The Economic Significance of Florida Bay

By Andrew Stainback, Ph.D., J.D.

Everglades Foundation
18001 Old Cutler Road, Suite 625
Palmetto Bay, FL 33157

January 2017

Abstract

Florida Bay is a shallow sub-tropical estuary located off the southern tip of the Florida peninsula and north of the Florida Keys and is mostly contained within the bounds of Everglades National Park. Because of its unique ecological characteristics and its location near densely populated urban areas, Florida Bay provides numerous ecosystem service benefits. To analyze the economic significance of these benefits two basic approaches were used. First, the monetary value of benefits in terms of recreational fishing, commercial fishing, its impact on home values, and the value of carbon sequestration in seagrass beds (climate change mitigation) was analyzed using information from a variety of sources. In addition, the annual economic impact of recreational and commercial fishing was estimated from a survey and input-output analysis using the software IMPLAN. The total monetary value in perpetuity of the ecosystem services analyzed is over $15 billion, which is equivalent to an annual value of over $455 million assuming a 3% discount rate. Specifically, Florida Bay is estimated to provide over $213 million in annual benefits to recreational anglers with a resultant value in perpetuity of over 7 billion. By providing crucial juvenile habitat, the Bay provides over $12.7 million worth of annual commercial harvests of pink shrimp and gray snapper combined which translates to a value in perpetuity of over $426 million. The annual economic impact of both recreational and commercial fishing is over $458 million. Florida Bay provides substantial benefits other than commercial and recreational fishing as well. The Bay adds nearly $1.2 billion to single family homes and another $193 million in annual value for carbon sequestration, science, and education benefits.

Economic Significance of Florida Bay

	Value in Perpetuity	Annual Value	Annual Economic Impact
Recreational Fishing	$7,121,324,467	$213,639,723	$438,690,467
Commercial Fishing	$426,452,420	$12,793,573	$19,977,299
Residential Real Estate	$1,181,622,839	$35,448,685	---
Carbon Sequestration	$4,529,394,426	$135,881,833	---
Gene Pool Protection, Spiritual Experiences, Cognitive Information	$1,935,000,000	$58,050,000	---
Total	**$15,193,794,152**	**$455,813,814**	**$458,667,766**

Note: The commercial fishing estimates are based on gray snapper (*Lutjanus griseus*) and pink shrimp (*Farfantepenaeus duorarum*) and do not include other important species (spiny lobster, sponges, etc.). Thus, the true economic value and impact of commercial fishing is likely greater than reported here.

Executive Summary

Florida Bay provides substantial benefits to society. These benefits include crucial habitat for numerous threatened and endangered species (e.g., smalltooth sawfish and American crocodile), recreationally-important fisheries (e.g., snook, tarpon, and redfish), commercially-important fisheries (e.g., stone crab and spiny lobster), and species of wading and migratory birds (e.g., reddish egret, roseate spoonbill, and white pelicans). Due to its incredible array of habitat offerings, Florida Bay also provides numerous opportunities for recreation, whether fishing, kayaking/canoeing, or birdwatching. Due to its vast area of seagrass meadows and mangrove forests, Florida Bay is also noteworthy in terms of its provisioning of important environmental functions such as mitigation of climate change and storm surge. Such benefits are often referred to as ecosystem services. Quantifying the benefits that society receives from these ecosystem services enables policy makers and the public to understand the importance of maintaining ecosystems such as Florida Bay and the tradeoffs involved in ecosystem management.

Summary of Methodology and Results

To analyze the economic significance of Florida Bay two basic approaches were used. First, the monetary value of benefits that Florida Bay provides to people in terms of recreational fishing, commercial fishing, its impact on home values, and the value of carbon sequestration in seagrass beds (climate change mitigation) was analyzed using information from a variety of sources. In addition, the annual economic impact of recreational and commercial fishing was estimated through conducting a survey and utilizing the results in an input-output analysis. The monetary value of an ecosystem service is a measure of how much someone (or society) is willing to pay for it. Economic impact is a measure how much economic activity is generated from an event or activity, such as recreational or commercial fishing. For all analyses and the survey, Florida Bay was defined as the region from Lostmans River in the north to the western end of the Seven-Mile Bridge in the south and Route 1 in the east.

Results for monetary values are presented as both annualized values and values in perpetuity. Annualized values represent the value of an ecosystem service over one year, whereas values in perpetuity represent the value of an ecosystem service over an infinite number of years into the future. Economic impact estimates are presented only as annual values. A summary of results is presented in table A. The total monetary value in perpetuity of the ecosystem services analyzed is over $15 billion, which is equivalent to an annual value of over $455 million assuming a 3% discount rate. Specifically, Florida Bay is estimated to provide

Table A. Summary of the value and economic impact of some of the ecosystem service benefits provided by Florida Bay. All values are in 2016 dollars. A 3% discount rate was used to calculate annual values and values in perpetuity. Only the economic impact of recreational fishing and commercial fishing were used to calculate total economic impact.

Ecosystem Service	**Value in Perpetuity**	**Annual Value**	**Annual Economic Impact**
Recreational Fishing	$7,121,324,467	$213,639,723	$438,690,467
Commercial Fishing	$426,452,420	$12,793,573	$19,977,299
Residential Real Estate	$1,181,622,839	$35,448,685	---
Carbon Sequestration	$4,529,394,426	$135,881,833	---
Gene Pool Protection, Spiritual Experiences, and Cognitive Information	$1,935,000,000	$58,050,000	---
Total	**$15,193,794,152**	**$455,813,814**	**$458,667,766**

over $213 million in annual benefits to recreational anglers with a resultant value in perpetuity of over 7 billion. By providing crucial juvenile habitat, the Bay provides over $12.7 million worth of annual commercial harvests of pink shrimp and gray snapper combined which translates to a value in perpetuity of over $426 million[1]. The annual economic impact of both recreational and commercial fishing is over $458 million. Florida Bay provides substantial benefits other than commercial and recreational fishing as well. The Bay adds nearly $1.2 billion to single family homes and another $193 million in annual value for carbon sequestration, science, and education benefits. Greater detail about the estimation of each of these values is given in the following paragraphs.

Recreational Fishing

There have been no studies conducted specifically on recreational anglers to determine their willingness to pay to fish in Florida Bay. However, numerous studies have surveyed recreational anglers throughout the country to estimate their willingness to pay (WTP) for the opportunity to engage in saltwater fishing at various locations. The WTP estimates for the value per day of saltwater fishing from Hindsley et al. (2012) were used to analyze the value of recreational fishing in Florida Bay. To estimate the number of angler days spent fishing in Florida Bay, a survey of Florida anglers and fishing guides was conducted with the assistance of Dr. Tony Fedler at the University of Florida. The results of the survey indicate that recreational anglers spent a total of 3,037,166 angler-days over the course of one year fishing Florida Bay. Based on this data, Florida Bay is estimated to provide over $213 million in annual benefits to recreational anglers. Assuming these benefits flow every year indefinitely into the future, the value in perpetuity of Florida Bay in terms of recreational fishing is $4.3, $7.1, and $8.5 billion at a 5%, 3%, and 2.5% discount rate respectively.

---

[1] The commercial fishing estimates are based on gray snapper (*Lutjanus griseus*) and pink shrimp (*Farfantepenaeus duorarum*) and do not include other important species (spiny lobster, sponges, etc.). Thus, the true economic value and impact of commercial fishing is likely greater than reported here.

In addition to the value that Florida Bay provides to recreational anglers, expenditures by these anglers impact the regional and state economy by generating income, jobs, and tax revenue. To estimate the impact of recreational fishing in Florida Bay on the regional economy, an input-output model built with IMPLAN software was used along with angler expenditure information collected from the above-mentioned survey. Survey results indicate that Florida Bay recreational anglers spent $261 million on equipment, transportation, food, lodging, and other items fishing in Florida Bay in the regional economy, defined as Monroe, Miami-Dade, and Collier counties, over the course of one year. These expenditures result in $439 million per year in economic output, over 4,100 jobs, and over $73 million in annual local, state, and federal tax revenue.

Commercial Fishing

Florida Bay is important to several commercially valuable fish species. For instance, it provides important juvenile habitat for the economically important Dry Tortugas fishery. Two Dry Tortugas commercial species whose juvenile life stages are dependent on Florida Bay are pink shrimp (*Farfantepenaeus duorarum*) and gray snapper (*Lutjanus griseus*) (Browder & Robblee, 2009; Ehrhardt, 2001; Richardson et al., 2014).

Based on data from Florida Fish and Wildlife Conservation Commission, the average value of the annual harvest of pink shrimp and gray snapper combined is over $12 million in 2016 dollars. If this is assumed the value of the harvest each year indefinitely into the future then the total value in perpetuity of commercial harvest at a 5%, 3%, and 2.5% discount rate is $256, $426, and $511 million respectively. In addition to providing a valuable product for consumers, commercial fishing generates economic activity in the state. For instance, money is spent on capital (e.g. boats, nets, and other equipment), fuel, and labor. These expenditures provide jobs, income, and state and federal tax revenue. Based on the annual catch of over $12 million, the annual impact of commercial fishing of pink shrimp and gray snapper in the Dry Tortugas fishery on the economy of Florida (again determined via IMPLAN) is almost $20 million per year, over 240 jobs, and almost $3 million in annual federal, state, and local taxes.

Real Estate Values

Natural amenities such as water bodies, forests, and open space can impact the value of real estate. For example, many home buyers are willing to pay a premium for a home near a significant water body such as Florida Bay.

Data on residential real estate in the Keys was obtained from the Monroe County Property Appraisers Office. Following Hindsely et al. (2012) single family homes were sorted into five groups based on their distance to Florida Bay – waterfront, distance of 100 to 1,000 feet, between 1,000 feet and 2,000 feet, between 2,000 feet and 3,000 feet, and between 3,000 and 4,000 feet. The Marginal Willingness to Pay (MWP) estimates for each distance category from the Hindsely et al (2012) study were converted to 2016 dollars using the Consumer Price Index from the U.S. Bureau of Labor Statistics. There was a total of 16,582 homes in all distance categories. For each distance category, the number of homes in that category was multiplied by the MWP for a home in that distance category to obtain the total value that Florida Bay provides to single family homes in that category. Based on this analysis the marginal value that Florida Bay adds to single family homes is slightly over $1.2 billion. The annualized values at a 5%, 3%, and 2.5% discount rate are $59, $35, and $30 million respectively.

Carbon Sequestration

Seagrass beds represent a significant store of carbon that, if they were to disappear, would be released back into the atmosphere and contribute to global climate change and its attendant negative consequences. The amount of Florida Bay covered with seagrass was obtained from personal communication with Dr. James Fourqurean, a Florida Bay seagrass expert at Florida International University. Florida Bay, as defined above, represents about 2,250 square kilometers of which 80% or 1,800 square kilometers is covered by seagrass (James Fourqurean, personal communication). Multiplying this area by the average amount of carbon per hectare in Florida Bay, 163.5 Mg C, results in the total amount of carbon in Florida Bay seagrass equal to 29,430,000 Mg C. This number is multiplied by the molecular weight of CO_2 (3.667) to convert to CO_2 equivalents (CO_2e). This results in 107,919,810 Mg CO_2e stored in seagrass beds in Florida Bay.

For carbon emissions in 2015 the latest Social Cost of Carbon (SCC) estimates are $12/Mg CO_2e (5% discount rate), $38/Mg CO_2e (3% discount rate), and $58 Mg CO_2e (2.5% discount rate (Interagency Working Group on Social Cost of Carbon, 2013). Multiplying these prices by the total amount CO_2e in Florida Bay seagrass results in total values of $1.38 billion, $4.53 billion, and $7.05 billion respectively. Annualizing these values using the same discount rates used in the SCC calculations produces annual values of $69.2 million (5% discount rate), $135.9million (3% discount rate), and $176.2 million (2.5% discount rate) respectively.

Other Values

There are many other benefits, besides those discussed above, that Florida Bay provides to society. The United Nations recently launched a global initiative called *The Economics of Ecosystems and Biodiversity (TEEB)* to compile estimates of the economic value of various ecosystem services from different ecosystems around the world. Results from this initiative have given estimates, among others, of gene pool protection, spiritual experiences, and cognitive information (e.g. education and science) of $209, $24, and $25 per hectare (adjusted to 2016 dollars) per year for the coastal biome (de Groot et al., 2012; Turpie, Heydenrych, & Lamberth, 2003). If Florida Bay is assumed to be approximately 2,250 square kilometers (or 225,000 hectares) in size, then the total value for these three ecosystem services is approximately $58 million per year. The total value in perpetuity at a 5%, 3%, and 2.5% discount rate is $1.2 billion, $1.9 billion, and $2.3 billion respectively.

The Economic Significance of Florida Bay

Chapter 1: Introduction

Florida Bay is a shallow sub-tropical estuary located off the southern tip of the Florida peninsula and north of the Florida Keys and is mostly contained within the bounds of Everglades National Park. It is at the southern terminus of the Everglades ecosystem where fresh water flowing down through the everglades mixes with salt water from the Gulf of Mexico and Atlantic Ocean. Florida Bay consists mostly of seagrass beds and mangrove islands. Because of its location on the transition between two climatic zones – subtropical and tropical – it provides unique and important estuary habitat for commercially and recreationally important species. It is also a popular destination for marine recreation. Much of the Bay consists of shallow basins partially separated from each other by banks (Browder et al., 2002). This has made seagrass beds in Florida Bay especially susceptible to changes in salinity as a result of changes of freshwater flow into the Bay.

Historic flows of freshwater have been re-routed away from Florida Bay over the twentieth century to drain a portion of the Everglades ecosystem. Because of these hydrological changes, Florida Bay has suffered ecological degradation due to increased salinity levels. As a result of drought and a persistent lack of freshwater flow, the Bay has experienced two massive seagrass die-offs. One occurred in the late 1980's following a three-year drought and the most recent in 2015 following a more acute localized drought. These large-scale die-off events have had significant impacts on flora and fauna through the loss of habitat, food, and degraded water quality. Efforts to restore the Bay focus mainly on restoring the historic pattern, timing, and volume of freshwater flows in the Everglades watershed that feeds the Bay and are therefore central to the restoration of the Greater Everglades Ecosystem.

Because of its unique ecological characteristics and its location near densely populated urban areas, Florida Bay provides numerous benefits to society. These benefits include providing crucial habitat for numerous threatened and endangered species (e.g., smalltooth sawfish and American crocodile), recreationally-important fisheries (e.g., snook, tarpon, and redfish), commercially-important fisheries (e.g., stone crab and spiny lobster), and species of wading and migratory birds (e.g., reddish egret, roseate spoonbill, and white pelicans). Due to its incredible array of habitat offerings, Florida Bay also provides numerous opportunities for recreation, whether fishing, kayaking/canoeing, or birdwatching. Due to its vast area of seagrass meadows and mangrove forests, Florida Bay is also noteworthy in terms of its provisioning of important environmental functions such as mitigation of climate change and storm surge. Such benefits are often referred to as ecosystem services. For a wide range and diversity of ecosystems, ecologists and economists have begun putting monetary values on ecosystem services and estimating their economic impact or contribution to society. Quantifying the benefits that society receives from ecosystems enables policy makers and the public to understand the importance of maintaining ecosystems such as Florida Bay and the tradeoffs involved in ecosystem management (Costanza et al., 1997).

In an effort to understand the value of Florida Bay and the significance of seagrass die-off, important ecosystem services provided by Florida Bay were inventoried and their monetary value and economic impact on South Florida's economy were estimated.

Chapter 2: Background

Ecosystem Services

Ecosystems, such as Florida Bay, provide many benefits to people. These benefits are increasingly conceptualized by economists and ecologists as ecosystem services (Millennium Ecosystem Assessment, 2005). Under this conceptualization, Florida Bay can be thought of as a capital asset from which benefits (ecosystem services) flow periodically. Some ecosystem services are bought and sold in markets and are thus very familiar to most people. Examples include fish or other raw materials. Other ecosystem services are not bought and sold on markets, but nonetheless directly or indirectly contribute to human welfare. Such ecosystem services include the purification of water or the regulation of climate.

To more fully understand the concept of ecosystem services it can be useful to classify them into different categories. Several such classifications have been used by ecologists and economists. One such scheme was developed by the United Nations initiative, *The Economics of Ecosystem and Biodiversity (TEEB)* (Kumar, 2012). Table 1 describes this classification.

Table 1. Description of Ecosystem Service Categories. Adapted from Kumar (2012).

Ecosystem Service Category	**Description**	**Examples**
Provisioning Services	Raw material or energy outputs from ecosystems	Fish, timber, biofuel
Regulating Services	Services regulating the quality of the environment or mitigating/controlling threats	Climate sequestration and storage, flood protection, water purification
Habitat Services	Food, habitat, and other provisions necessary to sustain plant and animal life and biodiversity	Habitat for various species
Cultural Services	The provision of positive human experiences from interacting with ecosystems	Tourism, recreation, aesthetic appreciation, spiritual experience

Provisioning services are material output that we get from ecosystems such as fish, timber, food, etc. Such services are frequently bought and sold in markets. Regulating services help regulate the environment and include things such as climate regulation, water purification, and pollination among others. Habitat services provide the structure, refuge, and food needed for various species to grow and reproduce, whereas cultural services provide positive human experiences including spiritual connections to nature, recreational opportunities, and scientific information. All but provisioning services are things we typically receive from nature for free, thus there are no developed markets for them. Economists have devised numerous and increasingly sophisticated ways of putting monetary values on such ecosystem services.

Monetary Valuation and Economic Impact

In assessing the economic significance of ecosystem services, or any other good or service, there are two basic approaches that can be used. One is to calculate the monetary value of the ecosystem service. The monetary value of an ecosystem service is essentially how much an individual or society is willing to pay for that service. Another approach to understanding the economic significance of an ecosystem service is to estimate the economic impact of an activity involving that ecosystem service – such as recreational fishing. An economic impact study calculates the economic activity generated by an event or events, such as recreational anglers spending money to engage in recreational fishing. This study utilizes both approaches. In the following paragraphs, the basic elements and rationale of both approaches will be discussed.

Monetary Valuation

To make decisions or tradeoffs involving ecosystem services it is often useful to estimate a monetary value for such services or monetize them. For ecosystem services that are bought and sold in markets and thus have a market price this can be relatively straight forward. However, ecosystem services that do not have a market price can be more difficult to value.

Economists have developed several techniques that allow for the monetization of non-marketed ecosystem services (see table 2). These techniques are commonly grouped in two distinct categories – stated preference techniques and revealed preference techniques. Stated preference techniques essentially ask people how much they value an ecosystem service.

Table 2. Description of some common techniques used by economists to value non-marketed ecosystem services. Adapted from (Tietenberg & Lewis, 2009).

Valuation Technique	**Description**
Stated Preference Techniques	People are asked how much they would pay for something (or how much they would need to be compensated to give it up).
Contingent Valuation	Survey asks respondents directly how much they are willing to pay or willing to accept for a change in an ecosystem service.
Choice Experiment Surveys	Survey asks respondents to choose between different scenarios with quantitative and/or qualitative differences in ecosystem services
Revealed Preference Techniques	People are observed in other related markets and value is deduced from their behavior
Travel Cost Method	Estimates how much people spend to travel to enjoy an ecosystem service (e.g. tourism or recreation).
Hedonic Pricing	Estimates the price variation of market goods or service when an ecosystem service related to the good or service changes. (e.g. how does water quality impact real estate prices)
Avoidance Costs	How much does it cost to compensate for the loss of an ecosystem service (e.g. how much does it costs to filter water)?

Two common stated preference approaches are contingent valuation surveys and choice experiments. Contingent valuation surveys ask people how much they would be willing to pay for a marginal increase in an ecosystem service or alternatively how much they would require in terms of compensation (willingness to accept) for a marginal decrease in an ecosystem service. Choice experiments use surveys or related instruments to present respondents with a series of choices of different quantities or qualities of an ecosystem service or set of ecosystem services. Each choice is associated with a price. Economists then use the choices made by the respondents to estimate the value of changes to an ecosystem service or set of ecosystem services.

Revealed preference techniques observe people's behavior, typically in market transactions, to deduce how much they value an ecosystem service. One type of revealed preference technique, the travel cost method, uses information on how much people spend to travel to a destination to deduce how much they value the ecosystem service or resource at that destination. For instance, how much a recreational angler spends to travel to a favorite fishing destination can be used to deduce how much that angler values the experience of fishing at that particular destination. Economists can sometimes use replacement costs or avoided costs to estimate the value of an ecosystem service. For example, how much it would cost to replace wetlands or forests that purify water with water treatment facilities can be used to estimate the value of water purification services provided by wetlands and forests. Finally, hedonic pricing can be used to estimate the value of some ecosystem services. Hedonic pricing uses information about how much an ecosystem service influences the price of an asset to estimate the value of that ecosystem service. For instance, how location relative to a pristine body of water or other natural area influence the price of homes can be used to estimate aesthetic or recreational ecosystem services provided by that body of water or natural area.

Economic Impact

In addition to analyzing the monetary or economic value of benefits from ecosystems, economists also analyze the local or regional economic impacts of various activities that depend on ecosystem services. These types of studies can investigate things such as the contribution of recreational fishing to a local economy or the impact of nature based tourism on jobs. The essential basis of these studies is the fact that when someone spends money, that expenditure has "ripple" effects in the economy. For example, a dollar that is spent on a good or service is then spent by the person or business that receives it on other goods and services. These expenditures increase economic output in the local or regional economy.

These effects or changes in output are usually categorized as direct effects, indirect effects, and induced effects (Mulkey & Hodges, 2015). Direct effects refer to the initial change in output in the local or regional economy that occurs in the industry in question. For instance, when someone buys a meal at a restaurant the direct effects would include the expenditures of local or regional industries that supplied the restaurant with the inputs necessary to make the meal. Indirect effects are the value of the goods and services purchased by the local or regional industries that provided inputs to the suppliers of the restaurant. Induced effects are the value of the goods and services purchased with the income accrued to businesses and people as the result of the direct and indirect effects. The economic impact of an activity or event is the sum of the direct, indirect, and induced effects. Economic impact analyses often also include estimates of the number of jobs and tax revenue created by these changes in output.

Economic impact studies are carried out using input-output models that consist of a matrix of transactions between different industries, usually called sectors, of a local or regional economy (Bureau of Economic Analysis, 2013; McConnell et al., 2016). This transaction table links each industry (or sector) to all other industries that supply it with inputs and to final consumers. Many input-output models also include transactions between government entities and the private sector. Impacts are calculated via multipliers that relate a change in one industry to changes to other industries (McConnell et al., 2016; Mulkey & Hodges, 2015). For instance, output multipliers are used to calculate changes in output, employment multipliers are used to calculate changes in employment, value-added multipliers are used to calculate changes in value added, and income multipliers are used to calculate changes in income. In some models, changes in government tax revenue can also be estimated. A schematic of a typical input-output model is shown in figure 1.

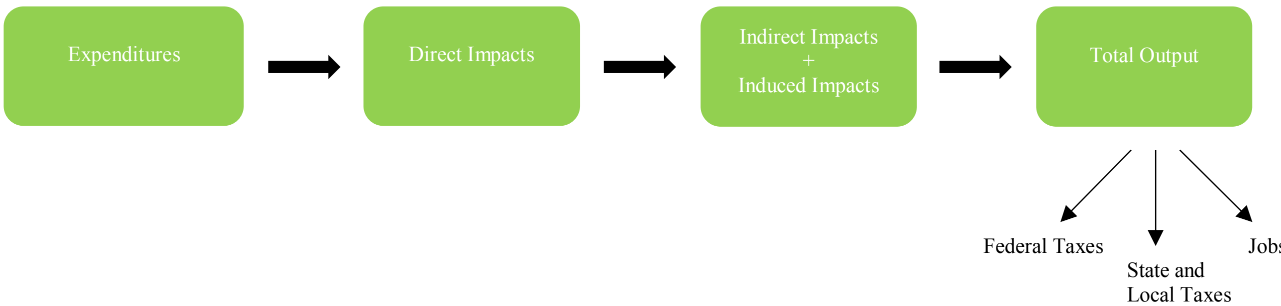

Figure 1. Diagram of a typical input-output model.

Monetary Valuation versus Economic Impact

It is important to emphasize that measures of economic impact are different than measures of monetary value. When economists talk about monetary value they are referring to how much someone (or society) would be willing to pay for something. By contrast, economic impact analysis measures the amount of economic activity generated by an activity or event. For instance, the economic value of fishing in Florida Bay would be how much people, specifically recreational anglers, would be willing to pay for the opportunity to fish in the Bay. The economic impact would measure how the money spent on things such as fuel, food, bait, and equipment by recreational anglers fishing in the Bay impacts the local economy. Both measures, economic impact and economic value, are important and give insight into the importance of ecosystem services but they are not the same and thus cannot be added or directly compared.

Chapter 3: Previous Studies

In this section, previous studies of ecosystem services, estimating both monetary value and economic impact, will be summarized. While these studies are not directly based on Florida Bay they have relevance for ecosystem service benefits from the Bay. The results from this study, which are specific to Florida Bay, will then be discussed.

Monetary Value Studies

There has been no study that has looked at the value of ecosystem services from Florida Bay specifically. However there have been a few studies that have analyzed ecosystem services from the Everglades and South Florida region where at least some of the results directly or indirectly provide information into the potential monetary value of Florida Bay. Florida Bay is the southern terminus of the Everglades ecosystem and is thus greatly impacted by most activities impacting the greater ecosystem. For example, the quantity and quality of freshwater flows through the Everglades are critical for ecosystem health and stability in the Bay.

Richardson et al., (2014) monetized the ecosystem service benefits that would be generated by completing the Central Everglades Planning Project (CEPP). CEPP is a suite of projects identified as critical for hydrological restoration of the central Everglades. The authors focused on the benefits derived from carbon sequestration in peat soils, commercial and recreational fishing in Florida Bay, recreational activities impacted by park closures due to high water and dry conditions, sediment reduction in the St. Lucie River and Estuary, and water supply to southeastern Florida. At a discount rate of 2.5% the total benefits came to approximately 1.8 billion dollars with the largest benefits being carbon sequestration at over $1 billion and water supply to southeastern Florida at over $600 million (Richardson et al., 2014).

These estimates are almost certainly an underestimate as many expected benefits from CEPP were not included in the study due to the lack of ecological and/or economic data.

Of particular interest to Florida Bay are the estimates for values of commercial and recreational fishing in Florida Bay. As most of Florida Bay is within the boundaries of the Everglades National Park, no commercial fishing is allowed in the Bay itself. However, the Bay serves as important nursery grounds for the Tortugas fisheries (Richardson et al., 2014). In terms of commercial fishing, the authors estimated that the completion of CEPP will increase the annual catch of pink shrimp (*Farfantepenaeus duorarum*) and gray snapper (*Lutjanus griseus*) by 0.53%. This increase was estimated to be worth approximately $1.2 million at a 2.5% discount rate (Richardson et al., 2014). The authors also estimated that the completion of CEPP would increase the habitat for species important in recreational fishing, specifically spotted seatrout (*Cynoscion nebulosus*), snapper (*Lutjanus* spp.), and grouper (*Epinephelus* spp.), by 9.95%. The increased catch due to this increase in habitat was estimated to be worth about $67.8 million at a 2.5% discount rate (Richardson et al., 2014).

In 2010 Mather Economics, an economics consulting firm, conducted a study of the economic benefits and cost of Everglades restoration as envisioned by the Comprehensive Everglades Restoration Plan (CERP) (McCormick et al., 2010). In the study the authors monetized a range of benefits that would be generated by restoration over the next 50 years and compared these benefits to the projected cost of restoration. The specific benefits investigated were ground water purification (or avoided costs of desalinization), increased real estate values due to improved water quality, changes in park visitation, increased open space, increases in fishing (both recreational and commercial), and changes in wildlife habitat and recreational hunting. The total value of benefits from restoration over the next 50 years was estimated to be $46.5 billion. Assuming a restoration cost over the same time period of $11.5 billion, the benefit cost ratio was determined to be 4.04 (McCormick et al., 2010). Due to the uncertainty of the estimates and the fact that not all benefits from restoration were monetized, the authors argue that $46.5 billion is likely an underestimate and that benefits could be as high as $123.9 billion (McCormick et al., 2010). By far the biggest restoration benefits (in monetary terms) were ground water purification, real estate, and wildlife habitat and hunting. These three benefits represented almost 90% of the total value.

In his book on the economics of Everglades restoration Richard Weisskoff (2005) estimated the value of ecosystem services from the greater everglades ecosystem. Using data from the South Florida Water Management District and following a seminal study by Costanza et al. (1997), he divided the Everglades into broad biome categories– freshwater wetlands, saltwater wetlands, temperate forests, tropical forests, urban areas, agricultural land, freshwater aquatic habitats, and saltwater aquatic habitats. Monetary values for ecosystem services derived from the Costanza et al. (1997) study were assigned for each biome and multiplied by the total area represented by that biome. The benefits included in the valuation estimate represented a broad range of ecosystem service values (e.g., climate regulation, soil formation, pollination, raw material, recreation, etc.). Collectively, the Everglades was estimated to produce $68.2 billion (in 2000 dollars) per year. This was equivalent to 34.8 % of the total GDP produced that year in south Florida (Weisskoff, 2005).

Jerath et al. (2016) estimated the amount and value of carbon stored in mangrove forests in the Everglades National Park. The authors first estimated the belowground soil (to 0.9 meters), belowground root (0.9 meters), and above ground carbon stored in mangrove forests throughout the park. The median total amount of carbon stored was 335.6 metric tons of carbon per hectare but varied from as little as 70 to as much as 537 metric tons per acre of carbon (Jerath et al., 2016). The authors used a range of carbon prices based on current market prices, the social cost of carbon estimated by the U.S. Environmental Protection Agency, and the marginal abatement cost (estimated based on the cost of protecting mangroves through implementation of CEPP). The study concluded that there are 144,447 hectares of mangroves in the Park resulting in a total value of stored carbon ranging from as little as just under $700 million to a little over $8 billion (Jerath et al., 2016). This range of values represents the substantial variation in estimates of the value of a ton of carbon - with international voluntary markets averaging about $14 per metric ton and the social cost of carbon being as much as $167 per metric ton.

Finally, a group of Florida economists conducted a choice experiment survey of public preferences for restoration of the Everglades and the South Florida region (Milon et al.,1999). In this survey Florida residents were asked about their willingness to pay for changes in different attributes of the Everglades ecosystem resulting from restoration. Attributes included hydrological conditions in Lake Okeechobee, Everglades Water Conservation Areas, Florida Bay, and Everglades National Park, populations of various species relative to their pre-drainage (i.e., historic) populations, and socioeconomic conditions such as annual cost of restoration, restrictions on water use, and reductions of farmland. The results from the study indicated that Florida residents were willing to pay for restoration of historic hydrological conditions and had a strong preference for wetland and estuarine species (as opposed to dryland species). Respondents also indicated that they viewed loss of farmland and restrictions on water use negatively (Milon et al., 1999). Overall, for full restoration, the results indicated that Floridians were willing to pay between $60 and $70 per household per year for 10 years for full restoration which amounts to an aggregate willingness to pay of around $3.4 to $4 billion (Milon et al., 1999).

For a summary of these studies see table 3.

Table 3. Summary of previous monetary valuation studies relevant to Florida Bay.

Focus of Study	Result	Reference
Value of Central Everglades Planning Project (CEPP)	$1.8 billion	(Richardson et al., 2014)
Value of Everglades Restoration as envisioned by Comprehensive Everglades Restoration Plan (CERP)	$46.5 over 50 years	(McCormick et al., 2010)
Value of Ecosystem Services from Greater Everglades Ecosystem	$68.2 billion	(Weisskoff, 2005)
Value of Carbon Stored in mangrove forests in Everglades National Park	$700 million to $8 billion	(Jerath et al., 2016)
Value of restoration of Everglades and South Florida Ecosystem	$3.4 to 4 billion over 10 years	(Milon et al., 1999)

Economic Impact Studies

While there have been no economic impact studies on Florida Bay specifically, there have been several economic impact studies conducted in which the activities investigated depend at least in part on Florida Bay or are otherwise relevant to Florida Bay. Again, it is important to keep in mind that economic impact studies estimate the economic activities generated by certain actions or changes. Economic impact studies are thus frequently used by economists and policy makers to understand the role that certain industries or policies may have for the economy.

The National Oceanic and Atmospheric Administration (NOAA) conducted a study of the economic impact of recreation to the Florida Keys and Key West in 2007 and 2008 (Leeworthy & Ehler, 2010). In this study two analyses were conducted. One estimated the economic impact of recreating visitors to the Florida Keys on the economy of Monroe County, which includes all of the Florida Keys and a mainland area enclosed within Everglades National Park. The other looked at the economic impact of recreating visitors to the Florida Keys on the economy to the region consisting of Monroe, Miami-Dade, and Brevard counties. The first analysis used U.S. Census data on wages, sales, and employment for Monroe County. It found that visitors to Monroe County (the Florida Keys) spent $1.995 billion in the 2007-08 year. This spending generated a total output (direct, indirect, and induced) worth $2.234 billion and 32,017 full time job equivalents. For the second analysis, that involved the economic impact in Monroe, Miami-Dade, and Broward Counties, the total visitor spending was $2.487 billion. This larger number reflects the fact that visitors to the Florida Keys often spend money in Miami-Dade and Broward Counties while travelling and preparing to travel to Monroe County. Using the input-output modeling software IMPLAN, the total impact of this spending was estimated to be $4.131 billion in the three counties generating 40,451 fulltime equivalent jobs.

Using original survey data and data from the U.S. Fish and Wildlife Service, Fedler (2009) conducted an analysis of the economic impact of recreational fishing in the Everglades region - defined as the area represented by the South Florida Water Management District. The study included freshwater fishing in this entire region and saltwater fishing in the "nearshore area and Florida Bay on the northern side of the Florida Keys" (Fedler, 2009). The Regional Input-Output Modeling System (RIMS II) developed by the U.S. Department of Commerce was used in calculating the impact that recreational fishing in the Everglades region has on the Florida economy. The results indicate that freshwater fishing results in $206 million in direct retail sales and saltwater fishing results in $517 million in direct retail sales. These expenditures produce $353 million in total output for freshwater fishing and $834 million in total output for saltwater fishing. It was estimated that recreational fishing in the Everglades region also resulted in 12,391 jobs (3,495 and 8,896 jobs in freshwater and saltwater fishing respectively), $91 million in federal tax revenue ($26 million and $65 million in freshwater and saltwater fishing respectively), and $73 million in state and local tax revenue ($19 million and $54 million in freshwater and saltwater fishing respectively).

Fedler, (2013) conducted a similar study on recreational fishing in the Florida Keys. Using original survey data, Florida Fish and Wildlife Conservation Commission (FWC) data, and the RIMS II model, the economic impact of recreational fishing in general and flats fishing in particular in the Florida Keys was estimated. The study found $434 million in direct expenditures for recreational fishing in general in the Keys and $250 million for flats fishing These expenditures resulted in $742 million and $427 million in total economic impact respectively for general recreational fishing and flats fishing. General recreational fishing and flats fishing in the Keys also, respectively, generated 7,536 and 4,340 jobs, $55 million and $32 million in federal tax revenue, and $45 million and $26 million in state and local tax revenue.

Finally, the Mather study, discussed previously, used multipliers from several sources – USDA Economic Research Service, previous studies on recreational fishing, the Shimberg Center for Affordable Housing, and the REMI II model (an input-output model from the University of Michigan)– to estimate the number of jobs from Everglades restoration. They found that if restored the net jobs created would be 442,000 over 50 years. In addition, the US Corps of Engineers estimated that 22,000 jobs will be created through the actual restoration work (McCormick et al. 2010).

For a summary of these studies see table 5.

Table 4. Summary of previous monetary valuation studies relevant to Florida Bay.

Focus of Study	Annual Economic Impact	Jobs	Reference
Recreation in Florida Keys	$2.5 billion	40,451	(Leeworthy & Ehler, 2010)
Recreational Fishing in the Everglades region	$1.2 billion	12,391	(Fedler, 2009)
Recreational Fishing in the Keys	$741 million	7,536	(Fedler, 2013)
Everglades Restoration	---	464,000	(McCormick et al., 2010)

Chapter 4: Economic Significance of Florida Bay

To analyze the economic significance of Florida Bay two basic approaches were used. First, the monetary value of benefits that Florida Bay provides to people in terms of recreational fishing, commercial fishing, its impact on home values, and the value of climate change mitigation (via carbon stored in seagrass beds) was quantified using information from a variety of sources. In addition, the annual economic impact of recreational and commercial fishing in Florida Bay was estimated by conducting a survey and utilizing the results in an input-output analysis. For all analyses and the survey, Florida Bay was defined as the region from Lostmans River in the north to the western end of the Seven-Mile Bridge in the south and Route 1 in the east (see figure 2).

Results for monetary values are presented as both annualized values and values in perpetuity. Annualized values represent the value of an asset over one year, whereas values in perpetuity represent the value of an asset over an infinite number of years into the future. The monetary value of ecosystem services is frequently reported in either format. Economic impact estimates are presented as annual values as this is what is produced from typical input-output models. Further, economies and industries can change substantially from year to year influencing the estimates for economic impact.

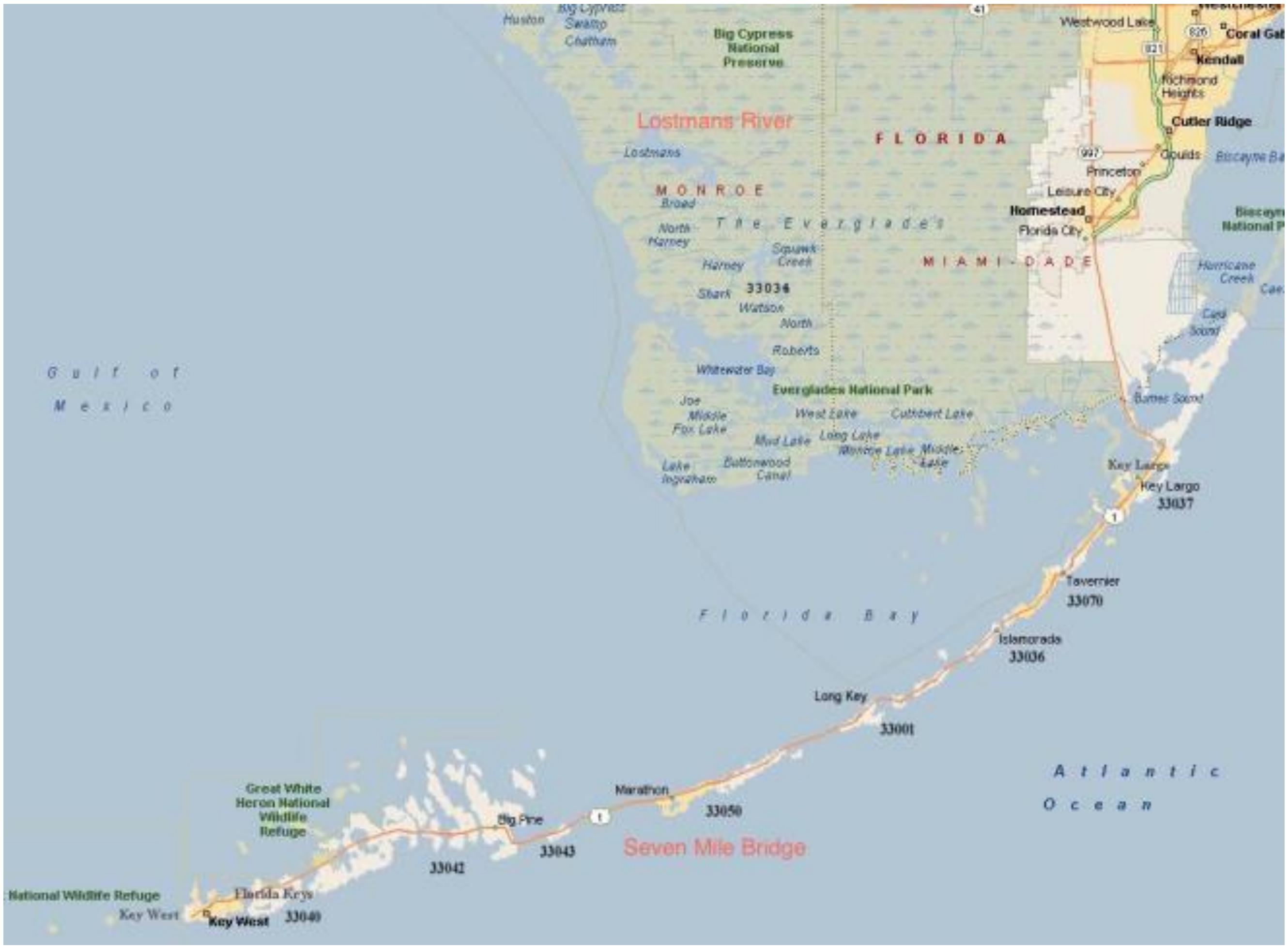

Figure 2. In this study Florida Bay was defined as the region from Lostmans River in the north to the western end of the seven-Mile Bridge in the south and Route 1 in the east. Source: http://realprogroup.com/pages/Monroe.html

When converting from annualized values to values in perpetuity or vice versa, a discount rate is typically used. The discount rate simply accounts for the time value of money – or the fact that a dollar in benefits today is not worth the same as a dollar of benefits in some future period. Assumed discount rates vary substantially within and among different studies on the value of ecosystem services. For instance, in the Mather Study of the benefits of Everglades restoration, a discount rate of 2.1% was utilized (McCormick et al., 2010). In their study of the benefits of CEPP, Richardson et al (2014) did a sensitivity analysis using discount rates of 2.5%, 3.5% (3%

for climate change benefits) and 5%. When the Environmental Protection Agency (EPA) estimated the social costs of carbon emissions in terms of climate change, they used discount rates of 2.5%, 3%, and 5%. (Interagency Working Group on Social Cost of Carbon, 2010). The discount rates used by the EPA were used in the current analysis when estimating the benefits of carbon stored in Florida Bay seagrass beds. To keep all calculations consistent and because this range of discount rates encompasses typical rates seen in the literature, they were also used in estimates of other benefits analyzed in this report.

A summary of the results of the valuation (assuming a 3% discount rate) and estimation of the economic impacts of ecosystem service benefits of Florida Bay can be seen in table 5. The total value in perpetuity of the ecosystem services analyzed is over $15 billion, which is equivalent to an annual value of over $455 million assuming a 3% discount rate. The annual economic impact of recreational and commercial fishing is over $458 million. The values reported here are very likely underestimates of the true value of Florida Bay for several reasons. First, only a subset of benefits is analyzed due to the lack of ecological data, economic information, or both. For instance, the value of recreation other than fishing, such as boating, birding, or swimming, was not included in this analysis. Also, in doing any such analysis certain conservative assumptions must be made. For example, in estimating the value of recreational fishing to anglers, average willingness to pay estimates from around the country for saltwater fishing were used. This does not account for the fact that Florida Bay is seen as a very unique destination in terms of recreational fishing with conditions and species not typical of most alternatives. The uniqueness and global recognition of the Bay mean that anglers are likely willing to pay more for the opportunity to fish in Florida Bay then for destinations more typical of those found throughout Florida or the country.

Table 5. Summary of the value and economic impact of some of the ecosystem service benefits provided by Florida Bay. All values are in 2016 dollars. A 3% discount rate was used to calculate annual values and values in perpetuity. Only the economic impact of recreational fishing and commercial fishing were used to calculate total economic impact.

Ecosystem Service	Value in Perpetuity	Annual Value	Annual Economic Impact
Recreational Fishing	$7,121,324,467	$213,639,723	$438,690,467
Commercial Fishing	$426,452,420	$12,793,573	$19,977,299
Residential Real Estate	$1,181,622,839	$35,448,685	---
Carbon Sequestration	$4,529,394,426	$135,881,833	---
Gene pool protection, spiritual experiences, and cognitive information	$1,935,000,000	$58,050,000	---
Total	**$15,193,794,152**	**$455,813,814**	**$458,667,766**

The remainder of this report gives more detail on how these numbers were estimated and the assumptions behind them.

Recreational Fishing

Florida Bay offers extensive outdoor recreational opportunities for boating, birding, swimming, and recreational fishing among other activities. Recreational fishing is one of the most significant outdoor activities throughout Florida and Florida Bay (Adams, 2014; Richardson et al., 2014). Thus, part of the economic value of Florida Bay is the value that it provides to recreational users such as anglers. Economists generally articulate the recreational value of a specific activity at a specific place through the concept of willingness to pay (WTP). For instance, in estimating the monetary value of kayaking at a specific location, economists could employ contingent valuation surveys[2] to ask people what is the maximum amount that they would be willing to pay for the opportunity to kayak at that location.

[2] See discussion in chapter 2 describing techniques to estimate the monetary value of ecosystem services.

There have been no surveys conducted specifically on recreational anglers to determine their willingness to pay to fish in Florida Bay. However, there have quite a few studies that have surveyed recreational anglers throughout the country to estimate their willingness to pay for the opportunity to engage in saltwater fishing at various locations. Hindsley et al. (2012) conducted a benefit transfer study of WTP studies throughout the Unities States and produced a meta-regression model of coastal and marine recreational activities. For the model, extensive data from a database of over 2000 estimates from WTP studies of outdoor recreational activities were used to build a model that accounted for recreation type (fishing, hiking, birding, etc.), characteristics of the recreation population, geographical region (southeastern, west, etc.), study type (peer-reviewed paper, government report, etc.) and type of recreational trip (multi-purpose, multi-trip, etc.) (Hindsley et al., 2012). The authors then used these attributes in the regression model to estimate the value of recreational activities, including saltwater fishing, on Sarasota Bay.

Sarasota Bay, an estuary in South Florida, shares more in common with Florida Bay, in terms of environment and location, than other studies of the willingness to pay of recreational saltwater anglers. Thus, WTP estimates for the value per day of saltwater fishing from the Sarasota Bay study were used in this analysis. To estimate the number of angler days spent fishing in Florida Bay, a survey of Florida anglers was conducted with the assistance of Dr. Tony Fedler at the University of Florida. The survey was conducted from September through November 2016. Since a saltwater fishing license is required for anyone under 65 and not fishing with a licensed guide to fish in Florida Bay, data on saltwater fishing license holders obtained from the Florida Fish and Wildlife Conservation Commission (FWC) were utilized to obtain information on saltwater anglers in Florida.

License holders were stratified into four geographic regions based on where the anglers resided. Region 1 consisted of Miami-Dade, Broward, Collier, Miami-Dade, Monroe, and Palm Beach counties. Region 2 consisted of Charlotte, Desoto, Glades, Hardee, Hendry, Highlands, Lee, Manatee, Martin, Okeechobee, Sarasota, and St. Lucie counties. Region 3 consisted of all other Florida counties and region 4 was defined as the U.S. (except Florida) and Canada. A total of at least 2,000 anglers were selected from each region and were sent an email with a link to an electronic survey implemented by Qualtrics, a survey company. There were at least 500 completed and returned surveys from each region. Hard copies of the survey were also sent through traditional mail to an additional 250 anglers from each zone (some with and some without email addresses) to check for differences between those who did and those who did not provide email addresses with their application for a saltwater fishing license. Among other questions, the survey asked respondents about their fishing habits in Florida and Florida Bay.

Survey results from just licensed anglers underestimate the number of anglers fishing Florida Bay as they do not account for anglers over the age of 65 who do not need a license to fish or those who fished with a guide, who also do not need a license. To account for anglers over the age of 65, the survey results were adjusted with the results from the 2011 U.S. Fish and Wildlife Survey of Hunting, Fishing, and Wildlife Associated Recreation, which included respondents over the age of 65 (U.S. Fish & Wildlife Service, 2014). Based on this survey it was assumed that 23.3% of recreational anglers are over the age of 65. To account for unlicensed anglers who fished with a guide, fishing guides were also surveyed. According to a previous survey done on anglers fishing in the Florida Keys, approximately 73.2% of the anglers fishing with a guide are unlicensed (Fedler 2013). Using this information and data from the survey on the frequency that anglers fish in Florida Bay, the number of angler-days was estimated. One angler-day is defined as one angler spending at least part of a day fishing. The number of angler-days spent by unguided anglers in each zone over one year in Florida Bay is shown in table 6.

Table 6. Estimate of angler-days spent on Florida Bay over the course of one year based on a survey of anglers with a Florida saltwater fishing license. Total angler-days include an estimate of the number of anglers over the age of 65, who do not need a license. These estimates do not include unlicensed anglers fishing with a guide.

	Licensed anglers who spent at least one angler-day fishing Florida Bay	Estimated unlicensed anglers of 65 Years and older who spent at least one angler-day fishing Florida Bay	Average number of angler-days spent fishing Florida Bay per angler	Total number of angler-days spent fishing Florida Bay
Zone 1	60,343	18,331	15.8	1,242,715
Zone 2	23,617	7,174	13.6	417,582
Zone 3	80,476	24,447	6.4	674,308
Zone 4	37,645	11,436	13.1	643,097
Total	**61,388**	**202,081**	**11.3**	**2,977,703**

The number of angler-days spent by unlicensed anglers fishing with a guide on Florida Bay, based on the survey of fishing guides in Miami-Dade, Monroe, and Collier counties, is shown in table 7. The estimates shown in tables 6 and 7 indicated that the total number of angler days spent fishing Florida Bay over the course of a year was 3,037,166.

From table 8 it can be seen that for a single purpose day trip the WTP for a day of fishing is $70.34 and a single purpose multi-day trip is $82.56. Assuming over 3 million days of

Table 7. Estimate of the number of angler-days by anglers fishing with a guide. The adjusted number of angler-days subtracts out the number licensed anglers to prevent double counting with the estimates shown in table 4.

Number of guides guiding in Florida Bay	Mean number of days guided in Florida Bay	Mean anglers per day	Total number of angler-days	Total number of angler-days after subtracting the estimate for those with a license.
362	102	2.2	81,233	59,463

fishing on Florida Bay each year and the conservative estimate for the single purpose day trip of $70.34, Florida Bay is estimated to provide over $213 million in annual benefits to recreational anglers. Assuming these benefits flow every year indefinitely into the future, the value in perpetuity of Florida Bay in terms of recreational fishing is $4.3 billion, $7.1 billion, and $8.5 billion at a 5%, 3%, and 2.5% discount rate respectively.

Table 8. The per day value and annual value of a day of fishing on Florida Bay. Per day values are from Hindsley et al. (2012). The annual values assume 3,037,166 days of fishing per year. All values are in 2016 dollars.

Day Trip		Multi-Day Trip	
Single Purpose	Multi Purpose	Single Purpose	Multi Purpose
Value for Day			
$70.34	$55.24	$82.56	$64.84
Annual Value			
$213,639,723	$167,785,502	$250,752,070	$196,935,918

In addition to the value that Florida Bay provides to recreational anglers, expenditures by these anglers impact the regional and state economy by generating income, jobs, and tax revenue. As described previously, such impacts are frequently estimated using input-output analysis that tracks expenditures through different industries. To estimate the economic impact[3] of recreational fishing in Florida Bay on the economy of Florida, an input-output model was used along with angler expenditure information collected from the above-mentioned survey conducted with Dr. Tony Fedler at the University of Florida. The survey collected information on the yearly expenditures by recreational anglers fishing in Florida Bay. This expenditure information was then used to estimate the direct, indirect, and induced impacts as well as the jobs and tax revenue generated by recreational fishing using the IMPLAN input-output software.

IMPLAN was originally developed by the U.S. Forest Service beginning in the 1970's to evaluate the socioeconomic impacts of forest service planning for U.S. National Forests throughout the nation. Currently it is owned and managed by MIG, Inc. and widely used by governments, industry, and others to estimate the economic impacts of activities on local, state, and regional economies. It uses data collected by the U.S. Department of Commerce, the U.S. Bureau of Labor Statistics, and other agencies to generate a traditional input-output model of 528

[3] In some of the literature economic impact only refers to the influence of some change in economic activity (e.g. a new factory or reduction in fishing) while economic contribution refers to how an existing activity (unchanged) such as recreational fishing influences the economy. To be consistent with terminology used in other studies of fishing and recreation in Florida, the term economic impact is used here.

industry sectors. This information is combined with other data to produce a Social Accounting Matrix of the economy that details linkages not only between industries but also between households and government. Using this information, the IMPLAN model can produce detailed estimates of the impact, including income, jobs, and taxes, of an industry or economic activity in a region, state, or subset of a state (e.g. county, congressional district, or zip code).

To conduct the impact analysis of recreational fishing in Florida Bay, the first step was to collect information from recreational anglers, via survey, on the amount of money typically spent in a year (and on what goods and services) in connection with fishing Florida Bay. As described above in discussing the WTP of recreational anglers, anglers were divided into four distinct regions based on where they reside. Survey questions regarding expenditures were divided up into two categories – trip and equipment. Trip expenditures are related to a single trip while equipment expenditures, such as fishing gear and boat equipment, are not limited to a single trip and can be used multiple times while fishing in Florida Bay and possibly other destinations. For both equipment and trip expenditures respondents were asked what percentage of their expenditures occurred in the Florida Bay region – defined as Monroe, Miami-Dade, and Collier Counties. The resulting mean annual trip and equipment expenditures per unguided angler in the Florida Bay region by zone can be seen in table 9.

To estimate the economic impact of these expenditures only the portion of expenditures that stay in the local or regional economy should be used. For example, when someone purchases something at a local convenience store only a portion of the retail expenditure stays in the local economy. The rest leaves (or is leaked) when the retailer pays wholesale distributers and manufacturers that may be located outside of the local economy. Thus, total angler expenditures per year were calculated in two steps. First, the total number of anglers were multiplied by the mean annual expenditure of anglers in each category. Second, the total retail expenditures were margined so that they reflect only the portion of expenditures that stay in the region (for regional impact analysis) or the state (for statewide regional impact analysis). The IMPLAN model margins these expenditures by using data from the U.S. Bureau of Economic Analysis Input-Output tables. The resulting total expenditures can be seen in table 10. Total annual expenditures for Florida Bay anglers are $204 million for trip expenditures and $37 million for equipment expenditures for a total of $241 million. These expenditures do not include unlicensed anglers that fish with a guide and thus these estimates represent an underestimate of expenditures related to Florida Bay recreational fishing. To account for these anglers, fishing guides were also surveyed. Over 400 of these guides in Miami-Dade, Monroe, and Collier counties were contacted via email and phone and 197 agreed to provide information about their customers and expenditures. To prevent double counting with surveyed licensed anglers, the number of angler days by licensed anglers was subtracted out from the total guided anglers. This was done by assuming that 73.2 percent of all guided anglers were unlicensed based on a previous survey done by Fedler (2013) of guided anglers in the Florida Keys. The resulting expenditure data from the survey of Florida Keys fishing guides are presented in table 11.

The expenditures by licensed and guided saltwater anglers were used with specific industry categories in IMPLAN to estimate the economic impact of Florida Bay recreational anglers. Based on this analysis, the direct impact of recreational fishing in Florida Bay, both guided and unguided, is $259 million. All of the results of the impact analysis can be seen in table 12. The impact of expenditures by recreational anglers fishing in Florida Bay on the regional economy (Monroe, Miami-Dade, and Collier counties) is $439 million per year in economic output, over 4,100 jobs and over $73 million in local, state, and federal tax revenue.

Table 9. Mean annual trip and equipment expenditures of unguided anglers in Florida Bay by zone.

			Trip Expenditures		
Expenditure category	Zone 1	Zone 2	Zone 3	Zone 4	Total
Food, drink, refreshments and ice	$202.59	$138.22	$166.93	$340.52	$206.56
Lodging, including campgrounds	$132.33	$243.09	$203.87	$757.82	$290.29
Public transportation by airplane, car rental including fuel	$1.49	$8.55	$9.66	$146.86	$32.65
Private vehicle transportation, including fuel	$146.51	$95.24	$136.29	$229.16	$151.85
Guide or charter fees	$81.88	$36.19	$83.09	$191.28	$97.40
Fishing licenses and tags	$16.84	$8.26	$16.59	$35.06	$19.13
Live and dead bait	$83.93	$47.50	$50.66	$93.87	$68.27
Boat and equipment rental	$27.32	$14.30	$16.05	$114.58	$37.57
Boat mooring, maintenance, storage, insurance, etc.	$206.64	$102.73	$102.04	$262.61	$163.27
Boat fuel	$290.98	$187.32	$164.66	$346.86	$238.97
Total	**$1,190.50**	**$881.39**	**$949.84**	**$2518.52**	**$1,305.94**
			Equipment Expenditures		
Rods, reels and components	$138.59	$105.29	$50.73	$250.30	$120.52
Lines and leaders	$34.11	$25.85	$15.61	$47.50	$28.27
Hooks, sinkers and swivels	$17.84	$20.06	$9.79	$21.56	$15.59
Artificial lures, baits and flies	$27.42	$30.89	$8.47	$26.78	$20.16
Tackle boxes, creels, landing nets, stringers, gaffs, etc.	$12.08	$24.71	$5.85	$21.53	$12.83
Minnow traps, cast nets, bait containers	$10.18	$6.10	$5.39	$13.86	$8.48
Electronic devices such as fish finders, depth finders and GPS and trolling...	$63.11	$70.18	$20.14	$133.15	$59.87
Boat payments	$193.50	$93.79	$101.90	$237.05	$153.48
Total	**$496.84**	**$376.87**	**$217.89**	**$751.72**	**$419.21**
Total Expenditures	**$1,687.34**	**$1,258.26**	**$1,167.72**	**$3,270.34**	**$1,725.15**

Table 10. Total annual trip and equipment expenditures by unguided anglers in Florida Bay by zone. Total expenditures are calculated using only the portion of expenditures that stay in the regional economy.

			Trip Expenditures		
Expenditure Category	Zone 1	Zone 2	Zone 3	Zone 4	Total
Food, drink, refreshments and ice	$4,391,970	$1,172,774	$4,826,327	$4,605,428	$14,996,500
Lodging, including campgrounds	$10,411,237	$7,485,222	$21,390,882	$37,194,664	$76,482,005
Public transportation by airplane, car rental including fuel	$116,937	$263,179	$1,013,561	$7,208,025	$8,601,702
Private vehicle transportation, including fuel	$1,436,697	$365,514	$1,782,431	$1,401,864	$4,986,505
Guide or charter fees	$6,441,622	$1,114,265	$8,717,907	$9,388,381	$25,662,175
Fishing licenses and tags	$1,324,487	$254,401	$1,740,445	$1,720,724	$5,040,055
Live and dead bait	$2,771,867	$613,971	$2,231,182	$1,934,169	$7,551,189
Boat and equipment rental	$2,149,648	$440,211	$1,684,307	$5,623,662	$9,897,829
Boat mooring, maintenance, storage, insurance, etc.	$16,257,522	$3,163,048	$10,706,194	$12,888,944	$43,015,708
Boat fuel	$2,853,329	$718,898	$2,153,378	$2,121,892	$7,847,497
Total	**$48,155,315**	**$15,591,483**	**$56,246,614**	**$84,087,755**	**$204,081,165**
			Equipment Expenditures		
Rods, reels and components	$4,577,314	$1,361,012	$2,234,362	$5,157,196	$13,329,884
Lines and leaders	$1,126,667	$334,178	$687,724	$978,579	$3,127,148
Hooks, sinkers and swivels	$589,254	$259,305	$431,161	$444,118	$1,723,838
Artificial lures, baits and flies	$905,754	$399,261	$373,212	$551,663	$2,229,890
Tackle boxes, creels, landing nets, stringers, gaffs, etc.	$398,970	$319,423	$257,492	$443,662	$1,419,547
Minnow traps, cast nets, bait containers	$336,099	$78,886	$237,614	$285,501	$938,100
Electronic devices such as fish finders, depth finders and GPS and trolling...	$2,084,459	$907,112	$887,269	$2,743,406	$6,622,246
Boat payments	$2,770,037	$525,465	$1,945,412	$2,117,005	$7,357,919
Total	**$12,788,553**	**$4,184,642**	**$7,054,245**	**$12,721,131**	**$36,748,572**
Total Expenditures	**$60,943,869**	**$19,776,125**	**$63,300,859**	**$96,808,886**	**$240,829,737**

Table 11. Annual trip and equipment expenditures of anglers using fishing guides. The number of angler-days subtracts out the number of licensed anglers to prevent double counting with the estimates shown in table 4. Based on Fedler (2013), it was assumed that 73.2% of anglers fishing with a guide did not have a license. Total annual expenditures reflect only the portion of expenditures that stay in the regional economy.

	Trip Expenditures		
Expenditure Category	**Daily Expenditure**	**Angler Days**	**Annual Expenditure**
Food, drink, refreshments and ice	$49.03	59,463	$802,998
Lodging, including campgrounds	$71.78	59,463	$4,266,072
Public transportation by airplane, car rental including fuel	$9.57	59,463	$568,481
Private vehicle transportation, including fuel	$23.76	59,463	$175,998
Guide or charter fees	$186.44	59,463	$11,080,537
Total	**$340.58**		**$16,894,085**
	Equipment Expenditures		
Rods, reels and components	$26.29	59,463	$655,993
Lines and leaders	$5.61	59,463	$139,852
Hooks, sinkers and swivels	$3.15	59,463	$78,614
Artificial lures, baits and flies	$5.35	59,463	$133,490
Total	**$40.40**		**$1,007,949**
Total Expenditures	**$380.98**		**$17,902,035**

Table 12. Estimated annual impact of recreational fishing in Florida Bay. Results are expressed in 2016 dollars. The economic impact was calculated from expenditures in the Florida Bay region defined as Monroe, Miami-Dade, and Collier counties. The impact in the Florida Bay region is the impact in the region, whereas the Economic Impact in the state is the economic impact that these expenditures have in the entire state of Florida

	Direct Impact	Indirect Impact	Induced Impact	Total Impact	Jobs	Federal Taxes	State and Local Taxes
Economic impact in Florida Bay region	$258,945,833	$86,668,667	$93,075,967	$438,690,467	4,111.64	$40,722,457	$32,354,420
Economic Impact in the state	$258,945,833	$104,220,431	$138,977,700	$502,143,965	4,588.34	$46,114,602	$36,084,314

Commercial Fishing

Florida Bay is important to several commercially valuable fish species. For instance, it provides important juvenile habitat for the economically important Dry Tortugas fishery. Two Dry Tortugas commercial species whose juvenile life stages are dependent on Florida Bay are pink shrimp (*Farfantepenaeus duorarum*) and Gray Snapper (*Lutjanus griseus*) (Browder & Robblee, 2009; Ehrhardt, 2001; Richardson et al., 2014). Data from the Florida Fish and Wildlife Conservation Commission (FWC) was used estimate the value of these two species in commercial terms and what economic contribution they make to Florida's economy.

To estimate the commercial value of pink shrimp and gray snapper, data on the annual amount of the two species harvested from the Dry Tortugas fishery was obtained from FWC's database on Commercial Landings (Florida Fish and Wildlife Conservation Commission, n.d.). The average yearly amount of pink shrimp harvested during a 10-year time span was 4.7 million pounds with a minimum yearly amount of 2.7 million pounds and a high of 6.2 million pounds. The average price of pink shrimp per pound during this time, after adjusting all prices to 2016 dollars using the Consumer Price Index from the Bureau of Labor Statistics, is $2.18 with a low of $1.76 and a high of $3.33. The average yearly amount of gray snapper harvested during this time span was a little over 29,000 pounds with a low of a little more than 11,400 pounds and a high of a little less than 39,000 pounds. The average price of gray snapper during this time, again adjusting to 2016 dollars, was $1.99 per pound with a high of $2.30 and a low of $1.44. The annual amount harvested, the price per pound, and the total value for each year from 2005 to 2015 are shown in table 13.

The average value of the annual harvest of pink shrimp and gray snapper combined is over $12 million. If this is assumed to be the value of the harvest each year indefinitely into the future then the total value in perpetuity of commercial harvest at 5%, 3%, and 2.5% is $256 million, $426 million, and $512 million respectively.

Table 13. The yearly catch, price, and value of landings for gray snapper (Lutjanus griseus) and pink shrimp (Farfantepenaeus duorarum) from the Dry Tortugass commercial fishery. All prices and values have been converted to 2016 dollars. Data are from Florida Fish and Wildlife's Conservation Commission Commercial Fisheries Landings Summaries database.

Year	Pounds (Gray Snapper)	Pounds (Pink Shrimp)	Price per lb (Gray Snapper)	Price per lb (Pink Shrimp)	Total Value (Gray Snapper)	Total Value (Pink Shrimp)
2005	33,089	4,991,555	$2.10	$2.32	$69,341	$11,574,418
2006	28,408	5,329,169	$2.47	$2.62	$70,100	$13,943,238
2007	33,783	2,683,201	$2.44	$2.32	$82,525	$6,221,806
2008	11,432	5,585,233	$2.37	$2.28	$27,076	$12,743,268
2009	22,243	4,397,827	$1.79	$2.29	$39,717	$10,088,615
2010	27,753	6,231,353	$2.84	$2.18	$78,807	$13,599,305
2011	31,635	4,898,796	$2.54	$2.60	$80,416	$12,756,465
2012	38,732	3,861,193	$2.55	$2.86	$98,937	$11,060,001
2013	26,758	3,856,873	$2.49	$3.21	$66,692	$12,386,733
2014	35,760	5,171,715	$2.64	$4.13	$94,449	$21,355,046
2015	32,419	4,852,339	$2.85	$2.93	$92,459	$14,199,885
				Mean	**$72,774**	**$12,720,798**

In addition to providing a valuable product for consumers, commercial fishing generates economic activity in the state. For instance, money is spent on capital (e.g. boats, nets, and other equipment), fuel, and labor. These expenditures provide jobs, income, and state and federal tax revenue. To estimate these effects for commercial fishing, IMPLAN was again used. Based on the annual catch worth a little over $12 million, the annual impact of commercial fishing of pink shrimp and gray snapper in the Dry Tortugas fishery on the economy of Florida is shown in table 14.

Table 14. Estimated annual impact of commercial fishing on the economy of Florida. Results are expressed in 2016 dollars.

Direct Impact	Indirect Impact	Induced Impact	Total Impact	Jobs	Federal Taxes	State and Local Taxes
$12,793,573	3,219,541	$3,964,185	$19,977,299	245.39	$1,559,198	$1,370,295

The impact of commercial fishing for these two species in the Dry Tortugas fishery is almost $20 million per year, over 240 jobs, and almost $3 million in federal, state, and local taxes.

Real Estate Values

Natural amenities such as water bodies, forests, and open space can impact the value of real estate. For example, many home buyers are willing to pay a premium for a home near a significant water body such as Florida Bay. Real estate values are impacted by a range of variables. For example, home prices are influenced by attributes of the home itself (e.g. size, number of bathrooms, year built, condition, etc.), its location (e.g. neighborhood, value of homes nearby, school district, etc.), and general market conditions (e.g. supply of housing, interest rates, state of the economy, etc.) as well as any natural amenities that may be nearby. The challenge for economists interested in the impact of a natural amenity is to measure the effect of only that amenity on the value of real estate. This is usually done using a technique called hedonic regression. Typically, in hedonic regression sale price data is regressed on a wide range of variables accounting for the multiple attributes discussed above as well as a variable representing the natural amenity of interest. Typically, though such regression takes large data sets, these analyses allow economists to isolate the influence of the amenity of interest, such as the proximity to a water body, on real estate values.

Hindsley et al. (2012) conducted such a hedonic regression analysis of the impact of proximity to Sarasota Bay and the Gulf of Mexico on residential real estate in Sarasota and Manatee Counties. The study used data on sales of single family residences from the Sarasota and Manatee property appraiser offices from 2008 through 2010 (Hindsley et al., 2012). A spatial autoregressive hedonic property model[4] was used to regress sale price on a variety of variables, including distance to the Sarasota Bay and the Gulf of Mexico. A large number of structural, locational, and environmental variables were included in the regression including house size, lot size, house quality, neighborhood, if the property was located on a canal or creek, distance to the city of Sarasota, etc. In the regression model distance to the bay was indicated by discrete distance groupings – water front, distance of 100 to 1,000 feet, between 1,000 and 2,000 feet, and between 3,000 and 4,000 feet (Hindsley et al., 2012). From this model, the marginal willingness to pay (MWP) for residential property close to or on Sarasota Bay and the Gulf of Mexico was estimated. For a property located on the Gulf of Mexico the MWP was $595,141 and the MWP of a property located on Sarasota Bay was $454,809 in 2010 dollars. The MWP for a property within 1,000 feet of the Gulf of Mexico was $148,841 and the MWP for a property within 1,000 feet of Sarasota Bay was $90,235 in 2010 dollars. It is important to note that these numbers represent the *additional* amount of money home buyers were willing to pay for a house within the indicated distance of the Gulf of Mexico or Sarasota Bay.

Both Florida Bay and Sarasota Bay are estuary systems in South Florida with similar amenities. Assuming the impact of Florida Bay on residential real estate is similar to the impact of Sarasota Bay, these estimates were used to estimate the impact of Florida Bay on single family homes. All residential real estate proximate to Florida Bay is located in the Florida Keys

[4] A spatial autoregressive hedonic property model is a regression model that accounts for the fact the values for real estate are often spatially correlated.

in Monroe County. First, data on residential real estate in the Keys was obtained from the Monroe County Property Appraisers Office. These data included, among other things, a listing of residential properties in Monroe County and their location. With assistance from Dr. Yogesh Khare at the Everglades Foundation, ArcGIS software was used to identify all single-family homes from Key Largo down to the seven-mile bridge in Monroe County and estimate the distance to Florida Bay for each home. Next, following Hindsely et al. (2012) single family homes were sorted into five groups based on their distance to Florida Bay – waterfront, distance of 100 to 1,000 feet, between 1,000 feet and 2,000 feet, between 2,000 feet and 3,000 feet, and between 3,000 and 4,000 feet. The MWP estimates for each distance category from the Hindsely et al. (2012) study were converted to 2016 dollars using the Consumer Price Index from the U.S. Bureau of Labor Statistics. The number of homes in all distance categories combined was 16,582. For each distance category, the number of homes in that category was multiplied by the MWP for a home in that distance category to obtain the total value that Florida Bay provides to single family homes in that distance category. Results from this analysis are shown in table 15.

Table 15. Estimates of Mean Willingness to Pay (MWP) in 2016 dollars for proximity to Florida Bay for single-family homes and total capitalized value. Total capitalized value is calculated by multiplying the MWP by the number of houses in that distance category. Lower bound and higher bound estimates for MWP are based on the 95% confidence interval. MWP data is adapted from Hindsley et al. (2012).

Distance to Florida Bay	Number of Homes	MWP (Lower Bound)	MWP (Mean)	MWP (Upper Bound)	Capitalized Value (Lower Bound)	Capitalized Value (Mean)	Capitalized Value (Upper Bound)
Water Front	463	$376,198	$504,838	$633,478	$174,130,708	$233,674,360	$293,218,013
100-1000 feet	4,160	$74,756	$100,161	$125,554	$311,007,057	$416,697,181	$522,341,126
1000-2000 feet	4,319	$36,378	$55,322	$74,266	$157,117,075	$238,937,999	$320,754,128
2000-3000 feet	6,001	$23,471	$40,819	$58,166	$140,841,191	$244,941,781	$349,035,710
3000-4000 feet	1,639	$15,932	$28,894	$41,857	$26,119,757	$47,371,518	$68,623,279
Total	**16,582**				**$809,215,788**	**$1,181,622,839**	**$1,553,972,256**

The annualized values for the mean capitalized value at a 5%, 3%, and 2.5% discount rate are $59 million, $35 million, and $30 million respectively.

Carbon Sequestration

As plants grow, the process of photosynthesis converts atmospheric CO_2 to carbohydrates that plants use for energy and the accumulation of biomass. Through this process, plants such as seagrasses sequester carbon from the atmosphere as they grow. Seagrasses cover much of the bottom of Florida Bay, and much of their biomass is stored in below-ground biomass (i.e., roots and rhizomes) as opposed to above-ground biomass, which is mostly comprised of leaves. As a result, seagrass beds represent a significant store of carbon that, if they were to disappear, would be released back into the atmosphere and contribute to global climate change and its attendant negative consequences. Seagrass beds (including the top layer of sediment) can contain as much carbon per hectare as tropical forests (Fourqurean et al., 2012a). Even though seagrass covers approximately only 0.1% of the world's sea floor it accounts for approximately 10% of the global carbon burial by oceans (Greiner et al., 2013). This amounts to between 4.2 million and 8.4 million Megagrams of carbon (MgC) (Fourqurean et al., 2012a).

Fourqurean et al. (2012) conducted an extensive study of the amount of carbon stored in seagrass meadows in Florida Bay. They found that on average the sediment, below-ground biomass, and above-ground biomass in these seagrass beds contain approximately 163.5 MgC per hectare (Fourqurean et al. 2012b). It is well documented that the health and sustainability of seagrass beds in Florida Bay are dependent on maintaining healthy estuarine conditions in the Bay with several seagrass die-offs in recent decades (Hall et al. 2016). Given the extensive area of Florida Bay containing seagrass, if this seagrass were to be lost, a significant amount of CO_2 could be released into the atmosphere[5].

Four basic steps were done to estimate the value of the carbon contained in Florida Bay seagrass beds. First, the area containing seagrass was determined. Next, to estimate the total amount of carbon, this area was multiplied by the amount of carbon per unit area contained in Florida Bay seagrass. Third, the total amount of carbon was converted to carbon dioxide equivalents or (CO_2e). This is done because different greenhouse gases have different impacts on the climate based upon such characteristics as the degree to which they trap heat and the length of time they remain in the atmosphere. To facilitate comparisons, scientists, economists, and climate offset markets typically express the global warming potential of different greenhouse gases with a common metric called carbon dioxide equivalents. A carbon dioxide equivalent of a greenhouse gas (or mix of greenhouse gases) is the amount of CO_2 that would generate an equivalent amount of climate change or global warming.

The amount of Florida Bay covered with seagrass was obtained from personal communication with Dr. James Fourqurean, a Florida Bay seagrass expert at Florida International University. For estimating the size of Florida Bay, the boundaries of the bay were defined as previously. This area represents about 2,250 square kilometers of which 80% or 1,800 square kilometers is covered by seagrass (James Fourqurean, personal communication). Multiplying this area by the average amount of carbon per hectare in Florida Bay, 163.5 Mg C, results in the total amount of carbon in Florida Bay seagrass equal to 29,430,000 Mg C. This number is multiplied by the molecular weight of CO_2 (3.667) to convert to CO_2 equivalents. This results in 107,919,810 Mg CO_2e stored in seagrass beds in Florida Bay.

---

[5] In addition to carbon, there are also ecological implications of releasing the nutrients tied up in seagrass plants back into the water column, leading to algal blooms and lasting water quality problems.

In 2009 and 2010 the U.S. government created the Interagency Working Group on the Social Cost of Carbon (Interagency Working Group on Social Cost of Carbon, 2010; US EPA, 2015). This working group was composed of scientific and economic experts and tasked with estimating the social cost of carbon (SCC). These estimates are intended to be used by the Environmental Protection Agency (EPA) and other government agencies in their calculations of the benefits and costs of programs or projects that are projected to have an impact on climate change through the release of greenhouse gases. The SCC basically estimates the economic damage from the release of one metric ton of CO_2. These estimates include things such as projected net changes in agricultural productivity, human health, damage done by increased flooding, changes in energy costs, etc. (Interagency Working Group on Social Cost of Carbon, 2010; US EPA, 2015). The damages are predicted over a significant period of time, usually until 2300, using three different integrated assessment models (IAM), each producing a range of damage estimates. Four SCC values are produced. Three of these values are based the average SCC of the three IAMs at a discount rate of 2.5%, 3%, and 5%. The fourth value is the 95th percentile estimate of all three IAMs discounted at a 3% discount rate (Interagency Working Group on Social Cost of Carbon, 2010; US EPA, 2015). This later estimate is intended to reflect a future in which damage from climate change is in the upper end of current projections. For carbon emissions in 2015 the latest SCC estimates are \$12/Mg CO_2e (5% discount rate), \$38/Mg CO_2e (3% discount rate), \$58 Mg CO_2e (2.5% discount rate), and \$109 Mg CO_2e (95th percentile) (Interagency Working Group on Social Cost of Carbon, 2013).

Multiplying these prices by the total amount CO_2e in Florida Bay seagrass results in total values of \$1.38 billion, \$4.53 billion, \$7.05 billion, and \$13.21 billion respectively. Annualizing these values using the same discount rates used in the SCC calculations produces annual values of \$69.2 million (5% discount rate), \$135.9 million (3% discount rate), \$176.1 million (2.5%

discount rate), and $396.3 million (95th percentile at 3% discount rate) respectively. These results are summarized in table 16.

Table 16. Estimated monetary value of carbon sequestered in Florida seagrass.

	Discount Rate			
	5%	3%	2.5%	95th percentile at 3% discount rate
Annual Value	$69 million	$136 million	$ 176 million	$396 million
Value in Perpetuity	$1.38 billion	$4.53 billion	$7.05 billion	$13.21 billion

Other Values

There are many other benefits, besides those discussed above, that Florida Bay provides to society. To give an idea of the magnitude of some of these benefits, studies investigating other similar ecosystems can be instructive. For instance, the United Nations recently launched a global initiative called *The Economics of Ecosystems and Biodiversity (TEEB)*. Part of this initiative is to compile estimates of the economic value of various ecosystem services from different ecosystems around the world. Results from this initiative have given estimates of gene pool protection, spiritual experiences, and cognitive information (e.g. education and science) of $209, $24, and $25 per hectare (adjusted to 2016 dollars) per year for the coastal biome[6] (de Groot et al., 2012; Turpie et al., 2003). If Florida Bay is assumed to be approximately 225,000 hectares (or 2,250 square miles) in size, then the total value for these three ecosystem services is $58 million per year. The total value in perpetuity at a 5%, 3%, and 2.5% discount rate is $1.2 billion, $1.9 billion, and $2.3 billion respectively. A summary of these results can be seen in table 17.

[6] The coastal biome was defined as sea-grass fields, shallow seas of continental shelves, rocky shores and beaches (de Groot et al., 2012).

Table 17. Estimated value of gene pool protection, spiritual experiences, and cognitive information from Florida Bay.

		Value in Perpetuity		
	Annual Value	**5%**	**3%**	**2.5%**
Value of gene pool protection, spiritual experiences, and cognitive information	$58 million	$1.2 billion	$1.9 billion	$2.3 billion

Chapter 5: Conclusions

The total value of the ecosystem service benefits provided by Florida Bay analyzed in this study comes to over $15 billion. To put this number into context, the Mather study concluded that Everglades restoration overall would produce $46.5 billion (2010 dollars), Richardson et al. estimated the benefits of CEPP would be about $1.8 billion (2014 dollars), Wiesskoff (2005) estimated all of South Florida ecosystems (including agricultural and urban areas) produce approximately $68 billion annually (2000 dollars), and finally surveys indicated that Florida residents were willing to pay $3.4 to $4 billion (1999 dollars) over 10 years for Everglades restoration (Cunningham, 2007; McCormick et al., 2010; Milon et al., 1999; Richardson et al., 2014). In addition, the annual economic impact of recreational fishing in Florida Bay was estimated to be over $438 million and the impact of commercial fishing (for pink shrimp and gray snapper) is almost $20 million. To put these numbers in context, the annual economic impact of recreational saltwater fishing in the Everglades region was estimated to be over $800 million (2009 dollars), and recreational fishing in the Keys was estimated to be over $700 million overall and over $400 million for flats fishing (both 2013 dollars) (Fedler, 2009; 2013).

This was the first study to systematically look exclusively at the economic significance of Florida Bay. The substantial value of the ecosystem service benefits analyzed in this study hopefully provides some insight into the importance of protecting Florida Bay and the Everglades on which it depends. Future studies should include analyses of other ecosystem services that likely have substantial value. For instance, studies on non-fishing recreational activities dependent on Florida Bay, other commercially valuable species in which the Bay provides important habitat, and ecosystem services specific to its seagrass beds, such as the benefits it provides to Florida's coral reefs, would be particularly useful.

References

Adams, A. (2014). Listening to the Fish. In D. Burkhardt (Ed.), *Florida Bay Forever: A Story of Water from the Everglades to the Keys* (pp. 80–87). Moreley, MO: Acclaim Press.

Browder, J. A., & Robblee, M. B. (2009). Pink shrimp as an indicator for restoration of everglades ecosystems. *Ecological Indicators*, *9* (6), S17–S28.

Browder, J. A., Zein-Eldin, Z., Criales, M. M., Robblee, M. B., Wong, S., Jackson, T. L., & Johnson, D. (2002). Dynamics of pink shrimp (Farfantepenaeus duorarum) recruitment potential in relation to salinity and temperature in Florida Bay. *Estuaries*, *25* (6), 1355–1371.

Bureau of Economic Analysis. (2013). *RIMS II: An essential tool for regional developers and planners*. U.S. Department of Commerce. Retrieved from www.bea.gov

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., et al. (1997). The value of the world's ecosystem services and natural capital. *Nature*, *387* (6630), 253–260.

Cunningham, S. (2007). The Economics of Everglades Restoration, Richard Weisskoff. Edward Elgar Publishing (2005), ISBN: 1843762420. *Ecological Economics*, *60* (4), 850–851.

de Groot, R., Brander, L., van der Ploeg, S., Costanza, R., Bernard, F., Braat, L., et al. (2012). Global estimates of the value of ecosystems and their services in monetary units. *Ecosystem Services*, *1* (1), 50–61.

Ehrhardt, N. (2001). Density-dependent linkage between juveniles and recruitment for pink shrimp (Farfantepenaeus duorarum) in southern Florida. *ICES Journal of Marine Science*, *58* (5), 1100–1105.

Fedler, T. (2009). *The Economic Impact of Recreational Fishing in the Everglades Region* (pp. 1–17).

Fedler, T. (2013). *Economic Impact of the Florida Keys Flats Fishery* (pp. 1–27).

Florida Fish and Wildlife Commission. (n.d.). Commercial Fisheries Landings Summaries. Tallahassee, FL: Florida. Retrieved from https://publictemp.myfwc.com/FWRI/PFDM/

Fourqurean, J. W., Duarte, C. M., Kennedy, H., Marbà, N., Holmer, M., Mateo, M. A., et al. (2012a). Seagrass ecosystems as a globally significant carbon stock, *5* (7), 505–509.

Fourqurean, J. W., Kendrick, G. A., Collins, L. S., Chambers, R. M., & Vanderklift, M. A. (2012b). Carbon, nitrogen and phosphorus storage in subtropical seagrass meadows: examples from Florida Bay and Shark Bay. *Marine and Freshwater Research*, *63* (11), 967.

Greiner, J. T., McGlathery, K. J., Gunnell, J., & McKee, B. A. (2013). Seagrass Restoration Enhances “Blue Carbon” Sequestration in Coastal Waters. *PLoS ONE*, *8* (8), e72469.

Hall, M. O., Furman, B. T., Merello, M., & Durako, M. J. (2016). Recurrence of Thalassia testudinum seagrass die-off in Florida Bay, USA: initial observations. *Marine Ecology Progress Series*, *560*, 243–249.

Hindsley, P. R., Debure, K. R., & Morgan, O. A. (2012). The Sarasota Bay Economic Valuation Project: Phase I, 1–94.

Interagency Working Group on Social Cost of Carbon. (2010). *Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866 (February 2010)* (pp. 1–51). United States Government.

Interagency Working Group on Social Cost of Carbon. (2013). *Technical Support Document: - Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis - Under Executive Order 12866* - (pp. 1–21). United State Government.

Jerath, M., Bhat, M., Rivera-Monroy, V. H., Castañeda-Moya, E., Simard, M., & Twilley, R. R. (2016). The role of economic, policy, and ecological factors in estimating the value of carbon stocks in Everglades mangrove forests, South Florida, USA. *Environmental Science & Policy*, *66*, 160–169.

Kumar, P. (Ed.). (2012). Chapter 1 Integrating the ecological and economic dimensions in biodiversity and ecosystem service valuation. In *The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations* (pp. 1–40). New York, NY: Routledge.

Leeworthy, V. R., & Ehler, R. (2010). *Economic Contribution of Recreating Visitors To The Florida Keys/Key West 2007-08* (pp. 1–26).

McConnell, E., Jeuck, J., Bardon, R., Hazel, D., Altizer, C., & New, B. (2016). *Methodology for Determining Forest Sector Contributions to North Carolina's Economy: Forestry Impacts*.

McCormick, B., Clement, R., Fischer, D., lindsay, M., & Wilson, R. (2010). *Measuring the Economic Benefits of America's Everglades Restoration (*pp. 1–173).

Millennium Ecosystem Assessment. (2005). Ecosystems and Human Well-Being (pp. 1–137). Washington, DC: Island Press.

Milon, J. W., Hodges, A. W., Rimal, A., Kiker, C. F., & Casey, F. (1999). *Public Preferences and Economic Values for Restoration of the Everglades/South Florida Ecosystem* (pp. 1–124).

Mulkey, D., & Hodges, A. W. (2015). *Using Implan to Assess Local Economic Impacts* (No. FE168) (pp. 1–7).

Richardson, L., Keefe, K., Huber, C., Racevskis, L., Reynolds, G., Thourot, S., & Miller, I. (2014). Assessing the value of the Central Everglades Planning Project (CEPP) in Everglades restoration: An ecosystem service approach. *Ecological Economics*, *107* (C), 366–377.

Rosenberger, R. S. (n.d.). Recreation Use Values Database. Corvallis, OR.

Tietenberg, T., & Lewis, L. (2009). Environmental Economics and Policy (6 ed.). Boston: Addison-Wesely.

Turpie, J. K., Heydenrych, B. J., & Lamberth, S. J. (2003). Economic value of terrestrial and marine biodiversity in the Cape Floristic Region: implications for defining effective and socially optimal conservation strategies. *Biological Conservation*, *112* (1-2), 233–251.

US EPA. (2015). *Social Cost of Carbon, EPA Fact Sheet (December 2015*) (pp. 1–4). United States Government.

U.S. Fish & Wildlife Service. (2014). 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (No. FHW/11-NAT (RV), 2014 ed.) (pp. 1–161). U.S. Department of the Interior. Retrieved from https://www.census.gov/prod/2012pubs/fhw11-nat.pdf

Weisskoff, R. (2005). The Economics of Everglades Restoration: Missing Pieces in the Future of South Florida. Cheltenham, UK

The author would thank Dr. Puneet Dwivedi (University of Georgia), Dr. Thomas Ochuodho (University of Kentucky), and Dr. Mahadev Bhat (Florida International University) for reviewing this document. All errors remain mine.