Contextual conservation: Antillean manatees (*Trichechus manatus manatus*) of Turneffe Atoll, Belize

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by

Suzanne Bremner Poloner Holguin

San Francisco, California

December, 2004

Certification of Approval

I certify that I have read *Contextual conservation: Antillean manatees of Turneffe Atoll, Belize* by Suzanne Bremner Poloner Holguin, and that in my opinion this work meets the criteria for approving a thesis submitted in partial fulfillment of the requirements for the degree: Master of Arts in Geography: Resource Management and Environmental Planning at San Francisco State University.

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Ellen Hines
Assistant Professor of Geography

_____

Barbara Holzman
Professor of Geography

_____

Jeffrey Bury
Assistant Professor of Geography

Contextual conservation: Antillean manatees (*Trichechus manatus manatus*) of Turneffe Atoll, Belize

Suzanne Bremner Poloner Holguin
San Francisco State University
2004

The Antillean manatee (*Trichechus manatus manatus*) is an endangered marine mammal found in the Caribbean Sea. Turneffe Atoll, located 50 km off the coast of Belize has a small population of manatees that has not been the focus of systematic surveys before this research. I have developed an approach called contextual conservation, upon which to base recommendations for the protection of manatees at Turneffe Atoll. A contextual conservation approach examines the abundance and distribution of a population in relation to the biogeography of their habitat and the political and economic agendas of the country. By applying the contextual conservation approach to the manatees of Turneffe Atoll the importance of maintaining local coral, mangrove and seagrass communities as linked habitats has become clear. Studying the politics and economics of Belize has identified how tourism, while a major source of revenue for the country, also contributes to environmental degradation through the commodification of nature and the associated increase in development. From surveys investigating the abundance and distribution of manatees at Turneffe Atoll, I have recorded the sightings of 16 manatees, predominantly in Douglas Caye/Lagoon, Jones Hole and Long Bogue. Using the contextual conservation approach, I have shown that manatees and their linked habitats must be protected from the anticipated increase in tourism and the associated negative environmental impacts. Specific recommendations include the establishment of legally protected areas, reduced-speed zones and limited development at Turneffe Atoll.

I certify that the Abstract is a correct representation of the content of this thesis.

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Chair, Thesis Committee Date

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1. Introduction

My research investigates the abundance, distribution and conservation of the Antillean manatee (*Trichechus manatus manatus*), in relation to the biogeography of Turneffe Atoll and the political and economic agenda of Belize. I am questioning both, 1) what are the biogeographic, political and economic factors involved and influencing manatee protection, and 2) how to effectively protect the manatees of Turneffe Atoll?

Belize is located in Central America, south of the eastern tip of Mexico and east of Guatemala. Off the coast of Belize, in the Caribbean Sea, extends the Belize Barrier Reef and three atolls, Turneffe, Lighthouse Reef and Glover's Reef (Figure 1). Turneffe Atoll has a population of manatees that has not been the focus of any investigation before this research expedition. Though rich with biodiversity, the atoll lacks legal protection and is threatened with development (Oceanic Society 2004, BCZMAI 2001).

Turneffe Atoll is the largest of the three Belizean atolls and is located approximately 50 km east of Belize City. Manatees have been opportunistically spotted around the atoll yet, information about them is lacking. Tourism and real estate developments are potential pressures for the atoll, and while 42% of Belize is legally protected (PACT 2004), Turneffe Atoll is not. With the anticipated pressures of development, commercialism and larger scale tourism activities on Turneffe Atoll (Oceanic Society 2004, BCZMAI 2001), conservation is critical for their protection.

Figure 1. Belize, the Barrier Reef and three atolls (Island Expeditions 2004, Ambergriscaye.com 2004).

The goal of this thesis is to contribute specific recommendations to protect the manatees and the habitat they depend on at Turneffe Atoll, Belize. To determine these recommendations I argue for a new approach towards conservation, called contextual conservation. A contextual conservation approach combines not only the abundance and distribution of a population but the biogeography, political and economic realities of the region that contribute to the current status of the population. A contextual conservation approach will help elucidate the region's socio-political environmental pressures from a layered perspective, determining what regional issues affect local conservation. As a specific example of the contextual conservation approach, I am investigating the abundance, distribution and conservation of Antillean manatees at Turneffe Atoll, Belize, to create effective conservation policy.

I propose this framework by first defining, in chapter 2, contextual conservation and why the apparent gap left in conservation biology requires a shift in thinking to include greater political and economic context in conservation recommendations. Pertinent research and theoretical analysis developed in the field of political ecology enhances this discussion by acknowledging the obvious role of politics in environmental issues. Combining aspects of both disciplines informs and enhances the contextual conservation approach. Just as contextual conservation involves the biology of the species, the biogeography of the region and the political and economic reality of the country, this thesis follows a similar flow.

Chapter 3 describes manatees and their history in Belize. This includes a description of the evolutionary history and current biology of the species, as well as previous research on the abundance and distribution of manatees in Belize. Investigating the natural history of manatees in the Caribbean Sea uncovers how they have adapted to, and evolved with, their environment.

Studying the biogeography of the region is a key component of contextual conservation. Chapter 4 addresses the biogeography and geomorphology of Turneffe Atoll, Belize. Three significant biological features of the manatees' habitat at Turneffe Atoll are the linked environments of the coral, mangrove and seagrass communities. Each of these important biogeographic components of the manatees' habitat are described, acknowledging their individuality as well as how they contribute to the functioning habitat. By habitat I am referring to the area that contributes to the sustenance of the population, both specific food sources and the environment that is necessary for that food source to grow (Garshelis 2000).

A contextual conservation approach should also investigate the political and economic agendas of the region to determine the root causes of developmental pressures that may contribute to the species' reduced numbers, towards recommending appropriate and realistic protective policies. Chapter 5 addresses the current political and economic agenda of Belize, in relation to the country's history and future goals. Understanding a brief history of Belize will place the country's current goals in

perspective. Rather than put forth conservation recommendations that are counterproductive from an economic standpoint, my recommendations are in the context of Belize's current economic and political goals.

I return in Chapter 6 to the manatees and my investigation of their abundance and distribution at Turneffe Atoll, Belize. Little data exists about the population at Turneffe Atoll, and my research contributes to baseline data. Combining both boat and aerial surveys of manatees in the waters of the atoll, a table and map are presented indicating the location and environmental variables of each sighting. Chapter 7 unites this thesis and includes the final discussion and recommendations for both policy makers and researchers based on information elucidated through the contextual conservation approach.

2. Contextual Conservation

Effective conservation must address the needs of the species in the greater context of its habitat to protect both the animal and the environment it thrives in (Reynolds 1999). Reynolds (1999) stresses that, 1) manatee conservation focused solely on manatees is doomed to fail if the habitat required by the animal is lost, and 2) identification and conservation of critical habitat is an essential element to manatee conservation programs. This requires an evaluation of not only the population, but also its entire habitat to better understand how it functions. For this reason, it is reductionistic to simply study the abundance and distribution of manatees, as if the presence or absence of an animal can address the future needs of the animal. My investigation is rooted in a contextual conservation approach, a form of conservation that considers the species in a physical and biogeographical context, understanding how the habitat functions and evolves. Beyond the species-specific approach, contextual conservation also incorporates the socio-political conditions in the region that have contributed to the current situation. Conservation strategies and effective recommendations must explore the social context behind the actions that deplete wildlife and degrade natural systems (Hines 2002).

In this chapter, I present my argument for investigating the manatees of Turneffe Atoll in relation to their environment, as an example of contextual conservation. How can we protect a species in its habitat amidst developmental pressures? Applied here,

how can the manatee population survive while its habitat is legally unprotected and threatened with increased tourism and development? A contextual conservation approach combines aspects of both conservation biology and political ecology to address conservation.

2.1 Approach and Justification

Contextual conservation is rooted in geography. Geography encompasses both the physical and the cultural worlds, and so does contextual conservation. Geography is also concerned with flow. Physical flow can be understood, for example, as the movement of the earth's crust through plate tectonics or the surface of the earth through land flows, movement of water through ocean currents and the flow of organisms from one location to another through migration or dispersal. Similarly, cultural flow can be recognized as the movement of ideas, concepts, cosmologies and philosophies around the world; the flow of money, power and influence, or generally, the flow of everything human related. Geography also involves scales, addressing issues from perhaps global, regional and/or local scales to understand the causes and effects apparent at each level and between levels. As developed in this specific example of the contextual conservation of the Antillean manatees of Turneffe Atoll, Belize, my approach examines both the physical and the cultural dimensions of conservation as it relates to the focus animal, and involves the global, regional and local scales.

The contextual conservation approach is enhanced by aspects and components of political ecology and conservation biology. Political ecology, also stemming from geography, is a powerful field of inquiry that demands recognizing the political, and therefore cultural aspects of the environment. The contextual conservation approach has been informed in part by research in political ecology because of the connection between the politics of the region and how they may impact the environment. Additionally, conservation biology's longstanding dedication to the study and preservation of species and habitats has contributed to the development of the contextual conservation approach, which aims to protect animals within their habitats. Yet, rather than add to the many forms of conservation biology, contextual conservation marks a conscious shift towards investigating politics and economics as they relate to the species or population. The following overview of conservation biology and political ecology will demonstrate the need for a contextual conservation approach. While a complete analysis of the field of conservation biology is beyond the scope of this thesis, I have drawn upon both peer reviewed sources as well as conservation biology textbooks to understand the general trend of how conservation biology is described and taught.

Conservation biology and its integrated, interdisciplinary approach is critical, but not holistic enough to address the sources of environmental pressures. Soulé (1985) defined conservation biology as addressing the biology of the species, communities and

ecosystems that are perturbed, while providing the principles and tools for preserving biological diversity. At that time, Soulé (1985) recognized the dependence of the biological sciences on the social sciences, but still applied the social sciences to determine the impact of park reserves on the local economy, rather than asking the reverse: how the local economy might facilitate or be counter-productive to the establishment of the parks?

Meffe and Viederman (1995) revisit science and policy in conservation biology ten years after Soulé's 1985 article, and suggested that conservation biology was maturing to encompass economic, legal and political issues, recognizing that the science of conservation biology was not sufficient to stem species extinction and ecosystem degradation. They effectively stated that as scientists, our research is worthless if it is not translated into effective policy, yet we can no longer simply hope that someone else will create the policy based on our research. Instead, scientists must anticipate the needs of policy makers by having relevant information available before the policy makers know it is needed (Meffe and Vierderman 1995). Though I agree with anticipating the needs of policy makers, I question how effectively this can, or has, been done if scientists do not know how to study the political and economic pressures that contribute to the problem at hand? The social sciences are recognized, but still not incorporated into a workable paradigm of conservation.

More recently, conservation biology has included economics within the principles of conservation, but only to determine the economic value of biological diversity (Primack 2000), rather than addressing the political and economic pressures that are contributing to the loss of organisms in their environments. The economic value of nature is based on its usefulness to humans and is measured economically by placing a monetary value on a component or function of nature (Trombulak et al. 2004). Nature is therefore regarded as an economic source, conforming to an economic model (Ricklefs 1993), rather than questioning how the economic model confronts nature. Economics are still largely being promoted in conservation biology as a means to quantify value- an after effect of economics- rather than learning from economics why the pressure is being placed on the environment in the first place. The valuation of nature does not alter or alleviate the pressures on nature, it simply tries to demonstrate how much more valuable nature is than whatever the current development scheme may be. I am not quantifying animals as economic sources, but rather I am exploring the economic pressures on the population in their habitat. Economics does not have to be an afterthought in conservation science; it can be a tool that explores the monetary values of those in power in the region to address why and how the environment is exploited for money.

While conservation biology indeed takes in a cross-section of disciplines, it is still rooted in the scientific method (Caughley and Gunn 1996, Meffe and Viederman

1995). Caughley and Gunn (1996) note that detection of a species in trouble, diagnosing the problems and following with treatment should conform to the scientific method, but I question where researchers can begin when little data exists? The most intriguing approach to management decision-making without ideal data is Johannes (1998) call for data-less management carried out specifically in the absence of data required for predictive models and statistical confidence limits. Johannes (1998) argues that we do not have the resources available to collect and process management data for tropical seagrasses, mangroves and coral reefs, among other organisms. We must instead make the best management decisions possible when such ideal and perfect data are unattainable. Combining both local knowledge from key informants with the research available, data-less management can contribute to informed decisions (Johannes 1998). When pressured with small endangered and threatened populations in legally unprotected areas, recommendations should be made from a contextual conservation approach because it addresses scarcity of data by maximizing the use of information from data that are available.

A contextual conservation approach is informed by significant research in the field of political ecology because it acknowledges the very existence of a politicized environment, especially in developing countries (Bryant and Bailey 1997). Political ecology has been defined as combining the concerns of ecology and a broadly defined political economy (Blaikie and Brookfield 1987) recognizing that environmental

problems are the interactions between biophysical processes, human needs and the wider, overarching political systems (Forsyth 2003). Political ecology seeks to contribute to the understanding of the causes and implications of environmental change (Bryant and Bailey 1997); applied here to the investigation of the causes and implication of Belize's politics and economics on manatees.

While conservation biology represents a synthesis of disciplines from anthropology and ecology, to genetics and sociology, it only includes the social sciences insofar as they provide insight on how people can be encouraged and educated to protect natural resources (Primack 2000). Instead, political ecology calls for rethinking explanations of environmental problems in ways that do acknowledge the linkages between social factors and the pursuit of conservation (Forsyth 2003). Of course conservation biology is a necessary and highly productive field with the goal of providing principles and tools for preserving biological diversity (Soulé 1985), but the connection between the political and economic pressures on habitat loss or the direct take of a species must be included in conservation, complimented with the biology and biogeography of the species.

The key component of political ecology that contributes to the contextual conservation approach is the recognition that environmental problems cannot be understood in isolation from the political and economic contexts with which they are created (Bryant and Bailey 1997). I cannot describe the threatened manatees without

simultaneously considering the political and economic processes that have generated, contributed to and exacerbated their vulnerability (Bryant and Bailey 1997). These perceptive views are here incorporated into a real conservation approach, with the goal of creating effective and informed policy. While the theoretical dimensions of political ecology have contributed to my investigation on how we perceive the environment and environmental problems (Peet and Watts 1996, Escobar 1996), conservation requires swift, effective and cautious action because organisms are losing their habitats and are threatened with extinction. Contextual conservation melds the science of conservation biology with political ecology's fundamental acknowledgment of a politicized environment.

As a crisis science (Soulé 1985), conservation biology may expect too much time and information to develop testable hypotheses when baseline data on abundance and distribution are needed. If combined with political ecology's goal to include both the ecological and the political dimensions of environmental issues (Zimmerer and Bassett 2003), the resulting contextual conservation approach maximizes the scarcity of data available on the biology, biogeography, abundance and distribution of a population in the context of the region's agenda to facilitate habitat protection. Through the contextual conservation approach, I will inform policy makers and future researchers as to the most appropriate protection and research strategies regarding the manatees of Turneffe Atoll.

3. Manatees of Belize

A contextual conservation approach should be informed by detailed information about the species in question. Before recommending effective conservation policy about the manatees of Turneffe Atoll we must understand what a manatee is, how they evolved and their basic biology, to advise the decision making process. This chapter explores these issues, as well as the previous research conducted on the abundance and distribution of manatees in Belize.

3.1 Sirenians

Manatees are marine mammals belonging to the scientific order Sirenia, of which there are four species still living today (Figure 2): the dugong (*Dugong dugon*) found in the coastal and island waters of the western Pacific and Indian oceans; the West African manatee (*Manatus senegalensis*) found in the coastal and riverine waters from Senegal to Angola in western Central Africa; the Amazonian manatee (*Manatus inunguis*) occupies the freshwater habitats throughout the Amazon River and its tributaries; and the West Indian manatee (*Trichechus manatus*) found in the mid-Atlantic region of the United States, the Gulf of Mexico, the Caribbean and parts of South America. The West Indian manatee is further divided into two sub-species: the Florida manatee (*Trichechus manatus latirostris*) primarily occupying the coastal waters of Florida and Georgia, and the Antillean manatee (*Trichechus manatus*

manatus) found from southwestern Texas down to the east coast of Central and South America, as far south as Brazil (Reynolds and Powell 2002) (Figure 3). All four extant species are listed as vulnerable (IUCN 2004).

Figure 2. Scientific order Sirenia (Folkens 1989).

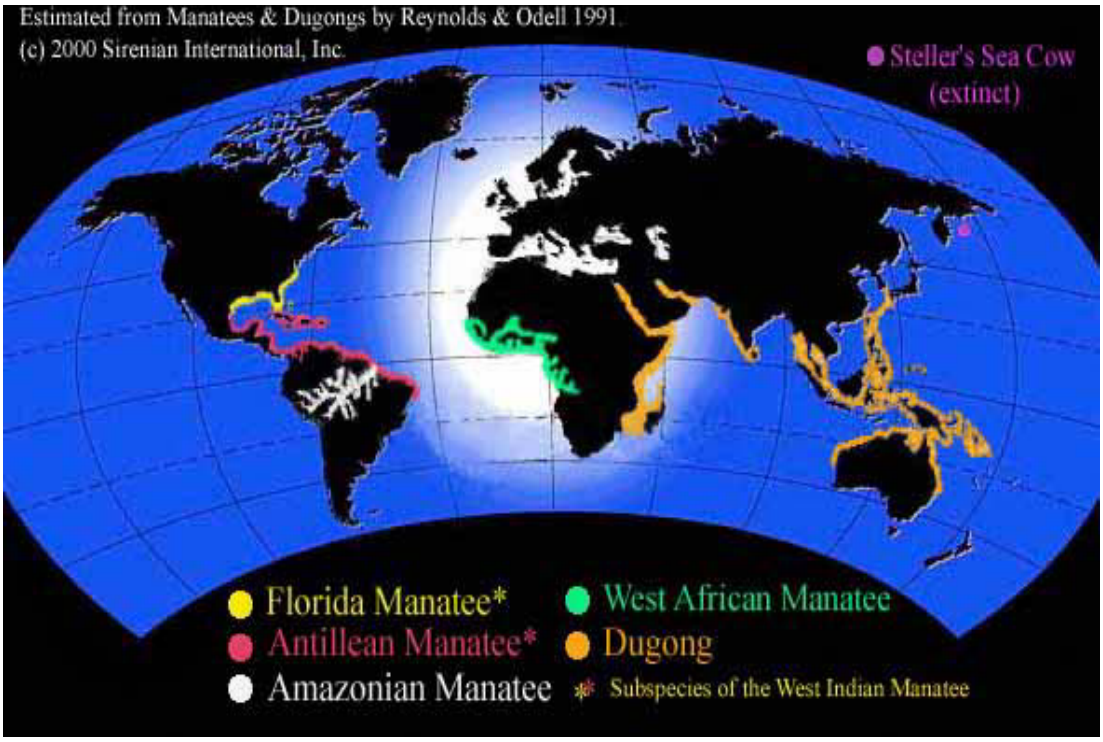

Figure 3. Sirenian distribution (Printed with permission from Sirenian International 2000).

The fifth species in the order Sirenia is the extinct Steller's sea cow (*Hydrodamalis gigas*), named for Georg Wilhelm Steller who recorded much of the information available on sea cows in the winter of 1741 (Reynolds and Odell 1991). Unique among sirenians, the 26-foot long Steller's sea cow inhabited cold, sub-arctic waters where the population was decimated and driven to extinction 27 years after it had been initially recorded (Reynolds and Odell 1991). It was the European-managed

whaling and sealing expeditions that slaughtered the small population of perhaps less than 2,000 (Bertram and Bertram 1973).

Sirenians may seem evolutionarily related to other marine mammals, yet they have evolved separately (Domning 2001). As recently as the 19th century, scientists still believed that manatees were a tropical version of the walrus, as seen in early lithographs and drawings (Reynolds and Odell 1991). In fact, sirenians are evolutionarily most closely related to elephants, hyraxes (furry rodent-like mammals) and aardvarks (Reynolds and Odell 1991). According to Domning (2001), sirenians are thought to have arisen in the Old World (Eurasia and/or Africa), with ancestral forms dating from the Early Eocene Epoch, about 55 million years ago. Sirenians appear to have spread quickly to the New World where their actual fossil record begins in the late Early Eocene of Jamaica. For 50 million years, all four families in the order Sirenia (Prorastomidae, Protosirenidae, Dugongidae and Trichechidae) inhabited the Caribbean western-Atlantic region, but it was not until the Miocene Epoch, about 15 million years ago, that a truly manatee-like animal appears. By the early Pliocene Epoch, about five million years ago, the Amazonian manatee's ancestors were isolated in the Amazon Basin, while other manatee successfully inhabited the Caribbean. The West African manatee is said to have occurred by a chance colonization of Africa from animals dispersing from the Caribbean (Domning 2001).

3.2 The Antillean Manatee

The Antillean manatee was proposed for sub-species status in 1934, but at the time, there was little anatomical evidence to support this idea (Reynolds and Odell 1991). It was not until the 1980s that sufficient anatomical evidence based on skull measurements confirmed the sub-species status (Domning and Hayek 1986.). According to the thorough descriptions of sirenian traits (Reynolds 1999, Reynolds and Odell 1991), adult Antillean manatees average 3 m and weigh 544 kg. Their thick, tough skin is sparsely scattered with hair and covers a layer of blubber less than an inch thick (Ripple 1999). Their bodies are streamlined, gray to brown in color with small eyes and prominent vibrissae on their large flexible upper lip. Manatee bodies are spindle shaped with short paddle-like front limbs and a large paddle-like tail for locomotion. Manatees travel at speeds of 3-10 km/h, and up to 24 km/h in short bursts (Ripple 1999).

Internally, manatees have very thick, heavy bones, with the ribs, longbones and forelimbs lacking marrow. The lack of marrow makes this heavy bone similar to ivory- a prized quality for bone carvers. The weight of their bones can help offset the buoyancy of their long, unlobed lungs, which occupy virtually their entire dorsal region (Reynolds and Powell 2002). Manatees are herbivores and consume angiosperms almost exclusively, ingesting the small invertebrates that may feed incidentally on the seagrasses as well (Reynolds and Powell 2002). Relying primarily on seagrass to

subsist, healthy seagrass communities are essential for manatees. To effectively consume seagrass and the gritty sediments associated with them, manatees have six to eight molars in each of their four rows of teeth that are continuously replaced throughout their lifetime (Reynolds and Odell 1991). In order to digest this high fiber, low protein diet, manatees have a hindgut similar to horses and elephants, and a huge large intestine (more than 20 m) (Reynolds and Powell 2002).

With a maximum life expectancy of 60 years, manatees become sexually mature at between 2.5 and 10 years of age (Bonde et al. 2004, Reynolds and Powell 2002, Boyd et al. 1999). They have an 11-20 month gestation period and calve every 2-5 years (Bonde et al. 2004, Reynolds and Powell 2002). Typically, a calf remains with its mother for approximately 2 years (Ripple 1999). A late sexual maturation combined with a long gestation to produce typically one calf creates a low reproductive potential. In turn, this low reproductive potential makes manatee populations easy to overexploit and slow to recover. Changes in the morbidity or fecundity will have significant effects on the long-term survival of a population (Marmontel et at. 1997). When one manatee is killed, it may take several years, if possible, to replace that reproductive potential (Reynolds 1999). Adult survivorship is particularly important and must be high for populations to be maintained (Boyd et al. 1999).

The manatee is primarily endangered as a result of contact with humans (Reynolds and Powell 2002, Lefebvre et al. 2001, O'Shea and Salisbury 1991, Bertram

and Bertram 1973, 1968). The coastal habitats occupied by manatees are the same coastal environments humans enjoy, exploit and increasingly develop. Not only have manatees been a source of food, but manatee tears, oil, hides, bones and incisors, among other parts, have been intertwined into traditional medicinal practices (Ripple 1999, Bertram and Bertram 1973). Their tough hides are used as whips, shields and machine belts (Reynolds and Powell 2002). Legal restriction of hunting has probably prevented the extinction of manatees in Belize, but other modern anthropogenic threats have taken the forefront including drowning in fish nets, boat propeller accidents and overall degradation and loss of habitat (Auil 2004, 1998, Reynolds and Powell 2002).

3.3 Previous Research on the Manatees of Belize

Not only were manatee populations historically more abundant as indicated by fossil findings (Domning 2001), but manatees contributed substantially to the diet of early settlers in the Maya regions and coastal sites in Belize (McKillop 1985). Sauer (1966, 58) recounts the importance of regional manatee meat to the local diet, stating how these ". . . large seacows pastured freely on plants of the estuaries and were an important food source until they were decimated by the Christians, who were permitted to eat them on fast days." Research on the historic exploitation of the manatee in the Maya and circum-Caribbean areas has identified manatee remains from a Middle Classic Period (400-700 Current Era- C.E.) site at Moho Caye, Belize, and carvings

from manatee bones have been found at both coastal and inland sites, demonstrating the widespread use of manatees (McKillop 1985).

Currently, throughout the Antillean manatee's range, aerial surveys have shown that the majority live in Belizean waters (Auil 2004, BCZMAI 2003, O'Shea and Salisbury 1991), though their numbers are not increasing (Auil 2004). The relatively large manatee population in Belize is often referred to as the last stronghold for manatees in the Caribbean (O'Shea and Salisbury 1991), yet the population consists of less than 900 individuals, with estimates varying between 300-900 (BCZMAI 2003). Within Belize, manatees are unevenly distributed in the Northern and Southern Lagoons of the mainland and throughout the coastal waters, ranging from Corozal Bay in the north, to Port Honduras in the south and extending east to include the off shore cayes, the Belize Barrier Reef and at least one of the three Belizean atolls in the Caribbean Sea, specifically Turneffe Atoll (Auil 2004, 1998, Self-Sullivan et al. 2003, Morales-Vela et al. 2000, Smith 2000, O'Shea and Salisbury 1991, Bengston and Magor 1979). Most manatee populations are found in the Northern and Southern Lagoons on the mainland of Belize, south of Belize City, as well as the coastal cayes west of the Belize Barrier Reef (Auil 2004, 1998, Morales-Vela et al. 2000, O'Shea and Salisbury 1991, Bengston and Magor 1979). Accurate data including population size, location, feeding habits and migration information are essential if we are to prevent the further extinction

of marine mammals. However, not all manatee populations have been thoroughly accounted for in Belize, potentially resulting in the loss of undocumented populations.

Currently, West Indian manatees are listed in Appendix 1 of the Convention on International Trade in Endangered Species as Threatened with extinction (CITES 2003), as Vulnerable by the World Conservation Union (IUCN 2003) and Endangered under the United States Endangered Species Act (TESS 2003, USFWS 2003). Antillean manatees have been protected in Belize since 1935 under the Manatee Protection Ordinances (McCarthy 1986). The Antillean manatee is further protected in Belize under the Wildlife Protection Act of 1981 and in Mexico by the Ecological Act of 1994. The United Nations Environment Programme (UNEP) has published a Regional Manatee Recovery Plan (UNEP 1995), and Auil, while with the Belize Coastal Zone Management Authority and Institute's (BCZMAI) Manatee Research Programme, has written the Belize Manatee Recovery Plan (1998) produced through the Belize National Manatee Working Group and the BCZMAI, which follows UNEP's recommended outline (BCZMAI 2004a, Sirenian International 2004a). In this comprehensive document, a four-year schedule of conservation activities was drafted with the goal of: 1) Preventing extinction or irreversible decline of the species in the near future, and 2) Preventing decline of the quality of their habitat (BCZMAI 2004a). The management plan includes manatees found in the four coastal districts of Belize where manatees are

typically found, but this does not include all areas of Belize where manatees have been seen. Specifically, the off shore atolls are not included.

3.3.1 Aerial surveys

The first countrywide aerial survey of manatees in Belize was conducted in September of 1977, and resulted in a maximum count of 101 manatees, nine of which were calves (Bengston & Magor 1979). A second aerial survey was conducted in May of 1989, and 102 manatees including 11 calves were sighted (O'Shea & Salisbury 1991). Both of these surveys investigated the same five regions thought to have the largest populations of Antillean manatees. Specifically, the Four Mile Lagoon and the New River in northern Belize; the lower Belize River from Burrell Boom to Belize City; off shore cayes near Belize City west of the Belize Barrier Reef; the Northern and Southern Lagoons near the central coast and; the Placentia Lagoon area on the south-central coast (Figure 4) (O'Shea and Salisbury 1991, Bengston and Magor 1979).

The BCZMAI flew fifteen additional aerial surveys between 1994 and 2002 that included six sites: Corozal Bay to the North, Belize City Cayes and River; the Southern Lagoon; the Placentia Lagoon; Indian Hill Lagoon and Port Honduras (Figure 5) (BCZMAI 2003). The highest count of manatees was in the wet season of 2002, with 338 manatees spotted (BCZMAI 2003). Most importantly, Turneffe Atoll was dropped from their aerial surveys as of 1999, and no individual data on Turneffe are given,

which suggests no manatees were seen. Furthermore, Turneffe Atoll is not included in the recommendations for future aerial surveys (Auil 2004). Morales-Vela et al. (2000) found a total of 11 manatees at Turneffe Atoll during their three aerial surveys during 1994-1996, but they too recommend against including Turneffe Atoll in each survey because manatees did not appear to use the atoll often. While abundance estimates of a small population in such a large area are difficult, further research and continued monitoring of their distribution and movement patterns is needed for their protection (Hines et al. in press).

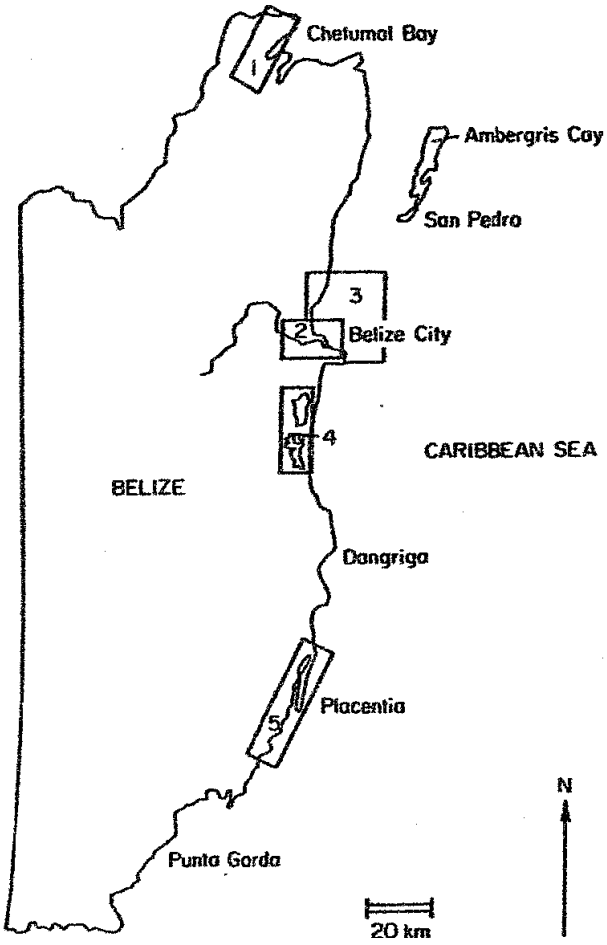

Figure 4. Map of Belize including the aerial survey regions investigated by O'Shea and Salisbury in May of 1989. 1). Four Mile Lagoon and lower New River, 2). Lower Belize River, 3). Waters and cayes off Belize City, 4). Southern Lagoon, and 5) Placentia Lagoon (O'Shea and Salisbury 1991).

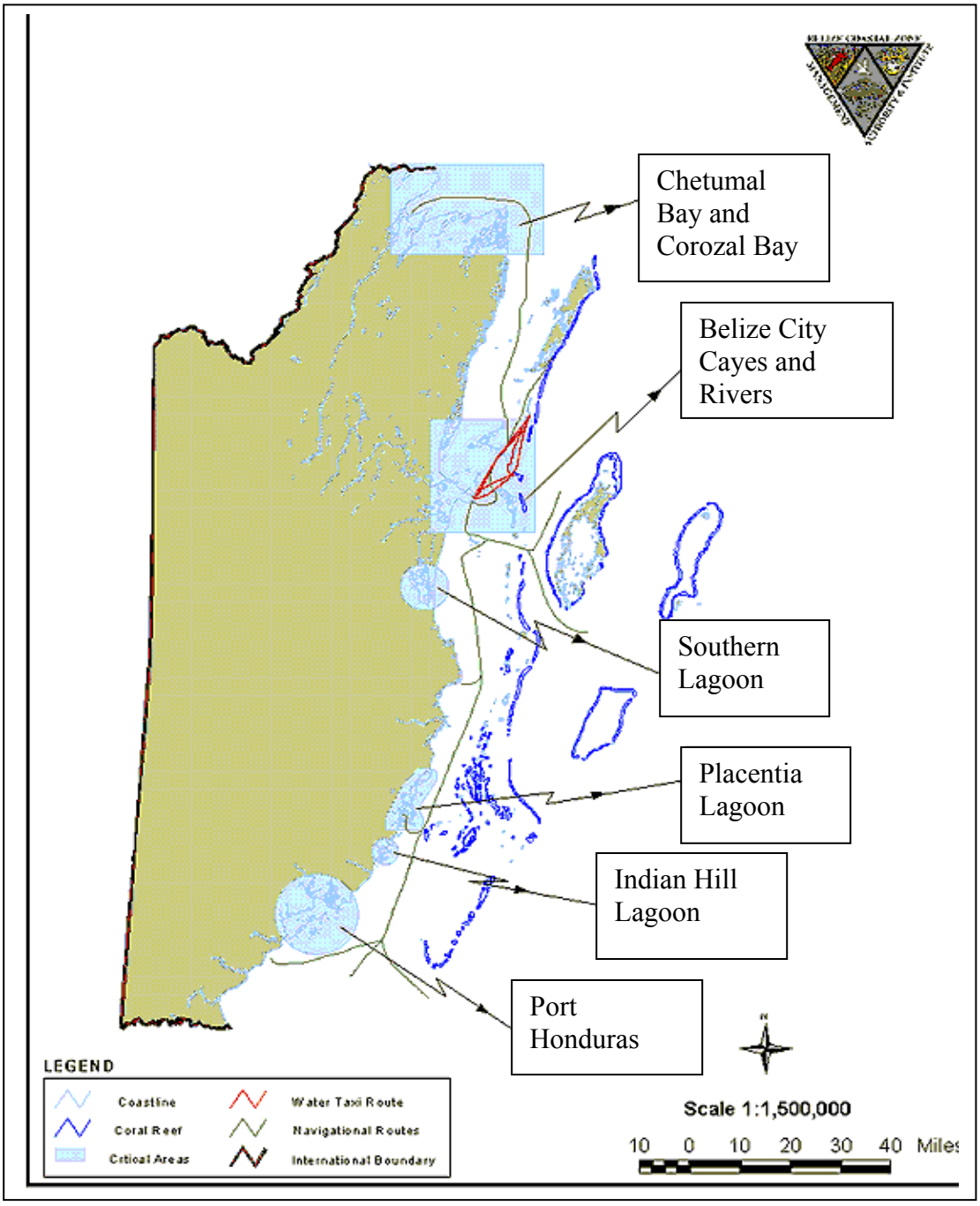

Figure 5. Aerial survey regions investigated by the Belize Coastal Zone Management Authority and Institute in 1997 (BCZMAI 2003).

4. Biogeography of Turneffe Atoll, Belize

As Quammen (1996, 17) states so concisely, "Biogeography is the study of the facts and the patterns of species distribution." The study of the geographic distribution of organisms includes studying where plants and animals are found, but also where they are not found. Biogeographic studies seek to understand why certain plants and animals are found in some environments and not in others. Biogeography attempts to study the distribution of life within the context of history, place, evolution, scale and movement, and can be as narrow as researching one species and its presence and absence, or as holistic as studying the spatial patterns of biodiversity within a region. What is unique about this field is the recognition of organisms in context, and their distribution in relation to the environment.

Beyond information from a natural history perspective, investigating the biogeography of a region naturally recognizes species in the context of their environments. The contextualized study of species in their environments generates questions regarding how species create, manipulate and use their environments. As my research has taken me to Turneffe Atoll, Belize to study the Antillean manatee population, I cannot separate the manatees from their environment, and have therefore used aspects of biogeography to learn more about manatee conservation *in situ*.

This chapter describes the biogeography of Turneffe Atoll as it relates to the manatees because recognizing the unique environment manatees have evolved within

will inform policy makers of the need to protect the entire habitat. The location and formation of the atoll has facilitated the growth of coral reefs, mangroves and seagrass communities, all of which constitute manatee habitat. Understanding how the biological components of the atoll are linked reinforces the need to protect manatees and their unique habitats.

4.1 Evolution and Formation of Turneffe Atoll

Off the coast of Belize in the Caribbean Sea lies the second longest Barrier Reef in the world (220 km) and three of the four atolls found in the Western Hemisphere, Turneffe, Glover's Reef and Lighthouse Reef atolls (Murray et al. 2003, Spalding et al. 2001) (Figure 6). Located approximately 50 km from the mainland of Belize, Turneffe Atoll is the largest of the three Belizean atolls in the Caribbean Sea, with a maximum width of 16.1 km, a maximum length of 48.2 km (Gischler and Hudson 1998). The atoll has an overall area of 525 km² (Gischler and Hudson 1998) and a land area of 22% of the atoll (Spalding et al. 2001). Although relatively close to the mainland of Belize, the islands of Turneffe Atoll are oceanic islands, having never been connected to the mainland. Just 9.6 to 16 km to the east of the Barrier Reef, Turneffe Atoll rests on an isolated carbonate platform (Gischler and Hudson 1998). Instead of forming on a volcanic hotspot typical of some atolls in the Pacific, the structural floor of the isolated

carbonate platforms and the Barrier Reef are situated on NNE-striking ridges at the passive continental margin (Gischler 2003, Dillon and Vedder 1973).

Figure 6. Satellite image of mainland Belize, the Barrier Reef and the three atolls: Turneffe at the top, Lighthouse in the middle and Glover's at the bottom of the image (Redtail Canyon 2004).

Turneffe Atoll is also referred to as Turneffe Islands, which begs the question, what is an atoll? Darwin presented the earliest scientific classification of ocean reefs and atolls based on shape and origin (Fagerstrom 1987). Darwin distinguished three main types of reefs: atolls, barrier reefs and fringing reefs, linked together in an age-related sequence (Stoddart 1978). Though the name 'atoll' significantly pre-dates Darwin's usage, it refers to a sub-circular or ring-like arrangement of narrow reefs, partially enclosing a shallow-water central lagoon, lacking a volcanic island in the middle (Fagerstrom 1987).

An atoll is therefore a type of circular coral reef. Additionally, Gischler and Hudson (1998) believe that plate tectonics produced the morphology of ridges and valleys that control the distribution of modern reefs in Southern Belize. Winds and storms control most of the sediments that develop on these platforms and subsequent reefs often develop due to the build up, especially on windward margins where we might expect atolls to be most similar (Wood 1999). Most sediments stem from a wide variety of calcareous shells and skeletons of protists, plants and animals (Hallock 1997), while Gischler and Hudson (1998) note the sediments on the Belize shelf are pure carbonate in the north, and mixed siliciclastic in the south. Thus, if the rate of carbonate production at the margins is high, combined with a steady rate of subsidence then, according to Wood (1999), a shallow reef will grow around the platform forming a deep central lagoon with patch reefs. The platform is now covered by the cayes that

make up Turneffe Atoll, with a central lagoon on the inside, encircled by fringing and patch reefs on the outside.

During the late Pleistocene (2 million years ago), the cayes of Turneffe Atoll were simply dish-shaped limestone islands that were likely fringed by coral reefs (Gischler 2003). The following description is from Gischler's (2003) explanatory Holocene flooding scenario, which began 8,000 years before present (BP) when Turneffe Atoll was simply a collection of emergent cayes. Between 7,000 and 2,700 years BP, the Holocene sea levels began to rise and the elevated levels of groundwater enhanced soil development. Eventually the marine waters breached the outer edges of the cayes and entered the center of the atoll, which was significantly lower, allowing mangroves to colonize the interior areas of the atoll. At around 4,800 years BP, as a result of the rising sea levels, mangrove-rimmed lagoons formed, yet at the highest sea levels, mangroves diminished and coral reefs colonized the rim. By about 4,000 years BP the sea level was close to 3.5 m below the present level, and Turneffe's central lagoon was largely developed. Simply stated, above the Pleistocene limestone bedrock rests basal soils, followed by mangrove peats and marine lagoonal carbonate sediments (Gischler 2003).

4.2 Linked Habitats

Presently, Turneffe Atoll is comprised of approximately 200 cayes, with about 23 gaps or channels less than 50 m wide consisting mostly of mangrove forests, with a handful of sandy cayes capable of supporting humans. The cayes of Turneffe enclose three main shallow lagoons less than 8 m deep: Northern or Vincent, Central, and Southern Lagoons, and several small lagoons (Figure 7). Manatees share the atoll with other threatened and endangered species including the American salt-water crocodile (*Crocodylus acutus*), hawksbill turtle (*Eretmochelys imbricata*), bottlenose dolphin (*Tursiops truncatus*), Nassau grouper (*Epinephelus striatus*), roseate tern (*Sterna dougallii*) and the white-crowned pigeon (*Columba leucocephala*). There are also several breeding seabird colonies including the brown booby (*Sula leucogaster*), sooty tern (*Sterna fuscata oahuensis*) and the magnificent frigate bird (*Fregata magnificens*).

Figure 7. Turneffe Atoll (Belize Now Network 2001).

The most prominent features of Turneffe Atoll supporting significant biodiversity are the coral reef, mangroves and seagrass beds. For a variety of fishes and invertebrates, the seagrass beds and mangroves function as nurseries or daily foraging habitats before migrating to the coral reef (Creed et al. 2003, Ogden 1997). In many ways, they depend on each other and have formed because of each other, and therefore coral reefs, mangroves and seagrass beds are often referred to as linked habitats (Mumby et al. 2004, AMNH 2004, Green and Short 2003, Creed et al. 2003, Hogarth 1999, Ogden 1997, 1980). All three communities thrive together because the mangroves filter pollutants and trap sediments that would otherwise smother seagrass and coral and prevent the sunlight required for photosynthesis from reaching them. Seagrass communities also clean the water, benefiting coral reef inhabitants by blocking the flow of silt and mud. In turn, coral reefs protect mangroves and seagrass from the wave force by slowing the surging waves (AMNH 2004, Green and Short 2003, Ogden 1997, 1980). Because the wave action hitting Turneffe Atoll comes from the north-northeast direction, the fringing reef helps to absorb much of the wave force and therefore, the more gentle water laps against the mangrove lined cayes (Murray et al. 2003). The less wave force, the less sediment agitation takes place, which keep the water clear enough for sunlight to penetrate the water and reach the seagrasses and coral.

Not only are the coral, mangroves and seagrass beds linked biologically, they also share similar threats to their existence (Jacobs 1998). Anthropogenic impacts of coastal development and pollution threaten seagrass beds (Creed et al. 2003), mangroves (Hogarth 1999, Klee 1999) and coral (Gibson and Carter 2003, Birkeland 1997). Both nutrient over-enrichment of the environment and the turbid water caused by land development lead to reduced light availability and therefore reduced photosynthesis (Green and Short 2003, Klee 1999). The development and pollution that adversely affects seagrass beds will also have an impact on manatee populations (Bonde et al. 2004). Therefore, conservation efforts should protect the connected corridors of mangroves, seagrass beds and coral reefs (Mumby et al. 2004).

4.3 Coral

Coral reefs are among the most biologically productive and diverse ecosystems in the world (Birkeland 1997, Campbell 1993). Corals are actually tiny animals, also called polyps, which secrete and then reside in a limestone/calcium carbonate skeleton. As the skeleton grows in varying shapes, other coral and algae begin to inhabit it (Campbell 1993). Hard coral, which helps to build the reef, grow on top of each other and leave behind the dead skeletons of previous coral polyps, gradually forming the coral reef (WCMC 2004, Belize Net 2004). Typical hard corals are brain corals, finger coral, elk-horn coral, stag-horn corals and plate corals (Belize Net 2004) (Figure 8).

Soft corals have a skeleton as well, but as their name suggests, it is not hard, such as fan coral (Figure 9). Within hard corals and some soft corals live tiny algae called zooxanthellae. In their symbiotic relationship, the zooxanthellae live inside the coral and in turn produce oxygen and nutrients through photosynthesis while processing the corals' waste materials (Belize Net 2004, Campbell 1993).

Within Belizean waters, 74 species of hard corals and 36 species of soft coral have been identified (Belize Net 2004). The reef is not only home to hard and soft corals, but associated organisms such as hundreds of fish species, as well as manatees, dolphins, octopus, lobster, conch, shrimp, anemones, seaweeds and countless others.

Figure 8. Brain coral (Holguin 2003).

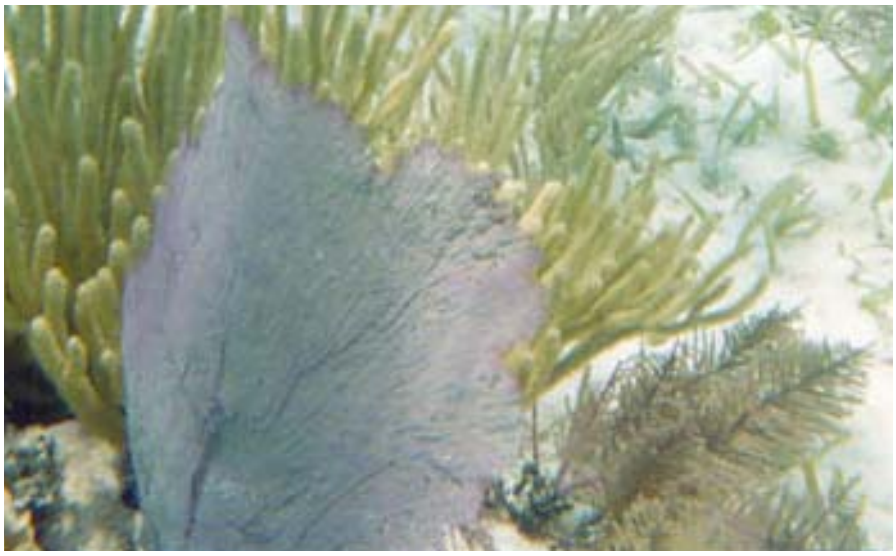

Figure 9. Purple fan coral (Holguin 2003).

In order to survive corals need:

1. Sunlight to grow in shallow water where the sunlight can reach them. Because the zooxanthellae are algae, they need sunlight to survive through photosynthesis,
2. Clear water, because the sediment and plankton can cloud the water and decrease the amount of sunlight for photosynthesis that reaches the zooxanthellae,
3. Warm water ranging from 20-32° C /68-90° F,
4. Clean water, not only due to the sediments that may settle on the coral preventing photosynthesis, but pollution from sewage and fertilizers increase the amount of nutrients in the water, negatively altering the coral reef environment,

5. Saltwater to maintain the balance of salt to fresh water, typically between 34-37 ppt (Coral Reef Alliance 2004, Gibson and Carter 2003, Hubbard 1997, Ogden 1997, 1980, Campbell 1993).

Fortunately, and evolutionarily, both mangroves and seagrasses have helped to maintain this ideal coral reef environment and have similar physiological and ecological roles (Hogarth 1999, Ogden 1997).

4.4 Mangroves

Mangroves are vascular plants that live in shallow seawater with the ability to adapt to the saline wetland environment by excluding and secreting salt from their tissues (Hogarth 1999, Klee 1999, Rutzler and Feller 1996). They are woody shrubs and trees that live along the edges and shores of rivers, estuaries and lagoons in areas sheltered from strong wave action (Chapman 1984, 1975). Mangroves can live in water up to 100 times saltier than most other plants can tolerate with the most tolerate species living along the shores and less tolerate species further away from the edge (AMNH 2004).

Mangroves have three essential adaptations that allow them to live in such extreme environments (AMNH 2004). First, mangroves are extremely salt tolerant and can filter out and exclude as much as 90% of the salt found in the seawater. Typically, this salt is then secreted out through the leaves of some species. Second, mangroves

also store freshwater in their thick succulent leaves, which have a waxy coating that helps to minimize evaporation (Hogarth 1999). Third, mangroves have aerating roots, which extend from the trunk and lower branches of the mangrove and help to stabilize the mangrove in its soft floating bed of unconsolidated sediments, or mud (AMNH 2004) (Figure 10). These sprouting aerial roots respire aerobically, which enables them to survive the oxygen deprived inter-tidal soils (Rutzler and Feller 1996). Mangrove aerating roots either emerge from the soil or extend from existing above water roots, as in the red mangroves (Chapman 1984). The root system retains sediments, consolidates the soil and provides physical stability to shorelines by creating dense, stable sediments, retarding coastal erosion (Hogarth 1999, Klee 1999).

To reproduce, mangrove species produce a large seedling called a propagule. After pollination the growing embryo remains on the parent tree and grows for many months growing into a true seedling, not a seed or a fruit (Hogarth 1999). The propagules germinate while still on the mangrove and are ready to take root when they fall from the branch (Figure 11 and 12). The floating propagule will follow the currents until it becomes lodged in another mass of mangroves or shallow seagrass bed, where it quickly begins to grow (AMNH 2004) (Figure 13).

Figure 10. Stabilizing aerial roots of the red mangrove (*Rhizophora mangle*) (Holguin 2003).

Figure 11. Propagules of the red mangrove (*Rhizophora mangle*) (Holguin 2004).

Figure 12. Close-up of red mangrove (*Rhizophora mangle*) propagule (Holguin 2004).

Figure 13. Red mangrove (*Rhizophora mangle*) seedlings with aerial roots growing in a shallow seagrass (*Thalassia testudinum*) bed (Holguin 2004).

The fringing reef of Turneffe Atoll has contributed to the growth of mangroves on the atoll by absorbing a majority of in-coming wave energy, which shelters the shore and provides sufficient conditions for mangrove seedlings to develop (Murray et al. 2003). Turneffe Atoll has become extensively covered with mangroves, covering two thirds of the atoll's land area, which constitutes 9.4% of all of Belize's mangroves (Murray et al. 2003). Turneffe Atoll includes three mangrove species zoned according to flood depth and salinity. Red mangroves (*Rhizophora mangle*) are the most prevalent mangroves on Turneffe, covering 22% of the atoll and found along the island edges (Gischler and Hudson 1998). Beyond contributing to the biogeography of the atoll, mangroves are associated with many other land species including vines, palms, orchids and climbing ferns and lichens (Hogarth 1999) and are home to several species of wood boring moths, beetles, ants, termites, spiders, roaches, scorpions, mosquitoes as well as several species of amphibians, reptiles, birds and mammals (Hogarth 1999, Rutzler and Feller 1996). Below the water, mangroves support populations of algae, crustacea, mollusks, sponges, tunicates, worms (Hogarth 1999) and of course several populations of fish for which the mangroves provide an intermediate nursery stage between seagrass beds and the patch reefs (Mumby et al. 2004).

Black mangroves (*Avicennia germinans*) dominate sites further inland with reduced salinity. Black mangroves are taller than the red mangroves and have a distinctively darker bark with long cabled roots that protrude out of the soil (Figure 14)

(Tomlinson 1986). Most rare are the white mangroves (*Languncularia racemosa*) with their distinctive feature being a grayish bark with oval shaped leaves that are dented at the tip growing very small propagules (Murray et al. 2003). White mangroves propagules cannot survive the salinity and periodic flooding that is common in lower areas, and are restricted to higher ground on Turneffe Atoll (Rutzler and Feller 1996).

Figure 14. Red mangroves (*Rhizophora mangle*) along the lagoon edge, with the taller, less salt tolerant black mangroves (*Avicennia germinans*) further inland (Holguin 2004).

4.5 Seagrass

The third significant biogeographic feature of Turneffe Atoll's linked habitats are the ample seagrass beds that form a highly productive system in the protected shallow waters of the atoll. Seagrasses are the only group of angiosperms known to have successfully adapted to sea life (Brasier 1975), and the current Caribbean seagrass

communities are similar to those found in the Eocene Epoch (Domning 2001). Seagrass communities filter coastal waters, dissipate wave energy and anchor sediments because their root-like stems, or rhizomes, extend horizontally under the sea bottom, and act as sediment stabilizers (Green Reef 2003, Garcia and Holtermann 1998, Brasier 1975). These rhizomes store carbohydrates and are therefore, important to the manatees' diet (Domning 2001).

Sediments that would otherwise settle on coral and prevent photosynthesis, tend to accumulate and become stabilized by the seagrass (Creed et al. 2003, Ogden 1997). When seagrass communities are near shore, they act to slow water movement and their long leaves act as filters, removing particles from the water and depositing them as fine sediment, held in place by their extensive root and rhizome system creating an organic and nutrient rich environment (Ogden 1997, 1980). Seagrass communities provide habitat and food for an enormous diversity of fauna including fish, conch, sponges, mollusks, lobster, waterfowl, turtles, bottlenose dolphins and manatees for feeding, breeding and protection (Creed et al. 2003, Ogden 1980).

The seagrasses of Turneffe Atoll are dominated by turtle grass (*Thalassia testudinum*) which thrives in areas that are protected from wind-driven current and surf (Green Reef 2003) (Figure 15). Also present in the atoll are manatee grass (*Syringodium filiforme*) (Figure 16), shoal grass (*Halodule wrightii*) (Figure 17), and the algae *Halimeda* (Ogden 1980). According to Lefebvre et al. (2000) *Halodule*

wrightii and *Syringodium filiforme* are fast growing seagrasses, but are more vulnerable than *Thalassia testudinum* to physio-chemical disturbances. They are shallow rooted and have fewer energy reserves than *Thalassia testudinum* and are therefore more susceptible to physical degradation and deterioration in water quality (Lefebvre et al. 2000). Future efforts to protect important manatee habitat should incorporate management issues regarding water quality and damaging physical impacts to the seagrass community. As the staple for the herbivorous manatee diet, seagrass conservation must be associated with manatee protection and survival (Lefebvre et al. 2000).

Figure 15. Turtle grass (*Thalassia testudinum*) (Hines 2003).

Figure 16. Manatee grass (*Syringodium filiforme*) (Florida Oceanographic Coastal Center 2003a).

Figure 17. Shoal grass (*Halodule wrightii*) (Florida Oceanographic Coastal Center 2003b).

4.6 Human Population

Studying the biogeography of Turneffe Atoll would not be complete without addressing the human population as well. The country of Belize has a human population of approximately 270,000, as of July 2004 (CIA 2004). Specific industries, including fisheries and tourism are located in the coastal zone, which is home to 45% of the population (BCZMAI 2004b). Though Turneffe Atoll is an hour and fifteen-minute boat ride east of Belize City, the size of atoll's population is both influenced and supported by the fishing and tourism industries.

From my field research, there are three smaller-scale resorts on the atoll, two field stations and approximately twenty fishing camps. The resorts cater predominately to divers, sports fisherpeople, snorklers and beachcombers. Most of the fishing camps are seasonally used, especially in lobster season. The Oceanic Society, a non-profit conservation organization, has a field station on Blackbird Caye, which supports the organization's primary mission to protect marine wildlife through integrated programs of scientific research, environmental education and volunteerism. Their environmental approach is to collaborate with local communities in conservation initiatives while involving volunteer participants in research projects. The University of Belize's Institute of Marine Science runs their field station on a neighboring caye. A realistic total of approximately 100 people, both local residents and tourists included, occupy the atoll.

Human habitation of Turneffe Atoll is part of the region's biogeography. Each resort, field station and fishing camp affects the environment in varying degrees through activities such as altering the landscape and coastal environment to 'beautify' the area, generating garbage and sewage, driving diesel boats, potentially over-fishing for natural resources and the general removal of coral and shells by tourists. A contextual conservation approach includes human contributions to the biogeography of the region because humans are a significant part of the region and directly impact manatee habitats.

4.7 Summary

This investigation of the biogeography of Turneffe Atoll has related most specifically to the manatees and their habitat. A complete biogeographical description of this area would also include extensive details regarding Turneffe Atoll's relationship to the Belize Barrier Reef and the mainland of Belize, as well as the entire Caribbean Sea region. However, it is beyond the scope of this study to extensively investigate Turneffe Atoll's relationship to the surrounding area because the contextual conservation approach should maintain its focus on the animal in question. There are numerous fascinating aspects of Turneffe Atoll's biogeography that may be studied in the future, but there are specific features of the atoll that relate most directly to the manatees, from a contextual conservation approach.

As significant components of the biogeography of Turneffe Atoll, the corals, mangroves and seagrass beds are rich and diverse enough to be studied independently. An understanding of how Turneffe Atoll has formed and its unique linked biogeography enhances the conservation measures aimed at protecting the manatees within their habitat. This overview is by no means exhaustive, but rather, describes how the biogeography of Turneffe Atoll is interconnected. Seagrass communities in the waters of an isolated atoll like Turneffe depend on the shelter and reduced wave action provided by the mangroves and corals. Therefore, effective conservation strategies for manatees must consider the health of these linked habitats.

5. Politics and Economics of Belize

A contextual approach to conservation should investigate the politics and economics of the region to determine how they may be influencing and impacting the protection of the species. The short-term economic goals of a country or region are not always conducive to long-term environmental protection. Informed conservation decision-making should assess the current economic goals of the country to place conservation in the context of the country's agenda. Realistic conservation recommendations must understand the economic pressures of the country affecting the focus population to be seriously considered and enforced.

In Florida, the economic impact of the boating industry significant affects manatee conservation. While Reynolds (1999) described the economic impact of Florida's boating industry on manatee conservation in Florida after he asserted his recommendations, I am bringing economics to the forefront to inform my recommendations. Tourism in Florida continues to be a threat to manatees, and the increase in what is popularly termed ecotourism has actually increased the amount of boat traffic threatening the manatees (Bonde et al. 2004). With more than 30% of documented manatee mortalities attributed to vessel collision in Florida (Nowacek et al. 2004) there is a tension between protecting manatees and the economically influential boating industry. The implementation of boating regulations can have a negative economic impact on state revenues because of the reduction in commercial, recreational

and tourists interests (Reynolds 1999). Whereas Florida has a large established boating industry, Turneffe Atoll, for example, has not developed these intensive boating patterns and therefore has the opportunity to implement protection policies now, before boating intensifies. Just as manatee conservation in Florida is affected by regional politics and economics, so too are the manatees in Belize.

Specifically, this chapter examines how the current political and economic agenda of Belize has developed over time to rely heavily on the importation of goods, the exportation of raw agricultural products and the tourism industry. In turn, these collective goals of the country affect manatees and their habitat. A brief overview of the history of Belize will place the current economic and political status in perspective.

5.1 Brief History of Belize

Some of the earliest settlers in the Caribbean and Central America were the Arawaks and Caribs, followed by the Maya who developed complex civilizations between 1,200 Before the Current Era (B.C.E) and 1,000 Current Era (C.E.) in what is now Belize (Leslie 2002). Most pertinent to this thesis is the British colonization of Belize. The first British in Belize were the buccaneers who plundered Spanish vessels carrying logwood to Europe (Waddell 1981). In the middle of the seventeenth century, these buccaneers, pirates and adventurers became known as Baymen and began cutting the local logwood (*Haematoxylon campechianum*) for exportation (Leslie 2002). After

several battles between the Spanish and the British, the Battle of St. George's Caye on September 10, 1798 officially marked British control in Belize, and is celebrated as one of their Independence Days. It was not until 1862 that the settlement of Belize was declared a colony and named British Honduras (Leslie 2002, Sutherland 1998).

Logwood harvesting was the economic basis for the British settlement in Belize for over 100 years (Leslie 2002). The logwoods had a valuable dye that was extracted when boiled, and was used to color woolen cloth. Logwood trade remained the most important Belizean industry until it peaked in the late nineteenth century. When logwood dye was replaced by new synthetic dyes, loggers turned their attention to mahogany and chicle (Setzekorn 1981).

Mahogany dominated the economic, social and political life of Belize until the middle of the 20th century (Leslie 2002). The exploitation of forests in general, has been termed the *raison d'être* of British Honduras (Waddell 1981). Though logwood was the first product exported from Belize, by 1779 the British had found mahogany a much more profitable export (Leslie 2002). Taking advantage of Belize's mountainous landscape and several tributaries, forest exploitation did not require much machinery, capital or roads, as loggers were able to chop down trees, tie them together and float them down river (Barry and Vernon 1995).

During a decline in mahogany trade in the 1800s, many landowners went bankrupt and partnerships were formed, resulting in an elite few controlling huge

portions of land. For example, the James Hyde & Company, which became the British Honduras Company in 1860, and the Belize Estate and Produce Company (BEC) in 1875, owned over one million acres in Belize, or about one fifth of the entire country (Leslie 2002). The BEC owned about half of the privately held land in the colony, and was the main political and economic power in Belize for over a century (Bolland 1986). This "forestocracy" controlled the legislature and finances of the colony, along with a small number of merchants who controlled other major imports and exports (Peedle 1999, 29).

One of the many results of the BEC's huge ownership was poor forestry practices, which affected the country's economic stability. Proper forest management was not employed, resulting in trees simply being cut and shipped, without being replanted. With no new trees ever planted, the loggers had to move deeper inland to find trees (Leslie 2002). The lack of a road network limited their reach, as did the rugged terrain of the Maya Mountains in the western part of the country. Fortunately, they did not clear-cut timber, but selectively harvested the logwoods and hardwoods, leaving much of the forest canopy intact (Barry and Vernon 1995). Due to the fact that logging companies virtually controlled the economy, the colony became dependent on the mahogany trade to the extent that when the price began to fall, the entire economic and social life of Belize was affected (Leslie 2002). The Baymen left behind a dual environmental legacy: while the logging industry leveled most of the hardwood growth

and violated all but the most inaccessible primary forests, the loggers also relied on the waterways to float felled timber to the coast, rather than creating an extensive and road system, leaving much of the country relatively untouched by modern development (Barry and Vernon 1995).

The campaign against colonialism began in 1950, but it was not until 1964 that Belizeans gained self-government. Finally, on September 21, 1981 Belize became an independent nation- the second of their celebrated Independence Days (Leslie 2002). There are currently two main political parties in Belize: the People's United Party (PUP) and the United Democratic Party (UDP). The PUP was the first elected party in Belize and promoted trade with the U.S. as the natural trading partner of Belize, rather than Britain (Peedle 1999). Initially, the PUP frowned upon the tourism industry and discouraged its development (Barry and Vernon 1995). In contrast, when the UDP gained control of the country in the 1984 elections, they were committed to deregulation, uncontrolled foreign investment and neoliberal economic policies including the privatization of public corporations and agencies. The UDP, a right-of-centre and pro-U.S. free market economics party, was the first Belizean administration to focus on tourism (Mowforth and Munt 1998). When the PUP returned to office in 1989, they promoted the industry while placing an increased emphasis on ecotourism (Barry and Vernon 1995). After losing to the UDP in 1993, the PUP has retained control since the winning the 1998 and 2003 elections, with Said Musa becoming

Belize's third Prime Minister. According to the Belize State of the Nation Address for 2003, by re-electing the PUP the country gave a strong mandate for continuity and sustained growth and development (Musa 2003).

Colonialism in Belize created a pattern of underdevelopment and dependence on forestry exports and the importation of goods instead of developing the land (Leslie 2002). After gaining self-government there was a change in land use and an economic shift away from forestry practices towards agriculture and crop production. New laws regarding land distribution made it possible to distribute over 200,000 acres to Belizean farmers between 1971 and 1975, and another 325,000 acres redistributed between 1975-1985. The land distribution has contributed to an increase in agricultural development for both export and small farming. Under colonialism, Belize was only allowed to trade with Britain, though now the United States has become their major trading partner. Presently, the majority of exported products from Belize are raw products, while most of the imported products are manufactured, and are more costly than the raw materials Belize is exporting (Leslie 2002). The costs of importing foodstuffs from Britain and the United States keeps the cost of living high and the price of everyday commodities out of reach of the average Belizean (Setzekorn 1981).

5.2 Current Economics of Belize

In Belize, the principal economic sectors and major foreign exchange earners are currently, 1) agriculture, 2) manufacturing, which primarily includes agro-products such as sugar and citrus products, and 3) services, which includes primarily tourism (Figure 18) (Belize Government 2004a). The agricultural sector also includes forestry, livestock products and mining; the manufacturing sector also includes food products, beverages, textiles, clothing, footwear, electricity and water; the services sector also includes wholesale and retail trade, general government services, transportation, communications, telecommunications, real estate, hotel, restaurant, community, social and personal services (BELTRAIDE 2004). Because the services sector has several categories, I cannot tease out the exact numbers to account for tourism's fiscal impact. While the Government of Belize recognizes tourism as driving the growth of the services sector, and of the country (Belize Government 2004a, Musa 2004a), I cannot isolate tourism's exact contribution and have relied on the Government of Belize's statistics regarding tourism.

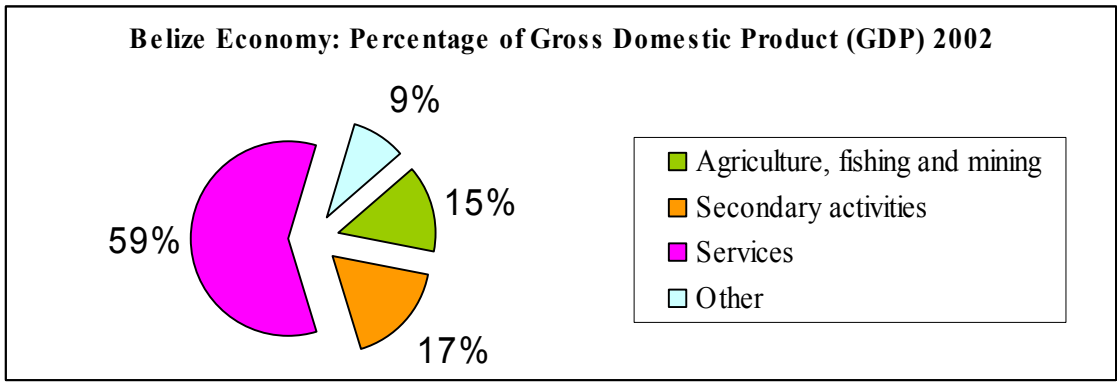

Figure 18. The contribution of Belize's principal economic sectors (agriculture, secondary activities including manufacturing and services, which includes tourism) to the Gross Domestic Product (GDP) (IMF 2004).

Belize's relies heavily on the exportation of its products. Currently, sugar, citrus and bananas account for at least 60% of the earnings accruing from merchandise exports, with marine products and small manufacturing contributing as well (Belize Government 2004b). Agriculture provides some 71% of the country's total foreign exchange earnings, and employs approximately 29% of the total labor force. Although about 1,998,230 acres of land or 38% of the total land area is considered potentially suitable for agricultural use, only 10% to 15% is in use in any one year. About half of this is under pasture, with the remainder in a variety of permanent and annual crops. Coastal extractive industries, including Belize's fishing industry, exported U.S. $12.15 million of marine products in 1996 (Belize Government 2004b).

The threat of future, increasingly global, free trade agreements may significantly alter the country's economic agenda because of their dependency on external support

(Peedle 1999). U.S. free trade agreements have the potential to undermine Belize's niche in the U.S. market, especially for sugar and citrus. Currently, significant proportions of the exported products are sold under preferential arrangements, which ensure that Belize receives a significantly higher price for its exported goods than world market prices (Belize Government 2004a). With the move toward free trade, these arrangements can be deemed illegal, and the Government of Belize would then have to phase out these special export arrangements with the U.S., Canada and Europe. Neither the government nor the private producers in Belize can compete in the open world markets against larger exporters such as Mexico and Brazil, as they undermine Belize's place in the market for sugar and citrus predominately (Peedle 1999, Barry and Vernon 1995).

Indeed, during the 2004 Belize State of the Nation Address, Prime Minister Said Musa bluntly pointed out the serious financial constraints of the country (Musa 2004a). Trying to counter the "continuing shock of the dismantling of the preferential access to industrial countries for . . . traditional agricultural commodities like sugar and bananas . . .", Belize is developing a macro-economic and budgetary strategy (Musa 2004a). Even with the positive growth trends and increased export volume of the transitional agricultural sector, the prices received for these commodities are reduced in the global marketplace (Musa 2004a). The government of Belize recognizes it is compelled to

diversify the range of goods and services they export, now including tilapia, papaya, hot pepper and red kidney beans (Musa 2004a).

The erosion of the preferential market access upon which the Belizean sugar industry is dependent, may result in potentially devastating consequences for Belize's sugar industry as well (Musa 2004a). The anticipated reduction of price paid for the exportation of sugar has forced Belize to examine alternative options, including growing high fiber cane to produce electricity with sugar and ethanol and by-products, with the potential to transform the Belizean economy in sugar producing regions. Even citrus processing plants are diversifying into the processing of pineapple concentrate in an effort to earn more money (Musa 2004a). Therefore, with the free trade agreements lowering the price received for exported goods, I suggest that the Belizean government will likely expand the tourism sector because it has been so profitable.

5.3 Tourism

Tourism is one of the twin pillars of the Belizean economy, along with agriculture (Belize Government 2004c). In the Government of Belize's economic overview, from 1997 through 2001 tourism averaged 20.2% of the Gross Domestic Product (GDP) (Belize Government 2004b). In 2003, the country's economic growth in the services sector was driven by a phenomenal increase in cruise passenger arrivals (Musa 2003). Both cruise ship passenger arrivals and overnight visitor arrivals had

shown dramatic increases over the first half of 2002 (100.2% and 12.1% increase respectively) (Musa 2003). Within the investment and trade sector of the economy, most of the new companies that have obtained the status of approved enterprises during 2003 have been related to tourism, aquaculture and non-traditional agriculture (Musa 2003).

According to Prime Minister Said Musa's State of the Nation Address for 2004, Belize's growth in tourism is explosive and leads the region (Musa 2004a). During the first eight months of 2004 there was an a 14% increase in the number of hotels, a 5% increase in the number of hotel rooms, an 8% increase in overnight tourist arrivals, a 79% increase in cruise ship passenger arrivals and a 57% increase in cruise ship calls to Belize's ports. Combined with an 11% increase in the number of persons employed in the hotel industry and a US$28.5 million in new hotel investment, tourism is growing in Belize. The private sector has been increasingly investing in tourism, as evident by the substantial investments made in new destinations, new shopping areas, tour operators, land and water taxis, gift shops and entertainment facilities. The government's tourism program has stated it will continue to focus on marketing Belize aggressively, indicating that increasing the revenues earned through tourism is an economic goal for Belize (Musa 2004a).

Responsible tourism is the key guiding principle for Belize's tourism development, which refers to an ethic and a set of practices ranging from what the

government calls deep eco-tourism at one end of the scale to more conventional mass tourism at the other. Responsible tourism has been defined as a way of carrying out tourism planning, policy and development to ensure that benefits are optimally distributed among stakeholders and that tourism resources are managed to achieve optimum benefits for all Belizeans (Belize Tourism Board 2004a). The target markets include those interested in marine activities (diving, snorkeling, fishing), soft adventure (archaeology, hiking, birding, caving, natural history), as well as families, retirees, honeymooners/weddings, cruise ship passengers, gaming and conventions (Belize Tourism Board 2004a). These categories include every form of tourism, and though the Belize Government promotes a catchy name like responsible tourism and highlights soft adventure, Belize is still promoting mass tourism, targeted at everyone.

The Belize Tourism Board (2004a) sees the challenges facing Belize's tourism industry as the need to strategically ". . . develop and upgrade its product . . . maintain the pristine quality of its environment . . . market effectively to high-potential, high-yield, niche markets, and . . . to forge stronger linkages between the public and private sectors, non-governmental organizations and communities around the country." Referred to as a catalyst for economic growth, tourism is considered a national priority with public and private sectors working together towards a sustainable tourism that provides economic growth while preserving the environment (Belize Tourism Board 2004a, Belize Government 2004c). Such loaded terminology referring to the

environment as a product and a catalyst for economic growth puts tourism (Belize Tourism Board 2004a), and thus the environment, at the heart of the economic stability of Belize.

The Government of Belize's commitment to tourism is further demonstrated by their recent US$50 million dollar investment contract with the Carnival Cruise Corporation to build a new cruise port facility in Port Loyola in the Southside of Belize City (Musa 2004a, Ramos 2004a). Carnival claimed 56.8% of the cruise ship market in Belize in 2003, and overall tourist arrivals from cruises are projected to reach a record of 1 million people in 2004 (Ramos 2004a). The Belizean Government anticipates a direct and indirect increase in tourism related jobs (Musa 2004a). While we would expect Belize to make significant earning from the cruise tourists, according to Ramos, there is no hard data on how much revenue cruise tourism has contributed to Belize's economy, and industry interests and observers claim that what cruise tourists do spend leaves the country and accrues in foreign bank accounts (Ramos 2004b).

The tourism industry is currently the single largest employer and contributor to economic growth in Belize (Belize Tourism Board 2004c). Currently, 1 in 4 jobs in Belize is directly involved with tourism, as stated on the radio commercials promoting tourism, heard during field research (Belize Tourism Board 2004c). The impact of tourism and its contribution to the economic stability of Belize cannot be overlooked. Tourism is even mentioned during an Independence Day speech made by Prime

Minister Musa, commenting on the new Marine Parade Boulevard that will soon open and facilitate the thousands of cruise tourists who visit the region every week (Musa 2004b).

The country's dependence on tourism is growing, as seen in Belize's tourism statistics (Table 1). Of special importance is the increasing number of tourists arriving by cruise ship, coupled with the increase in tourist expenditures, linking the tourism industry with Belize's economic stability. As the tourism industry grows in Belize, the task for environmental decision-makers is to prevent environmental damage caused by tourism, while trying to maintain or increase its economic advantages.

Table 1. Belize tourism statistics 1998-2003 (Belize Tourism Board 2004b).

Belize Tourism Statistics

Year	1998	1999	2000	2001	2002	2003
Hotel Revenues (US$ millions)	22	24.8	28.7	33.4	30.6	N/A
Tourist Expenditure (US$ millions)	108.3	111.5	120.2	120.5	132.8	156.2
Total tourists arriving by cruise ship	14,183	34,130	58,131	48,116	319,690	575,196
Total tourist arrivals (not including cruise ships)	176,054	180,795	195,766	195,955	199,521	220,574

5.4 Environmental Impacts of Tourism in Belize

While the tourism industry is thriving in Belize, the increased numbers of tourists alter the natural environment. The greater the number of tourists, the greater the pressure on the physical environment and the greater the demand on limited resources (Pattullo 1996). As the increasing majority of tourists visit the coastal zone of Belize, increased development, including infrastructure development, is unavoidable (Auil 1998). The cayes are sought after by an array of people ranging from local fisherpeople wanting to set up fishing camps, to investors and developers eyeing the land for personal development and/or tourism (Barry and Vernon 1995). While 42% of Belize's land is legally protected, the remaining open spaces are still threatened with development (PACT 2004), and 67% of the cayes have been claimed by locals and foreigners (Auil 1998 citing CZMP 1995). Coastal and caye development often means removal of littoral forests, seagrass destruction by dredging of canals and mangrove destruction that leads to the need for artificial barriers such as seawalls (Auil 1998). Development pressures include problems from liquid and solid waste disposal, increased risk of contaminating water supplies, increased dredging, loss of habitat and increased boat activity and pollution (Auil 1998, Barry and Vernon 1995).

At a workshop in September of 2004, hosted by the Belize Coastal Zone Management Authority and Institute, stakeholders met to discuss, assess and map the direct threats to the diversity and productivity of Turneffe Atoll. The workshop

participants concluded there were four principle threats to the diversity and productivity of Turneffe Atoll including, 1) unsustainable fishing, 2) mangrove clearing, 3) overdevelopment, and 4) dredging (BCZMAI 2004c). While these are all direct threats to Turneffe Atoll, I argue that these are indirect impacts of tourism, rather than population growth or other forms of development. The high estimated population of Belize for 2004 is 272,945, indicating an estimated increase of 2.4% (CIA 2004). Compared to the estimated doubling of cruise ship passengers visiting Belize projected at 1,000,000 people for 2004 (Ramos 2004a), and the expected increase in non-cruise ship tourists above the 220,000 visitors in 2003. Tourism growth has exceeded population growth and the environmental impacts are compounded by the lack of regulation, monitoring, enforcement, land use and tourism planning and zoning for the atoll (BCZMAI 2004c).

In Belize, the responsibility for undertaking functions related to the economic development, resource and environmental management of the coastal zone is divided among numerous agencies. Multiple agencies may lead to fragmentation of management responsibility and ad-hoc decision making on development (BCZMAI 2004b). With the trend of increasing tourism, environmental protection policies for Turneffe Atoll must anticipate increased pressure and begin to create effective policy immediately.

5.5 Commodification

More tourists are now entering Belize with the expectations to spend money on vacation experiences. This form of globalization has an impact on people's daily lives through commodification, by which everything is reduced to a product to be bought and sold (Went 2000). This "omnipresent commercialization" (Went 2000, 43) means that money can be made by turning more and more things (experiences, resources, etc.) into commodities, particularly the commodification of the environment through tourism. Tourism turns places, landscapes and people into commodities, and tourists consume these elements as products. Additionally, promoting tourism globally recognizes Belizeans as owners of their country, but owners only to the extent that they accept seeing and treating their land and themselves as reservoirs of capital (Escobar 1996). Nature-based tourism taps into the experience of being in nature or witnessing a natural event, and earning money from it. If we rationalize defending and protecting nature in economic terms, then we contribute to the growing economization of lives and experiences (Escobar 1996).

I make no distinction between tourism and ecotourism because they are both industries that make money by opening up remote areas of land to tourists, thereby bringing and perhaps initiating capitalism and the commodification of natural resources, which I do not promote as a means of conservation. Tourism is a multidisciplinary subject that can be regarded as an activity, which depicts how humans interact with the

planet and each other (Mowforth and Munt 1998). Choosing to avoid academic and discipline specific definitions, tourism can be simply defined as both traveling for pleasure, as well as the business of providing tours and services to tourists (Dictionary.com 2004). However, it is not a specific definition that matters here as much as people's individual concept of what tourism and travel means to them and how they choose to enjoy their vacations. Generally, all forms of tourism can be calculated in terms of economic success, because in order to work all forms of tourism must be profitable (Sutherland 1998).

In Florida, the environmental costs of tourism on manatees may outweigh the benefits. Swimming with manatees has become the commodified experience, even though little is known about the potential impacts about this form of wildlife observation on the population (Bonde et al. 2004, Sorice 2003). As boat traffic increases in part due to tourism, there is the potential increase in pollution and destruction of seagrass beds (Bonde et al. 2004). In addition, large numbers of humans entering the water with manatees present in Florida for their personal experiences may negatively impact manatees as well. Just as the resting behaviors of bottlenose dolphins (*Tursiops truncatus*) decreases with an increasing number of boats (Constantine et al. 2004), manatees are affected by an increasing number of boats as well as humans entering the water (King and Heinen 2004). Commodified experiences may benefit

some humans because of their power to buy adventures and experiences, but the environment does not necessarily benefit.

As a new form of commodity exchange, the Belizean tourism industry has been called the new colonialism because the economy is still influenced and constructed to meet the desires of wealthy international tourists who want new experiences (Belsky 2000, Mowforth and Munt 1998). Tourism ". . . creates an economy dependent on the hyperrealist perceptions of the tourist and the fashions of the industry (ecotourism being the latest fashion), and . . . can overwhelm the local culture, driving it in directions that make it accessible only to the most wealthy" (Sutherland 1998, 104). Increasingly, local communities and their cultural and physical environments are packaged and promoted as international destinations for affluent tourists from developed, capitalist economies (Belsky 2000).

Tourism extends the consumer based lifestyle to new locales and corresponds with the frequently destructive penetration of Western capitalism into the most peripheral and remote regions of the earth (Dilly 1999). This is exemplified through the USAID-initiated Belize Tourism Industry Association (BTIA), which has been called an umbrella group that simply represents private interests (Mowforth and Munt 1998). The BTIA's website promoting the recent Belize Tourism Expo uses the slogan, "Sell the adventure!" (BETEX 2004). This reduces the environment, and the Belizean experience itself, to simply a commodified product to be sold to anyone. The tourism

industry has become an essential part of Belize's economy. One of the resulting challenges is that as it expands it will need to develop more resorts, a stronger infrastructure, including air, road and sea transportation. At the same time, tourism and the resulting development must avoid significant damage to the environmental resources that attract tourists in the first place (Peedle 1999).

5.6 Summary

Colonialism and the resulting dependency on the importation of goods have affected Belize's current economic goals. Investigating the current political and economic status of Belize reveals an increasing dependency on tourism, which in turn affects the manatees. Understanding the economic pressures on conservation will strengthen the protection recommendations because they will consider and anticipate the economics demands on the environment and therefore act in advance to protect the species' habitat.

The tourism industry, while contributing to the economic stability of the country, has associated negative environmental impacts that threaten the already vulnerable manatee populations. While tourism generates money for the country, it also contributes to the commodification of nature and the notion that a dollar value can be placed on what tourists consider nature or a natural experience. Belize's economic agenda to expand tourism affects manatee conservation because of the threat of

increased development and the associated negative environmental impacts. Tourism's significant economic impact cannot be overlooked in protection recommendations. Rather, acknowledging the importance of tourism to Belize and creating policy that considers the economic goals of the country and how this affects the protection of the manatees will be most effective. These issues must be realistically addressed in protection recommendations because of their significant impact.

6. Abundance and Distribution of the Antillean manatees (*Trichechus manatus manatus*) of Turneffe Atoll, Belize

The objective of my field research was to survey the waters of Turneffe Atoll, Belize, to record baseline data on the abundance and distribution of the Antillean manatee (*Trichechus manatus manatus*). Determining the abundance and distribution of manatees can identify areas currently most in need of legal protection (Hines 2002).

6.1 Study Area

Turneffe Atoll is located approximately 50 km from the mainland of Belize, on the east side of the Belize Barrier Reef. With a maximum width of 16.1 km, a maximum length of 48.2 km, and covering an overall area of 525 km² (Gischler and Hudson 1998), Turneffe Atoll is comprised of over 200 islands surrounding three main lagoons with several small lagoons and creeks (Figure 19). The habitat is comprised of both hard and soft corals, mangroves (*Rhizophora mangle, Avicennia germinans* and *Languncularia racemosa*) and seagrass beds (*Thalassia testudinum*, *Syringodium filiforme* and *Halodule wrightii*).

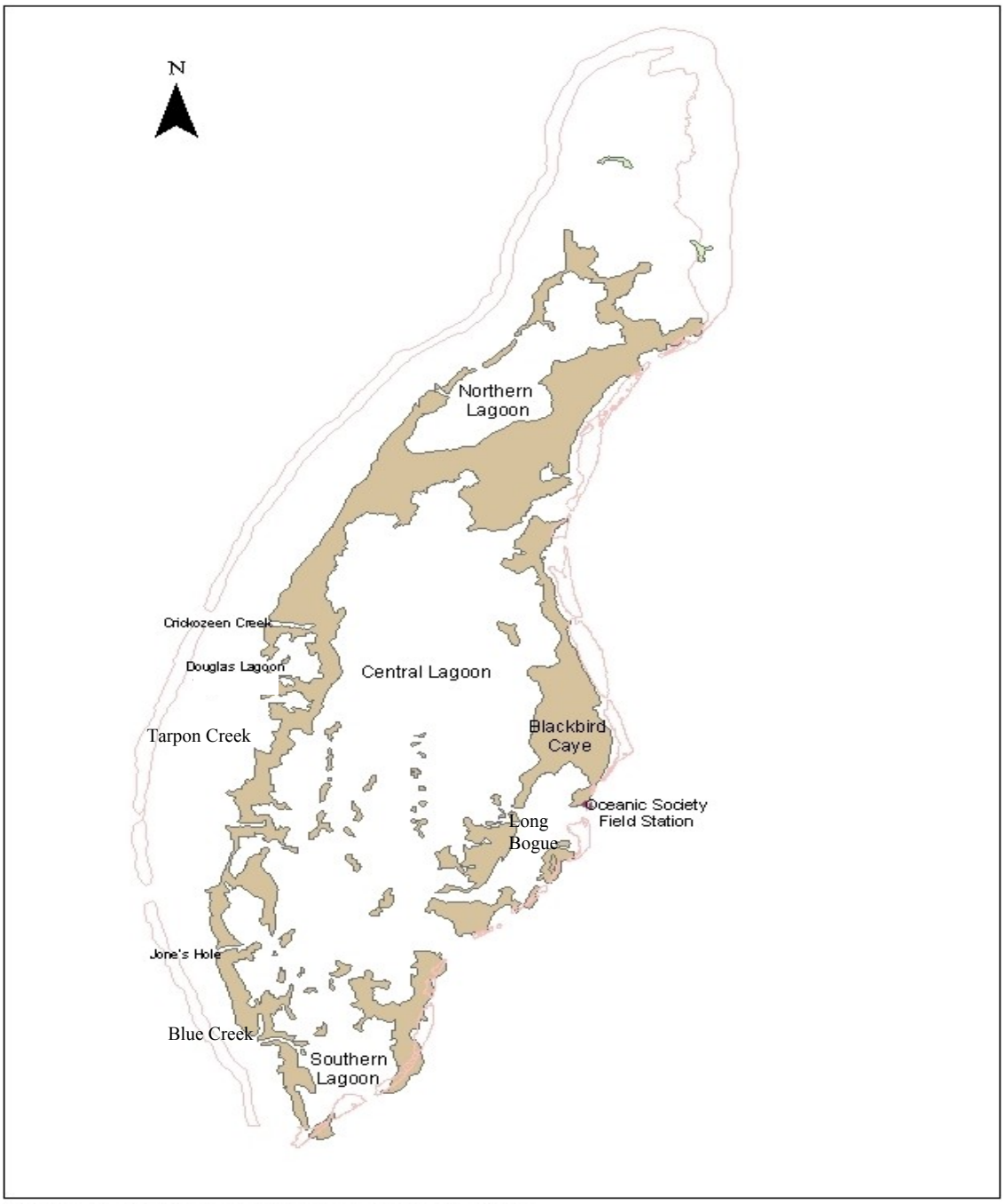

Figure 19. Turneffe Atoll.

6.2 Methods

Research was based from the Oceanic Society Field Station located on Blackbird Caye, Turneffe Atoll, Belize (Figure 20). Boat surveys were conducted throughout the waterways, driven by local Belizean boat captains. Survey destinations were determined based on, 1) previous aerial survey sightings, 2) previous opportunistic or incidental sightings recorded by other field researchers not conducting manatee research, and 3) key informants, including boat captains and fishermen, describing where manatees had been historically and recently seen. Boat surveys took place during July 12-26, 2003, April 3-10, 2004 and July 10-31, 2004 from a 26-foot skiff equipped with outboard engines.

Figure 20. Oceanic Society Field Station located on Blackbird Caye, Turneffe Atoll, Belize (Printed with permission- Hines 2004).

Boat scanning techniques differed between large and small locations due to the area of water visible at one time. In smaller locations (small lagoons, holes and creeks) we were able to see the entire area at one time. This allowed us to performed 20-30 minute scans with the motor off, confident that if a manatee had broken the surface to breathe we would have detected it. In larger locations (Central Lagoon and areas within the reef but just outside of the mangroves), the area is so great in size that we could not see the entire location at once. We investigated larger areas traveling very slowly, scanning in all directions. Boat speed was below 8 km/h when scanning, and we often took advantage of the wind patterns by shutting off the engine on one side of a lagoon to drift to the other side so as not disturb the animals, as well as to reduce noise and diesel fuel pollution. During the second week of surveys in July of 2003, the poling technique was applied, using a 20-foot pole to push our way through shallow areas.

Visually scanning for manatees took place in the boat at all times, as we did not enter the water in the presence of a manatee. Scanning for manatees involved looking for a manatee through the clear water, seeing a nose break the surface to breathe and seeing their back or tail above the water during a rolling dive. Additionally, we scanned for a manatee footprint on the surface of the water indicating a manatee was just below the surface, altering the pattern of the water above it. When manatees were identified from the boat, data were collected including exact GPS location, time of sighting, boat activity (motoring, anchored, poling or drifting), behavior (feeding, resting, breathing,

traveling towards or away from the boat), the number of animals and length of sighting-ranging from an initial sighting to two-hour long feedings. Boat surveys included 32 half-day expeditions each lasting approximately three and a half hours and 6 full-day expeditions lasting approximately 7 hours.

Environmental data were collected randomly during the boat surveys, as well as immediately after a manatee had been spotted. These data include water temperature, water salinity, water depth and Beaufort readings (ranging from calm, glassy water to small, white-capped waves). As a field researcher for the Oceanic Society, I had volunteer participants assist me in searching for manatees, after training them in the proper procedures. Volunteers helped scan the water for manatees, allowing us to survey in all directions, and assisted with environmental data collections including water salinity, temperature and depth.

The aerial survey took place on April 2, 2004 from a Cessna aircraft provided by the Lighthawk Foundation and piloted by an affiliated volunteer pilot. Joining me for the aerial survey were Nicole Auil and Angeline Valentine both of the Belize Coastal Zone Management Authority and Institute's Manatee Programme, and Dr. Ellen Hines of San Francisco State University and the Oceanic Society. We began at the northwest side of the atoll and flew in zigzag strip-transect lines from the surrounding coral reef to the lagoons inside, down to the southern tip and up the eastern side to Blackbird Caye.

The side door was removed for better viewing, and when manatees were seen our location and the number of animals were immediately recorded.

Several factors limited and biased this investigation: 1) The inherent bias in this investigation is my goal to protect the manatees and their habitat. The mere fact that I see a need to investigate and protect manatees has not been addressed, but rather it is assumed that we should protect and increase the populations of vulnerable species. 2) Boat research was often limited by availability of fuel. Fuel was purchased once a week from Belize City and rationed during the week. The high cost of fuel (over US$4) always demanded fuel economy. 3) The health and comfort of my advisors and volunteer participants was a priority, and on four occasions, boat surveys were ended early due to sickness. 4) Volunteer participants significantly funded this research through the Oceanic Society, and therefore volunteer participants expectations were also a priority. Investigation locations were occasionally altered in favor of areas with a higher probability of seeing a manatee, if their expectations had not been met by the end of their stay. 5) Because volunteer expectations were a priority, some locations were surveyed more often than others because of their higher probability of a manatee sighting. Therefore, each sighting does not necessarily indicate a different manatee. The same manatee may have been recorded more than once at different locations or at different times. 6) My own unfamiliarity regarding travel routes around atoll and boat driving forced me to rely heavily on the experience of the boat captains. Locations for

investigation were decided upon in conjunction with boat captains there may have been areas of the atoll that were unintentionally overlooked due to their natural biases as well. While these limitations are important to express, the integrity of the research has been upheld.

6.3 Results

Combined boat and aerial surveys as a result of this research recorded a total number of 23 manatees. Figure 21 depicts the sightings recorded during this research investigation as well as previous aerial surveys conducted by Dr. Ellen Hines and Julie Robinson in 2002 and by Dr. Ellen Hines, Julie Robinson and Angeline Valentine in 2003, as well as opportunistic sightings reported to the researcher.

Water temperatures for all collections ranged from 27.8°C/ 82°F – 32.9°C /91°F and typical salinity readings ranged from 34.2 ppt – 37.6 ppt. The depth ranged from 1.6 m – 5.7 m, and Beaufort readings ranged from 1– 2, though typically the water surface was smooth. Though the tidal range in Belize is small, 0.5 m – 0.8 m (Eden and Holtermann 1998), I included tidal information because it may be an important factor for locating manatees. For instance, during low tide, some areas may be too shallow for manatees. In addition, it is not well understood if there is fresh water lens on the surface of the water drawn from perhaps the mangroves or unidentified point sources,

detectable during an outgoing tide. Table 2 details the environmental variables recorded at each boat sighting location.

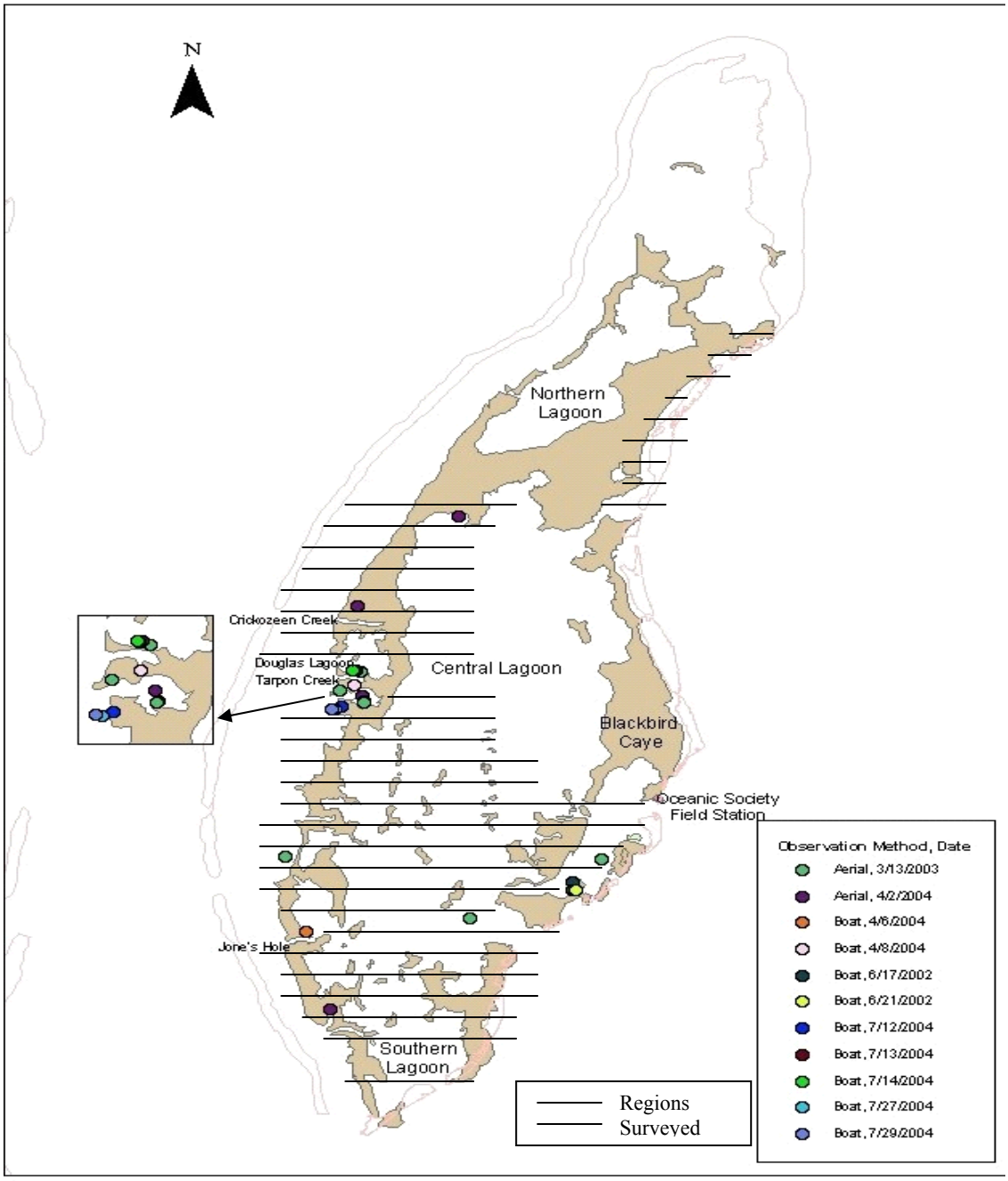

Figure 21. Manatee sighting locations and regions surveyed at Turneffe Atoll, 2002-2004.

6.3.1 Boat survey results

Boat research recorded a total number of 16 manatee sightings. Between July 12-26, 2003, there were twelve days of boat surveys for a total of 43 hours and 39 minutes of field effort. A total of nine manatees were identified during five separate sightings at three different locations. A manatee was spotted three times at the same location of Blue Creek, located on the southwest side of the atoll, but it could not be determined if it was the same manatee each time. Our longest sighting lasted over 2 hours and consisted of two feeding manatees; however, a maximum of four manatees were seen together in Douglas Lagoon. The last sighting is incomplete and lacks GPS data because the GPS was stolen before the information could be retrieved.

During April 3-10, there were five days of boat surveys for a total of 14 hours and 35 minutes of field research. A total of four manatees were identified including a calf during two separate sightings at two separate locations. Three manatees, including the calf, were found feeding in Jone's Hole on the southwest side of the atoll. With the motor off, we spent a total of 50 minutes in their vicinity. We were in the presence of a manatee in Douglas Lagoon, where we saw the turbid water patch indicative of a manatee feeding, but the manatee fled.

During the July 10-31, 2004, boat surveys there were a total of 6 manatees, each recorded individually at three different locations. Manatees were twice seen near Bird Caye feeding on manatee grass (*Syringodium filiforme*), on the west side of the atoll.

Three manatees were individually seen in Douglas Lagoon, and one near Tarpon Creek. Due to fuel shortages, we did not survey the Northern Lagoon.

6.3.2 Aerial survey results

The aerial survey took place during the morning of April 2, 2004, departing from the Municipal Airport in Belize City. Our survey lasted just over two hours on a clear day and we flew an average altitude of 168 m and traveled between 128-160 km/h. We spotted 7 manatees, including a cow-calf pair near Douglas Lagoon, and two manatees occupying different locations in Crickozeen Creek.

6.3.3 Fresh water

During the April 2004 boat survey we encountered very clear, red brickish colored water during the lowest tide of the day. We were informed by our boat captain that this was fresh water. Salinity readings were as low as 16.4 ppt within one inch of the water surface, yet still 37.8 ppt further below the surface. During the July, 2004, field season I surveyed the atoll for fresh water locations over one and a half days. Most freshwater locations appeared to be on the northeast side, though fresh water was locally reported to me by key informants to be found all around the atoll as a fresh water lens especially detectable during low tide. During the fresh water surveys,

salinity reading ranged from 12.5-35.2 ppt, tested at seven different locations (Figure 22).

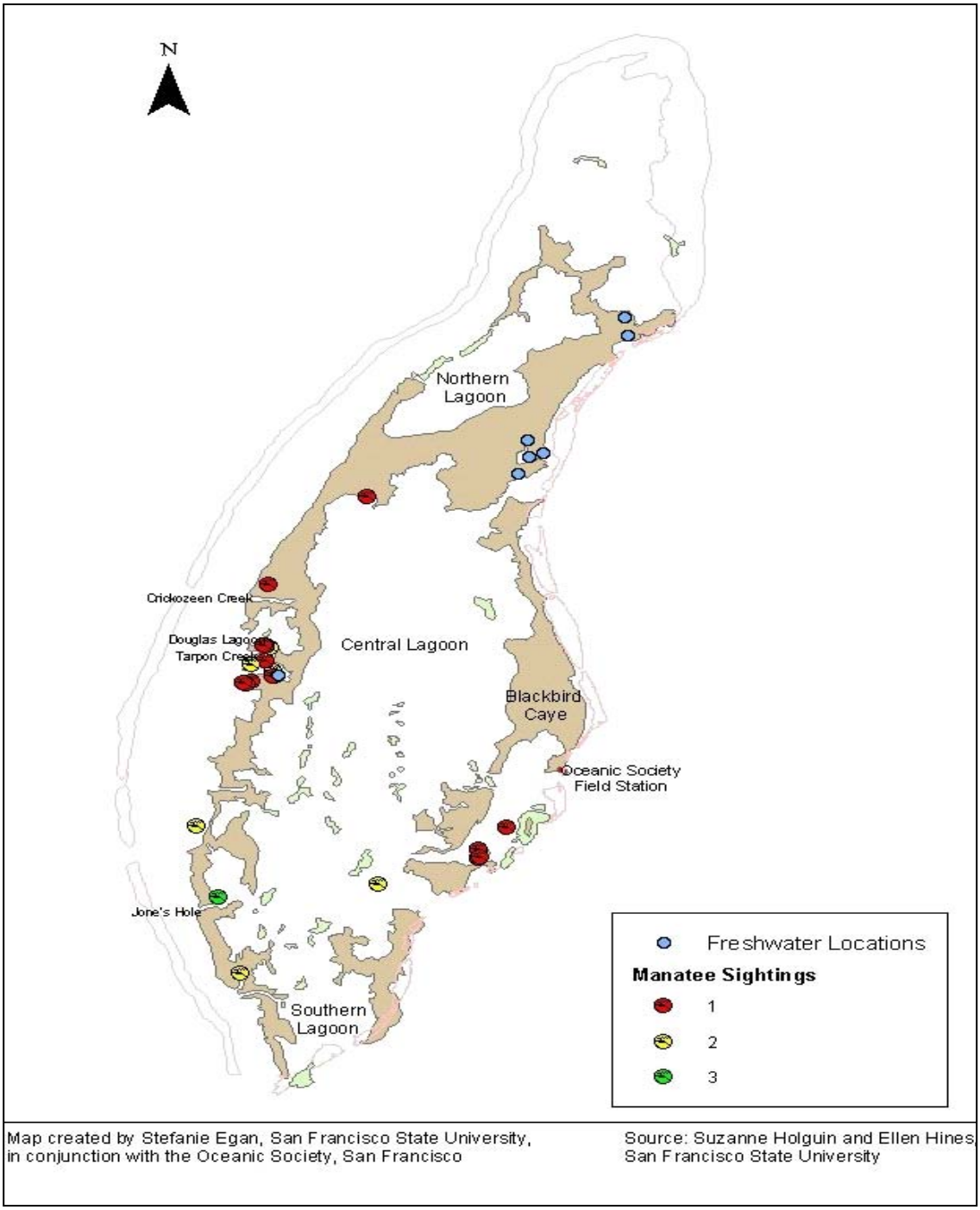

Figure 22. Fresher water locations at Turneffe Atoll

6.4 Discussion

This research marks the beginning of baseline data collection of manatees at Turneffe Atoll. Surveying over 500 km² is a daunting task, and without prior experience on Turneffe Atoll my investigations were influenced by the experiences of others (advisor, boat captains and participant needs).

The number of manatees seen at Turneffe Atoll is low, though the reasons why are not clearly understood. Perhaps it is a migratory population, a resident female population visited by migratory males, a small male and female population or a larger population than these data suggest, among other undetermined reasons. The ample seagrass beds do not suggest food sources are a limiting factor, however ample seagrass beds exist on the west side of the Belize Barrier Reef and are closer to known freshwater sources, which may affect manatee location choice.

The distribution of manatees at Turneffe Atoll is scattered and unevenly distributed, though certain areas have had repeated manatee sightings. Several manatee sighting on the west side of the atoll suggest that the manatees may be traveling to Turneffe from another location, perhaps from the mainland lagoons, coastal cayes or even Chetumal Bay in Mexico. The distribution of manatees in the Central Lagoon of the atoll may have been larger, but the area is so great in size that boat surveys are inefficient. Similarly, boat surveys to the Northern Lagoon require greater fuel expenditures due to the few entrances, which make circumscribing the entire Northern

Lagoon necessary. Though the distribution is scattered there is a trend towards high use in the Douglas Lagoon region that requires protection from increased boat traffic and development. Because boat traffic typically enters the atoll from the west side heading east, the entrances on the west side require manatee protection measures, such as limited boat speeds to prevent collisions and signage to display restrictions and promote awareness.

The discovery of fresher water locations at Turneffe Atoll adds another dynamic to this diverse habitat that requires further investigation. Though the literature states that manatees prefer drinking fresh water, the exact reasons why remain unclear (Olivera-Gomez and Mellink 2005, Ripple 1999, Reynolds and Odell 1991). We have preliminarily determined where the manatees of Turneffe Atoll may be accessing fresh water and recommend continuing this research.

Manatees have been shown to be affected by many human activities including habitat degradation, entanglement in fishing nets, poaching and watercraft (Auil 1998). With the increasing threat of anthropogenic pressures, these data suggest that the manatees of Turneffe Atoll require protection and further investigation to determine changes in their abundance and distribution, as well as their use of the atoll. The population could be resident, or perhaps some are crossing the Belize Barrier Reef and traveling to and from the mainland lagoons and/or coastal cayes, or perhaps north to and

from Chetumal Bay where they may be taking advantage of other freshwater opportunities (Olivera-Gomez and Mellink 2005).

If the manatees are indeed traveling to and from Turneffe Atoll, then the atoll becomes an important stopover location. Tagged Florida manatees have traveled 845 km, including Chessie who swam as far north as Rhode Island and Gina who was originally tagged in Florida and now resides in the waters of the Bahamas (Sirenian International 2004b). Knowing that Antillean manatees are found as far south as Brazil, the location of Turneffe Atoll outside of the Belize Barrier Reef provides a stopover for traveling manatees. Visiting manatees may not have to cross the barrier reef while perhaps going north towards the southeastern Caribbean Coast on the Yucatan Peninsula in the state of Quintana Roo, Mexico.

Indeed, just as this thesis nears completion, a radio-tagged manatee has crossed the Belize Barrier Reef and traveled to Douglas Lagoon in Turneffe Atoll. This is the first manatee for which there is evidence of its travel across the Barrier Reef and into the waters of Turneffe Atoll. Having this evidence signifies the need to protect the travel corridors to and from the atoll. Having proof that a manatee has traveled to the atoll suggests that others can do the same. Knowing the manatee entered the atoll from the west side headed east, it is important to extend protected areas to include travel corridors from at least the off shore cayes, though ideally from the Northern and Southern Lagoons of the mainland.

I recommend continued long-term research of the manatees of Turneffe Atoll to determine their future abundance, distribution and use of the atoll. Aerial surveys should be conducted at least once a year, and boat surveys should take place as often as is feasible. To build upon this research I recommend both returning to locations where manatees have been identified to follow up on their use of the area, as well as investigating new areas, specifically the Northern Lagoon. I highly recommend that future boat and aerial surveys include the Northern Lagoon because of the fresher water salinity readings taken near the lagoon. Investigating the atoll for fresh water sources is critical because of the important role it may play for the manatees, as well as other organisms, of the atoll. With the pressures of development threatening the atoll, the loss of fresh water sources might never be known if this research is not continued.

7. Conclusions and Recommendations

Applying the contextual conservation approach to the manatees of Turneffe Atoll has illustrated, 1) the linked habitats of the coral, mangrove and seagrass communities as they affect manatees, and 2) how the country's economic agenda to increase tourism impacts manatees. Understanding the entire system in perspective can yield the most effective conservation efforts because it realistically addresses the political and economic agenda in relation to habitat conservation. I have demonstrated the need to protect manatees in their habitats now, anticipating the pressure of development as a result of increased tourism. While manatees have been opportunistically seen at Turneffe Atoll and occasionally included in aerial surveys, this investigation initiated a systematic study devoted to recording the manatees at Turneffe Atoll. A contextual conservation approach has been necessary to comprehend the pressures on the entire system involving this population of manatees in order to appropriately recommend protected areas and guidelines.

Utilizing the contextual conservation approach has brought politics and economics to the forefront of conservation by identifying a significant pressure on the manatees' habitat: tourism. This is not to suggest that tourism has only negative impacts; rather, this research was significantly funded by small scale, research-based tourism. What contextual conservation has identified is how Belize's political and economic history as a colony has contributed to its current economic dependence on

preferential trade agreements and tourism. As free trade agreements increasingly alter previous trade relations with the U.S. and Europe by reducing the amount of money earned by agricultural exports, Belize will likely increase its dependency on tourism. Indeed, the Government of Belize intends to continue to market tourism in Belize aggressively as a catalyst for economic growth because the tourism industry has continued to grow in Belize (Belize Tourism Board 2004a, Musa 2004a). Tourism is a powerful force in Belize, and decision-making for manatee conservation should consider tourism's impact on conservation. Protection recommendations that are counter-productive to tourism policies may not be accepted by those in power if they reduce potential revenues. With the developmental pressures of tourism on the undeveloped and unprotected areas of Belize, Turneffe Atoll in particular, policy makers must create effective protection areas that allow entire habitats to thrive, including those depended on by manatees. Before the tourism industry grows any larger on Turneffe Atoll, the manatees and their habitats must be protected.

My recommendations are intended for both policy makers and researchers, acknowledging that both fields are affected by one another. In order for policy changes to take place, data from researchers must exist to support the recommendations. Similarly, the inclination to investigate and collect data regarding a specific threatened area or organism is often to change, create or facilitate policy. Recognizing the importance of tourism to the economic stability of Belize, manatee protection measures

should work with limiting the existing impacts of tourism on the atoll, rather than against it. The following recommendations are intended for those researchers, policy makers and concerned individuals who recognize the need to protect manatees and their habitat at Turneffe Atoll, Belize.

- Establish protected areas that include Douglas Caye/Lagoon, Tarpon Creek, Jone's Hole and Long Bogue as well as fresher water locations (Figure 23). These protected areas should include the linked coral, mangrove and seagrass communities that constitute manatee habitat. Protected areas should prevent all forms of further development including resorts and fishing camps, while allowing research to continue. Protected areas should be indicated with signs to both limit boat speed to 15km/h and increase awareness (GBRMPA 2004).
- Protected areas should extend west of the atoll to include travel corridors for manatees crossing the Belize Barrier Reef. With the evidence of a manatee traveling to the atoll from the off shores cayes near Belize City, it is imperative that safe, protected travel routes are established so animals can continue to enter the atoll from outer areas.

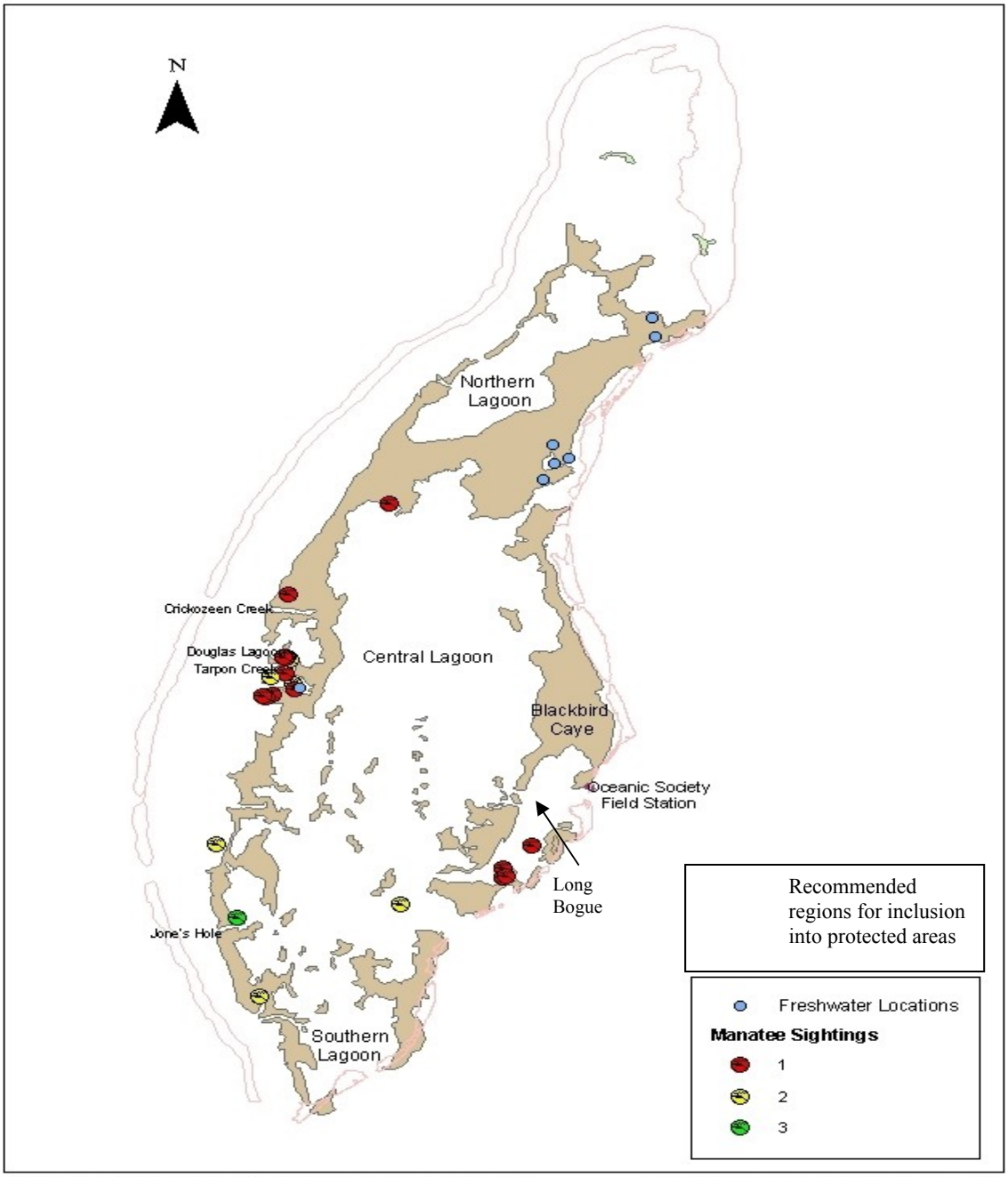

Figure 23. Recommended regions to be included in protected areas.

- If a manatee is observed, humans and boats should not advance closer than 50 m or if already closer, avoid where possible engaging the boat propeller and move away slowly. Individuals should not swim, dive or enter the water near a manatee, nor should they attempt to feed, touch or interfere with a manatee (GBRMPA 2004).
- To protect the health of manatee habitats, the growth of existing facilities should be limited and new developments on the atoll should be restricted because development will compromise the linked habitats of the coral, mangroves and seagrass, negatively affecting the food source and habitat of the manatees.
- Continue small-scale research on the manatees of Turneffe Atoll from both boat and aerial surveys. Systematic surveys of areas including Douglas Caye/Lagoon, Tarpon Creek, Jone's Hole and Long Bogue involving specific previous sighting locations should be used to provide statistically relevant data.
- Research should continue to involve key informants from the local community to, 1) increase manatee awareness, 2) inquire about where manatees have been seen, as well as, 3) assess how the protected areas might affect local livelihoods. Key informants may include those who work and/or reside on the atoll, as well as those individuals who earn money from activities involving the atoll.
- Continue to record and disseminate manatee GPS locations and environmental variables towards creating a spatially explicit Geographic Information Systems

(GIS) database and mapping system to be the data repository for future monitoring and modeling efforts.

- Additional research should be conducted to locate potential point sources of fresh water at Turneffe Atoll. Preliminary research has identified areas of fresher water near Douglas Lagoon as well as on the northeast side of the atoll, which need to be investigated further.
- Initiate and unify seagrass research to record the abundance, distribution, health and locations of the communities to be added to a GIS database and mapping system to monitor the seagrass communities over time.
- Initiate and unify coral reef research to record the abundance, distribution, health and locations of the communities to be added to a GIS database and mapping system to monitor the coral reefs over time.
- Initiate and unify mangrove research to record the abundance, distribution, health and locations of the communities to be added to a GIS database and mapping system to monitor the mangroves over time.

Each component investigated through the contextual conservation approach has contributed to my final recommendations. Specifically, studying the general biology of the manatee has elucidated the importance of adult survivorship at it reflects population growth, due to their low reproductive potential (Boyd et al. 1999, Reynolds 1999,

Marmontel et al. 1997). In addition, previous research on manatees in Belize has indicated that the population does not appear to be increasing (Auil 2004). My field research regarding the abundance and distribution of manatees at Turneffe Atoll suggests that the while the number of manatees using the atoll may be low, the distribution has shown a trend towards high use in the Douglas Lagoon region. Combining this information demonstrates a need to protect the manatee population from decreasing, and I recommend enacting legal protected areas for the manatees of Turneffe Atoll.

My investigation of the biogeography of Turneffe Atoll as a component of contextual conservation has also contributed to my recommendations. This approach has illustrated the linked habitats of the coral, mangroves and seagrass communities as dependent upon one other as well as susceptible to similar threats including development and the resulting pollution. These habitats consist of both specific food sources for the manatee and the environment necessary for that food source to grow (Garshelis 2000). The contextual conservation approach has identified the linked manatee habitat and therefore, protected areas for manatees at Turneffe Atoll should include coral, mangrove and seagrass communities.

The contextual conservation approach has examined the politics and economics of Belize as they affect manatees. Indeed, through this approach I have identified that tourism is a significant pressure on the manatees' habitat. As the country continues to

promote tourism as a potential catalyst for economic growth, I recommend that policy-makers anticipate the expected growth for tourism and create protected areas for manatees immediately.

The contextual conservation approach has elucidated the need to address conservation from different disciplines and different scales. Each component of contextual conservation, from the biology, the biogeography and the politics and economics, has addressed both what factors are involved and influencing manatee protection, while concurrently implying effective protection strategies. Having not developed this approach I might only offer recommendations reflecting where manatees have been seen without addressing what constitutes manatee habitat and why it is threatened with degradation. Instead, I have a more complete understanding of the manatees of Turneffe Atoll in relation to their environment and how they are impacted by the political and economic agenda of Belize. Through the contextual conservation approach I have developed a holistic method of inquiry that maximizes the scarcity of data available to create sound recommendations on which to base protection policies.

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