AN ABSTRACT OF THE THESIS OF

Julie Marie Barr for the degree of Master of Science in Marine Resource Management presented on May 18, 2006.

Title: Community-based Sea Turtle Monitoring and Management at Helen Reef, Hatohobei State, Republic of Palau

Abstract approved:

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Selina S. Heppell

Remote areas are frequently homes to regional subpopulations of endangered green sea turtles (*Chelonia mydas*) and their essential habitat. Local communities are often the users and primary stewards of this valuable and charismatic resource. Recognizing this, a Hatohobeian community group in Palau has engaged in long-term monitoring and conservation management within Helen Reef Reserve. Here, I report on and evaluate the motivations, monitoring methods, and results associated with this program. I provide recommendations for future monitoring and recovery planning of Helen green sea turtles based on field results, informal community interviews, community capacity, and existing literature.

Capture-mark-recapture, nesting female observation, nest monitoring, hatch success, collection of tissue samples, and habitat assessment methods and results between April 19, 2005 and December 8, 2005 are provided. A total of 301 nests were recorded with peak nesting activity in June. All 47 nesting females were measured and tagged and 301 nests were monitored. The total minimum number of emerged hatchlings is estimated at 24,000. No correlations were found between carapace length and

fecundity or hatch success. Additionally, 50 foraging green turtles and 6 hawksbill turtles were tagged.

Limited harvests for local consumption and cultural preservation, as well as beach habitat protection emerge as the primary near term recommendations. Long term recommendations focus on continued nesting and improved habitat monitoring toward a population assessment, the creation of regional and international alliances for collaborative efforts, and use of satellite telemetry tracking to link foraging and nesting grounds of Helen turtles.

I have determined several key factors influencing the successful implementation of sea turtle management and conservation at Helen in terms of (i) the structure of partnerships; (ii) scales of biological systems and capacity; (iii) relative remoteness; (iv) balance of costs and benefits; (v) adaptive capacity; and (vi) influence of traditional systems. Results of case study comparisons show that successful implementation of sea turtle conservation and management programs within the Republic of Palau is more likely when a local community drives the process and has the qualities of adaptability, capacity for truly bottom-up decentralized management, recognition of valuable aspects of traditional management systems, and ability to generate tangible benefits. Lack of adaptive capacity, equitable benefits, civil society leadership; as well as, top-down management are identified as key limiting factors for successful implementation of turtle conservation and management.

The Helen program emerges as a model for small-scale community conservation and management of wide ranging species demonstrating that an organic community-driven process is fundamental to successful local endangered species management.

Community-based Sea Turtle Monitoring and Management at Helen Reef, Hatohobei State, Republic of Palau

by
Julie Marie Barr

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Science

Presented May 18, 2006
Commencement June 2007

Master of Science thesis of Julie Marie Barr presented on May 18, 2006.

APPROVED:

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Dean of the Graduate School

I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Julie Marie Barr, Author

ACKNOWLEDGEMENTS

The author expresses sincere appreciation to U.S. Department of Fish and Wildlife Pacific Islands Division and Community Conservation Network for financial support. Special thanks to field partners: William Andrew, Elsie Nestor, Jay Andrew and Robinson Richard for inspiring and teaching me. Thanks to additional partners: Wayne Andrew, Mike Guilbeaux, and Scott Atkinson for logistical support and championing this project from the beginning. Thanks to: Rick and Melia Knecht, Peter Black, Krista Callinan, Ann Kitalong, Joshua Eberdong, Theo Ismau, George Balazs, Nicholas Pilcher, Paul, Peter, Jamos, Rosania, as well as Theres Aderiano and Harry Ngirmidol for providing me with accommodations, ideas, guidance, and information. Thank you to the leadership of Hatohobei, especially: Chief Sebastian Marino, Governor Crispin Emilio, Delegate Thomas Patris, and Steven Patris for your honesty and assistance. Thanks to Aquaculture CRSP, especially Hillary Egna, for fellowship support. I am particularly grateful to my advisors: Selina Heppell, Bryan Tilt, and Michael Harte for their guidance and mentoring, and to Stanley Gregory for volunteering his time and energy. To my family, friends, and fellow students; I am indebted to you all for your support through this process. Finally, to my partner, Craig Risien, who inspired me everyday and helped me sustain my passion for this work.

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COMMUNITY-BASED SEA TURTLE MONITORING AND MANAGEMENT AT HELEN REEF, HATOHOBEI STATE, REPUBLIC OF PALAU

Chapter 1: Introduction

The goal of my thesis is to review the available knowledge on the status of green sea turtles and to recommend management measures that will ensure conservative use of green sea turtles at Helen Reef in the Republic of Palau for the long term use and enjoyment of the Hatohobeian people. Additionally, this thesis provides information and recommendations to assist the Helen Reef Reserve Management Project (HRRMP), a community based conservation and enforcement organization, in meeting their stated vision, goals, and objectives put forth in the Helen Reef Management Plan (Andrew et al. 2006). Information presented in the chapters and appendices has been synthesized from direct observations, informal HRRMP staff and community interviews, peer reviewed publications, technical documents specific to the region or specific to turtle conservation, as well as, internal and public documents generated by HRRMP and partners.

I first traveled to Helen Reef and its associated island atoll in September of 2002 while serving as a Peace Corps Volunteer in the Republic of Palau. The trip objective was to conduct community-based marine resource monitoring (Emilio et al. 2002). In the summer of 2003, I returned to Helen as an ecology instructor for the first annual Hatohobei[1] Island-based ecology and local skills summer camp. Through these activities I built a strong rapport with the community and a broad understanding of the local reef ecosystem. The HRRMP, a community based organization with a mission to protect and conserve Helen Reef and its resources, invited me to return to Helen for the summer of 2005 to conduct field work that would benefit community conservation

[1] Except when referring to the Hatohobei State government, Hatohobei will be referred to as Tobi and the derivative Hatohobeian appears as Tobian throughout.

objectives and serve as a basis for this thesis. I partnered with the Community Conservation Network (CCN)[2], a Hawaii based non-governmental organization (NGO), to submit a proposal to the U.S. Fish and Wildlife Service Pacific Islands Division in Hawaii (Appendix 1). The overarching goal of the proposed project was to "promote collaboration, skills building, and sharing between the two Southwest Palau states of Sonsorol and Tobi and other partners so that both State programs can increase their effectiveness and capacity to monitor, manage and ultimately conserve sea turtle resources for future generations." This document, particularly Chapter 3, addresses Objective 1 of the proposed project (with an emphasis on Helen Reef), to "establish and strengthen basic green sea turtle nesting monitoring activities and protocols over a year's time to where appropriate data is collected and analyzed consistently by local field staff, and this information communicated to local and national stakeholders and decision makers on a regular basis." Chapter 4 of this document specifically serves Objective 2, to "develop or enhance area management plans within one year through a community planning processes that includes specific goals and objectives, as well as sea turtle conservation strategies" with regards to green turtles at Helen Reef. This document may also be used as guidance for other isolated community managed turtle populations especially Merir island in the Republic of Palau.

Sea turtles are endangered (Seminoff 2004) and provided protection by a multitude of local, national, regional and international laws, conventions and agreements.
Green sea turtles are of important cultural and nutritional value to the people of the Southwest Islands of Palau. These islands are known for historically abundant sea turtle populations. Although Helen and the Southwest Islands are the most remote and undeveloped in Palau, the area has not escaped human-related threats to sea turtle populations (Johannes 1986, Guilbeaux 2001). One of the largest threats is harvest for local consumption and commercial purposes; as transportation has increased to the islands so has the transshipment of turtles to the capital city. In addition, both illegal

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[2] Information on CCN and their involvement with HRRMP can be found at http://www.conservationpractice.org.

and licensed, foreign fishing vessels harvest sea turtles from Palauan waters; enforcement of national prohibitions on turtle bycatch retention is particularly difficult in the remote Southwest Islands region.

At Helen, the harmful practices of egg, nesting, and foraging turtle harvest have been significantly reduced by HRRMP's management and enforcement program. Community members remain concerned about the fate of their sea turtle population as the loss of the turtles would be culturally devastating. Frequent questions posed by residents and government officials are: "How many turtles do we have?" "Where do they go?" and, "How many can we reasonably harvest without jeopardizing future use?" These are some of the questions addressed in the following chapters. The community has demonstrated a keen commitment to the conservation of sea turtles by establishing a moratorium on the take of hawksbill turtles within the Helen Reef Reserve and limiting the take of green turtles from Helen Reef to five turtles per year.

Chapter 2 summarizes relevant geographic and oceanographic information, as well as, background on sea turtle biology, species status, and threats to regional sea turtle populations. Chapter 3 describes the organizational structure and methods, associated with the sea turtle monitoring program; as well as, summarizes the observational results from data collected from Helen in the summer of 2005. Chapter 3 is particularly useful for reporting on sea turtle monitoring activities to the Palau National Sea Turtle Monitoring Program (NTP) and turtle researchers throughout the region. The Chapter 4 recommendations, for future monitoring and management policies, provide the basis for a species specific recovery plan for sea turtles which will fulfill the mandate of the Helen Reef Management Plan to develop recovery plans for species of concern. Chapter 5 examines factors for successful implementation of community-based sea turtle management within the Republic of Palau. The chapter will compare and contrast Helen conservation efforts with similar attempts within the Republic of Palau drawing from social theory. Finally, Chapter 7 reviews key aspects of the thesis and validates the HRRMP and Tobian community in their conservation efforts to date.

Chapter 2: Background

This section provides background information to the reader on Helen Reef geography, oceanography, human settlement history, prevalent sea turtle species and associated threats and protections.

Helen Reef is a remote island atoll that supports high biodiversity of species closely related to those seen in Indonesia (Donaldson 2002). The atoll, being relatively pristine and unaffected by development, is an ideal place for conservation and research. Helen Reef, however, is a logistically difficult place to conduct observational monitoring and research. Supplies such as batteries, paper, food, etc. are often depleted or non existent. If equipment breaks one must wait several months to replace or repair it. Additionally, when there are staff conflicts or illness timely help is not available. These concerns limit monitoring and research activities significantly.

Transport to Helen is provided by the Hatohobei State Government vessel, the *Atoll Way*. Field trips to Helen occur three to five times per year and usually include stop over at the other Southwest Islands of Palau to deliver people and supplies. With the exception of the field trip expeditions, which sometimes last up to two weeks for research, island maintenance, or whether concerns, Helen has a current population of three to five HRRMP conservation officers and guests.

2.1 Study Site

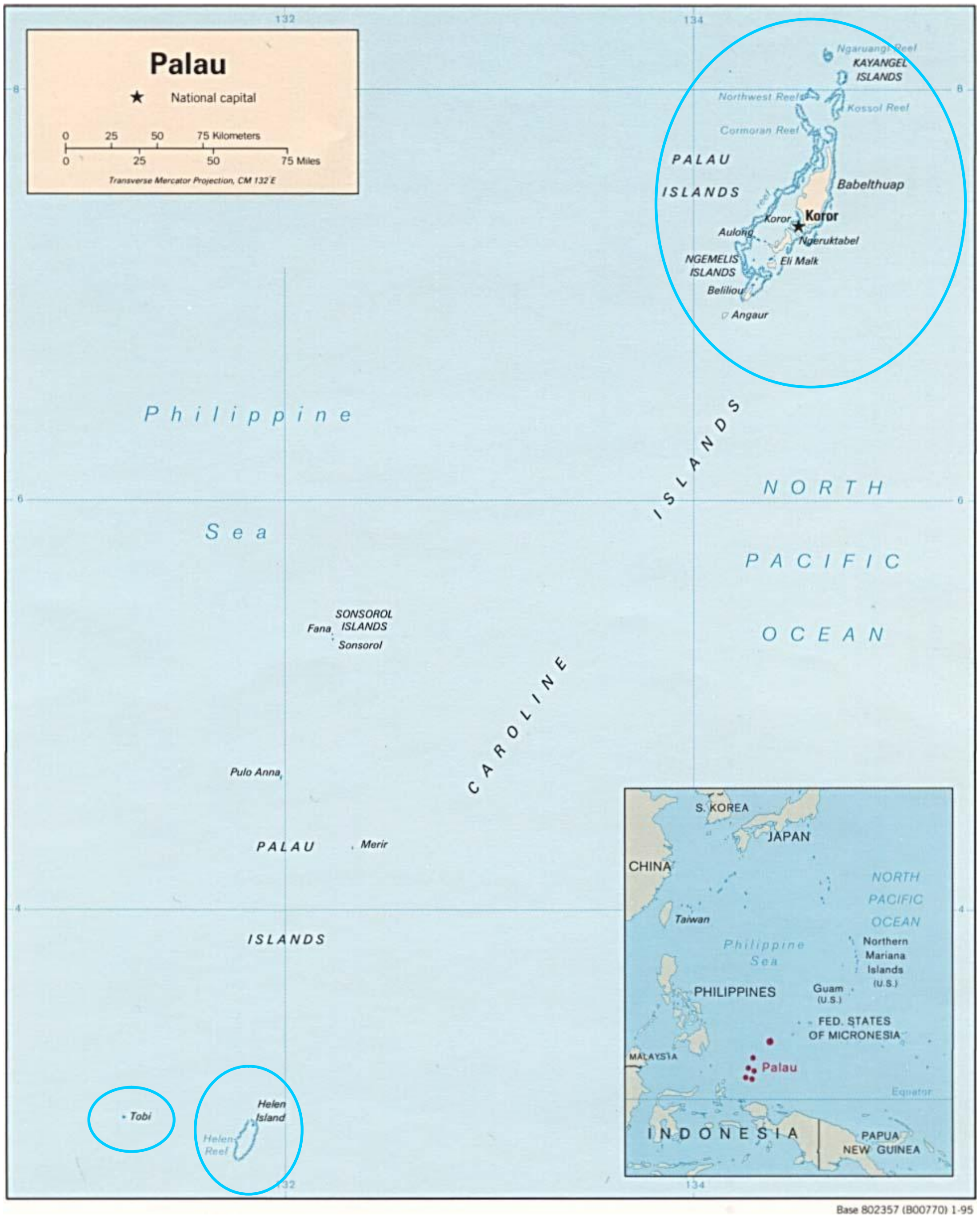

Figure 1: Map of Palau showing regional position and the location of Helen Reef and Hatohobei (Tobi) in the lower left corner. Palau and the capitol city of Koror are visible in the upper right corner (CIA 1995).

2.1.1 Geography of Helen Reef

Helen Reef, also called Hotsarihie, is located about 600 kilometers southwest of the main Palau islands (Figure 1). The reef extends 24kms long and 10kms wide with a total area of 162km^2 (Birkeland et al. 2000). The island of Helen is approximately 200m^2 comprised of sand, low grass, and wooded habitats (Knecht 2005). The reef can be observed in its entirety through satellite imagery (Figure 2)[3]. The Helen Reef Reserve includes the entire interior of the reef and extends one mile from the outer edges of the reef. The reserve is managed by HRRMP. Entry is limited to HRRMP staff, the Governor of Hatohobei State, and permitted guests; activities within the reserve are highly restricted.

Figure 2: Satellite image of Helen Reef retrieved May 2005 using NASA World Winds 1.3.

[3] NASA (National Aeronautics and Space Administration) World Wind 1.3 can be downloaded from http://worldwind.arc.nasa.gov/index.html.

2.1.2 Oceanographic Conditions

A previous report stated that the prevailing winds come from the east (Birkeland et al. 2000). However, monthly composite wind maps[4] reveal that during the summer months (May through Sept) stronger winds blow primary from the south-southwest (Risien and Chelton 2006). Fall and winter wind speeds are weaker and change direction to prevail from Northeast (Risien and Chelton 2006). Monthly mean maps of current speeds and direction[5] indicate that Helen lies just north of where the westward flowing Southern Equatorial Current turns back on itself and joins the Equatorial Counter Current along the western boundary of the Philippines. Winds and currents at Helen can vary dramatically within the span of one day and are often observed changing with the tide.

Helen Reef experiences semidiurnal tides; the gradual slope of the sand flats around the island causes a dramatic difference in the amount of exposed sand during high and low tides. Most turtles observed nesting at Helen approach the island close to high tide.

Changes in ocean atmosphere interactions during El Niño Southern Oscillation (Rasmunsen 1982) event result in drought at Helen. Rain that would normally fall over Indonesia and the Western Pacific moves eastward[6].

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[4] Wind directions and speeds estimated based on "Climatology of Global Ocean Winds" (COGOW) web based tool (Risien and Chelton 2006) used December 16, 2005 retrieved from http://cioss.coas.oregonstate.edu/cogow/. Monthly composite wind roses and maps can be viewed in Appendix 2.

[5] Current direction and speeds estimated based on "Ocean Surface Current Analysis – Realtime" (or OSCAR) web based tool (Bonjean et al.2002) used December 16, 2005 retrieved from http://www.oscar.noaa.gov/. Monthly composite plots can be viewed in Appendix 3. A mesoscale diagram of regional currents also appear in Appendix 4. The date and origin of this map is unknown.

[6] Detailed information about weather patterns and ENSO events can be downloaded at the NOAA Pacific Marine Environmental Laboratory website http://www.pmel.noaa.gov.

2.1.3 A Dynamic Atoll

The island at Helen Reef is subject to alteration from both natural and unnatural forces. The ebb and flow of the tide and constantly changing weather conditions work to change the shape and size of the island. Models based on historic ocean conditions and predicted emissions of greenhouse gases predict a trend of increasing sea surface temperatures, precipitation, and sea level for the region (Shea 2001). Thermal expansion results from increased sea surface temperatures and is the primary force in equatorial sea level rise. Also predicted is an increased frequency of El Niño Southern Oscillations (Barnett and Adger 2003; Shea 2001) and consequent drought at Helen. Since Helen is less than two meters in elevation the predicted sea level rise of about a meter over the next 100 years (McCarthy et al. 2001) could have dire circumstances for the stability of the island. Greater geological forces in terms of uplift and subsidence may also be factors contributing the changes at Helen. Human settlement and activities like clearing, raking, burning, and raising of domestic animals further change the structure and reduce the stability of the island. Additionally, the island may be losing sand over the edge of the reef and into the deeper regions of the lagoon before it can be replaced. Combined natural and anthropogenic forces are causing an average net movement to the southeast of about two to three meters per year (Figure 3), a trend that is estimated to have existed for at least 70 years (Knecht 2005). During the summer of 2005 alone an estimated two meters of beach was lost along the western side of the island due to storm event erosion.

Substantial evidence exists on the island to corroborate what Tobians already know about the movement of the island. The church (Figure 4) was built on the eastern shore of Helen in the early 1980s. The structure now stands on the western shore demonstrating that there is a net loss of sand from the western side of this island and net deposition on the eastern side and north and south extensions of the island. Additionally, a vessel that was abandoned on the east side of the island is now near the middle of the island. Finally, a tuna packing plant that operated on the island in the 1930s now is places more than 230m off the western shore (Knecht 2005).

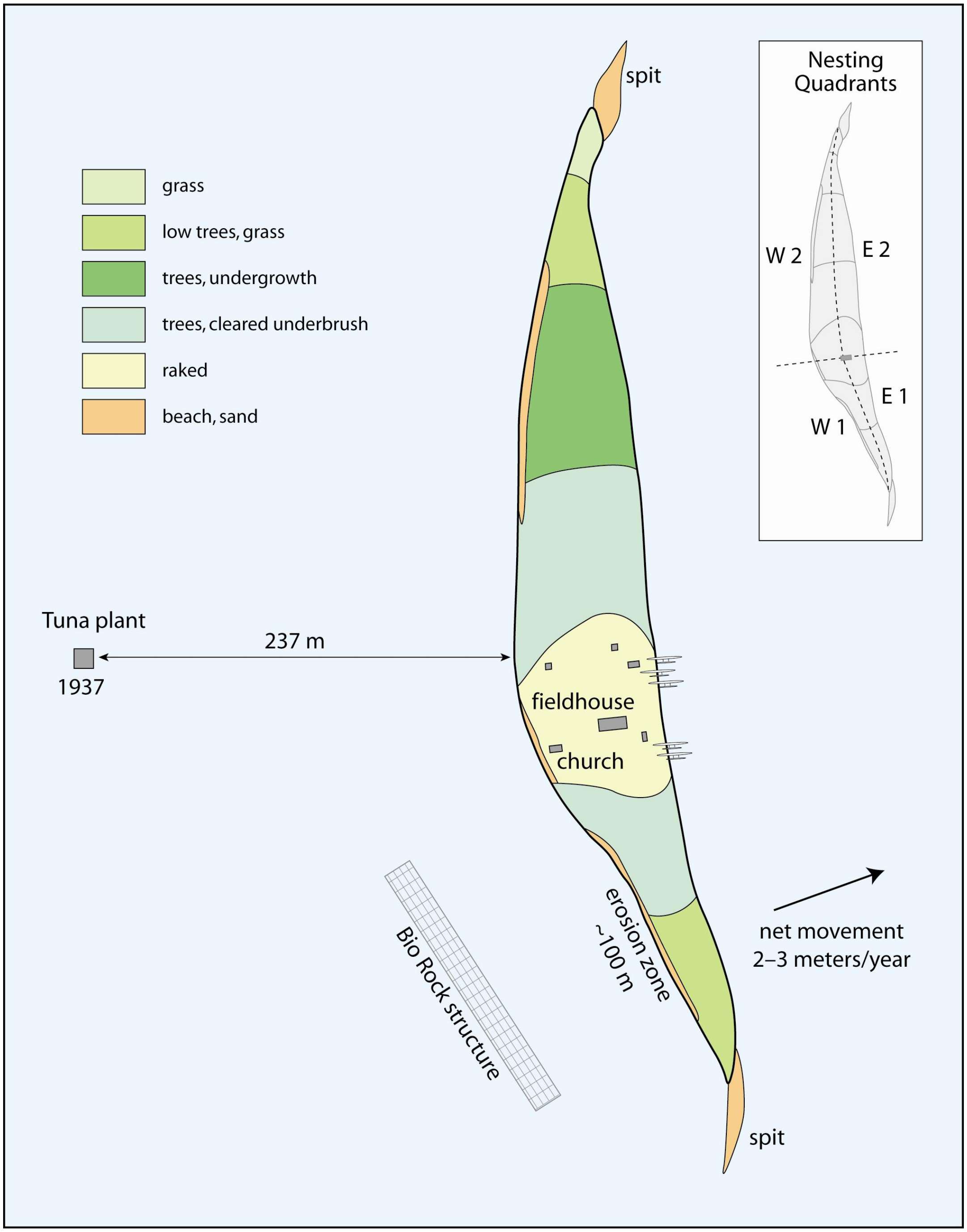

Figure 3: Map of Helen Island adapted from field survey (Knecht 2005). The length of the vegetated area (north to south) measured 560m, the treed length measured 400m. The widest section of the island measures approximately 55m. Net movement of the island is 2-3m per year to the east-northeast. Currently this island is about twice as long and half as wide as measured in 1937 by the Japanese when the tuna packing plant was in operation on the island (Knecht 2005). Inset depicts delineation of nesting quadrants.

Figure 4: View of the Church from the East side of the island, the church is quickly approaching the West beach. Photo: Rick and Melia Knecht

The watercolor (Figure 5) was completed after a 1937 Japanese survey of the island showing a oval shape and thick vegetation including coconut trees. The photo of the island shown in Figure 6 was taken by U.S. National Oceanic and Atmospheric Administration (NOAA) staff in 1972. Figure 6 shows a large circular island with thick vegetation and abundant coconut trees. In contrast Figure 7, a photo taken in the summer of 2005, shows Helen as a crescent shaped with low lying vegetation and three larger ironwood trees. One of the ironwood trees fell shortly after the Figure 7 photo was taken due to storm related erosion.

Survey reports by the Hydrographic Department of Great Britain (1946, 1956, & 1971) stated that Helen was a low densely wooded island. In 1965 the island was reported by the department to lie about four miles south-southeast of its previously charted position. It is unclear whether this movement was a result of constant erosion and deposition or due to faulty instrumentation.

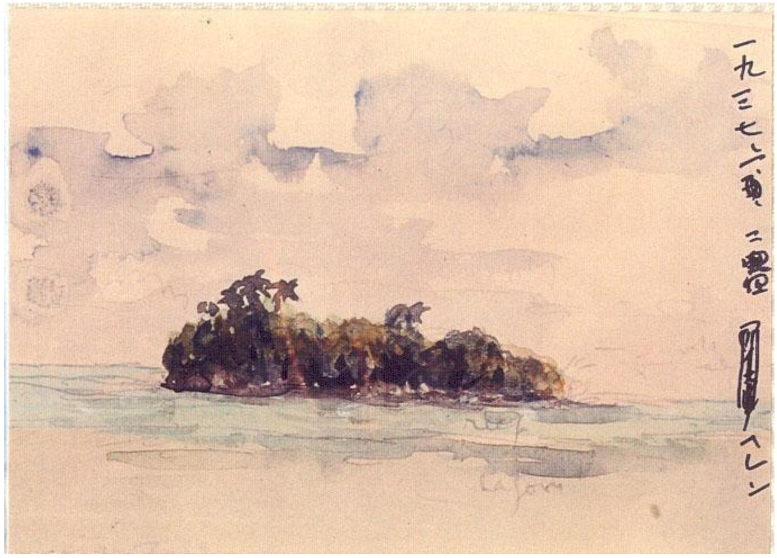

Figure 5: Watercolor of Helen Island January 1937 (Motoda). The island was approximately half as long and twice as wide existing more than 230m Southeast of its current location.

Figure 6: Helen Atoll June 1972 Dr. James P. McVey (NOAA). The island had longer and thinner than in 1937, coconuts persisted.

Figure 7: Helen Atoll July 2005. The island is about 560m long with a few large ironwood trees and no coconuts.

Helen Reef occasionally experiences tail storms from the outer bands of nearby typhoons which exacerbate erosion. Through viewing photos of the island and observing changes in vegetation one could conclude that island is moving faster than it is revegetating. If left unmanaged, this trend will eventually have dire consequences for the stability of the island and the amount of habitat available for turtle nesting. Additionally, flooding of turtle nests, which occurs during storms and spring tide conditions, could increase in frequency and reduce hatchling survival.

2.1.4 Human Settlement on the Island

Helen is often described as an uninhabited island; however, through the years there have been numerous settlements on the island, each with its own impact.

Around 1910 the people of Sonsorol Island reported a history of making trips to a populated village at Helen Reef (Eilers 1936). Between 1925 and 1937 approximately 17 employees of the Japanese tuna drying plant resided on the island. The plant operated into the early 1930s (Knecht 2005), but was abandoned by 1935 (Great Britain Naval Intelligence 1945). The settlement was destroyed by erosion by 1937 (Motodo 1937). In the late 1970s about 20 people lived on the island subsisting mainly on turtles, fish, birds and irregular supply ship visits. Throughout the 1980s and 1990s Helen was home to one man, Marino, who often subsisted alone on the island and occasionally hosted short term guests. In the late 1980s a small local business that harvested live reef fish, primarily grouper, was established and several Tobians were living on the island working as fisherman and subsisting off the resources (pers comm. Dominic Emilio & William Andrew August 2005). Helen supported another small subsistence population of men and children in the early 1990s. By 1997 there were only four people on the island, all of whom worked for the state government as stewards. After the 1997-98 El Niño event the island was evacuated due to drought, and an invasive rat population became established.

The Tobian community reclaimed the island in 2000. Their first conservation effort was successful eradication of the rats which threaten the nesting birds and turtles on the island. Since the establishment of the HRRMP in 2001, only three to four individuals stay on Helen at any given time. Island supplies, relief staff, and permitted visitors arrive at Helen aboard the supply ship three to five times each year. Since 2001, activities on Helen have focused on enforcement, but have also included calm seeding, bird monitoring, coral reef monitoring and construction of an artificial reef.

2.2 Species at Helen Reef

Helen Reef and Island are an isolated habitat source for migratory animals. Two species of sea turtles, hawksbill and green, use Helen and its abundant resources with occasional sightings of other migratory turtles. Hawksbills (*Eretmochelys imbricata*) can generally be seen foraging in the lagoon and along the outer walls of the reef, but do not nest at Helen. Green turtles (*Chelonia mydas*) exist at Helen in two distinct groups, foragers and nesters. This document will be focused on green turtles because conservation efforts can most immediately be implemented for the nesting group of this species.

2.2.1 Green Turtles (Chelonia mydas)

Green turtles are circumglobal, generally nesting at one beach location and migrating great distances to foraging grounds. In the Pacific, green turtles have been documented traveling up to 4000km[7] between their nesting and foraging grounds (Hirth 1997). Females of reproductive age exhibit high fidelity to both nesting and foraging sites (Limpus et al. 1992). Most nesting beach locations are known; however, specific migratory behaviors and patterns remain a mystery. According to mitochondrial DNA studies green turtles nest at their natal beach (Bowen et al. 1992);

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[7] Distance estimated from mark recapture studies throughout the Pacific. All studies were in Hirth 1997. Figure 15 is a map inclusive of possible migration destinations.

the exact means of navigation, after a juvenile period that spans decades, is unknown. In 1965 Archie Carr published a paper in Scientific American that considered celestial navigation as a means for directed migration (Hirth 1997). More recently the utilization of magnetic fields has been studied as a more likely means of navigation (Lohmann & Lohmann 1996, Lohmann et al. 2001). A study of displaced green turtles indicates use of an alternate mixed method of visual search strategy and response to beaconing properties of the wind (Åkesson et al. 2003).

All sea turtles exhibit slow growth and late age at maturity. The green turtle is estimated to reach maturity between 26 and 40 years (Seminoff 2004), exhibiting the oldest age at maturity among living sea turtle species (Hirth 1997), with an estimated reproductive longevity of 17 to 23 years (Carr et al. 1978; Fitzsimmons et al. 1995 in Seminoff 2004).

Comprehensive biological information on green turtles can be found in Hirth's 1997 *Synopsis of the Biological Data on the Green Turtle Chelonia mydas (Linnaeus 1758)*.

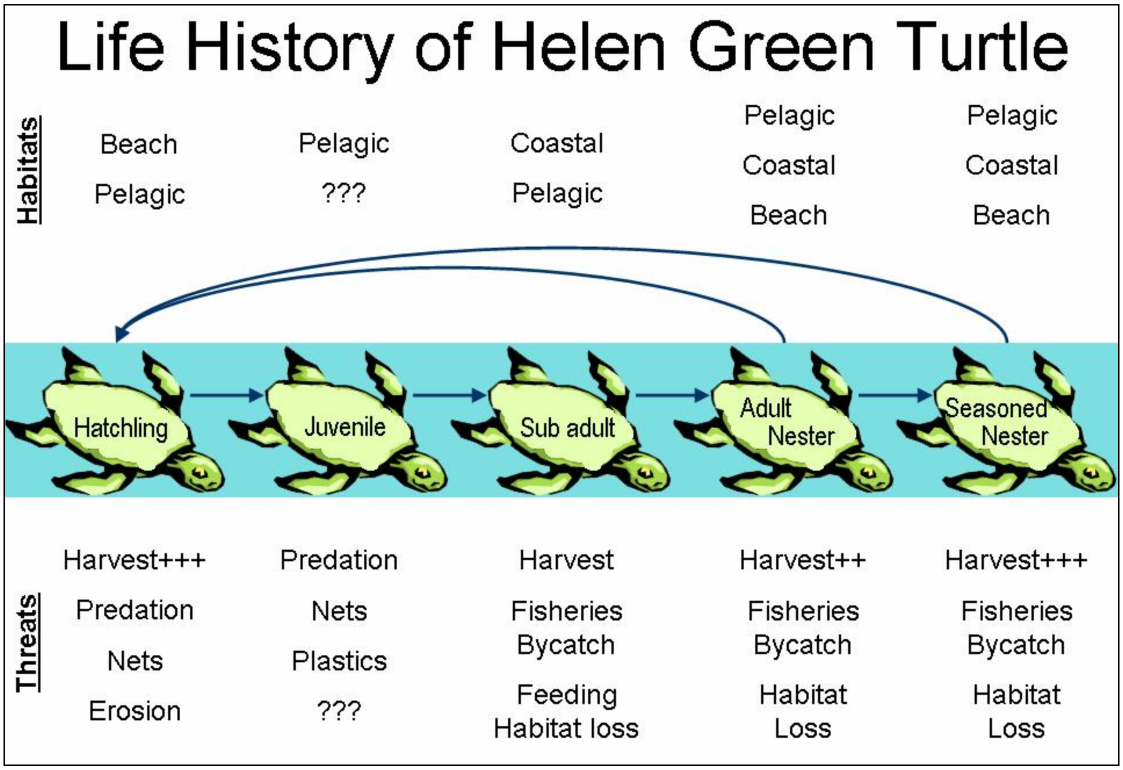

Figure 8: Life history of the green turtle. Diagram indicates habitats and threats during different life stages.

2.2.2 Hawksbill (Eretmochelys imbricata)

Hawksbill turtles are circumtropical; they reside in coastal waters and tend to nest in low densities (Meylan & Donnelly 1996). It is believed that hawksbills do not stray far from their foraging grounds, returning to nest on beaches within their natal region (Meylan & Donnelly 1996). Like green turtles, hawksbills are long lived, and do not reach sexual maturity until a minimum of 25 years (Meylan & Donnelly, 1999). It is reasonable to assume that the hawksbill turtles foraging at Helen Reef stay within the region, nesting on beaches in northern Indonesia or possibly in the Republic of Palau.

2.3 Threats to Regional Sea Turtle Populations

Green turtles are listed as endangered by the IUCN (World Conservation Union) (Seminoff 2004). Information complied by the Marine Turtle Specialist Group indicates that the global mean number of nesting female green turtles has declined 48 to 67 percent over the last three generations[8] (Seminoff 2004). The primary global threat to green turtles is direct harvest of eggs and nesting females. Harvest of juveniles and adults at foraging sites is also a major threat (Seminoff 2004). Pacific islanders historically use green turtles for food (Eckert et al. 1997), and harvest remains legal in much of the region (Seminoff 2004). Secondary threats to green turtles include bycatch by marine fisheries as well as loss of habitat and disease (Seminoff 2004). The primary threats at Helen are discussed in detail in Chapter 4.

IUCN estimates that in the last 20 to 40 years the global population of hawksbill turtles has declined 80 percent (2004). In 1996 the IUCN status was changed from "endangered" to "critically endangered" and hawksbill turtles were placed on the IUCN Red List (Meylan & Donnelly 1999). Both green and hawksbill turtles are protected under the Convention on International Trade of Endangered Species (CITES) and the Convention on Migratory Species (CMS) as threatened with extinction.

The hawksbill's sought after shell is economically and culturally important throughout much of the world. Sale of the shell and bycatch are often closely related, and are two of the largest contributors to the depleted status (TRAFFIC, 2004). The demand for shells and shell products remains high, and the price continues to increase. For a fisherman there is a great deal of incentive to keep incidental catch. Hawksbills, like green turtles, are particularly vulnerable because their long life history and late age at maturity (Meylan & Donnelly 1999). Confounding this vulnerability is a likely gross underestimation of the declines (Bjornjal 1999) resulting from insufficient information on the historical size of the population. For the hawksbill, commercial extinction may

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[8] Generation length is defined as age at maturity plus one half reproductive longevity and is therefore variable.

be synonymous with biological extinction (Bjornjal, 1999). Take of hawksbills is currently prohibited on Helen.

In 1997, the Pacific Sea Turtle Recovery Team prepared a recovery plan for U.S. population of Pacific green turtles. This plan included the Republic of Palau which is a protectorate under the Compact of Free Association with the U.S. The plan predicted that if current harmful practices and inadequate conservation efforts continued Palau is likely to lose their green turtle population by 2017 if not sooner; the plan describes the situation at Helen Reef and Merir Islands as "especially perilous" (Eckert et al. 1997). Locals confer that the amount of recently observed turtles pales in comparison to observations of past decades (Emilio et al. 2000). The recovery team recommended concentrated education efforts aimed at reducing harvest (Eckert et al. 1997). In recent years transport of turtles from Helen to the main islands of Palau has been reduced. The reduced harvest combined with the conservation and monitoring efforts described throughout this thesis indicate that the situation is less perilous now than it was at the time the recovery team completed their assessment.

2.3.1 A Note on Hawksbills

It is recommended that populations of nesting hawksbills be treated as individual management units (Meylan & Donnelly 1999). There is no information about the nesting locations of the hawksbills that forage at Helen Reef. The species is protected from harvest throughout the year within the Helen Reef Reserve. In the rest of the Republic of Palau, where both the regulations and enforcement are insufficient, hawksbills are protected only five months out of the year. Tobians do not harvest hawksbills for food. Occasional harvest of hawksbills for jewelry making, or sale to Palauan residents and visitors does occur. Local managers agree it is important reduce harvest and identify the nesting location of the Helen hawksbills; however these issues do not fall within the scope of this thesis.

2.3.2 Commercial Fishing

The Republic of Palau permits about 325 foreign vessels that make up their oceanic fleet (pers comm. Captain I. Tervet, August 2005). These vessels are primarily from Taiwan. The offshore fishery targets mainly tuna with longlining gear. When vessels that have illegally entered the Helen Reef Reserve are pursued and boarded bycatch of turtles and sharks are often sighted; it is assumed by officers, however, to go unreported when vessels reach port in Palau for inspection. False reporting of landings, and mother ship offloading just outside the EEZ, are common practices of the foreign fleet. It is clear that the fleet takes advantage of Palau's limited ability to enforce, relatively inexpensive permits, and lenient treatment of illegal activity. It is not clear, however, what the commercial fishery impact is on green sea turtles. Studies of Hawaiian longline fisheries indicate that green turtles, relative to other species, are uncommon victims of bycatch (Kobayashi and Polovina 2005). Observer data in the western Pacific show that greens are caught more often than most species, and almost as often as olive ridley turtles (SPREP 2001); however, coverage is inconsistent and results were highly variable for set at different time and depths.

Reports of transshipment of green turtles from the southwest islands to the main islands of Palau are numerous. In most cases transported turtles were gifted to family or traditional leaders. It is likely that some transshipment had commercial purposes. Today, transshipment has been significantly reduced and commercial activities are banned.

2.3.3 Habitat loss

Green turtles use the limited, but seemingly intact, sea grass beds in the lagoon and on the reef flat at Helen. They also rely on the island itself for nesting. Initial monitoring results and local knowledge indicate that the turtles that forage in the reef flat sea grass beds do not nest on Helen and most likely originate from a separate location. Preservation of both the nesting and foraging habitats is important.

Storm events, and associated erosion, results in four potential problems for nesting green turtles on Helen. First, beach area appropriate for nesting can be lost. Second, as the island becomes smaller and sea level rises (Barnett and Adger 2003) more nests become subjected to flooding or washing out. During one storm in June of 2005 an estimated 18 nests were washed out. Third, changes in coastline can prevent turtles from reaching the interior of the island where nests are safe from flooding and erosion. Occasionally, large pieces of drift wood block access of up to half of the island. Storm event erosion also leaves a stepped coastline which turtles are unable to climb in order to reach suitable nesting ground. Finally, slow changes in vegetation due to the process of erosion, deposition, and slow revegetation could change the shade coverage of the island potentially changing the sex ratio of hatchlings at Helen.

2.3.4 Harvest

Local harvest of turtle meat and eggs is a traditional practice of the Tobian people. However, increased transportation between Helen, the Southwest Islands and the main islands of Palau has increased the amount and of harvest (Guilbeaux 2001). Demand for green turtle meat remains high within the Palauan and Southwest Islands communities. In additional to subsistence harvest on Helen, harvested turtles have been an exported commodity and source of income for Southwest Islanders. In particular, crew from the transport vessel has contributed to this problem (Black 2000). In recent years, the HRRMP has conducted community meetings and other outreach efforts to inform about the need for conservation. These efforts seem to be curbing the practice of unsustainable take.

2.3.5 Predation

Predation is not a significant problem on Helen due to the absence of many common sea turtle nest predators. One native species of ghost crab is dominant on Helen and its presence threatens nests and hatchlings in three ways. First, the crabs dig from the surface into the nests to feed directly on developing embryos and fully formed emerging hatchlings. Second, emerged hatchlings become trapped in new and abandoned crab holes. The trapped hatchlings become prey for crabs or become too exhausted to climb from the holes and reach the sea. Several such instances were observed over the summer of 2005. Third, emerged turtles making their way to the water are sometimes observed to be injured or killed by the crabs. During the summer of 2005 many hatchlings were recovered with cuts in the neck, head or eyes; several were decapitated. Most of these hatchlings died, presumable from trauma or over exposure, but none of them sustained injuries beyond the head and neck. The percent of hatchlings suffering mortality is unknown. Given the high natural levels of mortality for hatchlings (Heppell et al. 1996) the crabs probably do not pose a significant threat to the population of green turtles and should not be managed until such time that information that indicates they are a threat becomes available.

2.4 Legislative Protection of Sea Turtles

Republic of Palau national statues are the primary means for protecting turtles in Palau (Guilbueax 2001). While Palau's constitution provides for each state to establish additional regulations and recognizes the authority of traditional leaders, who may establish protections, these opportunities for more effective management are rarely taken advantage of. The establishment of the Helen Reef Reserve by the Hatohobei State Legislature demonstrates a decisive commitment to conservation. Other states are following suit by establishing marine protected areas or marine managed areas. These areas are not usually not targeted at protecting turtles, but some have the potential to reduce turtle take, increase awareness, and conserve habitat within area perimeters.

Palauan law limits take of turtles to seven months of the year. During those seven months the minimum size for green turtle take is 34 inches (straight carapace length). The stated intent is to ensure that turtles have reproduced a few times before they can be harvested[9]. There is, however, no current documentation on the size of nesting turtles to warrant this minimum size. The closed season roughly overlaps with the nesting season on the main islands of the Palau archipelago. Both the dates and the size limitations may not be relevant to protecting turtles in the Southwest Islands where nesting seasons are extended and nesting turtles tend to be relatively larger than those observed in the main Palau archipelago. Recommendations for local restrictions on harvest appear in Chapter 4.

Hatohobei State legislation related to turtle use and conservation includes, the Helen Reef Reserve Management Act. In addition, traditional prohibitions on the take of eggs have been in place for several decades, but are rarely enforced. The 2006 Helen Reef Management Plan (Andrew et al.) provides for low levels of allowable ceremonial and subsistence harvest based on the recommendations in this thesis.

2.4.1 International and Regional Agreements and Conventions

Management of green turtles requires management of nesting beaches, feeding grounds and everything in between. Both transboundary management programs and regional coordination are imperative to success. Many such programs have been established and are described herein.

Six of seven species of marine turtles, including green turtles, are listed as endangered on the IUCN *Red List* of threatened species, indicating that a species is at risk of extinction in the near future. Hawksbills are listed as critically endangered, indicating the species is facing extremely high risk of extinction in the immediate future.

Green turtles, and five other species, are also listed under the 1975 Convention on International Trade of Endangered Species (CITES) under Appendix I, in danger of

[9] This information is provided to Palauan's through the Department of Fish and Wildlife and the Bureau of Marine Resources booklet on fishing regulations.

extinction. Commercial trade by signatory countries is prohibited. Palau started the process to become a signatory in 2004.

Green and hawksbill turtles are also protected under Appendix I, threatened with extinction, of the Convention on Migratory Species (CMS). A total of 87 CMS parties throughout the Americas, Africa, Europe, and Asia-Pacific work towards strict protection, conservation, and habitat restoration under the convention. The CMS also lists the greens and hawksbills, along with four other species, in Appendix II, which considers the species in need of international cooperation. Appendix II acts as a framework to establish unions between states, signatories or not. Collaborative efforts range from legally binding treaties or agreements to memoranda of understanding (MOUs). Most notably the MOU on the Conservation and Management of Sea Turtles and their Habitats of the Indian Ocean and South East Asia known as IOSEA. The IOSEA objective is "to protect, conserve, replenish, and recover marine turtles and their habitats, based on the best scientific evidence, taking into account the environmental, socio-economic, and cultural characteristics of the signatory States" (CMS 2001, p.4) There are a total of 24 signatory states including the United States and the United Kingdom which both lie outside the range of Indian Ocean turtles Palau is not a member of the CMS; however this does not preclude membership in the IOSEA.

Another regional collaborative effort called WIDECAST (Wider Caribbean Sea Turtle Conservation Network) was designed to address national and international sea turtle conservation priorities. The network has made available a forum for collaborative sea turtle conservation action by providing information on sea turtle status, specific management recommendations, and assistance to Caribbean nations in development of sea turtle conservation strategies. WIDECAST's expertise has benefited the SPAW (Specially Protected Areas and Wildlife) protocol of the Cartagena Convention. The Convention is a legally binding treaty that promotes the protection and development of the marine environment of the wider Caribbean region. The SPAW protocol specifically addresses the endangered status of green turtles and is recognized as the most comprehensive of its kind (UNEP 2004) with an objective to protect rare and fragile ecosystems and habitats, thereby protecting the endangered and threatened species residing within. The WIDECAST Recovery Action Plan for Antigua and Barbuda (Fuller 1992) serves as a useful model for collaborative sea turtle recovery in developing countries.

The Bern Convention of 1979 on the conservation of European wildlife and natural habitats put particular emphasis on coordinated conservation of endangered migratory species including green turtles as well as four other species of marine turtles. The Bern Convention attended to protecting turtle nesting beaches throughout Europe and has proved and important tool for wildlife conservation as a pioneer for multinational wildlife protection treaties (Jen 1999).

Recognizing marine turtles are highly vulnerable, and the multinational commitment required for turtle conservation, the U.S. enacted the Marine Turtle Conservation Act of 2004. The act established a mechanism for providing funding to foreign countries, which within their borders have nesting beaches and expertise in turtle conservation. The Act focuses on conserving nesting beaches, but also provides funding to address other threats to survival of marine turtles through a separate account of the Multinational Species Conservation Fund called the Marine Turtle Conservation Fund under which the guidelines require that projects must help to recover wild turtle populations.

The International Convention for the Prevention of Pollution from Ships (known as MARPOL 1973-1978), and the London convention of 1972 both strive to reduce wastes discharged on the high seas. This could benefit wide ranging turtles that are vulnerable to marine debris. Unfortunately, studies have shown there has been no significant reduction in turtle mortality with regards to plastics (Shaver and Plotkin, 1998).

The range of regional, national, and international laws, conventions, and agreements discussed above show growing determination in the multinational effort to protect wide ranging species like sea turtles. Recommendations to the HRRMP and Hatohobei State to consider participation in geographically relevant agreements, and utilizing existing agreements as a model for new regional actions are discussed in Chapter 4.

This chapter has provided background on the geography, oceanography, human interactions with Helen, turtle species present and primary threats to sea turtle throughout the region, as well as legislative protections for turtles ranging in scale from local to global. The background information provided above, when combined with field results and community knowledge (Chapter 3), establishes a basis for sea turtle management and conservation recommendations (Chapter 4). In addition the above chapter and associated appendices provides a source of extra-local reference for community managers.

Chapter 3: Sea Turtle Monitoring Program

3.1 Introduction

This chapter summarizes the organization, rational, methods, and results of the sea turtle monitoring program implemented by the Helen Reef Resource Management Project (HRRMP). HRRMP is a community group that works to protect and preserve Helen Reef. Portions of this chapter may serve as a report to the Palau National Sea Turtle Monitoring Program (NTP), or other regional sea turtle research and management interests, on the monitoring activities and results from the summer 2005. The NTP supported these efforts by supplying tagging equipment and training, as well as, supplementing fuel costs. The NTP procured funding for a national level program prior to the development of the complimentary HRRMP monitoring program. The NTP helped to support work at Helen. At the request of HRRMP I sought additional funding in collaboration with Community Conservation Network (CCN), a Hawaii based NGO, and HRRMP in order to enhance the monitoring efforts at Helen and better serve the information needs of the community for improved sea turtle management. This chapter will not distinguish between the portions of work that were due to collaboration with NTP and work that was solely driven by HRRMP. In practice, the contribution of both agencies and technical advisors resulted in a comprehensive monitoring program at Helen. The activities are therefore discussed in their entirety with an emphasis on the HRRMP staff's implementation of the monitoring activities. Each organization is responsible for reporting to their individual constituencies and funding agencies.

My role in this work was as a technical advisor through which I assisted with monitoring program planning and worked with the HRRMP staff and community leadership to enhance the monitoring scope and effectiveness. I also created the electronic database and analyzed the data presented in the following pages. Most training of field staff was done by NTP and the HRRMP field team manager who had participated in training through the University of Hawaii.

The overarching goal of the monitoring program as stated in the project proposal submitted on behalf of HRRMP to U.S. Fish and Wildlife Pacific Island Office in April 2005 is to:

> *Promote collaboration, skills building, and sharing between the two Southwest Palau states of Sonsorol and Tobi and other partners so that both State programs can increase their effectiveness and capacity to monitor, manage and ultimately conserve sea turtle resources for future generations.*

When actually implemented the program focused on Helen Reef. This was primarily because it is difficult for the transport vessel to stay at Merir Island, part of Sonsorol State, for extended periods of time in unpredictable weather conditions. To make up for this limitation, officers at Helen and Merir communicated regularly by radio sharing their experiences and collaboratively problem solving improving each field team's ability to continue monitoring and collect good quality data with minimum impact to the turtles. Program managers in Koror also stayed in communication with the Sonsorol State Liaison Office to coordinate logistics. Additional coordination with Merir occurred during short field trip stopovers by the NTP and HRRMP staff. Each stopover lasted less than one day, but served the valuable roles of cross training and data review. Interaction between field teams was a key source of motivation.

3.2 Organization

HRRMP is the central organization for turtle monitoring and management at Helen. The NTP and local NGOs, such as the Palau Conservation Society and the Palau International Coral Reef Center, also contribute to the success of this conservation and management program. One of the reasons HRRMP is successful is their ability to recognize the value, and sometimes necessity, of partnerships. HRRMP actively seeks out opportunities to build their own capacity. They do this in three ways. First, by seeking opportunities for general exchange with similar organizations, locally and regionally, they increase opportunity for capacity building. Often these exchanges are facilitated by larger organizations, but sometimes involve simply getting together with conservation officers from other Palauan states and talking about their experiences. HRRMP staff often participates in more formal workshops, conferences, or exchanges on the regional level. Second, HRRMP takes advantage of outside organizations' capacity building efforts related to larger scale conservation or development programs. Finally, as evident by my involvement, HRRMP seeks specific technical consultation needed to overcome programmatic obstacles. Such consultation is usually facilitated by CCN. International partners and networks, such as CCN and Locally Managed Marine Area Network (LMMA), provide HRRMP with technical oversight and linkages with other organizations facing similar challenges. HRRMP is not always on the receiving end of these benefits. In fact, they are often the organization with lessons to share and can play the role of mentor drawing from their experiences at Helen.

The organization also actively seeks the advice and support of the Tobian community and the Hatohobei State Government. Many Tobians have unique skills and knowledge that can contribute to the effectiveness of HRRMP programs. In part, HRRMP is an organization of service to the community, thus community interests are central to the operations of HRRMP. It is through this web of partnerships (Figure 9), which HRRMP has been able to organize and implement their sea turtle monitoring program.

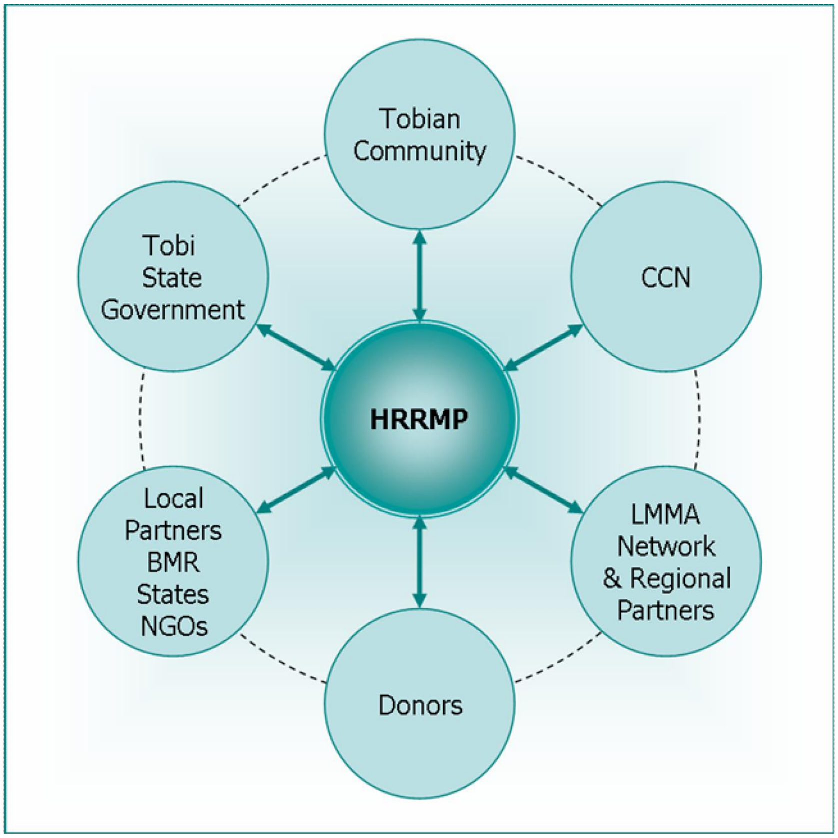

Figure 9: Simplified web of connections between partner organizations and Helen Reef Resource Management Project with respect to conservation and management of Helen Reef and sea turtles. HRRMP is the conduit for assistance and information; they are the primary organization responsible for management of Helen Reef. The Tobian community informs management decisions and oversees HRRMP in their stewardship. Community Conservation Network (CCN) provides technical assistance and funding to HRRMP as well as facilitates exchanges between HRRMP staff and similar projects throughout the Pacific. Locally Managed Marine Areas (LMMA) is a learning network established to assist small scale marine conservation efforts, the organization provides guidance and exchange of information. Donors include private foundations, NGOs, and foreign governments; they are sometimes involved in project design and are an important source of accountability. Local partners include other Palauan State Governments, the Palau Conservation Society, Palau Bureau of Marine Resources, and various multiagency working groups. The Hatohobei State Government works closely with HRRMP on logistics and facilitating community involvement.

3.2.1 Data Management

For HRRMP, data management has three important components. First, managing data means verifying that data collection is done in a careful, complete, and accurate manner. Second, data management includes a way of protecting original data, in this case field data sheets, through careful storage and remote redundancy. Finally, data management requires a database that provides easy access to, and enhanced utility of, datasets. Without sufficient data management the results of a monitoring program are short lived and may disappear with the turnover of managing staff. Because turtles have such a long life history, conservation efforts rely on information that is accumulated over several years and data management systems must be able to adapt over long periods of time.

Over the summer of 2005 HRRMP staff checked each others data sheets or collected data in pairs to check field activities. As a result field data sheets have been more complete and accurate. The process of double checking the data often raised discussion about the data and pointed out anomalies leading to debate and investigation into specific aspects of turtle behavior and biology. Data sheets were kept safe and entered into an electronic database custom made to store data relevant to the HRRMP monitoring effort.

3.3 Observational Methods

The sections below contain narrative descriptions of activities associated with monitoring of green turtles from April 19, 2005 through December 8, 2005. At the time of writing monitoring activities were reported by the HRRMP to continue using the methods described below. Learning from the challenges and mistakes of the first year of monitoring will inform adjustments and create a second generation adaptive management program; many related conservation and monitoring recommendations appear in Chapter 4. Observational methods were primarily determined by the standards of the NTP advised by NOAA. When necessary, methods were modified to address site specific concerns.

3.3.1 Nesting Females

Because Helen's available nesting habitat can be accessed by monitors at frequent intervals on foot it is an ideal place for nesting monitoring. Additionally, the island is free from vehicles, tourists, and residents with few noises, people, or lights to interfere with turtles' natural behavior.

Nesting females arrived on the beach nearly every night between April and August 2005. In general nighttime patrols occurred every two hours. These patrols consisted of one or two officers walking the entire beach in search of signs of nesting turtles, usually tracks. The skills to locate turtles are well developed as they are adapted from the skills required for harvest of eggs and nesting females. Flashlight use was limited because the light disorients and disturbs the nesting terns and is known to deter turtles from approaching the island (Witherington 1999).

On the east side of the island tracks were easily spotted at all tides. On the west side of the island tracks could only be spotted at low or medium tides. At high tides, when it is difficult to see tracks, officers monitored for other signs of turtles such as noises associate with digging, for example snapping twigs and flippers on the sand. Once a turtle was detected officers would approach carefully and determine which stage of nesting the turtle was in. Staff concluded that the previous assumptions that green turtles are in a trance once they begin laying eggs (oviposition) did not hold true for turtles on Helen. Females at Helen have often been observed fleeing a nest before completely covering their eggs due to relatively minor disturbances. Consensus was reached that the field staff should leave females undisturbed until they completed the covering of their nests. This means that eggs were rarely counted during nesting.

No.	Stage	Disturbance Likelihood	Monitoring Activities/ Restrictions
1	Site selection, stranding and emergence	Extremely High	No flashlights, no noise, minimal beach movement
2	Crawl from surf to nest area	Extremely High	No flashlights, no noise, minimal beach movement
3	Selection of nest site	High	No flashlights, no noise, do not approach
4	Clearing surface of nest site	High	No flashlights, no noise, do not approach
5	Excavation of body pit	Moderate – High	No flashlights, no noise minimal beach movement
6	Excavating of nest hole	Moderate	No flashlights, no noise, approach at end of stage
7	Oviposition	Low – Moderate	Egg counting ok minimize lights
8	Covering and packing of nest hole	Moderate	Prepare for tagging minimize lights
9	Concealing body pit and site	High	Measurements ok at near end of stage, cover head
10	Selection and Navigation of course out to sea	High	Tagging, measurements and biopsy
11	Entering wave wash	NA	NA

Table 1: Eleven stages of turtle nesting. Nesting stages adapted from Hirth's (1997) description of Carr and Ogren (1960) *The Green Turtles of the Caribbean Sea*: The Ecology and Migrations of Sea Turtles. Other columns are based on field observation on Helen. Staff was encouraged to use personal judgment and knowledge to improve upon these guidelines as needed.

Females were captured[10] as they left their nests and approached the water no sooner than stage nine (Table 1). Often a t-shirt, or other cloth, was used to cover the head of the turtle to protect the eyes from the flashlights used to collect and record data. Detention time was usually less than five minutes and most often less than three minutes. Occasionally, when an individual turtle was particularly resistant, it was assumed to be more important to work slowly and carefully to avoid injury to the turtle or the monitors while using blades for tissue samples or tagging equipment.

Three different carapace measurements were collected including, minimum curved carapace length (CCLmin), minimum curved carapace length to tip (CCLn-t) and maximum curved carapace length (CCLmax).

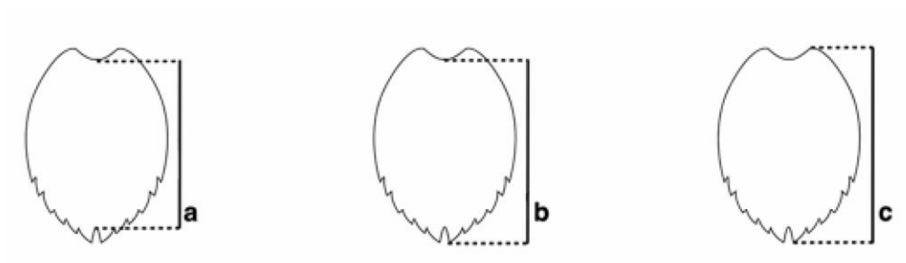

Figure 10: Measurement of curved carapace length (CCL) adapted Bolten (1999). (a) Minimum curved carapace length (CCL min) is measured from the anterior point at midline to the posterior notch. (b) Minimum carapace length to tip (CCLn-t) is measured from the anterior point at midline to the longest point of the posterior tip. (c) Maximum Curved Carapace length (CCLmax) is made from the anterior edge the posterior tip on the same side. The junction of the skin and the anterior of the carapace should be used as a starting point.

Curved carapace measurements were chosen because the method is the most cost effective and practical for all night monitoring on foot. With this method a monitor

[10] Capturing of turtles after nesting requires little effort as the turtles are exhausted and do not resist; applying a small amount of pressure horizontally on the front of the carapace was usually enough to prevent the turtle from escaping. This is certainly stressful for the turtle. Efficiency of data collection was emphasized to reduce the overall detention time and stress level of each turtle.

only needs a tape measure and some training, as opposed to straight carapace measurements which require cumbersome calipers. All three of these measurements were taken in order to be consistent with the NTP protocols. Variation in measurements can occur when the carapace surface is obstructed by barnacles. Injury, especially to the posterior tip, can also make it difficult to get an accurate measurement. Fortunately, observations of either barnacles or injuries are rare on Helen. Minimum curved carapace length is recommended because it is easiest to keep the tape strait and flat while performing this measurement (Bjorndal & Bolten 1989).

Figure 11: Measurement of female on her way back to sea. Photo: Krista Callinan

Turtle tagging has been the most important monitoring activity in terms of understanding the biology of sea turtles for conservation needs (Balazs 1999). Titanium tags were obtained through the South Pacific Regional Environment Programme (SPREP)[11] in American Samoa by the NTP. Field staff were trained, by the NTP, on application of the external self piercing hook and link style tags. All tags were placed on the front right flipper using the specially made applicator. Occasionally, applied tags incompletely hooked into the link on the opposite side.

[11] Information on SPREP and their Regional Marine Turtle Programme can be found at http://www.sprep.org.

This malfunction can injure the turtles and increase the potential for tag loss. It was discovered that some tags were sharper than others. In response the field staff sharpened all piercing points of the tags, improving the closures and reducing the incidence of injury. More complete information on tags and tagging can be found in *Research and Management Techniques for the Conservation of Sea Turtles* (Balazs 1999).

Figure 12: Titanium flipper tag on green turtle.

The tags served to track each female's nesting, or clutch, frequency and internesting period within the season. These tags, with continued monitoring, will help identify how often each female returns for a nesting season, called a remigration interval. Consecutive carapace measurements of returning tagged turtles can be used to estimate growth rates. Once remigration intervals are determined, monitoring results can be used to estimate recruitment into the nesting population as well as mortality of nesting females (Alvarodo and Murphy 1999). Understanding the complete nesting cycle of females on Helen will take decades, but may provide enough information to create predictive models of the population. These models could act as a guide for development of future management practices. Tags can also be used to track migrations as discussed in the *in water tagging* section of this chapter.

Samples for DNA molecular genetics analysis were collected by biopsies from turtles as they were tagged[12]. When analyzed, these samples will contribute to the NOAA Southwest Marine Fisheries Science Center's Marine Mammal and Sea Turtle Molecular Genetics Sample Archive[13]. They also will contribute to our understanding of the global genetic distribution of green turtles and will help to determine migration patterns.

3.3.2 Nest Tracking

Tracking of all nests began in April of 2005 as a result of collaboration and training with the NTP. Nests locations were recorded with a handheld GPS (Global Positioning System) and marked with a stake made of local driftwood. Each stake had an attached plastic ribbon indicating the nest date and a nest code. This system of tracking was inadequate as a result of limited power sources, small size of the island, interactions with turtles, environmental wearing of the ribbons, and field crew turnover.

The use of stakes and ribbons to mark nests created significant difficulties. Stakes were often dislocated by subsequent nesting turtles and the ribbons turned out to be an attractive building material for nesting birds. Additional problems were experienced with GPS precision and failing batteries. The field staff developed a method that eliminated interactions with nesting turtles and birds as well as reduced dependence on the GPS and generation of debris. Nests were marked using small strips of hard plastic (derived from beach debris) nailed to trees in a triangulation pattern from the nest. Nest dates, nest codes, and measurements for triangulation were written on the strips. With this method the GPS or the field data sheet could be used to find the general area of a nest. Then the exact location of the nest could be determined by using the triangulation markers. One concern, however, is the potential damage the

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[12] See Appendix 6 for tissue collection protocol.
[13] Information about the archive can be retrieved from http://swfsc.nmfs.noaa.gov

use of nails could cause to the sensitive vegetation. This method should be modified as better technology and financial resources become available to HRRMP.

3.3.3 Hatchlings

The planned method to estimate nesting success and incubation time was to count the eggs during oviposition, cage the nest, check the caged nests a few times each day, record nest date when trapped hatchlings appeared, count the hatchlings, and then release them. Several problems were encountered. The cages put the hatchlings at risk of injury, heat exposure, and predation. Monitoring of the cages to prevent harm to the hatchlings disturbed the nesting birds. Counting of the eggs during oviposition would have required more staff and more suitable lighting equipment than was available. After several modifications of these methods field staff agreed on the simple method of digging up nests at least two days after hatching was recorded.

Once each day, at least two staff combed the entire island to check for the locally known signs of hatching at each nest including a sunken patch of earth (for the mixed sand and soil areas) or fresh moist sand. If these signs were observed hatching was then recorded. The nests were then left for two additional days to allow for late emergence of hatchlings. After the two days hatched nests were dug up to confirm quantify successful hatch rates using count of empty shells (less dead hatchlings) as a proxy. Undeveloped, partially developed, and dead hatchlings were counted as unhatched. All remains and eggs were then buried in the nest hole and underdeveloped hatched individuals were either headstarted[14] or released – their survivorship is assumed to be zero. This method is not exact. The staff, however, felt that it had the least impact on the birds, hatchlings and nesting females. It was the best of available options with the existing resources. Data on hatch success notably increased when this method replaced the oviposition/cage method.

[14] Headstarting methods and feasibility is addressed in Chapter 4.

3.3.4 Habitat

The island was surveyed and measured to make a map of the types and status of the island habitat. High erosion areas and historical markers that indicate the distance and rate of island movement are included. Features on the island associated with human settlement, and human footprint were also measured.

To measure the area of available foraging habitat and the density of the turtles within the foraging habitat boat based assessments were attempted. Simple perimeter measurements were sought using GPS and turtle density by band transect. Unfortunately, fuel constraints, safety concerns, unknown diel patterns of Helen turtles, and subjectivity resulted in surveys that did not produce useable data.

In 2000 (Birkeland et al. 2000) and 2002 (Emilio et al. 2002) extensive resource monitoring was conducted at Helen Reef using underwater visual census techniques that included counts of both green and hawksbill turtles along 50 meter transects at varied habitats. This data is available in the project reports (Birkeland et al. 2000; Emilio et al. 2002) and could possibly be used for an estimated population census to inform a population model. The user of this type of data should be cautious as this technique is not ideal for determining turtle population size.

3.3.5 In Water Tagging

In addition to the tagging of nesting turtles, external tags were placed on some individuals from each of the foraging green and hawksbill groups of turtles at Helen. Turtles from these groups were captured in water and brought aboard the small patrol boat where they were measured and tagging in the same manner as described for nesting turtles. Handling time was usually under three minutes. Efforts were focused on tagging large green females to increase the opportunities for tag recovery on remote nesting beaches or to establish a connection between the foraging and nesting groups within Helen Reef.

Flipper tagging was not expected to reveal the migration patterns, but to yield insight towards that end and contribute to the global body of knowledge about sea turtle behaviors, biology and genetics. The titanium tags used were manufactured with a unique tag number and instructions for reporting recoveries. Locations of tagged turtles recovered and reported by fishing vessels, hunters, or similar monitoring programs can be pieced together to learn more about migration patterns.

The tagging portion of the monitoring program has been accompanied by an outreach and education program in the Republic of Palau about the tags and procedures for reporting sightings of tagged turtles. Nationwide activities were carried out by the NTP in collaboration with individual states. HRRMP and the Sonsorol State Conservation Officers took the lead within the Southwest Islands and Koror based Tobian community. For obvious reasons tag recovery reporting has been explicitly separated from all enforcement activities and reporting can be done anonymously. Recovery reports may increase with both additional tagging and outreach to regional organizations. Samples for DNA molecular genetics analysis were collected from turtles tagged in water using the same methods as used to biopsy the nesting turtles

3.4 Results

Results obtained during the summer of 2005 are presented and discussed in the sections below. Raw data are also presented in tabular form in Appendix 7. The utility and limitations of the results are included when appropriate; however, most monitoring, management, and policy recommendations based on these results are discussed in Chapter 4. It is important to realize that these results represent efforts from April 19 through December 8, 2005 and therefore do not reflect potentially significant interannual variability.

3.4.1 Nesting Females, Nests, and Hatchlings

The lengths of nesting females ranged from 92.5cm to 111cm (CCLmin, Figure 10), with a mean length of 101 cm CCLmin and a standard deviation of 4.77 (N=47). This range and mean are similar to observations in the Pacific and Indian Oceans, as well as the Mediterranean Sea (Hirth 1997). The exact relationship between age and size is unknown. Limpus and Chaloupka (1997) have developed regression models that estimate age from size. The models, however, are not employed here because age determination is not an objective of this program. Ages at maturity range from 12 to 50 years with estimations of ≥ 30 years in the Western Pacific and 40 to 50 years in Hawaii (Hirth 1997).

Internesting periods, or the time between nesting for an individual turtle, were recorded from 41 nesting females (N=146). Unfortunately, some of these nesting turtles were not observed each time they nested and were occasionally recorded as nesting when nesting was in fact unsuccessful. This is demonstrated by the false maximum internesting period of 50 days and a false minimum of 1 day. In order to better represent the actual clutch frequency outliers, <7 and >21, were removed from 146 records. Outliers were determined based on the assumption that turtles returning in less than 7 days were unsuccessful for at least one of the two nests, and turtles recorded as returning after more than 21 days may have nested twice in that period. Analysis without the outliers resulted in a mean interesting period of 13 days with a standard deviation of 4.3 (N=113). This is comparable to regional reports in the western Pacific and east Indian oceans with a range of 8 to 21 days (Hirth 1997). The median internesting period holds at 12 days for both the original (N=146) and truncated (N=113) datasets. Additional monitoring is needed to increase confidence in these results and fully understand the range.

The maximum number of days during which a turtle was actively nesting (including all internesting periods) was 118 with a median of 54 active days. Of 301 total nests on Helen only 191 were observed directly, meaning the nesting turtle was identified by a tag number. The original mean of 4 nests per turtle with a standard deviation of 2 is most likely an underestimate when the 110 indirectly observed nests are taken into account. To estimate the number of nests per turtle during the observation period a filtering exercise was necessary. Considering 47 individual turtles were observed nesting, and 301 total nests were observed, a average of 6 nests per turtle is more realistic representation (Figure 13). The observed range was 1 to 10 nests per turtle. One turtle was observed successfully nesting 10 times with a very regular internesting period of 10 to 13 days and one anomalous 24 day internesting period. During this 24 day internesting period and unobserved nest could have occurred. Additional unobserved nests could have occurred before or after observation of the set of 10 recorded nests.

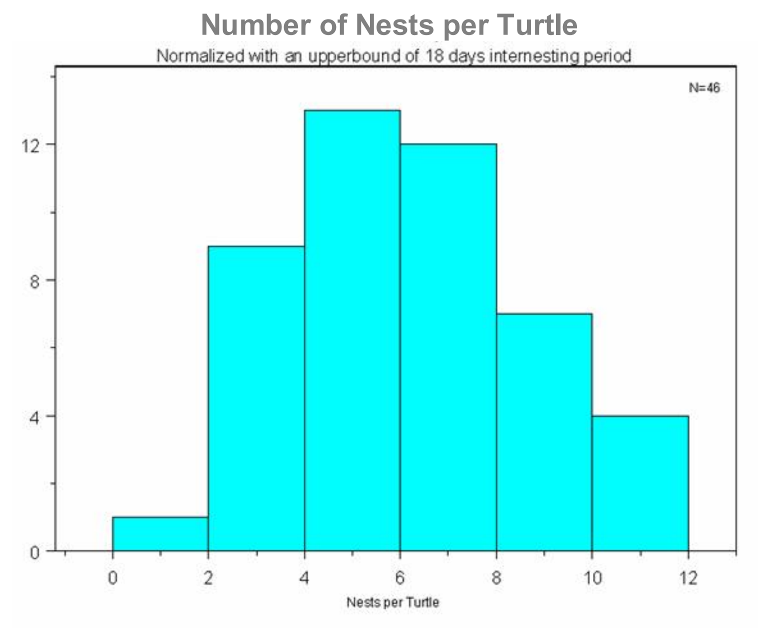

Figure 13: Estimated nests per turtle. The upperbound internesting was set at 18 days and each turtle that was observed nesting only once was presumed to have nested twice.

Comparisons of number of nests per turtle and CCLmin show no correlation (r^2=0.005, 35 d.f.). Similarly, comparisons of number of active days to CCLmin show no correlation (r^2=0.05, 44 d.f.). There is no evidence the larger turtles nest more often or for a longer period than smaller turtles.

Clutch size was distributed normally among turtles ranging from 44 to 156 eggs with a mean of 105 and a standard deviation of 23 (N=83) There is no evidence of a correlation between clutch size and CCLmin (r^2=0.009, 38 d.f.).

Clutch success was determined by the number of empty shells compared with the number of unhatched eggs. Number of empty shells was verified by 5 observations of emergence (No. 1 (+/- 0), No. 2,3, and 4 (+/- 1), and No. 5 (+6) empty shells); no significant difference exists between the number of empty shells and the number of emerged hatchlings (P>0.3, N=5). Hatch success ranged from 25 to 99 percent, with a mean of 83 percent and a median of 85 percent (N=52, standard deviation = 11.66). Because distribution is skewed by a few lowerbound outliers (<54 percent) the median may be a more representative statistic, but is relatively high compared to estimates throughout the Pacific and Indian Oceans (Hirth 1997). No correlation was detected between hatch success and CCLmin (ANOVA, P>0.3, N=40).

The total number of hatchlings that emerged during the period of April 19, 2005 to December 8, 2005 is estimated at 24,000. This is a conservative estimate; it accounts for nests lost to erosion as well as the mean number of hatchlings that emerged per nest. These numbers do not include mortalities after emergence on land or at sea. Sufficient data are not available to estimate post emergence mortality.

Some hatchlings were observed attempting to emerge from nests considered already hatched. Most of these were underdeveloped or deformed; others were found dead or dying when nests were dug. These hatchlings often occurred in small clusters of 2, 3, or 4. Since emergence was rarely observed, and post emergence predation by crabs on stragglers is known to have occurred, there is no way to know the total number of deformed hatchlings. It is likely that of more than 24,000 hatchlings these few deformations represent natural genetic variability.

Incubation period is measured as the number of days between nesting and emergence. This period was expected to be about 60 days by the NTP. Regional results (Hirth 1997) and local information suggested that the possible range could be large (≈47 to 75 days). Actual results from 17 nests give a range of 52 to 72 days with a median of 60 days. Although analysis indicates the incubation period in the shade is significantly higher that in the sun (Wilcoxon Rank-Sum, $P<0.006$, N=17), the sample size is small and may include bias as incubation periods were more often recorded for shaded nests than for full sun nests.

Local knowledge suggests a relationship between the timing of turtle nesting and the lunar cycle. However, I found no effect of lunar phase on nesting periodicity (ANOVA, $P>.3$, 3 d.f.), nor peak nest activity (ANOVA, $P>.3$, 3 d.f.). If a greater number of off-season records, when nesting frequency is lower, were analyzed an effect lunar influence might be detected. Tidal data was insufficient for analysis; however, local knowledge suggests the turtles nest more frequently near the high tide.

To analyze the spatial distribution of nesting I compared the occurrence of nesting on each quadrant of the island (East 1 and West 1 - corresponding with the south half of the island; East 2 and West 2 corresponding with the north half; see Figure 3 inset). Nests occurred on the north half of the island 75% of the time (N=299). This could be due to driftwood, excessive erosion, and downed root systems, blockading the southwest quadrant; as well as, occupation much of the southeast quadrant by field station related structures and storage (Figure 3). Although the quadrants were intended to be of equal size the southern areas are smaller a fact which may skew nesting location comparisons.

Storm related erosion washed out at least 18 of the 301 nests. All of the recorded washed out nests were close to the coastline and half occurred in the W2 quadrant. The other half was distributed between the remaining three quadrants. Many of these nests were also near root systems of trees that were downed by a combination of wind and beach erosion. Interannual variability in the spatial distributions of nests and nest wash-out zones on the islands is expected due to the dynamic nature of the island. In a matter of days one can observe dramatic shifts in the structure of the island and the amount of driftwood blocking the coastline.

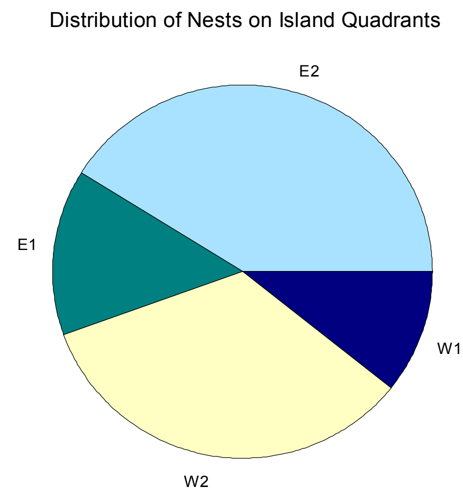

Figure 14: Distribution of nests, suggesting nesting female preference for or accessibility of quadrants.

3.4.2 Nesting Habitat

The available data on habitat allows for only rough estimations of the availability and conditions. Several nests were observed in the treed area with cleared underbrush. Most nests, however, were observed in the areas that were not cleared or raked. Approximately 75 percent of the island is suitable for nesting, but much of the approximately 1000m perimeter is obstructed by driftwood, storage of fuel and confiscated small fishing vessels, or a topographic stepped effect caused by erosion.

3.4.3 Foraging Turtles

Data collected on foraging turtle density, habitat composition and usage are unreliable and are therefore not reported here. Tagging of foraging green and hawksbill turtles did occur. Large females were targeted based on the assumption that the recapture rate would be higher for females of nesting size. Determining the sex of adult green sea turtles can be difficult (Wibbels 1999). Adult male sea turtles usually develop a large muscular tail as a secondary sexual characteristic (Wibbels 1999). This tail can be used to distinguish males from females. Females, however, sometimes have long tails, and males sometimes have shorter tails. Local experience, from hunting sea turtles, has provided the field staff with a keen ability to determine the sex of large adult turtles. Undoubtedly, the sex of some turtles was mistaken. A consequence of targeted capture is that size measurements are not representative of the foraging population.

A total of 6 hawksbills were captured and marked with titanium tags; five of these were captured on what is known as the "East Reef" foraging area and one was captured just west of the island. A total of 50 green turtles were captured and marked with titanium tags; the majority were caught at the "East Reef" with one on a southeast reef and the remaining few off the north tip of the Island. East Reef captures dominate because it is the closest foraging habitat to the island and does not necessarily indicate that densities are higher.

One green turtle originally captured and marked on June 30, 2005 on the East Reef was recaptured on August 14, 2005 while foraging near the original capture location. No other recaptures of foraging turtles occurred. Some reasons for this include limited recapture effort, low number of total turtles tagged, and separation of the nesting and foraging groups. 47 of the 50 foraging greens were captured before June 12, 2005. To date, however, none of the foraging tagged turtles have come to Helen to nest. At the time of publication recaptures of turtles tagged at Helen have not been reported in Palau or the Southwest Islands

3.4.4 Tagged Turtles

Migrations have most effectively been monitored through satellite telemetry tagging. However, even a few flipper tags can provide valuable information about migrations (Balazs 1999), especially when they are recovered at locations remote to the application site. To date, monitoring on Helen can be thought of as a pilot process to build capacity of the HRRMP staff while elucidating some unknowns about nesting, hatchling success, and migrations. It is hoped that proven competency in turtle monitoring will act as an impetus for obtaining the required funds to conduct a comprehensive satellite tracking study.

The external tags placed on nesting and foraging turtles at Helen have the potential to provide coordinate locations throughout their migrations. In particular, HRRMP and the Tobian community hope to learn where the nesting and foraging turtles from Helen spend the rest of their time. It has been hypothesized that the Helen foraging green turtles nest at Merir Island, and that the hawksbills nest in Palau or the Indonesian islands (pers comm. Sebastian Marino & Wayne Andrew June 2005, Nicholas Pilcher January 2005). Limited monitoring efforts are currently underway at Merir. HRRMP and NTP are actively working with conservation officers at Merir to increase capacity and effectiveness of monitoring. Green turtles are certainly capable of migrating much further distances (Hirth 1997). At this time only reports of recovered tags or the advanced technique of satellite telemetry can confirm or deny speculations on whether the Helen turtles are local or if they migrate significant distances to feed or nest.
A total of 103 turtles were tagged, of those, only two recaptures occurred as described above. It is interesting to note that no tagged female nesting turtles were recaptured in foraging grounds, although mating pairs were often observed in the channel and outside the reef in deep water. None of the turtles tagged in the foraging grounds came to Helen to nest. This information, while preliminary, is evidence that there are at least two separately functioning groups of green turtles dependent on Helen.

Parameter	Min	Max	Median	Mean	St dev	N
Nesting female CCLmin (cm)	92.5	111	100.7	101	4.8	47
Internesting Period (days)	1	50	12	15.7	7.9	146
Internesting period w/o outliers (days)	7	21	12	13	4.3	113
Nesting female activity (days)	1	118	54	50	28	47
Nests per female (observed)	1	10	4	4	2	191
Nests per female (estimated)	2	12		6		301
Hatch Success (percent)	25	99	85	83	11.7	52
Incubation time (days)	52	72	60	61	4.6	17
Eggs per nest	44	156	107	105	23.4	83
Comparisons	**Correlation**	**Test**	**Values**	**d.f.**		
Nests per Female and CCLmin	NO	SLR	$r2$=0.005	35		
Nesting Activity Length and CCLmin	NO	SLR	$r2$=0.05	44		
Clutch Size and CCLmin	NO	SLR	$r2$=0.009	38		
Hatch Success and CCLmin	NO	SLR	$r2$=0.025	38		
Nest periodicity and Lunar Phase	NO	ANOVA	P=0.39	38		
Longer Incubation and Shade Covered Nest	YES	Wilcoxon rank-sum	P=0.006	16		
Parameter			**Totals**			
Estimated minimum no. of emerged hatchlings			24000			
Total Tagged Turtles			103			
Tagged Nesting Females (green)			47			
Tagged Foraging Adults (green)			50			
Tagged Hawsbills			6			

Table 2: Summary of data collected on Helen from April 19, 2005 to December 8, 2005.

The 82 genetic samples, which could help determine the natal origin of foraging ground turtles and the relatedness of nesters, have yet to be processed. These results will become available to the public through the SWFSC at http://swfsc.nmfs.noaa.gov. It is likely to take several years before this method is perfected and the halotype library is expansive enough to be able to use mitochondrial DNA to determine stock structure and migratory patterns.

3.5 Conclusions

The organizational structure of the Helen Reef sea turtle monitoring program is complex. The multitude of partners involved, however, is one of the strengths that have allowed the program to move forward and promoted the collection of this modest but useful set of information.

The particular methods used were modeled after the NTP, but in practice methods were altered based on the relatively high capacity of the field staff as well as limitations involved with conducting monitoring in a remote location. The field staff showed incredible ingenuity and adaptability in modifying methods to suit the unique needs and limitations at Helen and despite several unforeseen circumstances monitoring continued at the expected pace. This first season was a success in terms of data quality and quantity, capacity built, community participation, and partner involvement. These attributes contribute to the development strong recommendations and the ability of the community to continue monitoring so they may implement adaptive management strategies that incorporate new information into iteratively improved management actions.

While the resulting data sets are modest in size they are significant for the region which is vastly under-monitored, making it difficult to develop and implement management plans that consider the unique situations within the region. This information provides some guidance in the planning of future monitoring and management measures and is considered in the Chapter 4 conservation and management recommendations.

Chapter 4: Conservation and Management Recommendations

4.1 Introduction

Reduced abundance of green sea turtles at Helen Reef has been noted by the Tobian community (Emilio et al. 2002). This decline is evident throughout the Pacific Islands (Eckert et al. 1997) and on a global scale (Seminoff 2004). An effort to provide immediate protection to sea turtles began in 2002 with completion of the Helen Reef Reserve Management Plan and continues today with observational monitoring and community education programs. The Helen Reef Resource Management Project (HRRMP) requested evaluation of the current management measures in terms of their ability to protect and preserve sea turtles for long term use and enjoyment by Tobians. I present the following recommendations for evaluation by HRRMP and partners and subsequent incorporation into the 2006 Helen Reef Reserve Management Plan (Andrew et al.) as the first of a series of species specific recovery plans. These specific plans will focus on species that are threatened, culturally significant, or important for commercial or subsistence harvest.

This Chapter and the resulting recovery plan are intended to be adaptable documents. Monitoring, research, and partnerships can improve our understanding Helen's sea turtles. Conservation and management efforts should reflect, and be modified based on, improved understanding of the ecology and biology of sea turtles as well as improved capacity of managers. These adaptations of management measures will create iterative generations of management activities, each improving on the last. The information presented here is specific to the current needs, capacity, and interests of Helen Reef Resource Management Project (HRRMP) and the Tobian community. Some inspiration, however, was drawn from both the Recovery Plan for the U.S. Pacific Populations of the Green Turtle (Eckert et al. 1997) and the WIDECAST recovery plan for the greater Caribbean (Fuller et al. 1992).

The recommendations provided throughout this chapter are informed by the collective and individual expertise of the Tobian community through the HRRMP staff and Board. Information from the observational monitoring conducted by HRRMP was also influential in its development. The recommendations are prescriptive, and utilize diverse sources of information. However, the challenges and limitations involved in obtaining and interpreting observational results specific to Helen Reef should be considered as management options are weighed and evaluated.

4.2 Monitoring and Research

Management decisions, and consequent actions, are intended to produce both a biological and a social response. Biological responses for sea turtles include increased nesting success, decreased predation, and increased population of nesting females. Biological responses need to be evaluated; this can be done through continued observational monitoring. As capacity for monitoring improves, the monitoring program can expand to better evaluate responses and utilize new methods and technology. Social responses include increased knowledge, decreased human impacts that contribute to turtle mortality, enhanced support for management efforts, and increased participation. Monitoring for social responses can be done through community meetings, interviews, surveys, and qualitative observation of behavior. Both biological and social monitoring entail the organized collection and analysis of observational data needed to implement project objectives and achieve project goals. Monitoring benefits the Tobian community in other ways. Consistent monitoring of both biological and social responses can help to demonstrate the results of management inspiring continued commitment of partners, funders, and the community. This evaluative process can highlight management successes and point out areas in need of improved management contributing to the adaptability of the program.

Individual community members, often HRRMP staff and volunteers, who participate in conducting monitoring, gain a unique understanding of the local environment at

Helen as well as the community's interactions with and reliance on the environment. This knowledge translates into a more widely applicable education on marine ecology with two obvious benefits. First, community members may use the knowledge and skills they have gained through the engaging in the monitoring program and training activities to advance into higher positions. They can also contribute to the regional, and even global, knowledge of green turtle ecology, biology, and conservation. This contribution will not only improve the effectiveness of HRRMP programs, but can help other communities to implement successful conservation programs. Second, monitoring knowledge becomes part of the community collective ecological knowledge and skill set. It can be passed to other community members through informal or formal means. The expanded knowledge base, and attention to resource management, have the cultural benefit of revitalizing the practice and associated knowledge of traditional resource management. Monitors are able to learn while doing tangible work, enhance their sense of community, and gain the skills necessary to evaluate the success of HRRMP in reaching the goals of the management plan.

It is important that new knowledge from organized monitoring and increased field experience be used to adapt both monitoring and management plans. Adaptive action will continually improve the project's ability to reach the goals set in the management plan. The goals themselves may even need to be adapted as the priorities, needs, or capacity of the community changes.

A comprehensive guidance document, *Research and Management Techniques for the Conservation of Sea Turtles*, was published in 1999 by the World Conservation Union (IUCN) Marine Turtle Specialist Group (Eckert et al.). This document provides detailed technical information for the collection and analysis of observational data on sea turtles. It is the recommended source for adapting any of the monitoring activities explicitly described in these recommendations. The IUCN document is limited in that it is not able to account for unique circumstances of location and capacity at Helen. However, the specific limitations and unique advantages of monitoring and managing sea turtles at Helen are taken into account here.

4.2.1 Data Management

HRRMP and partners have recognized that data management and data utilization has been a weak component of their monitoring programs. This may be, at least in part, due to the oral tradition of recording history within the Tobian culture. Staff often uses the knowledge of community members and their own memories to recall information about turtle populations for use in management programs. This information is useful when considering general trends or snapshots recorded by an individual or group living on Helen. Recent understanding about the importance of quantitative reports submitted to partners and donors has raised awareness about the need for quality and consistency in data collection and management. The learning curve has been steep, and while the methods are yet to be perfected, improvement over the last four years has been remarkable.

In *Research and Management Techniques for the Conservation of Sea Turtles* (1999) Briseño-Dueñas and Abreu-Grobois suggest four outcomes a model database should enable; they are modified here with a focus on the goals of the HRRMP monitoring program:

1. Regular updates of sufficient information for the purpose of monitoring the conservation status of a population and assessing conservation and management programs.
2. Long-term storage and easy retrieval of data.
3. Rapid transfer and exchange of data with partners, researchers, and regional monitoring programs.
4. Accumulation of a long time series of consistent parameters for use in analysis that can lead to a better understanding of the turtle populations.

Several other considerations are important in designing a database. A database should be consistent with the capacity of the users themselves and the available computing equipment. Data integrity should be preserved; users should not be able to easily delete records, make duplicate records, enter incomplete records, or separate individual fields from records. While custom databases applications can be developed to meet the specific needs a program, they generally have little flexibility once the design is complete and should be avoided. Microsoft Excel and dBase are generally easy to use programs and conducive to structural changes to accommodate inevitable changes in the specific data management needs of a monitoring program. Unfortunately, these programs do not preserve data integrity and have weak analysis components. In light of the expectations of a database, and limitations of the abovementioned options, Microsoft Access stands out as a practical choice for development of a database.

Microsoft Access is a relational database program. It is an ideal for entering and storing the HRRMP turtle monitoring data because it protects the integrity of the data and can be customized for the specific needs of the program without sacrificing flexibility. Access does not allow the user to accidentally delete data or enter duplicate data. It is easy for users to import, export, organize, search, and print data. Access is intended to work with Excel and other analysis applications. Since data stored in Access can be assigned relationships the database has powerful query capabilities. This is to say, when you ask a question of the database it will consider data from all related tables to provide an answer. Access also easily interfaces with geospatial mapping programs like ArcGIS, which will likely be useful for future datasets that include turtle movements.

The Access database I developed for the HRRMP program was replicated for the Palau NTP. Access customization and database structural changes can be done with relatively little training. The program comes standard with Microsoft Office Professional Suite and plenty of guidance is available through books, classes as Palau Community College, individuals at local agencies, and online tutorials. The HRRMP and NTP databases were designed with a user only interface allowing a user to enter, search for records, and view summaries of data without confusing the users with the more complex structure of relationships and queries. A manual for users is included in Appendix 5.

4.2.2 Nesting Turtles

Nightly monitoring and tagging of nesting females is a fundamental source of information of the local status of Helen's green turtle population. Nest counts, tagging and tag recoveries should continue until saturation tagging can be demonstrated. Saturation tagging means that all known females in the nesting population have been tagged so all untagged females can be identified as new nesters, or recruits to the nesting population. The level of recruitment and survivorship of nesting females at Helen is unknown, estimates for tag loss have not been made, and there is no information about remigration intervals. It is, therefore, difficult to set the conditions under which saturation tagging can be considered complete. Reductions in recruitment percentage can mean either decreased adult mortalities or an actual increase in recruitment (Bjorndal 1980). If the population is recovering the proportion of new nesters would be expected to increase overtime, and eventually level off. Managers will have to look at the nesting data over the next few nesting seasons to try to determine if untagged turtles are recruits, or returning turtles. One way to reduce confusion about this is to double tag each turtle to estimate occurrence of tag loss over time. If tag loss is known, and saturation tagging is achieved, estimations of mortality and recruitment will be more accurate. Alternatively, if funds could be secured, HRRMP could begin using PIT (passive integrated transponder) tags. PIT tags are more expensive and require a reader to retrieve tag information. It is also recommended that two PIT tags be used for each turtle until long term retention of the tags can be proven (Balazs 1999). Given that few people who may retrieve tag information will have readers, and the difficulty maintaining electronics on Helen, PIT tagging may not be ideal at Helen. The community should continue to work with partners to ensure that tagging methods are efficient and useful.

Nesting varies greatly from year to year (Balazs and Chaloupka 2004) and the number of nests per year and nests per female are strongly environmentally driven (Chaloupka 2001; Limpus and Nicholls 1988). Saturation tagging and subsequent continuous monitoring and tagging of recruits can provide information on the interannual variability allowing analysis of the data to better represent the true size of the nesting population and accurate remigration intervals. Relatively few records of remigration intervals report a range of 1 to 9 years between nesting seasons for female turtles with most of the means falling between 2 and 5 years (Hirth 1997). There is no way of knowing the interval for Helen until tagged turtles from 2005 begin to return for another nesting season. It is important to note that all the turtles tagged in 2005 will not necessarily return in the same year. Some will be lost to mortality, and some will return early or late relative to the mean remigration interval. Keeping this in mind, saturation tagging and continual year-round monitoring is one of the many steps that will enable estimates of mortality and nesting population size. Even with this level of effort it can take many years to detect an increase in numbers of nesting females as a result of management actions (Bjorndal 1999).

4.2.3 Foraging Turtles and Their Habitat

Understanding the extent of foraging habitat and the number of foraging turtles is essential to protecting Helen Reef sea turtles. Measures that protect individual turtles such as reduced harvest and bycatch are not enough to sustain the population. Protection of foraging habitat is vital. To adequately protect habitat managers must know the extent and location of sea grass beds, as well as, the seasonal and interannual variability.

Estimating the population size will require extensive field work. Boat based transect surveys to census the foraging turtle populations at Helen are expensive and have associated safety risks. The most practical method for estimating the size of the foraging population at Helen is mark recapture using flipper tags. An open mark recapture model that utilizes previous efforts spent tagging foraging turtles is recommended as it can be used over a longer period of time over a closed model that assumes no deaths, recruitment, immigration, or emigration (Gerrodette & Taylor 1999). For specific instructions on using this model refer to *Research and Management Technique for the Conservation of Sea Turtles* (1999, p.69-70). Census surveys of this population should not be an immediate priority, but should be considered in the next two to three years. Ongoing tagging efforts at a pace in accordance with local capacity can be incorporated into a future open model study.

There is a good chance that the foraging turtles at Helen nest at Merir (pers comm. N. Pilcher, Jan 2005) or other close by islands with limited foraging habitats. Continued flipper tagging of foraging turtles may also help illuminate any connection between Helen, Merir and the main Palau islands. It is assumed that there is a better chance of Helen foraging turtles being recaptured during nesting due to monitoring and harvest activities throughout the region. Tagging, therefore, should continue to be focused on females >92cm CCLmin (the minimum size of nesting turtles at Helen was 92.5cm in 2005). In the future it may be reasonable to plan at sea recapture efforts. In this event tagging efforts should be extended to include males, and subadults.

Regular acquisition of true color satellite imagery of Helen Reef, similar to that in Figure 2, can provide a dataset for use in analysis determining seasonal and long term changes in available habitat. This type of analysis would require use of a geospatial database like ArcGIS. It is not recommended that the community embark on this analysis until there is increase capacity in terms of computer training, computer programs, internet connectivity, and analysis skills. In the meantime digital images should be collected and archived with the assistance of partners with computing capacity such as CCN or the Palau Conservation Society.

Local maps of the reef and the habitat types generated through community meetings should be updated regularly as the HRRMP staff observes changes in the field. Fisherman utilizing zone limited fishing areas (Andrew et al. 2006) should be asked to contribute in regular 'state of the reef' meetings to update these maps. Annual monitoring at the regular stations (Birkeland et al. 2000, Emilio et al. 2002) can provide information on the health of the different habitat types. While aerial photos are difficult to obtain, those that are available should be archived at the highest possible resolution. Analysis of the archived satellite images, community maps, and aerial photos can be done using a GIS program. This type of analysis should begin in the next three years and should be ongoing to include any newly available information. Assistance with this type of analysis can be sought through the regional organizations listed in Table 5.

4.2.4 Turtle Movement, Linking Foraging and Nesting Grounds

The migratory nature of green sea turtles poses a challenge for conservation efforts. Local protection of turtles will have little, if any, impact if those same turtles are exposed to excessive threats during other parts of their migration. Identifying locations which the Helen turtles rely on for either nesting or foraging will provide managers with opportunities for targeted multilateral cooperative conservation initiatives.

Green turtles have been documented migrating more that 4000km (Hirth 1997). Long generation time, late age at maturity, and potential large geographic dispersal of hatchlings, makes it difficult to link foraging and nesting grounds (Limpus et al. 1992) for a given turtle. Figure 15 shows all locations within 4000km of Helen. While there is much speculation about the migration patterns of all three turtle groups that depend on Helen it is important to realize that the potential foraging grounds spans across at least 19 nations with coastline. It would be worthwhile to develop a map with potential nesting grounds, foraging habitats, and prevalent threats in the region. Habitat and threat mapping would require use of a geospatial database. It is recommended that this mapping be done by a regional entity with increased capacity in the areas of computing and internet connectivity. While the Tobian community and HRRMP can play an important role in regional mapping, and can benefit greatly from the resulting data, tackling this issue on a regional level provides an economy of scale.

Flipper tagging is a low cost method of tracking turtles that can provide useful information (Balazs 1999; Limpus 1992). Continued saturation flipper tagging of nesting turtles and periodic tagging of foraging turtles is recommended to increase the chances of reported tags. This traditional tagging method, while useful for linking foraging grounds to nesting rookeries (Limpus et al. 1992) is not enough. The need for better methods is demonstrated by a large scale mark recapture study in Australia's Great Barrier Reef which exerted significant recapture effort in foraging grounds, but was only able to recapture less than 1.2 percent[15] of tagged nesting turtles over a 21 year period (Limpus et al. 1992). On exceptionally large scales, in terms of number of tags and spatial extent, flipper tagging could be much more useful in determining migration patterns. It is important to note that even a few recoveries of flipper tags can link Helen turtles to at least some of their foraging or nesting destinations.

The potential for flipper tagging to provide useful information can be greatly enhanced by implementing outreach activities that inform communities and individuals that are likely to recover the tags of the significance and reporting protocols. Enforcement activities and tag reporting should remain separated. Outreach should start with Southwest Islanders through community meetings and informal education in Echang. Additionally, HRRMP staff should visit Southwest Islanders staying in the Southwest during field trips and discuss the tagging program. The Palauan public should also be a target for outreach about turtle tags. This is best done in collaboration with the NTP, which has already allotted significant effort towards outreach. Finally, regional outreach to agencies involved in management of endangered species should be conducted through letter writing and informal contact via email. A list of some of the appropriate regional agencies appears in Table 5.

[15] Of 94 nesting females in Gulf of Carpentaria, Australia and 34,675 nesting females in Eastern Queensland, Australia.

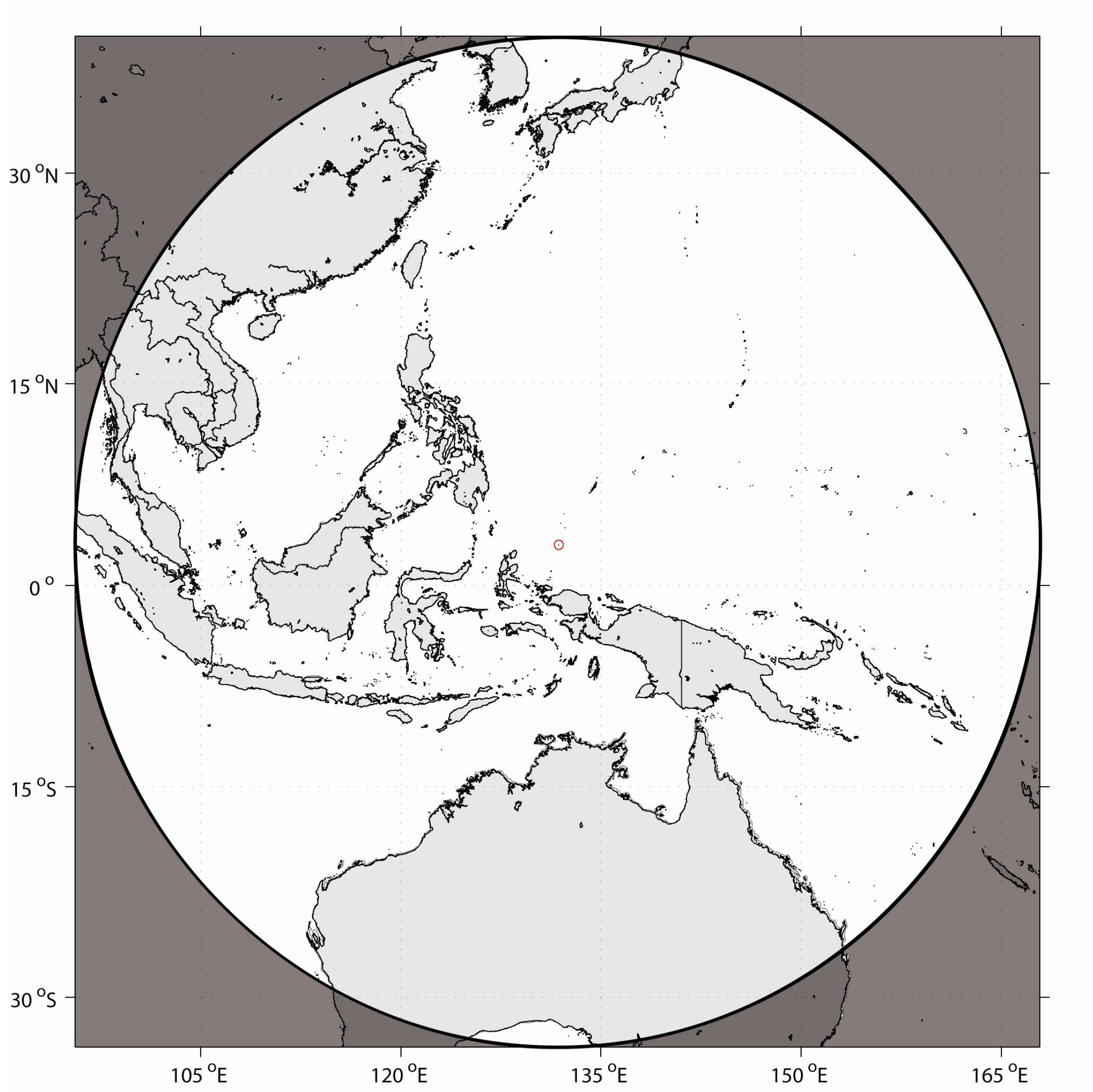

Figure 15: Map of Western Pacific potential scope of migrations to and from Helen. Helen Reef is centered on this map. 19 nations with coastline are each possible feeding or nesting destinations for the Helen green turtle populations. Nations include: Australia, Burma, Cambodia, China, Common Wealth of the Northern Marianas Islands, East Timor, Federated States of Micronesia, Indonesia, Japan, Malaysia, Nauru, Papua New Guinea, Philippines, Republic of the Marshall Islands, Republic of the Solomon Islands, Singapore, Taiwan, Thailand, and Vietnam.

Satellite tagging has the potential to provide answers to the community's priority question, "Where do our turtles go?" With information from the satellite tags HRRMP, and the community, can investigate the threats Helen turtles are encountering when they leave the reserve. Satellite tags will also provide the information needed to take monitoring and conservation to the regional level. Satellite telemetry tagging, although expensive, is a sophisticated and practical way to track the long distance movements of turtles. Technology is constantly improving, battery life increasing, and tag size decreasing making satellite tags an ever better tool.

Transmission of data to the satellite is accurate and efficient. The tags come with options to monitor several behavioral parameters, such as depth and duration of dives. Since these tags communicate with satellites, they do not have to be recovered in order to retrieve information about a turtle's location each time it surfaces. It is possible to track an individual turtle for over a year for about 4000 USD in capital costs. Tag application is simple and some HRRMP staff has already participated in the required training.

Satellite telemetry tracking should be a priority monitoring activity in the near term. Tags should be obtained for placement on 15-20 turtles. This sample size is within a reasonable funding range and will ensure that efforts will not be in vein due to a few lost or malfunctioning tags. A cycle of 24 hours on then 24 hours off is recommended to increase battery longevity so that up to a year and information can be obtained. Additionally, this cycle will record complete daily turtle behaviors and data obtained can contribute to the overall understanding of green turtles in the region.

Tag distribution should include hawksbills and both the nesting and foraging groups of Helen green turtles to reflect the communities concerns for all of these populations. For example, distribution for a 20 tag study could include 10 tags on nesting females, 6 on foraging greens from different parts of the reef, and 4 on hawksbills. This distribution would focus on nesting females, but also provide valuable information about hawksbills and foraging greens that may link the foraging and nesting grounds of these groups improving managers' ability to work towards recovery.

It is important to realize that tag malfunctions are possible. Once a tag is deployed there is a possibility that it will fall off the turtle, prematurely lose battery power, malfunction due to corrosion, or the turtle suffer mortality. Deploying several tags per target population can prevent loss of data due to malfunction. Redundancy also provides more information about the population and reduces uncertainty of too small of sample sizes. Turtles could go in multiple directions as reported by tag and recapture studies at Ascension Island (Carr 1984 cited in Hirth 1997) and several other locations (Hirth 1997). In spite of these challenges satellite tagging is a worthwhile endeavor that has provided very useful results for many sea turtle conservation programs in terms of migration patterns, navigation (Balazs 1994; Cheng 2000; Luschi et al. 1998; Polovina et al. 2000) and mortality (Hayes et al. 2003).

4.2.5 Population Modeling

Assessments of the population in terms of size, recruitment, and mortality are needed to determine sustainable harvest levels and evaluate success of conservation efforts. Confident estimates of population size, mortality, and recruitment – along with increased knowledge about nesting behavior – can enable the development of a population model that will help managers understand the impact of harvest. Using a population model as a predictive tool, however, is risky because it assumes a deterministic nature of a potentially chaotic system (Gillman & Hails 1997). A model that incorporates area specific information can more accurately project population responses to disturbances such as increased fishing mortality or climate change.

Given the long life history and migratory nature of sea turtles, population models can be difficult to develop. However, after several consistent years of data collection using the recommendations in this section there may be enough information to develop a model. Analysis with such a model could help to guide management by indicating the status of the population.

There are many uncertainties associated with management decisions. Some types of model analysis, like the Bayesian integrated population dynamics model, account for uncertainty (Hoyle & Maunder 2004). These models provide information that enable managers to make appropriate decisions under the conditions of uncertainty that are common for sea turtles, such as the immeasurable mortality rates of juveniles at sea. There are several models that are intended specifically for analysis of long-lived sea turtles (Heppell et al. 1996, Heppell & Crowder 1996, Heppell & Crowder 1998). Population models should be considered as future tool for predictive analysis of turtle population recovery or impacts of threats. Appropriately, the collection of data should remain consistent and of good quality. Utilization of the data management system described earlier in this chapter will enable a modeling savvy scientist to provide analysis.

Monitoring and Management	Method	Frequency	Relative Priority
Monitor social response	Community meetings, interviews, and surveys	Annually	Medium
Evaluate field data / adapt accordingly	Formalize review of field data with partners and community leadership	Each 6 months	High
Field data management	Assign a field officer to data quality control and management	Ongoing	High
Upkeep of electronic database	Assign a Koror based officer to electronic data management and reports generation	Quarterly	Medium–high
Data sharing	Quarterly meetings with on island partners and periodic meetings with off island partners	Quarterly	Medium
Nest monitoring	Beach patrols	Each 2 hours	High
Nesting female monitoring	Nightly patrols, curved carapace lengths	Each 2 hours	High
Nesting female population	Saturation tagging	Ongoing	High
Nest tracking	Triangulation and GPS	Ongoing	High–medium
Hatch success	Dig 25% of nest 48 hrs post hatching count hatched and unhatched eggs	Ongoing	Medium
Foraging turtle population	Tagging and open mark recapture study	TBD	Medium–low
Foraging habitat extent and changes	Collection and assisted analysis of seasonal satellite images. Community mapping sessions	Each 2 years	Medium–low
Migration behaviors	Satellite telemetry tracking	Once 20 tags	High
Population modeling	Outsourced analysis of available data	Each three years	Medium

Table 3: Summary of recommended monitoring and research activities at Helen.

4.3 Protecting Helen Sea Turtles

The implementation of longsighted, action-oriented conservation is crucial for the protection of green turtles. The monitoring and research activities prescribed above will generate information that will allow managers to create, or adapt, policies to adequately protect turtles. In addition, the protective policies already in place need continued, but more informed, support from the community and the Hatohobei State Government. The following sections of this Chapter make specific suggestions for enhancement of existing policies and support recommendations for new policies that can enhance managers' ability to protect turtles at Helen.

4.3.1 Nesting Habitat

Helen is a dynamic island with high natural rates of disturbance. For this reason it is vital that the habitat be protected from the impacts of unnatural alterations. Nesting habitat includes the entire island with its naturally intact flora and fauna. Since Sea turtle sex is determined by the temperature of the nests (Morreale et al. 1982). Turtles rely on both the shaded and the open sun areas. To ensure a natural gender ratio of hatchlings woody and grassy vegetation should be preserved to the maximum extent possible. Additionally, it is important to preserve the diversity of soil types and natural soil chemistry through reduced clearing and burning, elimination of toxic waste substances such as batteries, and careful disposal of human waste.

A map of the island (Figure 3) reveals that the human footprint on the island is significant including the raked area and the cleared underbrush area covering nearly 50 percent of the available turtle habitat. Few turtles were observed nesting in the raked area around the field station which includes the church, derelict boats, gardens, chicken pens, burn areas, recreational space, storage facilities, and a benjo. This area occupies approximately 25 percent of the island. Structures on the island like boats, storage sheds, cooking facilities, the field house, and other equipment create barriers to appropriate habitat. These facilities also take up precious limited space on the island. In addition to the physical elements of a nesting habitat the environment is important to nesting turtles and their hatchlings. Uncovered bright lights, loud noises, beach traffic, invasive species that may be perceived as threatening, and alteration of island topography all impact nesting turtles and hatchlings.

Many recommendations for general stewardship and management of the island ecosystem appear in Appendix 9. Preserving nesting habitat also preserves habitat for other wildlife dependent on Helen improving the efficiency of conservation and management on Helen. Recommendations specific to protection of nesting habitat are summarized in the list below.

- Reduce clearing of vegetation on the island to preserve sex ratio of hatchlings, stability of island, and natural soil chemistry and density.
- Reduce the use of lighting at the field station. When lights are needed for a task they should be shaded from the beach. When possible lights should be dimmed and covered with red cellophane or use low-pressure sodium vapor lights sparingly (Witherington 1999).
- Remove structures that act as a beach barrier or are unused. Required structures should be built close together to economize the use of space.
- Reduce loud noises, especially at night.
- Avoid unnecessary trampling of the vegetation.
- Prevent the introduction of invasive species that alter vegetation, soil composition or density.
- Eradicate or contain non-native species (chickens and dogs) that could alter the island or be perceived as predators to turtles.

4.3.2 Nests

In sea turtle conservation programs the primary justifications for nest relocation are often predation and poaching. These factors do not pose a significant threat to nests on Helen which are best left alone to incubate and hatch naturally. In most cases nest disturbance should consist only of marking and tracking nests for monitoring purposes. In rare cases, it may be appropriate to relocate a nest that is in danger of flooding or being lost to erosion. Because Helen is such a dynamic island it is difficult to establish a set distance from the mean high tide line within which relocation is prescribed. Some nests placed close to the high tide line, in pure sand hatch within normal success rates. Yet, some nests placed a greater distance from the high tide line and protected by grasses do not hatch.

Careful removal and relocation of nests from areas with a high risk of erosion, or flooding, to an area that is more stable can significantly improve the chances for hatchling survival (Boulon 1999; Wyneken et al. 1988). Relocation of nests should be decided on a case by case basis by the field officer in charge. It is important to be conservative in the decision to relocate a nest since the relocation itself can contribute to hatchling mortality and alteration of sex ratios (Witherington 1999).

Detailed instructions on the methods for collection and relocation of eggs appear in *Research and Management Techniques for the Conservation of Sea Turtles* (Boulon 1999 pp170-172). In general, the collection needs to be done during nesting, with relocation to a man made nest of similar conditions (shade, soil type, depth) occurring immediately (Boulon 1999). If collection and relocation is not possible within 12 hours it may be better to leave the nest in its original location.

4.3.3 Headstarting and Aquaculture

The term "headstarting" specifically describes the captive hatching and rearing of turtles which are then released into the wild where, after reaching a prescribed age, their survival is presumed improved (Heppell and Crowder 1996). The hope is that protecting hatchlings from the sources of mortality in their first year overall mortality will be reduced. Often these efforts to headstart sea turtles are based on "halfway technology" and do not address issues of juvenile, adult and subadult mortality, or habitat degradation (Frazer 1992).

Headstarting is the term that best describes attempts at Helen to rehabilitate slow or injured hatchlings for eventual release. Unaware and unaffected by the controversy associated with ad hoc headstarting, the HRRMP staff has engaged in this activity on a small scale with the intent to improve the survival of a limited number of individuals. Unfortunately, survival after release is unlikely. Attempts to rear turtles in artificial enclosures are largely unsuccessful due to poor water quality, circulation, temperature control, disease, parasites, and diet (Ross 1999). There are currently no facilities at Helen that can overcome these challenges. All headstarting projects, especially those attempting rearing beyond the first year, should be supervised by technical and veterinary expertise (Ross 1999).

Expectations of the benefits to local and regional turtle population through small scale headstarting may reach beyond the realistic contribution to the population as a whole. Most sea turtles experience high rates of mortality in their first year (Heppell et al. 1996). Captive turtle hatchlings have a higher rate of survival (Eckert et al. 1999) during the first year. After release, however, the headstarted turtles still have more than 20 years to survive in the wild before they reach reproductive maturity.

Costs, in terms of supplies and time spent caring for reared turtles, are extensive especially considering headstarting is unlikely to have a positive impact on the population. Tobians have engaged in experimental forms of headstarting for decades. Historically headstarted turtles were also marked by flipper clipping before release. These methods demonstrate the inquisitive nature of Tobians, and the application of science within the realm of traditional resource management. While many of the HRRMP staff participated in headstarting as young men on Tobi, this practice does not translate well to conservation programs on Helen. Visiting researchers and collaborators who are unfamiliar with Tobian methods for headstarting and marking turtles may be wary of these practices. In most cases on Helen, the health of individual hatchlings held in artificial containers without circulating water is visibly deteriorated.

It is tempting to 'help' hatchlings in distress. If capacity to properly implement headstarting activities were improved the practice may have the valuable benefit of invoking a sense of stewardship. However, it is best to recognize that turtle hatchlings are part of the food web and it may be best to let nature take its course. Additionally, facilities required for headstarting would occupy precious space on Helen and could adversely impact nesting success. The practice of headstarting is not recommended as part of the recovery effort at Helen.

4.3.4 Foraging Habitat

Protecting turtles and hatchlings is only the first step to conservation (Gibson & Smith 1999). Conservation efforts must also include protection of foraging habitats on which turtles depend (Frazer 1992). Fortunately, foraging habitat at Helen is currently well protected. This is in part because of the remoteness of the reef, but also due to increased of the awareness of the field staff and community, as well as effective enforcement against foreign fishing. The biggest threats to foraging habitat at Helen come from illegal fishing vessels and the transport ship. Pollution that can contaminate or smother foraging habitats comes in the form of fuel, petroleum based lubricants used for ship maintenance, sewage, paint, anti fouling chemicals, cleaning chemicals, and garbage. Pollution from vessels can enter the water through accidental spills. Often times, however, it is carelessness and ignorance of the polluter that results in damage to habitats. Another potential problem posed by large vessels is the introduction of invasive species through the discharge of bilge water. This may seem a minor threat, but introduction of invasive species that compete with the native sea grass community species could be devastating to the foraging sea turtles at Helen. Finally, physical damage to the corals and sea grasses from anchors and collisions pose a threat. This damage can even be inflicted by carelessness in using the small patrol boat.

Disposal of trash and pollutants is prohibited within the reserve, but the field trip vessel is often out of compliance with these policies utilizing field trips to repair the vessel as needed. Disregard of the regulations by the vessel crew is also to blame. Non-compliance is not the sole problem of the field trip staff, it also includes passengers. Family ties, and efforts to preserve good working relationships, make enforcement of these regulations difficult. It is recommended that community leadership set an example by not polluting. Leadership may need to exercise their power to take disciplinary action against repeated pollution related violations committed by vessel crew and passengers. The HRRMP officers should make every effort to educate the community on the impacts of pollution and inform them of regulations that prevent it. These regulations should be applied outside of Helen as well.

Enforcement efforts carried out by HRRMP officers are sufficient for prevention of pollution by illegal fishing vessels. It is important that the officers set the example for reducing pollution and physical damage on the reef. Anchoring of the patrol boat, maintenance, cleaning, disposal of fluids and trash should be done in such a way that minimizes impacts. In general, the HRRMP officers are diligent in this task, but awareness of the impacts should be passed on to all new staff. Reporting incidents of pollution, accidental or intentional, should be a required element of field trip reports.

4.3.5 Poaching

In coastal areas throughout the Pacific poaching of green sea turtle adults, subadults, and eggs remains a significant threat to sea turtle populations (Eckert et al. 1997; Seminoff 2004). Fortunately, poaching by Tobians at Helen has been significantly reduced due to the stewardship programs of the HRRMP and the elimination residences. Efforts at Helen to reduce poaching of fish and turtles by foreign vessel crews have also been very effective despite enforcement capacity limitations. The biggest constraint is the danger associated with using a small vessel with two or three officers to pursue a large vessel with a crew of several men. Additional safety concerns associated with navigating the reef prevent pursuit of poachers at night or in bad weather. The purchase of the larger, more stable, enforcement vessel slated for

2006 should reduce risks to officers. This development will provide HRRMP with improved capacity for effective enforcement thereby improving protection of Helen turtles from poaching.

It would be impossible to capture all illegal vessels. However, coordination with the Palau Maritime Authority customs agents can be helpful in monitoring bycatch of turtles on vessels that have been fishing at Helen. This can be done through participation of Koror based HRRMP officers in inspections of foreign vessel landings. Participation in customs inspections can help to build a relationship with national level authorities and to promote education of the HRRMP officers. Partnerships with Palau Maritime Authority can enhance HRRMP's ability to access information about fishing vessels and landings, as well as improve communication about vessels that participate in illegal fishing at Helen. HRRMP officers already have a strong relationship with the Palau National Patrol Boat captain and crew. It is recommended that this relationship be continually fostered as it has proven to enhance the ability of HRRMP to enforce state and national laws.

The Hatohobei State Government is limited in their authority to issue worthwhile fines to individuals, or vessels, which violate the no entry law at Helen. The inability of states to impose and collect fines suitable to offenses, high enough to mitigate damage and pay for enforcement, is a well discussed problem of the Koror State Department of Conservation and Enforcement, the Peleliu State Rangers, and the Kayangel State Conservation Program. Combining forces with these state programs to negotiate and collaborate with the Palau National Government, specifically the Ministry of Justice and the Ministry of Resources and Development, may lead to the issuance of authority more appropriate to the crimes each state is enforcing against.

Recommendations for improving the economic contribution of the pelagic fisheries include employment of Palauans, and compliance with various national and regional regulations governing tuna (FAO 2000). Income from fisheries has been less from export of landings, than from permitting and foreign subsidies (FAO 2000). The lack of Palauan citizen involvement with the pelagic fisheries eliminates the innate resource protection provided by national stewardship. National pride and responsibility can be a motivation for following regulations and improving long term viability of the fishery. Most fisheries violations, usually bycatch or boundary related, are not prosecuted. When major violations occur, and are prosecuted, judges tend to be lenient in issuing fines and punishment. The states themselves are limited by statute and can only issue fines of 200 USD per violation. When there are several violations this fine could be worthwhile. However, the states do not have the administrative capacity, or legal expertise to collect.

False reporting of landings, and mother ship offloading just outside the EEZ, are common practices of the foreign fleet (pers comm. Captain I. Tervet). It is clear that the fleet takes advantage of Palau's limited ability to enforce, relatively inexpensive permits, and lenient treatment of illegal activity. Investment of a portion of profits from this activity should be allocated to the long term sustainability of the fishery, the development of the Palauan economy, and protection of Palau's natural resources like sea turtles. HRRMP staff and Tobian community members may feel powerless to participate in regulatory action that protects Tobian owned resources. Fortunately, Palau's democratic government enables individual access to law makers and representatives to the national government. Tobians also have access to the Palauan Council of Chiefs through traditional leaders. At the very least managers should stay informed about commercial fishing related laws and regulations; however, it may be more effective to engage in advocacy activities. It should be noted that the political climate in the Republic of Palau may make advocacy difficult for Tobians.

4.3.6 Local Harvest of Sea Turtles

Local harvest of green sea turtles is practiced throughout the Pacific Islands (Eckert et al. 1997). Despite past abuses of harvest rights and privileges at Helen (Black 2000), local harvest is recognized as important to the Tobian people (Chapter 2). Harvest is important for nutritional reasons, but also for cultural and educational reasons. In an effort to maintain cultural identity and promote a sustainable use ethic, many other indigenous communities of Micronesian Trust Territories have requested permission for limited harvest of turtles (Kinan and Dalzell 2005).

While harvest is of importance to cultural identity, harvest on Helen has not, for the most part, been managed in a traditional way. Helen has a bounty of resources and so the island has earned a reputation for "fattening up" anyone who visits for extended periods of time. Peter Black (2000), an anthropologist who has extensively studied Tobian society, reported on Tobian behavior and perceptions related to Helen Reef, the following statements are based on his report. Substantial impact to the resources was considered by the community to be a result of the binging behavior of field trip personnel who, along with passengers, would load up the field trip vessel with turtles and other desired species. Human settlement during trust territory times consisted of small party "bachelor affairs" each occupying the island for three to six months. On trips to Helen personal freedoms were abundant and traditional rules often did not apply. In recent years awareness and concern about the potentially unsustainable lifestyle at Helen has grown. Recent oral histories express concern for diminishing resources and stress destruction of the island and reef instead of stories of a bountiful harvest to be exploited.

This new attitude of concern opens up an opportunity for a rebirth of the traditional management system to work in concert with the current secular system of partnership between HRRMP and Hatohobei State. Helen can and should be a place where harvest of turtles for traditional purposes takes place. The option for limited harvest, is itself, is a major motivation for turtle conservation.

Goals of a limited harvest policy should be explicitly defined. They may include: maintenance of cultural identity, preservation of traditional ceremonies, cultural education of youth, and strengthening of social interactions. If goals for harvest are established then regular evaluation of the extent to which the goals are met can take place.

It is extremely important that initial policies for allowable harvest are precautionary, explicit, and closely monitored. Limited harvest policies should not include sale of turtle meat or products, nor should they supply field trips with food except when traditional uses coincide with those field trips. Probable results of careless management measures, or sloppy implementation and enforcement of policies, include decline of the community's conservation ethic, criticism from partners and donors, difficulty developing regional partnerships, and further decline of sea turtle populations.

It is vital that collaboratively developed sound policies for limited turtle harvest be in place before subsistence field trips with zone limited fishing commence (Andrew et al. 2006). These field trips will bring many who expect to hunt and fish. Policies that include the interest of Tobian fisherman can ensure that turtle harvest is done with the established goals in mind thereby reaffirming the values underlying those goals.

It is difficult to assign a number of turtles that can be sustainably harvested because there is little information about the status of the turtle populations and the level of mortality they already suffer. Likewise, choosing a size, sex, or particular life stage on which harvest should concentrate is a gamble. In light of the fact that there is not enough information to determine which turtles (with regards to size, sex and populations) are the most delicate and which are the most resilient, it is best to establish a precautionary limited harvest policy. In the case of Helen a precautionary policy is one that estimates an exceptionally low allowable take under the current condition of uncertainty.

Until proper assessment of the population of foraging turtles on Helen is conducted, the recommended annual take, of subadult and adult turtles, should not exceed 5 individuals limited to on site consumption. Taking of nesting females should also be prohibited. Timing of harvest and size of harvested turtles should lie within Palauan National Law. Otherwise, negotiation with Palauan National Government should take place to make an exception for Helen Reef in response to any future comprehensive documented population assessments and current size estimations of nesting females. Managers may find it appropriate to ask for a legal conditional exception allowing the occasional take of smaller turtle for nutritional purposes when there are not enough people on Helen to justify the harvest of an adult.

In an effort to preserve turtle population for the future, harvest of eggs on Tobi has been prohibited since (at least) the 1970s (Johannes 1986). Palau National Law and the Helen Reef Management Plan also prohibit harvest of eggs. Harvest of eggs should remain prohibited. Removal of turtles from the reserve should also be prohibited. It is important that changes in the allowable harvest respond to increased information about the status of sea turtles at Helen. Care should be taken not to let political pressures set harvest limits.

4.4 Erosion and Island Stabilization

Concerns about erosion related to human impacts, storms, and global climate change have been threaded throughout this thesis. I believe the issue of erosion and the potential need to stabilize the island are critical and deserve timely attention. Erosion, by wind, as well as oceanic and tidal currents is worsened by reduced vegetation and activities like clearing and burning. Invasive species, primarily chickens, may be playing a role in reducing seedling production on Helen. Erosion events caused by storms pose and immediate threat to turtle nests. Larger scale issues of sea level rise (McCarthy et al. 2001), increased frequency and intensity of storms (Barnett and Adger 2003), and removal of sand from the island's budget will result in reduced nesting habitat. Even greater forces such as tectonic subsidence can, over time, eliminate the island all together.

If managers consider all of the abovementioned factors it is impossible not to be concerned about the future of the island as a cultural site, turtle rookery, as well as an important bird nesting site. The temptation to take action to stabilize the island is rightfully strong. However, limitations in terms of supplies, man power, and electricity make this a daunting task. Attempts by the Global Coral Reef Alliance (Goreau and Hilbertz 2004) to use electrified steel to build a limestone breakwater (Figure 1) failed to "stop erosion and start growing" the island. Unfortunately, all that remains of the breakwater project is rusty steel, solar panels, and wooden structures off the west side of the island.

Future efforts to stabilize the island should be informed by a suite of oceanographic and engineering information. A better understanding of the local currents, tides, sea level rise, sand budgets, and climatic events is needed to assess potential stabilization options. Much of this data is available but not readily accessible to Tobians given limited internet and computing capacity. It is recommended that HRRMP and the State government request the assistance of NOAA Fisheries Pacific Islands Resources Office with acquiring and interpreting data of this nature. Appendix 2 and 3 include available data on regional wind and currents respectively.

4.5 Outreach and Education

Outreach and education about environmental issues and linked cultural traditions is also threaded throughout this chapter. The transparency under which HRRMP operates lends itself to outreach efforts. Since HRRMP carries out conservation programs on behalf of the community, education of the community is a natural role for the organization. Here outreach and education activities are broken into two categories. Tourism is first discussed as an economic activity, and a way to educate foreign visitors about the ecology of Helen and HRRMP programs. Community education is discussed as a way to involve the community more deeply in the conservation efforts at Helen, increase support for those activities, and pass important information on to the next generation.

4.5.1 Tourism

Ecotourism is a form of outreach as well as a potential source of revenue and has been a useful tool for promoting stewardship and overall benefits of conservation of natural resources. In the context of Helen Reef ecotourism can be defined as a managed program that permits travel to Helen by non-Tobians for non-consumptive low impact purposes. These uses may include enjoyment of the ecology and scenery, planned shelter and stopover for personal sailing vessels, or research with objectives outside the scope of the Helen Reef Management Plan.

Although ecotourism is poorly studied in Oceania (Krüger 2005), it has a large potential to raise international awareness of local conservation issues. Conversely, tourism can pose threats to the ecosystem while generating insufficient revenues from significant investments. Nevertheless, ecotourism could prove to be an important addition to the long term management and sustainable financing of the HRRMP. This is especially true if sustainability of resources at Helen remains a priority throughout the development of an ecotourism program.

Krüger (2005) performed a useful study of ecotourism sustainability; he found that approximately 11 percent of ecotourism projects occur in Oceania, only 7 percent are centered on islands, and only 8 percent focus on reptile species. Of the total 188 projects studied, 62.8 percent of them are considered to be sustainable. On islands, however less than 40 percent of projects are sustainable. Of projects focused on reptiles about 60 percent are considered sustainable. For the achievement of sustainability Krüger emphasizes a program must have community involvement, comprehensive project planning, and the presence of a charismatic attraction (such as sea turtles). Table 4 highlights common elements of case studies and can be used in planning an ecotourism program. Since only 17 percent of studied programs reported beneficial effects – like revenue, improved community conservation ethic, and more effective conservation programs – it is imperative that managers fully consider the costs and benefits of implementation of an ecotourism program at Helen.

Ecotourism may be particularly challenging because of inconsistent transportation, remoteness, and lack of services on the island. It is important when considering overcoming the challenges involved with establishing turtle-based ecotourism that the implementation of a tourism initiative does not threaten the very thing that may attract tourists to Helen.

It is recommended that planning commence to develop an infrastructure for a differential fee system to permit, and gain revenue, from visiting researchers and passengers of personal sailing vessels. Hatohobei State should work with the HRRMP Board to develop a jointly agreed upon system of setting, collecting, and allocating fees. Fees should first go to pay for any services provided to visitors, then to compensate the managing agency. Any remaining fees would be directed to further research on the potential costs and benefits of an expanded ecotourism program. A system for HRRMP to receive donations from visitors that would like to support a specific program should also be established.

Visitors should be briefed on rules of visitation that protect the island ecosystem. Rules should be developed with a mind to prevent the generation of trash and sewage. Waste generated by visitors and not suitable for compost should be transported back to Koror and legally disposed of at the Palau land fill at the expense of the visitor. Tourist should never be allowed to contribute to illegal harvest of species from within the reserve, harassment of wildlife, or physical damage to the reef or island. Visitors should agree in advance to pay applicable fees and to incur the cost of mitigation for any damages they may cause.

Sustainable projects	
Benefits from sustainable projects	
	Improved effectiveness of conservation programs
	Increased revenue from non-consumptive uses
	Increased revenue regionally and nationally
	Altered conservation attitude of local community
Reasons for benefits	
	Local community involvement
	Effective planning and management
	Provides and economic advantage
	Draw of focus species
	Differential in fees (visitors from developed countries pay more)
Unsustainable projects	
Types of unsustainability	
	Habitat alteration, soil erosion, pollution
	No community involvement, allowing for consumptive resource use
	Altered behavior or status of focus species
	Insufficient revenue
Reasons for unsustainbility	
	Too many visitors
	Local community not involved
	Insufficient management and control
	Insufficient revenue
	Site becomes more important the societal needs
	No environmental education for locals

Table 4: Reasons for ecotourism sustainability and benefits compared with unsustainable projects. Adapted from Krüger 2005. Items under each of the four subheadings are listed in order of importance.

4.5.2 Community Education

Community education on the subject of sea turtle conservation provides a means for HRRMP to share their successes and challenges, knowledge to the community at large, and information on the methods for protecting sensitive sea turtles and habitat. A community education initiative should incorporate at least four elements:

1. Provide information to the Tobian community on the rational, methods, and outcomes of conservation activities.
2. Education of all Southwest Islanders visiting Helen on relevant reserve regulations and the reasoning behind them. Southwest Islanders should also have access to education on the general ecology of the island, and reef, and how it compares with that of other Southwest Islands and of Palau.
3. Targeted island ecology education of children and young adults through continued field camps.
4. In school education programs highlighting the work of HRRMP and the uniqueness of Helen.

Information sharing with the community already takes place during periodic community meetings. Involvement of some community members as HRRMP staff and Board also contribute to the open flow of information. To enhance the availability of information on HRRMP's conservation efforts poster style updates should be regularly placed at the Echang community center. In addition, HRRMP staff could work towards increasing participation in, and the regularity of, community meetings by door to door outreach, and distribution or posting of written agendas. These efforts to increase awareness and participation can improve support for HRRMP activities. Increased participation will ensure that HRRMP's activities truly reflect the wishes of the community.

Education of Southwest Islanders that visit Helen can be improved in two ways. First, an individual HRRMP staff member can be assigned to oversee visitor education for each field trip. This officer can act as a guide on the island, enhancing the visitor's experience and improving compliance through ensuring visitors are informed about policies. Second, written information can be provided to visitors in a brochure, and can be posted on the island itself. This information can include unique facts about the island, the status of conservation programs, and policies that need to be followed while visiting.

The annual summer ecology and cultural camp conducted on Tobi and Helen directly serves the third element to provide targeted ecology education to youth and young adults. Although the benefits of the camp - in terms of increased knowledge, stewardship, and community involvement – are perceived to outweigh the potential risk of ecosystem damage, it is important to ensure this balance is maintained. Even a short visit can have a significant impact. The appointed HRRMP education officer should ensure that camp activities do not pose a risk to turtles, nests, and habitat. It is recommended that the camp be continued and special attention be given to establishing goals and evaluating success on an annual basis.

In school education programs have been discussed, but never tackled by HRRMP. The primary reason cited is lack of interest and confidence among the officers to speak to children in a formal setting. Most of the HRRMP staff has no training in formal education, so their trepidation is understandable. Management should consider hiring a staff member with specific training, or interest, in education to serve this task. Significant educator guidance is available through Palau Community College, Palau Conservation Society, and Palau International Coral Reef Center. These organizations can provide training and partnerships to improve the effectiveness and reduce logistics involved with working with the Ministry of Education. It is important that the educator position be held by a Tobian, as Tobians are uniquely qualified to combine oral traditions, stories, and local knowledge about Helen. If possible this program should provide education in the Southwest Islands. This can be done by working with the on island educators either when they come to Koror, or over the radio. In Palau the program should focus on schools that have a significant Tobian student body. The program should also be extended to all Palauan schools so that Palauan children, who will one day be leaders, learn about the unique and beautiful Helen. Helen is already a source of pride for Tobians, but is worthy of appreciation by all Palauans.

4.6 Coordination

Managing an ecosystem like the Helen Reef Reserve is a difficult task. In spite of this HRRMP has been successful. I believe this is primarily the result of the collaborative approach the organization uses in developing and implementing conservation programs. It is not any one person, or organization, but a web of partners that turn conservation objectives into action. Coordination among organizations reduces redundancy and improves the implementation of programs. Collaboration provides an opportunity for organizations to learn from each other and ultimately be more successful in their conservation programs. It is important, however, for the amount of people involved to match the scale of the area, or resource, to be conserved. When there are too many collaborators relative to the geographic scale of the area or the project objectives it can cause a standstill. This 'too many cooks in the kitchen' syndrome achieves the opposite effect of appropriately scaled collaboration (Pomeroy et al. 1998). Collaborative efforts sometimes exhibit an irrational inertia towards standardization of conservation methods. It is important for a lead organization, in this case HRRMP, to considered weather or not standardization is appropriate to meet conservation objectives. Here coordination and collaboration are discussed by categories of geographic scope.

4.6.1 Local

For the purposes of this document the term local includes the Southwest Island community living in the Southwest, and Echang village. Local also includes collaboration with the Hatohobei State and Sonsorol State governments. Coordination with Sonsorol State and the Southwest Island community on a whole is a natural component of the HRRMP program. The Southwest Island community is not without its disputes. However, shared living space, language, and similar cultures can be extended to shared conservation efforts. This makes sense when the geographic expanse of the Southwest Islands in considered in contrast with the resources available for conservation. By coordinating efforts conservation programs can be more effective and incorporate an economy of scale. Collaboration on conservation programs can reduce costs (of fuel and equipment) and avoid repetitive efforts. Additionally, constant communication and collaboration can greatly improve the quality of information gathered on the status of green turtles.

Of particular importance is continued informal training and support of the Merir conservation officers who have proven to be dedicated managers. Most of the information in this document can be easily applied to the efforts to monitor and manage green turtles at Merir. If the populations at Helen and Merir are connected collaboration ensures the connection will not go unnoticed.

In Koror there are many collaborative efforts yet to be considered. For example, recently organized group of Southwest Island young adults strives to join forces of Sonsorolese and Tobians. This organization is controversial because it is perceived to threaten the political autonomy of the individual states. It seems, however, that this collaboration could prove effective for conservation and education programs.

Coordination with the Hatohobei and Sonsorol State governments has clearly been a priority of HRRMP managing staff. These partnerships are essential for the continuation of work at Helen.

4.6.2 Regional

Regional coordination includes working with partners throughout Palau and Micronesia, including the Palauan national government, NGOs, state governments, and community organizations.

Compatibility with the NTP has been built into the monitoring program. It is important to maintain this compatibility with a mind to balance the benefits of the partnership with the efficacy with which HRRMP is moving forward. The success of the 2005 monitoring effort at Helen shows that the assistance provided by the NTP was well utilized. The goals established for turtle conservation and monitoring by

HRRMP and Hatohobei State were more in line with the NTP than other states. This congruence has been demonstrated by the high level of commitment shown by Tobi relative to all other Palauan states, with exception of Sonsorol. It will take some time for the NTP to work with the other states to build their capacity. In the meantime HRRMP should not slow their pace, but should continue with monitoring efforts and act as an example to the other states. Their may be a role for HRRMP staff to act as mentors for turtle conservation efforts in other states.

Advancement of the HRRMP can benefit the NTP. The spirited nature of Tobians, the strong capacity of HRRMP to carry out conservation programs, and the ability to develop worthwhile partnerships are all factors that improve the adaptability of the national program. Adaptive management essentially means experimental management. When each management measure, and for that matter monitoring method, is an attempt to do the best possible job with the information available – and adequate effort is allocated to evaluation – then managers can learn from their mistakes and improve their programs. There are several examples provided in Chapter 3 of experimental, and thereby iteratively adaptive, monitoring methods. One example that stands out is the attempt to monitor successful emergence of hatchlings. This method started with the use of cages. The field team learned that the cages did not work through experimental use; they were able to adapt and improve the method yielding more reliable data. Through sharing information and lessons learned, partnerships can improve the efficiency of this adaptive process. When partnerships are fostered without the condition of standardization they can be most effective in learning by doing, or adaptive management.

Cooperation with the Ministry of Justice is a feature of the HRRMP enforcement program worth continuing. Cooperation with the Palau Maritime Authority should be developed with a goal to increase transparency of fisheries regulations and expand HRRMP knowledge of fisheries enforcement.

Many Micronesian island communities face the same conservation and management challenges as HRRMP. Some strong connections have been made through The Nature Conservancy's regional workshops, Locally Managed Marine Area Network, and other programs. These connections should be fostered to facilitate exchange between small islands resource manager, especially those from the outer islands of Micronesia. This solidarity not only opens up the opportunity to improve the individual conservation programs, it also can provide a mechanism for obtaining joint funding.

4.6.3 International

Extending collaborative efforts outside of Palau and Micronesia can enhance adaptive capabilities further. Partners can learn from the each others' trials and errors; therefore, when the pool of organizations learning from each other expands so too does the ability of partners to adapt. In November 2003 a group of 25 experts gathered to draft action plan on Pacific Sea Turtles. The resulting document is called the Bellagio Blueprint (WorldFish 2004). The Blueprint emphasizes the need to establish pan-Pacific policies and actions through strengthening of regional and international agreements, developing new regional coordination arrangements, and developing regional management plans. HRRMP staff and partners have also identified the importance of regional and international coordination for the recovery of sea turtles.

Participation of HRRMP, Hatohobei State, and Republic of Palau in existing regional and international efforts to conserve sea turtles can enhance the those efforts. Table 5 lists multinational efforts that work towards conservation and management of sea turtles.

New regional arrangements may become appropriate once more information is known about the migratory patterns of Helen sea turtles. In the meantime nations and communities within the Western Pacific region (Figure 15) should be considered for collaboration. The organizations in Table 5 can help in establishing and facilitating international partnerships, and provide models for regional management plans.

Regional management plans will be essential in order to adequately sustain and recover turtle populations. Successful stand alone conservation efforts at Helen could still see a decline in turtle populations. Therefore, to reach the goals of sustainability transboundary partnerships will be necessary. Regional or joint management plans will be most targeted when implemented with the knowledge of migration patterns and population connectivity. These unknown factors should not delay the development of regional agreements, or the participation in existing regional agreements like IOSEA. If migration patterns are learned and they are not within the region where management plans or agreements have been, then nothing is lost. Much can be gained from these partnerships in terms of other conservation objectives like joint management of migratory fisheries.

There is still much to be learned about turtle monitoring and conservation from partners outside of the Helen turtles' migratory route. Once knowledge of migratory patterns is gained, then agreements and partnerships can expand into the most relevant areas. On the other hand, inaction while waiting to learn migration patterns could result in an apathetic holding pattern that is disempowering to the community.

Name	Description	Goal	Recommended Involvement
LMMA	Locally Managed Marine Area	Improving the practice of marine conservation through networking	Continued involvement of HRRMP and Fostering Involvement throughout ROP
CMS	Convention on Migratory Species	Provide a framework for joint efforts to conserve migratory species throughout their range	Advocate for Palau to become a signatory
IOSEA	MoU on the Conservation and Management of Marine Turtles and Their Habitats in the Indian Ocean and South-East Asia	Support of Multilateral efforts to reduce threats, improve understanding, and foster collaboration for the conservation of Marine Turtles	Collaborate with the members, work with Palau to become a signatory
CITES	Convention in International Trade of Endangered Species	Ensure that international trade in specimens of wild animals and plants does not threaten their survival	Support enforcement of CITES regulations through local programs (Palau membership began in 2004)
CBD	Convention on Biological Diversity	Promote nature and human well-being through protection of biodiversity	Support Finalization of Palau's ratification (currently in accession)
SPC	Secretariat of the Pacific Community	Build capacity for marine resource development and improve understanding of marine resources	Participate in available workshops and working groups on marine conservation
SPREP (RMTCP)	Pacific Regional Environment Program, Regional Marine Turtle Conservation Program	Actively network governments and NGOS to reduce unsustainable harvest and habitat degradation	Foster enhancement of Palau National involvement, Begin HRRMP direct involvement
WCPFC	Western and Central Pacific Fisheries Commission	Conservation and management of highly migratory fish stocks through implementation of regional fisheries conventions	Promote participation and ratification of the Republic of Palau to encourage reduction of bycatch
FFA	Forum Fisheries Agency	Provide expert fisheries management and advice to member countries	Encourage assessment by FFA on bycatch and enforcement of National laws in Palau, support a request for national level audit and training to reduce bycatch

Table 5: Regional and international organizations and conventions. Participation with each of these organizations can improve the ability of HRRMP, Hatohobei State, and Palau to conserve and manage sea turtles. Specific recommendations on how to focus involvement are listed in the far right column. Palau and/or HRRMP are already involved with the majority of these organizations.

Chapter 5: Key Factors for Successful Community-Based Sea Turtle Management

This chapter investigates the social, political, and cultural aspects of sea turtle management at Helen Reef and seeks to identify the qualities of the Tobian community that have led to the successful implementation of a sea turtle management an conservation program. The chapter draws on literature in social theory and resource management utilizing Tobian and other Palauan communities' experiences as case studies. This chapter will be modified and submitted for peer reviewed publication.

5.1 Introduction

Green sea turtles are endangered (Seminoff 2004). Throughout the Pacific islands populations are vulnerable to nesting beach and coastal area harvest by indigenous peoples (Eckert et al. 1997; Seminoff 2004). Sea turtles also play an important cultural role and many Pacific islanders are interested in conserving sea turtle populations as a means of cultural preservation. Management of sea turtles throughout the region will only be successful when small scale communities have the capacity to protect their local populations and join in transboundary initiatives. This chapter discusses the challenges associated with community-based management and identifies key factors imperative to the successful implementation of sea turtle management and conservation programs at Helen Reef, Republic of Palau.

Co-management (Granek and Brown 2005; Jentoft et al. 1998), collaborative strategies, and integration of traditional ecological knowledge (Wildcat and Pierotti 2000; Berkes and Folke 1998; Johannes 1998) have often been described as methods to ease conservation and management challenges associated with incomplete science or lack of large scale agency capacity at the local level. Within the science-based worldview, resource management must be based on science (Hawley et al. 2004); therefore, the institutions with the capacity to produce science are then given power over the resources. True community-driven natural resource management, however, is more than just mitigation for lack of available science to inform conservation and management; it is an especially valid and appropriate model for small scale societies. Berkes (2004) recommends pursuit of projects where community values overlap with conservation needs. This much needed, self-determined and globally applicable approach will empower communities to identify their conservation and management goals and implement programs to reach those goals while concurrently working towards larger scale conservation objectives. Success is more likely when communities are not just collaborating (Wildcat and Pierotti 2000; Berkes and Folk 1998), but are seeking the assistance of scientists (Johannes 2002), development workers, or resource managers.

Small scale remote communities share several qualities, including a dependence on natural resources, fading traditional management systems, limited scientific information, threats to sustainability from outside sources, limited enforcement capacity, disproportionate financial returns from outside resource users, and limited capacity to generate alternative income activities. Each of these communities also has a unique culture and each is in a different stage of development resulting in varied relative importance placed on cash economy.

This chapter is intended to provide assistance to professionals working with small scale communities in planning and implementing for successful natural resource management and conservation programs. Additionally, academics may find this chapter as a useful source of comparative case studies. When community needs and desires are central to a conservation programming and success is considered meeting those needs and desires, then community participation is more than a required element or a bail out for lack of science. If the community drives conservation and management, then success is theirs to realize.

There have been several recent calls for detailed examination of case studies to determine the circumstances under which community-based collaborative and adaptive management works (Jones and Horwich 2005; Leslie 2004; Johannes 2002; Olsen and Christie 2000; Hønneland 1999; Brosius et al. 1998; Jentoft et al. 1998; Johannes 1998; McLain and Lee 1996). Examination of successes and challenges can help to identify the social, political, and biological linkages best suited for adaptive and collaborative community driven management. This examination can also establish the circumstances under which extra-local institutions can assist communities in reaching their conservation objectives (Armitage 2005). Such understanding can also help international NGOs and development agencies in prioritizing and directing assistance towards community-based sea turtle conservation efforts in remote coastal regions.

Here I present a case study of the successful implementation of a sea turtle conservation and management program at Helen Reef Atoll in the Republic of Palau driven primarily by the Tobian people. The study is contrasted with similar efforts in other communities within Palau, where programs failed to commence, demonstrating the subtle differences between top-down and bottom-up collaborative management approaches. These case studies are ideal for comparison because all communities are similar in culture and their sea turtle program objectives were the same. Each of the communities was a member in a nationally implemented sea turtle monitoring and management program. The reasons that one community far exceeded expectations of implementation, while others failed to begin the project are essential for understanding the key factors of successful community-based conservation projects and the qualities of communities who carry them out. What is different about the Tobians and their capacity to implement sea turtle conservation and management? I find that differences in the communities go deeper than simple issues of motivation and capacity, but include factors related to partnership, scale, remoteness, the balance of costs and benefits, adaptability, and tradition. Use of the case studies facilitates a closer look at the underlying factors contributing the relative success of implementation which may or may not apply to other management and conservation scenarios.

Several terms need to be defined in order to have a clear discussion about these case studies and my postulations about community driven natural resource management. The terms are: conservation, small scale, remote, community, co-management, collaborative management, collective action, adaptive management, and common pool resources. Conservation, in the Palauan context, refers to any project or program that attempts to protect, preserve, or recover natural resources. Small scale is used in terms of community size and describes those communities with political autonomy (Smith and Wishnie 2000) made up of culturally connected individuals ranging in size from a tens of individuals to a few thousand. Under this definition all communities in Palau, excluding the capitol city, are considered small scale. Remote regions are those with discrete biogeographical boundaries where there is limited or no development, little or no access to public services, and reduced emphasis on cash economy. Helen Reef Atoll is then considered very remote, while the rest of Palau is moderately remote. In examining the differences between communities in Palau it is useful to consider a community to be a group of individuals that share adjacent property and resource rights, linage from a particular region, language, and cultural traditions. In the Republic of Palau individual identification with one's community of origin is deeply valued and geographic boundaries are explicitly recognized.

Co-management is a decentralized approach to natural resource management that recognizes the knowledge and experience of resource users (Jentoft et al. 1998) as well as the need for larger scale institutional support. The user groups and the responsible institutions are co-managers of natural resources. Berkes and others (2001) distinguish between community-based natural resource management, which may need institutional assistance with legal matters – but are otherwise small scale – and co-management which is more useful for larger scales. Unfortunately, the goals of the resource users and the institutions are often quite different. Mere participation of the two groups in a co-management arrangement is often not sufficient to sustainably manage resources. This is why collaborative management is needed. The collaborative approach moves beyond participation of user groups to establishing formal or informal agreements to jointly determine management goals, design project objectives to met joint goals, and delegate tasks to collaborators with the particular capacity to complete them. Collaborative management can involve several groups of different scales. Collective action assumes individual costs are overcome by collective gain through a process of any group of people coordinating actions (Smith and Wishnie 2000) to produce a mutual outcome. In this chapter collaborative management is used to describe the approach that links international, regional, national, and local conservation objectives and capacity. Collaborative community-based management best describes efforts to conserve turtles at Helen Reef.

The term adaptive management, an experimental and evolving process, was introduced to the practice or resource management by Holling in 1978. Adaptive management was further described as an explicitly experimental approach (Lee 1993) that allows management activity without complete knowledge of the outcomes rather a focus on the need to take action. Lee (1993), in favor of adaptive management, claims there can be neither social learning nor development without experimentation. Here adaptive management refers to the idea that managers learn from doing and respond to social and biological feedback mechanisms resulting in an iterative process of improved generations (Olsen and Christie 2000) of management systems.

Finally, the term common pool resources refers to the concept popularized by Hardin (1968) in his article "Tragedy of the Commons" which describes the inevitable degradation of shared resources as a result of lack of individual consideration of costs to other users. Many papers have argued that Hardin's (1968) tragedy is not inevitable (Hønneland 1999; Jentoft et al. 1998; Ostrom et al. 1999) when resources are shared and managed in a collaborative way.

Community-based efforts to conserve sea turtle resources are unique. The long-lived nature of sea turtles makes quantitative evaluation of management exceedingly difficult. Additionally, little is know about the migratory patterns of sea turtles in Palau making biological indicators of success even more elusive. This chapter does not claim that the Tobian project is successful over others in Palau in terms of individual turtles protected. There is no evidence to make such a claim, since it will take decades before the impact of the project on turtle populations can be evaluated. For the purpose of understanding the difference between bottom-up community driven conservation and top-down imposed conservation success is here defined in a processual way: as participation in setting project goals, planning project activities, implementing those activities, and engagement in the adaptive process.

5.2 Case Studies

Information for case studies was primarily derived from my personal experiences working with the Tobian people and other communities in Palau since May 2002. My role was to assess community conservation needs and build sustainable capacity. I worked in the field with community members and participated in planning, implementation, and evaluations of conservation projects with community groups, traditional leadership, and governments. Since 2002 I have been on three conservation expeditions to Tobi and Helen Reef. My work in Palau included conservation planning, capacity building, project implementation, and monitoring. Through these activities I was able to build relationships in the communities and listened to concerns about the environment, local capacity, sustainability of resources, imposition of conservation initiatives, collaborative action disputes, lack of enforcement, and political and financial issues. During the summer of 2005, while fulfilling the Tobian community's request for assistance with implementation of their sea turtle program, I more intentionally examined the unique features of Tobian society related to resource management by holding informal field based problem solving focus groups sessions that discussed in detail resource depletion challenges and potential solutions from the Tobian perspective. It is through these semi-structured focus groups, informal discussions, meetings with leadership, interaction with partners, and review of literature on social theory and ecological management that my ideas have developed.

Endangered sea turtles (Seminoff 2004) ard provided protection by a multitude of local, national, regional, and international laws, conventions, and agreements. Green sea turtles are of important cultural and subsistence value to Pacific Islanders. In 1997 the Pacific Sea Turtle Recovery Team prepared a recovery plan for U.S. population of Pacific green turtles. This plan included the Republic of Palau because of its status as a protectorate under the Compact of Free Association with the U.S. The plan predicted that if current harmful practices and inadequate conservation efforts continue, Palau is likely to lose their green turtle population by 2017 and describes the situation at Helen Reef as "especially perilous" (Eckert et al. 1997). Given the recent efforts towards sustainable management of sea turtles I do not think the estimate for local extinction is reasonable.

5.2.1 Helen Reef

Helen Reef is a remote island atoll that belongs to the State of Tobi, Republic of Palau. Tobi, like all other Palauan States, has its own government, legislative body, and traditional leadership. The states of Palau operate under a similar system of representative democracy as the United States with an added recognition of traditional laws. Helen Reef is about 162 square kilometers (Birkeland et al. 2000), with an atoll about double the size of a football field. The reef lies approximately 600 kilometers to the southwest of the Republic of Palau and 40 kilometers from the historic population center of the State Tobi. Tobians historically traveled to Helen Reef, traditionally called Hotsarihie (*Reef of Giant Clams*), on canoe to harvest sea turtles and giant clams. Over the last several decades Helen has hosted several small temporary settlements of Tobians. In 2001, after an unanswered plea to the national government for enforcement assistance to reduce foreign poaching (Black 1991), the community organized to reclaim the abandoned island in order to manage and protect its resources. The Helen Reef Resource Management Project (HRRMP) was established soon after and Helen Reef, in its entirety, was designated a protected area under national and state law.

Helen Reef is known for an abundance of nesting and foraging sea turtles. While Helen is the most remote and undeveloped island in Palau, the area has not escaped human-related threats to sea turtle populations (Johannes 1986; Guilbeaux 2001) such as local harvest, commercial fishing bycatch, and transport of turtles back to Palau for sale or gifts. Increased transportation to Helen Reef translates to increased transshipment of turtles to the population center of Palau. Enforcement of national prohibitions on turtle take is logistically, culturally, and politically difficult at Helen.

At Helen, the harmful practices of egg, nesting, and foraging turtle harvest has been significantly reduced because of the presence of HRRMP. Although HRRMP started primarily as an entity to enforce against illegal foreign fishing, with help from international NGOs the group has actively built their capacity to monitor and manage natural resources. Community members are concerned about the fate of their sea turtle population as the loss of the turtles would mean the end of the traditional practices of hunting, preparing, and consuming sea turtles. In early 2005, after several years of harvest limited to five turtles per year, HRRMP with consent of the community decided they wanted to understand their turtle population to the extent of developing a strategy for sustainable use for cultural preservation and nutritional needs. Tobians including community members and government officials wanted to know the status of their turtle population. In addition, they sought details about the migrations, and potential sustainable harvest levels. These curiosities lead to the partnerships and conservation program discussed here.

The development of the partnerships to establish a sea turtle conservation program involving observational monitoring and development of a sea turtle management plan was driven by HRRMP as the synergistic organization bringing together several different agendas and capacity types. Today the HRRMP monitors and manages sea turtles with significant community participation and partnerships, with local, national, regional, and international level organizations. Through this the community has preserved autonomy and, within the constraints of national law, makes the final decision on management measures driving the conservation program. Success of the Tobian program to manage and conserve turtles at Helen Reef is contributable to appropriate partnerships and scale, balanced benefits that outweigh costs, adaptive capacity and awareness, and amalgamation of traditional values with contemporary management.

5.2.2 Palauan Communities

There are fifteen other Palauan states. One, Sonsorol, is similar in language and culture as Tobi, but is not discussed here. The remaining fourteen states share a culture and language distinct from Tobi's. Within each state exist separate communities each with its own ideals and traditional leadership. For the purposes of this chapter, however, states and communities will not be distinguished. These remaining fourteen states are in close proximity to each other. Ten exist on the largest Palauan island of Babeldaob, three are nearby outer islands, and the home state of the capitol city consists of a few populous islands adjacent to Babeldaob.

Sea turtles are presumed to use the entire archipelago making them a common pool resource shared between all fourteen states and the communities within. Green turtles are important to the Palauan people, as they are to the Tobians. While the levels of egg and in-water harvest of adults and subadults have been reduced as a result of availability of alternative food, successful education campaigns, and partial coverage national enforcement programs, the practices remain a threat. Additionally, coastal development and heavy use of nesting beaches has significantly degraded sea turtle habitat. Palauans are certainly aware of declining turtle populations, but at the community level there is feeling of powerlessness to stop the decline. This feeling of powerlessness is exacerbated by widespread knowledge of illegal harvest by law makers. A 'race for fish' perception is prevalent and many feel if one person restrains from harvest it means more turtle for the next person. In spite of this, awareness is growing, especially within the younger generations, and harvest restraint – even during the open season – is practiced on moral grounds. Harvest of sea turtles in the main Palau archipelago by Tobians, who make their primary residence there and are known for their ability to capture turtles in the water, is common. There seems to be a diminished sense of ownership of Palauan turtles over Tobian or Helen turtles among the Tobian people.

Recent attempts to monitor sea turtles in Palauan communities have been undertaken by the national government. These attempts have built on remarkably well received education campaigns carried out by a national NGO. The national program approached monitoring in a highly participatory manner, including stakeholders from each state in the planning and eventually depending on local labor in each community. Unfortunately, very little cooperation was experienced and the burden of monitoring fell primarily to a few national employees. Palauan communities failed to implement management and conservation programs.

5.3 Discussion

Helen Reef sea turtle conservation and management efforts differed from those of other Palauan communities in terms of factors influencing successful implementation (Table 6). The below table provides a quick reference for comparing the Helen Reef effort to others in Palau based on (i) the structure of partnerships; (ii) scale of both the communities and biological systems; (iii) remoteness; (iv) short term costs and long term payoffs from the community perspective; (v) adaptability, and (vi) the status of traditional practices. This is not meant to imply that a single recipe that can be deduced from these factors for successful community-based sea turtle management. My purpose here is rather to provide a set of criteria with which to evaluate the likelihood of successful conservation efforts based on qualities of the communities involved. This is a process that may be useful in identifying the small scale participants in large scale conservation efforts.

	Helen Reef Project	Other Palau Projects
Structure of partnerships	Bottom up	Top down
	Decentralized	Centralized
	Integration of international, regional, national, and local institutions	Integration of Aid nation, national government, and local individuals
	Self imposed restrictions	Nationally imposed restrictions
	National government is a partner	National government is sometimes viewed as an authority
	Active community level involvement in regional networks	Regional involvement at the national level
Scale	Small scale community	Large scale more integrated society
	Large and diverse inaccessible turtle habitat	Large and diverse easily accessible turtle habitat
Remoteness	Isolated, threats from outsiders	Threats from neighbors and internal profiteers
	Enforcement need is finite	Enforcement need is expansive
Costs and benefits	Short term costs balances by job availability and increased capacity	Loss of harvest rights with relatively few new jobs and capacity
	Conservation programming is a business	Conservation is an imposed task
	Conservation programming increases public service availability	No change in public services
	Tangible future benefit of allowable harvest shared with community	Future benefit of allowable harvest unlikely except for elites
	Conservation infrastructure exists within the community	Little or no community level infrastructure for conservation
Adaptive Capacity	Local legislative body integrated in conservation projects	Local legislative bodies disconnected from conservation projects
	Autonomous decision making with capacity to make changes	Autonomous decision making, tendency to adhere to national management strategies.
Tradition	Active revival of traditional practices	Limited revival efforts
	Less time since practice of traditional management system	Management systems affected by development for long period
	Less colonial impact	Colonial effect of rebellion against imposed regulations

Table 6: Key factors influencing success and challenges in implementation of sea turtle management and conservation programs

5.3.1 The Structure of Partnerships

Management of migratory species spanning ocean basins is dependent on international, national, regional, and local level institutional cooperation (Ostrom 1999). Without partnerships conservation objectives such as sea turtle recovery are impossible to accomplish. Local action will not necessarily result in local recovery.

Effective community-based management requires that managers be able to formulate and investigate questions of science and social behaviors (Wiber et al. 2004), but collaboration with varied levels of partners is needed when protection of the resource relies on extra local science and behaviors or when community level capacity is lacking. These partnerships can be top-down in structure with higher level institutions imposing agendas on communities or even coercing community participation (Ostrom 1999; Austin 2004). When the community is the partner that identifies concerns, and reaches out for capacity and assistance, then community-based management is driven by a bottom-up process.

The Tobian community web of resource management related partnerships is complex and involves partners with a range of geographic scopes and conservation agendas. This variety of partnerships results in robust conservation programming. Since inclusion and interactions are driven by the community programs do not get bogged down in the process of reaching stakeholder consensus because interactions are community-driven. Consensus of community groups and leadership therefore becomes a focus and resulting programs draw only assistance from partners, but direction from community desires and objectives.

The HRRMP has taken the synergizing role of bringing together several institutions with different agendas and capacity types. Tobian society has historically lacked access to Palauan administrative institutions (Black 1982); in part, their diverse set of partners is a result of the historical need for creativity when it comes to accessing skills and technology. The bottom-up structure is functioning in the case of Helen sea turtle management and is congruent with experiences in other locations where communities engaged more fully in the management process (Jentoft 1998; Wiber 2004). Bottom-up structured projects are the result of choice where trust, compromise, and mutual respect are more likely than in the top-down structure.

In the rest of Palau monitoring and conservation projects managed by the national government were participatory, even collaborative, but still top-down. Stakeholder communities were involved but lack of mobilization and cooperation in the field may have resulted from the top-down structure. This collaborative structure has many advantages including consensus, transformation of individual interests to joint interests, and flexible management structures (Meadowcroft 1999). Another advantage is institutional diversity (Ostrom 1999) and associated capacity. Unfortunately, when communities are not driving the process such advantages cannot be realized.

There is a general move towards decentralization of resource management which is viewed as a 'good thing' (Austin 2004). However, within the Republic of Palau, where population is small and resources vast, decentralization reduces the possibility practicing resource management with an economy of scale. Additionally, the migratory nature of sea turtles, and the common pool aspects of the resource, makes decentralized management seem unreasonable within the main Palau archipelago. Because Helen is remote and population of turtles is likely discrete from those in Palau, the issues of economy of scale are not as influential. It makes more sense for the Tobians to be the central management institution. The state, and prior traditional leadership, has always handled the demand of managing their own resources with little centralized control from Palau. I do not intend to imply that the assistance of the national government is not needed, indeed it is sought out; rather, that the web of partnerships evolved in an organic fashion and was not explicitly planned – a model that has proven successful in other situations (Berkes et al. 2001).

Decentralization of management, although based on the idea that local people are best equipped to solve natural resource issues (Austin 2004) can be taxing on the communities and requires the support in terms of capacity building from former centralized agencies (Wiber 2004). The additional capacity need arises from loss of traditional management systems and increased understanding about the complexity of threats to sea turtles. Because of the bottom-up structure of Helen sea turtle monitoring and conservation efforts managers have established ideas and strategies to implement management measures by drawing on the community for knowledge and creativity. Assistance from the national government, then, is just that – assistance – rather than imposition of a prescribed centralized program. Both local and larger scale NGOs can facilitate the synergistic method of revitalizing traditional methods and emphasizing participation (Austin 2004; Johannes 2002), but care should be taken by such organizations not to impose their agendas at the cost of success for the community.

Jones and Horwich (2005) contend that community-based conservation failures are not due to a flawed concept, but a result of ad hoc implementation. The Helen project has been able to assimilate the ad hoc implementation of the national turtle monitoring program because of their existing capacity and diversity of partners. Since the community is the central management body they have the benefit of gleaning expertise and resources from the national program without the burden of outside agendas.

National government involvement, however, can also hinder local ability to self organize (Ostrom 1999), this is seen as a local expectation within Palau that the national government will provide a plan to the communities and until that expectation is met inaction is the modis operandum. It is a rare community that organizes around a conservation effort above and beyond a known national agenda. In most communities of Palau the national program played an authority role imposing their agenda and objectives on communities which had little existing capacity to carry out sea turtle management activities and virtually no diversity of partnerships. Resistance, a common side effect of centuries of colonial rule (Ostrom 1999), was met in the form of inaction or failing to follow through on promises to participate in collaborative efforts. The national program’s improvised implementation was, in part, due to a differential between the time it takes communities to actively engage and the time requirements of government grants to developing nations. In the absence of an organic evolution of partnerships, well planned stakeholder identification and participation is needed. Unfortunately, this approach does not fit within the funding timelines and the resulting model is the top-down approach played out in most Palauan communities.

Top-down management can be a source or inequity of the costs and benefits of conservation programs (Berkes et al. 2001). The communities often bear the costs and the higher level institutions reap the benefits. In the case of turtle conservation, benefits, in terms of sustainable harvest are unlikely to be realized by any level of society. However with the building of civil society in each of the affected communities coordination could be improved and infrastructure for benefits in terms of jobs, capacity, and community participation could be realized by most communities in Palau.

True capacity takes a long time to build and chances for failure are enhanced by premature retreat of higher capacity institutions (Berger et al. 2005) who have met their development objectives or immediate grant requirements. Long term guidance is needed and although individuals often stay involved with the communities they work with, they are usually ineffective and not supported by their institutions (Berger et al. 2005).

External controls on resources damages local incentives for conservation (Smith and Wishnie 2000). So, in a way the Palau National Government's liaison role between Palauan communities and international agendas to conserve turtles is a better scenario than direct imposition by external governments and agencies.

The situation of empowerment at the local level at Helen is unique in that governments of developing countries do not often entrust small scale organizations with important resource management (Olsen and Christie 2000). In this situation the national government has not lost any power, but they have vested stewardship of the resource to the Tobians. I believe this to be due primarily to the remoteness of Helen. Powerful private interests do not have access to the resource and therefore are not concerned that they would incur personal costs from the mismanagement of sea turtles on Helen. Because of the involvement of international NGOs Tobi sends local representatives to actively engage in regional network programs. This opportunity empowers the Tobian community further by providing them the option to inform and influence regional policy and participate in development of regional recovery efforts. Local communities in the rest of Palau are represented by national government officials (often expatriates) in these regional forums limiting the capacity building potential.

5.3.2 Issues of scale

Management of common pool resources relies on informal systems of monitoring and local enforcement (Smith and Wishnie 2000). Successful examples of community-based management programs often come from small scale homogenous communities (Armitage 2005; Holmes 2001). While the Tobian community is small, with just over 200 members, it is far from homogenous with disputes over land, traditional titles, and clanship (Black 2000). The Tobian community is losing population and with this trend engagement in community activities becomes more important to some members, as demonstrated by commitment to civil groups, and less important to members who seek work and a sense of belonging outside the confines of Tobian life.

Many other communities of Palau exhibit even less homogeneity. Land disputes, traditional title disputes, emigration, relocation to the capitol, and adjustment to the democratic system are all factors that have caused conflict. These conflicts are breaking down the functional aspects of traditional society, but have also provided opportunities in education, leadership, and improved standards of living.

Smaller scale communities, like Tobi, meet less resistance in establishing civil organizations which can take driving roles in conservation programming. Smaller scale communities, that have overcome lack of capacity, have a much better chance of developing and implementing successful management strategies and therefore should be considered as priorities in directing funds and capacity toward coastal sea turtle conservation actions. Throughout the Pacific there are several such small scale communities. Identifying which of those communities host turtle foraging grounds or rookeries is a first step to prioritizing assistance.

Our approach to science and resource management is evolving from the traditional mechanistic to an alternative systems view (Berkes 2004; Capra 1982; Cortner and Moote 1999) which accounts for the unique contexts, including temporal and spatial scales, of each situation. Sea turtle management must be considered on scales ranging in size from that of Helen Atoll to the entire Pacific basin consequently fostering existing and new efforts to build infrastructure for multiscale, multilateral institutional participation.

When examining the scales of biological communities it is important to recognize the differences between Helen and the Palau archipelago. Both turtle habitats include foraging and nesting grounds, host two endangered species of sea turtle, have diverse biological community structures, face challenges related to global climate change, and are similar in size. Helen is virtually inaccessible and undeveloped, while the Palau archipelago supports more than16,000 diverse residents (CIA 2004) and significant coastal development. When considering the relative scale of management projects, one must consider the physical size of the habitat, diversity of constituents, accessibility, as well as the magnitude and nature of impacts. With this in mind sea turtle conservation in most Palauan communities requires substantially more capacity for monitoring, enforcement, education, planning, collaboration, and evaluation. Both regions will be required to continue activities on a scale of decades which is necessary to evaluate changes in population viability of sea turtles.

Local scale declines of sea turtles, unfortunately, do not have local solutions and local knowledge of sea turtles usually cannot lead to recovery. Communities and institutions can benefit from engaging in partnerships no matter the scale (Berkes et al. 2001). Each partner brings strengths to the table and participation of multiple levels of partners can result in a synergistic effect necessary in the short time available to make effective decisions for sea turtle management.

5.3.3 Remoteness

The idea that communities have a greater potential to benefit from local conservation management than a national or international entity is a primary driver for the community-based approach (Brosius et al. 1998). If resource users can be assured that their management efforts will not be counteracted by poachers and the long term benefits of conservation will be theirs to reap and the effect of incentives for long term conservation is likely to be robust (Smith and Wishnie 2000).

Due to enforcement efforts Helen receives relatively few foreign visitors. When vessels do arrive the community has the capacity to deter them from harvesting resources. Sea turtles at Helen are at minimal risk from outsiders. The remoteness of Helen allows the community to provide their own insurance against poaching of sea turtles in terms of a finite enforcement program. The community is aware that the wide ranging migratory nature of sea turtles could mean their recovery efforts will not be realized. In spite of this there is a demonstrated enthusiasm to participate in management and a stronger sense of ownership of the resource than observed in most Palauan communities.

In the main Palau archipelago the enforcement need is expansive. Nesting beaches and foraging grounds, where turtles are most vulnerable, are scattered in accessible, but often hidden areas. The threats to turtles come from neighbors and sense of ownership on the community level is weak.

5.3.4 Community Costs and Benefits

Conservation of common pool resources is assumed to include a cost to individual resource users. Ostrom (1999) suggests that restricting access and creating incentives are the two required elements for solving common pool resources problems. Those two elements essentially translate to costs and benefits. Costs are often considered short term and worth the investment in anticipation of longer term pay offs (Smith and Wishnie 2000) such as increased harvest or tourism. If conservation efforts fail, however, short term investments made by communities do not pay off leaving affected communities with a negative impression of conservation impacting future efforts. Additionally, if compliance associated costs are perceived by users as too high managers must consider that regulations may not be appropriate for the issue (Hønneland 1999). Alternatively, non compliance may not indicate high perceived costs alone. Instead, non-compliance could indicate lack of awareness, lack of available alternative nutritional sources, or even social unrest and rebellion.

I agree with authors that emphasize that incentives in terms of empowerment and equity are required for successful management (Berkes 2004; Olsen and Christie 2000). Additionally, tangible social or economic benefits have been shown to result in favorable attitudes for community-based projects (Mehta and Heinen 2001) whereas poor attitudes are likely when costs are incurred as a result of top-down agendas and tense relationships between partners can be a result. In the case of Helen incentives for conservation are the benefits of long term cultural preservation through opportunities for sustainable harvest, jobs created by conservation programs, increased capacity, and enhanced community involvement. Conservation programs focused on Helen resources have also increased community services such as regular transportation of supplies and people to home islands.

Unfortunately, in most communities in Palau harvest rights have been reduced as a result of government regulated resource management and protection measure. Rights are likely to be further infringed as regulations are not sufficiently enforced and resources appear to be declining. Conservation attempts at the state or community level has brought relatively few jobs and little new capacity. A few jobs and some capacity related to turtle conservation have been created in the capitol city, but many positions are held by expatriates and Peace Corps volunteers. Additionally, improved community services have not resulted from Palau turtle conservation. These factors along with a weak sense of resource ownership equate to lack of incentive to carry out sea turtle monitoring and conservation programs. It is a vicious cycle where top-down management dampens incentives and the prescribed solution is a strong top-down control which will further dampen motivation.

Community-based conservation programming in developing nations has sometimes been criticized for operating like a business in terms of communities profiting off funding agencies, and local conservation agendas being replaced by the goals and priorities of funding agencies (Igoe 2004). Small scale altruistic conservation programs based solely on preservation rather than on social and economic welfare are exceedingly rare (Little 1994; Smith and Wishnie 2000) and shortsighted corrupt efforts by individual leaders to make quick economic gains off community-based resource management are on the rise in the Pacific Islands (Johannes 2002). Truly participatory, or bottom-up, management that values local knowledge and exhibits good leadership establishes a system of checks and balances with which to monitor and expose corrupt profiteers (Johannes 2002). Enhancement of resources for community gain is a more practical incentive (Smith and Wishnie 2000) than profiteering which is likely to be unsustainable.

Conservation and recovery of sea turtle populations for community gain and increased capacity are the prevalent incentives in the Helen program. Belief that the community members will be awarded a benefit provokes investment on the part of leadership, individuals, and partners. Unfortunately, other Palauan communities fail to see what benefits they may achieve from harvest restraint or compliance with national laws that prohibit harvest of nesting females, and eggs with a seasonal limitation and minimum size limit on in water harvest. It is unlikely that the average fisherman in Palau will once again be able to harvest turtle from his local waters. Even if Palauan sea turtle conservation efforts are effective, populations may not increase because local efforts may be dwarfed by the detrimental impacts of regional activities such as harvest and coastal gillnetting. There has been enough outreach and education in Palau for locals to understand that regional action is needed to protect this endangered and migratory species. This knowledge may even contribute the perception, and likely reality, that local efforts will not result in local benefits.

With a monitoring program in place and local capacity to adapt monitoring of sea turtles accordingly, there is a possibility that useful evaluation of conservation success at Helen can and will take place. Conversely, in other Palau communities lack of knowledge about the status of sea turtles that utilize local beaches and foraging grounds makes eventual evaluation of success unlikely. While the Tobian community is likely to see conservation result in terms of recovery – keeping in mind that with sea turtles this will take decades – other Palauan communities will not. This lack of foreseeable benefits dampens local motivation in Palau.

5.3.5 Adaptive Capacity

Adaptive management is prescribed for sea turtle recovery. "If we knew all the answers to our management challenges there would be no need to experiment" (Olsen and Christie 2000). In the case of sea turtles it is clear that time to investigate and develop the perfect management strategy is not an available luxury. There is, however, a vast amount of known information on sea turtles. Many of the threats and precautions for protection have been uncovered (Seminoff 2004) and local knowledge is extensive in regions where turtles nest and feed. Incorporating scientific knowledge with local and traditional management systems is an adaptive step that will enable use of diverse information to launch monitoring and management programs. By definition the adaptive approach is an acceptance of inevitable short term failure. Communities, and the agencies they work with, need to be structured in a way that supports adaptive management (Mclain and Lee 1996) by evaluating management, being able to recognize failure and adjust management accordingly in an iterative process.

Results of management measures can never be accurately predicted (Sechelas et al. 2001). Adaptive capacity, to learn by doing, leads to a thoughtful and self-reflective approach that stands out as a superior method for remote region sea turtle management. Components of such adaptive programs include learning to live under conditions of uncertainty, reorganization and renewal, amalgamating different types of knowledge, learning, creating opportunities for self-organization (Armitage 2005).

Level of adaptive capacity can be limiting in resource management (Armitage 2005). High level bureaucratic institutions often lack the flexibility and quick reaction time needed to adapt management based on feedback. This is in part because managers are not in the field directly observing changes and responding to feedback. Top-down management systems are then limited by the lead institutions adaptive ability. Failures in adaptive management can often be attributed to underestimation of the complexity of a decision making process (Mclain and Lee 1996). On the other hand, small scale communities are not bogged down in bureaucratic process and can continually evaluate management efforts regenerating the management system with relative ease. The challenge is for small scale communities to be flexible, but not ad hoc (Sechelas et al. 2001). One way this has been achieved at Helen is through an overlap of community leadership legislators and managers. Resource managers have direct access to traditional and democratic leadership and have representation in the small state legislature. Participation of these three bodies ensures that there are checks and balances on adaptations. The Tobian community's small size and interwoven membership results in quick and well thought generations of the management system.

Olsen and Christie (2000) identify each adaptive generation as a "learning cycle" with five repeating elements; (i) issues definition; (ii) planning; (iii) institutional formalization; (iv) implementation; and (v) evaluation. Table 2 compares the current generations of turtle conservation for Helen Reef with generalized generations for other Palauan communities. In some respects it is unfair to lump all Palauan communities with the exception of Helen in one group; however, the similarities are real and this grouping allows for streamlined comparisons. The comparison provides hope in the sense that it reminds us that the Palauan communities have the opportunity to engage in the generational process and build their local capacity to adapt and thereby improve their monitoring and conservation programs. Failure of the turtle monitoring projects to launch in Palauan communities can be seen in a positive light as a first adaptive step. Mclain and Lee (1996) warn that both the will and capacity a required for institutions to respond to new knowledge and evaluation to engage in the adaptive process; achieving both will and capacity will be a challenge in most Palauan communities.

If community driven management is not achieved in Palau it will be necessary to adjust national level process to become more adaptive to management needs. Improvements in national level adaptability will only occur when a significant portion of society drives them (Olsen and Christie 2000). Adaptive capacity must go beyond the central project management and planning, it must be built into monitoring (Ringold et al. 1996), outreach activities, and partnerships.

Learning Cycle Elements	Helen Reef Status	Palau Communities Status
Issues Definition	Sea turtles are in decline, concerns are local, regional, and global	Sea turtles are in decline, concerns are local, and with neighboring communities
Planning	Improve monitoring, work on a regional scale, partner with national	Begin monitoring when provided funds by national
Institutional Formalization	Adding turtles to management plan and legislative protections beyond those of national; working with regional learning networks, regional and international organizations	Some communities developing civil groups that may forage formal relationships with national.
Implementation	Paid staff, and technical advisors implementing monitoring and changes to management plans and legislation	Individuals carrying out national program
Evaluation	Review of solicited evaluation of monitoring, and local practices that may threaten sea turtle sustainability	Evaluation by national government for purposes of planning for future monitoring and reporting on activities to grantors

Table 7: Current adaptive learning cycles at Helen Reef and other Palau locations

5.3.6 Traditional Practices

Ethnographic evidence indicates that humans have long used adaptive traditional management systems (Mclain and Lee 1996). Centuries of colonial rule in the Pacific islands, however, have resulted in loss of traditional knowledge based management systems (Johannes 1978). This loss of power has been described as a violence unleashed on local systems of knowledge (Shiva 1993), but Johannes (2002) and Berkes (1999) have identified several places were local knowledge is in a renaissance and contributes substantially to community-based natural resource management. It is not necessary to resort to top-down regulatory measures as Hardin (1968) suggests; rather, management efforts should inspire communities to rise to the challenge and adapt to new circumstances as Johannes (2002) suggests. Even communities with a strong base of traditional ecological knowledge are not fully equipped to deal with contemporary resource management challenges (Atran 1999; Johannes 1998); therefore, involvement in a web of partnerships may result in effective collaborative and adaptive management systems.

Traditional management systems result from a process of co-evolution between social and ecological systems (Hawley et al. 2004; Wildcat and Pierotti 2000; Berkes 1999; Redman 1999; Berkes and Folke 1998). However, the threats to sea turtles and the swiftness with which our knowledge of those threats, and associated appropriate management measures, is increasing too quickly for a co-evolutionary management system to keep pace. In order to overcome the gap between the evolution of traditional management systems and the more immediate need for action managers must use a Hegelian synergistic approach of integrating the applicable strategies from the past with newer strategies offered by contemporary science-based resource management. This is more than just replacing missing scientific information with traditional and local knowledge. I am suggesting an intentional synergistic process which enhances the co-evolutionary process where diverse knowledge types have equal chances to drive management based on feedback and adaptive capacity. The time scale available to implement effective turtle management will force creativity in developing synthesis solutions from a diversity of knowledge. Treasures from the past include adaptability, the sprit of experimentation, systems of taboo and clan totems (Johannes 1978), and lack of motorized access to sea turtles. From science and modern resource management there are benefits of technology for monitoring sea turtles such as satellite telemetry tracking and advanced capabilities in global communications which improve the ability to coordinate from local to international levels required for sea turtle recovery. An amalgamation of past and present, traditional and science-based management is a good starting point for a first generation adaptive program.

Both Tobian and Palauan societies traditionally practiced a form of taboo with regards to turtle harvest as regulated by traditional chiefs. These systems served to limit local turtle take. Other similar systems were presumably practiced throughout the region reducing threats to turtles throughout their migrations. Colonial rule and subsequent independence of a democratic Republic of Palau brought about a constitution that recognizes traditional law as equally authoritative, a system that as proven to be impractical in practice. However, out of respect for traditional uses national level regulations allow a certain amount of turtle take for customary purposes, of which democratic and traditional leadership inaugurations are included. Allowable take of turtle in Palau have little resemblance to traditional management systems. The Tobians have always regulated turtle through a process of permission by the chief who designated a time for turtle hunt, who would hunt, and who would consume the turtle meat. Similarly, Tobians regulate turtle take on Helen today in a manner distant from the traditional system. As the traditional system fades away, or evolves to adapt to new situations, the associated knowledge can live on and evolve itself feeding a collaborative and adaptive management approach.

5.4 Conclusion

Sea turtle conservation is a global issue. Time is short. Many predict that if behaviors do not change in the near future Pacific green sea turtle populations will perish (Eckert et al. 1997). Local, national, or even regional conservation efforts may not be enough to protect wide-ranging endangered sea turtles. Projects need to be implemented at all of these levels in order to achieve basin-wide and global objectives of recovering sea turtle populations. Conservation at the local level is in the hands of communities. The capacity of those communities can be greatly enhanced through collaboration with international, regional, and national organizations. NGOs and development agencies can be particularly effective through directing funds and technical assistance towards communities that show the potential to drive the management process. Care must be taken not to impose conservation agendas, rather to build capacity and facilitate community establishment of conservation objectives.

It is noted that success in other Palauan communities will mirror the success at Helen. These societies are different and therefore formulas for success will be different. This chapter outlines many issues that Palauan managers can address and provides contrasting scenarios for consideration. Palauan managers are faced with the difficulty of discovering the things about Palauan society that will lead to success, and creatively overcoming the aspects that impede it.

Here the focus has been on identifying the qualities of communities that can contribute to global sea turtle conservation through local actions with the least amount of resistance and investment. I have demonstrated a set circumstances under which community-based sea turtle management has been successfully implemented within the Republic of Palau. Success is attributable to several key factors that come together to produce decentralized community-based conservation programs that operate with an adaptive, collaborative, bottom-up structure. Unfortunately, this approach will not be enough to effectively recover turtle populations. Despite this barrier community organizations, through their own capacity and their partnerships, can drive the regionally coordinated efforts that will be required for recovery. Regional programs driven by communities with the qualities described in this chapter will be more effective than top-down managed regional efforts. I believe that successful implementation of programs, such as at Helen Reef, is transferable. This is corroborated by the recognition the Tobian community has received for their conservation programs in spite of their marginalized status within Palauan society. If subsequent positive impacts on sea turtle populations become a reality for Tobians, as well as communities that follow the model provided by the Helen program, global sea turtle recovery efforts will be greatly enhanced. Community-driven collaborative and adaptive management should be supported; it is a valid and appropriate model with encouraging potential to contribute to global sea turtle recovery.

Chapter 6: Outlook

I have a presented an interdisciplinary thesis reflecting three very different, yet interconnected, aspects of my graduate work. The first aspect was providing assistance to the Tobian community in building their capacity to be the driving force in sea turtle conservation and management. The second aspect was to provide technical advice on sea turtle monitoring enabling the community to collect a set of baseline data upon which continued monitoring and management decisions can be built. The third aspect is a reflective qualitative analysis – drawing from my own experiences with community-based management throughout Palau and from social theory – that highlights the key factors required, or observed in tandem with, successful community-based management.

This thesis has examined the biological and socio-cultural contexts within which recent management of Helen Reef resources has occurred, evaluated monitoring and management methods, and accordingly made recommendations for enhancement of sea turtle specific, as well as integrated, management in light of those biological and socio-cultural contexts. The conservation and management experiences of the Tobian community, along with my perspective on their successes and challenges, may be useful to professionals and community leadership working towards sustainable resource management with small scale communities. I felt it was therefore significant to provide a detailed examination of the key factors leading to successful implementation of sea turtle management as a contribution to the overall body of knowledge in marine resource management.

Community-based conservation efforts have differing degrees of success. The many examples of failures have led to heavy criticism of the approach. However, based on my experiences at Helen Reef I do not think it is wise to discard the bottom-up approach. Instead, an adaptive process that identifies the best elements of community-based programs and builds upon them can be the basis for dynamic successful conservation programs. Failures are not a result of the approach; rather attributable to ad hoc implementation as well as funding and development agencies that are driving programs to masquerade as community-based when in fact they are top-down. Failure to value local knowledge and contribute real capacity to communities to manage their own resources is a shortfall of science-based conservation intervention throughout the developing world. Agencies and practitioners undervalue communities when they view participation as required, co-management as mitigation for lack of science, or traditional knowledge as second rate. It is unrealistic to think science-based management is without flaws or that it is a more viable approach. However, when one spends enough time with a community, learns to listen to community needs and concerns, and appreciates the cultural and socio-political contexts then true partnerships can form that amalgamate the best of science-based management and best of local management into a contemporary and worthwhile model. Models, however, will only be effective with built in adaptability, flexibility, and contextualism.

Logistics of protecting sea turtles at Helen Reef are difficult. Uncertainty about the status of and threats to local turtle populations make management planning exceedingly difficult. In spite of this, the Tobian community has overcome the initial challenges of reducing harvest, increasing enforcement, educating the public, and implementing a comprehensive monitoring program. My evaluation has resulted in an exhaustive set of recommendations deserving of attention by managers and leadership; however, prioritization based on the needs and desires of the community should take place before finalizing the species specific recovery plan. Careful prioritization, along with a planned strategy for implementation that includes regular and thorough evaluation, will result in a highly adaptable and comprehensive recovery plan.
The achievements of the HRRMP and the Tobian community at large with respect to conservation are extraordinary especially given the complex political issues, difficult logistics, and the limited internal capacity. The ingenuity and enthusiasm exhibited by the community is a clear expression of the reverence Tobians have for Helen Reef. Admiration for the place is undeniably catching; over the last four years of working

with the Tobian community to protect and conserve Helen resources I too hold Helen in the highest regard as a unique and beautiful worthy of our conservation efforts.

Figure 16: East Beach of Helen Island. Photo: Melia Knecht

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APPENDICES

Appendix 1: Proposal Submitted to NOAA Fisheries April 2004

SEA TURTLE MONITORING AND MANAGEMENT IN THE SOUTHWEST ISLANDS, REPUBLIC OF PALAU, MICRONESIA

Project Proposal Submitted by the Community Conservation Network
on the behalf of the Sonsorol and Hatohobei State Governments, Republic of Palau

A. Project Summary

Located in the Southwest Islands of Palau, the Islands of Merir and Helen are host to the two largest known green turtle (*Chelonia mydas*) rookeries in the nation and represent significant turtle nesting densities within Micronesia. Yet, comparatively little is known about their characteristics or their relative stability given numerous threats facing turtle populations in the region. While brief assessments have been conducted in the past at these remote islands – the most remote island Helen being nearly 500 km from the Palau capital of Koror – none have been designed to offer sufficient characterization of these populations or provide information of vital management concern. Because sea turtles are an important part of the culture and diet of people of the Palau Southwest Islands (SWI), State Governments, Traditional Leaders, and community members have expressed interest in conserving and better managing sea turtle populations so that they may continue to be culturally used and appreciated in a sustainable manner. This proposal is designed to address these issues; as well as, expand the development of a sea turtle conservation awareness program for the islands.

Both the Hatohobei and Sonsorol State Governments, which have authority over Helen Island and Merir respectively, the have demonstrated commitment to developing sea turtle programs focused on strengthening monitoring activities and applied research to inform management. These programs also contribute to local and national awareness of conservation issues. Basic, continual field monitoring has been initiated on both islands since 2002, but these efforts need further technical assistance and basic support to develop more useful, consistent information from monitoring. Further support will also be used to help develop management plans and bolster conservation awareness activities. Because of their proximity and cultural similarity, the two State Governments have expressed an interest in collaborating so that resources, skills and learning can be shared to improve monitoring and overall management effectiveness. Both State Governments are participating in Palau's Sea Turtle Research and Monitoring Program, which has been established to effectively coordinate training and information collection regarding Palau's sea turtle populations. However, given the particular geographic distances and costs involved in implementing monitoring activities in the remote SWI, the level of support from the National Program, while useful at the national level, is insufficient for local, on-site activities and will likely remain so.

To address these and other issues, the collaboration of SWI State Governments and participating partners will focus on the development of a basic, yet comprehensive, conservation program to 1) strengthen the capacity to monitor sea turtle populations and manage information, 2) initiate or further develop local management plans for the conservation of sea turtle populations, and 3) promote awareness and understanding of the status and conservation of these sea turtle populations among local communities, resource managers, national and international bodies. This collaboration also includes the Helen Reef Resource Management (HRRM) Program of Hatohobei State, the community-based Southwest Island Learning Network, Oregon State University, and the Community Conservation Network, among others. Within the context of this collaborative effort, the project will use the proposed support, if approved, as matching for transportation costs to and from the Southwest Islands of Palau; as matching for state government field staff time to undertake related activities; for a dedicated technical advisor who will provide on-site training, support, and assistance with data management and management planning; and for associated field supplies.

B. Project Narrative

1. Statement of Need

Green sea turtles are of important cultural and nutritional value to the people of Hatohobei and Sonsorol, located in the Southwest Islands of Palau (see Map, Appendix). These islands are historically known for abundant sea turtle populations and small island societies dependant on sea turtles, in part, for food. While these locations are some of the most remote and undeveloped in Palau - and thus far removed from dense human populations - the area has not been without the growth of human-related threats to sea turtle populations (Johannes 1986, Guilbeaux 2001). Over the past several decades, these turtles have faced population decreases with the coming of increased modernization, erosion of traditional controls, and the increase of numerous other threats common to sea turtle populations in the region. Threats currently include human harvest for local consumption and commercial purposes; as transportation has increased to the islands so has the transshipment of turtles to the capital city. At Helen Reef, illegal foreign fishing boats for many years harvested sea turtles, although these infractions have been reduced by the management and enforcement program currently in place for the Atoll. Community members, learning about the biology of sea turtles, are also concerned about where these turtles might migrate to and possible threats in these areas. Frequent question posed by residents and government officials are: "How many turtles do we have?" "Where do they go?" and, "How many can we reasonably harvest without jeopardizing the health of the entire population." These are some of the questions that this program, with its associated and future activities, intends to address.

Description of Nesting Areas:

Helen Island of Hatohobei State is located within Helen Reef Atoll, Palau's largest Marine Protected Area and one of the Pacific's most outstanding atoll complexes in terms of marine biodiversity, ecological integrity, and biomass abundance. Helen Reef is also host to what is believed to be the second highest density of nesting green turtles in Palau

(NMFS & USFWS 1998; Andrew *et al.* 2005). Peak nesting season occurs in May, June, and July and recent information indicates approximately 400 turtle crawls a year. Located 500 km southwest of the main Palau islands, nearly 150 km from the north coast of Eastern Indonesia, Helen Reef also hosts a large number of foraging green and hawksbill turtles. Within the Hatohobei Government, a Management Board oversees the development of a management plan and directs field staff of the Helen Reef Resource Management Program, which partners with several agencies and community groups to ensure the long-term sustainable management of marine resources at Helen Reef, including sea turtle populations.

Merir Island of Sonsorol State is a raised coral island 150 km northeast of Helen Reef, lying on the transportation route between Koror and Helen Island. Merir is home to the largest extant green turtle rookery in Palau (Maragos, J. E. 1992, NMFS & USFWS 1998). Peak nesting season occurs in May, June, and July and recent information indicates approximately 700 turtle crawls a year. While calculations are imprecise, sea turtle nesting at Merir Island appears to have decreased precipitously since the early 1970's. Whereas Merir currently does not have a written management plan for its turtles, the Sonsorol State Government has become interested in turtle monitoring and learning more about the declining trend in sea turtle nesting on the island, as well as information on migration and other characteristics of its sea turtle populations.

The Tobian community has demonstrated a keen commitment to the conservation of sea turtles by establishing a moratorium on take of Hawksbill turtles throughout their State and limiting the take of green turtles from Helen Reef to five turtles a year. Management of Merir's declining sea turtle populations continues to be a debated topic within Sonsorol State; in response the State Governor has chosen to support investigation into the status of its populations. However, more information and insight about these turtle populations is needed from both Merir and Helen Reef in order to develop effective and sustainable management into the future. This includes better understanding of population numbers, understanding nesting behavior and reproductive success, investigating genetic characteristics and the possible connectivity of the two populations, and eventually attempting to identify migratory patterns (which may extend to regions of the Philippines, Indonesia, and areas of Melanesia and beyond).

A cornerstone of this effort will be Hatohobei State Government's Helen Reef Resource Management Program. Currently in its seventh year, this program – aimed at sustainably managing the Atoll's marine resources – addresses sea turtle management and monitoring as a major component. A Helen Reef Management Board guides the management of a 256 sq km Marine Protected Area which includes the 3 hectare sandy islet used as a nesting area for green turtles. The Management Program is supported financially in part by local and national government contributions as well as external donors and includes 8 field staff who have experience in sea turtle monitoring. The State of Sonsorol is just now beginning to develop a turtle monitoring program and employs two part-time staff on Merir who can contribute to monitoring activities. So far, field staff on both islands have done a commendable job to collect information, operating without tags or technical training in how to conduct certain activities. They have improvised and learned while doing – with commendable results. Wayne Andrew, deputy manager of the HRRM program, recently gave a presentation at the 2005 International Sea Turtle Symposium on the results of nesting turtle monitoring at Helen Reef and has helped to establish what is considered by many the most continuous sea turtle monitoring effort within the Republic of Palau (Andrew et al. 2005). The two States have agreed to partner with one another, so that field staff can learn from the each other and share resources, skills, and experiences. Together both programs could contribute information on up to an estimated 80% of Palau's sea turtle nesting (Nicolas Pilcher, pers. com., 2005). Both States are also participating partners of the National Sea Turtle Research Monitoring and Monitoring Program; however, timely and adequate assistance from this Program to remote areas is proving difficult.

To address these local needs, and to be better able to contribute to the national program and other regional programs, the States wish to initiate and strengthen their data collection and monitoring programs through this one year project proposal. Both states intend to develop specific sea turtle management programs which include components of monitoring, applied research, capacity building and outreach to support the objectives of regional and international conservation plans and programs, such as the NOAA/USFWS *Recovery Plans for U.S. Pacific Populations of the Sea Turtles* (NMFS & USFWS 1998). These State plans and activities are also consistent with the South Pacific Regional Environment Program's *Regional Marine Turtle Conservation Program Strategic Plan* (SPREP 1993) and IUCN's *Global Strategy for the Conservation of Marine Turtles* (IUCN 1995). The States have agreed to share resources such as necessary transportation to the outer islands, staff time knowledge, and key skills to help each other build their capacity for turtle monitoring and management. They have also asked for the assistance of partner organizations, skilled individuals, and experts that can help them with the development of such a program. They envision gaining the technical assistance through a team of partners that includes: staff of the National Palau Sea Turtle Research and Monitoring Program, a sea turtle expert familiar with conservation issues and capacity building in the Southwest Islands, a graduate student serving as a technical advisor that can travel to and work at the sites, and other professionals that can help with enhancing data collection and management skills. The two States are also intending to develop integrated sea turtle management plans that complement State and National goals for marine resources and biodiversity management.

2. Project Goals and Objectives

The overarching goal of the proposed project is to:

> *Promote collaboration, skills building, and sharing between the two Southwest Palau states of Sonsorol and Hatohobei and other partners so that both State programs can increase their effectiveness and capacity to monitor, manage and ultimately conserve sea turtle resources for future generations.*

Specific Objectives are listed below:

> **Obj 1. Improve Turtle Monitoring:** Establish and strengthen basic green sea turtle nesting monitoring activities and protocols over a year's time to where appropriate data is collected and analyzed consistently by local field staff, and this

information communicated to local and national stakeholders and decision makers on a regular basis.

Obj 2. Initiate or Strengthen Management Plans: Develop or enhance area management plans within one year through a community planning processes that includes specific goals and objectives, as well as sea turtle conservation strategies.

Obj 3. Increase Awareness: Increase awareness and understanding of sea turtle populations and management issues by local stakeholders by 50% (as measured by pre- and post- outreach program surveys).

The monitoring program seeks to answer priority ecological and management questions of the two States including estimating the size of nesting populations, the connectivity of the populations, and the success of nesting females. Utilization of mark and recapture methods by field teams will specifically address connectivity and establish a base for further applied research. Habitat monitoring has been ongoing at Helen Reef since 2000 as part of the HRRM Program. With the information collected, the Hatohobei State Government and conservation partners, such as CCN, the Palau Conservation Society and government agencies, will work together to create a long-term turtle conservation strategy and outreach program. We expect this project to result in a strong management plan that includes documentation of the need for and consideration of multilateral management cooperation.

3. Project Activities, Methods, and Time Table

The existing field staff and technical advisors in the Southwest Islands have a wealth of experience in conservation management skills and programs within the Republic of Palau. Activities and methods described herein are based on implementation and review of methods and community conservation projects in Palau and Micronesia, with which the staff and partners are familiar. Monitoring methods and other activities will be based on commonly accepted research and management techniques (as presented in Eckert et al. 1999) and will be tailored to local conditions, program goals and the ability of field personnel. At least two field trips provided by the Hatohobei State vessel, the Atoll Way, will be required, optimally planned at the beginning and end of peak nesting seasons for the islands to deliver and return supplies, staff, and technical advisors.

The table below lists each activity under its related objective and provides a timeline for one year of project work.

	Month											
	M	J	J	A	S	O	N	D	J	F	M	A
Objective One – Improve Monitoring												
1. Develop a monitoring plan and handbook	X	X										
2. Develop a user friendly data management system	X	X										
3. Conduct a joint training sessions on monitoring protocols		X										
4. Establish data management training and procedures -Implement on island data management systems, create and implement quality control standards for collected data, work with project management and individual staff to ensure usability of management system		X										
5. Nightly monitoring - systematic flipper tagging of nesting females, nest location, carapace length and clutch size surveys		X	X	X	X	X	X	X	X	X	X	X
6. Daily monitoring - each nest for incubation time, selected nests at representative locations for survival, temperature at selected nests to determine sex ratios			X	X	X	X						
7. Conduct a mark and recapture study - systematic flipper tagging of foraging adults and sub-adults, systematic recapture of individuals, recording and map all mark and recapture locations			X	X	X	X	X	X	X	X		
8. Analyze data -train project management, individual staff, and interested government and non-government partners on basic analysis methods and utilization of a data management system, work with technical advisors to determine conservation needs based on preliminary results				X		X		X		X	X	
Objective Two – Strengthen Management Plans												
9. Develop and review sea turtle management strategies through a collaborative process - facilitate stakeholder meetings, review analysis of data, suggest best-practices and create a feasible management plan										X	X	X

Objective Three – Increase Awareness												
10. Outreach - Communicate program progress and results to interested stakeholders including communities who own the resources and government agencies		X				X				X		X

4. Stakeholder Coordination/Involvement

Hatohobei State's Helen Reef Resource Management Program is of the most advanced, most accomplished community-based marine resource management projects in Palau. This program – based on a wealth of community involvement, participation, and coordination – wishes to share experience and approaches with the neighboring Sonsorol community to improve the monitoring and conservation of sea turtle populations. The Program has extensive participation and decision making by local individuals at all levels. Wayne Andrew is the Manager/Coordinator of the HRRM Program and is involved in several marine management committees or programs (including Palau MAREPAC, the Palau Protected Area Network, TNC's Micronesians in Island Conservation, the Locally Managed Marine Area Network, and other groups) which facilitate coordination and participation with other initiatives.

The two States wish to plan and coordinate this project together, for logistic and practical reasons. The two remote states, serviced by the same supply ship, are geographically and culturally related, making sharing and skills transfer between the two states feasible and desirable. Additionally, members of the two states are currently participating in a learning exchange between the two communities to address common goals. The collaboration, called the Southwest Island Learning Network (SWILN), envisions this project as one of the learning group's areas of collaboration.
Both States also participate in and contribute to the Palau National Sea Turtle Monitoring and Research Program, and thus will coordinate with the national program, as well as the SPREP Regional Marine Turtle Conservation Program. These organizations, and the individuals who represent them, have significant experience successfully working together to fulfill conservation and management objectives.

5. Anticipated Benefits and Outputs

This project will provide resource managers with a better understanding of the status of the nesting green turtle populations on Helen and Merir which may represent up to 80% of Palau's nesting sea turtles. The results will provide insight on the extent of interaction, if any, of the turtle populations of the two islands. The project will also serve as a foundation and skills building opportunity for future applied sea turtle research that may be needed to adequately address management issues.

The mark/recapture portion of this study is part of an on-going attempt to identify the movements of green turtles in Palau. It is intended that this first step will lead to eventual utilization of satellite tags and/or genetic analysis to definitively identify migration patterns. This information will be important for the development of effective management plans and inter-island and multinational cooperation.

The participation of community members in monitoring will help to raise awareness on and inspire stewardship of the endangered turtles. This project will also build the capacity of individuals, communities and agencies to effectively manage for conservation. Project advisors and staff will be available to provide advice and train those interested learning how to manage sea turtle monitoring information better though data base development workshop sessions and skills building. Establishing a framework for collaboration between the States of Palau's Southwest Islands will enable the two states to pool their limited resources in order to maximize conservation benefits.

Specific outputs include:

- Increased capacity of individuals, communities and agencies to manage sea turtle populations
- Improved usability and outcomes of existing monitoring techniques
- Increased systematic monitoring
- Insights as to the size, movements, status and nesting success of the populations
- Successfully initiated collaboration between the two States
- Improved general management plan and specific turtle management strategy

6. Project Monitoring and Evaluation

The proposed project will need to be reviewed and adaptively managed over the course of its implementation in order to ensure that the most desirable and useful outputs and results are produced at the conclusion of the project. Generally progress will be measured against the project timeline and indicated outputs (activities and products). More detailed evaluation of project outcomes will take place using more specific evaluative criteria presented below.

Project evaluation will occur over the lifetime of the proposed project in periodic mid-term evaluations, and culminate during a final evaluation and report after one year. Evaluation of project activity effectiveness would be ongoing following initiation of each of the project activities, and would be achieved by comparison to the related objective, its associated activities and outputs, and timeline. Evaluation will include input from all project partners. Particular effort will be made to assess the effectiveness and satisfaction of specific training events, approaches and tools through pre and post-training evaluations. Data management and field monitoring protocols will be evaluated informally through roundtable discussion of participating individuals. These roundtable discussions will take place soon after implementation of protocols, and will include discussion of necessary adaptive measures. As interim results begin to indicate specific success or needs for modification, results will be communicated among project partners to seek additional feedback and input on how to adjust ongoing activities. A final project evaluation will occur in conjunction with a project partner evaluation session and be presented in the form of a final report.

Objective	Activity	Related Outputs	Outcome Indicator	Method
Objective One - Improve Monitoring				
1.	Develop monitoring plan	Monitoring Plan and Handbook	Clarity and usability of the handbook as a tool	Ongoing roundtable with field staff
2.	Develop under friendly data management	Data management system protocol	Ease of use	Field tests by project coordinators
3.	Monitoring training sessions	Increased skill of field staff	Confidence of field staff, completeness and accuracy of data	Roundtable with field staff, concurrent data collection, review of data sheets
4.	Data management training	Increased skill of field staff	Confidence of field staff, ease of system use, number surveys that complete the system	Roundtable with field staff, monitoring number of surveys that complete the system, observation of field staff
5.	Nightly Monitoring	Survey results	Completeness and accuracy of data sheets	Concurrent data collection and review of data sheets
6.	Daily Monitoring	Survey results	Completeness and accuracy of data sheets	Concurrent data collection and review of data sheets
7.	Mark and Recapture	Survey results	Number of turtles marked and Number of recapture attempts	Monitoring activity
8.	Data Analysis	Knowledge of population status and dynamics	Scientific validity, usability for management decisions	Technical advisor review, stakeholder response
Objective Two - Strengthen Management Plan				
9.	Develop management strategy	Management strategy	Ecological validity and feasibility of implementation	Technical advisor review and project partner review
Objective Three – Outreach				
10.	Outreach	Increased awareness	Knowledge level of stakeholders	Pre and post knowledge assessments.

7. Sustainability

The proposed project will be integrated into ongoing programs that extend beyond the proposed project's one year timeframe. This includes the Helen Reef Resource Management Program (HRRMP) which has seven years of development with ongoing cost sharing between the state, national, and external donors. External donors and internal agencies have expressed an interest to continue to fund the program which is recognized as a priority area for biodiversity conservation in the region. It is currently planned that the sea turtle monitoring activities proposed here would be integrated into the on-going resource monitoring activities of the Program. The HRRMP well-developed program has a desire and capacity to assist the neighboring state of Sonsorol. In addition, the Southwest Island Learning Network (SWILN) has been established as a local initiative to foster collaboration, sharing and learning between the Southwest Islands, which are linked through their shared resources and culture. The goals and objectives of this project are supported by the Community Conservation Network, which seeks capacity building among local partners. Furthermore, both States receive assistance from the Locally Managed Marine Area (LMMA) Network, which supports Pacific and SE Asian community-based marine projects in peer-to-peer, skills building, learning and the improvement of conservation success.

Additionally, Oregon State Sea Grant is interested in providing support for development and implementation of a stateside educational program. The program will promote the "think globally" part of the well known phrase "think globally, act locally" through a mixture of school programs and adult learning seminars. Sessions will occur in Oregon and educate participants on the need for international cooperation in order to protect migratory engendered species using sea turtles as a flagship. The green turtles of the Southwest Islands and collaborative conservation efforts of the people of Palau will serve as an example. Attention will also be paid to how different cultures relate to, and depend on their marine resources.

8. Description of Organizations Undertaking the Project

Project Partners

Hatohobei State Government has jurisdiction over and is responsible for the management of marine resources of Hatohobei and Helen Reef.

Sonsorol State Government has jurisdiction over and is responsible for the management of marine resources Sonsorol, Pula Anna, Fanna, Merir Islands.

Helen Reef Resource Management Program was initiated in 1998 out of community concern for Helen Reef's unique resources and long-existing threats from foreign poaching. The program is largely a community lead program guided by a Management Board with supporting management legislation and eight management and field staff. The program includes a surveillance and deterrence program, both scientific and community resource monitoring, education and awareness outreach, and exploration of compatible use and financing activities for long-term sustainability.

Southwest Island Learning Network (SWILN) is a group of Southwest Island community members that are interested in collaborating to share knowledge and work on joint projects together that better their island environment and culture. The purpose of the Southwest Islands Learning Network is to promote and enhance 1) the culture of the peoples of the Palau Southwest Islands, 2) their education and personal growth, and 3) the sustainable economic development of the community. The SWILN seeks to achieve the mission above by engaging all levels of SW Islander society in building and maintaining Learning Centers that can be used to conduct community activities of this project in the three main locations where SW Islanders live, in Echang, Koror and on Hatohobei and Sonsorol Islands.

Community Conservation Network (CCN) has internationally-recognized expertise in building capacity for community-based conservation and natural resource management in the Indo-Pacific. The principal staff of CCN have assisted local communities in the Philippines, Palau, Indonesia, the Solomon Islands, Fiji, and Hawaii and other parts of the region to successfully establish and implement locally managed marine area projects. CCN's first project, initiated in 1998, was assistance to the Hatohobei State Government with the development of the Helen Reef Management Program. In addition, CCN staff helped to conceive of, and guide the development of the Locally Managed Marine Area (LMMA) Network, as well as other learning networks and co-management and research initiatives.

Palau Department of Resources and Development includes the Bureau of Marine Resources, which is in the initial stages is establishing a nationwide Sea Turtle Research and Monitoring Program. The program is funded in part by NOAA and USFWS and designed to build capacity and information on the status of sea turtle population within the Republic of Palau.

Oregon State University Marine Resource Management Program was developed on the principle that marine resource managers need a broad-based background in physical, natural, and social science, policy and law, and technical and communications skills. The college houses extensive spatial and relational data management and computing facilities. Faculty and a graduate student from the program will serve as technical advisors to the proposed project.

Project Manager
Wayne Andrew is the Manager of the Helen Reef Reserve Management Program that serves his home state of Hatohobei. He works with a state appointed, volunteer management board to guide the program. He has a background in education, architecture, and carpentry. Wayne participates in several national, and some regional collaborative efforts in resource conservation. He has attained a notable suite of management and monitoring skills. Currently, Wayne focuses much of his attention on developing effective communication tools to bridge gaps between the local community and partner agencies at the local, national and international level. Wayne currently participates in many management programs or initiatives, including the MIC, PAN, MAREPAC, LMMA Network, SWILN, etc.

Project Technical Advisors
Michael Guilbeaux is a co-founder of the Community Conservation Network and currently serves as its Executive Director. He has over a decade of experience in Pacific conservation and his interests include research and projects aimed at improving the impact of conservation approaches and capacity building, especially related to marine resources and ecosystems. Michael has extensive experience in the Republic of Palau where he as been involved in marine management since the early 1990's. Michael is an expert on sea turtle management issues in Micronesia, including Palau where he has been involved in sea turtle monitoring activities, training, management assessments, as well as program development. Michael holds a master's in Geography from the University of Hawaii and is the author of *Sea Turtles, Their Management, and Policy in the Republic of Palau: An Assessment of Stakeholder Perception*. His skills include training and planning for

community based marine management projects, resource monitoring and project evaluation, and community organizing.

Julie M. Barr is a graduate student in Marine Resource Management at the College of Oceanic and Atmospheric Sciences at Oregon State University. Julie worked with California non-profit organizations for 6 years as a coordinator regional citizen water quality monitoring; she also worked on kelp forest habitat restoration and monitoring. Most recently Julie served 2 years in the Republic of Palau as a U.S. Peace Corps Volunteer in the position of Marine Conservation Specialist. She worked with community based conservation programs to build capacity, and developed coral reef and fish aggregation monitoring programs. Her graduate work is focused on the conservation and management of endangered migratory species in developing countries.

Selina S. Heppell, PhD is a professor in fisheries ecology and conservation biology at Oregon State University in the Department of Fisheries and Wildlife. She has received degrees at the University of Washington, North Carolina State University, and Duke University. Her expertise is in conservation biology and populations modeling, with projects that evaluate trends in populations over time, develop monitoring metrics to identify when a population is "recovered", and that use simulation models to test different management strategies. She currently serves as a member of the IUCN Marine Turtle Specialists Group.

9. Project Budget

Project Budget - Sea Turtle Monitoring and Management in the Southwest Islands of Palau
May 1, 2005 - April 30, 2006

Item	FWS	CCN / HRRMP	Hatohobei State	Sonsorol State	Total
a. Personnel					
b. Fringe Benefits					
c. Travel					
d. Equipment					
e. Supplies					
f. Contractual (TA)					
g. Construction					
h. Other (fuel)					
i. Total Direct Charges					
j. Indirect Charges (@20%)					
k. TOTAL	$24,840	$6,900	$4,000	$5,500	$41,240

Notes:
USFWS – US Fish and Wildlife Service
CCN – Community Conservation Network
HRRMP – Helen Reef Management Program

10. Budget Justifications

Salaries

Request:

1 Sonsorol Conservation Officer x $0000/year x 50% time = $0000
1 Sonsorol Conservation Officer x $0000/year x 50% time = $0000

Match:

Sonsorol State Government:
1 Sonsorol Conservation Officer x $0000/year x 50% time = $0000
1 Sonsorol Conservation Officer x $0000/year x 50% time = $0000
Helen Reef Management Program:
1 Hatohobei Conservation Manager (Wayne Andrew) x $00,000/year x 10% time = $0000
1 Hatohobei Conservation Officer (William Andrew) x $0,000/year x 30% time = $0000
1 Hatohobei Conservation Officer (TBD) x $0000/year x 33% time = $0000

Travel

Request:

Travel for Technical Advisor (Julie Barr) -
Roundtrip to Palau from US West Coast Airfare and Taxes ~= $0000

Equipment

None

Supplies

Request:

Field Supplies, e.g. data sheets, notebooks, calipers, clip boards, fencing, etc. = $000
Notebook computer for data management = $0000
Skiff fuel (gasoline) for at sites for field activities = $000

Match:

Helen Reef Management Program:
Misc. field supplies provided ~= $000

Contractual

Request:

Expenses and Stipend for Graduate Student Technical Advisor, summer 2005
Per Diem in Koror, Palau: meals, transportation and incidentals *30 days x $00 = $000*
Lodging in Koror, Palau (local host family contribution) *30 days x $00 = $000*
Per Diem in field: meals and incidentals *60 days x $0 = $000*
Monthly Stipend *3 months x $000 = $0000*
Insurance *$000*

Other

Request:

Fuel:

2/3rds of required transportation costs (in Diesel Fuel) for 2 field trips to Southwest Island aboard Hatohobei State vessel, the Atoll Way (total fuel cost of one trip is $0000), $0000 in fuel per trip x 2 trips = $0000

Match:

Fuel:

Hatohobei State Government contribution to Transportation costs associated with Field Trips (1/3 of total costs), $0000 x 2 trips = $0000

Management plan development sponsored by the Helen Reef Management

Program:

Local transportation and venue for management planning meetings, $000 x 2 meetings = $000
Reporting, development, and management plan publication $000

Indirect Costs

A indirect rate of 00% totaling $0,000 has been applied to the total direct costs of the project ($00,000). CCN has applied for a Federal Negotiated Indirect Cost Rate Agreement (NICRA) in the fall of 2004 through NOAA and is currently awaiting official notification.

11. Governmental Endorsement

Attached are letters of support from the:

Hatohobei State Government
Sonsorol State Government
Marine Resource Division, Palau Bureau of Resources and Development

12. References

Andrew, Wayne et al 2005. *Results of Two Years of Field Monitoring of Nesting Sea Turtles of the Palau Southwest Islands (preliminary title).* Presentation at the International Sea Turtle Symposium. Savannah, Georgia.

K. L. Eckert, K. A. Bjorndal, F. A. Abreu-Grobois and M. Donnelly (eds.) 1999. *Research and Management Techniques for the Conservation of Sea Turtles.* IUCN/SSC Marine Turtle Specialist Group Publication No. 4.

IUCN. 1995. A Global Strategy for the Conservation of Marine Turtles. Prepared by IUCN/SSC Marine Turtle Specialist Group. The IUCN Species Survival Commission.

Johannes R.E. 1986. A Review of Information on the Subsistence Use of Green and Hawksbill Sea Turtles on Islands Under United States Jurisdiction in the Western Pacific Ocean. National Marine Fisheries Service, Southwest Region. Administrative Report SWR-86-2. 41pp.

Guilbeaux, Michael D. 2001. *Relating to Sea Turtles, Their Management, and Policy in the Republic of Palau: an Assessment of Stakeholder Perception.* Volumes 1 & 2. The Palau Conservation Society. Koror, Palau.

Maragos, J. E. 1992. *Draft Sea Turtle Recovery Plan for the Republic of Palau.* Draft report prepared for the Republic of Palau, Bureau of Resources and Development by The Nature Conservancy, Pacific Region, Honolulu, 39 pp.

NMFS & USFWS 1998. *Recovery Plan for U.S. Pacific Populations of the Green Turtle (Chelonia mydas).* National Marine Fisheries Service, Silver Spring, MD. 82 pp.

SPREP. 1993. *SPREP Regional Marine Turtle Conservation Program Strategic Plan.* Apia, Samoa.

13. Contacts:

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+01(808)528-3700
+01(808)528-3701 fax
mike@conservationpractice.org
www.conservationpractice.org

In Palau (project implementation and coordination):
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Program Manager
Helen Reef Resource Management Program
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+(680) 488-8044
+(680) 779-3478 mobile
+(680) 488-2218 fax
helenreef@palaunet.com

Appendix 2: Monthly Composites of Local and Regional Wind Speed and Direction.

Data in this Appendix was retrieved from http://cioss.coas.oregonstate.edu/cogow/ (Risien and Chelton 2006). The text is adapted from Risien and Chelton (2006) associated user manual to assist the reader in interpreting the diagrams below. The following 12 pages, one for each calendar month, contain a sub regional composite map (20°N to 5°S latitude and 120°E to 160°E longitude) with the Philippines visible on the right side and the northern Indonesian islands on the bottom left. The composite maps are best used to estimate direction and magnitude for the region; the accompanying wind roses are more suitable for estimating local direction and magnitude which may vary greatly relative to the regional conditions. Each of the monthly wind roses are from data centered as close as possible to Helen Reef (2.75°N and 131.75°E) and can be compared to each other.

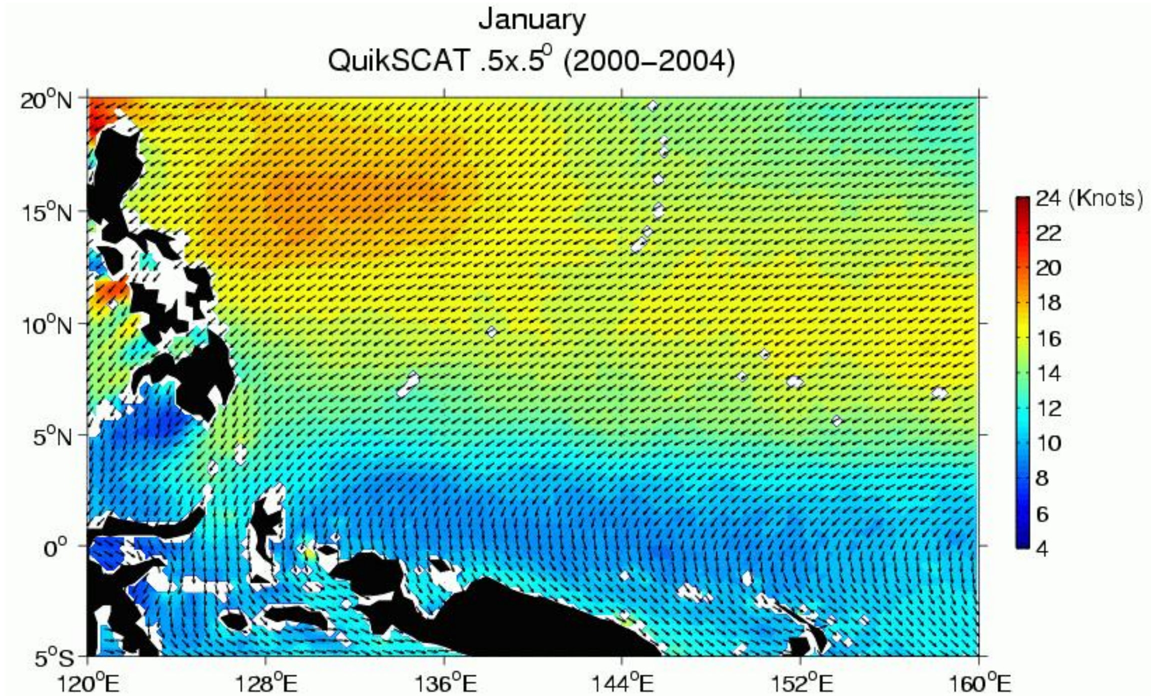
Monthly Composite Maps

The time averaged monthly composites are scalar and vector averaged for wind speed and wind direction respectively. In the sub-regional maps (used here), vector averaged climatological wind directions are plotted as unit vectors at a 0.5° latitude by 0.5° longitude resolution.

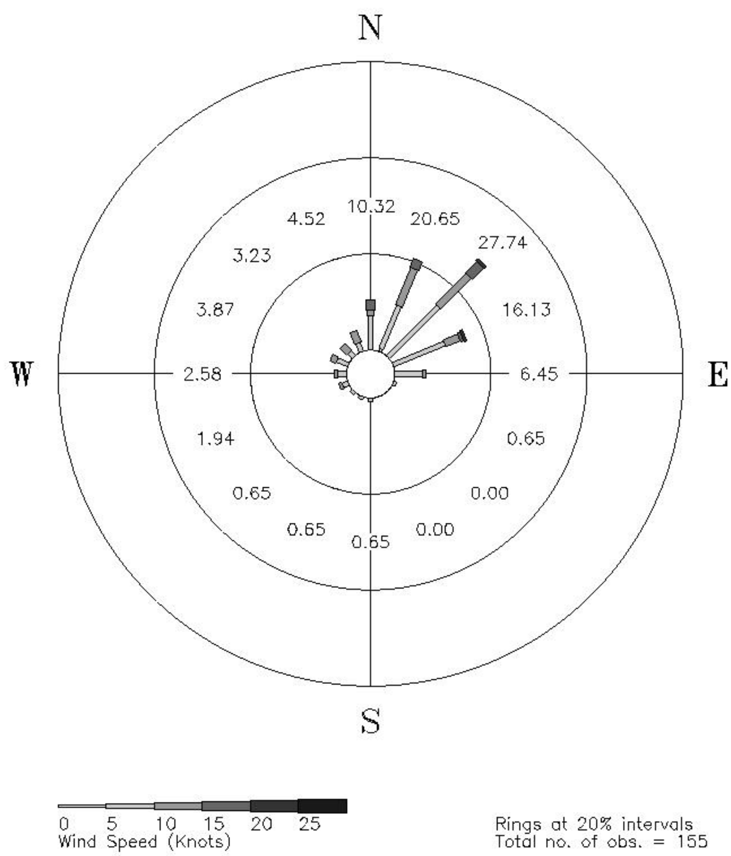
Wind Roses

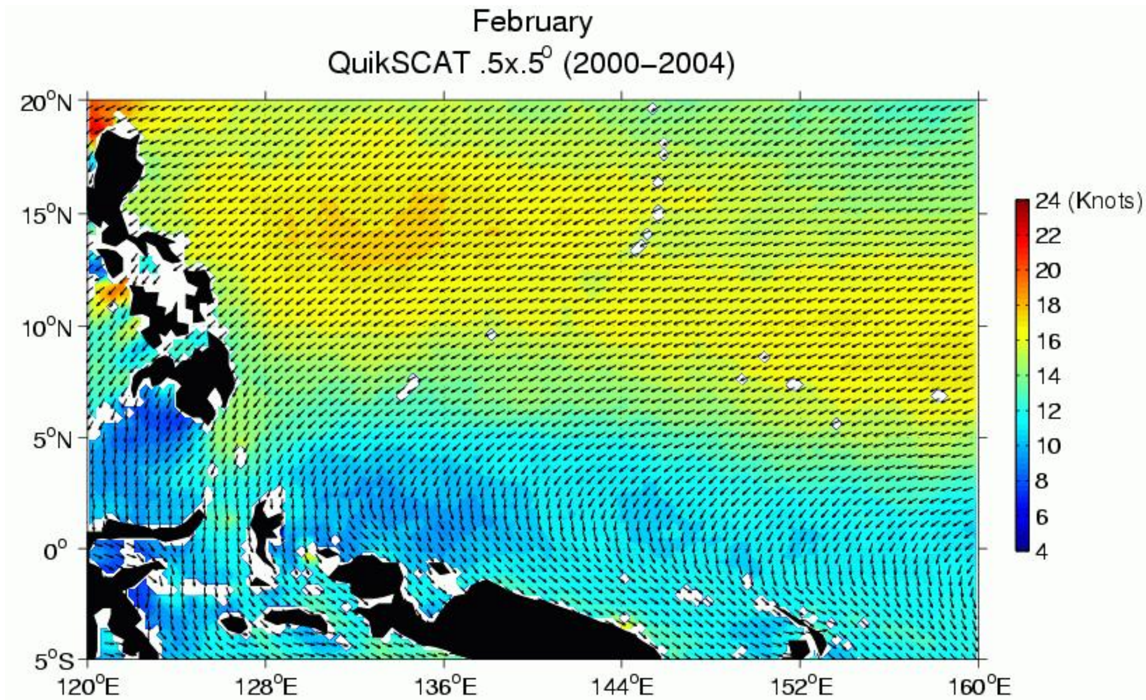
Wind rose plots were created from QuikSCAT observations that were smoothed temporally at 3-day intervals and spatially to a 0.5° latitude by 0.5° longitude spatial grid. The 0.5° latitude by 0.5° longitude spatial smoothing was applied to reduce data density.

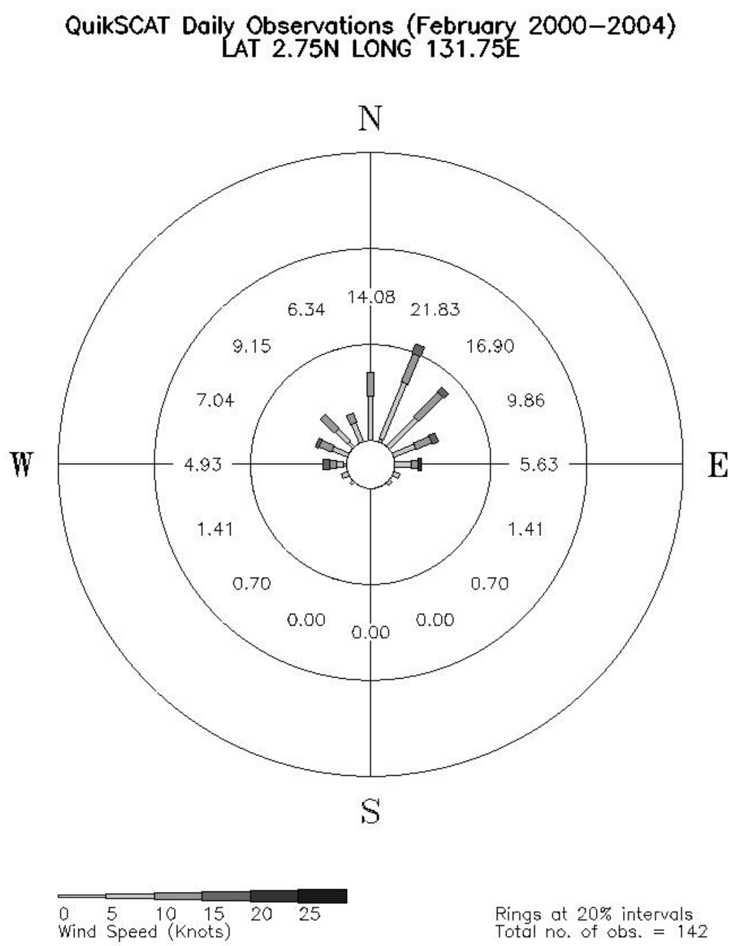
Wind roses summarize the occurrence of winds within a 0.5° latitude by 0.5° longitude bin, showing their strength, direction and relative frequency. The wind rose is interpreted as follows: the length of the barbs that extend radially from the center of the rose, reflect each direction's relative frequency. If the barb pointing from the north-northwest is twice as long as the barb pointing from the north, then the winds blew FROM the north-northwest twice as frequently as they did from the north. In each direction, the barb's appearance varies through several styles in sequence. The proportion of the barb's length in each style indicates the proportion of time winds blew from that direction at a given speed. For example, a thin, light gray rectangle extending from the centre indicates wind speeds of between 0 and 5 knots. Then, a slightly thicker, and slightly darker gray, segment indicates wind speeds of between 5 and 10 knots and so forth and so on until finally, a thick black rectangle indicates wind speeds greater then 25 knots. To aid with interpretation, concentric rings at 20 % frequency intervals are plotted on each wind rose. Additionally, the total number of observations used to create each wind rose is included in the lower right-hand-side of each plot.

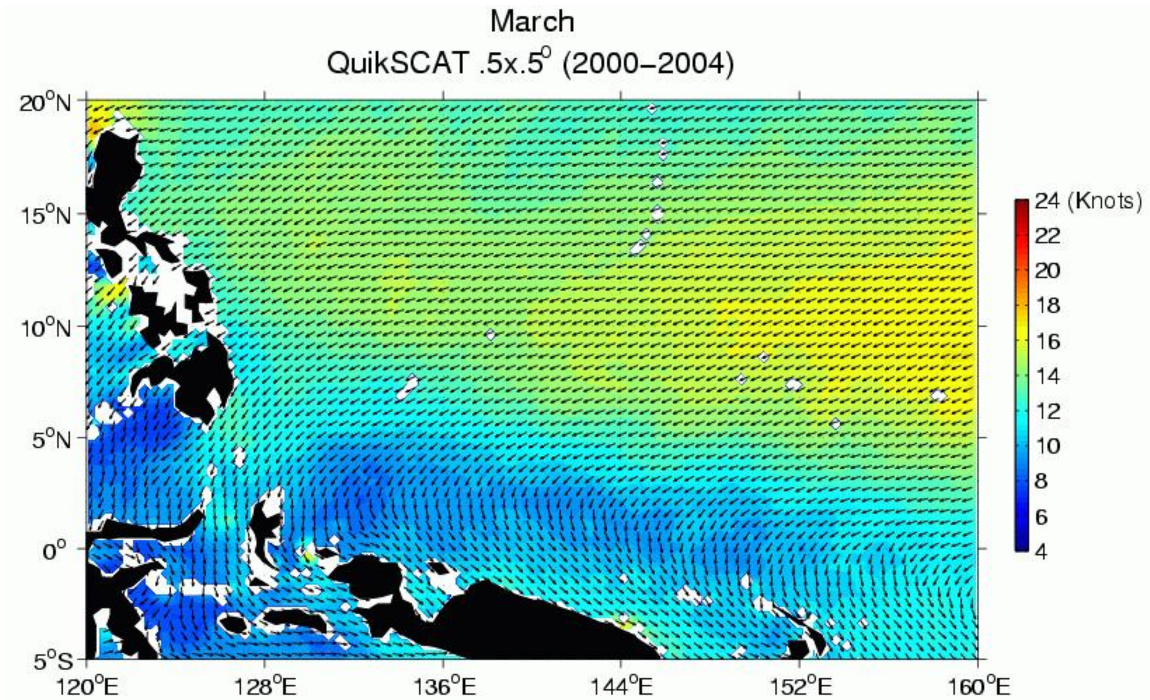


QuikSCAT Daily Observations (January 2000–2004)
LAT 2.75N LONG 131.75E

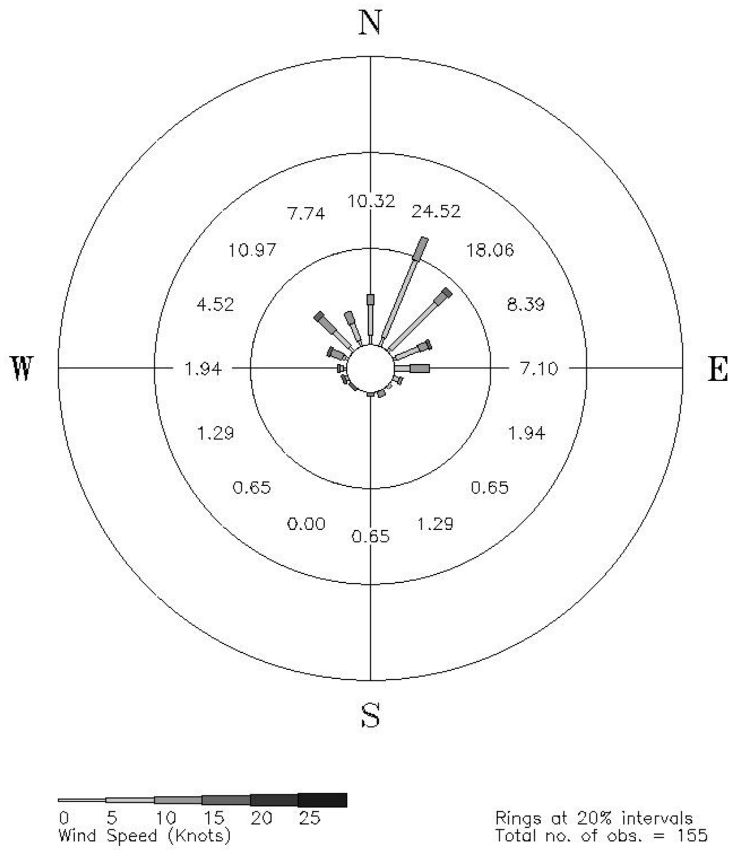


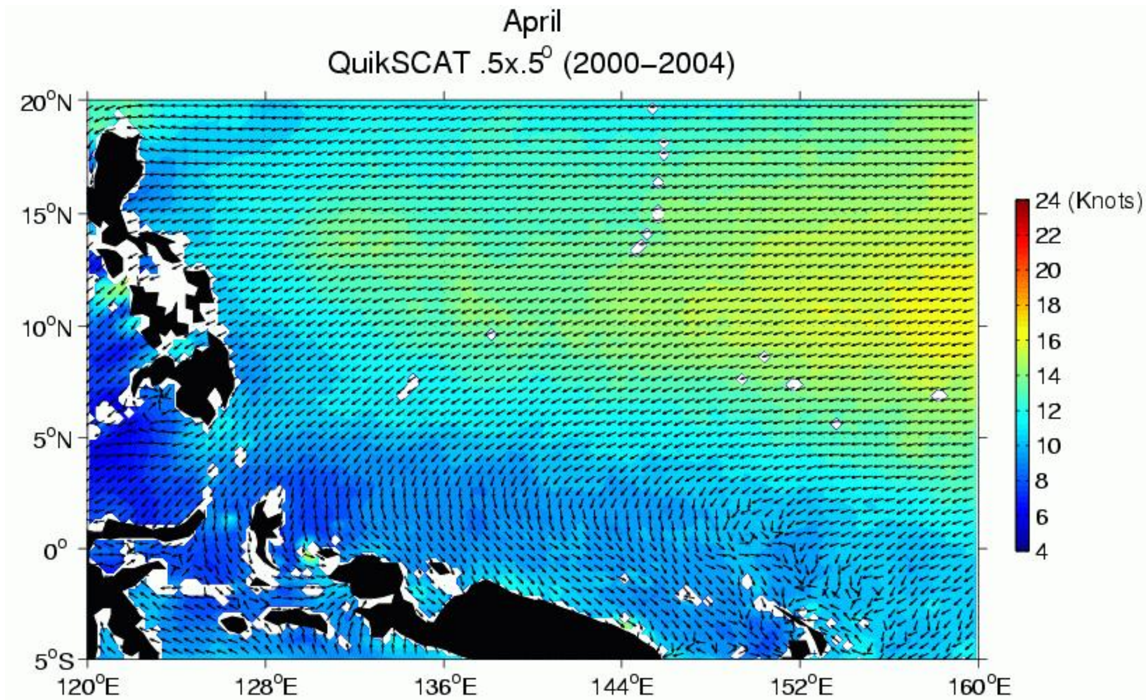

February
QuikSCAT .5x.5° (2000–2004)
20°N
15°N
10°N
5°N
0°
5°S
120°E
128°E
136°E
144°E
152°E
160°E
24 (Knots)
22
20
18
16
14
12
10
8
6
4


QuikSCAT Daily Observations (February 2000–2004)
LAT 2.75N LONG 131.75E
N
S
W
E
14.08
21.83
16.90
9.86
5.63
1.41
0.70
0.00
0.00
0.00
0.70
1.41
4.93
7.04
9.15
6.34
0 5 10 15 20 25
Wind Speed (Knots)
Rings at 20% intervals
Total no. of obs. = 142

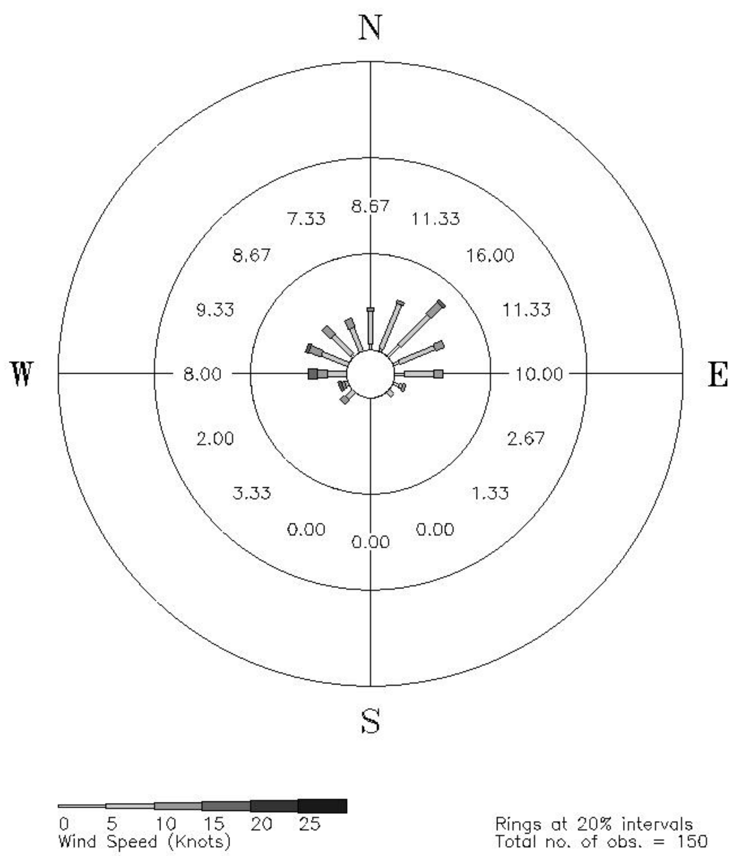


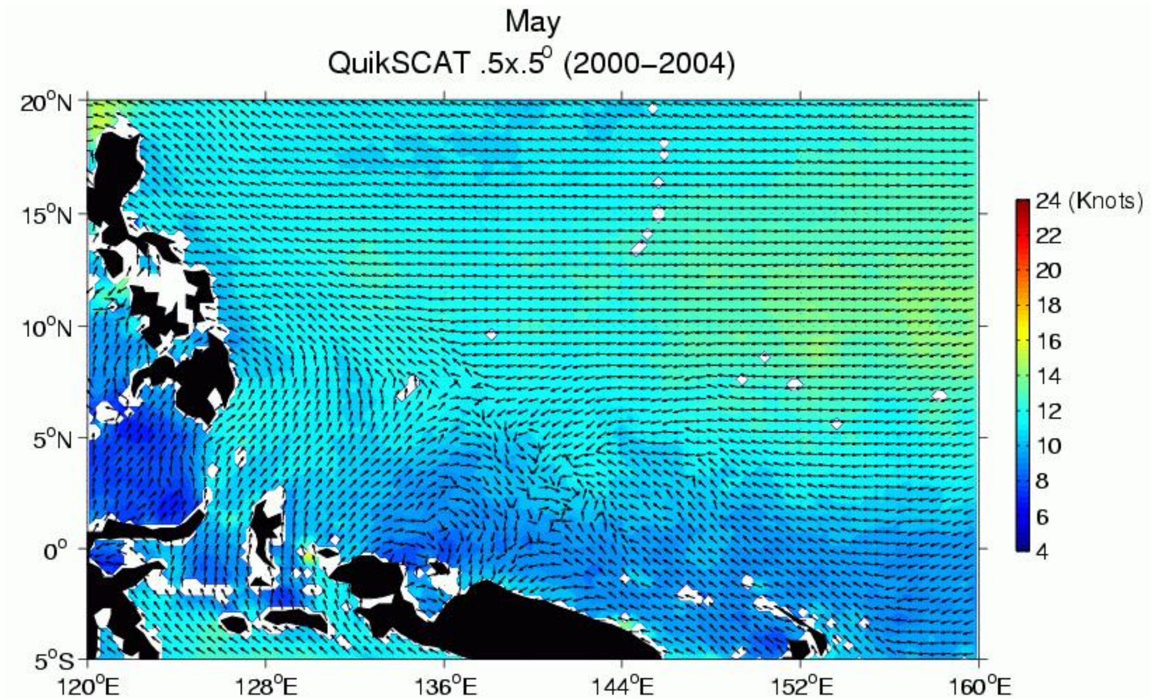
QuikSCAT Daily Observations (March 2000–2004)
LAT 2.75N LONG 131.75E

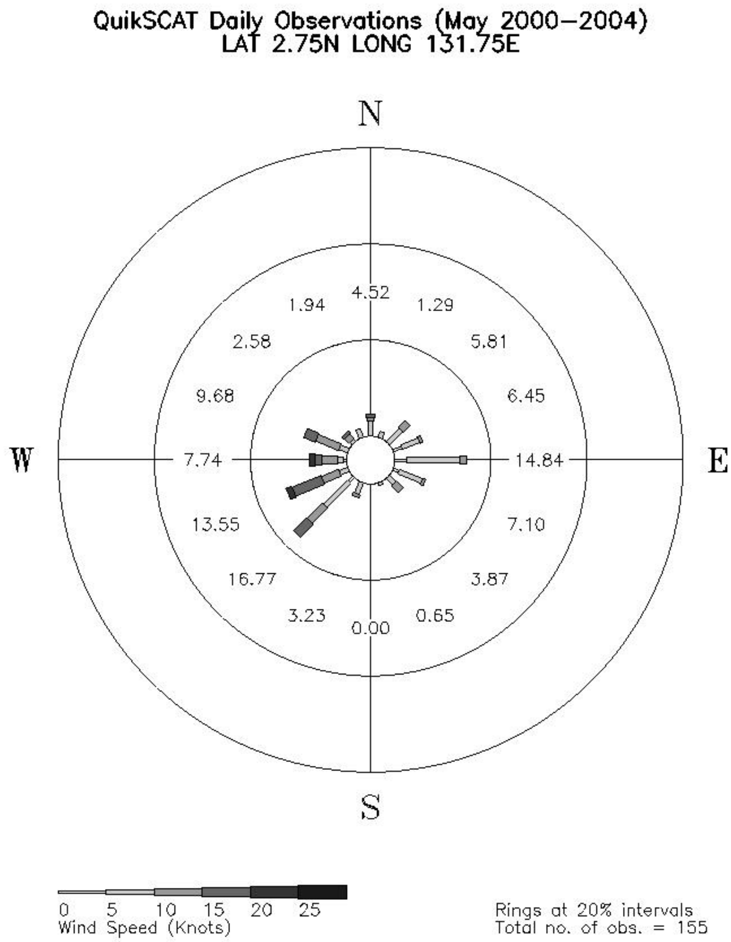


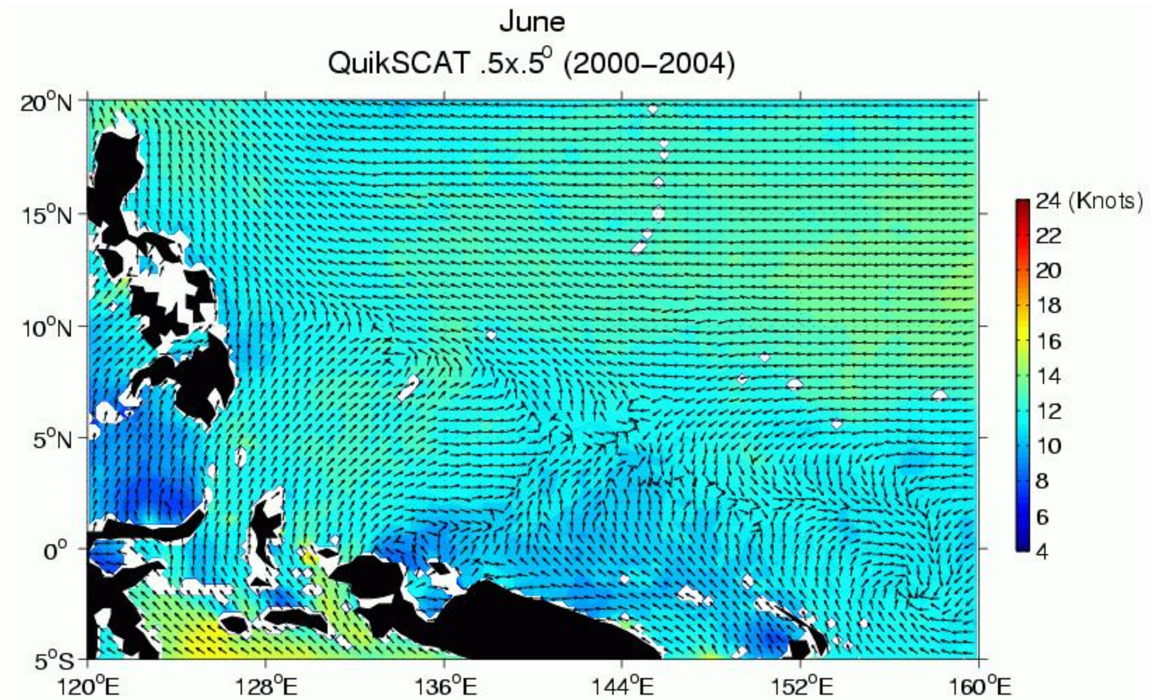


QuikSCAT Daily Observations (April 2000–2004)
LAT 2.75N LONG 131.75E

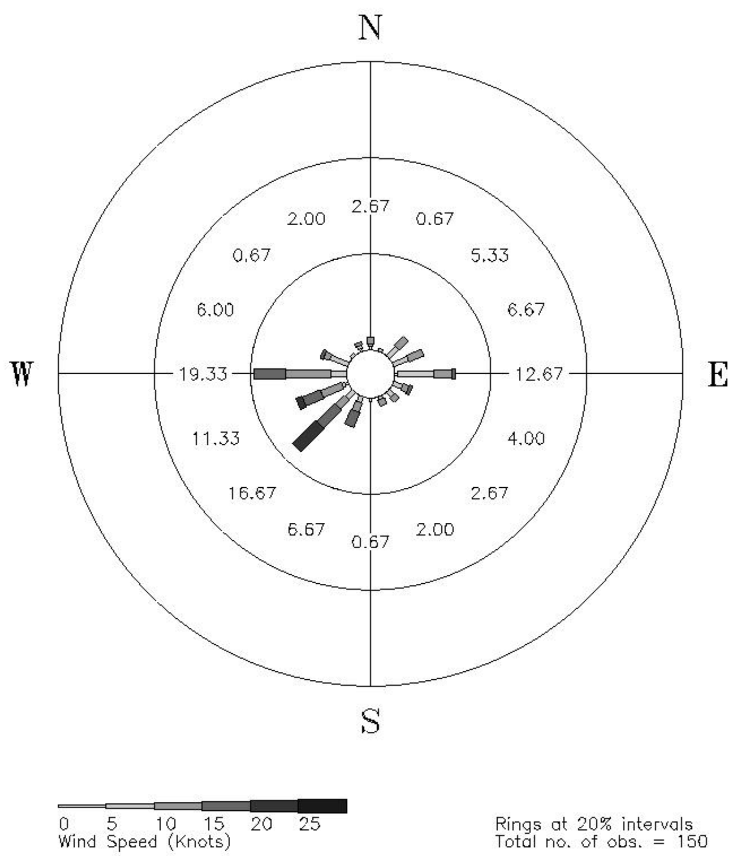


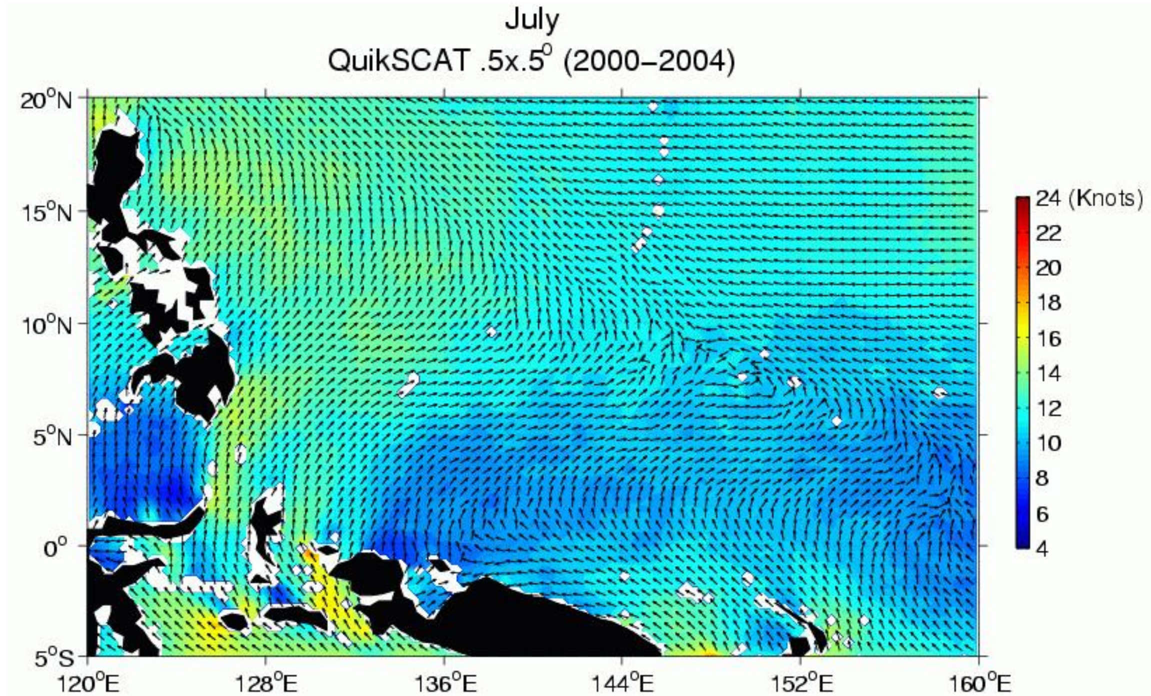

May
QuikSCAT .5x.5° (2000–2004)
20°N
15°N
10°N
5°N
0°
5°S
120°E
128°E
136°E
144°E
152°E
160°E
24 (Knots)
22
20
18
16
14
12
10
8
6
4

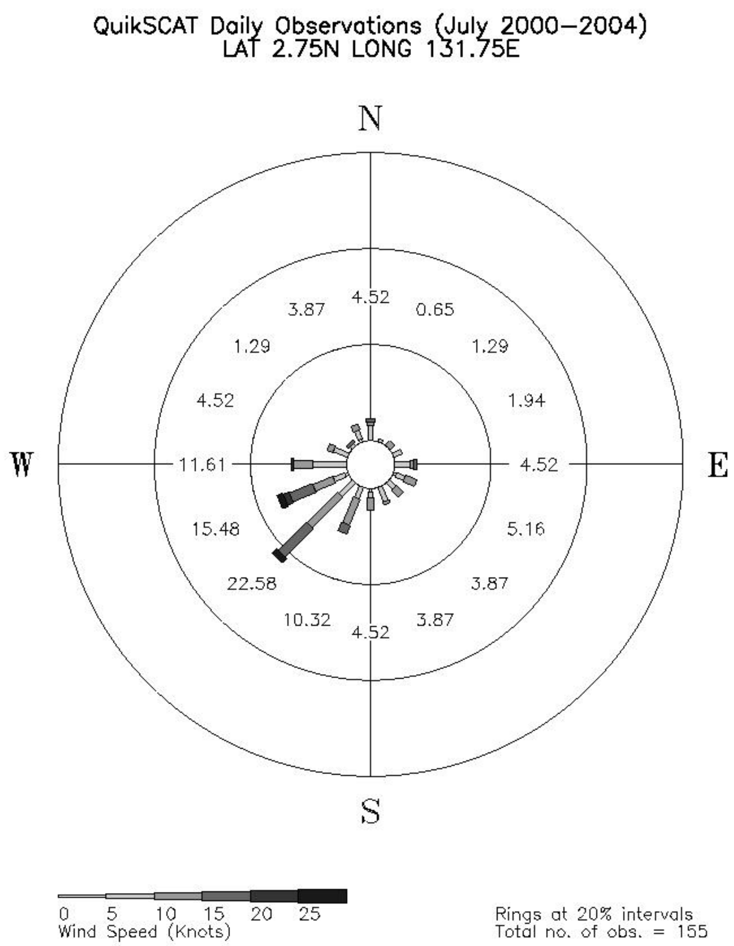

QuikSCAT Daily Observations (May 2000–2004)
LAT 2.75N LONG 131.75E
N
S
W
E
4.52
1.29
5.81
6.45
14.84
7.10
3.87
0.65
0.00
3.23
16.77
13.55
7.74
9.68
2.58
1.94
0 5 10 15 20 25
Wind Speed (Knots)
Rings at 20% intervals
Total no. of obs. = 155

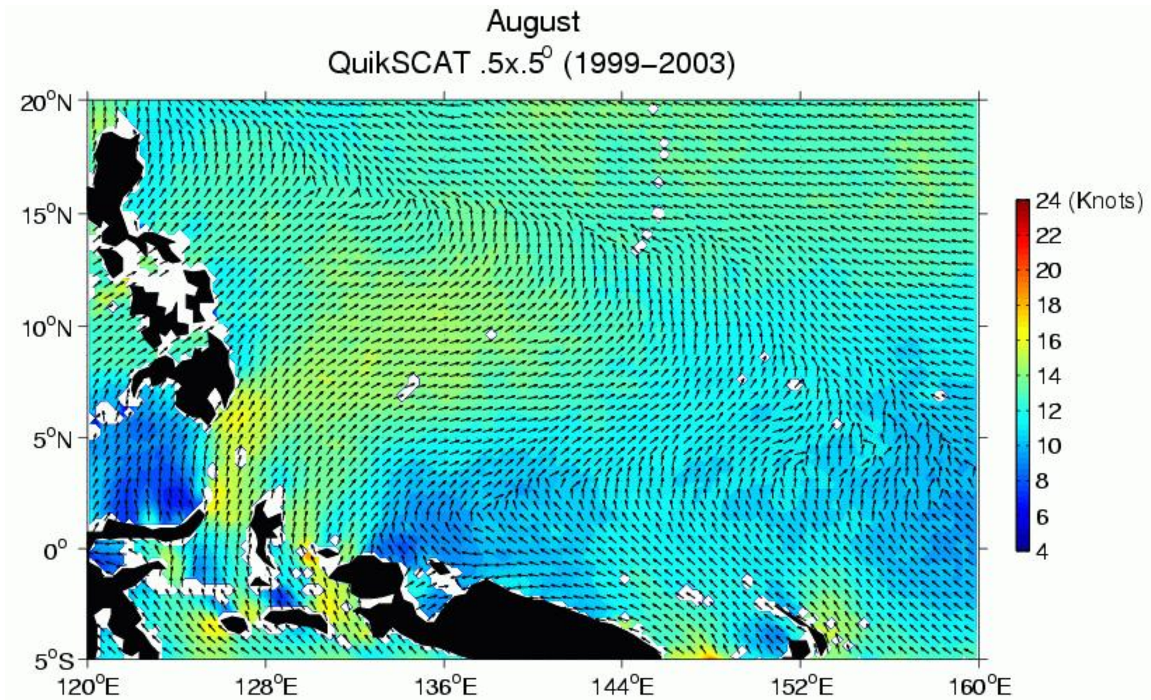


QuikSCAT Daily Observations (June 2000–2004)
LAT 2.75N LONG 131.75E

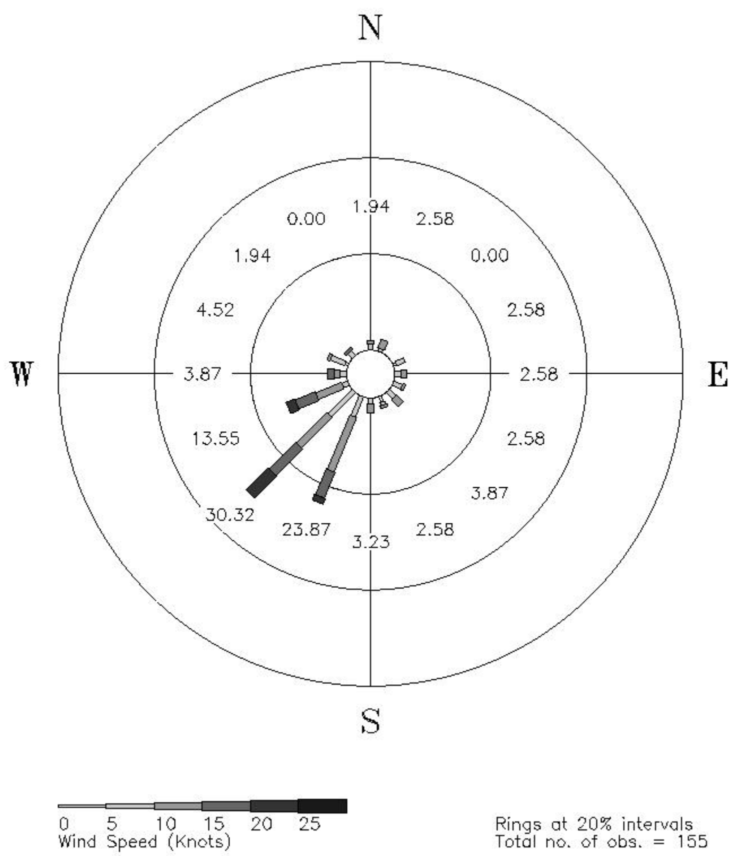


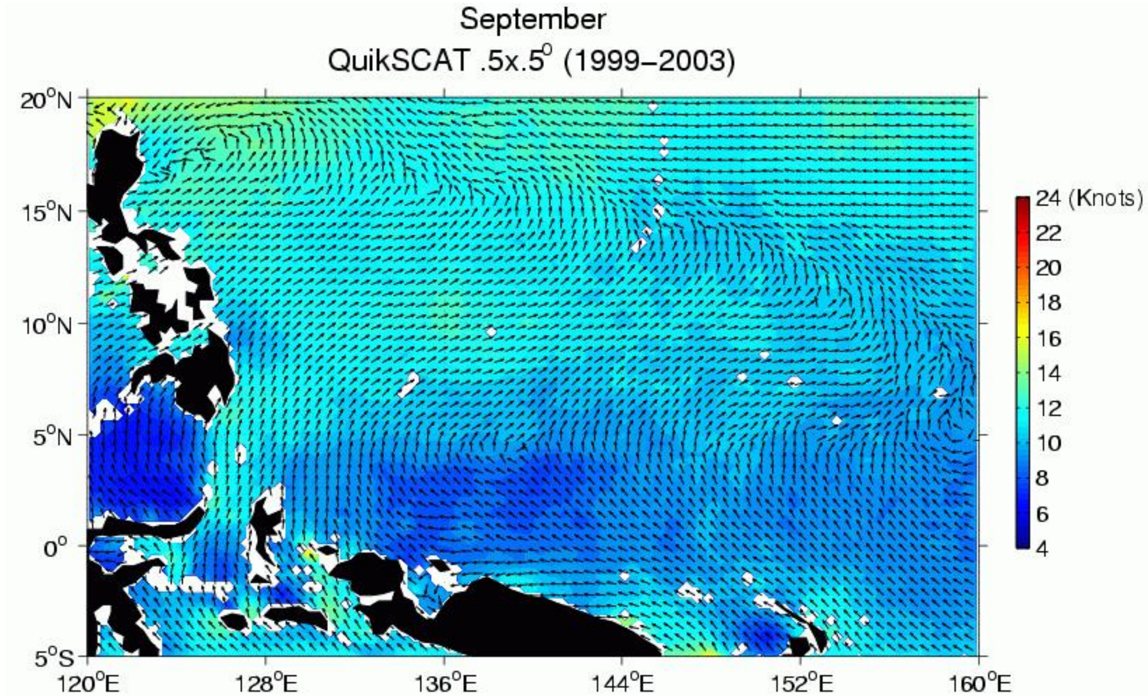

July
QuikSCAT .5x.5° (2000–2004)
20°N
15°N
10°N
5°N
0°
5°S
120°E
128°E
136°E
144°E
152°E
160°E
24 (Knots)
22
20
18
16
14
12
10
8
6
4

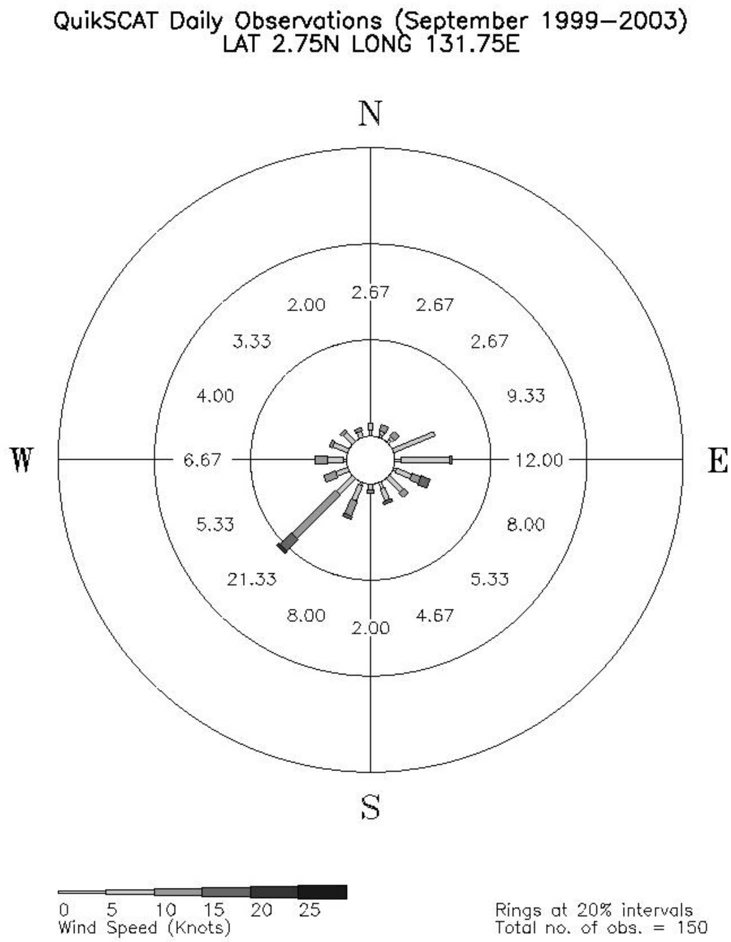

QuikSCAT Daily Observations (July 2000–2004)
LAT 2.75N LONG 131.75E
N
S
W
E
4.52
0.65
1.29
1.94
4.52
5.16
3.87
3.87
4.52
10.32
22.58
15.48
11.61
4.52
1.29
3.87
0 5 10 15 20 25
Wind Speed (Knots)
Rings at 20% intervals
Total no. of obs. = 155

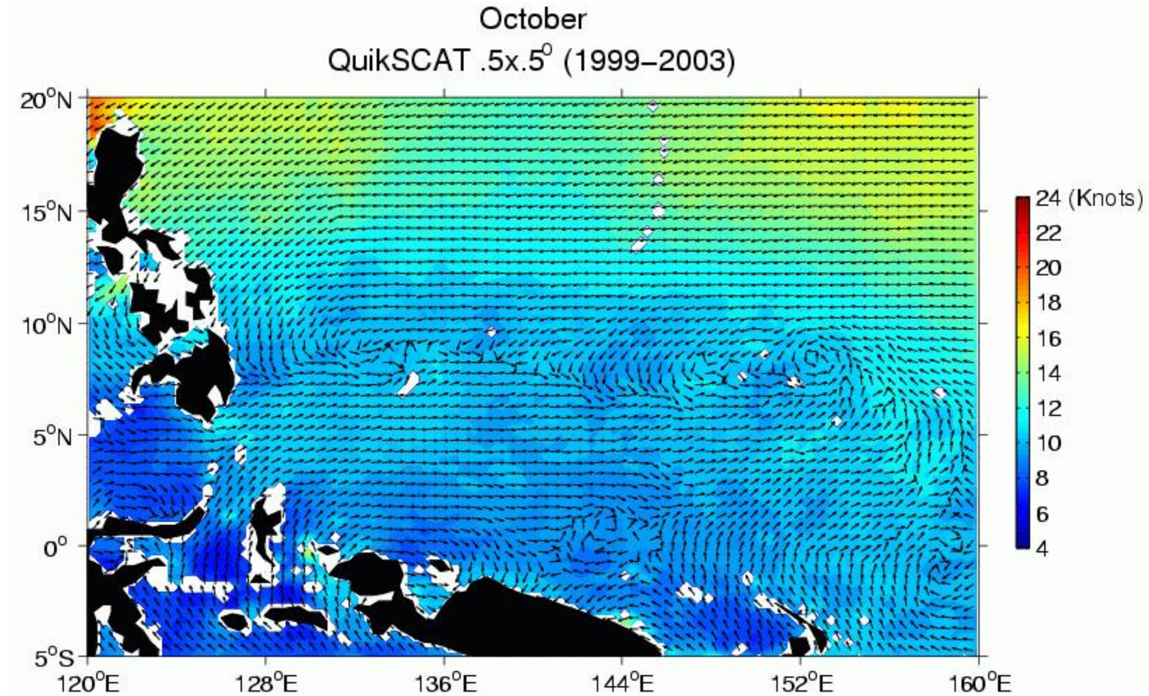


QuikSCAT Daily Observations (August 1999–2003)
LAT 2.75N LONG 131.75E

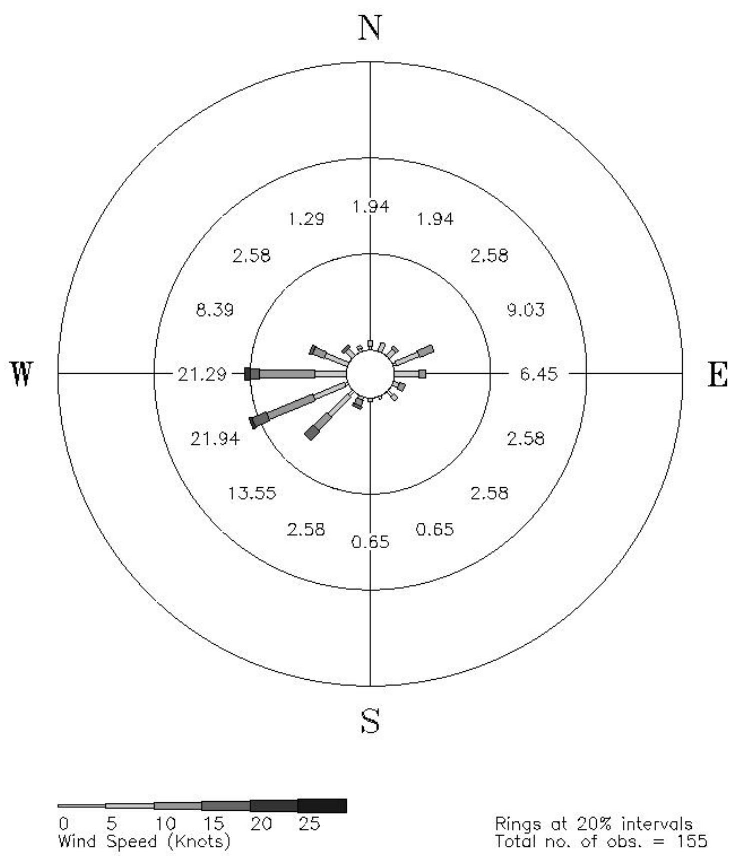


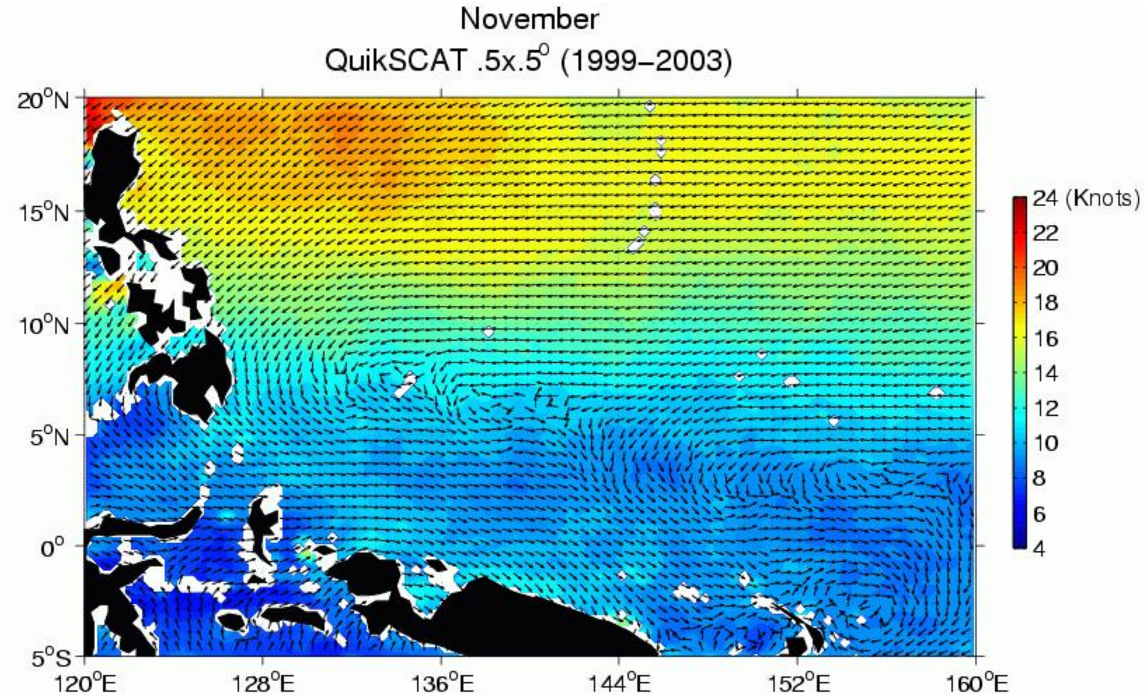

September
QuikSCAT .5x.5° (1999–2003)
20°N
15°N
10°N
5°N
0°
5°S
120°E
128°E
136°E
144°E
152°E
160°E
24 (Knots)
22
20
18
16
14
12
10
8
6
4

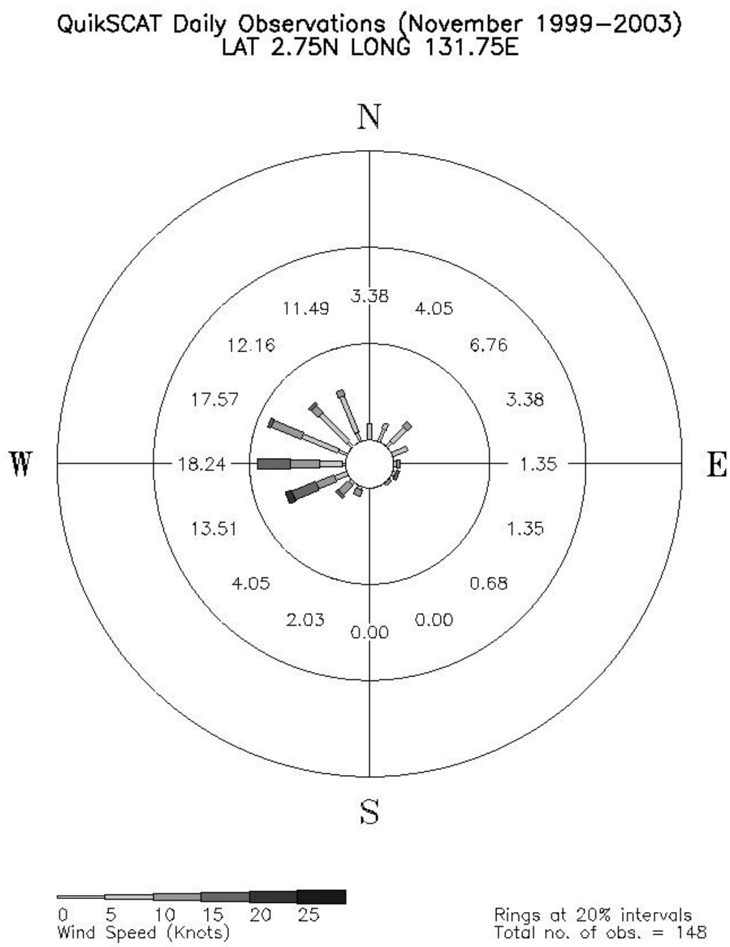

QuikSCAT Daily Observations (September 1999–2003)
LAT 2.75N LONG 131.75E
N
S
W
E
2.67
2.00
2.67
3.33
2.67
4.00
9.33
6.67
12.00
5.33
8.00
21.33
5.33
8.00
2.00
4.67
0 5 10 15 20 25
Wind Speed (Knots)
Rings at 20% intervals
Total no. of obs. = 150

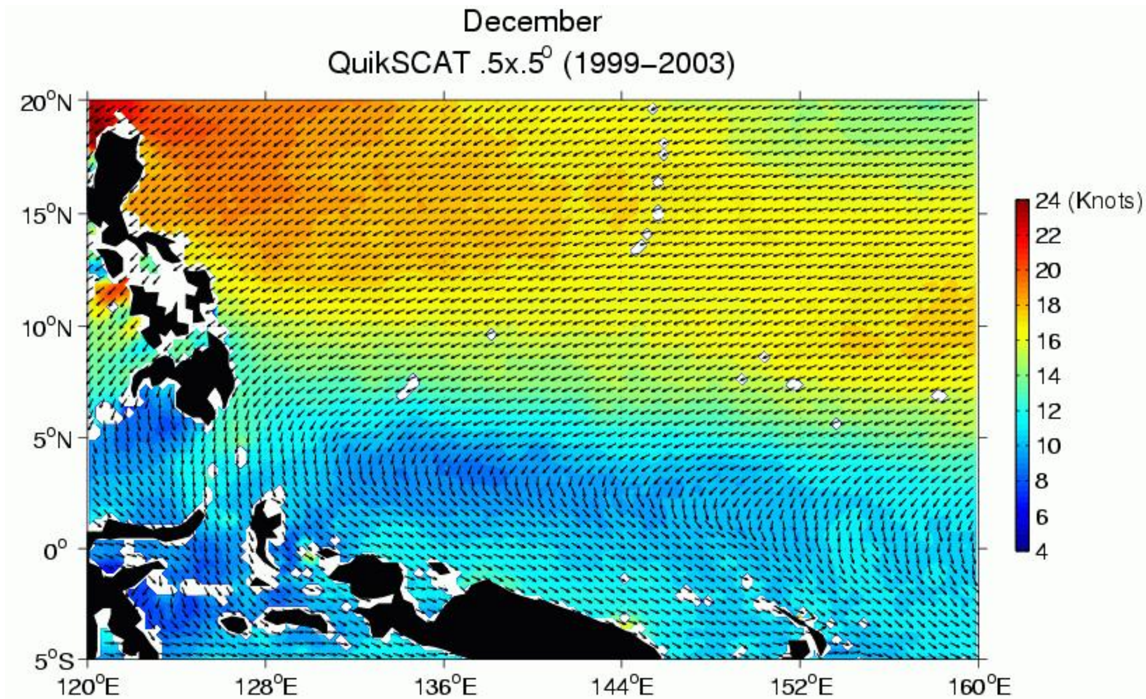


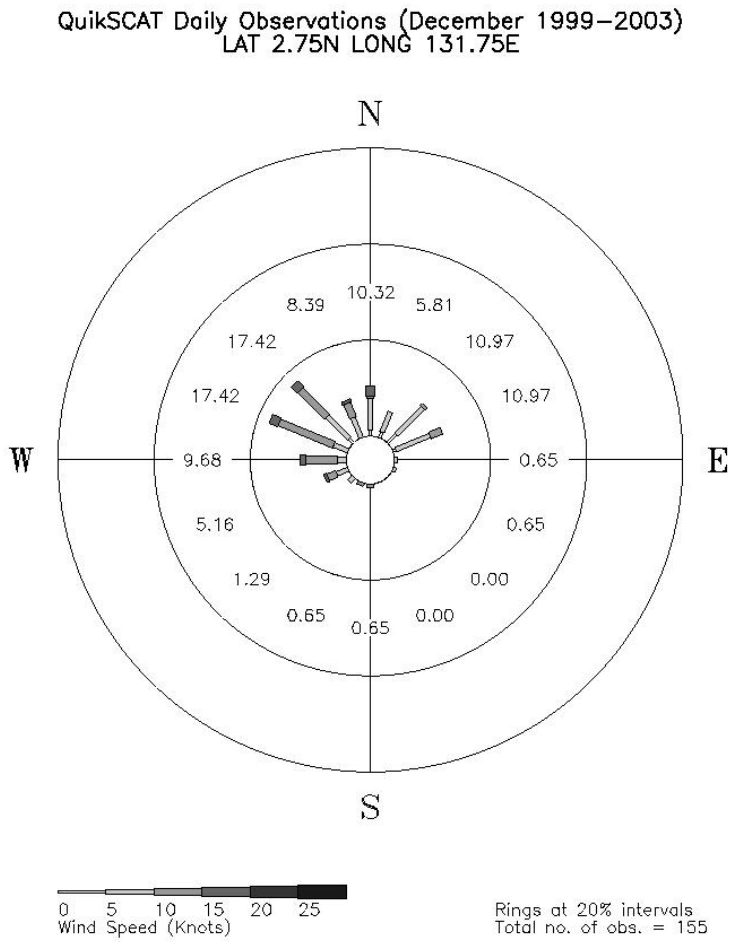
QuikSCAT Daily Observations (October 1999–2003)
LAT 2.75N LONG 131.75E




November
QuikSCAT .5x.5° (1999–2003)
20°N
15°N
10°N
5°N
0°
5°S
120°E
128°E
136°E
144°E
152°E
160°E
24 (Knots)
22
20
18
16
14
12
10
8
6
4


QuikSCAT Daily Observations (November 1999–2003)
LAT 2.75N LONG 131.75E
N
S
W
E
3.38
4.05
6.76
3.38
1.35
1.35
0.68
0.00
0.00
2.03
4.05
13.51
18.24
17.57
12.16
11.49
0 5 10 15 20 25
Wind Speed (Knots)
Rings at 20% intervals
Total no. of obs. = 148


December
QuikSCAT .5x.5° (1999–2003)
20°N
15°N
10°N
5°N
0°
5°S
120°E
128°E
136°E
144°E
152°E
160°E
24 (Knots)
22
20
18
16
14
12
10
8
6
4

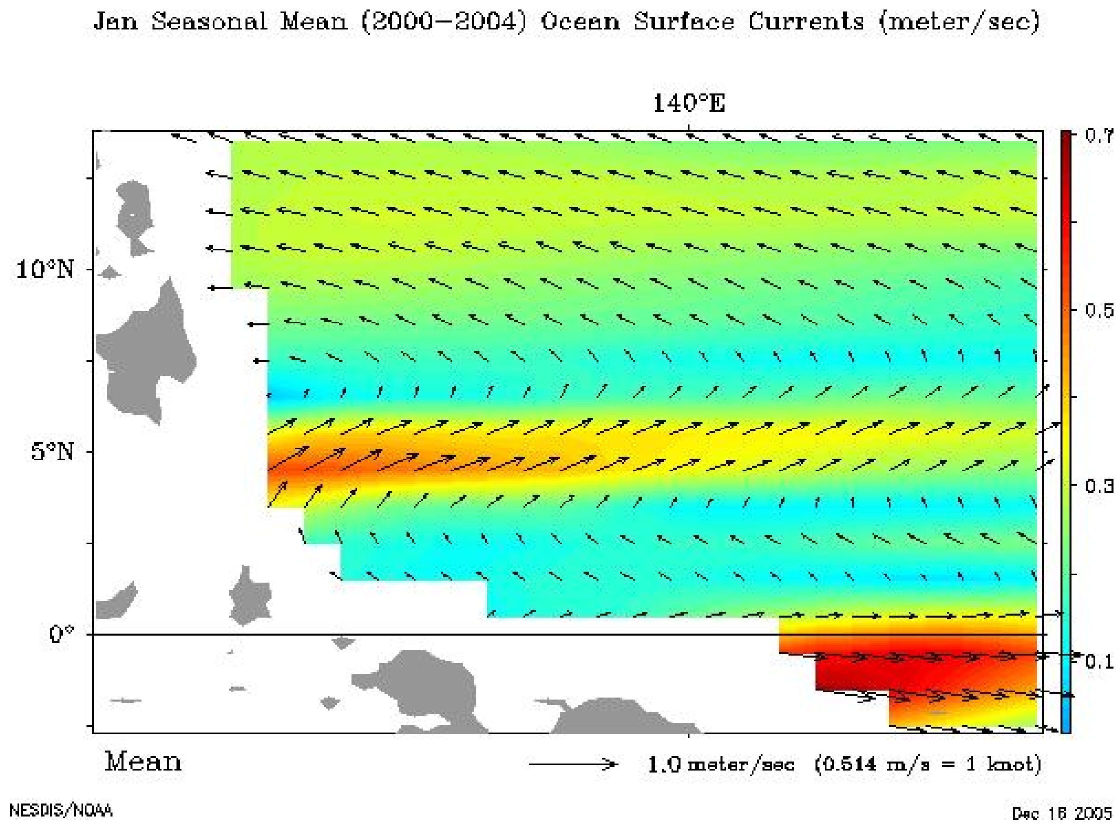

QuikSCAT Daily Observations (December 1999–2003)
LAT 2.75N LONG 131.75E
N
E
S
W
10.32
5.81
10.97
10.97
0.65
0.65
0.00
0.00
0.65
0.65
1.29
5.16
9.68
17.42
17.42
8.39
0 5 10 15 20 25
Wind Speed (Knots)
Rings at 20% intervals
Total no. of obs. = 155

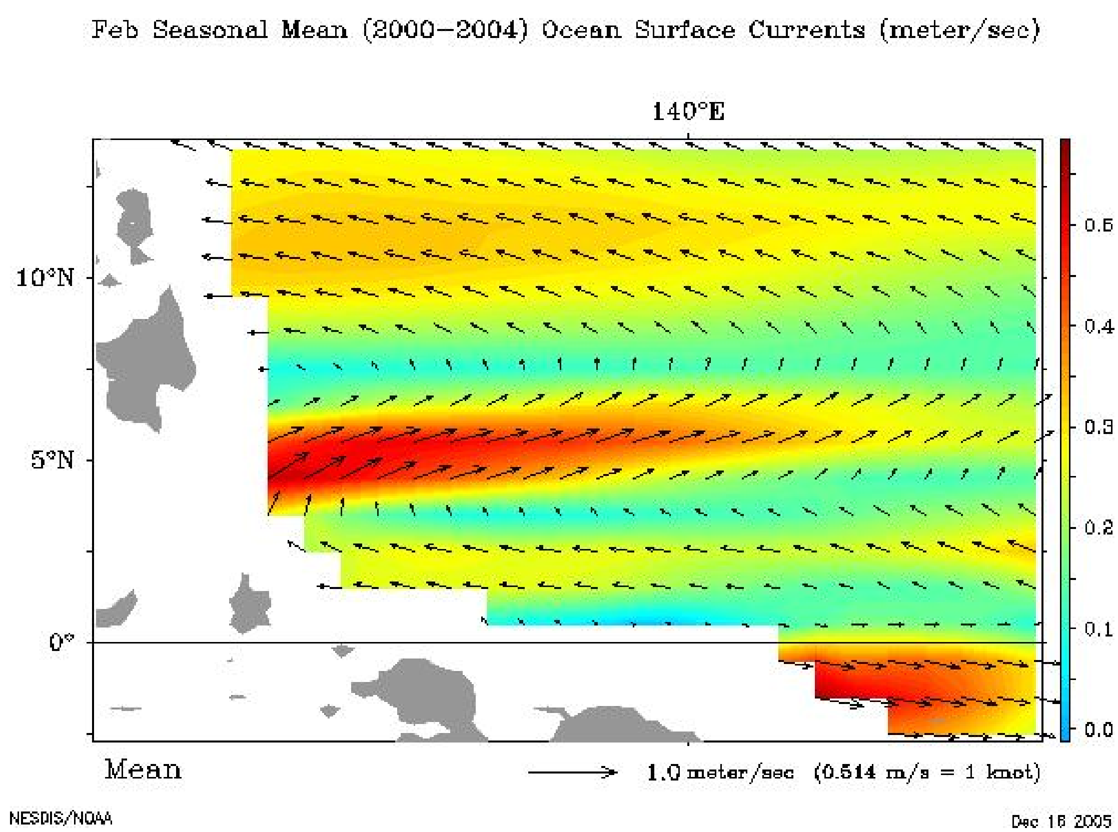
Appendix 3: Composites of Current Speed and Direction

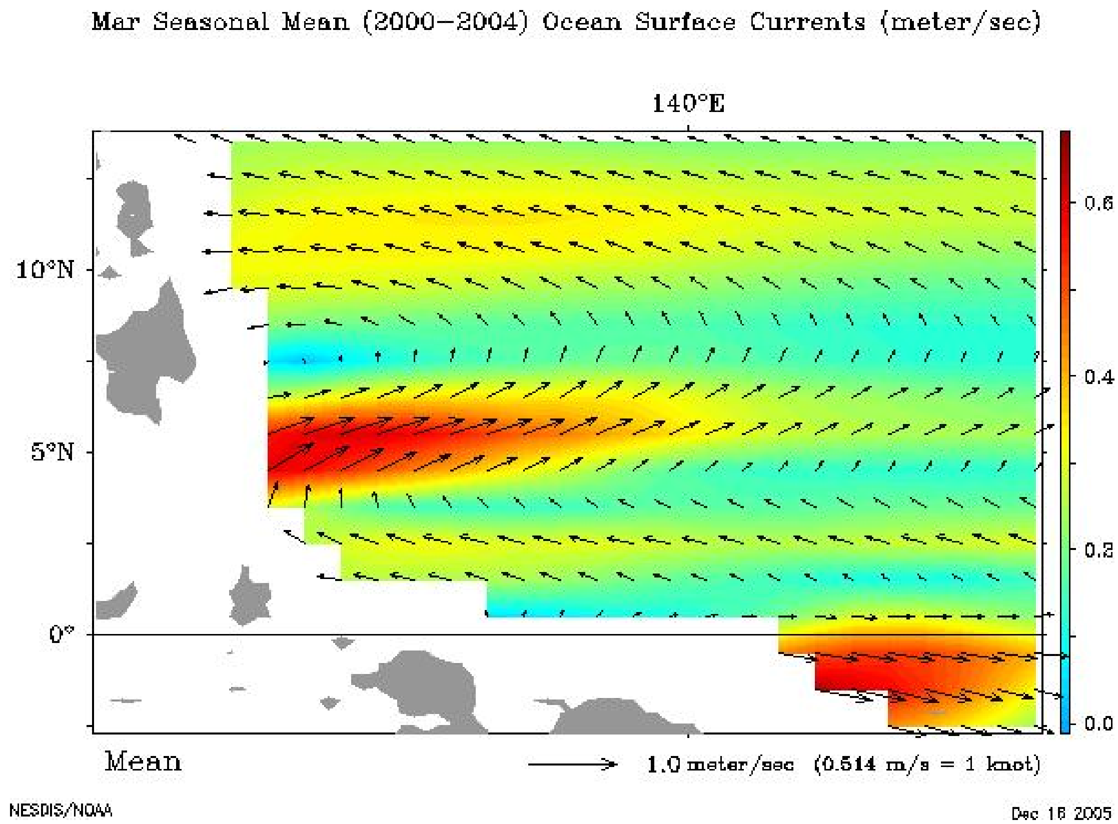
The plots below were retrieved from the OSCAR Ocean Surface Current Analysis – Realtime website http://www.oscar.noaa.gov/index.html. Methods for derivation of the currents are available in Bonjean F. and G.S.E. Lagerloef. 2002. Diagnostic Model and Analysis of the Surface Currents in the Tropical Pacific Ocean. Journal of Physical Oceanography, Vol. 32, No. 10, pages 2938-2954. The authors' abstract is presented below.

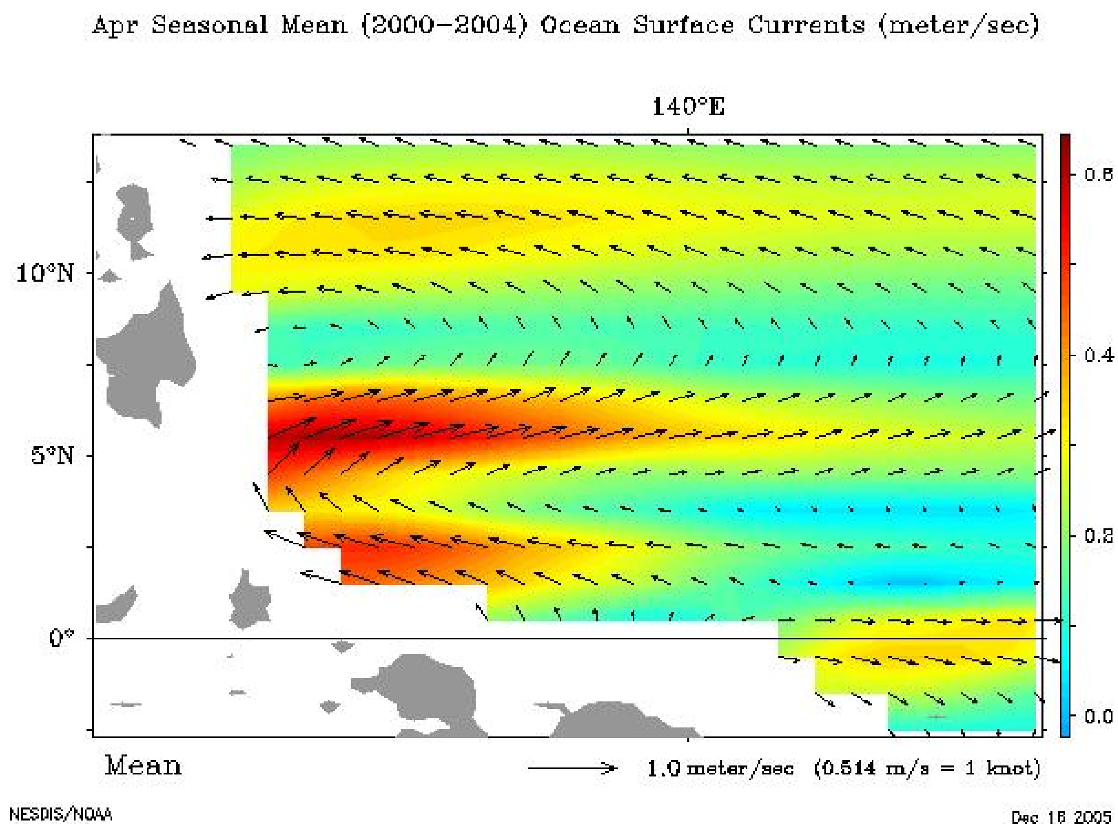
> A diagnostic model of the tropical circulation over the 0-30-m layer is derived by using quasi-linear and steady physics. The horizontal velocity is directly estimated from sea surface height (TOPEX/Poseidon), surface vector wind (SSM/I) and sea surface temperature (AVHRR + in situ measurements). The absolute velocity is completed using the mean dynamic height inferred from the World Ocean Atlas (WOA). The central issue investigated in this study is the more accurate esthnate of equatorial surface currents relative to prior satellite-derived method. The model formulation combines geostrophic, Ekman, and Stommel shear dynamics, and a complementary term from surface buoyancy gradient. The field is compared with velocity observations from 15-m-depth buoy drifter and equatorial Tropical Ocean Atmosphere (TAO) current meters. Correlations with TAO data on the equator are much higher in the eastern Pacific cold tongue than before. The mean field in the cold tongue is also much more accurate, now showing the equatorial minimum that splits the South Equatorial Current into northern and southern branches. The mean current strength is somewhat less than in drifter composites because the mean dynamic topography from WOA remains too smooth. However, the seasonal cycle and inter-annual variations are robust, especially anomalies on the order of 1 m s[sup -1] during the 1997-98 ENSO. This direct method using satellite measurements provides surface current analyses for numerous research and operational applications.

Maps are plots of monthly means for 2000 to 2004 for ease of comparison with COGOW data. Vectors below indicate direction and magnitude of currents.

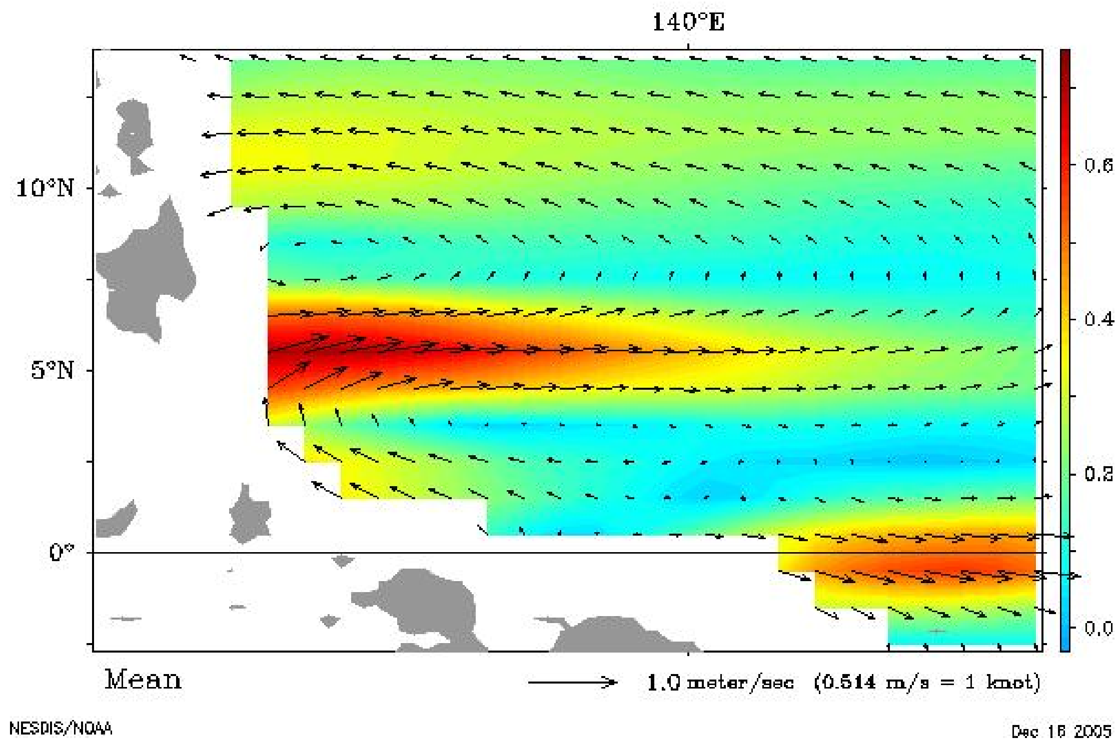

Jan Seasonal Mean (2000−2004) Ocean Surface Currents (meter/sec)
140°E
10°N
5°N
0°
0.7
0.5
0.3
0.1
Mean
1.0 meter/sec (0.514 m/s = 1 knot)
NESDIS/NOAA
Dec 16 2005


Feb Seasonal Mean (2000−2004) Ocean Surface Currents (meter/sec)
140°E
10°N
5°N
0°
0.5
0.4
0.3
0.2
0.1
0.0
Mean
1.0 meter/sec (0.514 m/s = 1 knot)
NESDIS/NOAA
Dec 16 2005

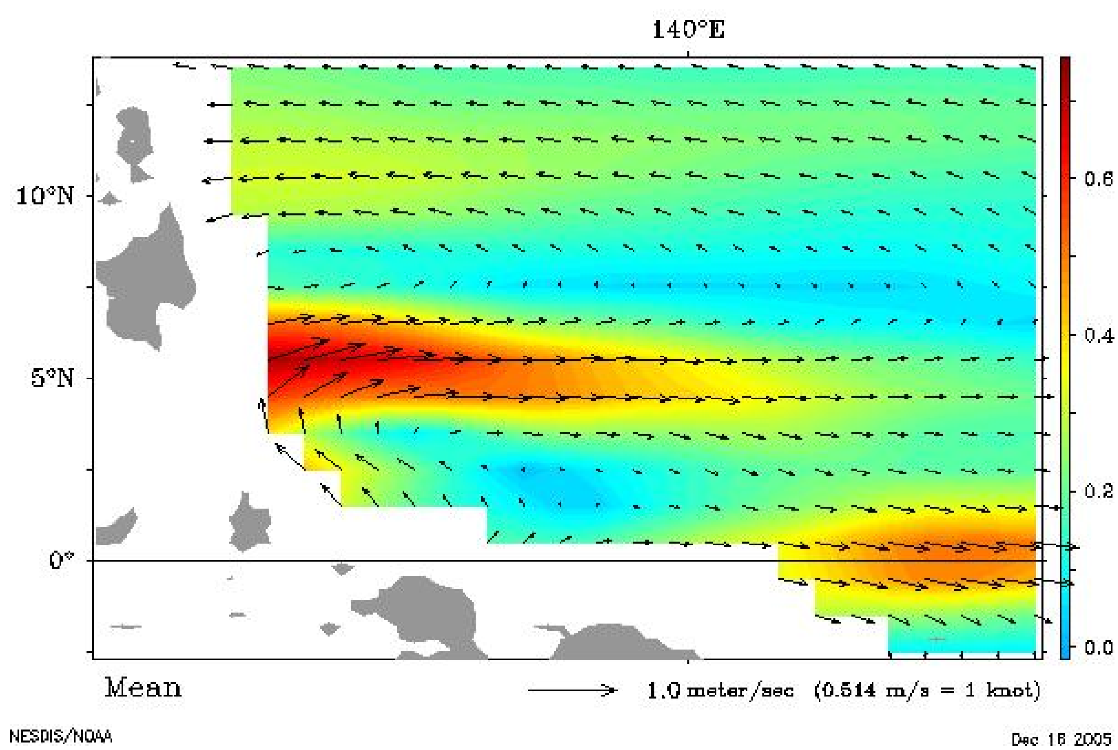

Mar Seasonal Mean (2000−2004) Ocean Surface Currents (meter/sec)
140°E
10°N
5°N
0°
0.6
0.4
0.2
0.0
Mean
1.0 meter/sec (0.514 m/s = 1 knot)
NESDIS/NOAA
Dec 16 2005


Apr Seasonal Mean (2000−2004) Ocean Surface Currents (meter/sec)
140°E
10°N
5°N
0°
0.6
0.4
0.2
0.0
Mean
1.0 meter/sec (0.514 m/s = 1 knot)
NESDIS/NOAA
Dec 16 2005

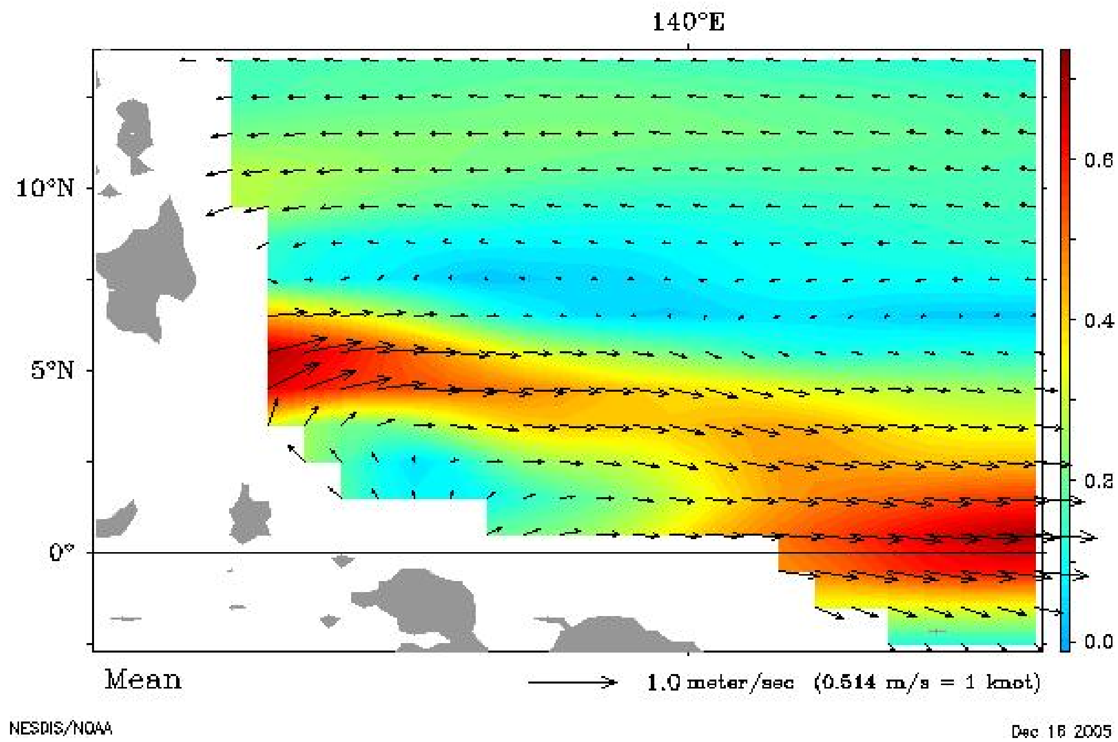
May Seasonal Mean (2000−2004) Ocean Surface Currents (meter/sec)



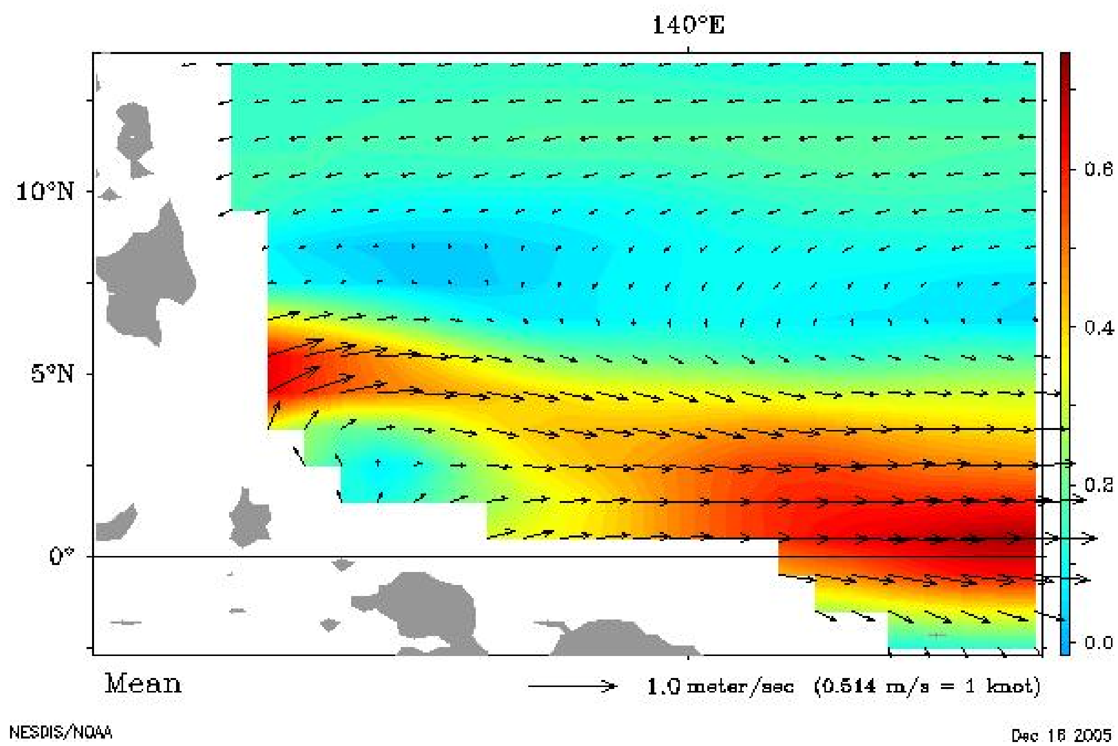
Jun Seasonal Mean (2000−2004) Ocean Surface Currents (meter/sec)



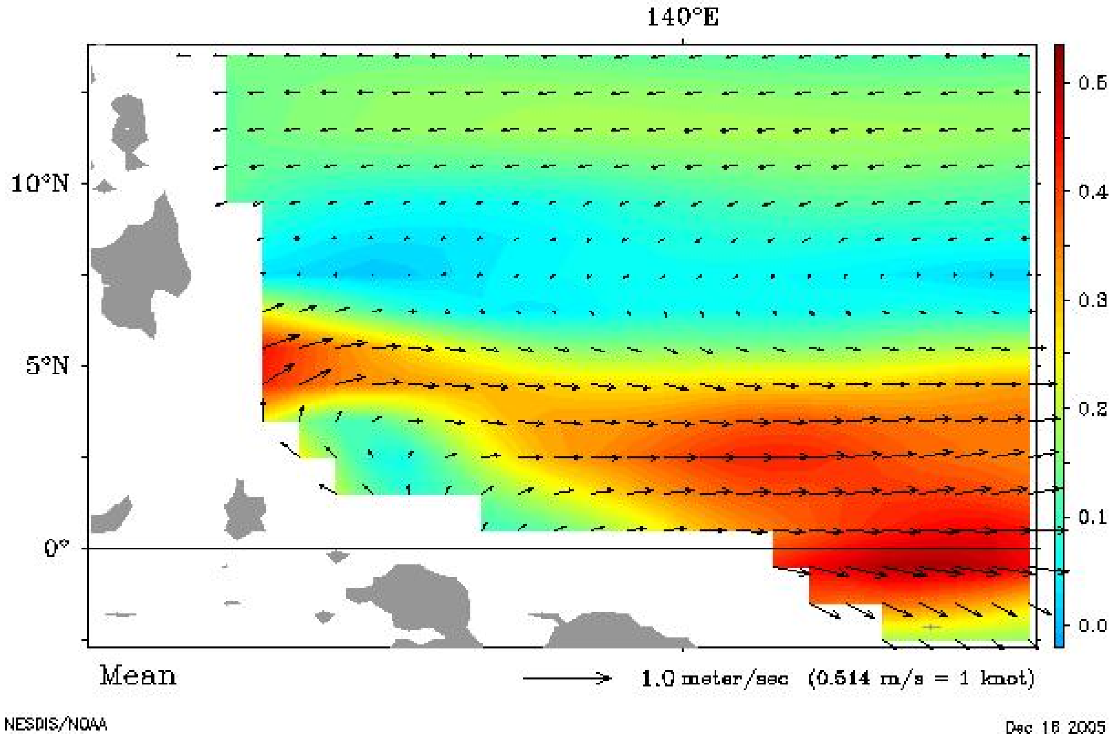
Jul Seasonal Mean (2000–2004) Ocean Surface Currents (meter/sec)



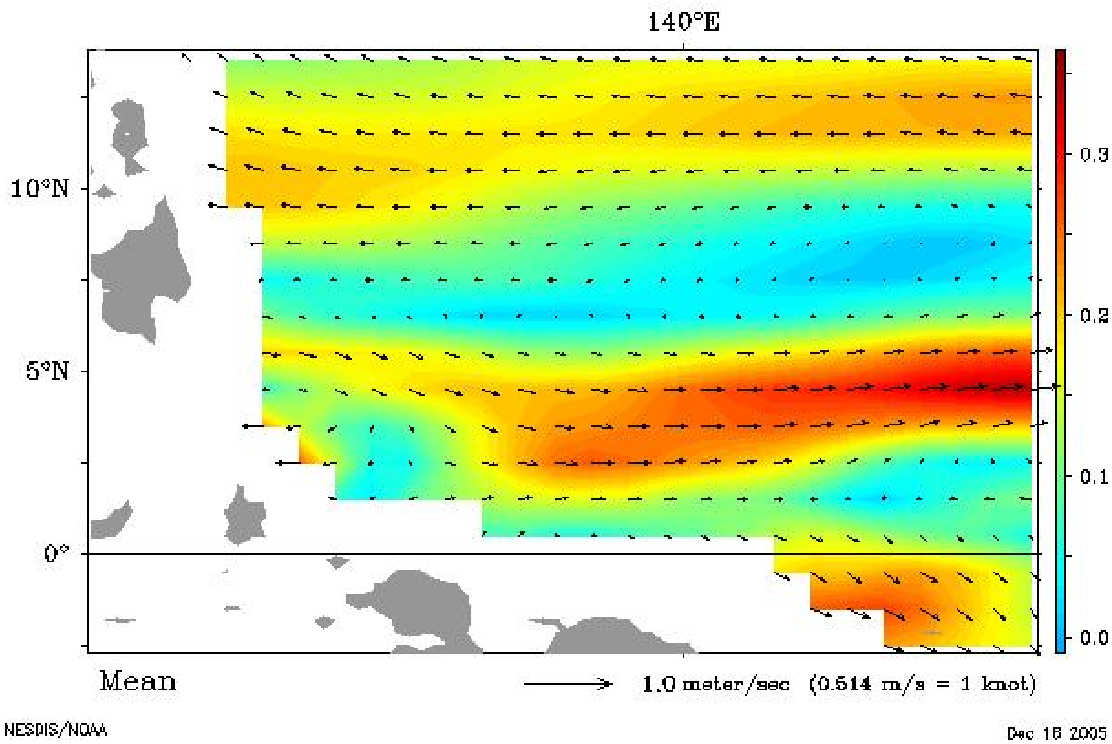
Aug Seasonal Mean (2000–2004) Ocean Surface Currents (meter/sec)

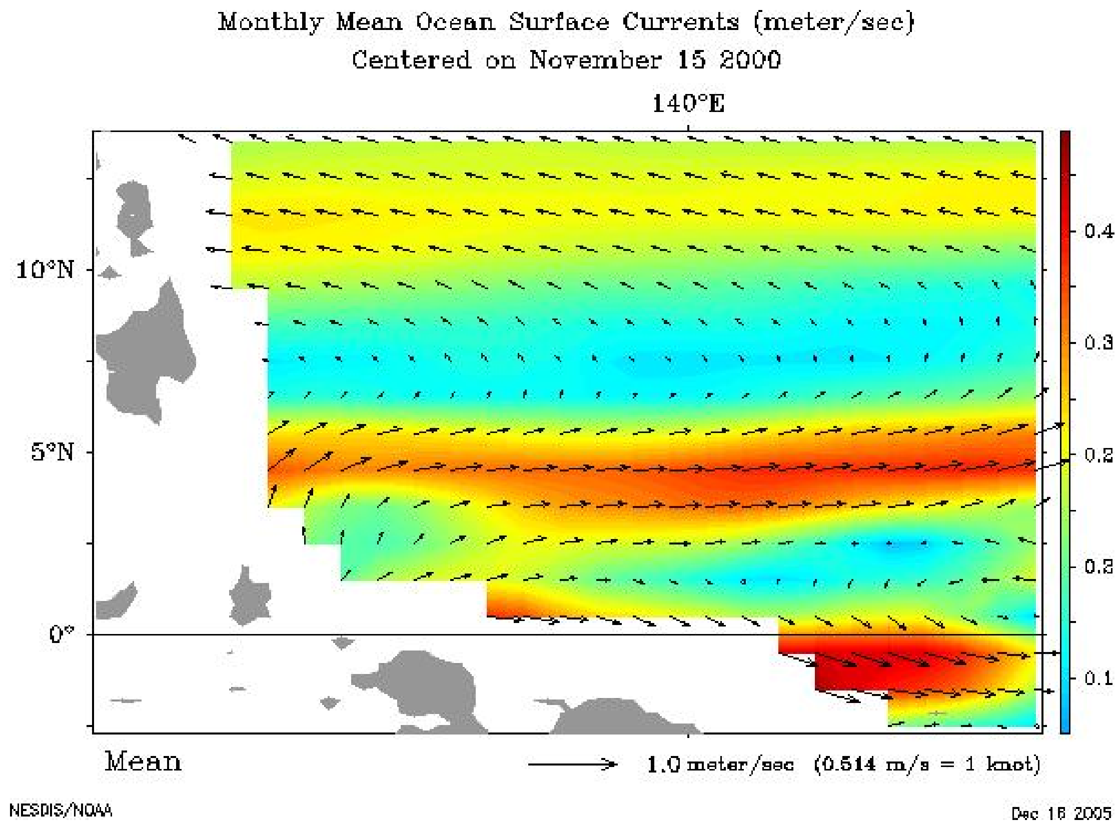


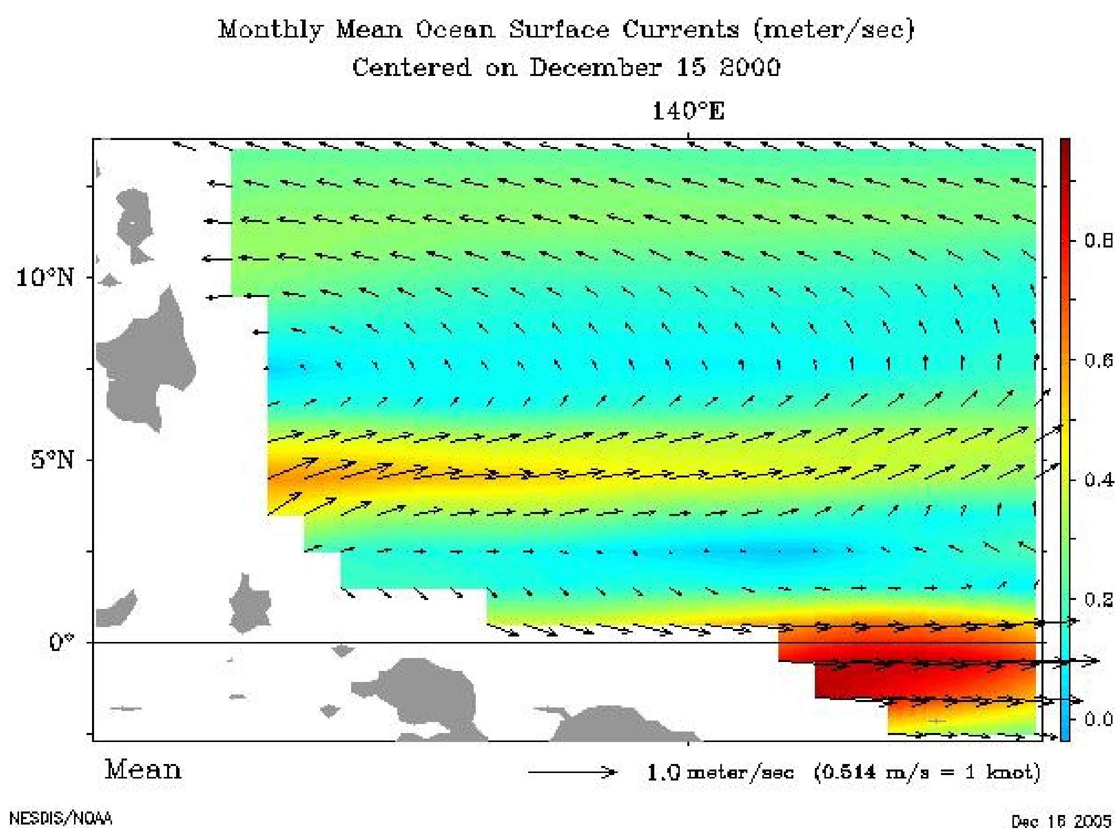
Sep Seasonal Mean (2000–2004) Ocean Surface Currents (meter/sec)



Monthly Mean Ocean Surface Currents (meter/sec)
Centered on October 15 2000

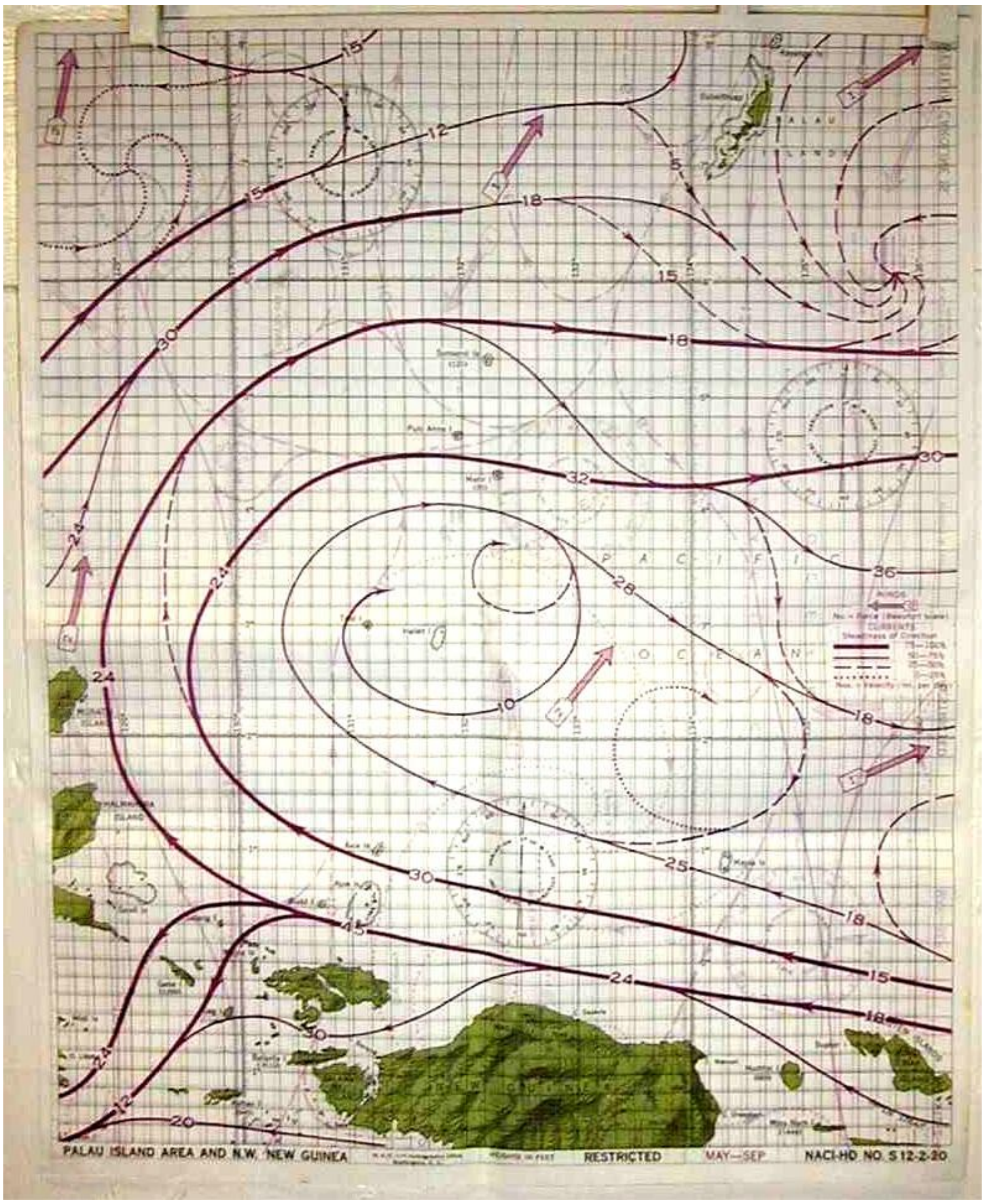



Monthly Mean Ocean Surface Currents (meter/sec)
Centered on November 15 2000
140°E
10°N
5°N
0°
Mean
1.0 meter/sec (0.514 m/s = 1 knot)
NESDIS/NOAA
Dec 16 2005


Monthly Mean Ocean Surface Currents (meter/sec)
Centered on December 15 2000
140°E
10°N
5°N
0°
Mean
1.0 meter/sec (0.514 m/s = 1 knot)
NESDIS/NOAA
Dec 16 2005

Appendix 4: Mesoscale Diagram of Regional Currents

This map was retrieved from the Friends of Tobi Island Website Archive at http://cas.gmu.edu/~tobi/researchandreference.htm. The source and date of the image are unknown. The notation indicates that the diagram represents currents from May to September.



Appendix 5: Using the Helen Reef Resource Management Project Database

Introduction

Microsoft Access is a Relational Database Program. It is an ideal program for entering and storing the HRRMP turtle monitoring data because it protects your data and can be customized for your needs. MS Access does not allow you to accidentally delete data or to enter duplicate data. It is easy to import, export, organize, search and print your data. Access is intended to work with MS Excel for analysis purposes. Access also easily interfaces with mapping programs like ArcGIS.

Using MS Access

Overview

MS Access preserves the integrity of your data. This means that data entered into the database has to be complete or the database will reject it. Additionally, once your data is entered it is difficult to accidentally delete it. So you can search, scroll, and look around in your data tables without risking loosing your data. It is important to note that data can be changed and a user must be careful not to accidentally change data.

Analysis of Data

When you have questions about your data you can ask MS Access by using a powerful tool called a query. Queries select data based on your request. With the selected data you can calculate averages, make charts, update data, organize a group of data, and much more.

Definitions

Field

A Field is one piece of information like Date, TagNo, or NestCode. Fields appear in one box of a datasheet or a data entry form. Fields appear in columns. MS Access can sort your data by one field at a time. Fields can contain numbers, text, dates, pull down menus, or check boxes.

Record

A Record is a collection of Fields. It appears as an entire row of data. A record will contain all the information on the Turtle Tagging Forms or the Nesting Beach Survey forms. MS Access saves every completed record automatically. You can search for a particular record if you know what is contained in only one of its fields.

Object

MS Access files consist of objects. The objects you may use include: Tables, Forms, Queries, Macros, and Reports. Each object serves a unique purpose and all objects are related to each other; this means that they each contain the same data that you have entered into your database file. If you add data to one object all related objects are automatically updated.

Tables

Tables are objects that look like Excel spreadsheets and function in much the same way. The major difference is that you can sort data in a table using one field without changing your records. This feature protects the integrity of your data. Tables are the fundamental object in your database all other objects are based on tables. Each table is based on one subject like Tagged Turtles, or Nests. All relationships between data exist at the table level.

Forms

Forms are objects that show one record of data at a time. Forms are based on tables. They are the ideal interface for searching records, and entering data. When you enter data into a form the table it was based on is automatically updated.

Queries

Queries are objects that select data from a table (or from more than one related tables) to answer a specific question or to group data together. Queries can be used to view data, perform calculations, or summarize data. If a query is saved then it will automatically update when new data is entered into forms.

Reports

Reports are objects that are useful for displaying and printing your data for sharing with others. Reports are based on Tables or Queries and are automatically updated when new data is entered into the database. Graphs and charts are types of reports.

Macros

Macros help to automate tasks in your database. Macros can be established to navigate between forms, save data, search for a record, view a report, print data, or repair the database. Macros are established by a database manager and are not often altered by other database users.

Database Window

The Database Window contains a list of all objects. While your database file is open the Database Window can be viewed at any time by pressing the function key “f11” or by clicking on the icon on the toolbar. From the database window you can open any object. You can create new objects, or change the design of existing objects. The Database Window will most often be used by the database manager. If you close the database widow then the database file will close, but don't worry all completed records will be saved.

Relationships

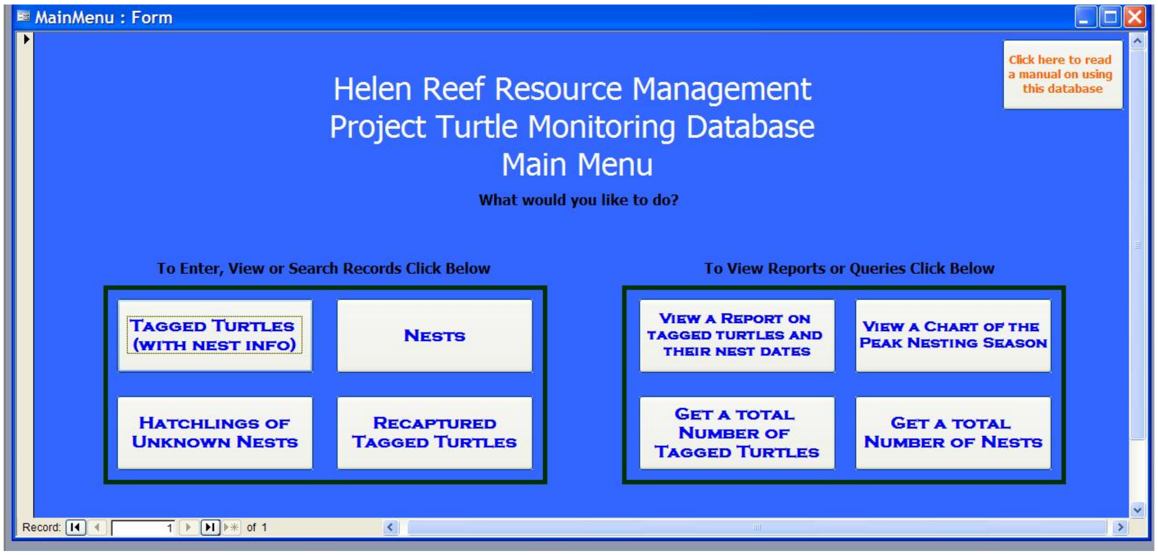
Relationships tie two or more tables together by common fields. Relationships help to protect your database from incomplete data, duplicate records, and accidental deletion. Relationships also allow queries to include data from more than one table. When and if the time comes to map your data, relationships make mapping more efficient and useful.

Using the HRRMP Turtle Database

Opening the File

The file name is "Helen Turtle Monitoring." There should be only one working copy of this file at all times to avoid losing or duplicating data. Additional copies should be for backup purposes only. When you open the file a security warning will appear. This is intended to prevent viruses from transferring files between computers. If you are confident that the file does not contain a virus click "Open".

Your custom Main Menu Form will appear



From here you can choose what you want to do by clicking on a button. If you accidentally close the main menu you can reopen it using the Database Window.

There are four major tables and forms in your database shown on the Main Menu. They are listed on the left side of the main menu. When you click one of the buttons, the related form will open and you can enter or search records.

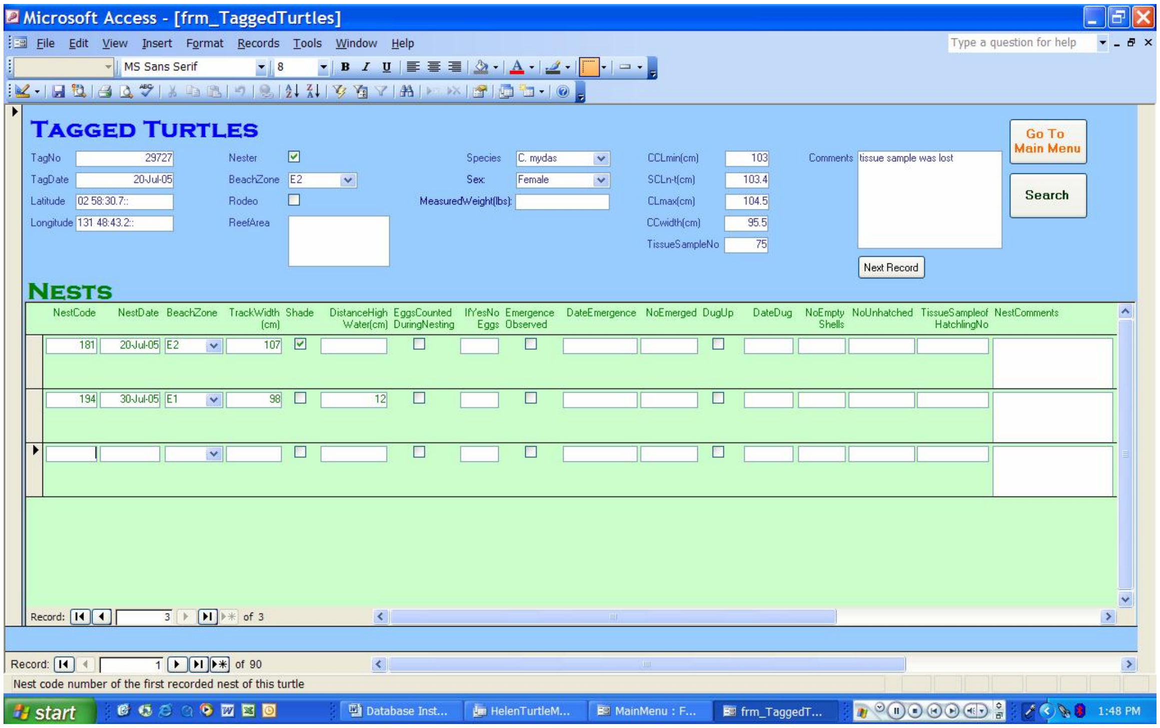
There are also four buttons on the right that open up to date queries and reports for a quick reference to common questions.

Opening Forms and Entering Data

The Tagged Turtle Form is unique because it lists all the nests that have been made by each tagged turtle so you can look at all the information at the same time.

When a new turtle is tagged, it must be entered into this form before information about it’s nests can be entered. The database has to know a turtle exists before it can store information about the turtle’s nests.

Click the “Tagged Turtles” button on the main menu and the “Tagged Turtles” form will appear.

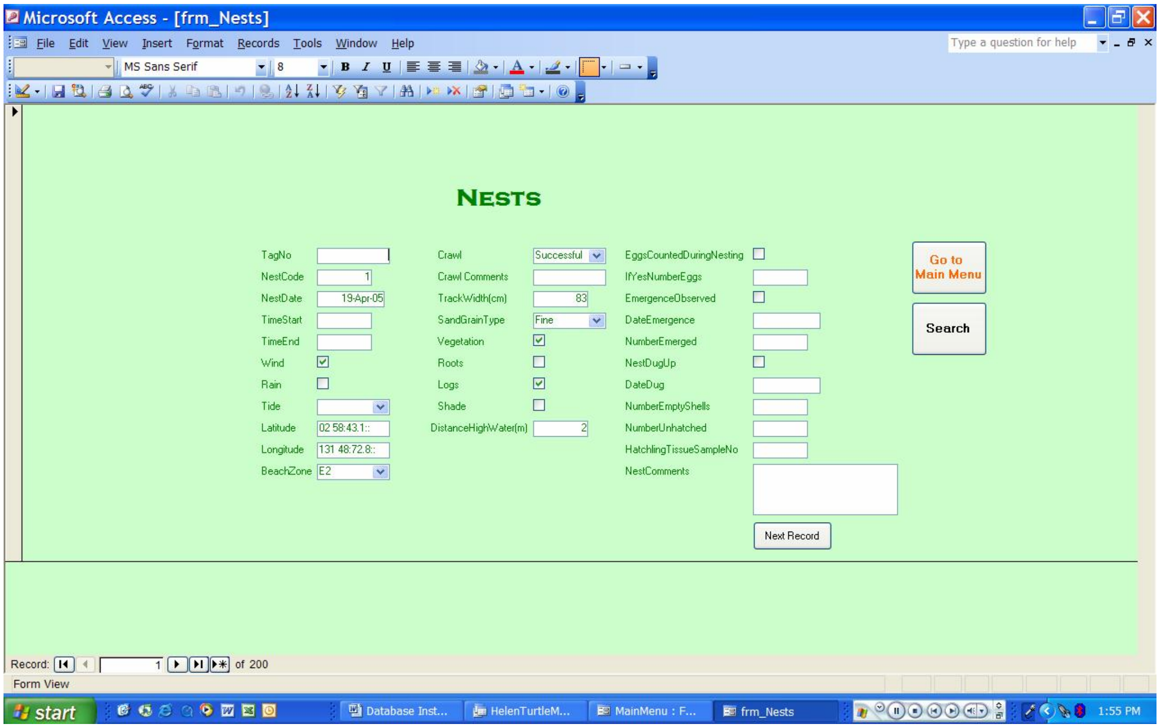


Use the "tab" key or arrow keys on the keyboard to navigate within one record while in a form. Forms have scroll bars at the bottom the keep track of the records and can be used to navigate between records. At the bottom in the scroll bar of this form the total number of records for tagged turtles appears. You can click through the records by using the arrow buttons. The scroll bar at the bottom of the green Nests form shows the number of nest records per tagged turtle.

You can use the black "Search" Button in the upper right hand corner to search for a particular tag number and see its measurements and the information about it's nests.

You can use the orange button in the upper right hand corner to close this form and return to the main menu

To enter information about nests click the "Nests" button on the main menu and the "Nests" form will appear.

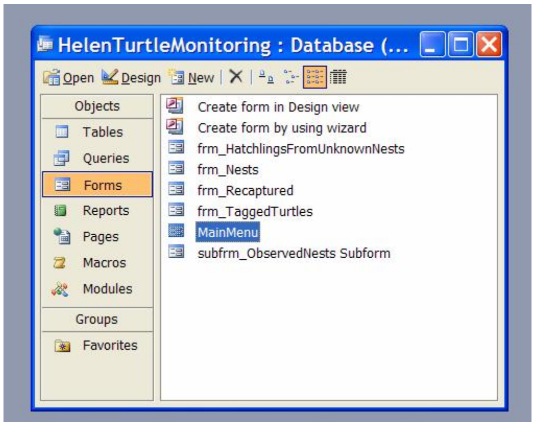


The scroll bar at the bottom shows the total number of nests. All the same rules apply for this form.

There are two other forms in your database. One for entering information about hatchlings that come from unmarked nests, and one for entering information about turtles when they are recaptured either rodeo style, next season when they come to nest, or when they are reported at another location.

The Database Window

To get to the Database Window at anytime press “f11” on your keyboard or use the icon on the toolbar.



In the database window you can find, open or create new objects. To navigate within this window use the tabs on the left to locate lists of objects (tables, queries, forms, etc.) then simply double click on the object you want.

Ask Questions about Your Data

To ask a question about the data already entered in the database use a queries. Select the "Queries" tab from the database window. A list of pre-designed queries will appear. Double click on one of these existing queries to get an updated answer to your question that will include any new data entered. The query will appear as a table. If you delete information from a query that information will be deleted from the database. If you want to make a new query, consult a tutorial. One can be found on the Internet at http://www.bcschools.net/staff/AccessHelp.htm.

Make Reports on Your Data

Like queries pre-designed reports can be found by navigating through the Database Window to "Reports" under the object tabs. When you select a report it will include any new data entered in the database. Reports are a good way to share data or to print data out and look at it for analysis.

Saving and Backing Up the File

When you close the database it will automatically save all complete records. This protects the user from losing data in a power outage. It is very important that each time new data has been added to the database that a back up disk be updated. When there has been significant additions of data to the database a second backup should be updated.

There should be only one copy of the database that is accessed for updating the data. All other copies should be only backups and should not be used to enter data. The best way to manage this will be to assign one staff member to do all the data entry or at least supervise the use and backing up of the database.

Appendix 6: SWFSC Molecular Genetics Database and Biopsy Protocol

Information below was retrieved from the NOAA website http://swfsc.nmfs.noaa.gov

SWFSC Marine Mammal and Sea Turtle Molecular Genetics Sample Archive

This database contains sample material for use in molecular genetic analyses. Samples were collected from marine mammal and turtle specimens opportunistically or through directed sampling. Nearly all recognized species or subspecies of cetacean, pinniped and sea turtle are represented, including 85 of 89 cetacean, 13 of 17 pinniped and 6 of 7 sea turtle species. However, the worldwide distribution for many species is not reflected in our collection. Regional biases are visible when the collection location locales are plotted (Sample distribution maps can be viewed from this web site.). We are continually collecting samples to improve the data sets available to address questions of phylogeny, ecology and behavior using molecular genetic techniques. A list of publications accessible through this web site provides an indication of research scope.

Protocol for Collection of Tissue for Genetic Analysis

MATERIALS included in biopsy kit:

Sat preservative: saturated NaCl with 20% DMSO in polypropylene tubes
Razor blade, scalpel, or biopsy tool
Permanent ink marker, pencil, parafilm, and notecards
TISSUE SOURCE

Live animals: skin or muscle biopsy
Dead animals: if fresh, heart and liver, if dead more than 2 hours, skin and muscle
Fresh eggs and whole embryos from non-viable intact eggs
METHOD

1) Collect 0.5 to 5.0 grams of tissue (0.5-2.0 cm diameter skin biopsies, or 2-3 strips of tissue 1.5x4cm). Wearing gloves while handling the tissue and changing gloves in between samples from different individuals is ideal. Use a new blade or biopsy tool when collecting from each different individual.

2) Chop the tissue a few times with a razor blade to increase penetration of the preservative.

3) Add tissue to the tube with preservative. On the small piece of bond paper, write in pencil the ID number, species, location, and date. Put the piece of paper in the vial with each sample.

4) Label each vial (cap and side of the vial) using the permanent pen with the species, location, date, and field ID number; this number should be the one you use as a reference in your field records to identify any other information you collect.

5) Wrap parafilm around the cap and the top of the vial by stretching the parafilm as you wrap. This will prevent leaking while the sample is in transport. Double wrap in an airtight plastic bag for shipping.

6) Samples can be stored at ambient temperature for at least 1 year. Avoid extended exposure to heat or sunlight.

7) Ship samples by airfreight or express mail. Please include copies of permits (if required) and data sheets or stranding report on the samples collected.

Appendix 7: Observational Results in Tabular Form

The tables presented here are for reference by the reader and intended to answer any outstanding questions not addressed in this thesis. Data contained herein may only be used with express written permission from the Governor of Hatohobei State, Republic of Palau. If anyone wishes to use this data for any reason other than personal interest s/he must send a written request for permission to the following :

Office of the Governor of Hatohobei State
c/o Helen Reef Resource Management Project
P. O. Box 1017
Koror, PW 96940
Tel: 680-488-8044
Tel/Fax: 680-488-2218
Email: helenreef@palaunet.com

The written request must contain the name and contact information of project/study leadership (i.e. Primary Investigators, Executive Directors for NGOs, etc), name and contact information for the individual responsible for data analysis, and the purpose of the study. The HRRMP, or the Office of the Governor, reserves the right to ask for additional information prior to granting permission.

If permission is granted HRRMP, or the Office of the Governor, may set further contingencies for use at anytime. If at anytime investigations using this data are planned to be submitted for publication the user is required to first submit a draft of the work to the Governor of Hatohobei State. The user agrees to wait for authorization in writing from the Office of the Governor prior to submission.

All Available Full Records for Helen Nesting Turtles April 21, 2005 to November 27, 2005 (N=14)

TagNo	CCLmin(cm)	NestDate	DateEmergence	IncubationTime	Number EmptyShells	Number Unhatched
29762	94	14-Jun-05	12-Aug-05	59	72	13
29763	101	15-May-05	15-Jul-05	61	80	30
29768	96.5	09-May-05	08-Jul-05	60	64	32
29772	105	20-May-05	31-Jul-05	72	91	19
29773	105.5	13-May-05	11-Jul-05	59	52	25
29776	109.5	22-May-05	29-Jul-05	68	114	8
29776	109.5	12-Jun-05	11-Aug-05	60	99	28
29781	105.5	16-May-05	10-Jul-05	55	110	7
29783	100	15-May-05	16-Jul-05	62	100	51
29784	102	16-May-05	13-Jul-05	58	51	31
29785	103.5	15-May-05	12-Jul-05	58	74	28
29787	93	26-May-05	26-Jul-05	61	87	5
29798	94.5	10-Jun-05	09-Aug-05	60	79	13
29800	94.5	11-May-05	09-Jul-05	59	94	16

All Recorded Nesting Activity on Helen April 21, 2005 to November 27, 2007 (N=191)

TagNo	CCLmin(cm)	NestDate
29725	100.5	27-Nov-05
29727	103	20-Jul-05
29727	103	30-Jul-05
29727	103	10-Aug-05
29727	103	20-Aug-05
29727	103	31-Aug-05
29727	103	01-Oct-05
29730	94	05-Oct-05
29730	94	25-Jul-05
29730	94	04-Aug-05
29730	94	20-Aug-05
29731	99.5	16-Sep-05
29731	99.5	03-Sep-05
29731	99.5	24-Aug-05
29731	99.5	30-Jul-05
29731	99.5	11-Aug-05
29732	106	08-Aug-05
29732	106	20-Aug-05
29732	106	12-Sep-05
29732	106	23-Sep-05
29732	106	16-Oct-05
29733	94	21-Oct-05
29733	94	09-Oct-05
29733	94	20-Aug-05
29734	107	09-Sep-05
29734	107	19-Sep-05
29734	107	28-Sep-05
29734	107	20-Oct-05

TagNo	CCLmin(cm)	NestDate
29734	107	29-Oct-05
29734	107	20-Aug-05
29736	100.7	06-Sep-05
29736	100.7	19-Sep-05
29736	100.7	01-Oct-05
29736	100.7	24-Oct-05
29737	99.7	13-Sep-05
29737	99.7	06-Oct-05
29738	97.4	22-Sep-05
29739	98.2	23-Sep-05
29739	98.2	16-Oct-05
29739	98.2	05-Nov-05
29741	100.7	27-Sep-05
29742	98	05-Oct-05
29742	98	28-Oct-05
29746	92.5	27-Jun-05
29746	92.5	11-Jul-05
29748	107	27-Jul-05
29748	107	13-Sep-05
29748	107	19-Aug-05
29748	107	22-Jun-05
29748	107	07-Aug-05
29749	99.5	20-Jun-05
29749	99.5	22-Jun-05
29749	99.5	03-Jul-05
29749	99.5	14-Jul-05
29749	99.5	24-Jul-05
29749	99.5	05-Aug-05

All Recorded Nesting Activity on Helen April 21, 2005 to November 27, 2007 - Continued

TagNo	CCLmin(cm)	NestDate
29749	99.5	20-Aug-05
29750	97.5	10-Jul-05
29750	97.5	21-Jul-05
29750	97.5	19-Jun-05
29751	105.5	11-Jul-05
29751	105.5	09-Aug-05
29751	105.5	23-Aug-05
29751	105.5	19-Sep-05
29751	105.5	16-Jun-05
29752	108	20-Aug-05
29752	108	12-Jun-05
29752	108	22-Jun-05
29752	108	01-Jul-05
29752	108	11-Jul-05
29752	108	20-Jul-05
29754	93.5	22-Jun-05
29754	93.5	12-Jun-05
29756	102.5	10-Jun-05
29756	102.5	23-Jun-05
29756	102.5	07-Jul-05
29756	102.5	20-Jul-05
29757	100	10-Jun-05
29758	102.5	03-Jun-05
29758	102.5	13-Jun-05
29758	102.5	24-Jun-05
29758	102.5	14-Jul-05
29760	98	19-May-05
29760	98	20-May-05

TagNo	CCLmin(cm)	NestDate
29760	98	21-Jun-05
29762	94	17-May-05
29762	94	27-May-05
29762	94	14-Jun-05
29762	94	05-Jul-05
29762	94	15-Jul-05
29762	94	25-Jul-05
29763	101	25-Jul-05
29763	101	15-May-05
29763	101	15-Jun-05
29763	101	05-Jul-05
29763	101	15-Jul-05
29765	111	15-May-05
29765	111	27-May-05
29765	111	10-Jun-05
29765	111	23-Jun-05
29765	111	08-Jul-05
29766	97	11-May-05
29766	97	25-May-05
29766	97	13-Jun-05
29766	97	25-Jun-05
29766	97	06-Jul-05
29768	96.5	09-Jun-05
29768	96.5	13-Aug-05
29768	96.5	21-Jul-05
29768	96.5	30-Jun-05
29768	96.5	20-May-05
29768	96.5	09-May-05

All Recorded Nesting Activity on Helen April 21, 2005 to November 27, 2007 - Continued

TagNo	CCLmin(cm)	NestDate
29768	96.5	11-Jul-05
29770	102.5	07-May-05
29770	102.5	19-May-05
29770	102.5	11-Jun-05
29770	102.5	23-Jun-05
29770	102.5	19-Jul-05
29771	106.8	07-May-05
29772	105	17-Jul-05
29772	105	02-Sep-05
29772	105	20-Aug-05
29772	105	08-Aug-05
29772	105	28-Jul-05
29772	105	23-Jun-05
29772	105	13-Jun-05
29772	105	07-May-05
29772	105	20-May-05
29772	105	05-Jul-05
29773	105.5	06-Jun-05
29773	105.5	17-Jun-05
29773	105.5	25-May-05
29773	105.5	13-May-05
29773	105.5	01-May-05
29773	105.5	10-Jul-05
29776	109.5	03-May-05
29776	109.5	12-May-05
29776	109.5	22-May-05
29776	109.5	03-Jun-05
29776	109.5	12-Jun-05

TagNo	CCLmin(cm)	NestDate
29776	109.5	24-Jun-05
29776	109.5	21-Apr-05
29781	105.5	16-May-05
29781	105.5	25-May-05
29781	105.5	21-Apr-05
29783	100	04-May-05
29783	100	15-May-05
29783	100	13-Jun-05
29783	100	21-Apr-05
29784	102	16-May-05
29784	102	21-Apr-05
29785	103.5	23-Apr-05
29785	103.5	04-May-05
29785	103.5	15-May-05
29785	103.5	27-May-05
29787	93	24-Apr-05
29787	93	20-Jun-05
29787	93	26-May-05
29787	93	05-May-05
29787	93	16-May-05
29788	106	05-May-05
29788	106	16-May-05
29788	106	06-Jun-05
29788	106	24-Apr-05
29788	106	07-Jul-05
29788	106	19-Jul-05
29789	102	16-May-05
29789	102	08-Jul-05

All Recorded Nesting Activity on Helen April 21, 2005 to November 27, 2007 - Continued

TagNo	CCLmin(cm)	NestDate
29789	102	25-Apr-05
29789	102	26-May-05
29791	102	17-May-05
29791	102	27-May-05
29791	102	16-Jun-05
29791	102	26-Apr-05
29797	106	18-May-05
29797	106	28-Apr-05
29798	94.5	10-Jun-05
29798	94.5	27-Apr-05
29798	94.5	29-May-05
29798	94.5	17-May-05
29799	98.9	23-May-05
29799	98.9	23-Jun-05
29799	98.9	29-Apr-05
29799	98.9	05-Jul-05
29799	98.9	11-May-05
29800	94.5	25-Jun-05
29800	94.5	01-May-05
29800	94.5	11-May-05
29800	94.5	22-May-05
29800	94.5	02-Jun-05
29800	94.5	12-Jun-05

Emergence Success from Unknown Helen Nests (N=26)

DateDug	Number EmptyShells	Total Eggs
25-Jul-05	40	44
02-Sep-05	41	63
08-Aug-05	58	75
26-Jul-05	67	85
10-Aug-05	78	85
02-Aug-05	37	86
10-Aug-05	84	87
01-Aug-05	88	94
10-Aug-05	85	98
27-Jul-05	72	99
10-Aug-05	73	100
10-Aug-05	81	101
25-Aug-05	88	101
10-Aug-05	100	102
25-Aug-05	100	107
01-Aug-05	91	108
05-Dec-05	64	114
01-Aug-05	99	115
27-Jul-05	108	116
10-Aug-05	101	118
11-Nov-05	114	120
10-Aug-05	114	122
10-Aug-05	105	122
01-Aug-05	106	137
07-Jul-05	142	152
02-Sep-05	125	156

Emergence Success from Recorded Helen Nests (N=56)

NestCodeNo	DateDug	Number EmptyShells	Total Eggs
240	12-Dec-05	27	109
239	02-Dec-05	30	108
4	18-Jul-05	45	82
57	01-Aug-05	46	69
35	27-Jul-05	47	87
54	18-Jul-05	51	82
44	13-Jul-05	52	77
13		53	64
241	02-Dec-05	53	56
233	11-Nov-05	57	130
39	10-Jul-05	64	96
227	08-Dec-05	64	66
117	17-Aug-05	66	83
19		69	78
112	17-Aug-05	72	85
238	02-Dec-05	72	97
48	18-Jul-05	74	102
232	09-Dec-05	76	92
24	13-Jul-05	77	89
98	17-Aug-05	79	92
49	18-Jul-05	80	110
252	02-Dec-05	81	84
118	19-Aug-05	83	96
6	13-Jul-05	85	88
263	08-Dec-05	85	92
72	01-Aug-05	87	92
8	13-Jul-05	88	89

Emergence Success from Recorded Helen Nests - Continued

NestCodeNo	DateDug	Number EmptyShells	Total Eggs	NestCodeNo	DateDug	Number EmptyShells	Total Eggs
265	12-Dec-05	88	115	268	09-Dec-05	133	143
22	18-Jul-05	89	94	247	01-Dec-05	136	144
261	12-Dec-05	90	95				
62	02-Aug-05	91	110				
231	01-Dec-05	91	108				
41	10-Jul-05	94	110				
255	08-Dec-05	94	113				
245	08-Dec-05	95	103				
27	01-Aug-05	97	115				
55		97	99				
106	17-Aug-05	99	127				
47		100	151				
258	01-Dec-05	101	107				
31	13-Jul-05	104	111				
234	09-Dec-05	105	136				
37		108	134				
51	13-Jul-05	110	117				
267	12-Dec-05	111	114				
9	13-Jul-05	112	113				
237	01-Dec-05	112	147				
225	02-Dec-05	113	116				
242	08-Dec-05	113	114				
64	01-Aug-05	114	122				
226	23-Nov-05	116	131				
115	17-Aug-05	122	152				
246	30-Nov-05	129	144				
264	12-Dec-05	133	140				

Green Turtles Tagged in Water (N=56)

TagNo	TagDate	CCLmin(cm)
29743	23-Aug-05	79.3
29744	23-Aug-05	77.3
29745	23-Aug-05	79.8
29778	20-Apr-05	68
29779	20-Apr-05	60.5
29780	20-Apr-05	44
33401	30-Jun-05	81.5
33402	30-Jun-05	80.4
33403	05-Jul-05	67
33404	06-Jul-05	76
33405	06-Jul-05	80
33406	06-Jul-05	80.6
33407	06-Jul-05	90.5
33408	06-Jul-05	56
33409	06-Jul-05	76
33410	06-Jul-05	82.5
33411	07-Jul-05	82
33412	07-Jul-05	85
33413	07-Jul-05	85.8
33414	07-Jul-05	82
33415	07-Jul-05	67.5
33416	07-Jul-05	83
33417	07-Jul-05	85.3
33418	07-Jul-05	82
33419	07-Jul-05	79
33420	08-Jul-05	88.5
33421	08-Jul-05	80
33422	08-Jul-05	89.5

TagNo	TagDate	CCLmin(cm)
33423	08-Jul-05	76.7
33424	09-Jul-05	77.7
33425	09-Jul-05	82.4
33426	09-Jul-05	81.9
33427	09-Jul-05	80.1
33428	09-Jul-05	94
33429	09-Jul-05	84.9
33430	09-Jul-05	85.8
33431	09-Jul-05	89.9
33432	09-Jul-05	81.4
33433	09-Jul-05	70
33434	09-Jul-05	87
33435	12-Jul-05	88.5
33436	12-Jul-05	88.8
33437	12-Jul-05	77.2
33438	12-Jul-05	91.8
33439	12-Jul-05	87.2
33440	12-Jul-05	69.5
33441	11-Jul-05	83.2
33442	11-Jul-05	85.1
33443	11-Jul-05	64.5
33444	11-Jul-05	87.7
33445	11-Jul-05	87.8
33446	11-Jul-05	86.5
33447	12-Jul-05	83.8
33448	12-Jul-05	81.3
33449	12-Jul-05	97.2
33450	12-Jul-05	79

Tissue Samples from Helen Green Turtles for Analysis by NOAA SWFCS (N=82)

TagNo	TissueSampleNo	Species	SCLn-t(cm)	CCLmax(cm)	CCwidth(cm)
29725	98	*C. mydas*	101	102.6	90
29727	75	*C. mydas*	103.4	104.5	95.5
29730	76	*C. mydas*	94.3	95.3	83
29731	79	*C. mydas*	100	101	85.5
29732	84	*C. mydas*	106.3	108	93
29733	86	*C. mydas*	94.3	95.3	85
29734	87	*C. mydas*	107.4	108	97
29736	92	*C. mydas*	101.5	103.7	90.2
29737	93	*C. mydas*	100.5	104	90.5
29738	94	*C. mydas*	98	99.5	86
29739	95	*C. mydas*	98.3	100.1	86
29741	96	*C. mydas*	100.9	103.6	95
29742	97	*C. mydas*	98.5	101.5	88
29743	91	*C. mydas*	80.1	81	71.3
29744	88	*C. mydas*	77.6	79.1	69.3
29745	90	*C. mydas*	80.3	81.5	71
29746	51	*C. mydas*	93	93.7	85.8
29748	78	*C. mydas*	107.5	110	97
29749	70	*C. mydas*	100	100.3	90
29750	48	*C. mydas*	98.5	100	84
29751	64	*C. mydas*	106		108
29752	7	*C. mydas*	108.5	111	104
29756	19	*C. mydas*	103	106	94
29762	10	*C. mydas*	94.7	96.5	94
29763	72	*C. mydas*	101.5	103	89.3
29766	9	*C. mydas*	98	100	95
29768	3	*C. mydas*	97	98	95
29770	74	*C. mydas*	103	103.5	92.5

Tissue Samples from Helen Green Turtles for Analysis by NOAA SWFCS - Continued

TagNo	TissueSampleNo	Species	SCLn-t(cm)	CCLmax(cm)	CCwidth(cm)
29772	73	*C. mydas*	106	108	97
29773	50	*C. mydas*	106	107.5	98
29788	29	*C. mydas*	106.2	108	90
29789	35	*C. mydas*	103	106	93
33401	4	*C. mydas*	83	38.8	71.4
33402	5	*C. mydas*	80	81.5	72
33403	11	*E. imbricata*	70	70.5	62
33404	12	*C. mydas*	76.3	78	73
33405	13	*C. mydas*	81.1	81.5	74
33406	14	*C. mydas*	81	81.8	75.2
33407	15	*C. mydas*	90.7	92.4	83
33408	16	*E. imbricata*	60	60.5	52.9
33409	17	*C. mydas*	76.4	77	65.5
33410	18	*C. mydas*	83.4	83.8	76.5
33411	20	*C. mydas*	83	83.5	76.4
33412	21	*C. mydas*	85.3	86.8	76.5
33413	22	*C. mydas*	86	87.5	73.2
33414	23	*C. mydas*	82.2	84.3	84.3
33415	24	*E. imbricata*	72.2	73.5	62
33416	25	*C. mydas*	83.5	83.8	73.5
33417	26	*C. mydas*	85.5	86.7	76.6
33418	27	*C. mydas*	82.8	84	72.5
33419	28	*C. mydas*	79.5	80.8	69
33420	32	*C. mydas*	89.2	90.5	83
33421	33	*C. mydas*	80.3	81.3	72.4
33422	34	*C. mydas*	90	90.6	81
33423	36	*C. mydas*	77.1	78.1	67.8
33424	37	*C. mydas*	77.9	78	68.4

Tissue Samples from Helen Green Turtles for Analysis by NOAA SWFCS - Continued

TagNo	TissueSampleNo	Species	SCLn-t(cm)	CCLmax(cm)	CCwidth(cm)
33425	38	*C. mydas*	82.9	84.6	77.1
33426	39	*C. mydas*	82.3	82.5	77.7
33427	40	*C. mydas*	81	82.5	71.6
33428	41	*C. mydas*	94.1	95.8	82.5
33429	42	*C. mydas*	85.1	86.5	76
33430	43	*C. mydas*	86.2	86.8	75.6
33431	44	*C. mydas*	90	91.6	81.6
33432	45	*C. mydas*	81.7	82.5	72.3
33433	46	*E. imbricata*	74.1	75	65
33434	47	*C. mydas*	87.5	89	79.5
33435	52	*C. mydas*	89	89.5	79
33436	53	*C. mydas*	89.1	90.1	81.5
33437	54	*C. mydas*	78.4	78.3	71
33438	55	*C. mydas*	92	93.1	82.2
33439	56	*C. mydas*	87.9	88	79.9
33440	57	*E. imbricata*	74.7	75.5	61.7
33441	58	*C. mydas*	84	85	77.2
33442	59	*C. mydas*	86	87.2	87.6
33443	60	*E. imbricata*	68	69.9	61.5
33444	61	*C. mydas*	87	88.6	79.2
33445	62	*C. mydas*	88	89.1	77.7
33446	63	*C. mydas*	87	87.5	79.7
33447	66	*C. mydas*	84.6	86.2	77.8
33448	67	*C. mydas*	81.9	83	71.4
33449	68	*C. mydas*	97.5	100.2	92
33450	69	*C. mydas*	80.5	81	73.5

Lunar Data by Quarters for April 2005 through December 2005

NewPeak	NewPeakTime	NewStart	NewEnd	FirstPeak	FirstPeakTime	FirstStart	FirstEnd
08-Apr-05	8:32:00 PM	05-Apr-05	12-Apr-05	16-Apr-05	2:37:00 PM	13-Apr-05	20-Apr-05
08-May-05	8:45:00 AM	05-May-05	12-May-05	16-May-05	8:56:00 AM	13-May-05	19-May-05
06-Jun-05	9:55:00 PM	03-Jun-05	11-Jun-05	15-Jun-05	1:22:00 AM	12-Jun-05	18-Jun-05
06-Jul-05	12:03:00 PM	03-Jul-05	09-Jul-05	14-Jul-05	3:20:00 PM	10-Jul-05	17-Jul-05
05-Aug-05	3:05:00 AM	02-Aug-05	09-Aug-05	13-Aug-05	2:39:00 AM	10-Aug-05	16-Aug-05
03-Sep-05	6:45:00 PM	31-Aug-05	07-Sep-05	11-Sep-05	11:37:00 AM	08-Sep-05	14-Sep-05
03-Oct-05	10:28:00 AM	30-Sep-05	06-Oct-05	10-Oct-05	7:01:00 PM	07-Oct-05	13-Oct-05
02-Nov-05	1:25:00 AM	30-Oct-05	05-Nov-05	09-Nov-05	1:57:00 AM	06-Nov-05	12-Nov-05
01-Dec-05	3:01:00 PM	28-Nov-05	04-Dec-05	08-Dec-05	9:36:00 AM	05-Dec-05	11-Dec-05

FullPeak	FullPeakTime	FullStart	FullEnd	LastPeak	LastPeakTime	LastStart	LastEnd
24-Apr-05	10:06:00 AM	21-Apr-05	27-Apr-05	01-May-05	6:24:00 AM	28-Apr-05	04-May-05
23-May-05	8:18:00 PM	20-May-05	26-May-05	30-May-05	11:47:00 AM	27-May-05	02-Jun-05
22-Jun-05	4:14:00 AM	19-Jun-05	25-Jun-05	28-Jun-05	6:23:00 PM	26-Jun-05	01-Jul-05
21-Jul-05	11:00:00 AM	18-Jul-05	24-Jul-05	28-Jul-05	3:19:00 AM	25-Jul-05	01-Aug-05
19-Aug-05	5:53:00 PM	17-Aug-05	22-Aug-05	26-Aug-05	3:18:00 PM	23-Aug-05	30-Aug-05
18-Sep-05	2:01:00 AM	15-Sep-05	21-Sep-05	25-Sep-05	6:41:00 AM	22-Sep-05	29-Sep-05
17-Oct-05	12:14:00 PM	14-Oct-05	21-Oct-05	25-Oct-05	1:17:00 AM	22-Oct-05	29-Oct-05
16-Nov-05	12:58:00 AM	13-Nov-05	19-Nov-05	23-Nov-05	10:11:00 PM	20-Nov-05	27-Nov-05
15-Dec-05	4:16:00 PM	12-Dec-05	19-Dec-05	23-Dec-05	7:36:00 PM	20-Dec-05	26-Dec-05

Appendix 8: Community Outreach Poster

Helen Reef Resource Management Project Turtle Conservation 2005

You probably already know that green and hawksbill turtles are in danger of becoming extinct. Southwest Islanders and Palauan's have noticed a decline in our own populations and a decline in the size of individuals. The Helen Reef Resource Management Project recognizes that turtle conservation is imperative in order for turtles to remain a cultural resource to the People of the Southwest Islands.

During the Spring of 2005 the Conservation Officers of Hatohobei State began monitoring the activities of the nesting turtles on Helen. This effort is part of a the National Turtle Monitoring Program overseen by Division of Marine Resources. The officers are working towards a better understanding of the turtle population so we can better conserve for the long term use and enjoyment of the people of Hatohobei.

What did we do?

•Attached identification tags to 93 green turtles (nesting and foraging) and 6 hawksbill turtles.

•Monitored every nest.

•Monitored how many eggs hatched and did not hatch from most nests.

•Collected skin samples for DNA analysis from 87 turtles. This analysis may help us understand something about the migration of our turtles.

What did we learn?

•Between April 19th and August 20th 219 nests were laid on Helen by green turtles.

•There were only 40 turtles nesting during the summer of 2005. Some nested only once, others came to the island as many as 8 times to lay eggs.

•The minimum carapace length of nesting green turtles is 93cm and the maximum is 111cm.

•The average number of eggs laid per nest was 101. On average 83% of the eggs hatched.

Why tag the turtles?
Sea turtles are migratory. That means the turtles that nest in the Southwest Islands may travel far from the islands between nesting seasons. Some green turtles are known to travel up to 4000km away from their nesting beach to forage, while others stray only 150 km. In order to achieve long term conservation of our turtles we need to know where they spend their time. It may be necessary to cooperate with other island communities or nations to conserve our native population. All over the Pacific communities are tagging turtles. We may find a turtle in Palau that has been tagged somewhere else, or our turtles may be found by fisherman, or other conservation programs. If they are reported then we will begin to understand the migratory patterns of our turtles. Additionally, we can monitor how often the turtles return to nest and how many turtles are actually nesting. In the future we hope to attach satellite tracking devices to some of our turtles to learn even more about their migratory behavior.

What if I find a turtle with a tag?
If you find a green or hawksbill turtle with a metal tag attached to its flipper be sure to record the tag number and contact information on the tag. Make sure you check for information on both sides of the tag. The tag may be from a turtle that nested in Palau or even from another country. Contact the Helen Reef Resource Management Project with any information on tagged turtles at 488-8044. No questions asked.

What are the major threats to our turtles?

•Accidental catch by longline fishing boats

Even though it is illegal for fishing boats in Palauan waters to keep turtles that are accidentally caught, many drown before they can be dehooked and released.

•Overharvest

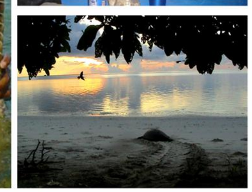
While turtles are protected while inside the boundaries of Helen Reef Conservation Area, they may be intensely harvested on other parts of their migration. This is why international cooperation may be necessary to conserve our own turtles.

•Loss of Habitat

Turtles depend on the beaches where they are born to be clean beaches and free from predators in order to nest. They are sensitive to artificial light and the presence of humans. Between nesting, turtles need a variety of sea grasses and algae for food; the habitats that support these foods are declining around the world. Plastics and other debris in the ocean are often eaten by turtles and can be fatal.

What about Merir?

Merir Island is known as one of the most important green turtle nesting beaches in all of Micronesia. Conservation Officers on Merir are working hard to estimate the number of nests and the number of turtles nesting on the island. They are also tagging turtles and collecting tissue samples for DNA analysis. Volunteers are needed to assist with monitoring on Merir.



Special thanks to U.S. NOAA Fisheries Program, Community Conservation Network, and PADI Project Aware for financial assistance.

Appendix 9: Stewardship and Management Recommendations for Helen Reef Reserve

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The following sections provide recommendations focused on areas in need on improvement; if considered these actions are a deliberate move towards more integrated management. The recommendations are made to HRRMP staff, board, and partners in response to a request by Community Conservation Network (CCN) and HRRMP project management for an evaluation of activities at Helen. They are based my field observations during the summer of 2009. Within the limitations of my knowledge, traditional management practices, local knowledge, and contemporary knowledge of biological systems are embedded into each recommendation. Modifications to the HRRMP operating procedures and overall approach to management based on these recommendations can greatly improve the outcomes of the project. The ability to achieve positive outcomes can enhance learning and participation of the community. Partnerships with collaborators and donors can also be strengthened through this process.

Tobian dependence on Helen for food, income, culture and recreation has been revitalized by the onset of community conservation at Helen and the upcoming opening of a small scale zonal fishery (Andrew et al. 2006). The persistence of those resources also depends on the ability of community-based management efforts to achieve the necessary biological and social responses. The weak central planning capabilities of the young sectoral national government as well as complex politics make it unlikely that integrated management efforts will be led by government agencies (Muller et al. 2000). The ability of Tobian leadership to mobilize the community and adapt to a fast changing world will be essential in conserving the entire ecosystem at Helen. Mindful fostering of an integrative management approach will have the maximum benefit to the community and sustainability of the resource. The HRRMP, alongside the Hatohobei State Government, has already implemented the integrated approach by employing interagency coordination, participatory planning, incorporation of education programs, and amalgamation of traditional management ethics with contemporary management tools. Establishment of the Helen Reef Reserve has provided a mechanism for managing the ecosystem as an interconnected entity reflective of integrated management. However, increased visitation to the island and opening of small scale fisheries will require managers and leaders to actively support a systems approach with regards to protecting natural resources at Helen.

The majority of this thesis has focused on monitoring and management specific to green sea turtles; however, an integrated approach that considers the ecosystem on which turtles depend, the social systems upon which management strategies are built, and organizational factors is more likely to effectively protect turtles with the added benefit of protecting their habitat and cultural significance. Managing the Helen ecosystem in discrete parts, or on a species by species basis, is limiting and not conducive to success of turtles, other species of concern, or the biological integrity of the system. Isolated management of the Helen Reef Reserve leaves the system vulnerable to exploitation and habitat destruction (Cicin-Sain and Belfiore 2009). An integrated approach can be successful at two levels. First, the approach can link Helen resources to broader marine environmental issues as addressed on the regional scale in Chapter 4. Second, the approach calls for addressing the complete local biological and social system for more effective management of the Helen ecosystem.

The scale of integrated management is small; family ties and community participation can therefore easily enhance managers' ability to communicate and integrate management, conservation, education, enforcement, legislative, capacity building, and cultural preservation activities (Aston 1999). In many ways the Tobian community has already been successful to this end. Additionally, with the exception of small scale Tobian managed fisheries Helen is not targeted for development.

Historically, Tobians depended on and lived within a precarious, but successfully adaptive ecological balance (Black 2000). Community members that are now responsible for decision making are left without complete knowledge of how to regain that balance. The first step is to adapt methods from the ecosystem based approach to management. These methods can be combined with both traditional management systems and local knowledge to create a more effective integrated approach to management that is uniquely suited to Helen Reef.

9.1 The Helen Reef Ecosystem and Primary Uses

Helen is considered a paradise by visitors. The island and reef are source of pride for Tobians who embrace a historical and current reverence for the place and its bounty. This vast resource, in its remote location, has remained relatively pristine, and is a haven for migrating marine species. Helen's abundance historically attracted Tobians to the island to harvest turtle and clam (Johannes 1986). It also has attracted fishers from the Indonesian islands (Johannes 1982), and today attracts commercial fishing vessels. The Helen Reef lagoon also provides travelers and fishers with shelter from storms. More recently, conservation programs run by HRRMP are the main protection and the primary user of Helen's resources. The 2006 Helen Reef Management Plan will open the reserve up to Tobians for zone limited subsistence fishing. This change in local policy is reasonable because harvest will be limited and adequately monitored. However, the increased visitation to the island and the reef will increase the possibility for inadvertent damage to the ecosystem. It is important for HRRMP to set the example for sustainable use of Helen and its associated resources and work with the State government to establish appropriate regulations and conduct outreach activities to keep the community informed of appropriate uses while at Helen. I encourage managers to solicit the advice and participation of the community in this process.

9.2 Human Presence

Presence of the HRRMP field staff on Helen benefits the natural resources of the island and the reef because it deters poaching and provides information on the ecological changes on the island. However, it is important that the staff regularly assess their own impacts on the island, and its resources, so that impacts can be minimized. Human presence on Helen should help to reach the goals of the management plan rather than inhibit them. The HRRMP settlement exists on behalf of the community for stewardship purposes. This is an honor and the lifestyle at the field station should reflect the stewardship ethic.

9.2.1 Clearing

The natural ground cover and vegetation protects the island from erosion. Clearing or cleaning of ground cover should be limited to narrow paths and areas immediately adjacent to the house. The cleared area currently covers about 29 percent of the entire island, 90 percent when one considers all the treed area with cleared underbrush. Effort should be taken to significantly reduce this footprint. Natural ground cover should be allowed to return as it provides habitat for the wildlife that Helen supports and protects the island from erosion. Additionally, the natural ground cover should enhance the ability of native vegetation to grow.

Clearing of tree branches should be limited to those that overhang the house posing a threat to the safety of drinking water. Other branches or trees should only be cut when they are not stable and they pose a physical risk to individuals or the house.

9.2.2 Lights

Birds and turtles are highly sensitive to lights. Wherever possible, bulbs should be replaced by low pressure sodium vapor bulbs (Witherington 1999) which reportedly do not attract sea turtles and are more energy efficient. Otherwise use of lights at the house should be limited to necessary activities. All lights should have opaque red tinted shades that direct the light downward where it is needed. Lights should be turned off when they are not in use, and shaded from the beach when they are needed.

Bright flashlights disturb the birds, confuse the turtle hatchlings, and deter nesting turtles from coming to the island. Their use should be limited. When flashlights are needed they should be dim or covered with red cellophane so they are less irritating to wildlife. Red lights also make it easier for the human eye to adjust to the dark.

9.2.3 Structures

Structures on the island should be streamlined east to west to reduce the footprint on the island. Structures that are not in use should be dismantled and materials should be stored in a compact way for recycling. No new structures that require expansion of the settlement area should be built. Care should be taken to keep coastline clear of unnatural debris that limit the available space for turtle nests, or act as a barrier. Generally, driftwood, and natural debris can left in place.

9.2.4 Harvest

Responsible harvest of some species should be allowed for human consumption while on the island. The officers should be sure to follow regulations set in the management plan, as well as national and local laws. For sensitive species (turtles, nesting birds, bird eggs, migratory birds, etc.) maximum take per year should be established. Officers should record their take to ensure that they do not exceed the established limit. Care should be taken not to waste natural resources. The amount of harvest should not exceed the subsistence needs of the field staff.

Harvest of ornamental species (snail shells, hawksbills, etc.) should not be practiced. Transport of sensitive species into and out of Helen should remain prohibited. Sale of ornamentals from Helen should also remain prohibited, until such time the resources can be assessed and a plan for sustainable harvest with a portion of profits benefiting conservation efforts can be established.

9.2.9 Disturbance of Wildlife

As already discussed, use of light should be limited. Unnecessary loud noises also disturb wildlife and should be eliminated. Sometimes noise is necessary, but should be limited to the daytime. If possible, noisy activities should be consolidated so that the total time of disturbance is reduced. Music at a reasonable volume does not appear to adversely impact the wildlife and should remain permissible. Excessive trampling of the vegetation and walking around the island should be avoided, especially when visitors are present.

Staff and visitors can easily be made aware of the sensitivity of the habitat, the location of bird eggs, and turtle nests. While walking the perimeter of the island, visitors and staff should avoid corralling or chasing bird fledglings down the beach or into the water. The fledglings are sensitive to predation and injury when they are chased.

Protocols for humane animal handling and interaction should be established, approved by the project manager, and followed by the field staff and visitors. These protocols should be followed when conducting any monitoring, research, or management activities.

9.2.6 Community Visitors

Visitors from the Southwest Islands are permitted in the management plan. Briefing visitors prior to arrival on the island can improve compliance with the current laws and regulations reducing the impact of visitors. Additionally, the officers can provide information on the sensitivity of the habitat, and the species that are nesting on the island. Visitors' experiences will be enhances through the learning associated with instructions on how to avoid disturbing these species and the habitat.

Harvest regulations should be enforced on all visitors, and the officers should keep track of the take by visitors to ensure that the annual take does not exceed regulations set in the management plan. Additionally, any waste items brought to the island by visitors should be removed on departure.

9.2.7 Research Visitors

Research visitors should be approved by the HRRMP project manager and the Governor of Hatohobei State. Researches may be required to demonstrate how their work will benefit the conservation area and/or the community prior to approval. Researchers should also be required to submit all data and reports related to their visit to Helen to the HRRMP and the State of Tobi in a timely fashion.

Research visitors should also be briefed about the laws and regulations of the island as well as the habitat sensitivity to ensure compliance.

In the future, project management and/or the Hatohobei State Government may want to institute a research permit system and/or a contract with researchers to ensure that data collected from the island is used responsibly and enhances conservation efforts.

9.2.8 Fishing Boat Visitors

Fishing boats that enter Helen Reef illegally should not be allowed to come to the island or harvest resources from the lagoon unless there is an emergency. Fishing vessels and small boat tenders can transport invasive species (like rats) to the island and should not be allowed on shore.

9.2.9 Waste Management

Human presence on the island creates non-biodegradable trash. These items harm sea birds, turtles and marine mammals. Storage of trash on Helen also occupies valuable habitat. An effort should be made to reduce the amount of non-biodegradable trash that is transported to the island. Visitors must be responsible to transport their own non-biodegradable trash back to Koror and dispose of it. The *Atoll Way*, or any other transport vessel, should inform their crew, staff and passengers that it is illegal to dump trash in the ocean (UNCLOS), and refrain from dumping at sea.

Composting can be established on Helen to dispose of degradable waste. Composted soil is rich in nutrients and can be used for contained gardens to supplement the on island food supply. A composting toilet on Helen, similar to those recently installed on Merir and Tobi, would reduce the space occupied by benjos, and could help preserve the soil chemistry of the adjacent areas.

Batteries and other toxic waste items should be collected in sturdy plastic containers and brought back to Koror for recycling or disposal by the Environmental Quality Protection Board (EQPB). Build up of such items on Helen could adversely affect the wildlife and contaminate the food supply.

Trash that washes up on the beach should be removed occasionally and transported back to Koror. This is primarily for safety of staff, and wildlife. Gloves should be provided to the staff so that they can safely remove the trash. Items that are hazardous (batteries, oil, medical waste, rusty metal etc.) should be placed in plastic containers so that they do not leak out of or puncture trash bags and potentially harm those transporting the wastes back to Koror. Managers can seek assistance for the EQPB to offset disposal costs. It may be appropriate to assign a staff member to oversee waste management on the island.

9.3 Wildlife Management

In addition to enforcing against poachers, and monitoring of native wildlife, it may be appropriate to occasionally manage wildlife in the island through alteration. Alteration of flora and fauna should only be done if it will protect the overall integrity of the ecosystem. In these cases the project management may seek advice from local and outside experts before taking action. Project staff must never proceed with alteration of the island and its resources without approval from the project manager. The project staff should bring ecological concerns to the attention of the project manager and create a permanent historical record by including them in written field trip reports.

9.3.1 Vegetation

Native vegetation on the Helen provides essential habitat and structural support to the island. Grasses, roots of dead or dying trees, and live trees protect the island against storm damage. Natural vegetation also provides shade; alteration of the amount of shade on the island could change the sex ratio of turtle hatchlings causing unpredictable long-term impacts on the returning nesting population. Helen is so small and host so few types of vegetation all decisions to remove or change vegetation need to be well thought out. The project manager would be wise to seek the advice of more than one terrestrial biologist before proceeding with altering vegetation.

Examination of aerial photographs of the island shows that the vegetation is thinner now than in years past. It is possible that the dominant *Cher* tree is not growing as fast a needed to maintain the vegetation density in the face of erosion and invasive species. Efforts to ensure survival or native plant seedlings may include exclusion of chickens and dogs, as well as protection of seedlings from trampling.

9.3.2 Invasive species

Invasive species include all species, even viruses and other pathogens, that pose a threat to the native ecological balance of Helen through ecological competition, predation, and spread of disease. Invasive species arrive on Helen by several different vectors. Ships carrying roaches, rats, ants, and livestock are probably the primary means for invasives to reach Helen. Items transported to Helen should be inspected for invasive species; staff may seek training from the Palau Invasive Species Task Force in identifying these species. Other vectors include, fishing boats, ship wrecks, livestock, pets, and even drift wood. Staff and visitors should not bring invasive species to Helen unless approved by the project manager. The project manager should seek advice from the management board and the invasive species task force in Palau on specific species before approving transport of any species with the potential to become invasive.

Invasive species observed (past and present) on the island include:

Singapore ants – These ants make living on Helen uncomfortable; they also pose a threat to electronic equipment and food supplies. The impact of the ants on the settlement is greatly reduced when the house is free from food waste and processed food supplies (ramen, sugar, etc.) are located where there are barriers of water, diesel or oil. Water barriers are just as effective as diesel. Use of harmful diesel or oil should be avoided as an ant deterrent whenever possible. An entomologist should be consulted about eradication or reduction of the ant population.

Dogs – Dogs are considered predators of turtles and birds. Dogs also carry disease and parasites that can be passed to other animals on Helen. Dogs on the beach can deter turtles from nesting on the islands. Dogs have been observed capturing, injuring and even killing nesting birds. The presence of dogs also alters the habitat of the island. However, dogs do provide an alarm when someone unknown approaches the island. Dogs also provide companionship and help to reduce food wastes on the islands. Staff should be permitted to bring dogs to the island only with explicit approval by the project manager. The project manager may want to ask advice from the management board, and an outside expert about the presence of dogs. If dogs are allowed on the island they should be subject to a health screening, be free of parasites and disease. This should be the expense of the dog owner. If a dog on Helen poses a threat to native wildlife it should be contained until such time it can be removed. If at anytime HRRMP staff or other stewards abandon the island dogs should be removed as well.

Rats – Even though rats have been eradicated from Helen, the island is constantly vulnerable to reestablishment of a rat population. Rats are highly destructive and quick to reproduce. The general rule is that if you see just one rat then there probably are several more. A few rat traps should be set and bated at all times near the house. The traps should be checked regularly by the field staff. If rats are observed they should be eradicated without delay and with the advice of the invasive species task force in Palau. Supplies for rat eradication should remain on the island so the immediate action can be taken. Eradication of rats is less expensive when it is done early.

Chickens – Chickens will eat anything, including invasive insects, native insects, and seeds of native trees. Chickens serve as pets, a source of protein, entertainment, and help to keep food waste under control reducing the impact of the ants. However, chickens can also transport disease to the native nesting birds and can change the ecological balance of the island. Chickens may also prevent vegetation from recovering from damage, and may remove seeds of the native trees preventing new trees from growing. Avian bird flu can be carried by chickens and can affect humans and other birds. To prevent transport of disease chickens should never be taken from fishing vessels. The project manager and the management board should consider the impacts of chickens on the island. It may be appropriate to allow a limited number of chickens and require them to be contained. Staff should not bring chickens to the island unless they have received approval from the project manager. As with dogs, if at anytime HRRMP staff or other stewards abandon the island chickens should be removed as well.

Garden Species – The field staff should be able to maintain a contained garden as food supply on Helen. Introduction of each new species should be considered and species that have a potential to out complete native plants should not be planted. The size of the garden should be limited to avoid taking too much of the natural habitat.

If for any reason Helen has to be evacuated, all domestic species should be removed. If these species are important for human subsistence on the island they can be reestablished upon recolonization.

9.3.3 Native species

Alteration of native species populations or habitats should only take place under the supervision of an ecologist/biologist. The field staff should not take it upon themselves to alter populations of native species as this activity could alter the balance of the system.

9.4 Management of Staff

The local staff is one of the keys to the success of HRRMP (Black, 2000). The shared cultural identity and knowledge of the resource managers with the community owners is a source of capital (Jentoft et al., 1998) for the project. In this sense, the staff and board of HRRMP are much more than resource managers, they are the conduit for the flow of information and the ambassadors for collaboration. Satisfaction among staff should be a priority. Jentoft and others (1998), author of *Social Theory and Fisheries Co-management*, wrote:

> "When (resource) users are given more responsibility for regulatory functions, they take on new roles within the management system, which in turn can change the management system further. With new roles and responsibilities, changes in social relationships, interests, values, learning processes, and hence, rationalities may follow."

The following is a set of recommendations for the organizational management of HRRMP. These suggestions are based on interactions with the staff and observations of organizational management and staff interactions over the summer of 2009. Suggestions of new roles for individual staff members are intended to achieve the enhancements discussed by Jentoft and others (1998). Modifying the structure and practices of staff management can lead to reduced misuse of natural resources and increased trust between staff members, as well as between staff and board members. Increased or modified responsibilities can enhance the learning of individuals thereby benefiting the community and conservation efforts of HRRMP.

9.4.1 Distribution of Workload

The field staff roles should be clearly identified in a job description. Additional roles or responsibilities during field trips should be agreed upon prior to departure. Fulfillment of those roles should be evaluated by project management on a regular basis.

Given the areas of recommendations discussed earlier in this chapter, it may be helpful to assign specific staff members to duties they can perform while in Koror. For example, one officer could be responsible for waste management, one for invasive species management, one for education of visitors, and one for reviewing research proposals. These additional responsibilities can alleviate the workload of the project manager and provide an opportunity for professional development of individual staff members.

9.4.2 Diversification of Staff

Since enforcement activities have been so effective the occurrence of violations has been reduced. A strong enforcement presence should remain, but other activities should be provided the appropriate staff energy and expertise. As biological monitoring, wildlife management, and education activities increase, the project management may consider hiring staff that specializes in these new areas. The skills and interests of the staff should reflect the work projected by the management plan and outstanding grant proposals. Deputized officers may not be the appropriate people to carry out all the programs the HRRMP undertakes.

Volunteers can be helpful in diversifying the staff. Volunteers are valuable when they work within their specific areas of expertise or interest. Volunteers going to the island should be briefed about laws and regulations, as well as, the sensitive habitat of the islands. Any volunteer should be approved by project management and should be assigned a field partner.

9.4.3 Teamwork

Teamwork relies on good communication and mutual understanding of goals and objectives of the project. When teamwork is not practiced the goals of the management plan are compromised. This can be avoided by clearly defining roles, improving communication, and conducting team building activities such as retreat days and regular staff meetings.

Working in close quarters and being separated from one's family can breed conflict between staff members. Sometimes these conflicts are exacerbated by family relations and past disagreements. Personality conflicts should be discussed and mediated by the project manager. In some instances it may be necessary to involve a member of the management board. A system for the staff to report grievances should be in place to protect the individual staff members.

9.4.4 Professionalism

Staff should maintain a high level of professionalism at all times. Standards of behavior and consequences for non-compliance should be established by the management board. It is important that staff understand that they represent the project and their behavior on the job reflects on the project. Each staff member should be informed, in writing, of professional standards which they are expected to practice.

9.4.9 Incentives and Professional Growth

Participation in field trips requires that staff make personal sacrifices. Incentives for a job well done should be created to offset the difficulties of being away from one's family and home. These could include: pay raises, promotions, professional development opportunities, awards, etc. Incentives require creativity and consistent updating to meet the needs of the staff, but are effective for reducing staff turnover and protecting the investment the project has made in its employees.

9.4.6 Ethics of Conservation Management

The officers and other staff serve as an example in the community. Accordingly, they should not violate local, national, or international laws. Staff should be well informed about current laws and share this information with the community. Beyond the laws and regulations officers should be encouraged to take initiative to learn about the ecology of Helen and how to best protect it. Subsistence harvest on the island is a privilege. Abuse of that privilege compromises the project's ability to meet the goals in the management plan. Standards of behavior on the island should be consistent regardless of the type visitors on the island. The staff should understand the reason for restrictions on the island and be able to justify actions to funders, visitors, and researchers. All visitors should be subject to the same standards of behavior observed by the staff.

9.4.7 Accountability and Evaluation

The above recommendations, existing operating procedures, contracted agreements, and other concerns of the community could be combined into a detailed SOP or standard operating procedure manual. Upon hire, staff can sign a contract that indicates that they have reviewed, and agree to abide by, the SOP which may include many of the recommendations above. Contracts should be updated each time the SOP is updated. Procedures for discipline should be in place to deal with breach of contract. Additionally, benefits and opportunities to take advantage of incentives should be clear to employees. Overall, the managing staff will have to strive for a balance between expectations and incentives.

The above recommendations may read as a laundry list. However, prioritizing and institutionalizing these recommendations into the existing management structure through a participatory process will make the conservation activities of HRRMP more integrated and therefore more effective. There are certainly subtleties related to the above issues in terms of cultural context, clan conflict, and Tobian life experiences that I do not understand. It is therefore important for managers and leadership to take these recommendations and fit them to the specific circumstances of Tobian society. The Tobian management style has evolved over thousands of years; however, the global context of natural resource management and threats are changing at a pace far beyond the rate of management evolution. I hope these recommendations will assist Tobian managers to continue to effectively protect and preserve their resources in a fast changing world.

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