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Cuban Coral: An Analysis of Environmental Policy, Conservation Practices, and Sustainable Development

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Cuban Coral: An Analysis of Environmental Policy, Conservation Practices, and Sustainable
Development

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ABSTRACT

Cuban coral reefs have been well-preserved due to a global economic embargo over the past sixty plus years, as well as strict environmental policies and goals implemented by the Cuban national government. This thesis examines sustainable natural resource management in the context of coral reefs in Cuba, studying the importance of reef ecosystems to the economic and ecological health of local communities as well as the strengths and weaknesses of environmental policies implemented by the Cuban government. As the U.S. embargo on Cuba begins to lift, there will be a dramatic increase in tourism and foreign industry into Cuba, bringing with it a host of environmental concerns. Australia, the Bahamas, and the Philippines are used as case studies to examine the relative successes of various environmental management strategies with each country receiving a numerical ranking based on a variety of criteria. Using the results of this ranking, a set of recommendations are made for Cuba to consider in order to best preserve the quality of the country's coral reefs while still allowing for economic growth and development.

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1. INTRODUCTION

A coral reef is the embodiment, the physical definition of a tropical paradise – the image of sparkling turquoise light, filtering in loose waves through schools of rainbow-shaded fish, that drift, then dart through a stone forest of pinks, blues, yellows and greens. Even those shimmering, white-sand beaches are products of this underwater world. Yes, the coral reef is paradise.

Flip this image then. Shattered pieces of gray and brown coral lay ruined on a dirty sea floor. The few creatures brave or resilient enough to stay have exteriors that match their drab, polluted surroundings. It is no longer sunlight that slips its way through the water, but plastic particles, strips of trash, and the oily residue of passing freight ships. This destruction is solely human-caused.

It is the latter of the two descriptions that is becoming more and more synonymous with coral reefs. As the world's population grows in size, demands, needs, and consumptive tendencies, so too grows the emission of carbon dioxide and other greenhouse gases. Human waste becomes an ever greater threat to delicate coral environments, and as anthropogenic climate change takes a stronger hold on the earth, the resulting consequences begin to manifest themselves in increasingly dramatic ways. Human development along coastlines, and the steady growth in demand for fishing, tourism, and commercial shipping have their own destructive impacts on coral reefs worldwide (Burke et al., 2011).

What is often unrealized about the picturesque beauty of the coral reef is its importance to both the ocean's ecosystems and health, as well as to the coastal-dwelling populations of humans whose livelihoods are dependent upon the various benefits and services the reefs provide. With millions of people residing in close proximity to reefs, and reliant in ways both direct and indirect, the preservation and sustainable management of coral reefs is an issue of critical importance to the future of many nations (Burke et al., 2011).

The concept of sustainable development has become a phrase synonymous with a multitude of environmental, social, and economic practices, designed to protect and preserve resources for the use of future generations. This concept, within the context of natural resource management, has taken on new

importance over the last several decades, mirroring the increasing global awareness of anthropogenic climate change. Within countries small or large, industrialized or undergoing development, the sustainable management of natural resources is a strategy that may be applied universally (WCED, 1987). This thesis seeks to examine various theories of sustainable resource management, applied specifically in the context of coral reef management.

One of the strongest examples of sustainable resource management of coral reefs is found in Cuba. A nation with a rich history of political, social, cultural, and environmental oscillations, Cuba's approach to conservation, environmental protection, and sustainable economic growth is both unique, and largely successful (Cabello et al., 2012). Despite a severe economic crisis, initiated by the collapse of the Soviet Union in 1990, Cuba has implemented and enforced strict environmental laws and regulations. Furthermore, the country strives to promote the ideas of sustainable development and environmental protection throughout both its government, and its citizens (Evenson, 1998).

Cuba's coral reefs are areas of vast ecological beauty. Considered to be among the better preserved reefs of the Caribbean, Cuba's successful ecosystems may be attributed to a wide variety of factors, including the economic isolation brought on by the U.S. embargo of 1960, and the strict policies enacted by the Cuban government to work to protect the reefs and their surrounding ecosystems (Wilkinson, 2008). As the U.S. embargo continues to lift, however, and Cuba continues to reestablish or strengthen ties with other countries, the potential for dramatic economic and social change is high. As such, Cuba represents a fascinating example of the potential of environmental planning to successfully achieve a balance between economic development and environmental protection (Cabello et al., 2012). In short, Cuba's coral reefs are a living example of the strengths of ongoing sustainable development.

This paper will introduce the concepts of sustainable development and describe the challenges and consequences of global climate change on delicate ecosystems. Next, it will examine the importance of coral to global and local ecosystems and economies, taking a thorough look at the issues threatening the health of coral worldwide. The paper will then focus on Cuba's approaches to climate change, the health and importance of coral, and possibilities of sustainable development in its efforts to sustain its

coral reefs. This information, including a comprehensive review of the methods used in this paper, strive to answer the following question:

How has Cuba implemented the goals of sustainable resource management for their coral reefs, and how should the country's environmental policies evolve to meet the future ecological, sociopolitical, and economic needs of both the country and the coral?

Finally, there will be a discussion section, including recommendations that compare the case of Cuba to other coral systems around the world and suggests courses of action to preserve Cuba's coral reefs, even in the face of a changing economy, society, and government.

2. BACKGROUND

2.1 Sustainable Development

Sustainable development is a vast, oftentimes all-encompassing term that is used to describe everything from access to clean water, to environmental regulations, to microfinancing. It covers the social, political, economic, environmental and cultural aspects of any society. With such a broad foundation, this can be an ideology that is difficult to understand even with a purely figurative perspective, let alone to conceptualize within the parameters of a real-world situation. It is the Brundtland Report of 1987 that best defines and describes this in a way that may be not just talked about, but applied.

Sustainable development is “development that meets the needs of the present without compromising the ability for future generations to meet their own needs” (WCED, 1987). There, written in a single line is the ultimate challenge. How does a society fulfill their own needs and goals in the present, without denying future generations a chance to make and succeed at their own goals? It is this question, among others, that is examined throughout this discussion.

The topic of sustainable development is often applied in the context of less developed, or non-industrialized countries, and it is important to understand the definitions of these terms. Less developed countries are nations in which a great percentage of the overall population “experience[s] great difficulties in meeting material needs” (Baker, 2013). These material needs include food and shelter, education, health care, or even physical security. Frequently classified through their respective gross domestic products (GDPs), countries undergoing “development” are in the process of shedding the aforementioned deprivations (Baker, 2013). It must be made clear, however, that GDP is but one indicator of a state’s social, economic, or cultural prowess, as will be demonstrated later on.

The goals of sustainable development may be applied to any facet of a society: education, healthcare, energy, infrastructure, and others. The management of natural resources, however, and the impacts of human resource use on the environment are perhaps some of the most interesting areas in which to examine the possibilities and implications of a sustainable development strategy. When defined in the terms of the environment and natural resources, the WCED report qualifies that sustainable

development must consider not only economic, agricultural or energy aspects of resource policy, but the ecological dimensions as well (1987). One of the key points of the WCED's most renowned definition (quoted above) is that any action taken in the present must not prohibit the success of future generations. The overexploitation of resources is a surefire method to endanger "the natural systems that support life on Earth," thus unequivocally compromising the essential needs of future eras (WCED, 1987).

Prohibiting overexploitation then begets the question of how to best manage resources. Renewable resources, or resources that are regenerative, can remain renewable so long as the rate of use remains below the rate of regrowth. For example, if fishers remove a quantity of stock from a fishery that is greater than the quantity that will be rejuvenated by the next year, then this fishery is unsustainable and will eventually collapse. If, however, the fishers remove *less* than the rejuvenated quantity (a point known as the sustainable yield), the fishery will be sustainable and available for use for generations to come (WCED, 1987). The loss of species through poor resource management may endanger a future generation. The same may be said of water, forests, or soil conditions. To put it more succinctly, resources (living or not) must not "be degraded beyond a reasonable recovery" (WCED, 1987).

The industrialized world has set a poor precedent for the management of resources, with a history of ever-accelerating rates of resource consumption to service large industry and high consumptive trends. The developing world, in comparison, has a history of resource exploitation to achieve and fulfill basic needs, including "food, fodder, fuelwood, and shelter" (Ramakrishnan, 2003). As such, it is less developed countries who, perhaps unfairly, are often the center-point of the discussion about sustainable development. Cuba, a country that has been in the throes of a severe economic crisis since the 1990s, is an excellent example of balance between meeting the basic needs of its citizens, without sacrificing commitment to long-term sustainability (Wiskind, 2007). The case of Cuba is discussed in greater detail later in this report.

2.2 Climate Changes All

Though there have been a multitude of factors that have influenced the steadily accelerating global movement towards sustainable resource management, one of the greatest catalysts has undoubtedly been anthropogenic climate change. As consumption and industry grow across the world, so too grows human emissions of carbon dioxide and other greenhouse gases. The increasing concentrations of carbon dioxide in the atmosphere, coupled with the planet's greenhouse effect (absorbing and reradiating surface heat back down to Earth) has resulted in a steady increase in global temperatures. These gradual temperature increases have resulted in a wide collection of changes in global climate and adjustments in everything from ocean temperature, to drought patterns (IPCC, 2014).

Though every ecosystem reacts with varying degrees of resilience to a changing climate, it is the most fragile that can carry the most profound messages about the implications of unchecked human resource use. Ramakrishnan asserts that climate change has been the trigger in moving international focus from limitless economic development, to the sustainable management of natural resources (2003). The principles of sustainable development provide "a useful framework" for the creation of strategies to preserve and manage natural resources.

2.3 The Complexity of Coral

Part of the quintessential beauty of a coral reef are the bright colors, juxtaposed with clear blue water, teeming with life in every size, shape, and shade. Indeed, coral reefs are one of the most "productive and biologically rich ecosystems on earth" (Burke, Reytar, Spalding & Perry, 2011). Approximately 25% of the world's marine species reside in the 250,000 square kilometers of coral reef that stretch across the globe. It is not just the organisms that reside among the coral structures that breathe; the coral itself is a living creature. Residing in compact colonies, these identical, yet individual animals (known as polyps) "secrete calcium carbonate to form a hard skeleton," thus creating the physical structure of the reef. Coral's bright colors stem from the symbiotic relationship shared between the polyps and the algae that reside within their tissues, known as zooxanthellae (Burke et al., 2011). Built upwards

from the sea bed over the centuries, these unique structures may only be found in a narrow band of tropical oceans. Because of the specific conditions needed for coral to grow successfully, coral reefs are among the most “sensitive of all major ecosystems on Earth to climate change,” and other local and global threats (Burke et al., 2011).

2.4 Threats to Coral Reefs

Indeed, the current global situation for coral is a gloomy one. Over 60% of reefs on the planet are “under immediate and direct threat” from multiple sources (Burke et al., 2011). When discussing the threats to coral health, it is important to make the distinction between the two primary categories of threats: local, and global. Local threats originate from human activities and practices that occur in close proximity to the reef. These threats have a “direct and relatively localized impact,” and include dangers such as overfishing, and coastal development. Global threats are indirect, affecting reefs through “human impacts on the global climate and ocean chemistry” (Burke et al., 2011). These threats include warming sea temperatures, and ocean acidification (both consequences of anthropogenic climate change) (Wilkinson, 2008).

2.4.1 Local Threats

Of any local pressures, overfishing is “the most pervasive, immediate threat,” with an 80% increase in the threat level since 1998 (Burke et al., 2011). This growing threat is largely due to increases in coastal populations residing in close proximity to reefs. As human populations increase, so too does the efficacy of fishing methods, and the tourist demands for access to the reefs. Within the global fishing market, there is high demand for the top (apex) predator of the reef, or the largest herbivore within the ecosystem. Removing these species from any ecosystem causes disruption throughout the entirety of the system. Known as a trophic cascade, the removal of the top predatory species means that there is no longer any form of population control for the prey species (small herbivores and algae), which results in an overpopulation of smaller herbivores within the reef (Burke et al., 2011). Coral reefs are dependent

upon the larger herbivores to keep the algal populations in check. Without these species, the algae may take over the coral (Wilkinson, 2008).

Similarly, destructive fishing techniques can be devastating to the health of a coral reef. Dynamite or poison fishing, used in several less developed countries can leave reefs unrecognizable (Wilkinson, 2008). Gill nets, or trawling nets, dragged along the bottom, flatten delicate corals, and pick up not only their intended prey, but juvenile fish, and unwanted or noncommercial species too (Burke et al., 2011).

Coastal development, another correlation of increasing population growth, can have far-reaching consequences for reef health. Among the first of the damages inflicted upon the reefs is the direct physical damage from dredging or filling in shallow reef areas to create new lands for development. The removal of coastal vegetation, such as mangrove forest and seagrass meadows, endangers the species within the reef, as well the coastal infrastructure and geography. Coastal vegetation provides a critical sediment trap that serves as protection against erosion and other damages “to nearshore ecosystems” (Burke et al., 2011).

There are a host of indirect consequences from coastal development, including increases in sediment runoff, pollution, and sewage. Of any listed, the latter is “the most widespread pollutant” in coral reefs (Burke et al., 2011). The high nutrient content within the often untreated sewage abets algae blooms that in turn encourage the “growth of seaweeds that compete for space” and resources on the reef (Burke et al., 2011). In addition to sewage, other pollutants originate from industry, agriculture, and common infrastructure, such as houses and parking lots.

Pollution, however, does not only originate from coastlines. Threats to coral reefs can stem from inland human activities such as agriculture, or animal husbandry. Over 130 million tons of fertilizer and pesticides enter global ocean-bound waterways each year, depositing massive concentrations of chemicals and nutrients into the seas. The inundation of nutrients into coastal waters creates massive algal blooms that outcompete the local corals. This problem is further exacerbated by the overfishing of any herbivorous fish large enough to keep the algae in check. Dead zones (areas of the ocean completely

devoid of marine life) are created when these massive, yet temporary algal blooms die and sink to the bottom, sucking any oxygen out of the water as they decompose (Burke et al., 2011).

Furthermore, there is a plethora of marine-based dangers that originate from oil and gas toxins, industrial shipping practices, and the physical damage of boats and freighters. Across the world on a daily basis, “thousands of commercial, recreational, and passenger vessels” move through or near coral reefs (Burke et al., 2011). These vessels may leave contaminated bilge water, fuel, or even raw sewage in their wake, consequences of leaky, inadequate, or poorly maintained or designed storage systems. In conjunction with leaking contaminants, the physical damage these ships may wreak upon the coral reefs is profound. Damages from groundings, or anchor placement can be severe, and invasive species, such as the Indo-Pacific Lionfish are often unknowingly transported on the base of vessel hulls (Burke et al., 2011).

Finally, tourism is classified as a local threat, due to the surfeit of consequences that often accompany increases in this industry. The hotel and vacation industry like to seek out places that have been previously unexplored or untouched, leading to higher levels of waste that correlate with increases in construction. Increases in coastal tourism leads to an increase in demand for local seafood, and inattentive, or ignorant site-seeing tourists can break or trample the fragile coral ecosystem (Burke et al., 2011).

2.4.2 Global Threats

Anthropogenic climate change is the product of increasing human emissions of carbon dioxide in the atmosphere. As these concentrations increase, so too does the atmospheric temperature. This, in turn, leads to an increase in sea surface temperatures, known as thermal stress (Burke et al., 2011). The fragility of coral reef systems, and the specificity of conditions on which their survival depends can make even small increases in average water temperatures catastrophic (Wilkinson, 2008). Warmer waters cause a phenomena known as coral bleaching, or the mass extinction of the zooxanthellae algae that live within the coral tissues. These algae are the organisms that provide the coral’s bright colors. In extreme bleaching events, the coral will die completely. In weaker events, bleaching from thermal stress will

weaken coral, lessen their productivity, and reduce growth and calcification, “leaving them vulnerable to disease” (Burke et al., 2011). Like most global threats, coral bleaching, and other consequences of rising ocean temperatures, are extremely difficult to address or mitigate because they result from the overall atmospheric consequences of human activity, rather than a single human action that might be resolved.

Unfortunately, rising sea temperatures are not the only consequence of increasing carbon dioxide concentrations. As the levels of CO₂ increase, the ocean’s pH decreases, making the water more acidic. As the carbon dioxide dissolves into the ocean, carbonic acid is created, lowering the pH of the water and simultaneously decreasing the concentrations of carbonate and aragonite compounds, which are necessary for coral skeleton growth (Burke et al., 2011). Without property quantities of carbonate ions, adult corals have a far more fragile physical structure, leaving them less resistant to erosion (Wilkinson, 2008).

There are, however, factors that help to increase the resilience of coral reefs to climate change. Corals have a great regenerative capacity, meaning that with good connectivity to less affected or resistant reefs, unhealthy coral ecosystems can recover (Wilkinson, 2008). Management policies that help to maintain an abundance of herbivore populations within the reef keep destructive algal populations below an overwhelming level, and the absence of human pollution and sedimentation threats allow reefs to recover and thrive. All of these factors are important parts of successful, sustainable reef resource management strategies (Burke et al., 2011).

2.5 The Human Implications of Coral Loss

What, then, are the consequences of coral reef degradation and loss of biodiversity that result from the aforementioned threats? The loss of coral reefs would encompass a far greater range of consequences than the loss of pretty fish. Coral reefs play an important role for both natural and human systems alike.

Coral reefs provide crucial shoreline protection to human infrastructure and delicate coastal ecosystems alike. Coral reefs mitigate approximately 75-95% of the wave energy that hits a coastline, protecting “over 150,000km of shoreline in 100 countries and territories” from storm damage and erosion

(Burke et al., 2011). Many coastlines depend on coral structures to protect communities from extreme storm or erosion damage.

Reef ecosystems play a starring role in the livelihoods of many coastal residents, providing “daily food and resources” (Wilkinson, 2008). Roughly 850 million people live within 100km of a coral reef, with 275 million of those people residing within 30km of the reefs (Burke et al., 2011). Furthermore, many of these residents are citizens of island nations, or less developed countries—areas “where dependence on coral reefs for food and livelihoods is high” (Burke et al., 2011). It is estimated that across these reef-reliant countries, an average of 29kg of fish and seafood per person is consumed by the population each year. This seafood is often the primary source of high-quality protein, and in particularly isolated places such as island nations, it may be the only source (Burke et al., 2011).

Loss of coral reefs may also have dangerous, or unanticipated consequences on human health. Species that live in reefs have adapted to a highly competitive environment, developing “complex chemical compounds” to protect themselves. Many revolutionary pharmaceuticals are based in discoveries from coral reef species, including treatments for cancer, HIV, and malaria (Burke et al., 2011). A loss of biodiversity stemming from coral reef destruction or degradation can have far reaching complications for human health, and for the possibility of future medical discoveries.

2.5.1 Implications for Economies

Vulnerability to a changing climate, and to the degradation of coral reefs is often most severe in less developed countries, where resources are limited and economies are less diversified. The loss of coral reef ecosystems has the potential to severely impact the economic bases of coastal nations.

Reefs are vital to the tourism industry of many coral reef countries, providing the white sand beaches that tropical oceans are known for, as well as the income generated by snorkeling and scuba diving interests. Though tourism generates a whole host of environmental concerns, it also provides an important source of revenue for developing nations (Buke et al., 2011). The same may be said of local fisheries, with reef-based fisheries contributing to approximately one fourth of the total fish catch per year

in developing countries. Because many reef-based fisheries are small, individual endeavors, the entry costs are low, making this vocation a feasible option for poor or migrant populations and providing an important avenue towards poverty alleviation (Burke et al., 2011).

2.5.2 Barriers to Reef Management

It is important, however, to recognize that in spite of the many benefits that coral reefs provide to communities, there are also potential consequences that accompany the implementation of environmental policies. Local communities are not unaware of the benefits provided to them by reef ecosystems. Rather, it is the fear of the side or short-term affects that make communities reluctant to implement policies such as no-take marine protected areas.

No-take marine protected areas (MPAs) are areas that have been protected by law in order to preserve the biodiversity and natural beauty of the space. In no-take reserves, fishing is prohibited entirely with the goal of increasing biomass density within the MPA. As Sala et al. explains, biomass density and biodiversity increase within a reserve, leading to the restructuring of the food chain into a more mature and complex model (2013). Furthermore, through a process known as “spillover,” adult fish move from the reserve into open fisheries, helping to increase biomass inside and outside of the reserve.

The primary concern among local communities is that the implementation of no-take marine protected areas will result in “the loss of fishing grounds and yields,” and that the resulting spillover of fish from the reserve will not be sufficient offset the loss of revenue from fishing within the MPA (Sala et al., 2013). For a community whose livelihoods are dependent upon their ability to harvest fish, a no-take marine protected area can be perceived as a significant threat to their economic well-being. Community opposition to a marine protected area can serve as a significant barrier to the implementation of such a policy. In spite of the plethora of ecological and economic services a reef system provides to a local community, there are other factors that influence a government’s willingness or ability to implement stricter environmental laws and protections.

The ecological and human importance of coral reefs to ecosystems, communities, and to their respective health cannot be overstated. While it is certainly legitimate to discuss these issues on a world-wide scale, contextualizing natural resource policy, coral reef management, and the importance of sustainable development on the scale of a single country can be crucial to understanding the complexity, and the importance of these concerns. Indeed, countries that are experiencing large economic or cultural transitions often have the opportunity to make beneficial adjustments to their goals and policies regarding the aforementioned areas (Kjørven, 2012). As the United States embargo on Cuba begins at last to lift, Cuba faces a host of environmental, political and economic decisions regarding their environmental policies, their natural resources, and their coral reefs.

2.6 The Case of Cuba

The nation at the center of this discussion about resource management, coral reefs, and sustainable development practices is one with a rich and varied history of political, social, and economic endeavors. To understand Cuba's current policies of environmental protection and sustainable resource management, it is crucial to understand the journey the Cuban nation has undergone to arrive at this point in time, carrying nearly seventy years of history, culture, and economic priorities. Beginning at the Revolution of 1959, Cuba's history has woven a complex foundation for the environmental mindset of today.

2.6.1 Cuba, a History

From the early 1900s, through the mid-1950s, Cuba's history was marked by a series of violent coup d'états followed by increasingly brutal dictatorships. In 1953, Fidel Castro Ruz, an anti-U.S., communist revolutionary led an unsuccessful coup against the oppressive dictatorship of Sergeant Fulgencio Batista. Exiled, he returned to Cuba in 1956. With the help of Ernesto "Che" Guevara, the next three years were dedicated to building support, and waging guerilla war against the Batista regime. In 1959, Castro's army invaded Havana, and he took power, with his brother, Raúl, as his second-in-

command. Immediately after the revolution, Castro set about re-establishing Cuba as a Communist, single-party State (BBCa, 2015).

The relationship between the U.S. and Cuba deteriorated rapidly, with first the Cuban nationalization without compensation of all U.S. private business in the country in 1960, followed by the U.S. response of a national embargo on Cuba. Events of 1961 further regressed the relationship with the failed U.S sponsored invasion of the Bay of Pigs by Cuban exiles (BBC, 2105). The invasion failure lead to the capture of most of the Cuban Underground, and the consolidation of the Communist Party of Cuba (One World Nations Online, 2006). Forming a close alliance with the Soviet Union (USSR), Cuba underwent rapid economic development, often with the consequences of severe environmental degradation. By 1990, the USSR was responsible for 85% of Cuba's trade. With the collapse of the Soviet Union in 1990, however, came economic devastation for Cuba (Evenson, 1998). The loss of Soviet subsidized oil imports led to a severe energy crisis, along with an economic crash caused by the disappearance of additional Soviet economic subsidies. Between 1989 and 1993, the national standard of living declined sharply, with decreases in national exports and imports of over 75% (One World Nations Online, 2006). Euphemistically referred to as "the special period in peacetime" by the Cuban government, the resulting economic crisis drove political and economic reforms. Cuba needed to find ways to support its economy within the stark parameters of limited resources, and hostile opposition in the form of the tightening of the embargo by the U.S. (BBCa, 2015).

Over the next decade, Cuba would work to adapt to the new economic conditions, transitioning to methods of agriculture and production that were not reliant on Soviet supplied fertilizers or fuel. Throughout this period, the political attitude in Cuba remained vehemently anti-U.S. There was no love lost between the two nations – in 1996, Congress declared the U.S. embargo against Cuba permanent, in addition to threatening controversial sanctions on any third-party country who attempted trade relations with Communist Cuba (One World Nations Online, 2006). Tensions between the two countries remained high through most of the first decade of the 2000s, until in 2008, following a series of increasingly

debilitating surgeries and illnesses, Fidel Castro stepped down from power, passing control to his brother, Raúl (BBCa, 2015).

Since the ascension of Raúl Castro to power, the Cuban government's restrictions on private businesses and access to private technology (trademarks of traditional Communist regimes) have been lifting slowly. The election of U.S. President Barack Obama in 2009 led to further loosening of the U.S. embargo, including the relaxation of U.S. travel restrictions to Cuba in 2011. Within Cuba, travel restrictions for Cuban citizens were also loosened, in conjunction with economic reforms meant to "encourage private enterprise" (BBCa, 2015). In 2014, Cuba began talks with the European Union about re-establishing ties broken in 1996, and in 2015, historic talks between Cuba and the United States led to the reopening of the American embassy in Havana for the first time in over fifty years (BBCa, 2015).

As of now, Cuba remains in economic transition, taking small but consistent steps away from a pure communist system. As the U.S. embargo continues to lift, and Cuba re-establishes political, social, and economic ties with other U.S. allies, it is reasonable to believe that broad changes will occur within the Cuban political and economic spheres. Since 1990 onward, however, Cuba has maintained a strong commitment to environmental protection, and sustainable development. Current environmental legislation mandates the consideration of environmental impacts on any economic development project, and sustainable development is a constitutional goal (Whittle, 2006).

2.6.2 Cuba's Approach to Sustainable Development

Cuba has a unique take on sustainable development, moving away from the traditional economic focus of the ideology, and making their approach more human-centered. Choosing not to focus solely on the quantitative measurements of successes (i.e. production and consumption), Cuba's approach focuses on the development and "expansion of the human potentialities," with a goal of "qualitative improvements" (Cabello, Garcia, Sagastume, Priego, Hens, & Vandecasteele, 2012). Indeed, the Cuban Constitution (2002) has given both sustainable development and environmental protection constitutional status, stating in Article 27:

“The state protects the environment and natural resources of the nation. It recognizes their close link with the sustainable economic and social development for making human life more sensible, and for ensuring the survival, welfare, and security of present and future generations. It is the responsibility of the competent state organs to apply this policy.”

Generally, less developed countries are not at the forefront of sustainable resource management, especially ones on the verge of both economic and political changes. Cuba, therefore, stands out for its sustainable practices, and continued focus on environmental policies. In a speech at the United Nation’s Conference on Environment and Development in Rio de Janeiro (the Rio Summit) in 1992, Fidel Castro made clear that in spite of facing the worst economic crisis since the Revolution of 1959, Cuba would not sacrifice environmental protection and reform for unregulated economic development (Whittle, 2006). Over the decade following the Rio Summit, Cuba enacted a series of environmental laws and regulations, aimed at directing the country down a path of sustainable resource management and environmental protection, while still supporting economic growth and achievement (Whittle, 2006).

2.7 Cuban Environmental Policy

Since 1990, Cuba has established, rewritten, and then re-established a comprehensive series of environmental laws, focusing on regulation, protection, and environmental standards. The following sections of the discussion, however, will focus solely on the environmental laws, organizations, and policies that are specifically related to sustainable development, natural resource management, and the management of coral reefs.

2.7.1 The Cuban Constitution

As mentioned above, the Cuban Constitution places the protection of the environment within the set of responsibilities held by the state. This is no paltry paragraph. The Cuban Constitution is the “principal legal instrument” of the country, in addition to being a “salient ideological document” within the Communist Party (Evenson, 1998). Upon his return from the 1992 Summit in Río de Janeiro, Brazil,

President Fidel Castro sought to create a stronger “constitutional link between economic development and environmental protection” (Evenson, 1998). The original language of Article 27 was changed to reflect these wishes, drawing stronger connections between not only the state’s responsibility to sustainable development, but also the Cuban citizen’s responsibility to commit to environmental protection. Indeed, in addition to paragraph quoted above, Article 27 continues on to say that:

“It is the duty of the citizens to contribute to the protection of the water, the atmosphere, the conservation of the land, the plant life, the animal life and all the rich potential of nature.”¹

The strong phrasing of the Constitution charges both the citizen, and the State with the application of environmental protection, and sustainable economic and social development, respectively (Evenson, 1998). Article 27, in addition to the new laws, policies and institutions discussed below, indicates the national government’s genuine desire to address the environmental and resource management problems of Cuba.

2.7.2 The Law of the Environment (Law 81)

Since the mid-1970s, has Cuba implemented a series of national policies, backed by varying government agencies, aimed at increasing both the cohesiveness of the national bureaucracy, and at enforcing stronger environmental regulatory policies (Whittle, 2006). These laws and attempted agencies, however, proved largely ineffective. Many laws failed to define any specific actions towards achieving environmental goals, providing instead “only general statements of policy with no implementation directions” (Travieso-Diaz, 2000).

Environmental law with stronger structure was implemented in 1997, with the passage of *Law 81*, also known as *The Law of the Environment*. Where prior legislation had been vague, the legal framework established by *Law 81* encouraged socioeconomic development that adhered to the principles of environmental awareness and sustainable development (Travieso-Diaz, 2000). It redefined the roles of national agencies, especially with regards to the responsibilities of each to uphold the goals of the

¹ Republic of Cuba, 2002

aforementioned principles (Evenson, 1998). Furthermore, *Law 81* established requirements for environmental impact assessments (EIAs) in order to determine environmental licensing and regulations for both private and public projects, particularly in “all land use planning decisions” (Evenson, 1998).

Perhaps the most influential part of *Law 81* was the order to make the already established Ministry of Science, Technology, and Environment (CITMA)² the primary agency in environmental management. As defined in *Law 81*, Article 11, CITMA is:

“...in charge of proposing environmental policy and guiding its execution through the coordination and control of the nation’s environmental management, promoting its coherent integration in order to contribute to sustainable development.”³

The language continues, defining the eleven areas of responsibility for the agency. Included among those (and most relevant to this discussion) are the authority to implement an environmental inspection system, and to define any corrective measures, including fines, penalties, or a withholding of necessary permits (Travieso-Diaz, 2000). The law also requires CITMA to work in conjunction with the Ministry of Education to develop an environmental education program to be implemented across the country (Evenson, 1998). This program is discussed in further detail below.

Furthermore, there are multiple agencies and government institutions that operate within CITMA, responsible for a large range of environmental management (including sustainable development and natural resources). The most topic-relevant agencies include the *Environmental Directorate* (DMA), responsible for “writing and overseeing the implementation of a wide range of environmental laws,” in addition to monitoring the policies of fellow agencies to ensure compliance with national environmental standards and regulations (Whittle, 2006). The *National Center for Protected Areas* is responsible for all policy and policy implementation regarding the National System of Protected Areas (explained in further detail below).

² All abbreviations are representative of their original Spanish titles. E.g.; CITMA is el Ministerio de Ciencias, Información Tecnológica, y Medio Ambiental.

³ CITMA, 2005

Finally, the *Environmental Agency* serves much the same capacity as the United States Geologic Survey (USGS); comprised of a “collection of research institutions,” the agency provides research and scientific testing and analysis to CITMA (Whittle, 2006).

Of all of the responsibilities and authorities assigned to CITMA, one of the most important is the agency’s duty to act as a coordinator between various government agencies. Seeking to unify the various bureaucratic arms of the national government, *Law 81* gives CITMA the authority to “participate in the planning and policymaking of other ministries,” thus ensuring that environmental concerns receive just consideration with agencies whose focus is on economic, or political development (Whittle, 2006).

2.7.3 Cuban Coastal Zone Management

Established in 2002, Decree Law 212 (DL 212), *Coastal Zone Management* provides protection to the ecosystems along, and off of Cuba’s coastline. Implementing strict zoning laws, the purpose of the DL 212 is to prevent further or future damage of coastal lands and waters from a variety of activities including tourism, waste treatment, fishing, and construction.

The Decree defines two types of zones: the coastal zone and the zone of protection. Both classifications have specific regulations and restrictions. Coastal zones extend inland for 20 – 40 meters, and are “generally off-limits to permanent structures” (Whittle, 2006). Within this zone are a defined list of prohibited activities, including the construction of new hotels and residences, and the extraction of sand. The zone of protection is a continuation of these restrictions, with an additional 20-40 meters of protected coastline past the coastal zone outer boundary. Within this secondary zone, many of the same restrictions (including the prohibition of residences and hotels) apply. In spite of the implications for tourism with regards to beachfront property, the enforcement of such protections are paramount for the preservation of “vulnerable wetlands, dunes, and waters” (Whittle, 2006).

2.7.4 The National Environmental Strategy, and Environmental Education

In 1997, CITMA published the *National Environmental Strategy* (EAN) which described the “severe environmental problems still plaguing the country and hampering environmental development”

(Whittle, 2006). Included on this list of adversities were soil degradation, pollution of water sources (both inland and along coastlines), and a loss of biodiversity. The rapid expansion of coastal tourism, especially, was responsible for obstructing the restoration of natural systems and for contributing to the ever increasing degradation of Cuba's unique ecosystems (Whittle, 2006).

In order to implement the goals of environmental protection, the EAN established a series of specific laws meant to move ecological concerns upwards on the list of national political and economic priorities. The EAN recognized that over the previous four decades, environmental concerns had been superseded by the priorities of rapid economic and social development, though it also asserted that sustainable development (both economic and social) were inherent parts of the government's socialist principles (Whittle, 2006). Rather than creating a new set of principles, the Strategy maintained, CITMA and other government agencies were adhering to long established goals held by the national government.

By virtue of Cuban communist ideals, Cuban law scholars argue that unlike capitalist governments and legal frameworks, which are prone to resist change (think about the length and process of amending the U.S. Constitution, for example), the Cuban system of law and government is dynamic. Laws are meant to "not only...regulate, but also to transform society" (Evenson, 1998). Frederick Evenson argues that the ultimate goal of Cuban environmental law is to "create a 'new' citizen," one who understands the principles of environmental protection, sustainable development, and any further environmental goals that are reflected, regulated, or explicitly stated within the legislation (1998). The primary means for achieving said goals are through environmental education, and the "development of codes of environmental behavior" (Evenson, 1998).

The environmental education initiative, implemented by one of CITMA's many programs, spans across all sectors of the Cuban population, and emphasizes the importance of sustainable natural resource use, as well as environmental protection. Included in worker education, national trade unions bear the responsibility of developing environmental behavior codes, as well as including environmental education and environmental impact in their worker training programs. Mass media, too, is mandated by *Law 81* to include environmental messages in their programming (Evenson, 1998).

2.7.5 The National System of Marine Protected Areas

The National System of Marine Protected Areas is actually a subsystem of the National System of Protected Areas (SNAP). The SNAP was mandated by *Law 81*, and has a set of thirteen objectives, including the maintenance of sites representative of biogeographical regions and outstanding scenic beauty, the conservation of biodiversity, the assurance that local production will not surpass sustainable yield, the protection, restoration, and management of marine resources, and the development of recreation and tourism in ways that are not degrading or harmful to the quality of their surrounding environment (CITMA, 2005). The National System of Marine Protected Areas (SAMP) follows exactly the same guiding principles, but focuses on marine, rather than terrestrial areas. Marine Protected Areas (MPAs) include “coastal wetlands, the submerged coastal zone (mean high water line to a depth of 200m), and off-shore keys” (Estrada et al., 2004).

The SAMP uses a variety of scientific techniques to influence the selection and design of MPAs. Rigorous conservation standards have been established based upon the already-existing coral reefs off the Cuban coast, taking into careful consideration sites critical for endemic or economically-important species. The connectivity between reefs (an important factor for coral reef health) is also considered, leading to the inclusion of a variety of ecosystems within MPA boundaries (Estrada et al., 2004). Within the MPAs themselves are a variety of zones, each with varying degrees of restrictions and permitted uses, such as fishing, recreation, commercial businesses, and tourism. Crucial to each MPA, “no take,” or conservation zones are established in which “only scientific or non-consumptive activities are permitted” and restrictions on any sort of extractive or potentially disruptive activities are strict (Estrada et al., 2004). The zoning system helps to resolve problems that arise in management regimes over the debate about the benefits of single, large protected areas, versus multiple smaller areas.

2.8 Cuba's Coral Reefs

Before beginning this section, it is important to note that data regarding the state of Cuba's coral reefs was often incomplete, or compiled without the cooperation of the Cuban government, and Cuban scientists. As such, the discussion that follows is based upon available information.

Cuba exists in a unique position socially, culturally and ecologically. With nearly 5,000 square kilometers of reef area, Cuba is included among the most well-preserved and well-managed coral reefs in the world (Wilkinson, 2008). Indeed, in the study conducted by Global Coral Reef Monitoring Network (GCRMN) in 2008, Cuba was included in the only 13% of Caribbean nations with greater than 30% coral cover. Three quarters of the Caribbean nations studied showed coral degradation of at least 50% from the average coral cover prior to 1984, making Cuba's record particularly impressive (Jackson et al., 2014). Again, however, it is important to note that Cuba did not actively participate in the GCRMN 2008 survey, meaning that results published by scientists working within Cuba may differ from those published by the GCRMN report.

Jardines de la Reina is a Marine Protected Area in South-Central Cuba, established in 1996, and is considered to be the largest continuous marine reserve in the Caribbean. The reserve is a no-take zone for commercial fisheries, and tourism within the reserve is managed through private-public partnerships of a single Italian tourism business (called Avalon), research organizations, and the State (Environmental Defense Fund, 2012). In a study published in 2014, analysis of the "abundance of commercially valuable reef fish species" within Jardines de la Reina demonstrated that the implementation of the marine reserve had "promoted significantly higher densities" of the considered species (Pina-Amargós, González-Sansón, Martín-Blanco, & Valdivia, 2014). The local communities around the reserve are actively involved in planning, management, and enforcement of the MPA regulations, with an estimated 10% of the local population working within the reserve for either Avalon, or the State. Furthermore, it has been established that the revenue collected by the local communities from tourism within the reserve is greater than the fishing revenue earned in pre-reserve times (Environmental Defense Fund, 2012). Due, however, to the limited resources the Cuban government has to put towards enforcement, poaching still occurs on the

outer edges of the preserve, though the presence of a research station in the center of the MPA provides extra security farther into the Jardines de la Reina area (Environmental Defense Fund, 2012). Again, it is important to note that there is little information about the relationship between Avalon and the Cuban government, and their business transactions remain murky.

Like many regional reefs, however, Cuban coral is still affected by large-scale threats, such as the invasive Indo-Pacific Lionfish, a nonnative species that is posing a significant threat to native species across the Caribbean. Southern Cuba has experienced unusual loss of live coral due to a period of uncommonly frequent and intense hurricanes that occurred from 2001 – 2006. North-Central Cuba has experienced live coral loss due predominantly to an increase in algal growth, brought on by the low abundance of larger herbivores (such as parrotfish) necessary for controlling algal populations (Wilkinson, 2008).

There are a variety of factors that have allowed Cuba's coral reefs to remain this healthy. Perhaps the most influential of reasons is the U.S embargo. Though the embargo had highly destructive consequences for the economic development of the country, it also allowed for significant environmental protection and preservation to occur (Siciliano, 2015). By preventing the rapid expansion of commercial businesses (such as shipping and large-scale fishing operations), as well as prohibiting tourism from the U.S. to Cuba, the island and its coral reefs remained relatively untouched. To illustrate the difference between Florida's and Cuba's tourism industry (a geographic separation of only 90 miles at the narrowest point), Cuba receives approximately 3 million tourists per year. Florida receives 90 million (Siciliano, 2015). Though tourism can often be crucial to the economic success of Caribbean nations, Jackson et al. suggests that "extremely high densities of tourists...are harmful to reefs," unless offset by the strict enforcement of comprehensive environmental regulations (2014).

Additionally, a combination of natural geography and aggressive government policy has maintained the quality of the coral ecosystems, even as the embargo has begun to lift. Over half of Cuba's reefs are separated from the mainland by cays, or "broad shallow lagoons with many patch reefs" (Wilkinson, 2008). This separation served as a buffer between the reefs and most of the human pressures

that originated at the coastline (point source pollution, construction, etc.), with the sole exceptions of fishing and a small number of tourist divers (Wilkinson, 2015). In spite of severe economic restrictions, the Cuban environmental policies implemented by *Law 81*, and by *Decree Law 201* (both discussed in detail above) have served to provide strong protections to the coral reefs, especially those contained within the 108 established Marine Protected Areas (MPAs) of Cuba (Wilkinson, 2008).

In 2004, for example, the Ministry of Fishing Industry, working together with the Ministry of Science, Technology, and Environment (CITMA) banned the use of set nets (stationary nets entrapping large numbers of fish) and implemented a policy of a 25% per year reduction in bottom trawling, a highly destructive fishing method that results in severe seagrass bed, and coral degradation (Wilkinson, 2008). The goal of these policies is to prevent further ecosystem destruction, as well as to allow for the recovery of fish stock, thus fulfilling goals set by the National System of Marine Protected Areas (SAMP) objectives: monitoring local production to maintain a sustainable yield level. The Cuban government also stayed true to its ideological goals of legislation meant to create sustainable development by offering generous subsidies or “alternative livelihoods [and] opportunities to participate in technical education” to any fisherman affected by the new legislation (Wilkinson, 2008).

Further practices implemented by the Cuban government since the establishment of *Decree Law 201* in 1999 have included intensive pollution control strategies, such as “obligatory tertiary wastewater treatment in tourist developments,” and staged eradication of destructive fishing practices, as discussed directly above (Wilkinson, 2008). The greatest challenge currently opposing the successful implementation of environmental policy is the difficulty posed by limited enforcement ability. The Cuban government faces a shortage in personnel, equipment, and communication technology to enforce environmental regulations and protections across all 108 MPAs.

With the Cuban shift in leadership, however, and the slow loosening of U.S. embargo restrictions, Cuba is facing a major change in the political, economic, and even ecological status quo. These changes have the potential to threaten the progress made in sustainable reef management. In an effort to address these threats, partnerships have been negotiated between a host of U.S. organizations and government

agencies, and the Cuban Ministry of Science, Technology, and Environment (CITMA), including scientists from the various Cuban agencies managing the national parks and MPAs. The goal is to work collaboratively to both preserve the Cuban coral reefs, as well as to share knowledge about successful, sustainable reef management strategies. To be clear, this exchange is not one sided – U.S.

nongovernmental organizations (such as the Nature Conservancy) readily admit the Cuban government has managed remarkable conservation results, with extremely limited resources (Smith, 2014).

In late November, 2015, the U.S. Department of Commerce’s National Oceanic & Atmospheric Administration (NOAA) and the U.S. National Park Service (NPS) announced a Memorandum of Understanding (MOU) with CITMA. The goal of the MOU is to “facilitate joint efforts concerning science, stewardship, and management related to Marine Protected Areas (MPAs)” (U.S. Federal News Service, 2015). The health of the Cuban reef system can have far-reaching impacts; crucial quantities of coral larvae, mutton snapper, and gray snapper originate in Cuba’s waters before spreading throughout the greater Caribbean (Smith, 2014). Any changes in the health of the island’s reef system will have direct impacts on the ecosystems of surrounding countries, especially the U.S. Thus, organizations such as the Nature Conservancy, and agencies such as NOAA and NPS seek active research and management within coral reef systems in both Cuban and U.S. waters, maintaining that the preservation of MPAs, and their contained ecosystems “are the foundation for thriving [coastal] communities and stable economies” (U.S. Federal News Service, 2015).

2.9 A Cuban Comparison

Cuba’s current environmental policies, (especially those pertaining to coral reefs), combined with the country’s changing political, social, and economic structures, provides a unique opportunity to address the research question stated at the beginning of this paper:

How has Cuba implemented the goals of sustainable resource management for their coral reefs, and how should the country’s environmental policies evolve to meet the future ecological, sociopolitical, and economic needs of both the country and the coral?

The remainder of this paper will use a specific set of case studies to compare Cuba's strategies with those of other countries. The following discussion will outline and explain the research methods used to evaluate these case studies. The goal is to determine where Cuba's strengths lie in relation to other countries, and which foreign policies Cuba might implement in order to insure the continued health and success of its coral reefs. This analysis will inform answers to the above question.

3. METHODS

The goal of the case study analysis is to develop policy recommendations that Cuba may implement, or continue to support and expand, in order to achieve the multifaceted goal of sustainable coral reef management. Within this overarching goal, the series of more specific objectives includes environmental protection and conservation, socioeconomic growth for Cuban citizens (especially those who are reliant upon the coral reef ecosystem), and most importantly of all, the continued commitment to compromise and common goals that the Cuban government and its citizens share.

A selection of case studies of coral reef management from around the world has been assembled to compare with Cuba's strategies. The countries selected for comparison are Australia, the Philippines, and the Bahamas. These case studies include examples from successfully managed reefs with thriving ecosystems, as well as examples of less successful management and conservation. The countries chosen for the case studies give a broad range of geographic, political, and economic variety.

Australia is the wealthiest country of the four assessed (including Cuba) with a GDP per capita (Gross Domestic Product divided by population) of US\$61,925.5 in 2014 (World Bank, 2016). It is both a "representative democracy and a constitutional monarchy, with Queen Elizabeth II as Australia's head of state" (Australian Government, 2016). Approximately 75% of Australia's reefs are within the country's extensive system of MPAs (Burke et al., 2011). The Great Barrier Reef, the focus of most of the data collected on Australian coral reef management strategies, is located in the northeastern corner of the country and is comprised of over 3,000 individual reef systems (Great Barrier Reef, 2016).

The Philippines, in comparison, has fewer resources and lower funding as well as much higher local threat levels to their reef systems (Burke et al., 2011). This is the poorest country of the four, with a GDP per capita of US\$2,872.5 (World Bank, 2016). The Philippines is comprised of over 7,000 islands, though the majority of the population inhabits only 11 of them (BBC, 2015b). The Philippines achieved independence from the United States in 1946, and maintained a democracy under a U.S.-styled constitution until the 1970s when a dictatorial regime took power. This "repressive rule led to economic

stagnation” and severely slowed the rapid economic development the Philippines had experienced up until that point. Though the Philippines regained democracy in in the early 1990s, there has continued to be high levels of political unrest and corruption (BBC, 2015b). Though the Philippines has extensive reefs around its islands, the country struggles with management and conservation of the natural resource.

The Bahamas were chosen because the country is in the same geographic region of the world as Cuba, and has a GDP per capita between those of Australia and the Philippines, at US\$22,217.5 (World Bank, 2016). Occupying the same geographic region means that first both the Bahamas and Cuba have ecological similarities between them and are both experiencing the same global threats to their reefs. Similar to Australia, the Bahamas are part of the Commonwealth of Nations, with a representative democracy that recognizes Queen Elizabeth II as the head of state (The Islands Of The Bahamas, 2016). The country is comprised of over 700 islands, and their economy is largely reliant on huge tourism and banking industries (BBC, 2012).

Though the economic, political, and ecological conditions of Cuba are reviewed in considerable detail in the Background, for comparison, Cuba’s GDP per capita in 2013 was US\$6789.8 (World Bank, 2016). There was no data available for 2014. Up until 2008 when Raúl Castro took over power, Cuba has been under strict Communist rule. Since 2008, however, economic restrictions on private businesses have begun to relax and under U.S. President Obama’s administration, the U.S. embargo and travel restrictions on Cuba have begun to lift (BBC, 2015a).

Case study data about management regimes, equity, and ecosystem health is drawn from documents from nongovernmental organizations such as the 2011 publication of *Reefs at Risk, Revisited*, from government documents, from media documents from each country, and from peer-reviewed articles and sources addressing the four countries. This is a qualitative analysis based on information gathered from multiple articles and publications. The data given in the series of matrices below is representative of each country as a whole, with each score given based on a broad picture of the overall situation of all four case studies. The goal of this analysis is to determine which policies (either new, or pre-existing) Cuba

could consider using to help maintain the quality of their reef system, while still continuing to support sustainable economic development.

The criteria used to evaluate the differences between each of the countries are listed below, and shall be presented in an evaluative matrix (Table 5).

3.1 Criteria

Coral reef health, feasibility, strength of management, and equity are the four criteria used to evaluate the chosen case studies. All of the factors used to define the criteria is explained below.

Coral Reef Health (Table 2): Defined by the Integrated Local Threat Level, as cited in Burke et al., 2011. This criteria incorporates the local threats to coral reef systems including coastal development, watershed-based pollution, marine-based pollution, overfishing, and other destructive fishing methods. In the assessment of the threat level, past thermal stress events are considered for determining the level of threat, given that bleaching events caused by thermal stress can compound the impacts of local threats on an “otherwise healthy reef” (Burke et al., 2011).

Feasibility: Defined by whether the policy implemented by the country under consideration is fully supported by the national government, and includes the ability of said government to implement and enforce the management strategies with the resources available to them at the time of analysis. There is graphical representation of this analysis; only qualitative conclusions are drawn, based on the analyzed documents.

Strength of Management (Table 3): Determined by the success of selected management strategies implemented by each country, including (but not limited to) the existence of Marine Protected Areas (MPAs), coastal zoning laws, fishing restrictions, and public environmental education programs. The effectiveness of these policies will be determined by their success in revitalizing fish populations, coral systems, and water quality. Said data is qualitative, and is drawn from scientific and government documents.

Equity (Table 4): Determined by whether or not all parties involved in coral reef management (government, industry, environmental groups and local citizens) are affected equally by management strategies, or, the determination of the degree to which single stakeholders are bearing a disproportionate share of the burdens and costs of the policy. This is determined through evaluation of community involvement in the planning, execution and management of MPAs, fishing restrictions, and coastal development policies, as well as government compensation to the local communities whose livelihoods were impacted. All data collected is qualitative and drawn from multiple sources.

3.2 Explanation of Scoring System

A point system (Table 1) has been determined for each of the evaluative matrices (Tables 2 – 4). The points accumulated for each country in the final column of Tables 2, 3, and 4 will be summed in Table 5 to determine the overall quality, sustainability, and ranking of the coral reef management strategies adopted by each country studied. The ranking system is determined in Table 6 below.

3.3 Matrix Comparison of Case Studies

Table 1: Evaluative Point System

Combined Threat Level (Coral Health)	Low = 0	Medium = -1	High = -2
Strength of Management	Low = 0	Medium = 1	High = 2
Equity	Low = 0	Medium = 1	High = 2
Feasibility given resources	Low = 0	Medium = 1	High = 2

In Table 2, a matrix evaluating the local and global threats to coral reef health is used to compare each country. Points are assessed on a negative scale, meaning that countries with high levels of coral reef threats receive negative point values. The worse the threat to the reef is, the lower the value of the point received. Each threat was evaluated based on the percentage of reef per country classified as having low, medium, or high risk. Table 2 is broken up into an analysis of local and global threats. All data assessed in Table 2 is drawn from *Reefs at Risk, Revisited* (Burke et al., 2011), *Reefs at Risk of the Caribbean*

(Burke & Maidens, 2004), and from the released data available through the *World Resources Institute* website.

Table 2: Local and Global Integrated Threats to Evaluate Coral Health (L/M/H)

Local
Global

Country	Coastal Development	Marine-Based Pollution	Watershed-Based Pollution	Overfishing/Destructive Fishing Practices	Thermal Stress	Ocean Acidification	Combined Threat Level
Cuba	-1	-1	-1	-2	-1	0	-6
Australia	0	0	0	0	-1	-2	-3
The Philippines	-2	0	-2	-2	-1	-1	-8
The Bahamas	0	-1	0	-2	-1	0	-4

(Burke & Maidens, 2004), (Burke et al., 2011), (World Resources Institute, 2011).

Table 3 evaluates the strength of management of coral reefs in each country. Data used in this Table is qualitative, rather than quantitative, with all sources cited below. Evaluated on a low, medium, and high scale (each represented by the point values assigned in Table 1), the table assesses the rigor of each management strategy within the respective country, including the rigor with which they are enforced.

Table 3: Management Strategies to Evaluate Strength of Management (L/M/H)

Country	Existence of MPAs ⁴	Enforcement of MPAs	Fishing Restrictions	Environmental Education	Effectiveness
Cuba	2	1	1	2	6
Australia	2	2	2	2	8
The Philippines	2	1	1	1	5
The Bahamas	2	2	2	1	7

(Fernandes et al., 2005), (Burket et al., 2011), (Pina-Amarós et al., 2014), (Mumby & Harborne, 2010).

⁴ Marine Protected Areas (MPAs)

Table 4 is also based on qualitative, not quantitative data. This matrix evaluates relative community involvement in the planning and management of marine protected areas, based on information drawn from peer-reviewed articles.

Table 4: Human and Community Impact to Evaluate Equity (L/M/H)

Country	Community Involvement in Planning	Community Involvement in Management	Equity
Cuba	2	2	4
Australia	2	2	4
The Philippines	2	1	3
The Bahamas	2	1	3

(Nursey-Bray, 2010).

4. DISCUSSION

Table 5 sums each point total from Tables 2 – 4, and includes a point value for the Feasibility criteria. As done for Tables 3 and 4, the Feasibility criteria was also assessed based on qualitative data found in peer reviewed articles and is representative of the ability of a government to implement and enforce its management strategies based on the availability (or existence) of funding and resources. The accumulated points for each country are summed in the Total Points column, and this information is used in Table 6 to explain the significance of each country's total point value.

Table 5: Complete Evaluative Matrix, including Feasibility

Country	Coral Health	Effectiveness	Equity	Feasibility	Total Points
Cuba	-6	6	4	1	5
Australia	-3	8	4	2	11
The Philippines	-8	5	3	1	1
The Bahamas	-4	7	4	1	8

Table 6: Rankings Based on Evaluative Matrix

Country	Ranking	Explanation of Ranking
Cuba	5	Low coral reef health, with high risk of overfishing; Relatively large network of marine protected areas; Lacks resources and funding to fully implement and enforce policies
Australia	11	High coral reef health with the greatest threat coming from ocean acidification; extensive network of well-enforced marine protected areas; wide community involvement in planning and management of marine reserves; Management system is feasible given available resources and funding
The Philippines	1	Very low coral reef health with severe local threats including overfishing and coastal development; large number of Marine Protected Areas, but most are poorly enforced with only a few well managed and preserved areas; Lacks resources and funding to fully implement and enforce policies
The Bahamas	8	High coral reef health with the greatest threat coming from ocean acidification; relatively well-enforced system of marine protected areas; strong community involvement in planning of protected areas, with less community involvement in management of existing areas; Management system is feasible given available resources and funding

Cuba scored approximately in the middle of the four assessed countries. Cuba scored relatively low in terms of coral health, with overfishing being the greatest local threat to coral health (Burke et al., 2011). As discussed in greater detail in the Background, Cuba has a growing network of marine protected areas (MPAs) that are relatively well-enforced, and a national environmental education initiative (Evenson, 1998). Furthermore, community engagement and participation in the management of MPAs is an important part of management strategies. In feasibility, however, Cuba only scored a 1 because the country's ability to enforce their reef management policies is severely limited by a lack of resources, personnel, and funding. As such, the current system of reef conservation and protection exceeds Cuba's economic and technological capabilities.

Australia scored the highest of any of the four countries. This is unsurprising, given Australia's high GDP. Compared to the other three countries, Australia has relatively few prevalent local threats, and none so large as to classify the Great Barrier Reef in Australia as above a threat level of Low. The

greatest threat to Australian reef health is through ocean acidification, a global threat against which management policies have very little recourse. Australia's system of MPAs is both extensive, and well-enforced, with strict restrictions on fishing both around and inside the reserve. When Australia committed to the implementation of a national system of MPAs in the 1990s, the national government began an extensive community engagement campaign. This campaign included a broad public education campaign, informal communication and feedback sessions with communities, and finally formal community participation events (Fernandes et al., 2005). Furthermore, the Great Barrier Reef Marine Park Authority (GBRMPA), the managing agency of the project, worked closely with the indigenous populations to create initiative that would allow indigenous populations to have influence in the creation of the new reserve areas (Nursey-Bray, 2010). Australia's management system is feasible for the resources and funding the country has at its disposal.

The Philippines was the lowest scoring country with severe local threats to the health of their coral reefs, especially concerning coastal development and overfishing. Though on paper the country has a significant number of MPAs, most of them are poorly enforced as the Philippine government "lack[s] the funds, and often the political will" to regulate resources (Alcala & Russ, 2006). Furthermore, there are extremely limited fishing regulations; most restrictions only prohibit certain destructive fishing techniques, and do not place any limit on the size or number of fish caught (Alcala & Russ, 2006). The few MPAs that are designated as no-take areas are enforced not through the national government, but through local community involvement and municipal governments. These community-managed reserves are well-enforced and protected; they are not, however, representative of the majority of the country's system of MPAs, which is why the Philippines received a score of 1 instead of 2 in this category. As such, there are localized environmental education programs in the communities surrounding the locally-managed no-take MPAs, but no nationalized program (Alacala & Russ, 2006). The Philippines scored low in feasibility because it lacks the resources and funding to successfully implement its national strategies for coral reef management.

Finally, the Bahamas scored well in the evaluative matrix, receiving scores similar to those of Australia. The Bahamas have a reasonably well enforced system of MPAs, and are continuing to expand their limited system of national parks and marine reserves (Burke & Maidens, 2004). The Bahamas have a localized environmental education program that engages “teacher and students in coral reef ecosystem research” (Ecology, Environment and Education, 2010b). Though this program is short-term and offered only in specific areas, it is raising awareness of sustainable resource use. Bahamian legislation regulates specific areas for fishing, and regulates commercial harvesting restrictions. There is relatively strong community involvement in the planning of marine reserves, but once in place, the National Environmental Management Action Plan of the Bahamas stipulates that the national Department of Fisheries is “responsible for coral reef monitoring” (SENES Consultants Limited, 2005). Enforcement and management within the MPAs is funded by the Bahamas National Trust, whose mandate is to develop national park systems, and conserve the historic and ecological beauty and biodiversity of the country (SENES Consultants Limited, 2005). Finally, in an effort to control the damages done to natural landscapes (including coral) by unsustainable tourism practices the eco-tourism and sustainable tourism units were created within the Bahamian Ministry of Tourism and promote eco-friendly and sustainable tourism guidelines and policies.

4.1 Recommendations and Discussion of Feasibility

Though it would be ideal for Cuba to implement a system similar to that of Australia, with extensive community engagement and national environmental education, this situation is unrealistic for Cuba. Australia’s GDP per capita is over nine times as large as that of Cuba (World Bank, 2016). Cuba lacks the resources and the infrastructure to implement a nationwide system of surveys and community meetings necessary to foster the community responsibility and ownership of the reef that makes Australia’s management strategy so effective. Furthermore, Australia used a high-tech, sophisticated software that was able to statistically compute areas (based on fishing statistics) that would be “minimum-impact, optimal solutions” for implementing new no-take reserve areas along their reefs (Fernandez,

2005). Finally, only 5% of Cuban citizens currently have access to the internet, which severely limits the government's ability to disseminate information, or receive feedback on policies (NPR, 2016).

Though the Philippines scored lower in the evaluative matrix than Cuba did, it has several individual, community-managed marine protected areas that implement successful sustainable resource strategies that could be used by Cuba. Sumilon Island and Apo Island in the Philippines both have no-take marine reserves off of their coasts, and are fished (outside of the reserves) predominantly by local fisherman. Data taken from Apo Island by Alacala and Russ suggests that the presence of marine reserves may help to increase the quantity of adult fish biomass *outside* the reserve (a phenomena known as 'spillover'). This is strong incentive for local communities to implement no-take reserves, because reserves may help to "enhance long-term local-fishery yields" (2006). In addition to fishing benefits, the presence of the reserves has drawn huge numbers of tourists to the islands. The additional income from tourism has "had a tremendous positive effect of the standard of living of the local community" (Alacala & Russ, 2006). Both the fishing and tourism benefits are incentives that could be as easily applied in Cuba as they are in the Philippines, especially with the predicted increase in visitors to Cuba (Wetherall, 2015).

In the lead-up to the establishment of both reserves, biologists from a Philippine university set up extensive marine-conservation education programs in local communities, working towards the goals of "community organization...and community empowerment" (Alacala & Russ, 2006). The overall management of the reserves is executed through a collaborative partnership between "organized fisher communit[ies], local government units, and a nongovernment organization" (Alalcala & Russ, 2006). By implementing community-based frameworks for the management of coral reef reserves, Cuba could expand their enforcement capabilities within their existing MPAs, as well as help to enhance the socioeconomic status of local communities. It would also allow Cuba to work within the limits of their existing funding and resources.

Finally, the environmental regulations implemented by the Bahamian government are very similar to those implemented by Cuba. Various national agencies manage various aspects of

environmental policy, with the care of coral reefs falling to the Bahama Department of Fisheries. In spite of the difference in GDP, and available technology and resources between Cuba and the Bahamas, the latter's use of a National Trust to fund sustainable resource management and conservation is one the Cuba could implement. The funding from the Bahamas National Trust helps to establish marine protected areas, as well as implement environmental education programs. As the U.S. embargo lifts and the tourism industry in Cuba begins to grow, the strategy of establishing a tax- or fee-funded trust fund could help to address Cuba's shortage of money and resources necessary to enforce their environmental policies and legislation.

The goals for Cuba are that the current health of the country's coral reefs be either preserved or improved as well as to implement greater community involvement in coral reef management. **The criteria for achieving these goals are that any recommended policies must be feasible** given Cuba's lack of funding and resources (including access to technology and transportation). Furthermore, any policy must help to both protect the health of the reef and improve the quality of life for members of the local communities.

This author recommends that Cuba use strategies from the above case studies to design a **system of partnerships** between local and national government (such as CITMA), nonprofits or universities, and local communities. These partnerships can be used to expand **marine education** in local communities, thus **empowering and incentivizing residents**, and to implement a management system that is enforced by members of the local community. This author also recommends that Cuba implement a **National Trust Fund**, using fees and taxes collected from the growing number of tourists and foreign industries to fund larger environmental education programs and to expand the current system of marine protected areas.

4.2 Limitations and Considerations

It is important to note the crucial role that Cuba's political, social, and cultural history has played in its resource management, as most of the other countries have not undergone the same economic

isolation that Cuba experienced. Thus, if the health of a reef ecosystem is determined poor, then the history behind each source of pollution, or degradation must be considered. The same is true of any successful management examples. It is crucial to recognize the sociopolitical influences within any resource management strategy and to understand how said influences may alter the physical health of a resource such as coral reefs, as well as the management strategy employed to address said resource.

Furthermore, it is important to again note that information regarding Cuba's coral reefs was oftentimes incomplete or assessed by sources outside of Cuban scientific or management agencies and institutions. This paper uses the information reported through academic databases and resources. As the author, I wish to acknowledge that given the historical lack of Cuban participation in international coral surveys and studies, there is a possibility for contradiction, or inaccuracies in the reported status of coral reef health and management. These possibilities were unavoidable given the constraints of available data, but it is important nonetheless to recognize their existence.

5. CONCLUSION

Coral reefs serve as the proverbial canary in the coal mine. These fragile ecosystems are among some of the most biodiverse places in the world, but they are also the most vulnerable to a changing climate, and human actions. When considering both local and global threats, “approximately 75% of the world’s reefs are rated as threatened” (Burke et al, 2011). Aside from the vast range of species coral is home to, reefs also provide important ecosystem services to human populations serving as erosion barriers to coastlines and providing sources of food and income to local communities.

Reefs can be protected through environmental regulations, community engagement, and the implementation and enforcement of marine protected areas. Community education on marine ecology and sustainable resource use can also serve to further conserve reef systems. The continued preservation, and sustainable use of coral reef ecosystems is essential for both protecting the biodiversity of the ecosystems and ensuring sustainable growth and development for communities.

Cuba occupies a unique economic, political, and ecological situation. Due to isolation imposed by the U.S. embargo, and environmental regulations and restrictions implemented by the Cuban government Cuban reefs systems have remained relatively well-protected. As the U.S. embargo begins to lift, Cuba is at the edge of a potentially dramatic shift in economic and political structure. It is important that Cuba maintains its current environmental policies to continue to ensure the good health and prosperity of their reef systems.

This paper has compared coral health and reef management policy in Cuba to three other countries, and made recommendations as to further actions Cuba might consider. As the increasing influx of tourists and foreign businesses continues, Cuba will need to adapt to a new balance between economic development and environmental protection. It is my belief that Cuba will find that balance by maintaining the constitutional and legislative protections they already have in place, as well as adopting new strategies to effectively manage a changing world.

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