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ECONOMIC VALUATION OF FLORIDA SEA TURTLES IN FACE OF SEA LEVEL RISE

by

AHMED HASSAN HAMED
B.S. University of Central Florida, 2012

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in the Department of Civil, Environmental, and Construction Engineering in the College of Engineering and Computer Science at the University of Central Florida
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Major Professor: Kaveh Madani
ABSTRACT

Sea level rise (SLR) is posing a great risk of flooding and inundation to coastal areas in Florida. Some coastal nesting species, including sea turtle species, have experienced diminished habitat from SLR. In an effort to assess the economic and ecosystem service loss to coastal areas with respect to sea turtles Contingent Valuation Method (CVM) and Habitat Equivalency Analysis (HEA) were used.

The CVM was used to measure the economic impacts of SLR on sea turtles. Open-ended and dichotomous choice CVM was used to obtain the willingness to pay (WTP) values of Florida residents to implement certain mitigation strategies which would protect Florida’s east coast sea turtle nesting areas. The problem of sample selection bias was reduced by surveying residents of two cities that would potentially have varying interest in coastal conservation due to their relative distance from the coast. The hypothetical WTP of Florida households to implement policies designed to protect sea turtle habitat from development encroachment was estimated to be between $21 and $29 per year for a maximum of five years. Characteristics of respondents were found to have statistically significant impacts on their WTP. Findings include a negative correlation between the age of a respondent and the probability of an individual willing to pay the hypothetical WTP amount. Counter intuitively, it was found that WTP of an individual was not dependent on prior knowledge of the effects of SLR on sea turtle habitat. As the level of this awareness increased, the probability to pay the hypothetical WTP value decreased. The greatest indicators of whether or not an individual was willing to pay to protect sea turtle habitat were the respondents’ perception regarding the importance of sea turtle population health to the ecosystem, and their confidence in the conservation methods used.
Concepts of Habitat Equivalency Analysis were used in order to determine the ecosystem service lost due to SLR. The study area of Archie Carr National Wildlife Refuge (ACNWR) has a continually increasing sea turtle population due to various conservation efforts. However, how the inundation of the coastal area will injure this habitat was assessed, and if mitigation strategies to compensate for the loss are necessary. The carrying capacity (CC) of the refuge was chosen as the metric of the ecosystem service. Using the estimated area of ACNWR and the approximate area needed by a sea turtle to nest, the theoretical number of sea turtle nests possible on the refuge was calculated. This value was then projected to the year 2100 using the sea level rise scenarios provided by IPCC (2007) and NRC (2010). In order to quantify the injury caused by the decrease in the refuge’s CC, the number of sea turtle nests on the refuge was projected to the year 2100 using the data obtained over the past 30 years. The analysis concludes a potential loss of service to be experienced as early as 2060’s due to the carrying capacity of the refuge diminishing with the loss of the habitat due to the increase in the mean sea level.

**Key Words:** Sea level rise, sea turtle, ecosystem service valuation, contingent valuation, Florida
In all honesty, if I mention the names of all the people that I am truly grateful for and the people that had a positive impact on my life this thesis would become a dissertation! I want to dedicate this thesis to my father and mother; Hajj Hassan and Hajji Nawal Hamed. Their great kindness and selflessness has taught me how to love for and care for the people I interact with. This, I believe, has caused a domino effect in my life in which I am attracted to positivity and I emanate the same. Without the years of hard work and dedication this will not be possible. They both sacrificed so much to provide their children with the best of this world. My father was forced to leave his parents at the tender age of 13 to escape despair seek a future. He arrived in the US as a refugee from Palestine with nothing but his dedication for success. He worked very hard, and suffered more than a person should, and that is a true motivation. My mother spent countless nights caring for me and great effort teaching me. She cared for all my siblings, teaching them to put this world in their hands, and the hereafter in their hearts. Nothing I can ever do will repay her for even the pain of one contraction.

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LIST OF ACRONYMS/ABBREVIATIONS

ACNWR- Archie Carr National Wildlife Refuge

CC- Carrying Capacity

CV- Contingent Valuation

CVM- Contingent Valuation Method

CVM-DC- Contingent Valuation Method- Dichotomous Choice

DC – Dichotomous Choice

HEA- Habitat Equivalency Analysis

IPCC- Intergovernmental Panel on Climate Change

m- Meters

m²- Meters Squared

NOAA- National Oceanic and Atmospheric Administration

NRC- National Research Council’s

SLR- Sea Level Rise

UCF- University of Central Florida

WTP- Willing to Pay/ Willingness to Pay
CHAPTER ONE: INTRODUCTION

Human actions have caused an increase in the amounts of greenhouse gases and aerosols in the atmosphere resulting in global climate change. Houghton et al. (2005) project the global temperature to increase by a range of 2-6 °C by 2100. Hawkes et al. (2009) estimate that the ocean will absorb 80% of the increase in atmospheric temperature, causing thermal expansion. Additionally, an increase in global temperature will cause melting of the ice sheets. The level of contribution of ice sheet melting to the global sea level is one of the greatest uncertainties in estimating sea level rise (Monaghan et al. 2006). Using satellite gravity measurements Chen et al. (2006) confirmed an accelerated melting of Greenland, the second largest ice cap in the world. Noting that recent studies suggest that ice loss was approximately 224 (+/-) 41 km³/year in 2005, much greater than the estimated value of 80 (+/-) 12 km³/year. Vermeer and Rahmstorf (2009) estimated the range of SLR by 2100 to be between 0.75 and 1.9 meters, significantly higher than the previously estimated value of 1 meter. This increase in sea level has recently been the focus as the main factor leading to the loss of habitat of many coastal nesting species including endangered species such as the Green sea turtle (Chelonia mydas) (Fish et al., 2005; Baker et al., 2007). This introductory chapter will begin by addressing the phenomena of sea level rise, discussing the various species of sea turtles found in Florida, and highlighting some of the methods considered for ecosystem valuation. It will also present a brief overview of the two methods used in this study, namely; Contingent Valuation Method (CVM) and Habitat Equivalency Analysis (HEA). These methods are used in order to valuate the ecosystem service provided by sea turtles. The use of CVM allows for an estimation of the value placed by respondents on a specific service. HEA, however, does not consider the value placed by an
individual but rather the cost of a compensatory restoration in the event that the service is injured or damaged. Considering both methods is advantageous due to the difficulty and uncertainty faced by ecosystem service valuation techniques.

1.1 Sea Level Rise

Over the past 100 years the rate of SLR has increased tenfold when compared to the rate over the last two millennia, implying a comparatively recent acceleration in the rate of SLR (Houghton, 2001; Sallenger et al., 2012). Currently, it is predicted that the mean sea level rise will range between 0.59 meters and 1.4 meters in the next 100 years (Fish et al., 2008; NRC, 2010). Risk indices classify approximately 15% of the East Coast of the contiguous United States as being at very high risk of inundation or increased erosion from SLR. The predicted rise in sea levels would threaten many areas of the world with erosion and inundation (Gornitz, 1994). SLR has impacts on both the natural and socio-economic systems, and is therefore one of the most studied consequence of climate change. Among the noticeable costs of climate change include that of the SLR and protection against it (Bosello et al., 2012).

Ellison (1991) predicted an immediate and direct effect on the ecosystems of intertidal zones due to SLR. Exacerbating the impacts of SLR, hard structures such as sea walls, obstruct the landward migration of beaches resulting in a diminishing beach width (Fish et al., 2008). The continual rise of the sea level has prevented the natural recovery of the sea turtle population that has been diminished due to anthropogenic activities on Florida coasts. Human utilization of coastal habitats and their destruction have caused major declines in the abundance of marine life such as leatherback sea turtles (Spotila et al., 1996). Additionally, the vulnerability of sea turtle nests increase almost always occur on low lying beaches (Yamamoto et al. 2012). For this reason
a reduction in beach width can result in an increased concentration of nests. This, consequently, will create density related issues such as nest infection (Fish et al., 2008). Additionally, Fuentes et al. (2010) attributed such increase in density to increased egg mortality.

1.2 Sea Turtles of Florida

Coastal areas are dynamic environments with high economic value and environmental resources. The Florida coastline spans over 2,000 kilometers (km), and contains diverse ecosystems and landscapes in addition to being habitat for many endangered species. The Florida coastline is especially important for various species of sea turtles. One of the most important nesting areas for loggerhead turtles (*Caretta caretta*) in the Western Hemisphere and green turtles (*Chelonia mydas*) in the United States is the 40.5-km coastline from Melbourne Beach to Wabasso Beach (Weishampel et al., 2003) in Florida (Figure 2). SLR, however, has significantly impacted such habitats leading to repercussions to the beach dependent species (Fish et al., 2008).

Sea turtles have various ecological roles, including: nutrient cycling, which is crucial for the coastal ecosystem; and maintenance of sea grass beds, coral reefs and beach dunes (Moran and Bjorndal, 2005, Hannan et al. 2007). Losing such services potentially affects the dynamics of near shore ecosystems (Heithaus, 2005). Aside from the obvious ecological services sea turtles provide, due to their charismatic nature they contribute in generating tourism activities, which yields great economic benefits (Clem and Clevo, 2001).

Ecosystems of intertidal zones will be directly and immediately affected by SLR (Ellison 1991). In coastal areas with high human activities and development, shoreline structures will prevent landward migration of beaches. Such barriers exacerbate the impact of SLR as beach
habitat is lost. Sea turtle nesting almost always occurs on low-lying beaches which make them particularly vulnerable to SLR (Yamamoto et al. 2012). Major loss of nesting beaches has hindered efforts to revive the depleted populations of sea turtles. Their survival is greatly threatened by the loss of their habitat. A reduction in habitat area will result in a higher concentration of nesting density, thus increasing density-related issues including increased nest infection (Fish et al., 2008) and crowding, which has the potential for nests to be lost by females nesting on top of existing nests (Canbolat, 2004). Gornitz (1991) highlighted the severity of beach erosion, and the washing away and flooding of nests due to SLR. Increased egg mortality will result from such occurrences and affect the reproductive success of the green turtle population (Fuentes et al., 2010).

Various mitigation strategies are being implemented to cope with SLR and the erosion of coastal areas that ensues. Some strategies including planned retreat and mandated setback, to allow for a buffer zone between the mean sea level and development, has been used to avoid building irreversible hard engineering structures which cause increased coastal erosion further down the beach (National Research Council, 1995). Additionally, non-structural strategies such as beach nourishment projects have been used to increase beach width, and to improve beach sand quality.

1.3 Ecosystem Service Valuation

Valuing ecosystem services provided by sea turtles is essential for assessing the efficiency of alternative ecosystem conservation policies and making cost-benefit analysis of various restoration programs (Wilby et al., 2010). However, in order to effectively estimate the value of such services, valuation techniques which incorporate both market and non-market value of the
An ecosystem service is necessary. The ecosystem service provided by sea turtles encompasses a variety of categories. In an effort to analyze the impacts of human action on ecosystems, the Millennium Ecosystem Assessment (2005) identified these ecosystem service categories as: provisioning, regulating, cultural and supporting services. The services within these categories are provided directly and indirectly and make up the total economic value of the ecosystem service (Figure 1).

Figure 1: Ecosystem services provided by sea turtles, their activities and their habitat

The value of a commodity falls within the market value category if the service or good can be purchased or sold. Non-market values, however, are different in that they do not have an appraisable market price and cannot be traded directly in markets. Consequently, valuation methods which rely solely on a market value are inapplicable (Bennett and Blamey, 2001). A more accurate estimate would be achieved if other values are considered as part of the total value of the environment; including option and existence values (Brookshire et al., 1983). Furthermore, within the non-market value category, there are use and non-use values (Carson and Bergstrom, 2003) such as bequest, option and existence value. Bequest value being the value an individual is
willing to pay to protect some public good for future generations. Option value is the value an individual is willing to pay to protect some public good they are unlikely to use, just to have the option to use it in the future if they pleased. The value an individual is willing to pay to maintain the mere existence of some public good or service is described as the existence value. A pure public good lacks a market because of its non-excludable or non-rival nature (Hanemann, 1994). In other words, once the good is available, no one can be withheld from enjoying it and the good is not subtractable. For instance, improving air quality results in a benefit all can enjoy, and none can be prevented from enjoying it.

1.4 Contingent Valuation Method

Contingent valuation is a stated preference method which draws upon economic theory and methods of survey research to directly elicit the value of some good or service from the consumer (Mitchell and Carson, 1989). It was first used in early 1963 by Robert Davis when he designed a questionnaire to estimate the benefit of pure public good, and subsequently used by others for various environmental and ecosystem valuation purposes (Desvousges, 1987; Whittington, 1990; Loomis, 2000; Whitehead, 2003; Bandara and Clem 2004). The hypothetical market being valued must not be abstract but rendered in terms of specific items (Hanemann, 1994). Although the contingent valuation method (CVM) has been extensively researched and applied, eliciting satisfactory estimates remains a constant struggle to avoid bias and increase precision (McLeod and Bergland, 1999).

1.4.1 Ecosystem Valuation Techniques

Valuing ecosystems is necessary so that they are not underrepresented by policy makers. If the policy being considered affects goods and services traded in normal markets, the cost and
benefit becomes evident with a straightforward analysis of the changes in price of some service versus the additional income received. However, when the policy affects the quality or the availability of some environmental good, such as sea turtle habitat, there is no observable price or income change. Consequently, the alternatives must be analyzed not only from an economic standpoint, but also an environmental and social standpoint. For each of these considerations a different valuation technique may be superior.

Many of the existing valuation techniques were considered in this study but eliminated due to not meeting the set criteria to be further analyzed and used for this study. The basic requirement the valuation technique to be chosen must have possessed in order to be useful in this study was the capability to measure the non-use value of goods or services. Non-use values, such as option, existence, bequest and altruistic values are significant when evaluating various environmental resources. Brown (1993) demonstrated that in some cases, non-use value has exceeded the use value. One of the main characteristics that make some resources difficult to value is its lack of a perfect and apparent market (Brown, 2001). In Table 1, a synopsis of some of the previously used ecosystem valuation techniques are presented. Their application potential was compared with the criteria to determine the suitability of each method for assessing the economic impact of SLR on sea turtle nesting habitat. Contingent valuation was the method settled on due to its ability to consider both the market and non-market value. Furthermore, it was chosen over the choice modeling method, which also considers the market and non-market values, because it lacked the disadvantages found in choice modeling including (Carson and Bergstrom, 2003).

Table 1 Ecosystem valuation methods

<table>
<thead>
<tr>
<th>Approach</th>
<th>Method</th>
<th>Market Value</th>
<th>Non-Market Value</th>
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Natural resources are periodically affected by natural and anthropogenic activities such as forest fires (Hanson et al. 2013), oil spills (Roach and Wade 2006), and vessel groundings (Milon and Dodge 2001). The Environmental Impact Statement regime provides rules for authorized impacts, including for the National Environment Policy Act (1969), the Clean Water Act (1975) and the Endangered Species Act (1973) (Levrel 2012). The Environmental Impact Statement requires avoiding, mitigating, or compensating for the injuries which are resulted from a project. This procedure has the goal of avoiding a negative ecological impact, in situations where the impact is inevitable, such as sea level rise, the negative impacts is to be reduced, existing significant negative ecological impacts are to be compensated (Levrel 2012). The lack of information regarding the economic costs of natural resources prior to an injury makes it difficult to obtain such needed estimates (Roach and Wade 2006). Estimating the natural resource damage (NRD) due to an injury will better equip us in determining the amount of compensatory
restoration required for mitigating the losses. The principle behind compensatory restoration is that the loss in an environmental service or ecological good should be compensated by the creation of a new but similar service or restoration of the injured area. Such will offset the loss to guarantee a net loss of zero to the service level.

Valuation techniques such as revealed preference tend to be limited to estimating market and use values, and therefore not suitable to assess natural resource with values such as non-use or passive use. Contingent valuation method, a stated preference approach, has been extensively used in non-use valuation, however, a high quality contingent valuation study can be costly and time consuming; a relatively simple damage claim can take over a year to complete costing hundreds of thousands of dollars (Unsworth and Bishop 1994).

Identifying an explicit linkage between the function of the service and human activities can be impossible in some situations. Therefore, the behavioral responses method cannot be applied to measure the economic value of loss due to the loss of some service (Milon and Dodge, 2001). The alternative, as suggested by Milon and Dodge (2001), is to assess the cost to restore or replace the damaged site to regain the service provided by that site. Within the last score, a method has emerged and is increasingly being used to determine the amount of compensatory restoration required for mitigating interim loss of natural resource services due to some injury (NOAA, 2000). Habitat equivalency analysis (HEA) was created in the early 1990’s and was used to estimate loss to an ecological service due to an injury and subsequently to scale a restorative compensation to that injured ecological service (Mazzotta et al. 1994; Unsworth and Bishop 1994;
To estimate the quantity required to offset interim losses due to an injury, a process known as scaling calculates the compensatory restoration (Thur 2007).

HEA differs from some valuation techniques in that its aim is to maintain ecological service baseline rather than a human welfare baseline (Roach and Wade 2006). It is considered a service-to-service approach, and so assumes that the public will accept the natural resource services provided by the restoration project as a compensation for those services lost due to an injury (Jones and Pease 1997). Estimating the amount of compensation using HEA is subject to some difficulties due to the assumptions that must be made and parameters surrounding many situations are not known with certainty (Dunford et al. 2004). Ultimately, the goal of HEA is to scale the size of the restoration or replacement project by equaling the present value services lost due to the injury to the present value of the services provided by the replacement project (Kohler and Dodge 2006).

The HEA has been used by the Trustees (NOAA, 2000) as a tool to calculate the amount of restoration required to compensate for the injured habitat. This compensation can come in the form of increased acreage using the common metric of Discounted Service Acre Year (DSAY). Noting a service acre year is used to represent ecosystem services that are provided by an acre of habitat. HEA logical framework will provide a fair and efficient method to conducting environmental injury assessments. The main requirement of this restoration is to be scaled in a manner to provide an equivalent quantity of service gain as was lost due to injury. A more detailed description of the HEA method and its algebraic calculations are presented in the report prepared by the National Oceanic and Atmospheric Administration’s (NOAA’s)
Damage Assessment and Restoration Program (NOAA 2006). The objective is to scale the compensatory restoration project required to offset the interim losses to sea turtle nesting habitat due to sea level rise.

1.5.1 Sea Turtle Nesting of Archie Carr National Wildlife Refuge

Sea turtles are crucial and provide key benefits to the overall coastal ecosystem health. As sea turtle nesting density increases it will encroach on the carrying capacity of the beach. A healthy coastal area is crucial to provide food for other trophic levels. Additionally, it is correlated with the many services provided by the coastal areas. It was therefore indicated the service levels for the injured site and for the restoration project site to be a function of the baseline mean density of sea turtle nests on the coast.

Sea turtles have a value to the public and therefore trustees must act on the public’s behalf to assure the ecosystem services provided by sea turtles is compensated in an event of an environmental injury such as sea level rise diminishing habitats. Such events are guaranteed to be addressed according to the Endangered Species Act for the level of treatment and restoration scaling of that species (English et al. 2009). In this thesis the Habitat Equivalency Analysis (HEA) method is applied to assess the compensatory restoration required to mitigate the impacts of sea level rise on the sea turtle nesting habitats in the Archie Carr National Wildlife Refuge (ACNWR).

The ACNWR lies between Melbourne Beach and Wabasso Beach on the east coast of Florida (Figure 2). It was established in 1991 and designated due to its great importance to sea turtles. With an area of 248-acres and a coastal stretch of 20.5 miles, this low-lying barrier island is the Western Hemispheres most significant loggerhead sea turtle nesting site in the Western
Hemisphere, and the most significant nesting site for green turtles in North America (Weishampel et al. 2003).

Figure 2: The Archie Carr National Wildlife Refuge
(Weishampel et al. 2003)

The refuge supports smaller nesting populations of endangered leatherback sea turtles (US Fish and Wildlife Service, 2001). Protecting this 20.5 mile nesting site is prudent to benefit the three species of sea turtles that nest there, and this habitat is particularly important to loggerhead
sea turtles. Assessing the impact SLR will have on this habitat will determine the urgency to establish protection techniques. Mitigating existing damages to this area is emphasized with its importance for sea turtle survival along with its susceptibility to injury due to SLR. Policy decisions regarding the management of this refuge will have extreme impacts on the nesting density and therefore reproductive success of this nesting site (Ussa 2013).

1.5.2 Coastal Habitat Functions and Measures of Economic Damages

The density of the human population of coastal areas is significantly greater than that of inland areas (Barbier et al., 2008). Estimates indicate one-third of the world's population reside in coastal areas and small islands which make up only 4% of the entire land area of the earth (Brown et al., 2006). The health of the coastal ecosystem will determine the long term sustainability of these populations. Despite the importance of the services provided by coastal ecosystems, such as storm buffering, fisheries production, and improved water quality, a degradation and loss to the habitats of these crucial ecosystems has been witnessed (Barbier et al., 2008). One of these ecosystem services being degraded and lost is that of the sea turtles and their nesting habitats. Such habitats contribute in providing multiple services, e.g., food and habitat production, eco-tourism, biological regulation, waste processing, nutrient cycling, fertility, as well as cultural and recreational opportunities (Wallace, 2007). It is evident that the health of the sea turtle population has economic benefits. The relationship between the service level of sea turtle nesting habitat and this benefit, however, has received little attention.

1.6 Thesis Structure

In chapter two the ecosystem valuation techniques that were considered and the process that was taken to choose the method for the study is described. A discussion of the CVM, designing
the survey, CVM scenarios, and sample selection is ensued. Chapter three will be the application of the Habitat Equivalency Analysis to the case study. The requirements to use this method and present the metric to be used are addressed. The results are presented in chapter four. The empirical results for the referendum votes to the WTP questions and the aggregate benefits are presented. A comparison of the economic characteristics of the sample selected will be compared to that of Florida’s. In the conclusion, the determinants of WTP according to the binomial logit models are discussed, as well as the aggregate benefits of sea turtle habitats of Florida coasts. The results indicate that Florida residents place a high value on sea turtles and their habitat, yet this value is significantly greater when an individual perceives that the existence of sea turtles impact his or her life. The projection of carrying capacity loss in relation to sea turtle nesting increase due to mitigation efforts is also presented. In chapter five conclusions are made and finally discuss some of the limitations that were faced in chapter 6.
CHAPTER TWO: CONTINGENT VALUATION METHODOLOGY

Protecting the sea turtle habitat from SLR is an environmental public good, therefore, no market exists that can be used for its valuation. However, a hypothetical market can be created and this hypothetical market can then be evaluated. Possibly the most popular method used to evaluate such hypothetical markets is the CVM. In the form of a survey, respondents are presented a hypothetical market and directly asked their willingness to pay for the service or good in the hypothetical market or scenario. The scenario is not abstract and the respondent will evaluate a specific scenario. Mitchell and Carson (1989) suggested that the challenge of a contingent valuation study is to create a scenario which is "sufficiently understandable, plausible and meaningful to respondents so that they can and will give valid and reliable values". The survey aims to clearly present to the respondent the nature of the improvement, the payment vehicle which will be used to fund the improvements, and the party responsible for performing the improvements.

The theory behind CVM follows the theory of welfare economics where the value of a good or service is the most someone is willing to pay for it (Mitchell and Carson, 1989). Here, the WTP value was calculated using the Turnbull estimator method (Turnbull, 1976). The Turnbull estimator, used to estimate the mean willingness to pay of respondents, is a maximum likelihood non-parametric estimator (Ahtiainen, 2007). This estimating method was paired with other techniques used to reduce hypothetical bias. Hypothetical bias arises in contingent valuation studies when the WTP respondents report exceeds the actual amount that people would pay (Loomis, 2011) To reduce the hypothetical bias and estimate a conservative value close to the actual cash WTP, the survey allowed respondents to indicate how certain they are of their
answers. A scale ranging from 1 to 10 was used to recode the respondent’s answers. If a respondent answered “yes” to a WTP question but indicated a certainty level of 6 or less, their answer was inputted as a “No” in the analysis. 6 out of 10 was chosen as the threshold for this study because it was felt that a certainty of 7 or above signified a relatively high level of assurance that the participant would fulfill what it is they said they would or would not contribute. Evidence suggests this practice yields a hypothetical WTP value relatively closer to the actual cash WTP and thus will reduce hypothetical bias (Champ et al. 1997; Park and MacLachlan, 2008; Blumenschein et al 2008; Morrison and Brown, 2009).

Additionally, the WTP was divided by two to adjust the hypothetical WTP to the actual cash WTP, as proposed by the National Oceanic and Atmospheric Administration (NOAA) in its draft Natural Resource Damage Assessment regulations (Austin, 1994). Such strategy was also used by Loomis (2011) where he found the hypothetical WTP exceeded the actual value by a factor of two to three, and used meta-regression analysis (MRA) to calculate calibration factors.

The area of focus for this study is Florida’s east coast sea turtle nesting sites. Residents from the cities of Cocoa Beach (a coastal community) and Oviedo (an inland community) were interviewed. CVM was used in order to empirically measure the total economic value of the ecosystem service provided by sea turtles. Failure to include the various nonuse values of the service under consideration will result in an underestimation of the service benefit; consequently, resources devoted to conservation measures may be under allocated (Whitehead, 1993). Although significant academic research has been dedicated to valuate various environmental services (Carson, 1992; Ready et al., 1995; Loomis 1996, Singh 1997) including sea turtles (Whitehead, 1993), none have sought to study the economic impacts on sea turtle habitat from
SLR in Florida. This thesis also empirically estimates the willingness to pay of Florida residents for measures to protect the sea turtle population.

2.1 Survey Design and Sampling Method

To study the economic impacts of sea level rise on sea turtle habitat the total economic value of the service provided by sea turtles of Florida coasts was estimated using the CVM. A CVM survey was conducted in two central Florida cities, namely Oviedo and Cocoa Beach. These cities were chosen because of their relative differences in proximity to sea turtle nesting sites. Cocoa Beach is a coastal city with sea turtle nesting sites. Oviedo is an inland city in central Florida.

Designing a survey is a difficult task because they are vulnerable to errors. Avoiding bias in wording survey questions is as important as avoiding a biased sample selection. The survey was designed in accordance to the procedures highlighted by the NOAA panel (Arrow, 1993). The design and pretest of the survey was conducted in the fall of 2012, with the support of the Survey Research Laboratory at the University of Central Florida (UCF). Data was collected using a questionnaire created in 2013 with the help of undergraduate student volunteers. The survey was used in order to elicit respondents to indicate their willingness to pay to protect the sea turtle habitat of Florida coasts.

2.1.1 Survey design

The design of the survey used for the contingent valuation method has been extensively researched and improved to reduce many of the issues that were faced when data was collected over the years. The survey challenge was to present a clear questionnaire which a logical respondent can read, analyze and answer according to their best judgment. Any description,
picture or question in the survey was pretested in order to assure that no item was ambiguous. The survey had a description of the harm faced by sea turtles from SLR. This scenario was discussed in detail, leading to a hypothetical market to be evaluated. This included the market that was to be changed or improved, and the institution that would be responsible for overseeing such changes.

A method of data collection also had to be decided. The alternatives were mail, phone, social media, or face-to-face interviews. Face-to-face interviews were chosen because this allowed the interviewers to remind the respondent to give the value they actually were willing to pay, and not what they thought was the “winning answer”. This was very important to reduce bias in the answers, and to eliminate responses without proper consideration (noise answers).

The Dichotomous Choice (DC) technique was adopted for the price elicitation of the study (Hanemann et al., 1991). It is considered to yield a more precise welfare estimate, that is to consider individual preferences (McLeod and Bergland, 1999), and is highly efficient when compared to open ended or the single bound technique (Hanemann et al., 1991). Additionally, its simplicity of use for data collection along with its relative easiness for respondents, compared to the bidding game, will reduced some of the concerns associated with bias in the willingness to pay results obtained by using the contingent valuation method. The DC technique has also been found to be useful when analyzing data with a small sample size. Kanninen (1995) calculated the bias of the DC and the single model estimates in a sample size of 100 observations and found that DC techniques have less bias.
2.1.2 CVM Scenario

In the survey, respondents were first given background information about the hypothetical scenario that they evaluate later. Following this was the hypothetical scenario which identified the specific “market” to be valued, the improvements that would be made to this “market” and the payment vehicle and the method in which such improvements would be financed. The background information provided to the respondents can be found in appendix 1.

Following this passage a set of questions were presented. Not all the questions were subject to being answered, due to the DC technique used for the survey. The respondents were presented with a value and if they indicated they were willing to pay this amount, they were then asked about an amount greater than the first one; however, if they indicated they were not willing to pay the first amount, the second amount would be lower. Three different versions of the survey existed, and respondents received one of the surveys randomly with bid values ranging from $10 to $75. The three versions are attached in appendix 1.

Following the DC style questions, an open-ended question was made available. The open ended option allowed respondents that answered “no” to a WTP of 10$ or “yes” to a WTP of $75 to specify what their maximum WTP is. This allowed for a greater efficiency and higher accuracy in indicating the WTP value (Yu and Abler, 2010). Additionally, a question was available to allow respondents to indicate their certainty in their answers on a scale of 1-10. Lastly, a set of 8 statements were presented, and the respondents gave their opinions by indicating a value between 1 and 5 for each statement (1= strongly disagree, 5= strongly agree). The statements are presented below:

- S1- Prior to this survey I was aware about the effects of sea level rise on sea turtles.
• S2- Sea turtle nesting habitat on Florida's coast should be protected.
• S3- The health of the sea turtle population will affect the ecosystem.
• S4- I enjoy seeing/would enjoy seeing sea turtles in their habitat.
• S5- The health of sea turtle population will have an effect on my life.
• S6- Sea turtle population will affect tourism in coastal cities.
• S7- Limiting coastal development is a good step to conserve sea turtle habitat.
• S8- Money collected for sea turtle conservation measures will be honestly and efficiently used.

2.1.3 Sample Selection

In choosing the sample the population of interest was specified, the sample frame and the method in which the survey would be conducted. It was decided to assure that the sample chosen would fit a random probability model. Due to the interests of finding the WTP of coastal city residence and that of inland city residence, face-to-face interviews with respondents from Cocoa Beach and Oviedo were chosen to be conducted. The 2010 U.S. Census Bureau data for those cities to randomly generate a list of city blocks which was used to conduct the interviews was then used. Once the blocks were designated, interviewers attempted to interview all residents of that block. A total of 72 respondents were interviewed from the coastal city of Cocoa Beach, and 71 respondents were interviewed from the inland city of Oviedo. Such a sample size was found to be adequate statistically (Loomis et al., 2000).

2.1.4 Sample Demographic Comparison

The economic characteristics of the entire sample are compared to the characteristics of Florida residents according to the 2010 Census. The results indicate that the demographics
sample mean had higher values than that of the sample mean of Florida’s demographics. Excluding individuals below the age of 18 from the study, to satisfy the Institutional Review board (IRB) requirements, could have resulted in such differences. This will have an effect on the average age, education, income (Table 2).

Table 2 Economics of sample compared to that of Florida

<table>
<thead>
<tr>
<th>Demographic Variable</th>
<th>Description</th>
<th>Sample Mean</th>
<th>Florida Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Age of respondent</td>
<td>47.2</td>
<td>40.7</td>
</tr>
<tr>
<td>Education</td>
<td>Years of schooling</td>
<td>14.6</td>
<td>13.3</td>
</tr>
<tr>
<td>Income</td>
<td>Annual household income ($1000’s)</td>
<td>56.3</td>
<td>47.8</td>
</tr>
<tr>
<td>Gender</td>
<td>Male=0; Female=1</td>
<td>0.56</td>
<td>0.51</td>
</tr>
</tbody>
</table>
CHAPTER THREE: HABITAT EQUIVALENCY ANALYSIS METHODOLOGY

To estimate the loss of sea turtle nesting habitat on the Archie Carr National Wildlife Refuge (ACNWR), due to SLR, Habitat Equivalency Analysis (HEA) is employed. Defining the injury, time scale of the injury, the baseline of the service level, and the compensation is therefore required. However, the case study is untraditional in that the injury is not a one-time injury seen in other applications of HEA (Milon and Dodge, 2001; Dunford et al., 2004; Cacela et al., 2005; Barbier, 2011). Due to the nature of SLR the injury will be an incremental one in which no obvious damage will be observed unless a holistic view is taken.

3.1 Overview of HEA Procedure

When an injury damages a natural resource the service level of that resource is compromised resulting in a decrease in the service level. The typical aggregate benefit an ecosystem provides is measured and indicated as a baseline assumed to be 100%. However, the injury will reduce the aggregate benefit to some value lower than 100% for a certain time period. The goal of HEA is to compensate for this interim loss of benefit level over a number of years by providing either a primary restoration or compensatory restoration. The fundamental requirement for using the HEA method is to define the indicator that captures the level of ecosystem service level of interest and any significant differences in the quantities and qualities of the services provided by the injured ecosystem compared to the replaced or restored ecosystem as illustrated in Figure 3 (Milon and Dodge, 2001; NOAA, 2006).
The indicator of the ecosystem service identifies the critical functions of the ecosystem (Strange et al., 2002; Dunford et al., 2004). One common indicator that has been used is area given in square meters (Milon and Dodge, 2001; English et al., 2009), however, other indicators of ecosystem service have been used such as biomass, population of organisms or water quality metric. The sea turtle nest carrying capacity (CC) of the ACNWR will be used as an appropriate indicator of baseline service levels because it represents current and potential production of hatchlings. The HEA method is summarized with the equation (1) below (Dunford et al., 2004, Zafonte and Hampton, 2007).

\[ V_I A_I (1 + r)(1 + r)^{-t_I} = V_R A_R R (1 + r)^{-t_R} \]  

- \( V_I \) is the value of the ecosystem or function impacted and \( V_R \) the value of the ecosystem or function compensated.

Figure 3 Relationship of natural recovery and active restoration to interim losses of a habitat. (Milon and Dodge, 2001)
• I is the intensity of impact and R the intensity of compensation.
• -tI is the time-scale of the impact and −tR the time-scale of the compensation.
• r is the discount rate.
• A_I is the number of acres impacted and A_R the number of acres compensated.

3.2 Requirements to Employ HEA

A variety of input parameters are required in order to employ HEA in an injury assessment. As is discussed in the NOAA’s overview on HEA (2006) a framework is designed for scaling compensatory restoration. Initially, the time scale and the extent of the injury should be estimated. This is measured from the time of injury until the service level reaches baseline. However, if the baseline level can no longer be reached it is measured to the maximum level. Additionally, the services provided by the compensatory project over the entire life of the habitat should be estimated. Both the injured area and the replacement project site will be assessed to determine their service level which will be presented as a percent of the baseline level.

The total service increase of the compensatory project should be calculated and must equal the total interim loss of services caused by the injury. However, to adjust for the value of the service levels at which are being lost and gained in different times, a discount rate parameter is used. Discount rate is simply a percentage rate over a period of time. Similar to inflation in currency value, environmental services provided now are more valued than similar services provided later. Such adjustments will be implemented by using a discount factor which will increase the value of past services, and decrease the value of future services. A discount rate of 3% is used by the NOAA (1999) and is supported by economics literature (Kopp et al. 1993). Finally the cost associated with the restoration project should be calculated. In a situation where
a responsible party will conduct the replacement project, the NOAA’s conditions suggest specifying a performance standard of that project.

3.3 Baseline Service Metric

The injury was assessed by estimating the loss of the habitat service loss. A great deal of discussion and research was involved in determining the service that will be used in order to quantify the injury, or lack thereof, to the site. Previous studies have used biomass, and population density of a certain species in a habitat as the metric to estimate the loss caused by an injury (Penn and Tomas, 2002; Bell et al., 2008). Using such service metrics as an indicator of a healthy habitat would not be ideal when considering sea turtles habitat impacted by SLR. Considering the gradual process of SLR a drop in biomass or population density is likely to not be a short term direct result of SLR. Furthermore, the quantity of sea turtle nesting is on the rise and improving in many parts of the world and especially ACNWR because of the great conservation efforts. Therefore using this type of indicator will give the false impression that population density and/or biomass is increasing as SLR increases.

3.3.1 Estimating Carrying Capacity

It was then decided to consider the carrying capacity of the habitat in ACNWR and compare it to the number of sea turtle nests. The carrying capacity in an environment is the maximum population size of a species that can be sustained in a habitat. In other words, it is an areas maximum load. Using current SLR projections the drop in carrying capacity can also be estimated. Other projections which will be estimated are the number of nests in the ACNWR. Previous studies have established the relationship between area and carrying capacity in that a
A sea turtle will use a specific area to nest. Different species will require slightly different areas for their nesting; therefore a range will be considered (Mazaris et al., 2009).

As was established by Mazaris et al., (2009) and Ussa (2013), in order to estimate the sea turtle nesting carrying capacity of the ACNWR, the nesting process of sea turtles and the area they require must be considered. It was estimated that on average a diameter of 2 m (area of 3.14m$^2$) will be required in the nest preparation and completion process (Lutz et al., 2002). Such area of disturbance is caused by the excavation of the body pit, digging the egg chamber, and covering the nest (Mazaris 2009). A decrease in area will thus cause an increase in population density leading to dangers such as nest destruction by neighboring nesting sea turtles. Figure 4 below is a rendition of how the carrying capacity is estimated. Mazaris (2009) used a GIS based model to estimate the number of nests (represented by circles 2 meters in diameter) that fits the habitat.
To estimate the CC of sea turtles of the ACNWR the nesting process was considered. Mazaris (2009) determined the area of approximately 3.14 m² in can be disturbed during the nesting process. It is therefore apparent that a reduction in area available for nesting can result in an of nest destruction by neighboring nesting sea turtles. This in turn compromises the carrying capacity or the ability for the beach to hold a certain density of nests (Mazaris 2009). The sea turtle carrying capacity of ACNWR is expected to vary depending on the ratio of sea turtle
species used. Loggerhead and Green turtles, the two most common sea turtles in Florida, have a nesting area requirement of approximately 1.76 m$^2$ and 6.158 m$^2$, respectively.

To project the loss in carrying capacity over time the projected sea level rise scenarios to the year 2100 as presented by IPCC (2007) were considered. Current and potential future rates of sea level rise has advanced considerably and therefore, more recent projections will be considered aside from the projections of IPCC’s fourth assessment report, which was based on data published in 2007, such as the National Research Council’s (NRC) 2010 report. In the past several years, research suggests that sea level rise can actually be several times greater than the estimates put forth by the IPCC (Grinsted et al., 2009; Rahmstorf, 2007; Vermeer and Rahmstorf, 2009). Current projections provided by the NRC (2010) are presented in Figure 5.

![SLR projections by NRC compared to that of IPCC](NRC, 2010)
3.3.2 Estimating Current and Future Sea Turtle Nesting Population

Green turtles have had a dramatic increase in abundance over the past 30 years (Balazs and Chaloupka, 2004). Additionally, the total number of sea turtle nesting has been increasing in the ACNWR as well as other parts of the world mainly due to the conservation efforts. Figure 6 below presents the counted number of nests over a period of 30 years (Kubis et al., 2009; Ussa 2013).

Figure 6 Sea turtle nests have increased due to conservation efforts as well as the ESA and fisheries regulations, such as TEDs.

These values will be projected to the year 2100 and compare them to the projected values of carrying capacity. As can be seen from Figure 7 and as mentioned above, carrying capacity will continue to decrease as SLR continues to inundate coastal areas. However, examining the
number of nests currently laid and projected number of nests in this area will be needed to
determine the injured service area, and the time frame in which an injury will occur.

Figure 7 Comparing ACNWR’s carrying capacity of sea turtle nests to actual number of sea
turtle nests.
CHAPTER FOUR: RESULTS

4.1 Contingent Valuation Results

In this chapter the results of the study will be presented and discussed. First the treatment of protest answers is discussed and discuss any assumptions that will affect the WTP. Next the methods used to estimate the WTP and the factors the affects respondents' WTP will be examined. Finally the estimated mean WTP and the aggregate WTP will be presented.

4.1.1 Protest Answers

Protest answers are one of the issues that may arise in a CV survey. In a situation where a respondent does not report their true WTP but rather a much larger or smaller value is considered protesting (Bateman at al. 2002). The total effect that protest answers have on the WTP value is unclear due to some respondents’ reporting a lower value and some higher values than they truly hold (Boyle 2003). Protest answers should also be differentiated from noise answers which is simply an answer given by a respondent without really understanding what is being valued.

As far as the analysis is concerned there are no established rules to deal with protest answers (Ahtiainen, 2007). There have been some researchers interested in excluding this data altogether (Bateman at al. 2002), however, Meyerhoff & Liebe (2003) claims excluding these answers is unjustified. In the survey to determine if an answer is a protest answer a comment section where respondents were free to express any thoughts was provided. For example some respondents indicated a WTP value of $0 followed by a comment that the cost should be the burden of beach front landowners. There were 6 such responses and therefore were considered insignificant (less than 5% of all surveys) and any WTP response of zero were kept in the analysis.
4.1.2 Estimating Willingness to Pay

Two types of value elicitation methods were employed in the survey. Respondents’ encountered questions categorized as Dichotomous choice which they simply answer yes or no to two questions regarding the value they are willing to pay. Next they received an open ended type question asking them what is the maximum value they are willing to pay (See Appendix 1 for survey). The tool used to estimate the WTP from the dichotomous choice data is the Turnbull estimator. The open ended values were averaged to estimate the WTP, but were further analyzed in a regression analysis to evaluate possible correlations between respondent characteristics and opinions to their WTP. In other words it was seeking to find out why they gave the value that they did.

4.1.3 Using Dichotomous Choice Data (Turnbull Estimator)

The dichotomous choice contingent valuation method (DC-CVM) offers a limited insight into the true WTP of an individual. If a responder says “Yes” to some value, this indicates that the responder is willing to pay that value or more. If the responder says “No” to the next value provided, it is evident that the hypothetical WTP is between that first and second amount (Haab and McConnell, 2002). The WTP value was calculated using the Turnbull estimator method (Turnbull, 1976). Using the upper and lower bound, the Turnbull estimator constructs an interval estimate for the WTP based on the values given by the respondents in the survey (Ahtiainen 2007). As would be expected the percentage of respondents voting “Yes” for the proposed referendum question decreased as the dollar amount increased as can be seen in Figure 8. Figure two also compares the probability a respondent will say yes to a WTP value from the two cities involved in the study. Oviedo (inland city) had a higher probability of WTP than Cocoa Beach
(coastal city). However, once the value increased residents of Cocoa Beach were more likely to pay.

Figure 8 Trend of decreasing “Yes” as WTP value increases

To estimate the WTP of Florida residents to protect sea turtle nesting habitat from diminishment due to sea level rise the Turnbull estimator was used to analyze the data obtained from our DC-CV survey. The estimator uses the "yes" or "no" responses provided by the respondents to construct WTP intervals. The respondent is first asked if they are WTP a value, if they answer yes to that value, a second question asks if they are WTP a higher value; if they say no however, they are asked if they are WTP a value lower than the first value they encountered. These choices are combined to obtain estimates for the frequency of responses of the different WTP intervals (Carson et al., 2004). The bids randomly distributed to the respondents were $10, $15, $20, $25, $30, $40, $45, $55, and $75. Table 3 below presents the nine intervals defined by the bid amounts.
To calculate the Turnbull WTP value the sum product was calculated between the lower bound values and the change in density.

\[(0\times0.14)+(10\times0.01)+(15\times0.01)+(20\times0.04)+(25\times0.06)+(30\times0.14)+(40\times0.09)+(45\times0.11)+(55\times0.13)+(75\times0.27)\]

The estimated WTP using this method was found to be $42.89. The median (50\textsuperscript{th} percentile) value of WTP fall in the $45 to $55 range, according to table 3. In this table the first two columns present the lower and upper bound values of the intervals. The third column presents of the 140 respondents that participated in the survey how many had said yes to the value presented to them. These values were used to calculate the probability of a respondent saying yes to a value. An estimated 86\% of all respondents agreed to pay a value between $0 and $15. The last column, change in density, is the difference between the probability of a respondent saying yes from one interval to the other.

<table>
<thead>
<tr>
<th>Lower Bound ($)</th>
<th>Upper bound ($)</th>
<th>Number of Yes</th>
<th>Probability of Yes</th>
<th>Change in Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10</td>
<td>121</td>
<td>0.86</td>
<td>0.14</td>
</tr>
<tr>
<td>10</td>
<td>15</td>
<td>120</td>
<td>0.86</td>
<td>0.01</td>
</tr>
<tr>
<td>15</td>
<td>20</td>
<td>118</td>
<td>0.84</td>
<td>0.01</td>
</tr>
<tr>
<td>20</td>
<td>25</td>
<td>113</td>
<td>0.81</td>
<td>0.04</td>
</tr>
<tr>
<td>25</td>
<td>30</td>
<td>104</td>
<td>0.74</td>
<td>0.06</td>
</tr>
<tr>
<td>30</td>
<td>40</td>
<td>84</td>
<td>0.60</td>
<td>0.14</td>
</tr>
<tr>
<td>40</td>
<td>45</td>
<td>72</td>
<td>0.51</td>
<td>0.09</td>
</tr>
<tr>
<td>45</td>
<td>55</td>
<td>56</td>
<td>0.40</td>
<td>0.11</td>
</tr>
<tr>
<td>55</td>
<td>75</td>
<td>38</td>
<td>0.27</td>
<td>0.13</td>
</tr>
<tr>
<td>75</td>
<td>$\infty$</td>
<td>0</td>
<td>0.00</td>
<td>0.27</td>
</tr>
</tbody>
</table>

Turnbull Estimate $42.89
4.1.4 Using Open Ended Data (Regression Analysis)

The open-ended approach to eliciting WTP is used and compared to the DC approach. It provides more freedom to respondents wanting to give a value that might not be found within the pre-determined values presented in a DC approach. Additionally, its values were used in a regression analysis in order to determine any correlations between the WTP value given by a respondent and the respondents characteristics and their opinion to a number of statements presented in the survey. The average WTP was found to be $57.10 using this method (Table 4).

Table 4 Estimated WTP from open ended data

<table>
<thead>
<tr>
<th>Descriptive Statistics</th>
<th>Open Ended WTP ($)</th>
<th>First Value Presented ($)</th>
<th>Second Value Presented ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>57.10</td>
<td>32.07</td>
<td>50.64</td>
</tr>
<tr>
<td>Median</td>
<td>50.00</td>
<td>30.00</td>
<td>55.00</td>
</tr>
<tr>
<td>Std. deviation</td>
<td>54.39</td>
<td>7.51</td>
<td>20.34</td>
</tr>
<tr>
<td>min</td>
<td>0.00</td>
<td>20.00</td>
<td>10.00</td>
</tr>
<tr>
<td>max</td>
<td>500.00</td>
<td>40.00</td>
<td>75.00</td>
</tr>
</tbody>
</table>

The open ended values were also used in a regression analysis to compute any significant correlations between the values given to the WTP question and the remaining questions including the respondents’ demographic questions, and statements S1-S8. Values marked with an asterisks (*) have a statistically significant correlation (Table 5).

Table 5 Correlations using open ended values

<table>
<thead>
<tr>
<th></th>
<th>Coefficients</th>
<th>Standard Error</th>
<th>t Stat</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-26.608</td>
<td>51.667</td>
<td>-0.515</td>
<td>0.607</td>
</tr>
<tr>
<td>First Value</td>
<td>-0.147</td>
<td>0.625</td>
<td>-0.235</td>
<td>0.814</td>
</tr>
<tr>
<td>Second Value</td>
<td>1.004</td>
<td>0.257</td>
<td>3.907</td>
<td>0.000***</td>
</tr>
<tr>
<td>Age of Respondent</td>
<td>-6.912</td>
<td>3.730</td>
<td>-1.853</td>
<td>0.066*</td>
</tr>
<tr>
<td>Gender:(0,M;1,F)</td>
<td>1.478</td>
<td>8.310</td>
<td>0.178</td>
<td>0.859</td>
</tr>
<tr>
<td>Education level</td>
<td>-3.407</td>
<td>5.592</td>
<td>-0.609</td>
<td>0.544</td>
</tr>
</tbody>
</table>
### Adjusting Hypothetical WTP Value

In the above two subsections (4.2.1 and 4.2.2) the WTP was found, using two different techniques, to range between $42 and $57. Before estimating the aggregate benefit using these values they will be adjusted for hypothetical bias. Hypothetical bias tends to arise in stated preference valuation approaches such as CVM. It is widely believed that individuals may overstate their economic valuation of a good resulting in a hypothetical WTP value greater than that of the actual WTP value. This hypothetical bias is defined as the difference between an individual’s revealed values and stated values. Studies dedicated to reduce the uncertainties surrounding the causes of hypothetical bias and ways to accurately calibrate survey responses for it has failed to provide a consensus (Murphy et al., 2004).

The National Oceanic and Atmospheric Administration (NOAA) in its draft Natural Resource Damage Assessment regulations (Austin, 1994) proposed the hypothetical WTP value to be reduced by a factor of two in order to adjust for hypothetical bias. Loomis (2011) also found the hypothetical WTP exceeded the actual value by a factor of two. Murphy et al., (2004) conducted a meta-analysis for hypothetical bias and estimated the median ratio of hypothetical to

---

<table>
<thead>
<tr>
<th></th>
<th>Coefficients</th>
<th>Standard Error</th>
<th>t Stat</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household Income</td>
<td>0.175</td>
<td>3.534</td>
<td>0.049</td>
<td>0.961</td>
</tr>
<tr>
<td># yrs in FL</td>
<td>-6.397</td>
<td>4.678</td>
<td>-1.367</td>
<td>0.174</td>
</tr>
<tr>
<td>S1</td>
<td>2.960</td>
<td>3.599</td>
<td>0.822</td>
<td>0.412</td>
</tr>
<tr>
<td>S2</td>
<td>15.161</td>
<td>10.621</td>
<td>1.427</td>
<td>0.156</td>
</tr>
<tr>
<td>S3</td>
<td>5.879</td>
<td>8.048</td>
<td>0.730</td>
<td>0.466</td>
</tr>
<tr>
<td>S4</td>
<td>-5.954</td>
<td>9.178</td>
<td>-0.649</td>
<td>0.518</td>
</tr>
<tr>
<td>S5</td>
<td>4.058</td>
<td>4.865</td>
<td>0.834</td>
<td>0.406</td>
</tr>
<tr>
<td>S6</td>
<td>7.123</td>
<td>6.183</td>
<td>1.152</td>
<td>0.252</td>
</tr>
<tr>
<td>S7</td>
<td>7.650</td>
<td>7.341</td>
<td>1.042</td>
<td>0.299</td>
</tr>
<tr>
<td>S8</td>
<td>-17.155</td>
<td>5.142</td>
<td>-3.336</td>
<td>0.001**</td>
</tr>
</tbody>
</table>

Codes of significance: * = 0.01 ** = 0.001 *** = 0
actual value to be approximately 1.35. In the analysis the recommendation of the NOAA was taken and divided the hypothetical WTP value by two to obtain the actual cash or revealed WTP. This decision will ensure a conservative value is obtained. The overall WTP per household over the entire sample was found to be between $21 and $29 when adjusted for the hypothetical bias (Table 6). This value was indicated by the respondents as the amount they are willing to pay to contribute to the Ecosystem Management and Restoration Trust Fund (See Appendix 1) in the form of a state-wide tax increase.

Individuals with a greater interest in an environmental amenity are more likely to participate in the survey and indicate a higher value than those who are less interested (Mitchell and Carson, 1989). The WTP value of non-respondent households is more likely to be lower than that of respondent households, or even to be unwilling to pay anything. However, the uncertainties attributed to such estimation are largely due to little known data on non-respondents (Whitehead et al. 1993), and therefore few have sought to address this problem (Edwards and Anderson, 1987; Loomis, 1987). Due to the lack of reliable information regarding adjusting the values to take non-respondent households into consideration, no difference in the values was assumed and therefore only analyzes the given data and do not adjust the values any further.

<table>
<thead>
<tr>
<th>Table 6 Aggregate benefits (Values are in 2012 dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Households</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Florida</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
4.1.6 Influence of Opinions on WTP

To estimate the economic influence of the respondents’ opinions, regarding some issues, on their willingness to pay the estimated WTP of respondents who selected “agree/strongly agree” for the S1-S8 statements versus the WTP of those who selected “disagree/strongly disagree” (Figure 9) was compared.

<table>
<thead>
<tr>
<th>S1</th>
<th>I am aware about the effects of sea level rise on sea turtles.</th>
</tr>
</thead>
<tbody>
<tr>
<td>S2</td>
<td>Sea turtle nesting habitat on Florida's coast should be protected.</td>
</tr>
<tr>
<td>S3</td>
<td>The health of the sea turtle population will affect the ecosystem.</td>
</tr>
<tr>
<td>S4</td>
<td>I enjoy seeing/would enjoy seeing a sea turtle.</td>
</tr>
<tr>
<td>S5</td>
<td>The health of sea turtle population will indirectly affect my life.</td>
</tr>
<tr>
<td>S6</td>
<td>Sea turtle population will affect tourism in coastal cities</td>
</tr>
<tr>
<td>S7</td>
<td>Limiting coastal development is a good step to conserve sea turtle habitat.</td>
</tr>
<tr>
<td>S8</td>
<td>Money collected for sea turtle conservation measures will be honestly and efficiently used</td>
</tr>
</tbody>
</table>

Figure 9 Respondents were presented with this to indicate their opinions
In table 7 below, four columns are presented. The first is the estimated WTP of respondents that agreed or strongly agreed to a specific statement. Second column is the percentage of respondents indicating they agree/strongly agree to that statement. Third column is the WTP of the respondents that disagreed or strongly disagreed to the statements. Finally, the fourth column presents the percentage difference between the WTP of those who agree and those who disagree.

The overwhelming majority of respondents (94%) agreed that action must be taken in order to protect sea turtle nesting habitats of Florida coasts (S2) as can be seen in Table 7. These respondents were willing to pay on average $21.76 per year more than the 6% of respondents that did not think sea turtle habitat should be protected. Those who agreed or strongly agreed with the statement “limiting coastal development is a good step to conserve sea turtle habitat” (S7) were willing to pay on average $27.07 per year for five years more than those that selected disagreed, an estimated 722% increase. This was found to be the greatest difference in the WTP between individuals who agreed or disagreed to a statement. The estimated difference between the WTP of respondents that agreed to a statement versus those who disagreed to that statement ranged from a little over $3 to over $27. When concerned with establishing methods to raise public interest in conservation and willingness to contribute for such projects, an assessment of these scenarios can provide a framework for the policy makers to follow. Educating the public on the interconnectedness of sea turtle population and the ecosystem is likely to increase the WTP. The WTP to protect sea turtle nesting habitat was approximately 331% greater when individuals indicated they agreed with statement S3.
Our results indicate a very small difference in the hypothetical WTP value of coastal city vs. inland city. However, when comparing the hypothetical WTP values of respondents that agreed or disagreed to the statement that the health of the sea turtle population will have an effect on their lives (S5), a typical difference of $23.13 per year was found. What must be noted here is that this yielded the highest hypothetical WTP value ($35.20), which is an indication that individuals that perceive an improvement to their lives as the state of the sea turtle population improves have a higher utility value attached to sea turtles, which follows the theory of welfare economics. Additionally, it was found the respondents that were familiar with eco-tourism were willing to pay $25.67 more than those who were not.

Respondents agreeing to the statement “The health of the sea turtle population will affect the ecosystem” (S3) were much more likely to pay some amount. Respondents that enjoy seeing sea turtles were willing to pay, on average, $21.76 more than respondents who were indifferent about sea turtles or did not enjoy seeing them. This value is mostly the non-use value as shown in Figure 10.

Table 7 Hypothetical WTP ($) by category of opinions

<table>
<thead>
<tr>
<th></th>
<th>Estimated WTP value if respondents “Agree/Strongly Agree” ($A)</th>
<th>Percentage Agreed</th>
<th>Estimated WTP value if respondents “Disagree/Strongly Disagree” ($D)</th>
<th>Percentage Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>31.56</td>
<td>62%</td>
<td>28.41</td>
<td>11%</td>
</tr>
<tr>
<td>S2</td>
<td>29.26</td>
<td>94%</td>
<td>7.50</td>
<td>290%</td>
</tr>
<tr>
<td>S3</td>
<td>32.34</td>
<td>81%</td>
<td>7.50</td>
<td>331%</td>
</tr>
<tr>
<td>S4</td>
<td>29.26</td>
<td>91%</td>
<td>7.50</td>
<td>290%</td>
</tr>
<tr>
<td>S5</td>
<td>35.20</td>
<td>52%</td>
<td>12.07</td>
<td>192%</td>
</tr>
<tr>
<td>S6</td>
<td>33.17</td>
<td>67%</td>
<td>7.50</td>
<td>342%</td>
</tr>
<tr>
<td>S7</td>
<td>30.82</td>
<td>88%</td>
<td>3.75</td>
<td>722%</td>
</tr>
<tr>
<td>S8</td>
<td>29.73</td>
<td>67%</td>
<td>14.38</td>
<td>107%</td>
</tr>
</tbody>
</table>
4.1.7 Correlation Assessment Using Binomial Logit Model

Once the WTP for the service was calculated, the correlations between the respondent’s demographics or opinions on the scenario statements to their WTP were assessed. Binomial logit models of the determinants of WTP were estimated. The respondent’s demographics and opinions to the scenario statements were analyzed as explanatory variables to the dependent variable (probability of saying “yes”). Some clear indications of relations were found. In Table 8 how these affect the probability of an individual to pay some amount was estimated.
Table 8 Correlation of explanatory variables (listed above) and the dependent variable of WTP

| Variable   | Description                                      | Coefficients | Standard Error | z value | Pr(|z|)  |
|------------|--------------------------------------------------|--------------|----------------|---------|---------|
| **Demographics** |                                                |              |                |         |         |
| Age        | Age of respondent                                | -0.69        | 0.28           | -2.50   | 0.0133 *|
| Education  | Years of schooling                               | 0.11         | 0.32           | 0.33    | 0.742   |
| Income     | Annual household income ($1000's)                | -0.08        | 0.20           | -0.42   | 0.67401 |
| Gender     | Female/Male Ratio                                | 0.54         | 0.49           | 1.10    | 0.269   |
| In Florida | Number of years in Florida                       | -0.03        | 0.28           | -0.12   | 0.9065  |
| **Scenario Statements** |                                              |              |                |         |         |
| S1         | Aware about the effects of SLR on sea turtle habitat | -0.16       | 0.20           | -0.83   | 0.40827 |
| S2         | Sea turtle Habitat should be protected           | 0.59         | 0.29           | 2.00    | 0.0456 *|
| S3         | The health of the sea turtle population will affect the ecosystem | 1.22       | 0.30           | 4.10    | 4.88e-05 *** |
| S4         | I enjoy seeing/would enjoy seeing sea turtles   | 0.69         | 0.29           | 2.40    | 0.0163 *|
| S5         | Health of sea turtle population will have an effect on my life | 0.95  | 0.25           | 3.70    | 0.000193 *** |
| S6         | Sea turtle have an effect on tourism of coastal cities | 0.95 | 0.26           | 3.70    | 0.000211 *** |
| S7         | Limiting coastal development will help conserve sea turtle habitat | 1.14  | 0.28           | 4.10    | 4.03e-05 *** |
| S8         | Funds collected for conservation measures will be efficiently used | 1.13  | 0.26           | 4.30    | 2.02e-05 *** |

Note:
a For a unit increase the correlation is greater. High negative value indicates a greater negative correlation.

Codes of significance: * = 0.01 ** = 0.001 *** = 0

Estimated impact on WTP indicates the impact the explanatory variables have on the dependent variable (i.e, probability to pay some amount). The most conservative WTP value was used in this analysis ($21). Correlations which had a statistically significant impact are indicated with an asterisk (*). Some of these statistically significant correlations include the age of respondents, which was found to negatively correlate with the probability of an individual to pay some amount. That is, as age increases the probability that an individual will pay the $21 cost will decrease. This could be due to multiple factors including the recent emphasis on environmental consciousness among the youth. Also, it can be argued that older respondents were more responsible in the values they gave, to assure it fits in their budget. Other negatively correlating impacts include variable S1. This scenario statement asked if the respondents were aware about the effects of SLR on sea turtle habitat. Counterintuitively, it was found that as the level of this awareness increased, the probability to pay some amount decreased.

Other statistically significant correlations were also found, notably variables S3 and S7. In S3 and S7, the respondents were to indicate their level of agreement to the respective statement; “The health of the sea turtle population will have an effect on the ecosystem”, “Limiting coastal development is a good step to conserve sea turtle population”. The WTP probability increased as the level of agreement towards S3 and S7 increased (Table 7).

SLR poses a great risk to many species that depend on coastal areas to nest and forage for food (Worm et al., 2006). Measures to protect these areas would improve their quality and will
help maintain the habitat of sea turtles. In this study, finding the WTP of Florida residents to protect sea turtle nesting habitat was sought. The CVM was employed, and a total of 143 responses were used to calculate the WTP, and to estimate the economic contributions to this value.

Using the Turnbull estimation method the hypothetical WTP was found to be between $21 and $29 per year, for a maximum of five years. These values were adjusted for hypothetical bias, and assumptions about the behavior of non-respondent household were made. Additionally, protest zero answers were negated due to their insignificance. The hypothetical WTP was multiplied by the number of households in Florida to estimate the aggregate benefit. Florida residents are willing to pay approximately 750 million to 1.035 billion dollars over a five year period to protect sea turtle nesting habitats of Florida coasts. In the development and conducting of the survey as well as the analysis of the data decisions were made to assure a conservative figure. The extent of effort that went into keeping a conservative value leads us to believe the estimated value is not inflated, but close to the actual value respondents would be willing to pay.

From the binomial logit model age, of the demographic variables, to have the greatest impact on WTP. It was found to negatively correlate with WTP, so as age increased the probability to pay some amount decreased. Statements S3, S7 and S8 had the greatest impact on WTP, as can be seen in Figure 11. In this figure a unit increase indicates a correlation between the variable and the WTP. A negative value indicates a negative correlation.
The carrying capacity estimates are based on the area of ACNWR which is used for nesting most commonly by the sea turtles. Weishampel et al., (2003) found that approximately 50% of all sea turtle emergences would cause disturbance without nesting. We further analyzed the values of false crawls to estimate the non-nesting emergences of each species. Additionally, we considered the areas in which the bulk of the nests are found which are 12-15 meters away from the mean tide line and 3-5 meters away from the dunes. To take other uncertainties into consideration we evaluate the carrying capacity over a range of 10-15 meters over the 20.5 miles stretch. Taking into consideration the difference in nesting area requirement and the difference in species presence the carrying capacity for all species was found to be approximately 70-96 thousand (Table 9). It was estimated that that Green turtles, and the Leatherback have the same area requirement for nesting (Mazaris et al., 2009).
Table 9 Estimating the carrying capacity of sea turtles on ACNWR

<table>
<thead>
<tr>
<th>Species</th>
<th>Percentage</th>
<th>Nesting area required (m²)</th>
<th>Available nesting area (Sea turtle) (thousand m²)</th>
<th>Non-Nesting Disturbances</th>
<th>Carrying Capacity (thousands)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green Turtle, Leatherback</td>
<td>0.18</td>
<td>6.158</td>
<td>53-73</td>
<td>0.468</td>
<td>4-5.5</td>
</tr>
<tr>
<td>Loggerhead Turtle</td>
<td>0.82</td>
<td>1.767</td>
<td>294-406</td>
<td>0.528</td>
<td>88-121</td>
</tr>
<tr>
<td>All Species</td>
<td>1</td>
<td>2.55738</td>
<td>358-495</td>
<td>0.498</td>
<td>70-96</td>
</tr>
</tbody>
</table>

The IPCC scenarios are divided into four families of scenarios representing different world futures. Additionally, the National Research Council Scenario is added. Each scenario has different quantitative and qualitative inputs that drive the outcomes and two distinct dimensions such as a focus on economic concerns versus their environmental counterpart, and global versus regional development patterns (IPCC 2007). Five scenarios are presented in Table 10.

Table 10 Projected sea level rise and global average temperature change at the end of the 21st century
(IPCC, 2007; NRC 2010)

<table>
<thead>
<tr>
<th>Sea Level Scenarios</th>
<th>Sea Level Rise (meters)</th>
<th>ACNWR Area Loss (percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1 scenario</td>
<td>0.18-0.38</td>
<td>22.68-23.05</td>
</tr>
<tr>
<td>A1T scenario</td>
<td>0.20-0.45</td>
<td>22.71-23.17</td>
</tr>
<tr>
<td>A1B scenario</td>
<td>0.21-0.48</td>
<td>22.73-23.22</td>
</tr>
<tr>
<td>A1F1 scenario</td>
<td>0.26-0.59</td>
<td>22.81-23.41</td>
</tr>
<tr>
<td>NRC</td>
<td>1.4</td>
<td>24.73</td>
</tr>
</tbody>
</table>

The carrying capacity will be assessed after considering B1 scenario and the predictions of the NRC as it pertains to SLR. These are used such that an optimistic carrying capacity decrease is used (Table 11) and pessimistic carrying capacity decrease (Table 12) scenario.
Table 11 Carrying capacity of all sea turtle species on ACNWR after B1 scenario area loss

<table>
<thead>
<tr>
<th>Species</th>
<th>Percentage</th>
<th>Nesting area required (m²)</th>
<th>Available nesting area (Sea turtle) (thousand m²)</th>
<th>Non-Nesting Disturbances</th>
<th>Available nesting area (m²) after Loss (B1 Scenario, Optimistic) (thousands)</th>
<th>Carrying Capacity (thousands)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green Turtle, Leatherback</td>
<td>0.18</td>
<td>6.158</td>
<td>53-73</td>
<td>0.468</td>
<td>41-56</td>
<td>3.1-4.3</td>
</tr>
<tr>
<td>Loggerhead Turtle</td>
<td>0.82</td>
<td>1.767</td>
<td>294-406</td>
<td>0.528</td>
<td>227-314</td>
<td>68-94</td>
</tr>
<tr>
<td>All Species</td>
<td>1</td>
<td>2.55738</td>
<td>358-495</td>
<td>0.498</td>
<td>268-370</td>
<td>52-72</td>
</tr>
</tbody>
</table>

Table 12 Carrying capacity of all sea turtle species on ACNWR after NRC predictions area loss

<table>
<thead>
<tr>
<th>Species</th>
<th>Percentage</th>
<th>Nesting area required (m²)</th>
<th>Available nesting area (Sea turtle) (thousand m²)</th>
<th>Non-Nesting Disturbances</th>
<th>After Loss (NRC Scenario, Pessimistic) (thousands)</th>
<th>Carrying Capacity (thousands)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green Turtle, Leatherback</td>
<td>0.18</td>
<td>6.158</td>
<td>53-73</td>
<td>0.468</td>
<td>40-55</td>
<td>3-4.2</td>
</tr>
<tr>
<td>Loggerhead Turtle</td>
<td>0.82</td>
<td>1.767</td>
<td>294-406</td>
<td>0.528</td>
<td>221-305</td>
<td>66-91</td>
</tr>
<tr>
<td>All Species</td>
<td>1</td>
<td>2.55738</td>
<td>358-495</td>
<td>0.498</td>
<td>261-360</td>
<td>51-70</td>
</tr>
</tbody>
</table>

Using the values obtained from the carrying capacity loss due to SLR, a graph was created to compare current and projected carrying capacity to current and projected sea turtle nests (Figure 12).
Figure 12 Comparison of carrying capacity of ACNWR and the actual number of nests there
CHAPTER FIVE: CONCLUSIONS AND FUTURE RESEARCH

Sea turtles on Florida’s coast have suffered severe population decrease as coastal anthropogenic activities increased. Notable impacts on the sea turtle population include the excessive harvesting by commercial fisheries in the late 1800s (True 1887, Wilcox 1897). Due to the ongoing efforts to raise awareness about the dangers faced by sea turtles and being the subject of conservation and protection, the number of nests has steadily increased at the Archie Carr National Wildlife Refuge since being protected under the U.S. Endangered Species Act in 1978. Additionally in 1992 further protection was provided through a ban on gillnets in Florida (Kubis et al., 2009).

Sea turtles are a part of various ecological roles; including: nutrient cycling, which is crucial for the coastal ecosystem; and maintenance of sea grass beds, coral reefs and beach dunes (Moran and Bjorndal, 2005). Losing such services potentially affects the dynamics of near shore ecosystems (Heithaus, 2005). Aside from the obvious ecological services sea turtles provide, due to their charismatic nature they contribute in generating tourism activities, which yields great economic benefits (Clem and Clevo, 2001). Sea turtles and their habitat have social, ecological, and economical values that will not be accurately measured using traditional market valuation techniques. Such values include use and non-use values (Carson and Bergstrom, 2003) such as altruistic, bequest, existence and option value (Brown, 1997).

Increased rate of sea level rise is encroaching on coastal areas and will adversely affect the habitats of coastal species. Inundation of such areas can result in a great ecological and economical loss provided by coastal habitats. Estimating the interim loss of natural resource services due to some injury will better equip us in determining the amount of compensatory restoration required
for mitigating the losses. In the study estimating the economic value placed on sea turtles of Florida coasts by Florida residents is sought. Additionally, what ecosystem service damage would be caused by the continual increase of the mean sea level is assessed. In this study Contingent Valuation Method (CVM) and Habitat Equivalency Analysis (HEA) were used in order to valuate the ecosystem service provided by sea turtles. The use of CVM allows for an estimation of the value placed by respondents on a specific service. HEA, however, does not consider the value placed by an individual but rather the cost of a compensatory restoration in the event that the service is injured or damaged. Considering both methods is advantageous due to the difficulty and uncertainty faced by ecosystem service valuation techniques.

5.1 Discussion for CVM

In this thesis a gap was filled in the ecosystem valuation literature by assessing the economic impact of sea level rise on sea turtle nesting habitat of Florida’s coast. The contingent valuation method was applied to estimate the willingness to pay (WTP) of Florida residents to protect this habitat. Residents from two Florida cities, namely; Cocoa Beach and Oviedo, participated in a survey interview and were asked to indicate their WTP to protect sea turtle nesting habitat. The survey, designed with the assistance of UCF’s Survey Research Laboratory, introduced the respondents to the phenomena of SLR and its effects on coastal areas. Additionally, the survey discussed the mitigation strategies considered to protect sea turtle nesting, the agency which will administer such mitigation projects, and the vehicle of fund collection. The survey also allowed respondents to indicate their views on eight statements by choosing whether or not they agree with the statement. This was then used in a binomial logit model to investigate correlations between an individual’s views on the statements and there WTP. This model was also used to draw correlations between demographics such as age, gender, education, etc. to their WTP.
Notably, a negative correlation between age and WTP was found and women were more likely to pay than men.

From the indicated WTP value the Turnbull method was used in order to estimate the hypothetical WTP of a coastal city (Cocoa Beach) residents and inland city (Oviedo) residents. The difference between the WTP of these two cities was negligible. Greater differences in WTP, however, were found between those who agreed versus those who disagreed to the eight statements. Upon indicating their WTP value, respondents answered “agree” or “disagree” to a list of statements. The estimated WTP value was significantly higher when respondents agreed to statements such as “The health of the sea turtle population will affect the ecosystem”, “Sea turtle population will affect tourism in coastal cities” “Limiting coastal development is a good step to conserve sea turtle habitat”. Additionally, it was found that prior knowledge of the effects of sea level rise on sea turtle nesting habitat did not significantly increase an individual’s WTP.

Our findings estimate Florida residents are willing to pay between, 750 million to 1.035 billion dollars over a five year period to help protect sea turtle nesting habitat from the impact of sea level rise. Correlation models suggest the top indicators of an individual’s WTP include their trust in the proposed mitigation method, their understanding of eco-tourism, and the ecosystem. Educational campaigns aiming to increase public interest in conservation of habitats, such as that of sea turtles, need to stress two critical points: (1) the proposed method of protection, the mandatory setback, is an effective, workable, cost-efficient conservation method (2) the importance of sea turtles to the overall ecosystem, and (3) the importance of sea turtles to coastal city tourism.
5.2 Discussion for HEA

To estimate the appropriate amount of compensatory restoration for interim losses, the concepts of habitat equivalency analysis (HEA) are used. The sea turtle nesting carrying capacity is estimated for the study area of Archie Carr National Wildlife Refuge (ACNWR). This is used as a metric of the baseline service and will be analyzed with respect to the injury that is caused to it due to sea level rise (SLR). Seeking to find whether the carrying capacity will be reduced to the point where sea turtle nesting will be significantly constrained, SLR rise projections published by IPCC (2007) and NRC (2010) were used. Also, existing data to project the sea turtle nesting increase on the refuge was used. It was found that the sea turtle nesting carrying capacity of ACNWR under the grimmest SLR scenario is significantly greater than optimistic sea turtle nesting projections leading us to conclude SLR will not hinder sea turtle nesting on ACNWR within the next century.

The conservation efforts have proved to be fruitful with some areas such as the Indian River Lagoon estimating a population recovery of more than 600% from 1982 to 2002 (Ehrhart et al. 2007). Other areas including some nesting sites in Hawaii has shown a dramatic green turtle nester population increased since protection began in 1978 under the US Endangered Species Act. Similar trends in green turtle nest productions have been seen in the Archie Carr National Wildlife Refuge (Weishampel et al., 2006). Estimated annual population growth rates for the three Pacific rookeries and the two Atlantic rookeries increased linearly over the past 25 years or more, additionally in that same time period the Archie Carr National Wildlife Refuge sea turtle rookery had an annual growth rate of 13.9% (Chaloupka et al., 2008).
A range of the carrying capacity of Archie Carr National Wildlife Refuge (ACNWR) was first estimated by estimating the total nesting area available and comparing that value to the estimated area needed by a sea turtle to lay a nest. Such range was used to consider the uncertainties involved in making such estimations. In the analysis three different sea turtle species were taken into consideration due to the difference in nesting area needed, and the difference in presence of these species on ACNWR. The future carrying capacity was then estimated by taking SLR projections from IPCC (2007) and NRC (2010). The most optimistic SLR projections was 0.18 meters by 2100 (B1 Scenario) and the most pessimistic was a 1.4 meter increase in sea level (NRC projections). Both of these were used in the analysis to provide for an upper and lower bound carrying capacity. A comparison between the most pessimistic situation regarding carrying capacity loss and the most optimistic situation of sea turtle nesting increase leads us to conclude lost area due to sea level rise to hinder the progress of sea turtle conservation.

The dangers of sea level rise can undermine all of these efforts if the beach’s carrying capacity declines below projected sea turtle nest values. Balazs and Chaloupka (2004) estimated the number of sea turtle nests in certain rookeries could be approaching the foraging habitat carrying capacity. A decrease in carrying capacity will set a limit on the sea turtle nesting population and the high population density will result in various density related injuries (Jackson et al., 2001). Potential damages to sea turtle habitat as carrying capacity continues to decrease causing injury to sea turtle population are considered. An analysis comparing the projected refuge’s carrying capacity and the number of sea turtle nests leads me to conclude a potential
loss of service to be experienced as early as 2060’s. Considering the high costs in acquiring land to preserve such habitats this finding is alarming, and should be addressed.

5.3 Improvements for CVM

The contingent valuation method has greatly improved over the years with more researchers applying this method to a broader range of valuation needs. However, it is still relatively controversial, and some question whether it accurately measures the willingness to pay for environmental quality of the public. This concern mainly stems from the understanding that people are unfamiliar with placing dollar values on an environmental or public goods and services. Additionally, for a greater efficiency in bid collection the dichotomous choice method was employed, this however can introduce a source of bias as it provides some kind of expectation for the respondent (Karl, 1985).

Statements S7 and S8 of the survey show a strong correlation between individuals that agreed with them and the probability to pay. Such correlation indicates that the payment method and the method of the improvement affected the responders answer. This expresses that answers to the willingness to pay question may be biased because the respondent is expressing their feelings about the scenario or the mitigation method rather than the value for the good. Some of these responses were protest answers; this was obvious in a few surveys when respondents indicated they would not be willing to pay anything as soon as they learned the payment vehicle is an increased tax. Further research is warranted in designing contingent valuation surveys to avoid responses dependent on the payment vehicle and the method of improvement. Other limitations included reaching a larger sample size in a higher
number of areas. Because interviews were face to face, the ability to send out mass requests for survey completion was hindered.

5.4 Improvements for HEA

The objective of this thesis was to assess what loss, if any, will be caused to sea turtle nesting habitat due to sea level rise on the Archie Carr National Wildlife Refuge. There are significant constraints and limitations that were faced in attempting to assess this. In comparing the carrying capacity to the number of nests, data obtained over a 30 year period to project the number of sea turtle nests on ACNWR to 2100 was used. The many uncertainties involved with prediction of climate change, predator presence, food supply, conservation efforts, reproduction of sea turtle, etc., could result in a significant difference to the projected sea turtle nest values. Additionally, it is known that sea turtle nesting rate is a factor of temperature, however, change in temperature was not considered in projecting the number of nests. With respect to carrying capacity, some assumptions had to be made about the nesting behavior of sea turtles. It was assumed that a sea turtle had no preference in selecting a nesting location along the beach. That is each square meter of beach area on the refuge was equally likely to be chosen as a nesting site, and is capable to serve as a nesting site.

5.5 Main Findings

The task of valuating an ecosystem service proved to be a sensitive and controversial one. We opted to use multiple methods which were both applicable and provided valuable insight. Using the Contingent Valuation Method, a stated preference approach, the WTP of Florida residents to protect the services provided by sea turtle was assessed. Additionally, an assessment was conducted on the effects of the respondent’s demographics and views regarding various
aspects of the mitigation process proposed on the respondents WTP. These of which are highlighted in the results, such as the estimated WTP of 750 million to 1.035 billion dollars over a five year period to help protect sea turtle nesting habitat from the impact of sea level rise. Using the Habitat Equivalency Analysis, the injury time on sea turtle habitat due to sea level rise was assessed. It is estimated that the diminishing level of ACNWR’s sea turtle carrying capacity will hinder the the increasing number of sea turtle nesting by 2060’s. Such injury could be found to be extremely costly to repair, if not irreversible altogether.
APPENDIX A: SURVEY VERSIONS
The following attachments are the three different survey versions which were provided to the respondents.

Survey Version 1

UCF RESEARCH Survey

With the funding received by the U.S Fish and Wildlife Service, the University of Central Florida research group, HEESA, is studying the socioeconomic impacts of sea level rise on sea turtles in the state of Florida. Your participation in this research survey is requested.

This survey takes about ten minutes to complete will be used in part to evaluate the ecosystem services provided by sea turtles. This survey will provide valuable data for the research. Participation in this survey is voluntary, and respondents will not receive any direct benefit. The interviewers are students whom have volunteered to conduct these interviews. You must be at least 18 years of age to participate in the survey.

If you have any questions about the study, please content James Wright, the principal investigator, at 407-823-5083. Thank you.
Climate change has led to a significant increase to the mean sea level in the past few decades. One of the impacts of sea level rise includes loss of coastal areas. Reduction in coastal areas translates to a decrease in the nesting habitat of certain species. This could be detrimental to the survivability of coastal nesting species such as sea turtles. (See Figures 1a and 1b below)

Sea turtles have existed and benefited the earth for over 100 million years. They maintain the habitats of other species such as coral reefs, and sea grass beds; additionally they contribute to the process of nutrients cycling, and balancing the food web. In the past few decades their numbers have drastically declined and are now considered endangered. (See Figure 2a and 2b)

The level at which sea level rise will impact the sea turtle habitat is largely dependent on the land-use behind the beach and whether the inland retreat of habitat is restricted. Under natural conditions beaches will shift landward in response to a rise in the sea level. But in areas which have high human modification and development, sea level rise can eradicate coastal habitats. (See Figures 3a and 3b)

Studies have shown that one promising strategy to protect sea turtle habitat is by identifying and legally protecting it. This can be done through implementation of a Coastal Construction Control Line or CCCL. A Coastal Construction Control Line will prohibit construction within a certain distance of the sea. This allows for a buffer zone between the mean sea level increase and the development which will protect sea turtle habitat of Florida coasts.

Suppose Florida policymakers were considering a proposal to extend the length of the CCCL by 100 feet in order to secure sea turtle nesting habitat. Such changes could lead the government to impose a state wide tax increase to contribute to the Ecosystem Management and Restoration Trust Fund. Suppose this proposal was put to a referendum vote.

1) Would you vote in favor of this proposal if it will cost each Florida household $40 per year for five (5) years?
   a. Yes → (skip question 3)
   b. No → (skip question 2)
   c. Don’t know, it depends → (skip question 2)

2) Would you vote in favor of this proposal if it costs each Florida household $75 per year for five (5) years?
   a. Yes
   b. No
   c. Don’t know, it depends
3) Would you vote in favor of this proposal if it costs each Florida household $25 per year for five (5) years?
   a. Yes
   b. No
   c. Don’t know, it depends

4) What is the maximum amount you are willing to pay to secure sea turtle nesting habitat?
   $_____/year for five (5) years.
   You can use the space below to make any comments:

   

5) If you were voting on this referendum today, how sure are you that you would vote the same way you answered above?

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<tr>
<th>Absolutely Sure</th>
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<th>4</th>
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</tr>
</thead>
</table>

Question 6:

Note: This question is independent of the previous questions.

Compare alternative A, B, and C in the table below and select the option you most prefer.

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<td>Rare</td>
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<td>Once per 2 years</td>
</tr>
<tr>
<td>Green Turtle ESA Status**</td>
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<td>Threatened</td>
<td>Recovered</td>
</tr>
<tr>
<td>Cost per year Added cost to your household each year for 5 years</td>
<td>$0</td>
<td>$35</td>
<td>$70</td>
</tr>
</tbody>
</table>

*Beach Nourishment: Consists of the placement of large quantities of good quality sediment on the beach to advance the shoreline seaward

**Expected result in 50 years for each option /

Endangered < Threatened < Recovered

Question 7:

Please read the statements below and check the box which best fits your views.
Prior to this survey I was aware about the effects of sea level rise on sea turtles.

Sea turtle nesting habitat on Florida's coast should be protected.

The health of the sea turtle population will affect the ecosystem.

I enjoy seeing/would enjoy seeing sea turtles in their habitat.

The health of sea turtle population will have an effect on my life.

Sea turtle population will affect tourism in coastal cities

Limiting coastal development is a good step to conserve sea turtle habitat.

Money collected for sea turtle conservation measures will be honestly and efficiently used.
Respondent Characteristics

1) Age of respondent
   a. 18-30
   b. 30-45
   c. 45-60
   d. 60+

2) Gender
   a. Male
   b. Female

3) Educational Background
   a. Less than high school diploma
   b. High school graduate
   c. Some College
   d. 4-yr college Degree (or above)

4) Household Income
   a. Below $20,000
   b. $20,000-40,000
   c. $40,000-80,000
   d. Above $80,000
   e. No answer

5) Number of years in Florida.
   a. Less than 1 year
   b. 1-5 years
   c. 5-10 years
   d. More than 10 years

6) City where interview took place
   a. Cocoa Beach
   b. New Smyrna
   c. Oviedo

Comments:
Survey Version 2

UCF RESEARCH Survey

With the funding received by the U.S Fish and Wildlife Service, the University of Central Florida research group, HEESA, is studying the socioeconomic impacts of sea level rise on sea turtles in the state of Florida. Your participation in this research survey is requested.

This survey takes about ten minutes to complete will be used in part to evaluate the ecosystem services provided by sea turtles. This survey will provide valuable data for the research. Participation in this survey is voluntary, and respondents will not receive any direct benefit. The interviewers are students whom have volunteered to conduct these interviews. You must be at least 18 years of age to participate in the survey.

If you have any questions about the study, please contact James Wright, the principal investigator, at 407-823-5083. Thank you.
Climate change has led to a significant increase to the mean sea level in the past few decades. One of the impacts of sea level rise includes loss of coastal areas. Reduction in coastal areas translates to a decrease in the nesting habitat of certain species. This could be detrimental to the survivability of coastal nesting species such as sea turtles. *(See Figures 1a and 1b below)*

Sea turtles have existed and benefited the earth for over 100 million years. They maintain the habitats of other species such as coral reefs, and sea grass beds; additionally they contribute to the process of nutrients cycling, and balancing the food web. In the past few decades their numbers have drastically declined and are now considered endangered. *(See Figure 2a and 2b)*

The level at which sea level rise will impact the sea turtle habitat is largely dependent on the land-use behind the beach and whether the inland retreat of habitat is restricted. Under natural conditions beaches will shift landward in response to a rise in the sea level. But in areas which have high human modification and development, sea level rise can eradicate coastal habitats. *(See Figures 3a and 3b)*

Studies have shown that one promising strategy to protect sea turtle habitat is by identifying and legally protecting it. This can be done through implementation of a Coastal Construction Control Line or CCCL. A Coastal Construction Control Line will prohibit construction within a certain distance of the sea. This allows for a buffer zone between the mean sea level increase and the development which will protect sea turtle habitat of Florida coasts.

Suppose Florida policymakers were considering a proposal to extend the length of the CCCL by 100 feet in order to secure sea turtle nesting habitat. Such changes could lead the government to impose a state wide tax increase to contribute to the Ecosystem Management and Restoration Trust Fund. Suppose this proposal was put to a referendum vote.

1) Would you vote in favor of this proposal if it will cost each Florida household $30 per year for five (5) years?
   a. Yes → (skip question 3)
   b. No → (skip question 2)
   c. Don’t know, it depends → (skip question 2)

2) Would you vote in favor of this proposal if it costs each Florida household $55 per year for five (5) years?
   a. Yes
   b. No
   c. Don’t know, it depends
3) Would you vote in favor of this proposal if it costs each Florida household $15 per year for five (5) years?
   a. Yes
   b. No
   c. Don’t know, it depends

4) What is the maximum amount you are willing to pay to secure sea turtle nesting habitat?
   $_____/year for five (5) years.
   You can use the space below to make any comments:

5) If you were voting on this referendum today, how sure are you that you would vote the same way you answered above?

<table>
<thead>
<tr>
<th>Absolutely Sure</th>
<th>10</th>
<th>9</th>
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</table>
Question 6:

Note: This question is independent of the previous questions.

Compare alternative A, B, and C in the table below and select the option you most prefer.

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<tr>
<td>CCCL (feet)</td>
<td>50</td>
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<td>200</td>
</tr>
<tr>
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<td>Rare</td>
<td>Once per 7 years</td>
<td>Once per 2 years</td>
</tr>
<tr>
<td>Green Turtle ESA Status**</td>
<td>Endangered</td>
<td>Threatened</td>
<td>Recovered</td>
</tr>
<tr>
<td>Cost per year Added cost to your household each year for 5 years</td>
<td>$0</td>
<td>$35</td>
<td>$70</td>
</tr>
<tr>
<td>Check one box</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

*Beach Nourishment: Consists of the placement of large quantities of good quality sediment on the beach to advance the shoreline seaward

**Expected result in 50 years for each option /

Endangered < Threatened < Recovered

Question 7:

Please read the statements below and check the box which best fits your views.
Prior to this survey I was aware about the effects of sea level rise on sea turtles.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
</table>

Sea turtle nesting habitat on Florida's coast should be protected.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
</table>

The health of the sea turtle population will affect the ecosystem.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
</table>

I enjoy seeing/would enjoy seeing sea turtles in their habitat.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
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</tr>
</thead>
</table>

The health of sea turtle population will have an effect on my life.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
</table>

Sea turtle population will affect tourism in coastal cities

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
</table>

Limiting coastal development is a good step to conserve sea turtle habitat.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Neutral</th>
<th>Disagree</th>
<th>Strongly disagree</th>
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</table>

Money collected for sea turtle conservation measures will be honestly and efficiently used.

<table>
<thead>
<tr>
<th>Strongly Agree</th>
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Respondent Characteristics

1) Age of respondent
   a. 18-30
   b. 30-45
   c. 45-60
   d. 60+

2) Gender
   a. Male
   b. Female

3) Educational Background
   a. Less than high school diploma
   b. High school graduate
   c. Some College
   d. 4-yr college Degree (or above)

4) Household Income
   a. Below $20,000
   b. $20,000-40,000
   c. $40,000-80,000
   d. Above $80,000
   e. No answer

5) Number of years in Florida.
   a. Less than 1 year
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   d. More than 10 years

6) City where interview took place
   a. Cocoa Beach
   b. New Smyrna
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Comments:
UCF RESEARCH Survey

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*Suppose Florida policymakers were considering a proposal to extend the length of the CCCL by 100 feet in order to secure sea turtle nesting habitat. Such changes could lead the government to impose a state wide tax increase to contribute to the Ecosystem Management and Restoration Trust Fund. Suppose this proposal was put to a referendum vote.*

1) Would you vote in favor of this proposal if it will cost each Florida household $20 per year for five (5) years?
   a. Yes  \( \rightarrow \) (skip question 3)
   b. No  \( \rightarrow \) (skip question 2)
   c. Don’t know, it depends  \( \rightarrow \) (skip question 2)

2) Would you vote in favor of this proposal if it costs each Florida household $45 per year for five (5) years?
   a. Yes
   b. No
   c. Don’t know, it depends
3) Would you vote in favor of this proposal if it costs each Florida household $10 per year for five (5) years?
   a. Yes
   b. No
   c. Don’t know, it depends

4) What is the maximum amount you are willing to pay to secure sea turtle nesting habitat?
   $_____/year for five (5) years.
   You can use the space below to make any comments:

5) If you were voting on this referendum today, how sure are you that you would vote the same way you answered above?

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5) Number of years in Florida.
   a. Less than 1 year
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   c. 5-10 years
   d. More than 10 years

6) City where interview took place
   a. Cocoa Beach
   b. New Smyrna
   c. Oviedo

Comments:
The photos and descriptions provided here were presented to the respondents participating in the survey. They had an opportunity to review it, while the description in the survey was read to them by one of the interviewers:

- **Reduction in coastal areas decreases the nesting habitat of coastal species.** *(Figures 1a and 1b)*

(Figure 1a: A sea turtle nest prior to sea level rise)      (Figure 1b: A sea turtle nest after sea level rise)

- **In the past decades sea turtle numbers have declined and are now endangered.** *(Figure 2a & 2b)*

(Figure 2a: 90% of loggerhead nesting in the United States occurs in Florida) 
(Figure 2b: Green turtles are second most common sea turtle on Florida coasts)

- **Areas with high coastal development prevent landward movement of beaches.** *(Figures 3a & 3b)*
(Figure 3a: Nesting habitat before coastal construction)  (Figure 3b: Coastal development can eradicate coastal habitat)
APPENDIX C: CORRELATION PLOTS
Correlation plots obtained using r commander are presented below:

Probability of saying “Yes”, to a WTP value, decreased as age increased.
Probability of saying “Yes”, to a WTP value, increased as education level increased.

Probability of saying “Yes”, to a WTP value, slightly decreased as respondents income increased.
A male respondent was indicated with a zero (0), a female respondent was indicated with a one (1). Probability of saying “Yes”, to a WTP value, was higher among female respondents.
Probability of saying “Yes”, to a WTP value, was statistically independent of the number of years a respondent resided in Florida.

S1 effect plot

S2 effect plot
Approval of Exempt Human Research

From: UCF Institutional Review Board #1
FWA0000351, IRB00001138

To: James D. Wright and Co-PI: Ahmed Hamed

Date: January 08, 2013

Dear Researcher:

On 1/8/2013, the IRB approved the following activity as human participant research that is exempt from regulation:

- Type of Review: Exempt Determination
- Project Title: Sea Turtle Habitat Preservation Survey
- Investigator: James D. Wright
- IRB Number: SBE-12-08992
- Funding Agency:
- Grant Title:
- Research ID: N/A

This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these changes affect the exempt status of the human research, please contact the IRB. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of Sophia Dziegielewski, Ph.D., L.C.S.W., UCF IRB Chair, this letter is signed by:

Signature applied by Joanne Muratori on 01/08/2013 11:12:42 AM EST

IRB Coordinator
REFERENCES


Wilcox, Chris, C. Josh Donlan, and Sean Pascoe. "The potential role of compensatory mitigation to seabird and turtle bycatch in fisheries."


