known or inferred existing threats based on best available information): **C** - potential susceptibility to Catastrophes such as hurricanes, **D** - high prevalence of Disease in the species, **H** - associated with a threatened or restricted Habitat type, **I** - high likelihood of competition with Introduced species, **L** - presumed Low or no current threats identified, **P** - susceptible to Predation by humans or introduced species, **S** - susceptible to declines due to Small population sizes.

Conservation Class (conservation study priority class): **I** - High priority: insufficient data available to make informed assessment of conservation status, **II** - High Priority: available data permits identification of threats or known low population sizes, **III** - Priority: ongoing studies or conservation and management efforts, **IV** - Moderate Priority: high abundance, widespread distribution, or lack of known imminent threats, butmonitor for em erging threats, **V** - Low Priority: species for which local extinction would be satisfactory.

Data (reliability or recency of sources of data used in Abundance, Distribution, and Threat columns): **H** - High reliability, based on recent publications or current/ongoing but as yet unpublished survey data, **M** - Moderate reliability, based on irregular surveys, incidental captures, or repeated anecdotal evidence and personal observations, **L** - Low reliability, based on possibly dated literature reports or infrequent anecdotal or personal observations.

APPENDIX 3. MARINE SPECIES KNOWN OR THOUGHT TO HAVE HAD RESIDENT BREEDING POPULATIONS IN THE TERRITORY OF AMERICAN SAMOA.

Fish and marine invertebrate species are ranked and sorted by species of greates conservation concern. All marine mammals know within the territory are included.

Species	Common Name	Taxonomic Status	Distribution	Abundance	Threat	Conservation Class	Data
Tridacna maxima	giant clam	W	M	U	P, H	II	H
Tridacna squamosa	giant clam	W	M	U	P, H	II	H
Acropora speciosa	hard coral	W	M	U	C, H	II	H
Pavona diffluens	hard coral	W	M	U	C, H	II	H
Holothuria fuscogilva	sea cucumber	W	M	R	P	II	H
Holothuria whitmaei	sea cucumber	W	M	R	P	II	H
Euphyllia paradivisa	hard coral	W	M	R	C, H	II	H
Actinopyga mauritania	sea cucumber	W	M	M	P	II	H
Etelis carbunculus	Ruby snapper	W	M	M	P	II	H
Etelis coruscans	Flame snapper	W	M	M	P	II	H
Pistipomoides filamentosus	Pink snapper	W	M	M	P	II	H
Acropora globiceps	hard coral	W	M	M	C, H	II	H
Isopora crateriformis	hard coral	W	M	M	C, H	II	H
Epinephelus lanceolatus	Giant grouper	W	M	V	P	III	H

Bolbometopon muricatum	Bumphead parrotfish	W	M	V	C, H, P	III	H
Epinephelus polyphekadion	Camouflage grouper	W	M	U	P	III	H
Cheilinus undulatus	Napoleon wrasse	W	M	U	C, H, P	III	H
Kajikia audax	Striped marlin	W	G	U	P	III	H
Carcarhinus falciformis	Silky shark	W	G	U	P	III	H
Carcarhinus longimanus	Oceanic white-tip shark	W	G	U	P	III	H
Plectropomus areolatus	Squaretail grouper	W	M	R	P	III	H
Plectropomus laevis	Black-saddled grouper	W	M	R	P	III	H
Epinephelus fuscoguttatus	Brown-marbled grouper	W	M	R	P	III	H
Carcarhinus amblyrhynchos	Grey reef shark	W	M	R	P	III	H
Carcarhinus melanopterus	Black-tip reef shark	W	M	R	P	III	H
Triaenodon obesus	White-tip reef shark	W	M	R	P	III	H
Sphyrna lewini	Scalloped hammerhead	W	M	R	P	III	H
Rhincodon typus	Whale shark	W	M	R	P	III	H
Nebrius ferrugineus	Tawny nurse shark	W	M	R	P	III	H
Stegostoma fasciatum	Zebra shark	W	M	R	P	III	H
Negaprion acutidens	Sicklefin lemon shark	W	M	R	P	III	H
Taeniura meyeni	Black-blotched stingray	W	M	R	P	III	H

Urogymnus asperrimus	Thorny stingray	W	M	R	P	III	H
Manta alfredi	Reef manta ray	W	M	R	P	III	H
Thunnus obesus	Big-eye tuna	W	G	M	P	III	H
Palola viridis	palolo worm	W	M	C	P? H?	III	H
Charonia tritonis	trumpet shell	W	M	V	P	I	L
Hippopus hippopus	giant clam	W	M	U	P, H	I	L
Acropora retusa	hard coral	W	?	U	C, H	III	L
Selar crumenopthalmus	Big-eye scad	W	M	A	P?	IV	M
Marine mammals							
Megaptera novaeangliae	Humpback whale	W	G	M	S	II	H
Balaenoptera acutorostrata	Minke whale, (Dwarf/Antarctic)	W	G	U	S	I	L
Balaenoptera bonaerensis	Minke whale, (Dwarf/Antarctic)	W	G	?	S	I	L
Physeter macrocephalus	Sperm whale	W	G	U	S	I	L
Kogia sima	Dwarf sperm whale	W	G	?	S	I	L
Orcinus orca	Killer whale	W	G	?	S	I	L
Pseudorca crassidens	False killer whale	W	G	?	S	I	L
Globicephala macrorhynchus	Short-finned pilot whale	W	G	?	S	I	L
Tursiops truncatus	Bottlenose dolphin	W	G	M	S	I	L

Tursiops aduncus	Bottlenose dolphin	W	G	?	S	I	L
Stenella longirostris longirostris)	Spinner dolphin	W	G	M	S	I	L
Stenella coeruleoalba	Striped dolphin	W	G	M	S	I	L
Stenella attenuata	Pantropic spotted dolphin	W	G	M	S	I	L
Steno bredanensis	Rough-toothed dolphin	W	G	M	S	I	L
Ziphius cavirostris	Cuvier's beaked whale	W	G	U	S	I	L

Taxonomic Status: **U** - Unique to American Samoa in the USA, **E** - species or subspecies globally endemic to the Samoan islands, **I** - indigenous but occurs elsewhere in the USA, **C** - commensal with man, exotic or introduced, **W** - geographically widespread, some migratory

Abundance (known or inferred abundance *in the territory* where the species occurs, and scaled for expected values for the species): **V** - very rare, **R** - rare, **U** - uncommon, **M** - moderately common, **A** - abundant, **?** - data deficient

Distribution (known or inferred spatial distribution *in the territory*): **V** - very restricted, occurs on a single island and is not widespread thereon,

R - restricted to a single island, or to rare habitats on several islands, **M** - restricted to specific habitats that are not rare on more than one island, or to a subset of islands, **G** - occurs in many habitats, or on most or all islands, **?** - data deficient.

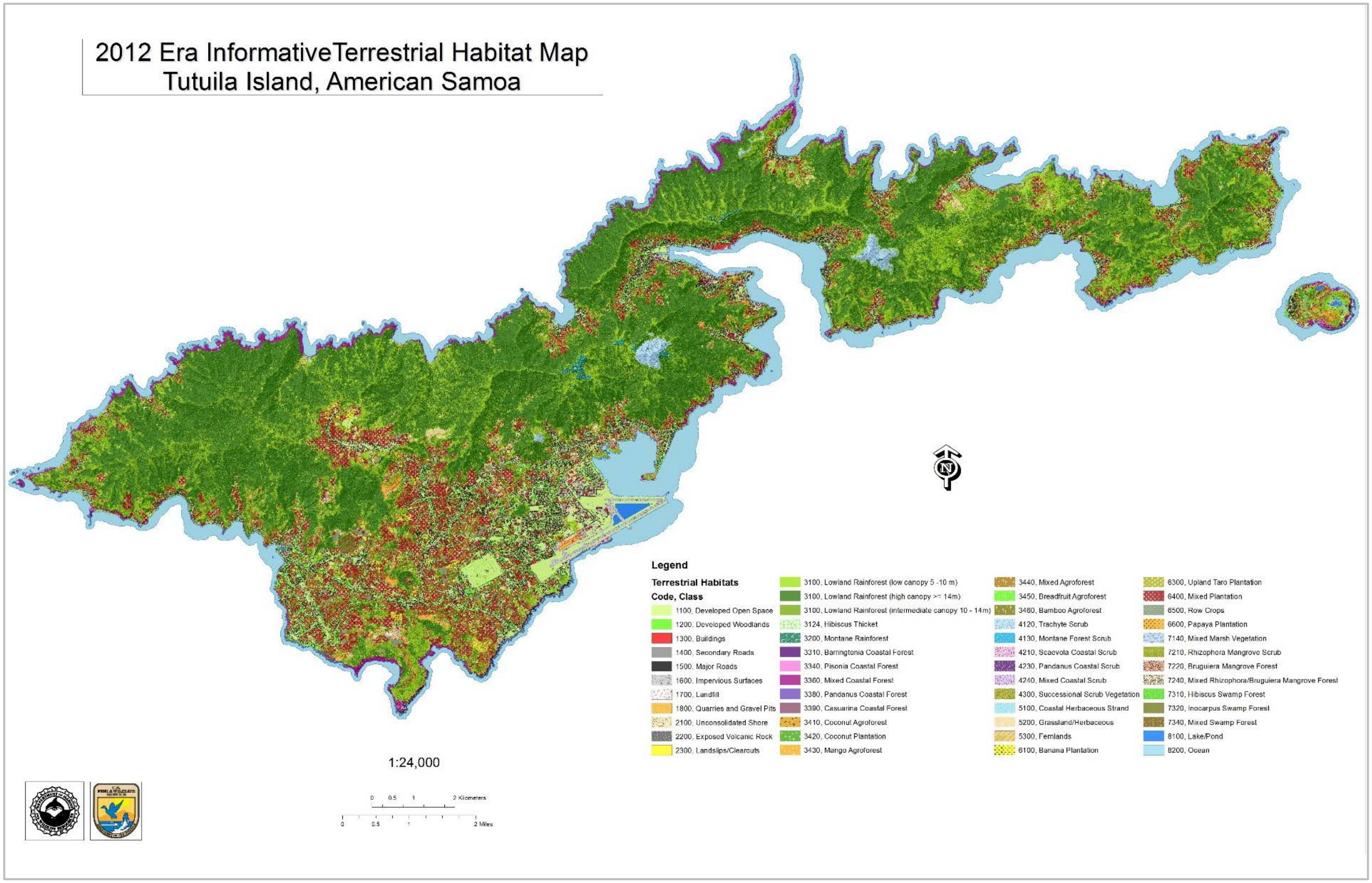
Threat (known or inferred existing threats based on best available information): **C** - potential susceptibility to Catastrophes such as hurricanes, **D** - high prevalence of Disease in the species, **H** - associated with a threatened or restricted Habitat type, **I** - high likelihood of competition with Introduced species, **L** - presumed Low or no current threats identified, **P** - susceptible to Predation by humans or introduced species, **S** - susceptible to declines due to Small population sizes.

Conservation Class (conservation study priority class): **I** - High priority: insufficient data available to make informed assessment of conservation status, **II** - High Priority: available data permits identification of threats or known low population sizes, **III** - Priority: ongoing studies or conservation and management efforts, **IV** - Moderate Priority: high abundance, widespread distribution, or lack of known imminent threats, butmonitor for em erging threats, **V** - Low Priority: species for which local extinction would be satisfactory.

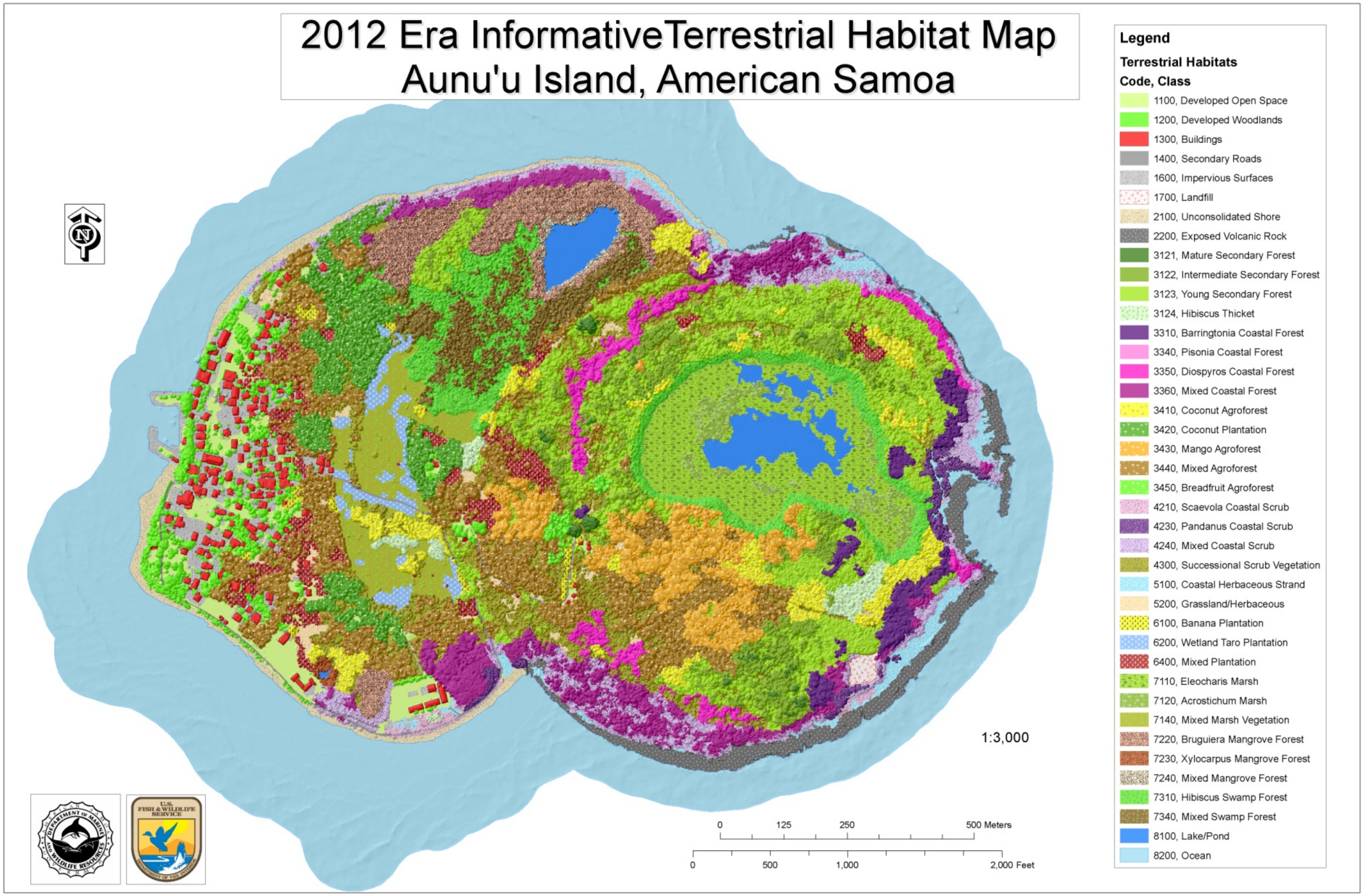
Data (reliability or recency of sources of data used in Abundance, Distribution, and Threat columns): **H** - High reliability, based on recent publications or current/ongoing but as yet unpublished survey data, **M** - Moderate reliability, based on irregular surveys, incidental captures, or repeated anecdotal evidence and personal observations, **L** - Low reliability, based on possibly dated literature reports or infrequent anecdotal or personal observations.

APPENDIX 4. TERRESTRIAL HABITAT MAPS FOR THE ISLANDS OF AMERICAN SAMOA.

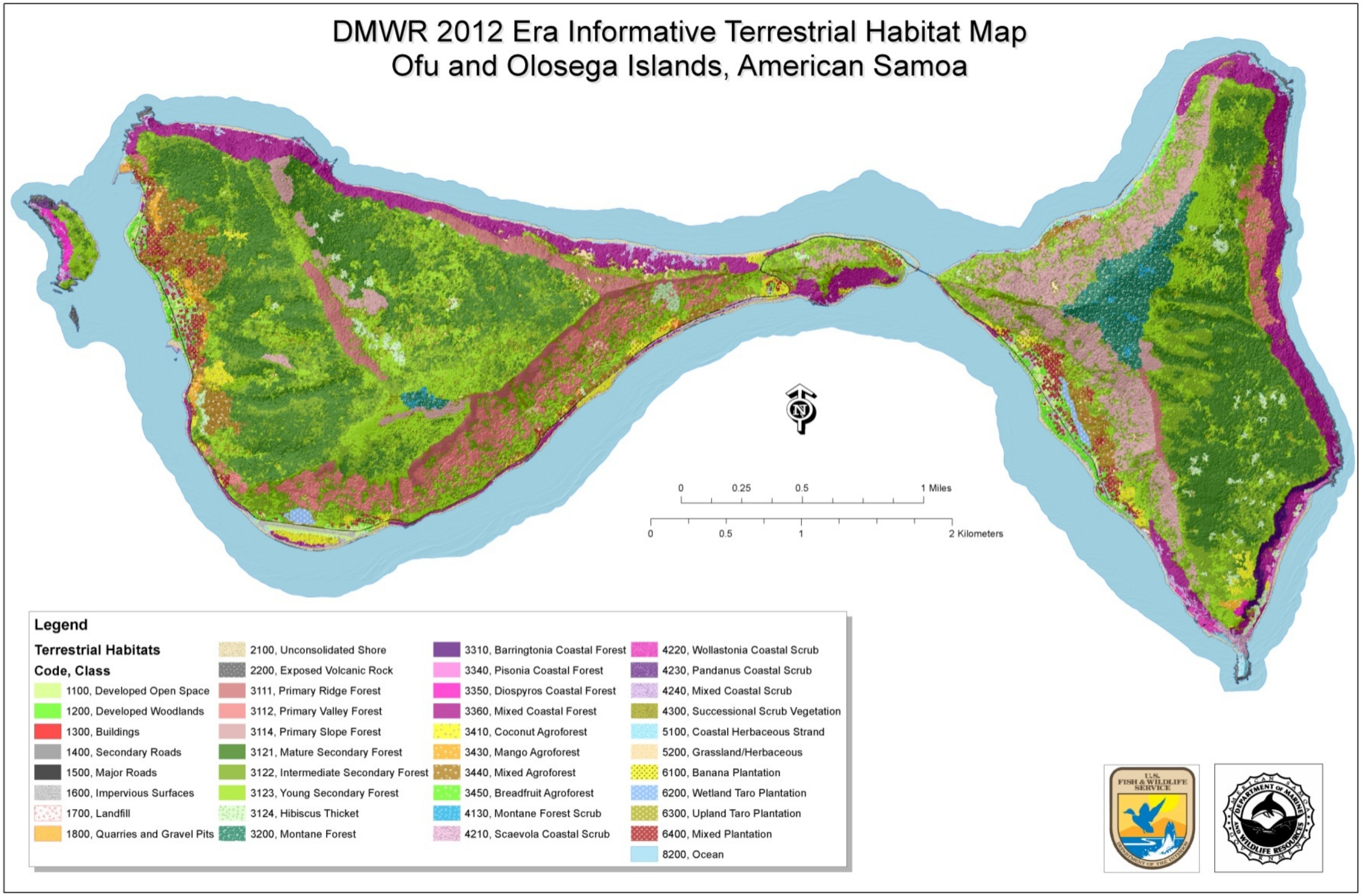
A. HABITAT MAP OF TUTUILA ISLAND, AMERICAN SAMOA.



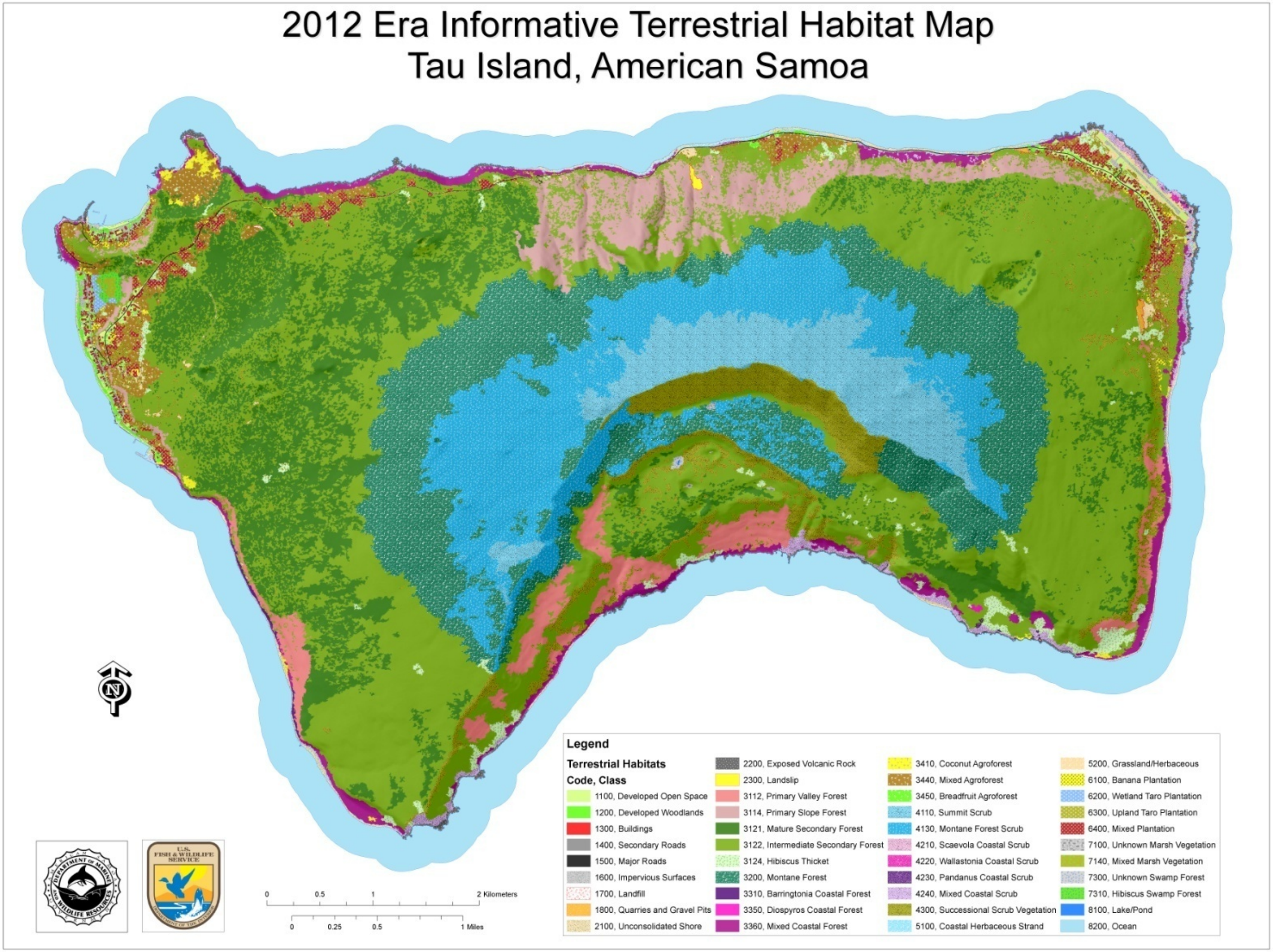
B. HABITAT MAP OF AUNU'U ISLAND, AMERICAN SAMOA.



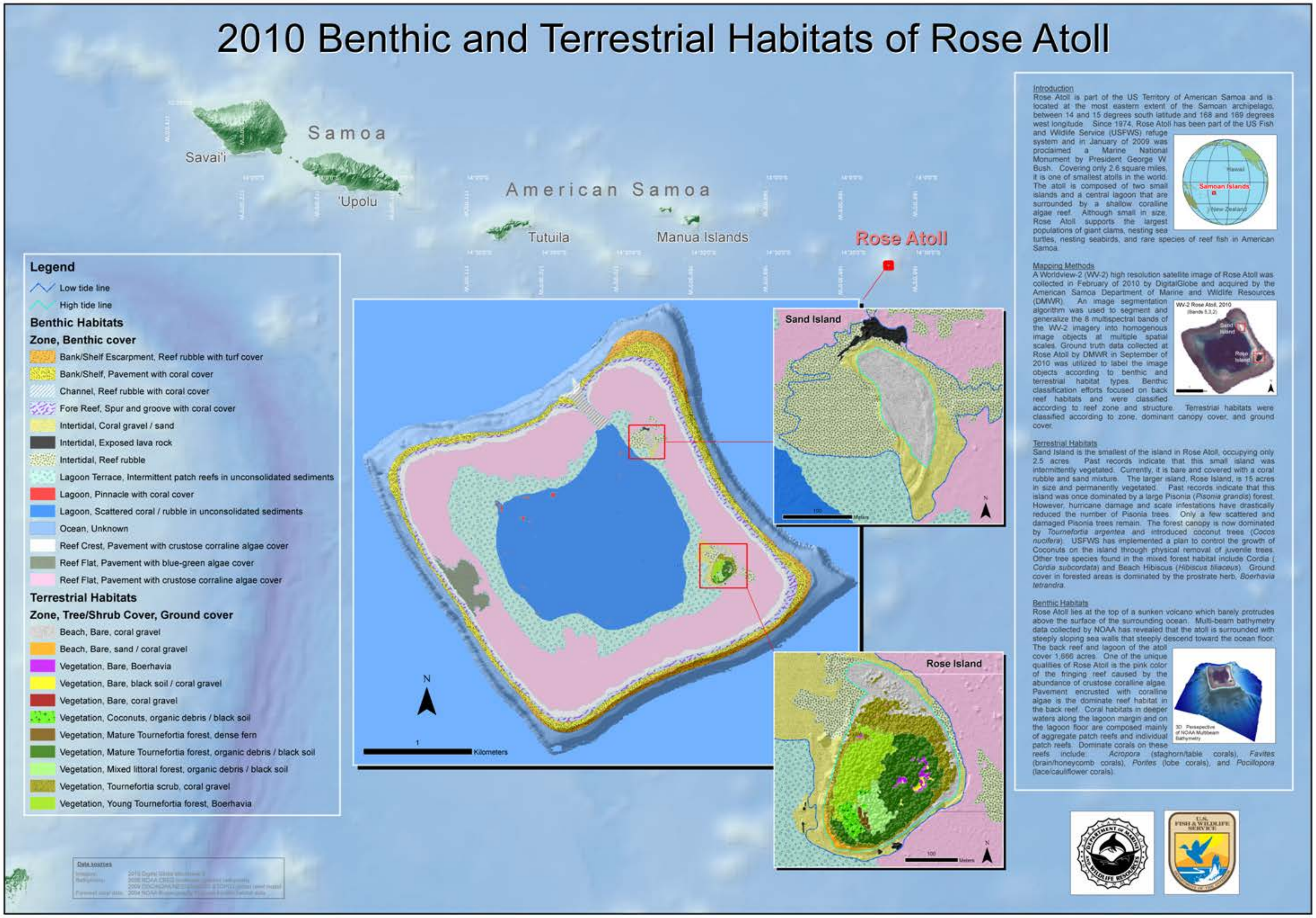
C. HABITAT MAP OF OFU AND OLOSEGA ISLANDS, AMERICAN SAMOA.



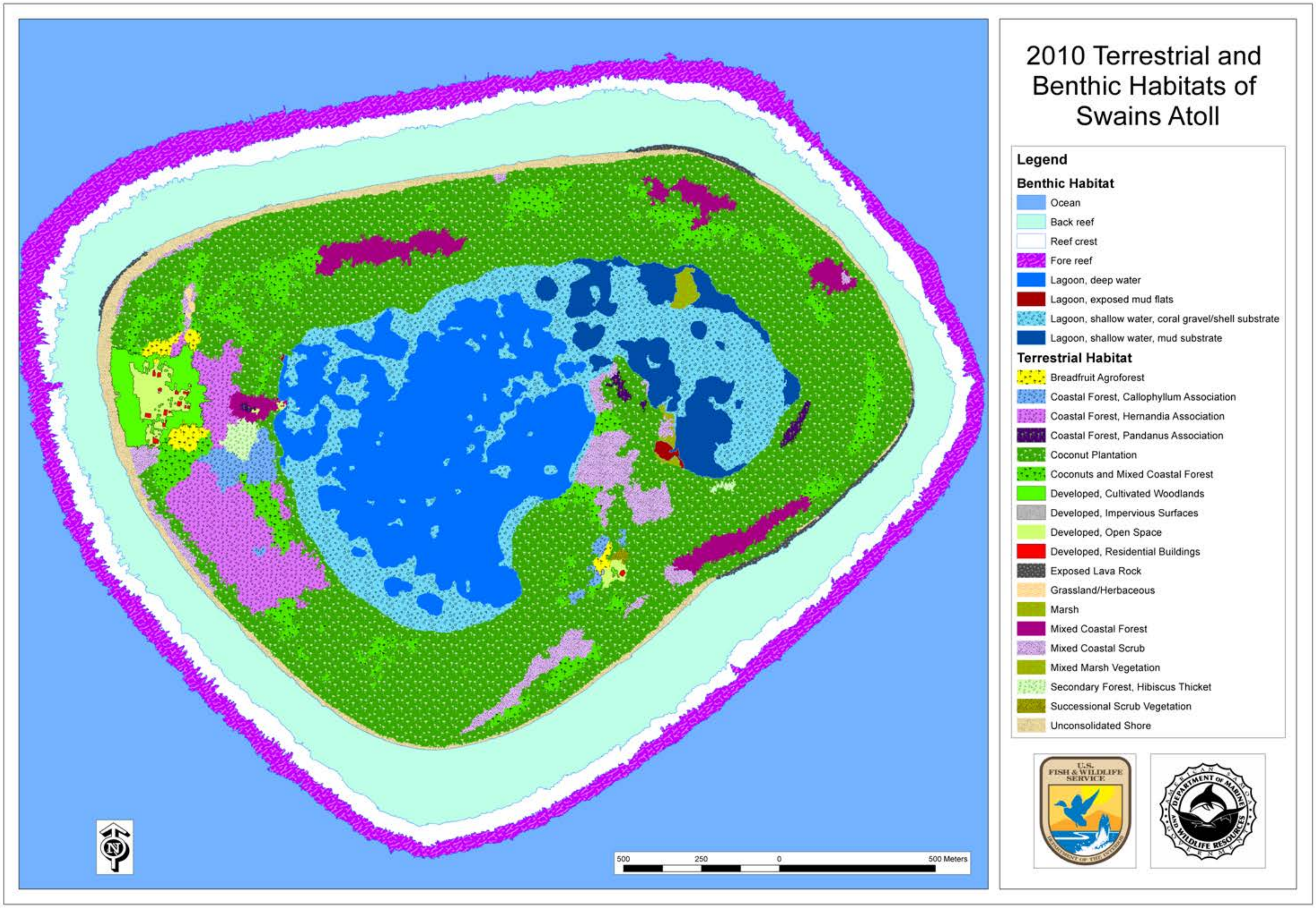
D. HABITAT MAP OF TA'U ISLAND, AMERICAN SAMOA.



E. HABITAT MAP OF ROSE ATOLL, AMERICAN SAMOA.



F. HABITAT MAP OF SWAINS ATOLL, AMERICAN SAMOA.



END OF DOCUMENT