Advancing Marine Conservation in New York Waters through Ecological Valuation

Marielena Alcaraz, Evan Carfagno, Maria Jose Guillen, Graham Higgins, Amber Ingram, Aharon Kestenbaum,

Courtney Lang, Lucy Lu, Jamie Nash, Carl Otto, Manoela Reis, Bradley Visokey

Executive Summary

The New York Bight is a 16,000-square-mile coastal ecosystem from Montauk, New York, to Cape May, New Jersey comprising of both marine and estuarine habitats that are critical to the preservation of biodiversity in the region. In addition to their value as essential components of functional, healthy ecosystems, many products of the New York Bight are of significant economic, cultural, and recreational value to the more than 22 million people who live in the tri-state region. Whether as extractive, direct-use resources like edible fish, shellfish, and waterfowl, or as non-extractive observable wildlife such as whales or migratory birds, the values to society of viable ecosystems are often inestimable and diverse. While market value for marine commodities and revenue from associated businesses are easily quantified, less tangible benefits like aesthetic and cultural value are difficult to incorporate into a balance sheet.

This paper attempts to assign not only monetary, but inherent and often intangible value to ecosystems and their component parts in an effort to aid in conservation policy-making for the New York Bight. Where possible, this paper provides valuation methodologies used to calculate the estimated quantifiable value of the ecosystem services laid out in each of the three case studies. Through the process of extrapolating the values of the shortfin mako shark, an apex predator; the river herring, a forage fish; and the broader ecotourism industry within the New York Bight, a suite of valuation methodologies were examined. While the process of valuing the entirety of the New York Bight is a significant challenge, these three case studies each offer an opportunity to examine key components of the ecosystem. Each case study — and the respective market and non-market indicators incorporated in its value — reveals the broader complexities associated with the ecosystem service valuation process. This paper also identifies research gaps that need to be filled in order to more accurately estimate value using less common methods, such as ecological production function and willingness to pay. The ability to quantify the price of natural assets — recognizing the environmental, economic, and social values of ecosystem services — can influence policy-making and even public perception toward conservation.

Across the three case studies examined in this report, the financial benefits of marine conservation are clearly demonstrated. Each case study integrated ecological and financial data to create a model that compared a baseline scenario to an alternative that would, through conservation policy, increase the health of the ecosystem. To standardize the case studies against each other — and because ecosystem changes require time to take effect — a ten year period was

analyzed for each, comparing a series of chosen value streams and operational costs associated with each examined ecological resource. Ultimately, the net cash flows from each scenario were discounted to a net present value (NPV) at a 2.5 percent discount rate to match the current federal fixed income rate. Across all chosen case studies, the scenario incorporating conservation policy resulted in a higher valuation than the baseline. Within the scope of this report, it is clear that targeted conservation efforts that advocate for the sustainable management of marine resources offer the opportunity to generate economic value in the New York Bight.

Background on the Bight

Part of the larger Mid-Atlantic Bight Region of the North Atlantic Ocean, the New York Bight extends seaward nearly 100 miles out to the limit of the continental shelf (U.S. Fish and Wildlife Service, 1997). "Bight" is a general term for a natural bend or curve in the shoreline of an open coast. The vastness of its relatively shallow continental shelf and the number of adjacent high-quality estuary systems that nurture and protect estuarine-dependent fish are major contributing factors to this area's biodiversity. Home to more than 338 species of marine fishes, including more than 40 species of sharks and rays, the New York Bight also provides critical migration routes for globally threatened species like sea turtles and whales (New York Seascape, 2019).

The New York Bight has been an important resource for the tri-state region for thousands of years. When the Lenape people settled the east coast of North America between 7,000 and 10,000 years ago, they gathered oysters and other shellfish from New York's coastal waters (Kurlanski, 2016). Oysters and clams were once plentiful in the New York Bight, and the indigenous people cultivated these ecosystems by returning oyster shells to the ocean as a base for future spat. Fish figure strongly into the history of the New World, with cod oil and flesh bringing westward-moving European fishing fleets to rich North American waters in the seventeenth century. Today, the New York-New Jersey harbor is home to the largest port complex on the U.S. East Coast. The three shipping lanes that enter New York Harbor are busy areas for commercial vessels, and U.S. international container traffic is projected to at least double from 2001 to 2020. Because this port generates $30 billion in revenue and $620 million in state and local taxes annually, there is a significant economic incentive to dredge — remove material from one part of the water environment and relocate it to another — in order to maintain

navigation channels and port access (New York Ocean Action Plan, 2017). This process has the potential to harm key components of the New York Bight's ecosystem, limiting the positive financial impact of its associated ecosystem services.

The New York Bight's beaches, bays, and estuaries boast ample opportunity for recreational activities like fishing, hiking, diving, and bird-, whale-, and seal-watching. According to the New York State Department of Environmental Conservation (DEC), the approximately 65 million people who visit New York state parks each year contribute nearly $2 billion in economic activity annually. Commercial and recreational fishing are major economic drivers in New York, landing more than 27 million pounds of finfish and shellfish combined in 2011, worth $37.6 million and generating $5 billion in sales in local communities. In 2011, these industries contributed $1.8 billion to the gross state product, and supported 42,000 jobs. That same year, recreational anglers generated $369 million in sales, contributed $212 million to gross state product, and supported 3,000 jobs. Additionally, aquaculture contributes approximately $13 million to the New York economy, of which $11 million is from shellfish and $2 million is from finfish (New York Ocean Action Plan, 2017).

These benefits are made possible by the uniquely diverse and productive ecosystems present in the New York Bight. Each habitat type provides specific resources for key species, both endemic and migratory. The Hudson River estuary — the mouth of the Hudson where ocean tide meets river — is ranked among the most productive systems on the northern Atlantic coast for fisheries (U.S. Fish and Wildlife Service, 1997). Marine spawning species use the lower estuary as a nursery area, while estuarine fish — including winter flounder, bay anchovy, hogchoker, and mummichog — use this area to reproduce. Many species of shellfish are also found in the estuary, although they are not certified for human consumption due to existing water quality concerns. The habitat is critical for birds, including vulnerable species like the peregrine falcon, bald eagle, and osprey. The U.S. Fish and Wildlife Service (1997) documents 240 species of special emphasis that are crucial to the health of the broader ecosystem and regularly use the lower Hudson River estuary, including 151 bird species and 80 fish species.

The nearshore zone (the area of marine waters between Cape May and Montauk Point, offshore to the sixty-six foot depth contour) is significant for more than 60 species of marine and anadromous fish. Anadromous fish use the nearshore zone as a feeding area, moving up the Hudson River during warmer seasons to spawn, and undertaking long coastal migrations to semi-

tropical waters in the fall and winter. Commercially and ecologically important marine species in the nearshore zone include Atlantic menhaden, a schooling pelagic (open-ocean) fish, as well as river herring (see Case Study 1 below) and squid, which are utilized for food by tunas, coastal sharks, marine mammals, and birds (U.S. Fish and Wildlife Service, 1997). Marine mammals and sea turtles also use the nearshore zone, many of which are endangered or threatened species. According to the Wildlife Conservation Society (WCS), priority species for conservation include American eel, river herring, sand tiger shark, shortfin mako shark, blue shark, smooth dogfish, skates and rays, and seven species of whales.

The U.S. Fish and Wildlife Service (1997) states that continental shelves of the world's oceans represent only about 10 percent of the total area, but 99 percent of the global fish harvest. In the New York Bight, two to four times greater primary productivity than comparable continental shelf systems has been observed, and can be attributed to nutrient enhancements from the area's rich estuarine systems. Besides the well-known pelagic fish, the New York bight is full of benthic organisms — living at the ocean's bottom — like ocean quahog, as well as echinoderms, annelids, arthropods, and plankton as well (U.S. Fish and Wildlife Service, 1997). Benthic organisms (benthos) are often considered indicators of anthropogenic environmental stress because of their orientation to the bottom of the ocean, where chemical contamination often settles (U.S. Fish and Wildlife Service, 1997). In addition to their ecological significance, benthos can also relay important information about the health of the ocean to humans studying it.

The Hudson Canyon, an extension of the Hudson River Valley, is another ecosystem in the Bight that is critical for area biodiversity. It runs from the break of the continental shelf up to 400 nautical miles out to sea, at points reaching depths of 10,500 feet (Marine Conservation Institute, 2019) — comparable in size to the Grand Canyon. It contains diverse deep-sea life, including extensive and complex deep sea coral and sponge formations, and provides an over-wintering refuge for fish species like summer flounder and black sea bass. Tilefish are commercially significant and unique to the canyon, using the steep walls to create funnel-shaped burrows. They feed mostly on crustaceans, but stomach content analysis has revealed the presence of galathied crabs, bivalve mollusks, echinoderms, annelid worms, sea cucumbers, anemones, tunicates, sea urchins, American lobster, shrimp, and squids in the Hudson Canyon (U.S. Fish and Wildlife Service, 1997).

A study by Worm et al. (2006) concluded that positive relationships exist between biodiversity, ecosystem function, and ecosystem services in coastal and marine environments. Ecosystem services are the varied benefits that humans gain from properly-functioning ecosystems in the natural environment, usually grouped into the categories of provisioning (fish to eat or timber to sell), regulatory (ecosystem processes such as climate regulation and water purification), supporting (providing living places for plants and animals), and cultural (ecosystems supporting indigenous gathering techniques, or supplies for traditional clothing) (World Bank, 2004). Ecosystem services in the New York Bight range from market products like fish to non-market services like coastal protection, erosion control, nutrient cycling, water purification, and carbon sequestration (Barbier et al., 2011). Each of the chosen case studies in this report demonstrates a range of ecosystem service valuation tools and details the inherent complexity associated with valuing these material environmental services.

State of the Bight

Beginning with the first European settlers' neglect to return oyster shells to seabeds as the Lenape people had, the New York Harbor oyster population has continued to decline exponentially into modern times, becoming an archetype for the mismanagement of natural resources. As the population of this key ecosystem engineer began to decline, so do did the health of the broader aquatic ecosystem. The development of more advanced commercial fishing equipment and techniques in the 18th, 19th, and 20th centuries led to an overfishing predicament that is present today. Core marine and coastal species have declined in alarming numbers, compounded by other anthropogenic effects like pollution and climate change (Sanderson, 2013).

Although most are considerably diminished compared to pre-colonial conditions, the New York Bight is still rich in living resources despite more than 300 years of human settlement and its impacts (U.S. Fish and Wildlife Service, 1997). Ecological consequences from urban and suburban development include pollution by industrial effluents, chemical and oil spills, human sewage, recreational overuse, floatable materials, dredging and dredged material deposition, over-harvesting of fishery resources, competition from exotic and invasive species, and destruction of essential natural habitats. WCS also cites increased vessel traffic; inadequate fisheries management; coastlines vulnerable to natural disasters; climate change and its

associated impacts, such as extreme weather and rising sea levels; the lack of a New York ocean ethic; and under-prioritization of marine conservation efforts as threats to the New York Bight.

WCS's New York Seascape Program seeks to restore healthy populations of target species, protect key offshore and nearshore habitats in the Mid-Atlantic, and inspire a local ocean ethic and a vocal marine conservation constituency in the New York Bight (New York Seascape, 2019). Since 2010, WCS has been conducting field research to understand the migratory movements and habitat use of key species in order to further conservation efforts. Their goals include the development of a Mid-Atlantic Ocean Action Plan, and to secure additional protection for the Hudson Canyon and other ecologically rich areas. In 2016, WCS pursued National Marine Sanctuary nomination with the National Oceanic and Atmospheric Administration (NOAA) for the Hudson Canyon, which was reviewed and deemed successful in 2017. NOAA's Office of National Marine Sanctuaries serves as the trustee for a network of underwater parks as the organization works with diverse partners and stakeholders to promote responsible, sustainable ocean uses that ensure ocean health (NOAA, 2019).

In 2016, the New York Aquarium engaged in a Mid-Atlantic Fishery Management Council (MAFMC) effort to establish protections for unmanaged forage species — fish and invertebrates that serve as the base of the food chain. The Mid-Atlantic Unmanaged Forage Omnibus Amendment (2017) prevents the development of new, and the expansion of existing, commercial fisheries on certain forage species until the MAFMC has adequate opportunity and information to evaluate the potential impacts of forage fish harvest on existing fisheries, fishing communities, and the marine ecosystem. The amendment implements an annual landing limit, possession limits, and permitting and reporting requirements for Atlantic chub mackerel and certain previously unmanaged forage species caught within Mid-Atlantic Federal waters.

Problem Statement

With competing human and natural interests, conservationists face myriad obstacles and opponents ranging from political and industry stakeholders to a lack of data that quantifies the ecological and economic importance of keeping species in the water. In addition, extractive market activity such as commercial fishing, interest in oil and gas exploration and development, as well as offshore wind development, threaten to compromise ecosystem function in the New York Bight. In 2017, United States President Donald Trump issued an "America-First Offshore

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Energy Strategy" to open previously protected parts of the Outer Continental Shelf (OCS) to oil and gas exploration (New York State Assembly, 2019). The Bureau of Ocean Energy Management (BOEM) oversees the National Outer Continental Shelf Oil and Gas Leasing Program for oil and gas development, which establishes a schedule of oil and gas lease sales proposed for areas of the OCS. The program specifies the size, timing, and location of potential leasing activity that the Secretary of the Interior determines will best meet national energy needs (BOEM, 2019). While the program has been sidelined indefinitely as of April 2019 (Puko, 2019), and New York State passed a ban on granting permits for oil or gas exploration in offshore areas controlled by the state (Associated Press, 2019), ecosystems are still at risk. With species migrating from southern waters to access the New York Bight, oil and gas exploration anywhere in proximity could pose a threat (New York Seascape, 2019).

In 2015, New York State Governor Andrew Cuomo established a benchmark that New York utilities must source 50 percent of their electricity from renewable energy by 2030. In 2017, Cuomo set a target that 2.4 gigawatts (GW) of that power would be generated by offshore wind (OSW). On January 16, 2019, the Governor announced a quadrupling of New York's offshore wind target to 9 GW by 2035, and shortly after New Jersey Governor Murphy signed a bill committing New Jersey to the goal of 3.5 GW of OSW by 2030. Although renewable energy development offshore is a critical step toward reducing New York's and New Jersey's contributions to greenhouse gas (GHG) emissions, it comes with environmental risks of its own. OSW development is a complicated, multi-phased process that includes planning and analysis, leasing, site assessment, construction, operations, and decommissioning. Each phase involves various risks for marine wildlife, such as habitat disturbance from geologic and geophysical surveys and construction, enhanced risk of ship strikes from increased vessel traffic, noise from exploratory surveys and pile driving during construction, and electromagnetic fields from seafloor cables that deliver power from the turbine to the shore (WCS, 2019).

In order for conservationists to compete with industry stakeholders with readily available economic incentives to overfish, pollute, drill, and dredge, they must come to the table with their own economic reasons for keeping ecosystems intact and functional. Ecosystem valuation attempts to capture the range of benefits, as well as the costs and trade-offs, associated with complicated natural webs, by using a range of economic methodologies. Often taken for granted as public benefits, ecosystem services lack a formal market and are traditionally absent from

society's balance sheet (de Groot et. al, 2012). As a result, their critical contributions can be overlooked in public, corporate, and individual decision-making. Quantifying the price of natural assets — recognizing the environmental, economic, and social values of ecosystem services — is one way to promote conservation. According to Stahl (2008), the success of a decision often hinges on an accurate portrayal of the value of ecological resources, the trade-offs to be made, and other factors that may be important to the array of stakeholders, such as their willingness to accept risk, which changes across the range of the perceived value of the resource as well as among cultures, geographical regions, and generations.

Ecosystem valuation is not a perfect science, although the need for an integrated approach between ecology and economics has been widely recognized. According to Barbier et al. (2011), "the fundamental challenge of valuing ecosystem services lies in providing an explicit description and adequate assessment of the links between the structure and functions of natural systems, the benefits (i.e., goods and services) derived by humanity, and their subsequent values." One of the problems facing ecosystem valuation is a lack of understanding about the effects of a change in ecosystem function on the ecosystem service, and thus its value to humans. Measurement issues, data availability, and other limitations continue to prevent the application of standard valuation methods to many ecosystem services. Omitted variable bias — a statistical problem stemming from unknown or unaccounted-for variables in a model — results in the model attributing the effect of the missing variables to the estimated effects of the included variables. Thus, if data about an ecosystem is missing, and corresponding valuation models are constructed without this information, the estimated value will include a significant margin for error. If ecosystem valuation is to become more accurate, ecological data like food web modeling must be further studied — and the standard deviation reduced — in order to correctly identify all inputs and variables (Barbier et al., 2011). Thus, valuation with a conservation focus is best accomplished through a three-pronged system: Identify, Quantify, Monetize. This framework hinges upon the need to correctly identify all of the complex processes that create a valuable ecosystem function before attempting to determine the quantity of services or their monetary value.
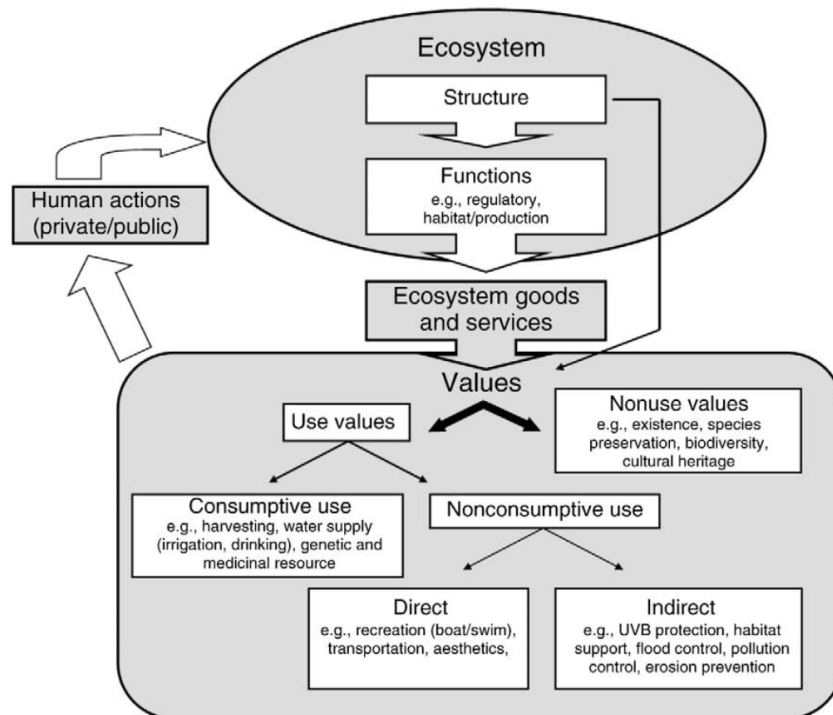
Figure 1: Economic valuation of ecosystem goods and services. UVB is ultraviolet-B radiation from sunlight, which can cause skin cancer. Figure from Barbier et al. (2011).

Valuation of Ecosystem Services

Ecosystem valuation can be categorized into use value or non-use value. Use-value includes direct-use value — the direct ecological yield as it would exist in commodity markets — and indirect-use value, or value attributed to indirect utilization of ecosystem services, through the positive externalities that ecosystems provide. Examples for direct-use value include the market price of water, timber, fish, or other commodities if immediately developed and sold. Direct-use can be consumptive, such as harvesting of food products, or non-consumptive, like the enjoyment of recreational and cultural activities that do not require harvesting of products. Indirect-use values are derived from ecosystem services that provide benefits outside the ecosystem itself, like natural water filtration which often benefits people far downstream, and carbon sequestration which benefits the entire global community by abating climate change (World Bank, 2004). Non-use values are often less tangible, but markets are being created to price them. Some examples are option value, attributed to preserving the option to utilize ecosystem services in the future; existence value, attributed to the pure existence of an

ecosystem; altruistic value, based on the welfare the ecosystem may give other people; and bequest value, based on the welfare the ecosystem may give future generations.

Some ecosystem services, like carbon sequestration, are more readily monetized through markets or incentives, while others, like biodiversity, are more difficult to quantify in economic terms. Biodiversity contributes to the health of the ecosystem itself (Worm et al., 2006), but is also valuable to humans for recreational and cultural purposes. Methods to value these benefits exist, but contain inherent uncertainties, potential bias, and margin for error. Aesthetic and cultural value might best be quantified using tools like contingent valuation — a survey-based economic technique for the valuation of non-market resources, such as environmental preservation or the impact of contamination — or "existence value," where people are asked what dollar amount they would pay for the knowledge that a species exists. Often, this type of valuation is done for "charismatic megafauna" like whales or elephants, whose presence on Earth give most people a sense of joy. However, species that are less recognizable, have negative reputations (like sharks), or are more difficult to anthropomorphize in the eyes of survey respondents are likely to be undervalued by this technique, unless the species is known to provide an irreplaceable ecosystem function (like honeybees) (Marris, 2013). Another type of stated preference valuation is choice modeling, in which a questionnaire asks respondents to state their preference for the ecosystem services under consideration. Value transfer techniques — which adapt monetary values from past valuation studies and transfer the respective economic values to the area under consideration — are also useful when data for a given location is unavailable or incomplete (UNEP, 2014).

Since ecosystem services produce both market and non-market benefits, economists use a wide range of tools including market and non-market valuation techniques. Monetary-based techniques can further be broken down into Supply-based, Demand-based (market), Cost-based, Contingent valuation, and Value transfer, while ecosystem-based techniques include Habitat Equivalency Analysis and Ecosystem Service Analysis (UNEP, 2014).

Approach/technique	Description	Examples
Supply-based		
Ecological production function*	Relates changes in the output of marketed goods and services to a	The reduction in fishery output as a result of clearing a mangrove

	measurable change in ecosystem goods and services	swamp or salt marsh
Habitat equivalent analysis	This technique uses an algorithm to determine the amount of environmental compensation required based on units of habitat damaged and created	The approach may determine that 3.5m2 of coral reef needs to be restored for every 1m2 of damaged coral reef
Ecosystem service analysis	The level of ecosystem service compensation required is based on biophysical units of the resources damaged and created	Five hundred trout need to be replaced in a river damaged by a pollution incident
Demand-based		
Market prices*	How much it costs to buy an ecosystem product or service or what its sales value is	The market price of timber, fish or water
Travel cost	Using information on the amount of time and money people spend visiting an ecosystem for recreation or leisure purposes to calculate a value per visit	The transport and accommodation costs, entry fees and time spent visiting a national park
Hedonic pricing	The difference in property prices or wages that can be ascribed to different ecosystem qualities or values	The difference in price between houses overlooking the sea or areas of natural beauty compared to similar ones that do not
Cost-based		
Replacement cost	The cost of replacing ecosystem goods or services with artificial or man-made products, infrastructure or technologies	The cost of coastal protection infrastructure after the loss of mangrove swamps and coastal wetlands
Mitigating or averting expenditure	The cost of mitigating or averting the negative effects of ecosystem services loss (similar to replacement costs)	The additional water treatment infrastructure required to maintain water-quality standards after the loss of natural wetlands
Avoided damage cost	The costs incurred to property, infrastructure and production when ecosystem services that protect economically valuable assets are lost, in terms of expenditure saved	The damage to roads, bridges, farms and property resulting from increased flooding after the loss of catchment-protecting forest
Contingent valuation		
Willingness to pay (WTP)*	Identify ecosystem values by asking people directly (via survey, in-person, or through a focus group) what their willingness to pay for	How much would you be willing to contribute towards a fund to clean up and conserve a river?

	them or accept compensation for their loss is	
Stated preference	Presents a series of alternative resource or ecosystem use options, each defined by various attributes set at different levels (including price) and asks respondents to select which option (i.e. sets of attributes at different levels) they prefer	Respondents' preferences for conservation, recreational facilities and the educational attributes of natural woodlands
Value transfer		
Unit value*	This technique uses average willingness to pay values taken from existing and similar studies, and adapts these to specific cases, taking into account key factors that characterize the two contexts, including income levels and the impacts on ecosystem services – i.e. the environmental impact	The average willingness to pay of recreational visitors to one beach area in Cuba applied to another similar beach in the country. If applied to a beach in another small island developing state, the value is converted using difference in gross domestic product/capita factor
WTP transfer function	This technique uses the benefit or 'bid' function, a formula that describes the willingness to pay value in terms of key characteristics (e.g. environmental and socioeconomic factors, such as incomes)	Insert specific site-related variables (e.g. average income, education levels) into the willingness to pay bid function for visitors to a beach in Cuba (policy site) calculated for a similar beach in another small island developing state (study site)
Meta analysis	This technique takes the results of a number of studies and analyses them in such a way that their variations in willingness to pay values can be explained	Analysis of many willingness to pay studies for beach recreation worldwide to identify trends in the key variables affecting willingness to pay values to establish a suitable value or macroeconomic adjustments for the country being assessed

methods used in this paper

Figure 2: Contains definitions for each of these techniques as specified by the United Nations Environment Programme (UNEP).

A well-known example of a technique used in scientific studies is the ecological production function, a set of mathematical expressions that estimate the effects of changes in the structure, function and dynamics of an ecosystem on outputs that are directly relevant and useful to decision-makers. Once collected, this information is used to calculate the levels of ecosystem services and biodiversity required to offset their loss from damaged areas of similar habitat

(UNEP, 2014). According to Barbier et al. (2011), the first step involves determining how best to characterize the change in ecosystem structure, functions, and processes that gives rise to the change in the ecosystem service. For instance, the change could be in the spatial area or quality of marsh vegetation, or a change in a key population, such as fish or apex predator. The second step requires tracing how the changes influence the quantities and qualities of ecosystem service flows to people, which requires a deep ecological understanding of inputs and outputs. Only when these first two steps are completed is it possible to conduct the final step, which involves using existing economic valuation method to assess the changes in human well-being that result from the change in ecosystem services (Barbier et al., 2011).

Methodology: Ecological Production Function

In economics, a production function describes the relationship between inputs and outputs, where inputs can refer to the amount of labor, land, and capital used in the production of a good (output) (UNEP, 2014). In an ecosystem valuation context, the production function method assesses the contribution of healthy ecosystem functions as additional inputs to the output of commercially marketed goods. Ecosystem functions can also be valued through quality-based criteria, in that their quality affects the productivity of other inputs. An example in the New York Bight of the quality of an ecosystem affecting populations can be seen with forage fish species like river herring. The abundance of dams throughout the region bar the anadromous river herring from reaching its ancestral waters upstream to spawn, thus keeping the population of this important species relatively low. However, if all dams were removed in the Hudson River, the herring population might be expected to increase, affecting the populations of all other species that feed upon it. The ecological production function does not necessarily require market price data since the economic value can be expressed in terms of the marginal productivity (defined as the result of adding one more unit of a given input while keeping all other variables constant) of the selected output production, such as commercial fisheries. Where market prices are available, analysts can express marginal productivity value in monetary terms, given that the ecosystem function inputs are well-understood (UNEP, 2014).

A step-by-step valuation of ecosystem services using the production function technique:
- **Step 1: Policy scenario – specify the change in the quantity of the product or service**

- ○ In the river herring case study in the next section of this paper, a hypothetical policy was introduced by New York State resulting in dam removals throughout the Hudson River.
- **Step 2: Identify the ecosystem services and populations affected by the policy**
  - ○ Ecological food web modeling can help understand the effects of a change on an ecosystem. While it is impossible to predict every change that might occur, ecologists have successfully modeled trophic cascades — powerful indirect interactions that can control entire ecosystems, occurring when a trophic level in a food web is suppressed — for a wide range of scenarios.
  - ○ Ecologists interviewed for the case study agreed that the demolition of dams will allow the anadromous river herring to reproduce upstream unimpeded, which will most likely lead to an increase in population.
- **Step 3: Identify the inputs that affect output production, and model production function using statistical analysis**
  - ○ Dams along the Hudson River must be removed, costing money, labor, and time (inputs).
  - ○ With an increased river herring population (output), the species who depend on them for food will most likely increase as a result. Striped bass, for example, are an economically valuable species in commercial and recreational fishing. The catch of striped bass (output) can be valued.
- **Step 4: Estimate the production function using statistical analysis**
  - ○ The up-front costs of dam removal and the implications to property values surrounding them must be taken into account at the outset of this analysis. A discount rate must be applied and, over a 10-year period, the costs and benefits of dam removal on the striped bass catch by commercial and recreational fisheries can be calculated.
- **Step 5: Calculate the change in revenue**
  - ○ With the future value estimated and the present value (current revenue generated by striped bass fishing) known, the monetary value of the dam removal policy can be measured.

Case Studies:

1. Forage Fish: River Herring

Overview

The river herring is a moniker for two remarkably similar species: the alewife (*Alosa pseudoharengus*) and the blueback herring (*Alosa aestivalis*) (Maine River Herring Fact Sheet, 2016). These two species can only be distinguished when live; once the fish is dead for a few hours, they are practically indistinguishable from each other. Both species of river herring are anadromous fish, meaning that they are born in streams, reach maturity in the open ocean, and then return up to three times to their natal streams to reproduce. The life history of these species embodies the connection from land to sea — freshwater to saltwater — via energy and nutrient flows, demonstrating the connectivity of ecosystems in the New York Bight. Historically, river herring was caught to be smoked and salted, but its salty, fishy taste stopped mass consumption by humans in the mid-19th century (Beaty, 2014). Commercial landings of river herring declined 95% from over 13 million pounds in 1985 to about 700 thousand pounds in 2005 (ASMFC, 2019). However, it is still used as a chum species and in a variety of other products such as pet food (Beaty, 2014).

The traditional economic valuation for river herring is based on its use as bait for lobster and hake: species that have a commercial market value. A novel approach to valuation, perhaps based on the assumption of the inherent value of a functioning ecosystem, has yet to be modeled and is recommended for future study. This case study provides an economic valuation of river herring through a proxy: dam removal throughout the New York Bight.

Dams are detrimental to the life cycle of the anadromous fish such as river herring because they prevent the fish from moving upstream to reproduce. These dams are relics of the industrial 19th century economy which depended upon water wheels for energy (Magilligan, 2016). If not well cared for, these dams are a public safety consideration, especially if they collapse in an extreme weather event such as Superstorm Sandy. One way to show the value of a forage fish such as the river herring is to model a restored riverine ecosystem and its benefits to the economy. Two scenarios were created for valuation in this study: current stock — or "business as usual" — value of river herring, with low population numbers due to dams; and a projected scenario in which all dams with suitable herring habitat in the New York Bight were removed, and the expected population expansion as a result. A range of various scenarios could

be projected using the same methodology, modeling different extents of dam removal to find the scenario that would maximize ecological benefits while minimizing economic costs.

Although dam removal has been more successful in the Pacific Northwest, the Northeastern U.S. is starting to buy into the end of the "grey infrastructure" paradigm (Kimmel, 2013). As a part of this paradigm shift, there has been a growing number of dam removal projects in the Northeastern U.S. An excellent example of a successful dam removal is the Kennebec River Project in Maine. This project removed two dams: the Edwards Dam and the St. Croix dam on the Kennebec River, which led to a population explosion of river herring. Despite being extirpated from that section of the Kennebec River in previous decades, at least 25 million river herring now live in the Kennebec (Natural Resources Council of Maine, 2019). Besides restoring stream ecosystems to their former function, a new value is potentially created by the energy flows to terrestrial habitats. These flows would facilitate the a return of animals such as bears, herons, and river otters (ASMFC, 2009). This case study and resulting analysis shows the value of ecosystem restoration through dam removal.

Methodology

Since the valuation process done in this study is through the proxy of dam removal, it began with the exercise of identifying what ecological changes would occur in the region within ten years. A ten year study period was chosen because it is the maximum time period that financial models are generally accepted as valid, and it would give enough time for the river system to regenerate post-dam removal. It is unlikely that many of these removals would happen consequently, so ten years would allow time for a significant number of dams to be demolished. Crafting the proxy and resulting scenarios included interviewing subject matter experts in the New York Bight involved with marine life and economics. Various impacts of the dam removal were identified, including: the recovery of the river herring population, predatory species' subsequent increase, the increase of recreational fishing in the area, an additional cost of maintaining increasing marine life, and ecological benefit and aesthetic value of a free-flowing river.

Beginning from a baseline using 2019 data, a model was created to project the growth of river herring commercial fishing, striped bass (a commercially valuable species that feeds on river herring) commercial fishing, and recreational fishing and angler trips. For the purposes of this study, striped bass was used as a proxy for all manner of predatory fish that depend upon

river herring as a food source. The baseline commercial data for striped bass and river herring was derived from the reported amount from the 2017 NOAA Fisheries Landings (NOAA). Much of the river herring data was not easily accessible due to diffuse stream surveys within the bight. Atlantic herring data was used as a proxy of river herring in some calculations. Atlantic herring was used due to the similar life history to river herring and the abundance of data found for this species. The baseline for recreational and angler fishing trips revenue was derived from the Fisheries Economics of the United States Report 2016 (NMFS, 2016). Striped bass and herring catches were divided by the total amount of the species caught in this report, and the resulting percentage yielded the recreational and angler fishing expenditures and equipment revenue that could be attributed to herring and striped bass. Using the annual landings data from NOAA Fisheries, the average growth rate in the years of 2007-2017 for commercially-caught striped bass and river herring was also calculated (NOAA).

With the additional aquatic life in the Hudson River, it was hypothesized that there would be additional maintenance costs for the management of the river area. This cost was estimated using the New York State Department of Environmental Conservation's (DEC) 2018 budget on fish, wildlife, and marine life. The total budget was then divided by a rough estimate of the portion used on New York Bight. The growth of this cost was calculated using the data derived from commercial fishing for striped bass, including annual inflation.

Results

To create a discounted cash flow model, all variables needed to be accounted for. The model assumed a 2% rate of inflation, which is the common Consumer Price Index (CPI) value for inflation. The chosen discount rate of 2.5% was used across all three case studies in this paper, which is the current ten year risk-free rate (U.S. Department of the Treasury, 2019). The recreational fishing and angling rate was calculated as the average of the striped bass and river herring growth rates, and the growth rate of commercial fishing of striped bass was 6%. This amount was selected for the model because it was the average growth rate of landings of striped bass from 2007-2017 (NOAA, 2019). The growth rate of commercial fishing of river herring was 35% based on the same landing dataset from NOAA NMFS division, and the value of total recreational and angling fishing expenditures was determined via the Fisheries Economies of the U.S. Report, 2016. To derive a willingness to pay value, the household total of the two counties with dam removals (Nassau and Suffolk) were added, and the sum divided by 12 for the number

of dams removed in the projected scenario. Each year, as more dams were removed, the number of households in the model incrementally increased until reaching the total households for the two counties at the end of ten years. The per-household number of $118 was used as a proxy in the model (Mullins, 2010).

Costs were also incorporated into the model. Assuming a standard size for all dams, the most expensive dam found in the government study (the Edwards dam) was used. The value was adjusted due to inflation since this dam's removal in 2003 by a $2% growth rate per annum. The second category of costs was the costs of environmental maintenance, including dredging and environmental law enforcement (rangers). To value environmental maintenance, the New York State Department of Environmental Conservation (DEC) salaries of fish and wildlife/marine officers for 2018 were incorporated. Also included was the value for all supplies used in the fish, wildlife, and marine section of the New York DEC (2017). The sum of these two values was found and a quarter of that value was allocated to be used for the New York Bight. The final results show that the "business as usual" case — without dam removal — created $1.6 billion in value over ten years, while the dam removal scenario created $4 billion over the ten year period.

Recommendations

The limited timeframe for the study and the lack of availability of New York Bight-specific data resulted in some margin for error. Given additional data and analyses done to enhance the overall accuracy of this valuation of river herring, further studies can build upon these models or transpose them to work with other scenarios or species.

More accurate models of population growth over time could be acquired using advanced software like ECOSPACE, which is better equipped to account for environmental complexities and would include more species than the striped bass to use as a proxy. More granular and area-specific dam data should be incorporated into this model, enhancing the accuracy of the costs of dam removal and/or maintenance. This data, combined with dam-adjacent real estate property values to provide the positive and/or negative effects of dam removal on surrounding areas, should be included as dam removal could potentially enhance the overall value for the region.

It is recommended that other maintenance-related costs — as well as those from other regulatory departments besides the DEC — be reviewed to assess the true financial impact of increased activity in the Hudson River. In this model, the DEC budget was used to evaluate the potential cost increase, but other state and federal entities may also have an increased budget due

to the increased aquatic life. In addition, the Federal Energy Regulatory Commission (FERC), which regulates the non-federal entities that produce hydropower, may see reduced costs with fewer dams to regulate, therefore increasing the benefit of dam removal.

Finally, this analysis only included striped bass as a market-valued river herring proxy. There are many other species that consume river herring such as hake, bluefish and pollock (ASMFC, 2009). To make a stronger analysis, more predator species could be used — such as hake — or other forage fish species like Menhaden. Including as many of these species as possible would give a more precise valuation of the role of forage fish in a healthy New York Bight.

2. Apex Predator: Shortfin Mako Shark

Overview

The shortfin mako shark is a predator that lives in open ocean habitats across the world, including the New York Bight (OCEANA, n.d.). The mako shark has a wide geographical range — they have been known to travel over 2,092 kilometers (km) in one month on average — and can be found from tropical to temperate latitudes due to their highly migratory nature (OCEANA, n.d., Pelagic Shark Research Foundation, n.d.). An endothermic circulatory system allows the mako to maintain a higher body temperature than the surrounding water, which allows them to reach speeds from 35 kilometers per hour (kph) to 80 kph, earning the mako its reputation as the world's fastest shark (MarineBio, n.d). Shortfin mako sharks are relatively large, growing up to 13 feet in length and reaching weights of 545 kilograms (kg) (OCEANA, n.d.). They feed mostly on tunas and billfish, but can also eat squid, dolphins, mackerels, blue sharks, and sea turtles. The mako has no natural predators, making it an apex species (Pelagic Shark Research Foundation, n.d.).

Male shortfin mako sharks reach sexual maturity at approximately 6.5 feet long, while females are ready to reproduce at about 8.5 feet long (Shark Sider, n.d.). These sharks mate via internal fertilization, with gestation periods that last 15 to 18 months, and give live birth to litters usually totalling less than eight 28-inch-long pups (OCEANA, n.d., Shark Sider, n.d.). Some specialists believe that after giving birth, the mother mako shark must undertake an 18-month period of rest before she is able to begin another cycle of fertilization (MarineBio, n.d.).

However, mako shark reproduction remains poorly understood since the pregnant females captured for study purposefully abort their fetuses (Pelagic Shark Research Foundation, n.d.).

Apex predators such as shortfin mako sharks are blamed for the depletion of other commonly-fished animals like tuna and mackerel (Marine Bio, n.d.). However, it is important to highlight that these sharks are frequent victims themselves (Marine Bio, n.d). Across all of their habitats, they are constantly caught as bycatch, for sport, or for purposeful consumption (OCEANA, n.d.), which has led NOAA to officially declare the species overfished and subject to overfishing (ICCAT, 2017). Their slow reproduction cycle and slow growth rate cause the mako shark to be vulnerable to overfishing and extinction, which makes conservation action vital to their continued survival. "Overfished," in this context, means that the stock of mako sharks is below the International Commission for the Conservation of Atlantic Tunas (ICCAT) limit, while "subject to overfishing" refers to the rate extraction being too high (ICCAT, 2000). The shortfin mako shark is believed to be a keystone species — a species on which other species in an ecosystem largely depend, such that if it were removed the ecosystem would change drastically (Marine Bio, n.d.).

Most shortfin mako sharks landed by commercial fisheries are caught by accident during the capture of tunas and swordfish (NMFS, 2018). In the U.S., where 9.2% of the North Atlantic shortfin mako shark population is caught, 60% of the total catches were recreational and 40% were commercial (NMFS, 2018). Based on the ICCAT 2017 stock assessment, there have been some fishing restrictions put in place to help rebuild the stock of shortfin mako shark, such as the recommendation to increase the minimum size of the sharks landed recreationally from 54 in fork length (FL) to 83 in FL (NMFS, 2018). The United States National Marine Fisheries Service (NMFS) has been actively trying to reduce mako shark fishing through regulations in order to conserve the species (NMFS, 2018). In addition, there is currently a proposal under consideration to include the mako shark in Appendix II in the upcoming Conference of Parties so that will receive further protection from exploitation (CITES, n.d.). Other local initiatives include the 2013 legislation signed by Governor Andrew Cuomo to ban the possession, trade, and distribution of shark fins in New York State. (New York State Governor's Office, 2013).

Methodology

The goal of this case study was to demonstrate the value that the presence of mako sharks offers to the New York Bight under two different regulatory scenarios — one in which they are

fully exploited for near-term monetary value, and one in which their population is protected and is allowed to recover to healthy stock levels per ICCAT's estimations. These valuations were performed using separate discounted cash flow (DCF) models to calculate a net present value (NPV) over a ten-year period for each scenario.

Under the "exploited" scenario, the estimated value of mako sharks caught by the local commercial fishing industry and brought to market for consumption was calculated to be $192mm in NPV over a 10 year period. In addition, the contribution made by the local recreational fishing industry under the assumption of minimal limitation on the number and size of sharks that can be caught was added. Data obtained from NOAA, U.S. Department of the Interior, and U.S. Department of Commerce, as well as from numerous interviews with recreational and commercial fishing professionals and fishmongers, provided the baseline for this study. This data enabled the creation of a reasonably-accurate estimate of the current net profit contributions from these industries to the local economy. The DCF analysis using this data — as well as inflation rate assumptions from the Consumer Price Index and growth rate assumptions from the data search and interviews — projected an NPV of these sub-industries to the New York Bight economy.

Under the "protected" scenario the valuation became more complex, and required some extrapolation and assumptions until further research is able to be conducted in the New York Bight. This case study presents a framework under which to do so in the future once that data is collected. It was estimated that over the same 10 year period as the previous scenario, if the shark population was protected and allowed to partially recover by following the recent ICCAT regulations, the shortfin mako shark population would be worth $470mm. Recreational fishing in the Bight would likely remain prevalent in the protected scenario, but some loss of revenue is to be expected due to an estimated decrease in demand. This study also incorporated a contingent valuation method to capture the non-market value mako sharks contribute to the New York Bight. Any environment has stakeholders who do not partake in the ecosystem's extractive benefits, but value its existence in another capacity. Contingent valuation attempts to capture the value of an unexploited resource to stakeholders beyond the direct users by using survey data to calculate a maximum "willingness to pay" to maintain the resource. This value is also referred to as an "expressed preference" (UNEP, 2014).

To achieve the most accurate estimation of the value stakeholders of the New York Bight place on the mako shark population, a direct survey would be required. While none that are specific to sharks and the New York Bight were available at the time of this study, analyses have been performed in other locations such as in Baja California Sur and on other apex predator species such as the wolves in Yellowstone. For this case study, an existing peer-reviewed paper was extrapolated to fit the demographics of stakeholders in the New York Bight in order to estimate the contingent valuation.

To perform a similar contingent valuation in the New York Bight a survey would need to planned, filled, and collected. This survey could be answered by a similar group as in the Economic Assessment of Tourism Based on Shark-Seeing and Diving as a More Profitable Activity than Commercial Fishing study conducted by Plata Zepeda et al. in 2018. They identified a group of stakeholders — both locals and tourists — that could be interested in shark-seeing and diving, as well as shark fishermen to gage if they would be interested in switching industries. The proposed survey could potentially cover local NGOs focused on marine biodiversity protection and local communities, including hotel and restaurant owners in the area. It would include common demographic questions, socioeconomic information (income), a sliding scale to represent interest in sharks, and a supplement crafted for each section of the population based on their activities. For example, it is relevant to ask shark fishermen how often they go fishing, how long they spend on a fishing trip, how much they earn per trip, and how much it costs to operate. Local businesses can share their opinion on shark ecotourism. Tourists can be asked if they would be interested in shark-seeing and/or diving and how much they would be willing to pay for it. The selection of the sample of stakeholders to be surveyed must be randomly generated. The number of surveys needed to accumulate a statistically significant sample will depend on the population size identified for the New York Bight and the inherent margin of error.

Similar to the protected scenario, the appropriate growth rate assumptions driven by inflation and population growth were applied to the contingent valuation data. For the purposes of these calculations, aggregate stakeholders were defined as visitors to New York and New Jersey beaches within the New York Bight. Valid arguments exist to expand the stakeholder base, most compellingly due to the fact that mako sharks are highly migratory and therefore can impact ecosystems across a vast oceanic expanse. However, the mako shark's role in supporting

a healthy ecosystem can be used as justification for narrowing New York Bight stakeholders to those with likelihood of being able to directly experience this local ecosystem.

Willingness to Pay

The willingness to pay data used in this case study is based on another study conducted in Baja California Sur, Mexico, where researchers undertook an economic assessment that found shark-seeing and diving were more profitable than commercial fishing (Plata Zepeda et al., 2018). This study included mako sharks as part of the analysis, so the data could be applied to Atlantic shortfin mako sharks found in the New York Bight. This data was combined with that of visitors to beaches in the New York Bight, and then broken down further into different beach activities. This comparison found that the percentage of people who use charter boats to observe marine wildlife and go scuba diving comprises 0.5% of total beach-goers (Surfrider Foundation et al., 2014). This 0.5% was applied to the 27 million people who visit the beach in this area in order to calculate a number of stakeholders. In the Mexico study, the researchers categorized survey respondents by wages earned and by willingness to pay, with the highest bracket's monthly income defined as $803 to $1,070 (1% of respondents) and the highest willingness to pay stated as over $213 (recorded by 46% of respondents) (Plata Zepeda et al., 2018). Based on these numbers, $213 is a reasonable willingness to pay assumption for the New York Bight due to generally higher average incomes in the New York area. Less than 4.1% of New York visitors, and 4.7% of New Jersey visitors earned less than $25,000 per year (Surfrider Foundation et al., 2014).

Recommendations

In order to accurately estimate a value, it is important to understand the object of the valuation. There are still many unknowns regarding the shortfin mako shark, including their reproduction cycles, behavior, travel patterns, and their specific contributions to the ecosystem. More research is recommended to understand the roles these animals play in their habitat and how their presence enhances their surroundings. As previously mentioned, a willingness to pay study conducted in the New York Bight area could obtain a more accurate contingent valuation. Lastly, economists, the government, and other relevant actors need to study the effects different fishing restrictions have on the local economies that depend on recreational fishing as their source of income. This additional research will help understand the role of the mako shark and the economic value it has, both in the New York Bight and globally.

3. Ecotourism and Recreation

Overview

The New York Bight is rich in natural capital, providing humans with benefits beyond those gained through extractive methods like fishing or drilling for natural gas. Recreational, cultural, and even spiritual value attracts tourists every year to the Bight. Each recreational industry sub-category has unique drivers, stakeholders, and experiences for tourists.

Some of the most popular forms of tourism in the New York Bight are whale watching by boat, scuba diving, bird watching, and beach-going (NYDOS, 2013). Whale watching tours allow participants to get up-close to the New York Bight ocean ecosystem, where most cetacean sightings occur during the migratory summer season as seen in the NY Department of State seasonal cetacean sighting maps (NYDOS, 2013). Other popular wildlife watching activities focus on harbor seals — also common in the New York Bight — and shore-birds (NYS DEC, n.d.).

In addition to providing aesthetic and spiritual value to those participating, ecotourism helps promote a thriving tourism economy. Hotels, small businesses, recreation equipment manufacturing, and local communities receive an economic boon through the influx of people looking to enjoy the natural capital. Marine ecosystems provide hundreds of thousands of jobs in recreation fields, as well as billions of dollars in income to the New York Bight.

Methodology

To determine the total value of tourism and recreation in the New York Bight, including the coastal economies of New York and New Jersey, this case study began by defining the relevant industry sub-sectors. The industry sub-sectors include eating and drinking places, which includes full service restaurants, limited service eating places, cafeterias, snack and non-alcoholic beverage bars; hotels and lodging which includes hotels, motels, and bed and breakfast inns but excludes casino hotels such as those in Atlantic City; marinas; recreational vehicle (RV) parks and campsites; scenic water tours and sightseeing transportation on water; sporting and athletic goods manufacturing; amusement and recreation services including scenic and sightseeing transportation on land, sports and recreation instruction, recreational goods rental, and amusement parks such as Coney Island; and aquariums and zoos. These sub-sectors were used because NOAA defined them as the most relevant to coastal ocean economics analysis.

NOAA's Economics Now Ocean Watch (ENOW) Explorer database provided information about the annual GDP contribution of each of these sub-sectors separately from 2005 to 2016 (NOAA ENOW, 2019). Interviews with industry experts — an associate professor in the Department of Human Dimensions of Natural Resources at Colorado State University, Dr. Kelly Jones, to learn more about aquarium valuation methods; and Jake Salcone, a member of the UN ECOSOC committee — were conducted during the development of a valuation approach.

The business-as-usual (base) case was constructed using the collected data, assuming a discount rate of 2.5%, for the aforementioned reason that this is the federal funds rate. The annual GDP growth rate was determined for each industry sub-sector by calculating that sub-sector's compound annual growth rate (CAGR) from 2015 to 2016. The CAGR formula is: (Value in 2016 divided by Value in 2005) all to the power of (1/(2016-2005)) minus 1. The end result of a CAGR is a smoothed growth rate per year. This rate of growth would result in the ending value, from the starting value, in the number of years given, if growth had been at the same rate every year. Thus, it is a simplified way to get an idea of what the growth rate could be going forward, if the future behaved the same as the past. First, the 2016 data was projected out to 2018 so that this study could start from the same date (end of 2018) as the Mako Shark and River Herring case studies. Then, each sub-sector was projected out for 10 years from 2018 to 2028 using the historical growth rates given by the CAGR analysis for each sub-sector. After projecting the data, the summed projected GDP of each category per year resulted in its net present value (NPV). The summed discounted cash flow of each of the industries per year resulted in a value of roughly $243 billion in GDP contributed by ocean and coastal tourism and recreational industries in the New York Bight from 2018 to 2028.

To demonstrate potential fluctuations in the value of tourism and recreation in the New York Bight due to better or worse ocean ecosystem conditions, a sensitivity analysis of the data was conducted. In the low case — a model of the worst-case scenario for the ecosystem — assumptions were made about the decrease in tourism and recreational industry growth rates to account for the decreased demand in ocean activities due to worse ecological conditions and water quality. For the low case scenario, the following assumptions were made to reflect a scenario of extreme ecosystem degradation, to properly showcase the potential impact to the local GDP from the "base case," or business as usual, assumptions. For this particular scenario, the assumptions made are based off of how impactful a large-scale oil spill in the New York

Bight would affect the broader "Recreation and Tourism" industry, and the sub-economies that depend on its health. All percent GDP declines are based off of original "base case" figures in the model.

In an attempt to make assumptions that most accurately represented the outcomes of the low and high case models, a scenario analysis was used to assess the impact of an oil spill, or policy change, to each sector of the recreation and ecotourism market. The thought process and results of this scenario analysis are detailed below. With more time and resources, a more scientific approach would have been used to perform interviews with industry sub-sector experts in the region, obtain financial data from companies, and review historical data showing what has happened to each sub-sector in the past when facing these types of events. This data capture would have allowed for much more accurate assumptions, and thus a more realistic representation of real-world interactions in the model. Given the scope of this study, a scenario analysis provided relatively accurate assumptions to convey the low and high case models, and served as a starting point for future research.

Aquariums and Zoos – A 4% decline in GDP growth, from 6.7% to 2.7%.

A 6% decrease in GDP growth was assumed for zoos and aquarium due to the limited physical and infrastructural impact that an oil spill would realistically have on these institutions. The living collections and exhibits of the New York Aquarium source and filter water from the New York Bight, so oil could be devastating to these exhibits. The actual location of the zoos and aquariums, chiefly those located on the coast of the Bight (like the New York Aquarium), would be the greatest driver of the decline as visitors may likely avoid any coastal tourism as a result of the oil spill. This assumption is made based on past visitor decline to beaches during pollution events in the 1980's (Swanson, R. L. et al., 1991)

Boat Dealers – A 5% decline in GDP growth from -2.7% to -7.7%.

A 5% decrease in GDP growth was assumed for boat dealers due to the aquatic nature of the product they are selling. Boat dealers in close proximity to the New York Bight, and dealers of ocean faring boats in particular, would likely see the sharpest declines as local consumers would be unmotivated to spend money on a boat to take out in a bay or ocean suffering from severe ecological pollution. This assumption is supported by past economic downturns on recreational fishing boats after the Deepwater Horizon oil spill (Alvarez, 2014)

Eating & Drinking Places – A 3.5% decline in GDP growth from 3.1% to -0.4%.

A 3.5% decline in GDP growth was assumed for eating and drinking places along the coast of the New York Bight. Similar to the assumption for aquariums and zoos, the actual infrastructural and service integrity of these places isn't what is being compromised, but rather it is the local areas that attract patrons to these places that is driving GDP down during an oil spill. An assumption was made that eating and drinking places would be hit harder than aquariums and zoos because they rely on crowds attracted by other activities, such as beach goers, whale watchers, or boaters. Past marine pollution events in Long Island, New Jersey and New york have shown economic losses due to marine degradation, specifically on beach attendance and avoidance (Ofiara, D. and Seneca, 2006). Because eating and drinking places themselves do not offer the "recreational" attraction, and rather depend on it, a 3.5% decrease was assumed.

Hotels and Lodging – A 3.5% decline in GDP growth from 2.1% to -1.4%.

A 3.5% decline in GDP growth was assumed for hotels and lodging with the same rationale as described above for eating and drinking places. This market captures secondary spending from the recreational markets and thus will be impacted by a significant event like an oil spill. Because they also have the ability to stand alone from the recreational market and capture other revenue streams, they will not suffer a dramatic GDP crash. However, for those located in close proximity to the coast of the NY Bight and rely on coastal recreation and tourism, it must be must assumed that there will be some decline in GDP growth.

Marinas – A 5% decline in GDP growth from 0.9% to -4.1%.

A 5% decline in GDP growth was assumed for marinas with a similar rationale for the 5% decrease in boat dealership. Because the industry is so reliant on the actual health of the ecosystem and water itself, it is rational to assume there will be a decline in the amount of recreational boaters in the NY Bight in the event of an oil spill. Therefore, it was assumed that less boats will be entering and docking, or using the marina at all, until the oil is cleaned and the demand for boating recreation in the Bight increases back to pre-oil spill levels.

RV Parks and Campgrounds – A 3% decline in GDP growth from -0.3% to -3.3%.

A 3% decline in GDP growth was assumed for RV parks and campgrounds because of their reliance on natural capital for activity. The integrity of the actual coastal campgrounds may decrease due to oil on adjacent beaches and could not continue to host as many campers and RV drivers. Due to the ecological degradation of an oil spill, it was assumed that usership would decline some as the draw to a coastal campground is the integrity of the surrounding ecosystem.

Because of that, a 3% decrease was assumed — halfway between the other infrastructure independent categories and ecosystem reliant categories.

Scenic Water Tours – An 8% decline in GDP growth from -12.8% to -20.8%

A large 8% decrease in GDP growth was assumed for water tours because of its almost sole reliance on ecosystem quality as an indicator of market health. The very nature of the market is taking interested consumers to view a healthy and vibrant ecosystem, and in the event of an oil spill it can be assumed the market will suffer greatly. The base case showed that this market is already struggling as is, so the assumption that an ecosystem degradation would only further this decline was made.

Sporting Good Manufacturing – A 6.5% decrease in GDP growth from -2.9% to -9.4%

A 6.5% decrease in GDP growth was assumed for sporting good manufacturing in the NY Bight due to its partial reliance on coastal ecological health. The sporting good manufacturing and outfitting market, particularly on the coast and specific to ocean activities, such as diving gear, surfboards, or sailing, would of course suffer greatly. The desire to engage in activities in oil polluted water would be non-existent, and thus the market will suffer. However, this sub-sector is projected to decline less than scenic water tours because the of the potential for a sustained revenue stream for the purchase and use of these materials in other waters, which is a portion of the markets revenue stream.

Amusement & Recreation Services – A 3.5% decrease in GDP growth from 6.9% to 4.9%

A 3.5% decrease in GDP growth was assumed for amusement parks and recreation services in coastal areas along the Bight. The structural integrity of these places will be slightly compromised by the oil, and the decline also comes in the lack of consumer draw by natural capital, like a clean beach. The amusement parks (e.g. Coney Island) maintain their own draw too however, which will allow for a sustained source of income. However, a portion of the people who may have previously come to both enjoy the beach and visit the amusement park will likely be lost without a clean beach to initially draw them in.

Using these projected growth rates, the same steps as in the base case were taken to calculate the discounted cash flow value of tourism and recreation. The determined value was roughly $201 billion in GDP contributed by ocean and coastal tourism and recreational industries in the New York Bight from 2018 to 2028, given much worse ecological conditions and water quality. The roughly $41 billion dollar difference in GDP between the business as usual case and

the low case represents the economic value of protecting our oceans from oil spills to the New York Bight economy.

In the high case scenario, assumptions were made about the increase in tourism and recreational industry growth rates to account for the increased demand in ocean activities due to better ecological conditions and water quality. For example, programs that encourage cleaning up plastic on the surrounding beaches and policies to improve management of coastal and offshore fisheries can lead to an increase water quality and promote ocean ecosystem health in the New York Bight.

The assumptions for the high case scenario are simply a mirror-image of the low case assumptions. For example, a 4% decrease in GDP growth for aquariums and zoos in the low case scenario, reflects as a 4% growth in GDP for our high case scenario. It was decided that this approach should be taken to maintain as much impartiality in our assumptions as possible. In the discussion of whether or not to take this approach, the potential issue of creating a new "scenario" for the high case was identified. In using a strict anti-pollution policy as the high case scenario, the issue identified was that policy change versus an actual physical and measurable depletion of ecosystem health (in an oil spill) could have very different implications for each category, and thus potentially incomparable assumptions, which was decided may jeopardize the quality of the overall assessment. Therefore, it was decided that mirroring the low case assumptions to maintain consistency and communicate the model would tell the best and most effective story. Using the process detailed above, the determined value of ocean and coastal tourism and recreation in the New York Bight was roughly $293 billion in GDP from 2018 to 2028, given much better ecological conditions and water quality. The roughly $51 billion dollar difference in GDP between the business as usual case and the high case represents the economic value of protecting oceans, cleaning up beaches, and regulating overfishing through conservation policy in the New York Bight.

Conclusion

Ecosystem valuation is an iterative process that requires many inputs, both ecological and economic, to provide an accurate, usable result. Over the course of the three case studies outlined in this paper, a consensus was not reached to declare the overall value of the New York Bight as an ecosystem, but each of the resulting valuation models found that more value was generated in

the high case (improved ecosystem) scenario than in the low case (ecosystem degraded) scenario. This proves that for these three cases, ecological valuation makes a case for conservation as opposed to continued exploitation at the expense of ecosystem health. The process of valuing these components of the New York Bight also served to create methods and frameworks for future study, whether in the area or elsewhere.

The scope and ecological complexity of the New York Bight posed challenges during the valuation process. Recommendations for future valuation attempts include gaining a more thorough understanding of each food web — and the trophic cascades resulting from changes in these webs — from a range of ecologists and biologists versed in the population dynamics of the region. The limited timeframe for the case studies in this report did not allow for as deep an ecological understanding as is required in order to create accurate scenarios for conservation. Area-specific willingness to pay surveys — incorporating the rigorous anti-bias methodologies of survey scientists — in the New York Bight, asking specific questions to stakeholders about the species and industries outlined in each case study, would also benefit a more holistic and accurate valuation.

Because of the lack of peer-reviewed research valuing the New York Bight and the novelty of this ecological-economic approach, data limitations and the resulting use of proxies impacted the models produced. However, given the growing interest in ecological valuation, more sound methods and data are likely to become available that will improve upon the models produced here. More thorough modeling — such as the inclusion of marine mammals who feed on forage fish in the river herring case, for example — is possible going forward. This report is a a step towards a deeper understanding of the value of conserving two significant species within the New York Bight as well as the macroeconomic impacts of ecosystem conservation on ecotourism and recreation within the region. Each of the case studies detailed within this report is defined by a set of valuation techniques that collectively provide a suite of ecological and economic tools that can be applied in a variety of future contexts. Ultimately, this report and corresponding models are living documents serving as an initial framework to understand the value of ecological resources — and the benefits of conserving them — within the New York Bight.

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