

GO FISH:
AN ANALYSIS OF ECONOMIC RENTS IN PANAMANIAN FISHERIES
AGAINST ECOSYSTEM SERVICE VALUES

by

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ABSTRACT

Global demand of fish for consumption in developing nations is expected to continue to rise in the near future, putting pressure on stocks that are already overexploited. In the territorial waters of Panama there is a constant struggle between commercial vessels with high yield, subsistence fishermen trying to feed a remote village, and ecosystem services struggling to sustain themselves. These services are the direct and indirect benefits received by the population in the form of food, raw materials, nutrient cycling, and disaster regulation. They are being degraded by illegal and unregulated fishing, bottom trawlers raking the benthos and destroying coral reefs, longlines responsible for thousands of sea turtle and bird deaths, and purse seines that decrease species biodiversity in fish stock. While the government has passed laws to reduce the environmental impact the industrial fisheries have, they lack effective enforcement. An alternative approach is to place monetary values on ecosystem services to show the monetary value of previously unrepresented natural capital. Application of this method to fisheries management can educate policy makers on the economic losses to expect if overfishing of the seas continues and provide the economic imperative to lessen impacts on oceanic ecosystems. Through comparative analysis it is shown that the market value of all fish catch in Panamanian waters is less than that which is provided by the ecosystem services in the area. Open ocean and coral reef ecosystem services provide a combined \$103 billion per year while the highest grossing fish catch in Panamanian waters managed to net \$356 million in 2004. There is an economic and political imperative to protect and promote sustainability of not only the fish stock, but all ecosystem services in the ocean.

This work is dedicated to my mother for constantly proving to me that the impossible is possible, with the minor sacrifice of sleep. And to my father for being a positive influence, a voice of common sense, and for always being there with a supportive roll of his eyes.

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TABLE OF CONTENTS

ACKNOWLEDGMENTS	iv
LIST OF FIGURES.....	vi
LIST OF TABLES	vii
LIST OF ABBREVIATIONS/NOMENCLATURE	viii
CHAPTER ONE: INTRODUCTION	1
Introduction	1
Country Profile	4
CHAPTER TWO: LITERATURE REVIEW.....	12
Ecology and Economic Value	12
Assessment of Fisheries.....	23
CHAPTER THREE: ECOSYSTEM SERVICE VALUE.....	31
Ecosystem Services	31
Methodology of Valuation	33
Limitations and Assumptions	35
CHAPTER FOUR: FISHERIES PROFIT AND IMPACT	37
Legislation and Enforcement.....	37
Makeup of Fisheries Fleet	43
Fishing Methods.....	44
Profit of Fisheries.....	48
CHAPTER FIVE: RESULTS	50
Results	50
Analysis of Results	51
CHAPTER SIX: DISCUSSION & CONCLUSION.....	55
Discussion.....	55
Conclusion	61
LIST OF REFERENCES	66

LIST OF FIGURES

Figure 1. Relationship between fishing effort and benefits derived from different objectives	27
Figure 2. Ecosystem Services and Benefits	32

LIST OF TABLES

Table 1. TEEB Values	34
Table 2. Industrial Longlining catch, metric ton.....	46
Table 3. Industrial Purse Seine catch, metric ton.....	47
Table 4. Fisheries Profit and Employment	48
Table 5. Total TEEB Values for Panama	50
Table 6. Fish Consumption per capita 2001.....	51
Table 7. Gross Value Compared to Minimum and Maximum TEEB Estimated Food Provision Value	52
Table 8. Gross Value Compared to Minimum and Maximum TEEB Estimated Total Provision Value.....	53

LIST OF ABBREVIATIONS/NOMENCLATURE

AMP	Panama Maritime Authority
ANAM	National Environmental Authority
ARAP	Aquatic Resources Authority of Panama
B/	balboas, equivalent to one US dollar
CBA	Cost-Benefit Analysis
CBD	Convention on Biological Diversity
CPUE	Catch Per Unit Effort
EEZ	Exclusive Economic Zone
FAD	Fish Aggregation Device
FAO	Food and Agriculture Organization
FIRMS	Fishery Resources Monitoring System
GRT	Gross Register Tonnage
IATTC	Inter-American Tropical Tuna Commission
IUCN	International Union for Conservation of Nature
IUU	Illegal, Unreported, and Unregulated
MDG	Millennium Development Goals
MEA	Millennium Ecosystem Assessment
MEY	Maximum Economic Yield
MPA	Marine Protected Area
MSY	Maximum Sustainable Yield
NGO	Non-Governmental Organization
NOAA	National Oceanic and Atmospheric Administration
NPV	Net Present Value
OSPESCA	Organization of Fisheries and Aquaculture in the Central American Isthmus
PDF	Panamanian Defense Forces
PES	Payments for Ecosystem Services
PGY	Pretty Good Yield
TED	Turtle Excluder Device
TEEB	The Economics of Ecosystems and Biodiversity
UNEP	United Nations Environmental Programme
WCPFC	Western and Central Pacific Fisheries Commission
Benthic	lowest level of a body of water
Bottom trawling	dragging a weighted net along the sea floor
Bycatch	non-targeted species caught during fishing
Cast nets	circular nets with weights around the edge to sink after it is thrown
Economic rents	net economic benefits attributable to a natural resource
Fishing capacity	rate at which fish are caught, differs based on gear used
Gillnets	a net used to trap fish of a certain size by their gill covers

Gross Register Tonnage total internal volume of a vessel measured by cubic feet
Longline fishing line possibly miles long with thousands of bait hooks
Pelagic near the surface of coastal water and open ocean
Purse seine a net hung vertically in the water column, dragged behind a boat
Ton metric ton (1,000 kilograms)

CHAPTER ONE: INTRODUCTION

Introduction

Fisheries are increasingly impacted by climate change and overfishing as demand for fish protein increases. Panama leads this demand in Central America and has overexploited its fisheries due to mismanagement of growth (Durán & Puentes 2012, pg. 13). The research question of this thesis is: are economic rents derived from the fishing industry less than the ecosystem service values? The hypothesis is that rents are indeed less than ecosystem services values.

Using a method derived from extensive academic research on ecosystem values, we will assess the total economic worth of the ecosystem provisions of Panama's open ocean and coral reefs. These ecosystems are the source of natural capital for the country and are commonly unvalued due to difficulties in assessment. The Economics of Ecosystems and Biodiversity (TEEB) method provides estimates of the ecosystem and its provisions, giving us a platform to compare the contributions of the ecosystems to the value of fisheries.

Ecosystems provide value in terms of climate regulation, materials, nutrient cycling, and erosion prevention. Poor regulation of these services leads to loss of national wealth and the beneficial effects of said systems (TEEB 2010, pg. 43). Examining the regulations and enforcement policy of Panama and the fishing activity will provide a metric of efficacy of the agencies charged with ensuring environmental longevity in the country.

This thesis seeks to expand the application of the ecological economic model to a region at a crucial point of development in which natural capital is not properly monetized and will likely be sacrificed for short-term profit and progress. The profit maximizing imperative of fisheries, as with all market-based industry, has specific desire to lessen regulation as these

regulations can often place costs on vessels or lessen their maximum profit by lessening catch. Regulation policy through means of gear, method, limits, and areas of restriction are the most common. Limitations or alterations on gear can require vessels to purchase new nets due to size restrictions. As seen in Panamanian legislation the method of reeling in longline and purse seines requires specific size rollers, meaning previous mechanisms must be scrapped or sold off and new rollers purchased to continue using the same method. These kinds of regulations cost vessels capital investment. Some of these regulations even lessen catch rate, and thereby profit “rate” (FAO 2008). The implementation of no-fish marine protected areas (MPAs) effectively reduces the area in which vessels can actively troll for their target species. As the tuna and skipjack species, especially in the Pacific region, are known to travel quite far in search of their own food they have a greater chance of ending up schooling in no-fish MPAs (IUCN 2012). These areas have compounding positive impacts on fisheries as a whole (Halpern 2003, Pérez-Ruzafa et al. 2008). These restrictions and regulations become politically charged as they limit profits of vessels and are commonly argued by industry to not support sustainable levels of fish stock. Research suggests the opposite, posing a need for policy influenced by peer-reviewed science to shape regulation decisions (Cowan et al. 2012, Durán & Puentes 2012, Fletcher et al. 2012).

Trophic mining, the systemic targeting of top-level fish species, allows for high catch rates that can be followed by decline in population and possible unsustainable levels of stock (Pauly et al. 1998). A moderate decline in fish catch has been recorded by Panamanian fisheries since 2006 (UN Data, 2011). While specific species analysis in Panamanian waters has yet to be conducted, the consensus of the Inter-American Tropical Tuna Commission (IATTC 2012), the International Union for Conservation of Nature (IUCN 2012), and other regional studies is that there is current overexploitation of the fish stock. The damage and possible collapse of this

ecosystem as result of a poorly managed fishery will affect the economy of Panama. This research aims to place a value on the natural capital of the ecosystem compared to the economic rents derived from it, providing an analysis of fisheries management that fails to account for the total natural wealth at stake and the policies that have been unable to promote sustainable practices.

The TEEB report that is the foundation for the economic analysis states that “valuation may play an increasing role in policy making” (2010, pg. 43). Policy decisions can often be decided based upon cost-benefit analysis (CBA) as it offers a simple comparison of actions and their gains or losses in standardized monetary value. Making these comparisons while failing to account for ecosystem service values, which can “save on future municipal costs, boost local economies, enhance quality of life and help secure livelihoods” (TEEB 2010, pg. 174), lacks a complete picture of total costs and benefits. Placing values on the ecosystem services gives a dollar value to the contributing material and energy outputs of said systems that, in a natural and sustainable position, come at no cost to the public or state. Failing to account for these values would result in catastrophic damage to an entire nation’s ecological wealth, and should be characterized as a loss of prospective gross domestic product (GDP) in as such these ecosystems contribute directly to the health of a state’s economy (TEEB 2010: p. 35).

The accessible records of Panamanian fishery legislation, beginning in 1959, are outlined and examined for their impacts on fisheries management. The restriction of fishing methods and technology, designating of MPAs, regional restrictions, and creation of enforcement agencies are the most common policies enacted by the National Assembly of Panama. As noted previously, the IUCN (2011), Fishery Resources Monitoring System (FIRMS 2012), and Durán & Puentes (2012) all define the region of Panamanian fisheries to be overexploited. This serves to show the

policies of fishing regulation in Panama are not functioning to ensure a sustainable system as decreed by Law Number 17 in 1959.

The TEEB reports serve as a policy making guidebook for various levels of state actors. It has been used in eight Caribbean island nations to influence national governments to enact policy for endangered ecosystems through the TEEB valuation methods. The economic imperative of preservation when provided the monetary value of the services of ecosystems has been proven in these developing nations. By using the methodology of ecosystem service valuation, analyzing the policies enacted by the Panamanian government, and considering their impact on the environment, the hypothesis as to whether economic rents are prioritized over ecosystem services will be explored. Policies enacted will also be examined as a measure of sustainable actions to prevent or decrease overexploitation of the fish stock.

Country Profile

Panama's history is one of the more unique in Latin America due to impactful influences from outside nations, most notably the United States. Native tribes were subjected to exploitation from the Spanish Empire in the 16th and 17th centuries. Coastal tribes such as the Cueva were completely exterminated in the exploration of gold and pearls on the isthmus as well as the explorers search for a path to the Pacific Ocean. Little is known of these tribes as their history was not well documented and most traces were destroyed by the Spanish conquistadors. Christopher Columbus is noted as having formed the first settlement in the to-this-day remote area of the Darién in 1503 (BBC News 2001).

The isthmus became more important as colonization of the western side of South America by Europeans increased, most notably the finding of precious metals. Portaging, the practice of carrying a ship over land between two bodies of water, was used to decrease the time

to transport goods to and from Spain and its new settlements. The dense jungle and hostile tribes that managed to persevere caused more and more losses of these trips, along with pirates from other European trading companies, placing an imperative on Spanish explorers to quell the rebellious natives and secure their control of the isthmus.

Over the next two centuries the region was torn apart by colonialism from Spanish, Dutch, Scottish, and English armadas. Spain would eventually manage to control the region, deeming the city of Panama to be a crucial outpost in the New World. Much of the population that opposed this new rule fled to the interior or to outlying islands. This would become important in the demographics of the country later. In the early 18th century, Spain began to lose influence and power in Panama as the population became rebellious and left the city to develop the land in attempt to declare independence. In 1821 the Spanish Empire was ousted from the city of Panama with help from Colombia in exchange for agreeing to become part of the neighboring state. Interest from the United States started shortly before the new independence from the European influence and quickly developed as the U.S. expanded westward (Harding 2006).

Throughout the 19th century the United States attempted to garner influence in the isthmus, competing with France in attempts to build a trans-oceanic canal. Populations that had moved to the interior were removed from the influence of the new governance of Colombia. Only the city of Panama was in true control. Infighting between Spain and Colombia included the new province of Panama with the start of the Thousand Days War. During this time the United States attempted to gain rights to build a trans-oceanic canal in the Colombian province of Panama. The resulting Hay-Herrán Treaty was signed and ratified by the U.S. Senate, but not the Colombian Senate. Historians suggest that the reason the treaty was not ratified in Colombia

was the rogue nature of Herrán's negotiations, lacking direct support from the Colombian government. While Colombia managed to overcome the Spanish Empire, the United States had turned to another avenue in order to gain rights to build the canal in Panama. Support for a Panamanian rebellion was fueled by U.S. support in exchange for "sovereign right" to the area extended out 10 miles on either side along the canal to be built as result of the Hay–Bunau-Varilla Treaty on 1903 which included Panama's declaration of independence from Colombia. Construction started on the canal that year and was finished in 1914, though Colombia would not recognize Panamanian independence until 1921 when the United States finally ratified the Thomson–Urrutia Treaty to pay Colombia its dues to accept the terms of independence (McCullough 1977). The influence of the United States would further shape the political turmoil still present in the country today.

The Panama Canal construction caused an influx of exploited labor from the Caribbean and Asia. Military influence from the United States was even more widespread as the stability of the new nation was imperative to completion of the project. The Panamanian government was carefully watched over by U.S. interests though it was considered independent. It was imperative that the formative domestic government did not harm the security or profitability of the Canal. Massive immigration to sustain the Canal and military bases created an interesting culture which developed into tension as U.S. influence spread into the sovereign government. In 1964, students from Panama stormed a U.S. controlled building in the Canal Zone, considered sovereign U.S. territory and attempted to fly the Panamanian flag alongside the U.S. flag. This resulted in the death of 21 students and 4 U.S. soldiers. The date, January 9th, is deemed Martyr's Day in Panama to remember the students attempt to proclaim sovereignty over the Canal Zone. Panama broke off diplomatic relations shortly after, demanding renegotiation of the Canal Treaty. A

temporary agreement in 1964 led to the reopening of communication, but the resulting treaty was not ratified by the Panamanian government. Increasing tensions between Panamanian citizens and the U.S. occupation of the Canal Zone lingered over the next few decades. The election of President Arias in 1967 was marred by violence caused by accusations of corruption from his opponents. This set the stage for future perceptions of Panamanian governance and their penchant for bribery and exploitation. Some consider the watchdog nature of the U.S. military influenced these bribes and contributed in the degradation of political justice and due process (Lindsay-Poland 2003: p. 69).

President Arias attempted to reorganize the national protection force against the original agreement after his election. This resulted in a coup led by Omar Torrijos who would form the “Revolutionary Government” and enacted constitutional changes while oppressing all opposition, including any participation in political parties, to his directives. Torrijos used his military influence to ensure his complete rule of the country, while allowing elections to be held though he would be the final decision maker in an attempt to feign democratic constitutionality. The United States saw Torrijos as a threat to the security of the Canal and opened talks on a new treaty in 1977; the result was the Torrijos-Carter Treaty. The agreement included full transition of Canal ownership from the United States to the Panamanian government on December 31st, 1999. Congressmen in the United States were adamant that this was kowtowing to a possible military dictatorship, but the treaty was passed.

Over the next five years the Panamanian Defense Forces (PDF) came to power under Torrijos, who placed Manuel Noriega in control after his support during the coup of President Arias. It was during Torrijos’ ascension to power in the late 1960s that the CIA enlisted Noriega to support overthrowing Torrijos, as the military leader was unwilling to renegotiate the treaty

signed in 1977. The United States understood the loss of such a strongpoint in global military control that the transition agreement in 1999 to Panama was no longer acceptable. The unexpected death in 1981 of Omar Torrijos in a plane crash left a power vacuum in the country. There is speculation that Noriega and the CIA were behind the supposed assassination, and this is widely agreed upon by Torrijos' supporters to this day. Noriega had been promoted to General of the Panamanian Defense Forces and maintained control through the 1984 elections. Though the former President Arias who ran in 1984 was considered the winner by many, it was the PDF supported candidate Nicolas Barletta that was declared the elected president. The country was in economic ruin from unpaid loans to the IMF and World Bank and lacked the massive income available from ownership of the Canal. These factors contributed to growing civil unrest as unemployment skyrocketed and GDP continued to fall. It is important to note during this time that the 20-mile wide sovereign area of the Canal Zone was not affected by these economic downturns. The Canal Zone was essentially a self-sustaining region, with little input required from Panama. Control of power and water generation was located within the Canal Zone to ensure security and continued efficiency of the Canal. Again, this disparity would spark resentment for what was considered to be a U.S. occupation by Panamanian civilians.

The late 1980s was marred by infighting in the PDF and political pressure from rival parties. Noriega was accused of rigging elections, sparking Black Friday in which hundreds of Panamanian citizens were injured by PDF riot control in attempts to quell any rebellion. It was made public by a former PDF officer that Noriega had been torturing and killing civilians to extract information on his opposition. Up until this point, General Noriega had been supported by the United States government for his cooperation on supporting the Nicaraguan Contra forces after it was declared illegal by the U.S. Senate to continue to support the rebel force.

The global outlook on Panamanian and United States relations worsened, leading President Reagan to enact sanctions on the Central American isthmus in efforts to reduce the influence of General Noriega. The Panamanian dictator was accused of drug trafficking charges in 1988 as the U.S. government stopped all aid funding to Panama through its organizations, causing further economic damage. The 1989 Panamanian election resulted in Noriega's opposition winning, only to have the election be annulled by the General as he continued his reign.

December 20th, 1989 saw the execution of Operation Just Cause, a massive invasion of Panama by U.S. military forces in attempt to protect U.S. citizens and free the Panamanian population from the military dictatorship. This resulted in the largest invasion the U.S. had participated in since the Vietnam War. Hundreds of U.S soldiers, PDF soldiers, and Panamanian civilians were killed in the ensuing two week long engagement as Noriega held up in his bunker. He was eventually extracted and delivered to sentencing in the United States in early January 1990. One of the most impoverished areas of the city of Panama, El Chorrillo, was set aflame during the invasion. It is not clear if this was the result of PDF actions to incite anger against invading forces or from misguided U.S. rockets. The neighborhood was made of all wooden constructed homes and was burned completely to the ground in under a day as fire services and the public could not put out the raging fires. Some 20,000 people were displaced as a result (Lindsay-Poland 2003: p. 122).

While the immediate impacts of the invasion caused record levels of unemployment and widespread violence the previous election was reinstated and President Guillermo Endara was given control for the constitutional allotment of five years. The election of 1993 was closely monitored by international organizations and highly scrutinized by the United States. A former

support of General Noriega was elected and watched closely through the next few years as fear of resurgence in rebellion could be sparked. President Mireya Moscoso, widow to former President Arias, was in office during the Panama Canal transfer. It took the election of Omar Torrijos' son, Martin, to begin institutional changes and enforcing transparency. Martin Torrijos took a strong anti-corruption stance, but failed to gain support as many incidents occurred within his administration that were never acted upon (Kessler 2004). The current president is a supermarket magnate, Ricardo Martinelli, known for his business influence. His policies have Panama increase GDP at record rates in Latin America, though questions remain if the new income wealth is being dispersed in an effective manner as the nation still struggles with poverty (CIA 2013).

The political turmoil and historical unrest of Panama is a result of external influences, namely the global importance of the Canal. U.S. interests in ensuring security of the Canal resulted in a supported dictatorship as means to attempt renegotiations. The 23-year rule of de facto governors had incredibly negative effects on Panamanian prosperity in terms of GDP and cultural infighting (CIA 2013). A system that lacked proper checks and balances was the legislating force that enacted many of the fisheries laws still on the books today. Corruption was rampant during the military rule and the current administration is constantly under fire for their actions supporting large corporations (Jackson 2012). It is possible that this method of politician greasing has become commonplace in the higher echelons of Panamanian politics. The Panama Canal almost matches the GDP influence of fisheries at 7.5% (A Singapore for Central America? 2011, CIA 2013). Obviously the prosperity of fisheries is high as the income from the Canal is seen as the most important contributor to the Panamanian economy. This would place it within the realm of corruption to ensure it maintains the desired level of production.

As mentioned previously, there is still a notion of cultural infighting between the main city of Panama and the remaining indigenous tribes in the interior as well as the outlying islands and coastal areas. Legislation was enacted to allow some freedoms for indigenous populations, but it is still unclear if other small industrial vessels are encroaching into their tribal water or if their uninhibited actions are causing unsustainable catch of fish.

The historical context of Panama has indefinitely influenced the manner in which it presents and passes legislation. While this thesis cannot make assertions as to the level of corruption within the fisheries management, there is sufficient evidence that corruption does occur in normal business of the country (A Singapore for Central America 2011). Unfortunately this aspect will not be directly addressed, but it should be noted throughout the analysis as it could point to reasons for how Panamanian fisheries management has come to be such a powerful part of the domestic economy.

CHAPTER TWO: LITERATURE REVIEW

Ecology and Economic Value

The TEEB study (UNEP 2011) was conducted through partnership with the United Nations to address the issues surrounding environmental degradation. The intent of the TEEB approach is to create a final stage of monetary valuation for an ecosystem and its services based on peer-reviewed scientific study. Authors of the study state that “the potential for using valuation to inform policy making is still largely unrealized” (p. 12). The approach is three-fold; identify and assess the totality of ecosystem services and the populations affected, capture and monetize the value of ecosystem services, and provide a basis for more informed policy formation and analysis to better manage and sustain these systems. The use of the TEEB study helps to found the research question of comparing economic rent derived from fisheries, taken as the value of fish sold at market, to the wealth provided by ecosystem services. The comparison of these two by means of monetization shows where values may be misrepresented in the case of natural resources. Policy advocated through the TEEB method is based upon the alternatives available to policy makers, the costs of providing the same ecosystem services through man-made measures. It is in this way that politics can be influenced with the TEEB system, as we seek to prove.

TEEB studies are broken down into their applications; ecological and economic foundations, national and international policy making, local and regional policy and management, business and enterprise. For the purposes of this thesis the Ecological and Economic Foundations (Kumar 2010) and National and International Policy Making (United Nations Environment Programme 2011) reports will be used.

The framework for the TEEB study is based upon the application of specific valuation methods: market prices, market alternatives, surrogate markets, stated preference, participatory, and benefits transfer (TEEB 2010 p. 44). A combination of these methods is used to provide a general estimate for ecosystem services and provisions which is used for the value calculations in this thesis.¹ Each method is explained to provide policy makers and advocates tools to apply methods that may be better suited to stakeholders. An example is the use of replacement costs in the market alternative model. The report uses an example of human-engineered alternatives to an ecosystem service or provision, such as water purification. Evaluating the cost of building and maintaining a man-made alternative can provide a metric of value for the “free” ecosystem service, provided that the ecosystem is healthy and functioning properly (TEEB 2010 p. 45).

The general estimate is based upon a total method valuation, the market alternatives listed previously, set within net present value (NPV). The TEEB (2010) report defines NPV as “the sum of the discounted benefits minus the sum of discounted costs” (p. 53). Discount rates in the TEEB method are suggested to be set between one and four percent, “as we cannot assume we will have more of this resource in the future” (2010, p. 52). The report states that fisheries may be subject to systemic cost-benefit analysis (CBA) failure due to low rates of return when coupled with high discount rates as would be common in capital investment scenarios. Values and methods used in this thesis are based upon the overall TEEB estimates for the natural capital of ecosystem services and provisions set in net present value (NPV) with discount rates between the given 1-4% (2010 p. 53-55). High discount rates denote a greater value to current consumption. This low discount rate provided in the TEEB analysis supports the notion that the value of these ecosystem services is of greater value to future generations and thusly the future of the fishing industry in terms of profit maximization and sustainability.

¹ See Table 1 for general values

Akpalu (2008) finds that implementation of high discount rates increases the occurrence of illegal fishing as it places the economic gains in the present rather than discounting them for future value. Fehr & Leibbrandt (2011) conducted a study of fishermen in a remote area of Brazil that were experiencing decreasing catch numbers. They found through game theory and field testing that lowering the discount rate of the shrimp led to more sustainable practices. Cooperation towards more sustainable practices is also seen if fishermen are given the opportunity to switch to less intensive methods if a certain amount of other fishermen also agree to the same methods (Fehr & Leibbrandt 2011, p. 1151). The reduction of discount rates similar to levels the TEEB study has suggested, with the notion set forth by Fehr and Leibbrandt, that structured agreements can reduce fishing impact on ecosystem services and supports the foundation of this report. The values contributed by the TEEB method are properly discounted according to long-term sustainable practices (Akpalu 2008, Fehr & Leibbrandt 2011), while policy making can create cooperation to reduce illegal and exploitative fishing methods. The TEEB values and discount rates can be used to further argue for conservation of ecosystem services from an economic standpoint, as demonstrated in a case study of the United Kingdom (TEEB 2010, p. 54-55). It was found through the same methods and values used in this report, at a discount rate of 3.5%, that the “cost-benefit ratio of marine conservation in this case was 10:1” (p. 55).

The TEEB method can be used to prove that stability and preservation through valuation of ecological infrastructure can lead to positive long-term socio-economic impacts, especially in poor and developing areas (p. 25). Included in this approach of assessing nonmarket values of ecosystems is the intent of eliminating subsidies that overexploit said services. Payments for

ecosystem services (PES) are also advocated by the reports to lessen the consumption and degradation of unsustainably managed resources.

Policy recommendations in the TEEB reports are based on expert analysis and hundreds of scholarly articles on the topic to value and internalize biodiversity and ecosystem services. There is apprehension to enact strict environmental policy due to the difficulty of valuation and secondary impacts. The TEEB reports resolve this through connecting policy decisions to monetary value that is attributed to security, cultural well-being, and resource provisions to: “[m]ake the implicit explicit” (p. 32). A historical global perspective is used in the reports to examine how previous policy decisions affected biodiversity and the economic welfare of states. Case studies, as well as general analyses, are combined to present an estimated value on regional systems alongside a decision making scenario that states can adapt to suit their specific needs.

Ecological banking, land planning, and alternative valuation techniques are presented to provide a workbook for states wishing to ensure the continuity of their natural capital (TEEB 2010, p. 43). The TEEB reports address the concept that traditionally non-valued services (i.e. spiritual or sacred land) can be monetized when framed within a cultural biodiversity lens. An estimated TEEB value is not assigned to these services as the authors explain they are extremely variable based on the importance of the cultural services within that state. Ascher (1999) and Clark (1995) state that the attempt to value ecosystem services fails to account for the intrinsic cultural wealth imparted to the population. While Ascher and Clark claim that the idea of monetization does not provide a proper framework for sustainable development, the TEEB methodology has aimed to address this issue. The TEEB system is intended to provide monetary values to systems that have market alternatives, such as artificial fish breeding for open ocean fisheries, natural hazard regulation by means of levees, coral reefs mitigation of damage to

coastline from storms, and production functions, the link between the change in land use of an ecosystem and the monetary impact it has on the inputs for the system (TEEB 2010, p. 45). The valuation of cultural services is not included in the TEEB methodology as noted in the limitations of the study (2010, p. 63). The TEEB report does note as with all other systems and provisioning services that simply because there is no value attributed does not make said system worthless. This is a crucial assumption in this report as there is much discussion over the valuation of cultural and aesthetic services and their value as result of regional and societal differences that are beyond the scope of this research.

However, by providing methods in which national policy makers can examine these values, they avoid the general trend of previous research to simply state that they cannot be calculated. These TEEB methods allow a more complete analysis of all services that the regional ecosystems can provide, informing decision making more completely.

Overall, the TEEB reports attempt to value ecosystems and their services while providing guidelines to possible solutions at various levels of state actors. While international agreements can be made to ensure environmental protection and sustainability, the TEEB method can also be directed at the regional level in which decisions are made outside the realm of these agreements. The decision to allow artisanal fishermen to use higher yield methods for fishing would not be within the scope of an international agreement, therefore the national policy should address the impacts of such a decision (TEEB 2010, p. 17).

The combination of ecological principals and economic provisions of services gives policy makers an array of tools to better manage their natural resources. “Ecosystem services account for a large proportion of the goods and services consumed by the rural poor in developing countries” (TEEB 2010, p. 15). Millennium Development Goals (MDG) are noted as

having direct ecosystem services that can be used to reach the targets. Considering the above statement that poor and rural populations are dependent upon the natural provisioning services of ecosystems, one can assume and is confirmed by Shackleton et al. (2008) that the continued availability of these services is critical to the survival of poor populations. Shackleton et al. (2008) state, “there is a need and obligation for the state to underpin the safety net offered by biodiversity” (p. 523). This provides the political imperative of state action in preserving ecosystems and their services. An estimated 80% of the Panamanian population lives along the coast (FAO 2008) and the consumption of fish per capita is the highest in the region (UN Data 2012). The dependence on the natural resources of fisheries for the rural population is clear, though not fully analyzed specific to Panama in any recent study. Comparatively, Panamanian legislation of fisheries policy is decades behind the steps taken in the United States and other ‘developed’ fishing nations. Such a delay in action and enforcement is the possible cause for current levels of overfishing. The TEEB method also serves as the foundation for this thesis as a means of comparing ecological damage based from total value of services and economic rents of activities consuming resources.

The Millennium Ecosystem Assessment (MEA 2005) on marine fisheries lists the following as drivers of change; climate change, subsidies, demand and fish prices, shifting food preferences and consumption, technological change, illegal fishing, and globalization (p. 490-2). The assessment goes on to state that, “[i]n some areas there is a lack of surveillance, enforcement, and monitoring due to high operational costs” (p. 491). Panama would certainly be grouped in this category due to the underfunding of enforcement agencies such as the Panama Maritime Authority. The analysis of Panamanian legislation explores the delayed response of fisheries management in Panama compared to that of developed fisheries.

Conflicts of use are explored by the MEA in terms of tradeoffs of consumption. The consumption of marine resources such as oil and gas can cause negative impacts on fisheries as well as eutrophication of coastal areas due to development (MEA 2005 p. 492-493). The loss of tourism and sportfishing in regions where fish stock has been deemed “overexploited” can be detrimental to economies. Jiménez et al. (2010) found that in Costa Rica, which is not defined as “overexploited”, the sportfishing industry contributed almost \$600 million a year, equal to 2.13% the countries 2008 GDP. The contribution of commercial fisheries to GDP was \$530 million a year in Costa Rica. While Panama lacks any academic analysis of the impacts of the sportfishing industry, it is considered to be a dream destination for those that partake, considered to be much better than Costa Rica. Though this will only continue for as long as larger and more desirable fish are caught in Panamanian waters with greater consistency. Access and health of marine ecosystems are easily spotted by sport fishermen, noticing declining catch size and abundance decreases their chances of returning. Ensuring the sport fishing industry continues to grow and contribute to the economy is the result of proper management and enforcement.

The MEA report also denotes that an importance placed on non-consumable aspects of ecosystems for proper assessment. Climate change mitigation is mentioned as an important service from marine ecosystems, one that is directly linked to fisheries management (MEA 2005, p. 498). The geographic distribution of fish as well as the biomass can affect macro and micro algal species of lower trophic fish, changing the ability for the system to act as a carbon sink (p. 498). While there has not been a long enough time-series analysis to definitively show the outcome of climate change on fisheries, the decrease in biomass will certainly affect fish species ability to adapt to any large scale changes in the marine system according to the MEA (2005 p. 498). Ensuring proper biomass size depending upon reproduction rates that ensure enough

genetic variance in the species should be one of the main goals of sustainable fisheries regulation.

MPA assessment and legitimacy is also addressed by the MEA report. While open ocean no-fish MPAs experience little property right questioning, coastal MPAs are commonly fought against by local and indigenous populations (MEA 2005, p. 498). The MEA report defines 'aboriginal' as "descendants of the original inhabitants of countries whose population now largely consists of recent immigrants" (p. 499). There are distinct indigenous/aboriginal populations in Panama, most of which live in coastal areas and are dependent upon fish as their main source of protein (Meneses 2010). Management systems that use coastal no-fish MPAs will be forced to address the access issue for these populations as they do not have the same intensity of industrial fishing, but their common practice of sale and trade of fish should be monitored (MEA 2005, p. 499). In the case of Panama, constitutional legislation allows indigenous tribes the right to fish using traditional methods, which are commonly low-intensity and near-shore. There is also a distinct lack of no-fish MPAs in coastal areas of Panama, save for Coiba Island that is not populated by indigenous tribes.

The MEA (2005) report on marine fisheries also attempts to address the political aspects of stakeholders and user groups. The report argues that the equity of access, level of catch, and rents should be assessed on a case-by-case analysis (p. 499). Balancing the methods in which access is granted is of particular importance in countries with competing artisanal and industrial fishing groups, as is present in Panama. These two groups are withdrawing resources from the same common pool resource, require similar inputs (i.e. fuel, nets, workers), yet are subject to different economies of scale and legislative restrictions of method. Governmental subsidization of industrial fishing is also able to increase the incidence of lowering fish prices to the point that

artisanal fishermen are no longer able to compete (p. 500). Separating the industries through management (i.e. license-specific fishing areas, gear restrictions, catch limits) is capable of minimizing the political friction between artisanal fishermen that commonly garner support from the general public, and the industrial fisheries that contribute large amounts to national GDP (MEA 2005, p. 500; FAO 2008). It is further found that because of the institutional tendency to align with industrial fisheries, and the political derisiveness of enforcing regulations on artisanal fishermen that can negatively impact their livelihood, governments are usually averse to acting (MEA 2005, p. 501). Again we see this issue occur in Panama as there is a lack of enforcement from institutional organizations tasked with keeping industrial vessels out of MPAs and restricting methods deemed too exploitative (FAO 2008, Meneses 2010).

The World Bank in conjunction with the Food and Agriculture Organization (FAO) conducted a study (World Bank 2009) of international fisheries, found that 75% of all monitored stocks are considered overexploited or fully exploited (p. 3). This proves to be an even more widespread issue in areas such as Panama where overcapacity as result of mismanagement of licenses combined with restricted areas can cause increased rates of illegal, unreported, and unregulated (IUU) fishing (Le Gallic, Cox 2005, p. 690). The lack of adequately supported monitoring agencies in Panamanian waters effectively reduces the negative effects of being apprehended in the act of IUU fishing (p. 691).

Research from the World Bank (2009) report shows that of the drivers of fish stock levels include climate change as well as increases in illegal of overfishing in recent decades (p. 5). The focus of this thesis will be the impacts of fishing activity on the wild fish biomass as the report claims the stock is near “long-run biological maximum” (p. 3). The World Bank report draws attention to this issue by stating, “[g]rowth in demand for fish is concentrated in developing

countries where populations and per capita income shows strong growth” (p. 11). Panama fits this definition with GDP per capita increases of \$3,938 in 2000 to \$4,785 in 2005 to \$7,154 in 2009 (United Nations 2011).² If fish consumption follows the historical trend in Panama, one could expect to see increases in the coming years (UN Data 2011). This coupled with the lack of a strong enforcement agency in the state, increases in profit, and restrictions from no-take marine protected areas (MPAs) could lead to illegal overfishing (Le Gallic, Cox 2005).

Increases in fishing capacity over recent decades has had a greater impact in developing nations that have been prone to much greater leaps of advancement through technological advancement (p. 21). This leads to higher economic rents being received by fishing fleets, driving incentives to catch more. The report underpins the greatest downfall of fisheries; “economically healthy fisheries require biologically healthy fish stocks, while biologically healthy fish stocks do not necessarily mean economically health fisheries” (p. 31). The statement shows that there is an economic imperative, and thus moral hazard, to catch more economically profitable fish with disregard for the health of the fish stock. Lax regulation and enforcement in the fishing industry allows for high profits in foreign trade for developing (p. 44). Over \$6 billion per year would be attained if bycatch of fisheries decreased. The majority of this amount derived from developing nations where methods of improvement would yield greater reductions (p. 45).

The World Bank report helps to define aspects for the rest of this thesis. Use of the term ‘economic rents’ will pertain to the “measure of the net economic benefits attributable to a natural resource” (p. 29);

“The resource rent is a measure of the net economic benefits from the harvest of wild fish stocks. Different fisheries generate different levels of resource rent. For example, a fishery for a high-value species in coastal waters (which has a low cost

² All values held to 2011 USD

of harvesting) will generate more rent (or profits to fishers) than a fishery for a low-value species harvested at high cost in deep water. As more fishers join a profitable fishery, they add to the aggregate costs of catching the limited quantity of fish available. As a result, the aggregate net benefit, or economic rent, decreases, becoming dissipated among the fishers in the form of higher costs and lower returns for their fishing operations or fishing effort. The rents may even become negative when public financial transfers or subsidies are provided to support an economically unhealthy fishery. As more fishers make greater efforts (for example, by fishing longer hours or investing in more fishing gear) to maintain their previous profits or catch levels, the fishers tend to deplete the fish stock capital that sustains the productivity of the fishery. This further reduces the potential net benefits.

As soon as the level of fishing effort moves above the point of maximum economic yield, a situation of economic overfishing exists. Such economic overfishing can exist even if the fish stock itself remains healthy or biologically sustainable.” (p. 30)

This applies to both the fish stock and the ecosystem services the stock supports and is supported by. The economic analysis of this research outlines the principal that “[t]he depletion of a nation’s fish stocks constitutes a loss of national wealth, or the nation’s stock of natural capital” (p. 50). The TEEB report provides guidance on the political economics of resource policy, the ecosystem services have intrinsic values that should be considered when making decisions. This management of a common pool resource such as fisheries falls into the realm of policy enforcement that is not well defined. Whether or not the state has the ability to enforce policy

beyond industrial fisheries to artisanal is questioned in the World Bank report (p. 52) as indigenous populations are granted cultural rights to fish their ancestral waters.

To draw a parallel, Haller & Merten (2008) conclude in their study that the lack of a strong institution, in the form of Kenyan fisheries regulation organization, coupled with a strong ideological citizenry resulted in overexploitation and illegal methods in fisheries. The legitimacy of the Kenyan institutions had been lost as a result of enforcement failures and the creation of new departments in attempts to regulate was met with minimal commitment by the public (p. 713). Clearly the state having an enforcement agency and regulations does not mean that it will become accepted by the population, especially indigenous peoples that are commonly given limited freedoms in fisheries.

Assessment of Fisheries

Agardy's (2000) research indicates that biodiversity is often not properly managed in fisheries, and as a result creates negative ecological impacts at a far greater scale than previously imagined. Agardy places the importance for conservation of biodiversity over maximum economic yield (MEY) as the effects of overfishing apex species causes irreversible harm to the system (p. 761). Biodiversity is given higher rank in Agardy's system of fisheries management due to the asymmetrical distribution of apex fish and diversity in fisheries. This offset system is more susceptible to damaging effects of overfishing when MEY is the operative policy of the fisheries management (p. 761). As fishing is conducted in search of apex or economically viable species, trophic mining is experienced and affects non-targeted species. Pauly et al. (1998) claims the trophic level of fish landings has declined over the past 45 years. An increase in landings while eliminating top level predators was shown to trend upwards, introducing the possibility of "widespread fisheries collapse" (Pauly et al. 1998). Essington et al. (2006) also

states that the method of “fishing down the food web” is capable of having negative effects on the ecology of fisheries. It is also found in Essington et al. that the North Atlantic fisheries experienced fisheries collapse under circumstances of overcapitalization and climate-induced decreases in fish stock (2006, p. 3173). The FIRMS (2012) report confirms these circumstances to be consistent with the Eastern Pacific Ocean, in which Panama performs 90% of its fish catch. This, in conjunction with bycatch of sea birds and turtles from long-lining, including raking of the benthos by bottom trawling, demonstrates the interdependency of species in fisheries and the extensive impacts of current practices (Agardy, 2000: p. 762).

Because there is asymmetrical distribution of biodiversity in the ocean, Agardy and Pauly et al (1998) argue for the use of no-take MPAs as an effective tool in maintaining sustainability in the system (Agardy, 2000: p. 762). Access to MPAs can be outlawed for fishing vessels, providing protection for the entirety of the ecosystem as opposed to species specific catch limits. Agardy argues that restricting fishing in these regions can also have positive effects on surrounding areas as it provides a safe haven for spawning and ecological restoration. Pauly et al (1998) suggests increases in no-take MPAs as a method of ensuring food-web security. These changes to fisheries management allow it to be possible for biomass to increased, creating a healthier ecosystem and providing greater catch for fisheries while supporting a growing stock (Agardy 2000: p. 764).

Agardy covers a growing concern of shifting the burden of proof for environmental impacts from industry to conservation and environmental groups. Many other large industries that partake in consumption of natural common pool resources (oil, coal, water) are under specific regulations to conduct intensive environmental impact studies beforehand and to propose plans to ensure the consumption of the resource does not impact other systems. Fisheries

are not under such regulation and Agardy argues that this leads to the industry conducting unsustainable actions in pursuit of short-term profits while causing environmental agencies to spend more time and money to conduct said reports to argue for regulation (2000 p. 763). The position taken by fishermen is that any attempt to regulate the industry is a form of social discrimination, even when academic research suggests regulation can increase economic profits of fisheries (p. 764).

In Panamanian fisheries regulatory impacts are even more important to low wage fishing industry workers who see short-term income increases as more beneficial than long-term sustainability managed through regulation (p. 764). Combined with lack of enforcement and education, fisheries such as this are susceptible to illegal practices. Agardy argues the onus should be placed on decision makers of regulating organizations and those in positions of political power to increase public awareness and propose legislation to place responsibility and restrictions on fisheries. Properly managed policies coupled with education and enforcement could result in healthier ecosystems and greater long-term economic benefit for the fishing industry (p. 764).

The IUCN (2012) has labeled yellowfin tuna, one of the top grossing fish on the market, as Near Threatened. This means that while the species is not in immediate threat of extinction it requires reevaluation at set intervals to monitor progress of the population regeneration. Mortality rates of this fish have increased in previous years, leading researchers to speculate that regulatory methods and fishing limitations are not strict enough to ensure a sustainable spawning stock. The report indicates that the greatest threat for yellowfin tuna is the use of purse seines and longlines. While both methods are legal, it is their high fish catch that causes damage to the species genetic diversity, lessening survivability in the leftover spawning stock (IUCN 2012).

Assuming biodiversity is being underutilized in assessing equilibrium stock catch, the level at which reproduction rate for species is within sustainable range of the catch rate of the species, Akpalu (2009) argues that rates should be set lower to account for this (p. 2729). The research uses specific tuna species of fish at the top of Panamanian fisheries catch rates: skipjack, yellowfin, and bigeye. By accounting for phenotypic variance of fish, the equilibrium catch rate is significantly lower compared to catch rates based on fish stock alone (p. 2732). By lowering the catch rate, variance is maintained and allowed to increase, creating a healthier ecosystem which creates better fish stock and thus higher profits for fisheries. Again, we see that interdependence of species in marine environments is crucial to creating long-term economically beneficial and ecologically responsible regulations.

The state of fisheries is based upon assessment of fish stock and the perceived health of the ecosystem. Hilborn (2007) states;

“Lack of good governance, inappropriate incentives, high demand for limited resources, poverty and lack of alternatives, complexity and lack of knowledge, and the interactions of the fisheries sector with other sectors and the environment, have all been identified as primary causes of non-sustainability.” (p. 153)

Attempts to confront this non-sustainability are met with poor regulation that, according to Hilborn, convolutes the difference between MSY and MEY as policy seeks the path of least resistance. Partial reason for this is a trend of politicians to bend to the will of fishermen in a similar manner to farmers (Hilborn 2007, p. 154). Hilborn argues that the previous trend of regulation places more importance on the balance of yield and employment as opposed to maximization of economic rents and conservation of the ecosystem, as displayed below.

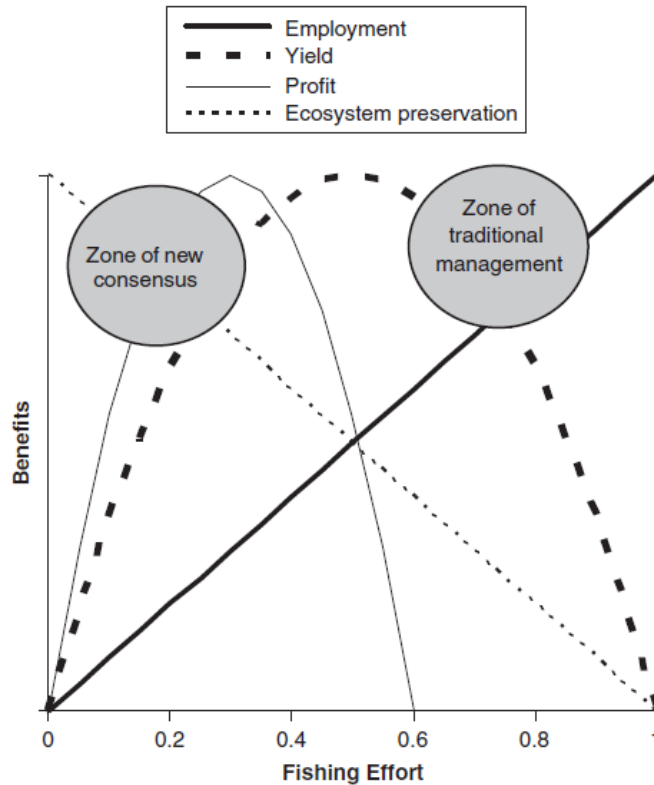


Figure 1. Relationship between fishing effort and benefits derived from different objectives³

Hilborn (2007) addressed the main conflict of ecosystem conservation as the limitation of the ability to withdraw resources from said ecosystem decreases as efforts to conserve and protect increase (p. 155). This can be seen in the above figure and can be used to illustrate the struggle between academic attempts to decrease withdrawals of resources through methods such as MPAs to reduce economic rents even further and the fishing industries push for maximizing employment, yield, and profit (p. 155). Hilborn claims that the desire for environmental organizations in states where the traditional method of management is followed (Fig. 1) conflicts with industrial desires as the use of no-fish MPAs decreases biological yield, reducing the scope of the fishing industry in supportable size of employment and vessels (p. 156).

³ Source: Hilborn 2007, p. 154

The concept of MSY is the cause of many conflicts in regulation, as is further explored by Hilborn and Stokes (2010). Applying the term “overfished” to fisheries in which MSY is exceeded fails to fully explain the difference between fishing beyond levels of sustainable yield and that of high rates of exploitation (p. 113-114). Hilborn and Stokes (2010) argue for the use of historical levels of abundance to be used as metrics for regulation, selecting breaking points based on historical records at times when fish stock was considered to be of adequate size to attempt to achieve (p. 116). Through this method there is little chance for the MSY to become convoluted in attempts to properly account for biomass and the compound effect exploitation has on such a variable (p. 115). Hilborn and Stokes make the statement that the term “overfished” is be inappropriately applied to certain fisheries, claiming regions in Pacific fisheries are at 98% of MSY thereby not on the downward trend towards unsustainable levels of catch intensity (p. 117). Their snapshot of large fisheries shows that none of them should be defined as “overfished” when compared to a biomass baseline of zero exploitation and the current levels of intensity.

Hilborn (2010) goes on to create a new definition for measuring catch and exploitation of fisheries, Pretty Good Yield (PGY), that is 80% of the optimum harvest rate for specific fisheries (p. 193). Hilborn’s new assessment measure attempted to encapsulate more fully the tradeoffs between mortality rate, vulnerability of stock, size of biomass, as well as economic and biological concerns (p. 193-194). Doing so would offer another method of measurement to define fisheries in terms of fishing beyond, at, or over their sustainable means. The 80% of optimum catch level serves as a buffer for both conservationists and fishermen, attempting to place them equidistant from their divulging desired points as can be seen in Figure 1. This measure is then shown to allow for sustainable levels of catch to be measured in fisheries that the traditional definition of “overfished” had previously been applied (p. 195).

Stakeholders are of particular interest for Hilborn (2007) as they are the key definitions of how success and failure is labeled. Hilborn (2007) makes an important statement that within the realm of fisheries legislation, stakeholder “winnings” are commonly zero-sum as their perceptions of ‘proper’ management differ in terms of which benefits are more important (p. 157). It is this aspect that causes struggle for management of fisheries resources and creates a political watershed moment, forcing regulatory agencies and their political backers to essentially choose a side.

Cowan et al. (2012) address this political backlash of regulation by expanding upon the methods in which ecosystem based approach to management is applied to fisheries. Their argument stands on the foundation that applying what is perceived as complex and difficult methods can create political issues that lead to more generally appealing “faith-based solutions” (p. 496). The authors do operate on the basis that ecosystem management is not yet perfected, pointing to advancements by CBD as progress, though the current traditional management methods do not properly account for ecological aspects (p. 498). They go on to state that;

“A perfect match of ecological and management scales may be impossible, as there is no single spatial scale that will encompass all the key components of the fishery ecosystem. Some of the key benthic communities and habitats may have important structure on scales of tens of kilometers or less, whereas some ecologically important highly migratory predators in many systems disperse and migrate over hemispheric spatial scales, creating linkages among far-distant local food webs.” (Cowan et al. 2012, p. 498)

To address this shortcoming, they offer a four question test of fisheries to provide a less politically charged process of fisheries management. First, a system must question whether the traditional measures of management have failed to ensure sustainability. Cowan et al. call for

thoroughly evaluated assessment of current practices to test whether the fisheries are being overfished. The traditional measures of management are listed as “restrictions of catch and effort, gear limitation, closed areas, and rights-based management” (p. 498). Assessment of the fisheries must encompass more than the levels of fish stock for the most profitable species, as this does not provide a wide enough scope to ensure a healthy system. The “fisheries must have sustainable outcomes biologically, economically, and socially” according to Cowan et al. (2005 p. 499).

The second question posed is whether current regulations can be supplemented to promote health and sustainability of the fisheries. Applications such as rights-based management should be applied in conjunction with MPAs to promote more favorable practices (p. 506). If such management continues to fail, management should proceed to more complex systems such as an ecosystem approach which places importance on the drivers of the fish stock as regulating points (p. 506-507). This system will only serve as an intermediary to mitigate the more drastic impacts on the system but will not provide a structure in which sustainability of the fishery is improved by adequate means. Management then proceeds to the last question of whether restoration of the fishery needs to be attempted. This is commonly a result of habitat loss and eutrophication (p. 507).

CHAPTER THREE: ECOSYSTEM SERVICE VALUE

Ecosystem Services

For this analysis, the use of the TEEB studies definition and characterization of ecosystem services will be used. ‘Ecosystem services’ applies to all goods and services that the human population can benefit from, both directly and indirectly (TEEB 2010: p. 9). As noted previously, there are four main categories for services; provisioning, regulating, supporting, and cultural (TEEB 2010). Within these four categories are subsets of services provided, such as raw materials, nutrient cycling, water and waste management, and disaster prevention. This is done to better assess what aspects of ecosystems are contributing to their economic valuation. While these services are dependent on one another we can extract general estimates of their contribution through careful analysis (p. 19). It is through this economic analysis that policy makers can be better educated on possible impacts and long-term effects of implementation to specific areas in a standardized metric of money. Public benefits of preservation and restoration are commonly unrecognized in policy making, as they are difficult to quantify. The purpose of the TEEB analysis and categorization of ecosystem services is to provide a toolkit with which policy makers can be given estimates in dollar values as a way to quickly compare the cost of possible actions. The approach labels these direct and indirect benefits as “constituents of well-being”, as seen in the MEA (2005) report adapted to the TEEB study.

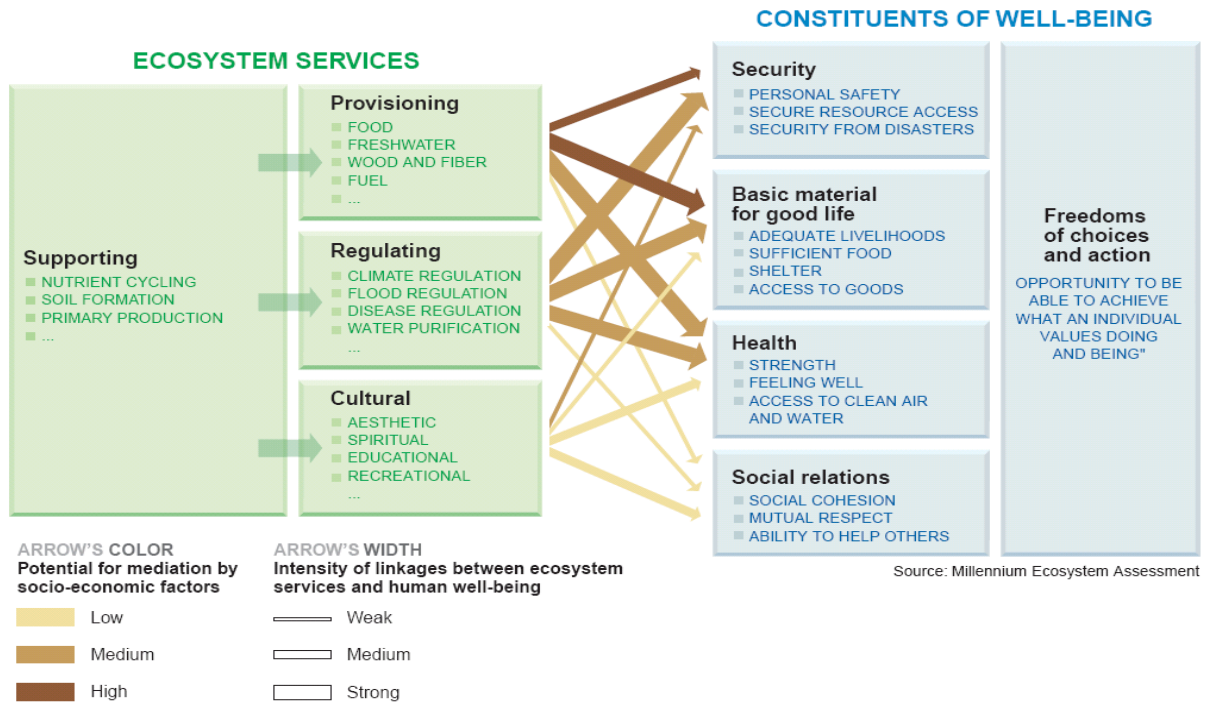


Figure 2. Ecosystem Services and Benefits⁴

Research has shown that ecosystems are capable of adapting to change and degradation, however human impact has overloaded this ability by inflicting rapid and vast changes (TEEB 2010: p. 23). The MEA states that “[o]verfishing drives ecosystem change, including changes in biodiversity” (2005 p. 491). The conservation of natural capital is imperative as it provides services that cannot be imported; clean air, cultural activities, intrinsic natural beauty. Sustainability is key to our analysis and is defined as “maintaining the capital stock necessary to insure that economic output does not decline” (Kumar 2010: p. 15). We will apply this term to natural capital in our comparison of economic rents of fishing to that of the ecosystem services benefit that fisheries take from.

The importance of ecosystem services is not a constant value across populations or over time. Those in rural areas are more dependent on these resources for their survival (Fletcher et al. 2012, TEEB 2010). The delineation between subsistence/artisanal fishing and

⁴ Source: MEA 2005

commercial/industrial is crucial when assessing ecosystem services and their valuation. For rural fishermen using manual labor, the fish stock is absolutely vital to their livelihood, yet they do not have the means to take more than they need due to limitations of their vessel and gear. Commercial vessels have an economic imperative to capture as much as possible, and are capable of having a higher fish catch due to their advanced gear methods. Preservation of ecosystem services is also imperative for future generations as we are not yet able to replicate the natural balance of these systems (UNEP 2010: p. 184). The analysis of ecosystem service valuation attempts to serve as a general estimate for both of these populations.

Methodology of Valuation

Theory would dictate that the value of ecosystem services is infinite due to our immediate dependence on them and inability to substitute all process effectively over a long term. We also know that resource consumption comes at a cost. The point at which we define that cost (manufacturing, processing, purchase, etc.) can be extended to the resource itself. Previously, ecosystem services have been deemed as ‘priceless’ due to a lack of econometric methods to assess their overall value, in part because of the lack of knowledge of the extent of ecosystem services. The TEEB study, along with previous efforts from the CBD, IUCN, and the World Bank, provide a toolkit for advisors and policy makers to value said services.

For the purpose of this analysis, we will use the combination of the direct market price method and stated preference contingent valuation method (TEEB 2010: p. 44). Valuing ecosystem services and their provisions through market prices will allow a direct comparison to the economic value from fish sales. The addition of the state preference contingent is to take into account the estimated value of other provisioning services (water quality regulation, moderation of extreme events, tourism, etc.) that may be more imperative to a region or nation’s national

wealth or security. An example would be Louisiana and the wetlands service of flood mitigation taking a higher value to the limited coral reef systems on its coast. This stays in line with Costanza's (2000) argument that we must account for ecological sustainability as well as economic viability. While one can argue that ecosystem services are infinitely valuable, this does not mean that there is not a maximum economic yield for the provisions. The manner in which MEY is defined that affects regulation and consumption of natural capital.

The TEEB report sets forth estimated values of various biomes, of which we will use Open Ocean and Coral Reefs as these are the ecosystems directly related to fishing activities (UNEP 2010: p. 372-5). Values are measured in dollars per hectare per year (\$/ha/yr).

Table 1. TEEB Values⁵

	Open Ocean		Coral Reefs	
	Min/ha	Max/ha	Min/ha	Max/ha
Provisioning Services	\$ 8	\$ 22	\$ 6	\$ 40,970
Food	\$ 8	\$ 22	-	\$ 3,752
Raw Materials	-	-	-	\$ 16,792
Genetic Resources	-	-	-	\$ 20,078
Medicinal Resources	-	-	-	-
Ornamental Resources	-	-	\$ 6	\$ 348
Regulating Services	\$ 5	\$ 69	\$ 8	\$ 220,435
Influence on Air Quality	-	-	-	-
Climate Regulation	\$ 4	\$ 55	-	\$ 627
Moderation of Extreme Events	-	-	\$ 2	\$ 33,556
Waste Treatment/Water Purification	-	-	\$ 5	\$ 77
Erosion Prevention	-	-	-	\$ 186,168
Nutrient Cycling	-	\$ 7	-	-
Biological Control	\$ 1	\$ 7	\$ 1	\$ 7
Habitat Services	-	\$ 2	-	\$ 56,137
Lifecycle Maintenance	-	-	-	-
Gene Pool Protection	-	\$ 2	-	\$ 56,137
Cultural Services	-	\$ 1	-	\$ 1,084,809
Aesthetic Information	-	-	-	\$ 27,317
Opportunities for Recreation and Tourism	-	\$ 1	-	\$ 1,057,492
Inspiration for Culture, Art, and Design	-	-	-	-
Spiritual Experience	-	-	-	-
Cognitive Information	-	-	-	-
Total	\$ 13	\$ 94	\$ 14	\$ 1,402,351

⁵ Adapted from Kumar, P., & Economics of Ecosystems and Biodiversity (Project) 2010

Limitations and Assumptions

Because this analysis is based on data and methods from TEEB and MEA studies, their limitations apply here. The valuation of ecosystem services should serve as an estimate, albeit an educated one, of provisions and biodiversity. The complexity of these systems is not yet fully understood, but through careful study of ecology and resource economics the methods of estimation should serve as sufficient guidelines for policy makers. It is imperative to note that while these services should be considered ‘priceless’ due to our dependence and inability to substitute them, the application of a fixed value should not overshadow the importance of biodiversity. The estimated monetary value of these services is not equivalent to the idea of “buying them back” once they are gone. This is an intangible value that must be considered when performing comparisons in policy. There is no ‘substitutability’ for any ecosystem services mentioned in this analysis. This means that there are no human-engineered alternatives that completely replace an ecosystem and all the services it provides.

Also accepted, the statement, “[a]ll oceans are affected by humans to various degrees, with overfishing having the most widespread and the dominant direct impact on food provisioning services, which will affect future generations” (MEA 2005: p. 479).

These intangible values extend to the Cultural Services, used by the TEEB method to account for aspects such as spiritual, inspirational, and educational value. While one could use hedonistic valuation methods for these services, we accept the limitation of the TEEB method which states that these values are subject to high variance due to cultural differences (2010: p. 63).

In accordance with the Panamanian Constitutional Article 237 and the subsequent Law No. 17 of 1959, it is accepted that the state and its organizations have sovereign right to regulate and enforce policy upon vessels within its territorial waters.

CHAPTER FOUR: FISHERIES PROFIT AND IMPACT

Legislation and Enforcement

While this thesis aims to address the ecological issues at stake in Panamanian fisheries, we must also consider the political aspect. Providing the history of regulatory systems, organizations, and policies enacted in Panama allows examination over time. This section addresses the progression of Panamanian legislation and enforcement.

The first available legislation on fisheries in Panama is Ley No. 17 (Law Number 17) of 1959, which sets forth regulations on the export of fish from the country (Asamblea Nacional de la República de Panamá). It is important to note that this law references the ability of the government to regulate fisheries based on constitutional Article 237, granting the state responsibility to protect flora and fauna. Law No. 17 also requires the use of scientific methods to set limits which promote renewable fish stock (p. 2). This gives us the constitutional and regulatory background to support future policy implementation that the state has the right and ability to enact regulation as well as enforce it.

Law No. 17 Article 4 defines the following types of fishing;

“Subsistence - which has the main purpose of feeding of those who participate, their families and neighbors, or whose daily value is not greater than the salary of a laborer. Included in this category, for the purposes of this Decree-Law, the fishing is carried out from the beaches and shores or from canoes or other boats classified as minor under Chapter IV, provided that no other device is used besides the cast net, harpoon or a cord that carries a maximum of three (3) hooks, and for which none is for sport fishing.

Commercial - which aims to supply the domestic market of fresh and dried fish, including employing major tools as dinghies, trawlers, gill nets, purse and trawl, hook line and in high seas fisheries, longlines at depth or surface, etc.

Industrial - which is performed for export in order to submit the product to industrial processes such as canning, processing into fishmeal or fertilizer, freezing, etc., but excluding the simple process of salting and drying.

Scientific - which is made solely for purposes of research and study.

Sport - which is done as a distraction or exercise and no other purpose than its actual conduct.”⁶ (p. 3)

Law No. 17 (1959) also outlines the institutions that have policy-making abilities. Most power is delegated to the Ministry of Agriculture, Commerce, and Industry (Article 27). This ministry has since split to that of the Ministry and Agriculture and the Ministry of Commerce, and Industry. During the time Law No. 17 was enacted the Ministry served as the regulatory body of imports, exports, and agricultural production. This Ministry would serve as the acting body in international agreements on fishing policy, such as IATTC. There is also a special court for disputes, punishments, and future regulation is created specifically for the fishing industry. Even at this early time, the National Assembly outlines the rules against dumping of waste while at sea, providing punishments of B/200.00, equivalent to USD\$1,582 in 2013.⁷ Dumping while underway was considered to be cost saving, thus the fine reduced the incentive to dump.

In 1964, Decree No. 127 was enacted to tighten regulations specifically of the tuna catch in Panamanian waters. It expands the jurisdiction of the Ministry of Agriculture, Commerce, and Industry to include the provisions set forth in the IATTC agreement of 1963. At this 16th meeting

⁶ Translated text

⁷ Inflation calculated from Bureau of Labor Statistics

of the IATTC (1963), it was discussed that yellowfin tuna stock had dropped below maximum sustainable yield (MSY). The commission recommended a reduction in total catch from 81,000 tons to 73,000 tons to allow the fish stock to return to above MSY levels (IATTC 1963, p. 5). Decree No. 127 introduced these reductions to national policy. Included are open season dates for fishing of tuna from September 10 to August 30 of the next year and only within 12 miles of shore (Article 3). A majority of Decree No. 127 restricts the sale of catch from Panamanian waters in other markets. Combining these restrictions with Article 4, requiring all commercial vessels to keep catch records of tonnage and species to be turned into the newly formed Department of Fishing and Industry Relations (p. 4), Panama made steps to ensure proper regulation of fisheries in attempts to promote the sustainable practices laid out in Law No. 17 of 1959. Decree No. 127 also provided the Ministry of Agriculture, Commerce, and Industry to issue fines of up to B/10,000 (USD\$74,283) for failure to report catch or have proper licenses for tuna fishing.

While Panama managed to institute regulations with strict consequences and promoted sustainability in fisheries management, there was no agency dedicated to enforcement of policies. In 1998 with Decree No. 7 the Panamanian Maritime Authority (AMP) was created and given the power to stop illegal practices within Panamanian waters. The AMP was granted jurisdiction through the entire EEZ to ensure the promotion of national fishing regulations. This was the first regulation in 34 years, a period known as “The Fishing Bonanza” (Meneses p. 6). In 1970 there was an estimated 60,000 tons of fish catch, increasing to an all-time high of 290,000 tons in 1985 (FAO 2008). The lack of an enforcement agency and new methods of fishing that decreased effort and increased catch are the most likely influences on this increase (Le Gallic, Cox 2005).

In 2004, the National Assembly took action to create the Coiba National Park with Law No. 44 (Asamblea Nacional de la República de Panamá). This marked the first sizeable marine reserve in the country, covering 2,171km² (Encyclopedia of Earth). Article 2 of the law lay out the allowance of artisanal fishing in the MPA, given that the boat does not exceed 30 feet, has a motor of less than 55 horsepower, and the method of fishing is mostly human powered and with a “lower technology”. Subsistence fishing is also permitted, referring back to the definition set forth in Law No. 7 of 1959. Sectors were created to allow for sport fishing within the marine reserve. All aspects of industrial and commercial fishing were strictly prohibited within the law. The AMP was named the agency in explicit control of regulation enforcement within the confines of the reserve.

Law No. 9 (Asamblea Nacional de la República de Panamá: Feb 2005) expanded fines for illegal fishing practices, and Executive Decree No. 83 (Asamblea Nacional de la República de Panamá: Abr 2005) required turtle excluding devices (TEDs) to be used on all trawlers in Panamanian waters. Law No. 9 allowed the AMP to exact fines for all manners of illegal fishing (safety violations, dumping, etc.) up to B/10,000. It is important to note the timeframe of legislation for TEDs in Panama as the United States Department of State enacted laws requiring their use on all trawling vessels in 1989.

In 2006 the National Assembly passed Law No. 44 to create a new institution, the Aquatic Resources Authority of Panama (ARAP). Duties given to the institution were solely administrative and policy education and formation (Article 1). There was no extension of enforcement power to ARAP nor was it given legislative power to enact regulations on its own. Articles 2 and 3 give imperative directions for ARAP to promote aquaculture and support new, less invasive methods of fishing.

Early 2009 saw the passing of Decree No. 7 (Asamblea Nacional de la República de Panamá: Feb 2009) to outlaw the use of purse seines in the Pacific waters of Panama. Greenpeace considers these fish aggregating devices (FADs) to be detrimental for species such as skipjack and yellowfin tuna due to these fishes tendency to shoal with non-targeted species, increasing the amount of bycatch (Mackenzie 2010). Again, for comparison we note that Florida outlawed the use of all purse seines in 1967 (Associated Press). The ban was then expanded to all Panamanian waters in July of 2010 with Executive Decree No. 239 (Asamblea Nacional de la República de Panamá: Julio 2010b).

Executive Decree 95 (Asamblea Nacional de la República de Panamá: Nov. 2009) increased restrictions on tuna fishing licenses, requiring renewal each year for domestic ships, and 6 months for foreign vessels (Article 3). Seven months later this is repealed with Executive Decree No. 238 (Asamblea Nacional de la República de Panamá: Julio 2010a). Executive Decree 98A (Asamblea Nacional de la República de Panamá: Enero 2010) is seen as the replacement. It sets forth a national plan to deter and prosecute illegal, unreported, and unregulated (IUU) fishing. ARAP is given responsibility for the regulation, but they lack an enforcement arm, and the actual enforcement agency, the AMP, is not mentioned in the legislation. In December 2010, Executive Decree No. 438 outlawed all use of longlines for commercial and industrial vessels (Asamblea Nacional de la República de Panamá: Dic 2010). Vessel under 6 tons are still permitted to use longline methods, as this constitutes the majority of artisanal fishing boats, which are less intensive compared to the higher effort industrial vessels.

In early 2011, the General Assembly granted legislative rights to ARAP, with the requirement that any resolution must be passed through the General Assembly before becoming law. This imparted more legitimacy and autonomy for the organization tasked with regulation

Panamanian waters, with the intent of lessening corrupt political will. All aforementioned resolutions passed through the General Assembly.

Panama joined the Fisheries and Aquaculture Sector Organization of the Central American Isthmus (OSPESCA) in with the Resolution No. 74 (Autoridad de los Recursos Acuáticos de Panamá: Julio 2011). By passing into law the OSPESCA rules and ethics, Panama bound itself to promoting sustainable fisheries and aquaculture. To expand upon their ability to ensure proper fishing methods, Resolution No. 86 is passed to require all vessels to account for their gear while on the high sea (Autoridad de los Recursos Acuáticos de Panamá: Agosto 2011), an attempt to lessen dumping of nets and gear which causes fish deaths if caught in abandoned gear. The resolution also gives ARAP the ability to confiscate any floating gear left on the high seas with no recourse for the owners to have it returned. This increase in enforcement allowed more resources to be used in conjunction with the AMP to better police the waters of Panama for illegal fishing activities.

Resolution No. 113 requires that all fishing vessels over 20 meters be registered with the state (Autoridad de los Recursos Acuáticos de Panamá: Nov 2011). This serves to allow the AMP and ARAP to better manage fishing vessels as well as restrict vessels larger than 20 meters to industrial or commercial status. With Resolution No. 125, ARAP places very strict rules on longlining, one of the more devastating forms of fishing. It requires that all vessels using longlines must have manually powered rollers to reel in the line, no more than 600 hooks, and sets limits on the dimensions of the rollers (Autoridad de los Recursos Acuáticos de Panamá: Dic 2011). By restricting rollers to be manually powered it requires more effort for vessels, combined with limiting the number of hooks on the line we see an increase in effort and a decrease in possible catch as well as turnover. While the restrictions do not place longline fishing outside of

economic viability, it does lessen the possible impact on bycatch and overfishing. The penalties for vessels not adhering to the new regulations are able to be fined up to USD\$250,000.

Makeup of Fisheries Fleet

There are two sectors of the Panamanian fishing fleet; the Caribbean and the Pacific. The Caribbean fleet is mostly artisanal vessels, those under 10 gross registered tonnage (GRT) as defined by an addendum to Law No. 17 (Asamblea Nacional de la República de Panamá, 1959), operated by native tribes such as the Embera and Kuna. While recommendations from ARAP have been made to these tribes, there is no legal enforcement of seasons or catch limit because they are protected under native law. The FAO (2008) report the MSY to be exceeded in this area by artisanal fishermen as their numbers increase and they continue to compete for the resources with illegal methods of catch.

A majority of the vessels in the Caribbean are artisanal, causing the statistics on numbers of vessels to be severely underestimated, with only 500 known to be active (FAO 2008). The main target catch in this sector is lobster and shrimp, economically valuable benthic species (NOAA 2011). The Caribbean coast of Panama is dotted with hundreds of islands inhabited by native tribes, all of which are largely dependent upon these species as their main source of protein. Even with primitive methods, this growing sector of artisanal fishing has caused massive ecological damage to the region. Because lobster and shrimp are attracted to coral reefs, one of the most valuable ecosystem services according to the TEEB study, this is where most of the damage from activity is done. Spalding et al. (2001) recognizes that native peoples have lived in an almost symbiotic relationship with coral reefs for millennia (p. 57). What the area is experiencing now is pressure of population growth, increasing the imperative to fish more, thus causing more damage and extending past the point of sustainability.

The issue is compounded in the Pacific region as there is increased competition among industrial and artisanal fishermen for the same limited fish stock. Ineffective enforcement of MPAs and illegal fishing methods has pushed the Panamanian Pacific fishery into overexploited status (IUCN 2012). Over 5,000 registered vessels are active in this area (FAO 2008), though this does not begin to express the large amount of artisanal fishing vessels. 80% of the population lives along the Pacific coast (FAO 2008). While diligent tracking of methods is not conducted on artisanal fisheries, the FAO (2008) did report an estimate tenfold increase in the use of gillnets from 1986 to 1995.

Because the Panamanian EEZ is so large, it allows international vessels to fish the outer waters to maximize the economic rent from the fishery. These vessels require special permits issued by ARAP and are monitored by the AMP through global positioning system (GPS) trackers. According to the FAO (2008) report there were 223 of these vessels, making up less than 5% of the total fishing fleet in the Pacific sector. These ships are highly modern, with flash freezing capabilities and holds of over 150 GRT, making them adept at intensive fishing far offshore (FAO 2008). Being hundreds of miles away from shore limits the amount of enforcement that can be applied to these vessels. While they are tracked by GPS, there are no auditors on these vessels to ensure proper methods of returning bycatch. Other industrial vessels are required to follow the rule of law, but the ability for the AMP to actively enforce these regulations is difficult due to the sheer number of vessels in the area.

Fishing Methods

Industrial and artisanal fishing differs in the application of the same methods of fishing. Industrial vessels typically have larger nets or longer lines. Artisanal fishermen can use similar methods, though their catch rate is much lower due to smaller boats and crew sizes.

Shrimp fisheries use of bottom trawlers in Panama has shown a strong negative effect, with a rate of 80% bycatch as well as the indiscriminate raking of the benthos by the weighted net (Kelleher 2005). While total landings of shrimp have decreased since 1996 to present, the damage done to crucial reefs has not reversed. Legislation has managed to keep the number of legal shrimp trawlers to below 250. Part of the legislation rules that the vessels cannot be replaced or modernized, meaning they are using older, more ecologically harmful methods with a lower catch rate (FAO 2008). This low catch rate drives fishermen to spend more time trawling to be able to bring in a high tonnage and therefore make more money. The requirement of TEDs was advancement for sustainability and limiting bycatch in trawling vessels. The delay between their requirement to be used on Panamanian vessels and that of a majority of the rest of the fishing world should be noted as a specific lack of timely regulation, which had been shown to avoid overexploitation of their natural resources.

The artisanal alternative to bottom trawling is cast netting. This method is used most commonly for shrimp and other shallow water benthic species. The weighted circular net is thrown by one man and pulled up from the floor. The limited size of the net decreases damage caused to coral reefs.

Industrial longlining consists of miles of line with thousands of hooks pulled behind a vessel. Panamanian legislation limits the number of hooks per line to limit the catch rate, more hooks equates to more fish on the line. This increase in hooks also increases bycatch, as the target species (tuna, mahi mahi, etc.) tend to school with non-target species as well as birds and sea turtles. Pachecho et al. (2011) argue that changing from the common j-hook to circle hooks would increase landing rates of target species by 40% (p. 43) though only marginally decrease bycatch of certain non-target species. The United States and other nations have adopted

regulations to require circle hooks due to their decrease in catch mortality. One would assume it is in fisheries best interest to use a superior hook, though the method has not become commonplace in Panama, and the ecosystem suffers as a result.

Table 2. Industrial Longlining catch, metric ton⁸

Year	Yellowfin	Bigeye	Total
2011	-	-	-
2010	-	-	-
2009	-	-	-
2008	-	-	-
2007	-	-	-
2006	2,164	37	2,201
2005	1,782	30	1,812
2004	2,802	48	2,850
2003	-	-	-
2002	907	6	913
2001	732	80	812
2000	359	14	373
1999	-	-	-
1998	-	-	-
1997	-	-	-
1996	-	-	-

The artisanal use of longlining is similar, though not as expansive. Vessels used are commonly less than 20 meters and lack the engine power of the larger industrial boats as required by legislation. While both types of vessels are restricted to manually power rollers used to reel in the lines, artisanal longline boats tend to have line lengths of less than a mile and far fewer than the thousands of hooks.

Purse seining is only conducted by industrial vessels due to the required engine power to pull the net through the water. The net size affects the amount and type of catch. A smaller net

⁸ Source: UN Data 2011

opening means less fish can escape, leading to higher catch rate, bycatch, and mortality. Even with the temporary outlaw of this method, it is the most common in Panamanian waters. The CPUE is declining in Panamanian waters, indicating overexploitation of the fish stock (FAO 2008, IATTC 2012: p. 13, 14). Included in a 2012 IATTC report is the restriction of U.S. canneries from accepting tuna caught in purse seines that were also responsible for dolphin catch. No such restriction exists for Panamanian vessels, canneries, or waters. The closest attempt was the temporary restriction on the method that was overturned mere months later. These regulations have done little to direct the fishery towards more sustainable catch.

Table 3. Industrial Purse Seine catch, metric ton⁹

Year	Yellowfin	Skipjack	Bigeye	Total
2011	18,530	31,003	7,018	56,551
2010	34,538	19,213	7,089	60,840
2009	35,228	26,973	11,807	74,008
2008	26,993	43,230	11,018	81,241
2007	26,024	28,475	7,029	61,528
2006	22,521	44,639	14,099	81,259
2005	33,393	25,782	10,707	69,882
2004	33,563	20,051	8,294	61,908
2003	16,591	25,084	6,222	47,897
2002	15,719	9,757	4,726	30,202
2001	9,552	6,967	3,858	20,377
2000	5,796	9,573	7,028	22,397
1999	5,782	5,286	1,220	12,288
1998	3,330	1,136	12	4,478
1997	4,807	4,277	1,811	10,895
1996	3,084	3,619	1,445	8,148

Gillnets are exclusively used by artisanal fishermen, commonly hung from behind small, low powered vessels. These nets purposefully trap fish, indiscriminately, by their gill covers.

⁹ Source: UN Data (2011)

Fish are then unable to escape from the net, causing high mortality rates as they sustain injuries or are not thrown back before expiring on the vessel. While this method is only practiced in remote areas for subsistence fishing it can create devastating effects on ecosystems and non-target fish species (Meneses 2010, p. 6).

Profit of Fisheries

To properly compare the value of ecosystem services to the economic rents of fisheries, we must have data from the fisheries. As stated previously, recording of catch and enforcement of proper methods are not consistent in Panama. The UN Data set (2011) does have estimates of catch value in Panama from 1996 to 2010 along with employment for industrial vessels.

Table 4. Fisheries Profit and Employment ¹⁰

Year	Gross Value at Basic Prices	Total Employment
2010	\$ 170,400,000	NA
2009	\$ 252,900,000	NA
2008	\$ 286,000,000	9,100
2007	\$ 269,200,000	9,800
2006	\$ 302,900,000	9,946
2005	\$ 317,900,000	9,529
2004	\$ 356,800,000	9,430
2003	\$ 350,200,000	9,682
2002	\$ 305,700,000	10,642
2001	\$ 259,000,000	11,168
2000	\$ 171,100,000	9,696
1999	\$ 125,200,000	10,448
1998	\$ 181,700,000	9,268
1997	\$ 132,200,000	9,671
1996	\$ 116,500,000	9,374

As noted, these are gross market value prices to give a proper frame of reference for our ecosystem service value comparison. The employment numbers are primary, those working on

¹⁰ Values at 2010\$. Source: UN Data (2011)

the boats and for the vessels. Secondary sector employment is not included in this analysis as fishing is Panama's second highest GDP contributor, but is an area for future research (FAO 2008).

CHAPTER FIVE: RESULTS

Results

First, we must value the totality of ecosystem services for Panama's open ocean and coral reefs. Using values from FAO (2008) for EEZ area and Spalding et al. (2001) for coral reef area, applied to Table 1, the following is the result.

Table 5. Total TEEB Values for Panama¹¹

	Open Ocean		Coral Reefs	
	21,877,700 hectares		72,000 hectares	
	Min	Max	Min	Max
Provisioning Services	\$ 175,021,600	\$ 481,309,400	\$ 432,000	\$ 2,949,840,000
Food	\$ 175,021,600	\$ 481,309,400	-	\$ 270,144,000
Raw Materials	-	-	-	\$ 1,209,024,000
Genetic Resources	-	-	-	\$ 1,445,616,000
Medicinal Resources	-	-	-	-
Ornamental Resources	-	-	\$ 432,000	\$ 25,056,000
Regulating Services	\$ 109,388,500	\$ 1,509,561,300	\$ 576,000	\$ 15,871,320,000
Influence on Air Quality	-	-	-	-
Climate Regulation	\$ 87,510,800	\$ 1,203,273,500	-	\$ 45,144,000
Moderation of Extreme Events	-	-	\$ 144,000	\$ 2,416,032,000
Waste Treatment/Water Purification	-	-	\$ 360,000	\$ 5,544,000
Erosion Prevention	-	-	-	\$ 13,404,096,000
Nutrient Cycling	-	\$ 153,143,900	-	-
Biological Control	\$ 21,877,700	\$ 153,143,900	\$ 72,000	\$ 504,000
Habitat Services	-	\$ 43,755,400	-	\$ 4,041,864,000
Lifecycle Maintenance	-	-	-	-
Gene Pool Protection	-	\$ 43,755,400	-	\$ 4,041,864,000
Cultural Services	-	\$ 21,877,700	-	\$ 78,106,248,000
Aesthetic Information	-	-	-	\$ 1,966,824,000
Opportunities for Recreation and Tourism	-	\$ 21,877,700	-	\$ 76,139,424,000
Inspiration for Culture, Art, and Design	-	-	-	-
Spiritual Experience	-	-	-	-
Cognitive Information	-	-	-	-
Total	\$ 284,410,100	\$ 2,056,503,800	\$ 1,008,000	\$ 100,969,272,000

In this view we can examine the estimated values of the various provisions within this complex system. It is imperative that areas with no values are not to be interpreted as being a value of zero

¹¹ Adapted from FAO (2008), Kumar, P., & Economics of Ecosystems and Biodiversity (Project) (2010), Wood L. J. (2007)

dollars. The limitations of the analysis deem these sectors contribution to the economy too difficult to measure accurately, or their values would differ among cultures.

Analysis of Results

The purpose of this thesis is to address the known overexploitation of Panamanian fisheries (IUCN 2012, FAO 2008, FAO 2012, IATTC 2012) and the lack of regulations to correct the issue. The use of the TEEB model to compare the value of ecosystem services and the economic rents gained from the fishing industry is to base the following analysis in similar units of measure. The loss of fish stock equates to a monetary loss of natural capital which we have measured in dollar values. The collapse of the ecosystem, as a result of overfishing and a very real possibility in Panamanian waters (IUCN 2012), would result in total maximum estimated loss of over \$103 billion a year.

Economic rent is a driving factor of business and industry. In markets of natural resources, the issue of sustainability quickly comes into question as profit drives increases in consumption.

Table 6. Fish Consumption per capita 2001¹²

	kg/yr
Panama	14
Costa Rica	7
Colombia	5
Nicaragua	2
Honduras	4
Belize	8
Mexico	11

¹² Source: UN Data 2011

As population in Panama is projected to grow, this consumption of fish per capita may grow as well. Catch rates have already been categorized as over the MSY (IUCN). According to Kumar (2010) and the TEEB study, continuing to consume resources, especially fish, after the MSY point there is an exponential decrease in catch rate as well as profit. Short-term incentives of overfishing are not properly discounted by the long-term negative effects of a collapsing ecosystem.

The average value of the food provision, as measured through the TEEB method, is \$463,237,500 per year. None of the years for which data is provided on fisheries gross value at market is greater than this value. The years noted in red are less than the minimum value of the TEEB estimated food provision.

Table 7. Gross Value Compared to Minimum and Maximum TEEB Estimated Food Provision Value¹³

Year	Gross Value of Fisheries at Basic Prices	TEEB Food Provision Minimum	TEEB Food Provision Maximum
2010	\$ 170,400,000	\$ 175,021,600	\$ 751,453,400
2009	\$ 252,900,000	\$ 175,021,600	\$ 751,453,400
2008	\$ 286,000,000	\$ 175,021,600	\$ 751,453,400
2007	\$ 269,200,000	\$ 175,021,600	\$ 751,453,400
2006	\$ 302,900,000	\$ 175,021,600	\$ 751,453,400
2005	\$ 317,900,000	\$ 175,021,600	\$ 751,453,400
2004	\$ 356,800,000	\$ 175,021,600	\$ 751,453,400
2003	\$ 350,200,000	\$ 175,021,600	\$ 751,453,400
2002	\$ 305,700,000	\$ 175,021,600	\$ 751,453,400
2001	\$ 259,000,000	\$ 175,021,600	\$ 751,453,400
2000	\$ 171,100,000	\$ 175,021,600	\$ 751,453,400
1999	\$ 125,200,000	\$ 175,021,600	\$ 751,453,400
1998	\$ 181,700,000	\$ 175,021,600	\$ 751,453,400
1997	\$ 132,200,000	\$ 175,021,600	\$ 751,453,400
1996	\$ 116,500,000	\$ 175,021,600	\$ 751,453,400

TEEB valuations show that the fisheries in Panama are overexploited and the economic rents currently being pulled from the ecosystem and its services are below their expected level. There

¹³ Adapted from Kumar, P., & Economics of Ecosystems and Biodiversity (Project) (2010), and UN Data (2011)

is a declining trend from 2004, likely a result of the trophic mining that allowed for the highest levels of catch in the previous years (Pauly et al. 1998). According to the IUCN (2012), yellowfin tuna are at Near Threatened status, requiring monitoring to ensure they avoid extinction. A failure to ensure their continued existence could result in even greater reductions in food provision values of the Panamanian fisheries.

As shown in Table 6, the consumption of fish is higher than the average in Central American countries. This would denote demand for the product, driving the industry to maximize profit and provide sufficient supply. This action has the possibility of pushing an overexploited fish stock to extinction if regulation is not enacted or enforced (IUCN 2012).

If overexploitation is not reversed, there will be a continued loss of a fish stock, and can lead to complete ecosystem collapse (Agardy 2001, Akpalu 2010, FAO 2008, IUCN 2012).

Now we turn to the total value of the open ocean and coral reef ecosystem services.

Table 8. Gross Value Compared to Minimum and Maximum TEEB Estimated Total Provision Value¹⁴

Year	Gross Value of Fisheries at Basic Prices	TEEB Minimum	TEEB Maximum
2010	\$ 170,400,000	\$ 285,418,100	\$ 103,025,775,800
2009	\$ 252,900,000	\$ 285,418,100	\$ 103,025,775,800
2008	\$ 286,000,000	\$ 285,418,100	\$ 103,025,775,800
2007	\$ 269,200,000	\$ 285,418,100	\$ 103,025,775,800
2006	\$ 302,900,000	\$ 285,418,100	\$ 103,025,775,800
2005	\$ 317,900,000	\$ 285,418,100	\$ 103,025,775,800
2004	\$ 356,800,000	\$ 285,418,100	\$ 103,025,775,800
2003	\$ 350,200,000	\$ 285,418,100	\$ 103,025,775,800
2002	\$ 305,700,000	\$ 285,418,100	\$ 103,025,775,800
2001	\$ 259,000,000	\$ 285,418,100	\$ 103,025,775,800
2000	\$ 171,100,000	\$ 285,418,100	\$ 103,025,775,800
1999	\$ 125,200,000	\$ 285,418,100	\$ 103,025,775,800
1998	\$ 181,700,000	\$ 285,418,100	\$ 103,025,775,800
1997	\$ 132,200,000	\$ 285,418,100	\$ 103,025,775,800
1996	\$ 116,500,000	\$ 285,418,100	\$ 103,025,775,800

¹⁴ Adapted from Kumar, P., & Economics of Ecosystems and Biodiversity (Project) (2010), and UN Data (2011)

Again, red denotes years in which the gross fisheries value does not exceed the minimum TEEB estimated value for total ecosystem services of open ocean and coral reefs in Panamanian waters. Compared to Table 7 we see a higher instance of the gross value totaling to less than the minimum TEEB estimate. As it has been stated previously, the oceanic ecosystem has strong dependency links between services and species. The ecosystem is affected by overexploitation of its resources, namely the biological type, resulting in diminished catch rates and thus declines in gross value (FAO 2008). The estimate also provides an upper limit, which the gross value attained by Panamanian fisheries reaches a maximum of about one third its value.

The TEEB method was developed to assist policy makers on decisions pertaining to natural capital, i.e. the ecosystem from which they pull resources. Fishing is the second largest contributor to GDP in Panama (FAO 2008). It has been clearly demonstrated the current state of fisheries in the country are operating beyond MSY and producing economic rents lower than would be expected according to estimates. This is due to a lack of proper regulations and enforcement.

CHAPTER SIX: DISCUSSION & CONCLUSION

Discussion

Panama is in danger of depleting the fish stock in its waters to a point it will not be able to return (IUCN). Going beyond the point of biological return would result in the devastation of open ocean and coral reef ecosystems due to their interdependency. It is the duty of policy makers to create legislation that is enforceable, measureable, and does not punish economic profit unfairly. The TEEB method of valuation helps to set the boundaries for legislation, while scholarly research assists in providing ecologically sound regulations.

We must first examine the reasons why fisheries in Panama are being overexploited and what parties would benefit from such actions. As previously stated, fishing is the second largest contributor to GDP, making it a politically and economically difficult target for restriction. Any regulations to impede the growth of profit for the industry would be seen as an attack on a sector of the economy that creates over 9,000 primary jobs and tens of thousands of secondary employment (FAO 2008, UN Data 2011). This can be seen explicitly in the retraction of purse seine restrictions just months later (Asemblea Nacional de la República de Panamá Feb 2009, Asemblea Nacional de la República de Panamá Nov 2009). There was public and international support for the ban though the ARAP interpretations of what was thought to be banning lead to a different outcome than expected (Zea 2011). This of particular importance when we consider that the purse seine method accounts for over 80% of fish catch in Panamanian waters (FAO 2008, UN Data 2011). The backlash from restricting its use in all Panamanian waters was quickly felt by the National Assembly, who directed ARAP to merely “limit” the methods use. Ubiquitous use of purse seines on industrial vessels requires regulations to be slowly applied in order to

avoid inflicting undue economic loss as well as ensuring the political support of an important employment sector.

Direct regulation of fishing methods would include catch limits as a secondary means of ensuring sustainability and is supported by researchers (Akpalu 2009, Fletcher et al. 2012). In-depth analysis of current fish stock would assess and account for the regeneration time required to maintain healthy biomass. This would provide ecological guidelines to establish a catch limit per vessel to then be implemented and enforced at offload. Research argues that larger spaced nets would decrease bycatch and reduce the negative impact of the purse seine method (World Bank 2009). Reducing bycatch is shown to increase value of catch through decreasing effort (SICA/OSPESCA 2005). The larger spaced nets would potentially allow more juvenile fish to escape, resulting in higher spawn rates. This increase in base fish stock would create more growth in the fish population to allow for higher catch limits and thus higher profit for fisheries. It is difficult, given the current state of research, to assess what the exact impact of instituting these changes to Panamanian fishing vessels would be, though we can assert that it would create a positive increase in fish stock. The crucial question becomes the cost imparted to the vessels and fishermen through needing to purchase new nets to avoid fines.

It is possible that the increase in fish stock, with proper management to ensure increasing reproduction rates, could lead to higher limits of catch which would raise profit of these vessels to possibly outweigh the original cost of new nets. Again, as fish become easier to school and catch as result of there being a larger fish stock, we can assert that fishing effort would decrease. This is seen as a positive from a point of efficiency, but could result in decreases in primary sector employment of fishermen unless new vessels enter the market, which is possible as catch limits are raised and profit margins become more appealing. It should be noted that these are just

outcomes from passing strict legislation that merely requires larger spacing a nets in one of the most common fishing methods in Panamanian waters. The economic and ecological benefits have been proven in other regions, but the legislation has yet to be passed in Panama.

Longlining has been successfully regulated, from an environmental and ecological perspective, in Panamanian waters through restriction of mechanical rollers, requiring more effort and decreasing catch rate. As shown previously in Table 2, this regulation has decreased the use of this method. The UN Data (2011) resource does not have reports on longlining after 2006, though it is reasonable to assume the method is still in use as it was not outlawed and can still operate at an economic profit (FAO 2008).

While the National Assembly regulated the length of line and numbers of hooks, Pacheco et al. (2011) argue that a more effective means of reducing ecological impact would be a change from j-hooks to circle hooks. Not only would it increase catch efficacy but would also reduce bycatch of sea birds and turtles. Lessening impact on non-target species increases economic rent as there are fewer hooks occupied with bycatch. J-hooks are considered superior options in targeted catch methods, as opposed to line-and-pole fishing where the ability to quickly remove fish from the hook allows for faster recasting. The j-hook lessens the chance of fish being able to come unhooked, thereby ensuring a higher rate of retention for the method.

The political and economic arguments against longline regulation are not nearly as strong as other methods of management due to its decline in use through the region. This does not mean that it should still not be monitored and made more sustainable. Tuck & Polacheck (1997) found that longlining had the highest rate of non-target bycatch of any other method. This becomes a compound issue as it negatively affects sea bird and sea turtle populations, the latter which has a large spawning ground on specific beaches on Panama's Pacific coast. Echwikhi et al. (2011)

found that sea turtles in the region were more likely to feed on squid compared to mackerel. It is common for squid to be used as cheap bait in Panamanian longlining operations as mackerel is the more expensive option and does not impart any noticeable benefit of catch rates. A regulation enforcing the use of mackerel bait only would decrease the incidence of unintentional sea turtle catch. This could be argued as an effective holistic approach to ecosystem sustainability as one sector is being regulated to ensure protection of another that could become threatened if actions are not altered.

We must note that the culture surrounding longlining, while more established in the region, is losing ground in terms of usage. This can become a boon for regulators as the amount of support continues to decrease and the voice of those against any forms of regulations becomes quieter. While artisanal fishermen are not affected, it is becoming more apparent to the public that longlining can impart more damages to the ecosystem than positives it garners (Pacheco et al. 2011).

Implementation of MPAs would be an effective method to promote biomass health (Agardy 2000). This “non-direct” approach to regulation could reduce political backlash from the fishing industry as it would impart perceived ‘taxation’ in the form of requiring new materials for altering methods. The limitation of fishing areas would allow the free flow of fish stock to move into unfishable waters and spawn to then be reintroduced to open water and be caught. Arnason (2000) goes further and argues that property rights management is the most effective form of regulation for fisheries. Allowing vessels to fish specific regions would create a direct incentive to ensure the fish stock is well supported as the moral hazard of overfishing now comes at a price to the fishermen’s own bottom line. The use of area restrictions has been a common staple not only in other regions but the management of other species, namely scallops

and clams. The difference being is that fish are able to move in and out of restricted waters, which requires the restricted areas to be sufficiently large to allow effective protection and allow spawning. Arnason (2000) does note that this can be a difficult balance to maintain, thus requiring dedicated research and monitoring of fish stock regeneration. While Panama does have organizations in place to create MPAs, as it did with Coiba Island, there is an apparent disconnect in political imperative to continue to pursue increases in protected areas. Another alternative to consider are the semi-autonomous areas that belong to indigenous tribes. While still under the authority of the Panamanian government they are not subject to the entirety of the law, specifically fishing regulations. This creates an interesting management performed by the tribal leaders to ensure that their main staples stay abundant (Pollnac 1977). It could be that Panama sees using tribal influence to ensure sustainability in their own regions, allowing for areas of biological regeneration to then feed into open water available to industrial vessels. There is a clear distinction that industrial vessels do not fish in the exact areas of artisanal vessels. Whether this is out of respect for fellow fishermen or some alternative agreement, it does allow for pockets of low-intensity fishing to exist. Since Pollnac's assessment of Panamanian artisanal fishermen in 1977 there has not been any academic analysis of this population. While they would not be able to be monitored rigorously by governmental organizations, per constitutional amendments, it would be telling to conduct analysis of their habits and specific catch rates. This information could be used to further examine any possible need for influence from governmental agencies or to draw parallels to influence industrial fishing regulations.

Enforcement of regulations and monitoring through ARAP and the AMP would be beneficial for proper fisheries management, as their current influence cannot be specifically tied to current management policies. Both organizations are tasked with monitoring fishing both on

the water and at offload of vessels, but there is a distinct lack of publically available reporting information. Through stronger presence of enforcement agencies a reduction in IUU would decrease mortality of non-target species as well as overall bycatch. While industrial vessels are monitored via GPS trackers, per National Assembly legislation (Asemblea Nacional de la República de Panamá Feb 2005), it is likely that the enforcement agencies lack the capabilities to run checks on the hundreds of industrial vessels in Panamanian waters. Patrolling MPA regions would ensure these are kept as fishing free havens to allow fish stock to spawn and regenerate. Direct monitoring on vessels would be an alternate, albeit more intensive solution. This would result in more accurate reporting, providing data to better influence future catch limits and regulations. As shown by Aranson (2000) this method of fisheries management can provide a less politically charged option. By orienting the regulations on the marine system as opposed to directly upon fishermen and their vessels it avoids most disapproval and accusations of levying taxation in the form of requiring new gear.

As shown in the historical analysis of Panamanian regulations, there is still much to be learned about the process. The influence of governance on the isthmus from external forces could have created an adverse environment, specifically the United States desire for oligarchical commercial control of regulations (Lindsay-Poland 2003). The support of the U.S. in Panama's independence and subsequent backing of Noriega shows that importance on U.S. interests was placed higher than the domestic stability of Panama. The first legislation of fisheries was passed in 1959 with President Torrijos taking office shortly after. Noriega was an important part of subverting power from Torrijos. It is likely that this influenced many, if not all, policies enacted during this time. Fisheries have been a historically large part of Panama's economy (FAO 2008) making legislation affecting them high profile and susceptible to corruption for ulterior motives.

This area lacks academic support and could be further explored through specific political analysis of Panama. However, given the news and reports surrounding current and previous political officials it would not be beyond the ability of this thesis to assume that corruption is present in the system and could be influenced by industrial fishing interests. This possibility is an important aspect as we look at the whole of Panamanian legislation.

Conclusion

Overexploitation of Panamanian fisheries should be examined through the TEEB method of valuation in order to properly assess the natural capital loss. When compared against economic rents gained by fisheries the unsustainable direction of the industry becomes apparent. The IUCN, World Bank, and FAO consider the current rate of fishing to be unsustainable. Collapse of healthy fish stock would result in total loss of the estimated \$103 billion ecosystem services provided by the open ocean and coral reefs. This value is almost four times the 2011 GDP of Panama (CIA 2013) and should be considered national wealth lost and would not be able to be reversed. While recent actions have been talked about, there has been little in the way of implementation to show an outward attempt of ensuring environmental sustainability of fisheries. This could be due in part to the complicated political culture of Panama.

The National Assembly of Panama has the ability to enforce legislation that would result in sustainable methods to avoid collapse of the system. Doing so would require active legislation directly upon fishing vessels by means of catch limit, alternative catch methods, or creation of MPAs. These regulations require balance between ensuring fish stock longevity and maintaining economic profitability to avoid political backlash. The values derived from the TEEB report will provide a base level of economic rent comparison while ecological research should be applied to catch limits and other methods of regulation. The latter will need to be expanded in the case of

Panama as it lacks in-depth analysis to properly support legislation from an ecological perspective.

Using an analysis tool, such as the TEEB method, to provide a monetary value for natural resources such as the open ocean allows policy makers to garner support for regulation from an economic standpoint. Comparisons require a common denominator and money speaks volumes about the value of ecosystem services and their importance to a nation's wealth and well-being. Industry, especially the second largest contributor of GDP, is notoriously adamant against regulation that will impact their bottom line. The use of a tool like the TEEB method can show the specific economic losses possible to industry if their current practices threaten the ecosystem services. From this, policy arguments can be made from the argument that to not act of current practices could result in X amount of economic loss to the industry. This value can be specified and altered as we account for specific species, locations, and alternative fishing methods. An approach of this nature requires more ecological analysis, but would provide a much more coherent picture of possible ecosystem losses and therefore more accurate values to economic gains and losses.

It has been shown previously in this thesis that there are academically and ecologically proven alternatives to current methods used in Panama that would reduce negative impacts on fisheries and increase sustainability and even profitability in some cases. The political climate behind the lack of action on these alternatives is difficult to explore as there is little publically information available on the process of proposing legislation. Considering the surrounding corruption of political offices in Panama, it is possible that actors involved with industrial fisheries have coerced legislators to avoid keeping up with the global movement of fisheries management (World Bank 2009). In examining the legislation history we see that there was a

delay in enacting any policy to enforce the use of TEDs, though it had been made mandatory in the United States and other countries of similar economic standing as Panama.

One explanation for the various delays in action on fisheries management (TEDs, purse seining, bottom trawling) could be the lack of a strong environmental movement in the countries politically active populous. While a majority of the population lives within the capital Panama City, the majority of the remaining population lives along the coastline (FAO 2008). According to the most recent available data the primary sector of industrial fishing employs only 9,000 Panamanians (UN Data 2011). But again, this is a politically strong group on the side of industry as it contributes over 7% of GDP alone (CIA 2013, FAO 2008). There is a short-term economic imperative to avoid added regulation, specifically the regulations that would impose immediate upfront cost to vessels by way of changing gear requirements. While the best option in the long-run would result in regulation, industry has a difficult time taking discount rates into their assessment. The TEEB method attempts to resolve this issue, but would still require politically strong backing to garner support.

Artisanal fishermen, while not being directly regulated by the government, can suffer from mismanagement and unchecked catch rate of industrial fishing. This thesis cannot provide empirical data on this assumption, but the theory behind its possibility is strong. By the same argument in Aranson (2000), Sanchirico et al. (2008), Suman (2002), and Pérez-Ruzafa et al (2008) that fish are able to enter and exit MPAs we can assume fish enter and exit regions that artisanal fishermen can access with their lesser developed equipment. The artisanal fishermen and industrial vessels are truly competing for the same resources as tuna school and migrate within the region (IATTC 2012).

We can clearly see that there is a political power struggle here, as the artisanal fishermen, though having far less of a direct impact on the economy and fish stock due to their low intensity methods to avoid regulations, cannot push legislators to enact further restrictions on industrial vessels as their political power is centered within the city and has a much stronger economic argument for avoiding their regulation. While there does seem to be an unspoken agreement that industrial vessels do not encroach upon the ‘territorial’ waters of artisanal fishermen for the most part, this does not alter the fact that fish stock is estimated to continue to decline (IUCN 2012). This could place a strain on this agreement and cause more friction between the two groups. A further study of the political strength of these groups could lead to interesting results and provide information on why certain regulations have or have not passed. This is an area for future study, but it is still a valid assumption to this thesis that there is political imbalance between the groups of artisanal and industrial fisheries.

The use of the TEEB method in combination with the various academic reports has shown the evidence of an economic imperative to ensure sustainability of protection of ecosystems and their services. Through the use of replacement and alternative pricing models the UNEP supported study provided guidance to establishing monetary maximum and minimum values for the open ocean and coral reef systems, the two main ecosystems directly affected by fishing activity. Costanza (2000) argues that we should be careful in our valuation as it can be misused and the methodology, while improving, is not foolproof or all-encompassing of unforeseen variables in the future.

The political culture in Panama is quite convoluted due to the external influences throughout its history. Legislative processes of fisheries management are likely to be as corruptible, or already corrupted, as the rest of the political arena that includes presidents. There

are further restrictions that could increase ecological sustainability in measureable ways that are not being enacted by the National Assembly. This is likely a result of a strong political presence of environmentally conscious persons with the ability to fight a likely strong and well-connected industrial fishing lobby.

The hypothesis of this thesis was that Panama is not extracting the full amount of economic rents available from its fisheries. According to the assumptions and methodology of the TEEB valuation, it is falling far short of what it could be drawing from the territorial waters compared to commercial economic rents. Further specific analysis of the political structure and actors in the commercial fishing industry would assist in providing a holistic explanation. But through the research conducted it would be reasonable to assert that Panama is not properly discounting the value of these ecosystems and their provisioning services. Given the general consensus of research cited in this thesis that ecological collapse is possible in the most profitable fish species in Panama, the lack of action could result in massive losses of the second largest contributor of GDP in the country, right behind the Panama Canal.

LIST OF REFERENCES

- Agardy, T. (2000). Effects of fisheries on marine ecosystems: a conservationist's perspective. *Ices Journal of Marine Science*, 57: 761–765.
- Akpalu, W. (August 01, 2009). Economics of biodiversity and sustainable fisheries management. *Ecological Economics*, 68, 10, 2729-2733.
- Arnason, R. (2000). Economic instruments for achieving ecosystem objectives in fisheries management. *Ices Journal of Marine Science*, 57, 3, 742-751.
- Ascher, W. (1999). Resolving the hidden differences among perspectives on sustainable development. *Policy Sciences* , 32, 4, 351-377
- Asemblea Nacional de la República de Panamá. (1959). *Decreto Ley No. 17 - Por el cual se reglamenta la pesca y se regula la exportación de productos pesqueros en la república de panamá*. Panamá, República de Panamá.
- Asemblea Nacional de la República de Panamá. (1964). *Decreto No. 127 - Por el cual se reglamenta la pesca de atún en las aguas jurisdiccionales de la república de panamá*. Panamá, República de Panamá.
- Asemblea Nacional de la República de Panamá. (1998). *Decreto No. 7 - Por el cual se crea la autoridad maritima de panamá, se unifica la distintas competencias maritimas de la administración pública y dictan otras disposiciones*. Panamá, República de Panamá.
- Asemblea Nacional de la República de Panamá. (2004). *Ley No. 44 – Que crea el parquet nacional coiba y dicta otras disposiciones*. Panamá, República de Panamá.
- Asemblea Nacional de la República de Panamá. (Feb 2005). *Ley No. 9 - Que modifica el articulo 297 del código fiscal, que sanciona las infracciones al capítulo v del título vi del libro i de este código o a las normas reglamentarias sobre la pesca*. Panamá, República de Panamá.
- Asemblea Nacional de la República de Panamá. (Abr 2005). *Decreto Ejecutivo No. 82 - Por medio del cual se establece el uso del dispositivo excluidor de tortugas marinas a todas las embarcaciones que se dediquen a la pesca utilizando redes de arrastre, en las aguas jurisdiccionales de la República de Panamá*. Panamá, República de Panamá.
- Asemblea Nacional de la República de Panamá. (2006). *Decreto Ley No. 44 – Que crea la autoridad del los recursos acuaticos de panama, unifica las distintas competencias sobre los recursos marino-costeros, la acuicultura, la pesca y las actividades conexas de la administracion pública y dicta otras disposiciones*. Panamá, República de Panamá.

- Asemblea Nacional de la República de Panamá. (Feb 2009). *Decreto No. 7 – Que crea una zona de exclusión, comprendida en la areá del Pacífico panameno, en la que se prohíbe la utilización de redes de cerco para la pesca de atún.* Panamá, República de Panamá.
- Asemblea Nacional de la República de Panamá. (Nov 2009). *Decreto Ejecutivo No. 95 – Por el cual se regula la pesca de túnidas en las aguas jurisdiccionales de la república de panamá.* Panamá, República de Panamá.
- Asemblea Nacional de la República de Panamá. (Enero 2010). *Decreto Ejecutivo No. 98A – Por el cual se aprueba el plan de acción nacional de la república de panamá para prevenir, desalentar, y eliminar la pesca ilegal no declarada y no reglamentada.* Panamá, República de Panamá.
- Asemblea Nacional de la República de Panamá. (Julio 2010a). *Decreto Ejecutivo No. 238 – Que deroga el decreto ejecutivo no. 95de 11 de noviembre 2009, “Por el cual se regula la pesca de túnidas en las aguas jurisdiccionales de la república de panamá.”* Panamá, República de Panamá.
- Asemblea Nacional de la República de Panamá. (Julio 2010b). *Decreto Ejecutivo No. 239 – Que prohíbe la pesca de túnidas con redes de cerco en las aguas jurisdiccionales de la república de panamá.* Panamá, República de Panamá.
- Asemblea Nacional de la República de Panamá. (Dic 2010). *Decreto Ejecutivo No. 486 – Por la cual se restringe el uso linea o palengre en las aguas jurisdiccionales de la república de panamá.* Panamá, República de Panamá.
- Associated Press. (1967, May 10). Fishermen applaud purse seine outlaw. *Daytona Beach Morning Journal*, p. 3.
- Autoridad de los Recursos Acuáticos de Panamá. (Julio 2011). *Resolución ADM/ARAP No. 73 – Por el cual se adopta el regulamento ops-04-1, relativo al código de etica para la pesca y acuicultura responsable en los estados del itmo centroamericano.* Panamá, República de Panamá.
- Autoridad de los Recursos Acuáticos de Panamá. (Agosto 2011). *Resolución ADM/ARAP No. 086 – Por el cual se establecen medidas para realizar la actividad pescuera.* Panamá, República de Panamá.
- Autoridad de los Recursos Acuáticos de Panamá. (Nov 2011a). *Resolución ADM/ARAP No. 113 – Por la cual se oredena el registro de los buques pesqueros de mas de 20 metros de eslora, y dictan otras disposiciones antes las organizaciones regionales de ordenamiento pesquero.* Panamá, República de Panamá.

- Autoridad de los Recursos Acuáticos de Panamá. (Nov 2011b). *Resolución ADM/ARAP No. 114 – Por medio del cual se establece una veda espaciotemporal para buques de pesca cerqueros y de cebo vivo en el golfo de guinea*. Panamá, República de Panamá.
- Autoridad de los Recursos Acuáticos de Panamá. (Dic 2011). *Resolución ADM/ARAP No. 125 – El suscrito administrador general de la autoridad de los recursos acuáticos de panamá, en uso de sus facultades legales*. Panamá, República de Panamá.
- Autoridad de los Recursos Acuáticos de Panamá. (Feb 2012). *Resolución ADM/ARAP No. 002 – El administrador general de la autoridad de los recursos acuáticos de panamá, en uso de sus facultades legales*. Panamá, República de Panamá.
- Autoridad de los Recursos Acuáticos de Panamá. (Julio 2012). *Resolución ADM/ARAP No. 34 - El administrador general de la autoridad de los recursos acuáticos de panamá, en uso de sus facultades legales*. Panamá, República de Panamá.
- BBC News. (October 31, 2001). ‘Columbus ship’ found in Panama. *BBC News Americas*. Retrieved from: <http://news.bbc.co.uk/2/hi/americas/1630529.stm>
- Bureau of Labor Statistics. (n.d.). *CPI inflation calculator*. Retrieved from http://www.bls.gov/data/inflation_calculator.htm
- Castillo, A., & Lessios. (May 01, 2001). Lobster Fishery by the Kuna Indians in the San Blas Region of Panama (Kuna Yala). *Crustaceana*, 74, 5, 459-475.
- CIA. (March 15, 2013). Panama Country Profile. *World Fact Book*. Retrieved from: <https://www.cia.gov/library/publications/the-world-factbook/geos/pm.html>
- Cipriani, R., Guzman, H. M., & Lopez, M. (August 01, 2008). Harvest History and Current Densities of the Pearl Oyster *Pinctada mazatlanica* (Bivalvia: Pteriidae) in Las Perlas and Coiba Archipelagos, Panama. *Journal of Shellfish Research*, 27, 4, 691-700.
- Clark, J. (1995). Economic Development vs. Sustainable Societies: Reflections on the Players in a Crucial Contest. *Annual Review of Ecology and Systematics*, 26, 225-248
- Costanza, R. (January 01, 2000). Social Goals and the Valuation of Ecosystem Services. *Ecosystems*, 3, 1, 4-10.
- Cowan Jr., J. H., Rice, J., Walters, C., Hilborn, R., Essington, T., Day Jr., J., Boswell, K. (2012). Challenges for implementing an ecosystem approach to fisheries management. *Marine and Coastal Fisheries: Dynamics, Management, and Ecosystem Science*, 4, 1, 496-510.
- Department of State. (1989). *Conservation of sea turtles; importance of shrimp*. (Pub. L. 101-162, title VI, Sec. 609, Nov. 21, 1989, 103 Stat. 1037). Retrieved from <http://uscode.house.gov/download/pls/16C35.txt>

- Durán, I., Puentes, V. (2012). *Sistema de gestión regional para el uso sostenible de los recursos pesqueros del corredor marino del pacífico este tropical (CMAR)*. Resultados de Gestión en Panamá. Cross Market Ltda. 100 pg.
- Echwikhi, K., Jribi, I., Bradai, M. N., Bouain, A. (2011). Effect of bait on sea turtles bycatch rates in pelagic longlines: An overview. *Amphibia-Reptilia*, 32, 493-502.
- Encyclopedia of Earth. (2009, May 27). Protected Areas of Panama. Retrieved from http://www.eoearth.org/article/Protected_Areas_of_Panam%C3%A1
- Essington, T. E., Beaudreau, A. H., & Wiedenmann, J. (2006). Fishing through marine food webs. *Proceedings Of The National Academy Of Sciences Of The United States Of America*, 103(9), 3171-3175. doi:10.1073/pnas.0510964103
- FAO. (n.d.). *FISHLEX – Coastal State Requirements for Foreign Fishing in Panama*. Retrieved from <http://faolex.fao.org/fishery/index.htm>
- FAO Fisheries and Aquaculture Dept. (2012). *The state of world fisheries and aquaculture 2012*. Rome: Food and Agriculture Organization of the United Nations.
- FAO. (2008). Fishery and Aquaculture Country profiles. Panama. Fishery and Aquaculture Country Profiles. In: FAO Fisheries and Aquaculture Department [online]. Rome. Updated 5 August 2008. http://www.fao.org/fishery/countrysector/FI-CP_PA/en
- FAO, OSPESCA. Documentos presentados en el Taller Regional FAO/OSPESCA sobre el Mejoramiento de los Sistemas de Información y Recolección de Datos Pesqueros para América Central y el Caribe. San Salvador, El Salvador, 23–26 de enero de 2006. FAO, Informe de Pesca y Acuicultura. No. 919, Supl. Roma, FAO. 2010. 137p. [En línea]
- Fehr, E., Leibbrandt, A. (2011). A field study on cooperativeness and impatience in the tragedy of the commons. *Journal of Public Economics*, 95, p. 1144-1155
- FIRMS. (2012). EPO Tunas and billfishes fishery, 2011. FIRMS Reports. In: *Fishery Resources Monitoring System (FIRMS)* [online]. Rome. Updated 7 December 2012.
- Fish Source. (October 2012). *Yellowfin Tuna – Atlantic*. Retrieved from http://www.fishsource.com/site/goto_profile_by_uuid/a0bbcf68-203b-11e1-9419-40406781a598
- Fisheries Centre (Vancouver, British Columbia). (2008). *Fisheries Centre Research Reports: A comparative assessment of biodiversity, fisheries, and aquaculture in 53 countries' exclusive economic zones*. Vancouver, BC: Fisheries Centre.
- Fletcher, S., Saunders, J., Herbert, R., Roberts, C., and Dawson, K. 2012. Description of the ecosystem services provided by broad-scale habitats and features of conservation

- importance that are likely to be protected by Marine Protected Areas in the Marine Conservation Zone Project area. *Natural England Commissioned Reports*, Number 088. 154pp.
- Haller, T., Merten, S. (2008). "We are zambians — don't tell us how to fish!" institutional change, power relations and conflicts in the kafue flats fisheries in zambia. *Human Ecology*, 36, 5, p. 699-715
- Halpern, B. S. (2003). The impact of marine reserves: Do reserves work and does reserve size matter? *Ecological Applications*, 13, 1, S117-S137.
- Harding, R. C. (2006). *The history of Panama*. Westport, Conn: Greenwood Press.
- Hassan, R. M., Scholes, R. J., Ash, N., & Millennium Ecosystem Assessment (Program). (2005). *Ecosystems and human well-being: Current state and trends : findings of the Condition and Trends Working Group of the Millennium Ecosystem Assessment*. Washington, DC: Island Press.
- Hilborn, R. (2007). Defining success in fisheries and conflicts in objectives. *Marine Policy*, 31, 153-158.
- Hilborn, R. (2010). Pretty good yield and exploited fishes. *Marine Policy*, 35, 193-196.
- Hilborn, R., Stokes, K. (2010). Defining overfished stocks: Have we lost the plot?. *Fisheries*, 35, 3, 113-120.
- IATTC. (1963). *Summary Minutes of the Annual Meeting*. Panama, Republic of Panama
- IATTC. (2012). *Fisheries Status Report*. La Jolla, California
- IUCN. (2012). Thunnus albacares. Retrieved from <http://www.iucnredlist.org/details/21857/0>
- Jackson, Eric. (August 28, 2012). Martinelli references in another Italian corruption probe. *The Panama News*. Retrieved from: http://www.thepanamanews.com/pn/v_18/issue_07/news_03.html
- Jiménez, Max A.S., et al. (May 30, 2010). *Final report: Analysis of the economic contribution of recreational and commercial fisheries to the Costa Rican economy*. Universidad de Costa Rica, Instituto de Investigaciones en Ciencias Económicas. 141p. (<http://rbassets.com/images/postattachments/3371/original/CostaRicaMarineFisheriesEconomics5-30-10.pdf?1283362574>)
- Kelleher, K. (2005). Discards in the world's marine fisheries an update. *FAO Fisheries Technical Paper*, 470.

- Kessler, Glenn. (August 27, 2004). U.S. denies role in Cuban exiles' pardon: Panama frees 4 convicted in plot to kill Castro. *Washington Post*. Retrieved from: <http://www.webcitation.org/6AhMDcJCS>
- Kumar, P., & Economics of Ecosystems and Biodiversity (Project). (2010). *The economics of ecosystems and biodiversity: Ecological and economic foundations*. London: Earthscan.
- Le Gallic, B., & Cox, A. (2006). An Economic Analysis of Illegal, Unreported and Unregulated (IUU) Fishing: Key Drivers and Possible Solutions. *Marine Policy : the International Journal for Economics Planning and Politics of Ocean Exploitation*, 30, 6, 689-695.
- Lindsay-Poland, J. (2003). *Emperors in the jungle: The hidden history of the U.S. in Panama*. Durham [N.C.: Duke University Press.
- Mackenzie, W. (2010, May 18). When purse-seining goes bad. Retrieved from <http://www.greenpeace.org/international/en/news/Blogs/makingwaves/when-purse-seining-goes-bad/blog/11803/?accept=2a4c27f0b7c1b45fe1e541bbffed390c>
- McCullough, D. G. (1977). *The path between the seas: The creation of the Panama Canal, 1870-1914*. New York: Simon and Schuster.
- Meneses, I. (June 2010). *Analisis historico e institucional del sector pesquero de panama*. Retrieved from Panama Tourism Authority (ATP) database.
- Millennium Ecosystem Assessment. (2005). *Ecosystems and human well-being: Current state and trends : findings of the Condition and Trends Working Group of the Millennium Ecosystem Assessment*. Washington, DC: Island Press.
- Monterey Bay Aquarium. (n.d.). Fishing methods fact card. Retrieved from http://www.montereybayaquarium.org/cr/cr_seafoodwatch/content/media/MBA_SeafoodWatch_Longlining&PurseSeiningFactCards.pdf
- NOAA. (2011). Bottom Life. Retrieved from <http://www.nefsc.noaa.gov/ecosys/ecology/Benthos/>
- Ordoñez, C., Troëng, S., Meylan, A., Meylan, P., & Ruiz, A. (May 01, 2007). Chiriqui Beach, Panama, the Most Important Leatherback Nesting Beach in Central America. *Chelonian Conservation and Biology*, 6, 1, 122-126.
- Pacheco, J. C., Kerstetter, D. W., Hazin, F. H., Hazin, H., Segundo, R. S. S. L., Graves, J. E., Carvalho, F., Travassos, P. E. (2011). A comparison of circle hook and J hook performance in a western equatorial Atlantic Ocean pelagic longline fishery. *Fisheries Research*, 107, 39-45.

- Pauly, D., Christensen, V., Dalsgaard, J., Froese, R., & Torres Jr., F. (1998). Fishing down marine food webs. *Science*, 279(5352), 860.
- Pérez-Ruzafa, A., Martin, E., Marcos, C. (2008). Modelling spatial and temporal scales for spill-over and biomass exportation from MPAs and their potential for fisheries enhancement. *Journal for Nature Conservation*, 16, 234-255.
- Pew Charitable Trust. (n.d.). *The sea around us project*. Retrieved from <http://www.seaaroundus.org/eez/591.aspx>
- Pitcher, T. J., Varkey, D., Pramod, G., Kalikoski, D., & Short, K. (March 01, 2009). An evaluation of progress in implementing ecosystem-based management of fisheries in 33 countries. *Marine Policy*, 33, 2, 223-232.
- Pollnac, R. B. (1977). *Panamanian small-scale fishermen: Society, culture, and change*. Kingston: International Center for Marine Resource Development, University of Rhode Island.
- Sanchirico, James N., Martin D. Smith, Douglas W. Lipton. (January 2008). An empirical approach to ecosystem-based fishery management. *Ecological Economics*, Volume 64, Issue 3, 15 January 2008, Pages 586-596, ISSN 0921-8009, 10.1016/j.ecolecon.2007.04.006. (<http://www.sciencedirect.com/science/article/pii/S0921800907002364>)
- Shackleton, S., Campbell, B., Lotz-Sisitka, H., Shackleton, C. (2008). Links between the local trade in natural products, livelihoods and poverty alleviation in a semi-arid region of south africa. *World Development*, 36, 3, p. 505-526
- SICA/OSPESCA. (2005). Fisheries and Aquaculture Integration Policy for the Central American Isthmus. 19.
- A Singapore for Central America? (July 14, 2011). *The Economist*. Retrieved from: <http://www.economist.com/node/18959000>
- Spalding M.D., Ravilious C. and Green E.P. (2001). *World Atlas of Coral Reefs*. Prepared at the UNEP World Conservation Monitoring Centre. University of California Press, Berkeley, USA.
- Suman, D. (January 01, 2002). Panama revisited: evolution of coastal management policy. *Ocean and Coastal Management*, 45, 91-120.
- TEEB - The Economics of Ecosystems and Biodiversity. (2010). *The economics of ecosystems and biodiversity for local and regional policy makers*. London: Earthscan.

- Tuck, G.N. & Polacheck, T. (1997) Trends in Tuna Longline Fisheries in the Southern Oceans and Implications for Seabird Bycatch: 1997 Update. CCSBT-ERS/97/35. Commission for the Conservation of Southern Bluefin Tuna– Ecologically Related Species Working Group, Canberra, Australia.
- Tyedmers, P. H., Watson, R., & Pauly, D. (2005). Fueling global fishing fleets. *Ambio*, 34(8), 635-8. Retrieved from <http://ezproxy.lib.ucf.edu/login?url=http://search.proquest.com/docview/207674214?accountid=10003>
- UN Data. (2011). Panama. Retrieved from <http://data.un.org/Search.aspx?q=Panama>
- United Nations. (2011). *Panama*. [ONLINE] Available at: <http://data.un.org/CountryProfile.aspx?crName=Panama#Economic>. [Last Accessed 12/15/2012].
- United Nations Environment Programme. (2010). *Global environment outlook: Latin America and the Caribbean*. Panama City, Panama: United Nations Environment Programme.
- United Nations Environment Programme. (2011). *The economics of ecosystems and biodiversity in national and international policy making*. London: Earthscan.
- Western and Central Pacific Fisheries Commission. (2012). Annual Report to the Commission Part 1: Information on Fisheries, Research and Statistics: Panama
- Wood, L. J. (2007). MPA Global: A database of the world's marine protected areas. Sea Around Us Project, UNEP-WCMC & WWF. www.mpaglobal.org
- World Bank, & Food and Agriculture Organization of the United Nations. (2009). *The sunken billions: The economic justification for fisheries reform*. Washington, DC: World Bank.
- Zea, Mary. (December 29, 2011). Arap restringe más el arte del palangre. *La Prensa*. Retrieved from: <http://laprensa.com.pa/impreso/economia/arap-restringe-mas-el-arte-del-palangre/51450>