VALUATION OF SHORELINE PROTECTION IN JAMAICA BAY, NEW YORK:

A CONTINGENT CHOICE SURVEY

by

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(Under the Direction of Craig Landry)

ABSTRACT

After Hurricane Sandy breached the United States, decision-makers were concerned with which shoreline protections the populations of the Northeast Seaboard preferred for restoration. Weather and storm patterns are changing, creating an interest in efficient beach management and coastal defense systems for communities. We administer a survey with a discrete choice experiment to counties surrounding Jamaica Bay, New York involving two restoration alternatives, shoreline armoring and living shorelines, as well as a status quo option. The significant factors in the restoration alternative that were chosen for each household include outdoor recreation, the amount of tax increase, federal funding, and beliefs in future storm expectancy. Respondents were more likely to choose living shorelines and have a higher willingness-to-pay for a tax increase to fund living shorelines in comparison to shoreline armoring. The willingness-to-pay for living shorelines was 3.73 times higher than for shoreline armoring.

INDEX WORDS: Choice Model, Coastal Restoration, Hurricane Sandy, Willingness to Pay, Nonmarket Valuation

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1 Introduction

Policymakers are discovering a necessity for information to help mitigate the effects of global climate change. Observations and projections indicate that global temperatures and sea level rise are rising at increasing rates (Elsner, 2006). Accelerating sea level exposes populations in low-lying coastal areas to extreme floods and coastal erosion (Pielke et al., 2005). Knutson et al. (2013) find evidence that high intensity hurricanes will occur more frequently due to the effects of climate warming. More than one-third of the world's population lives in coastal areas and on small, low-lying islands and will be the most immediately affected by the increasing risk of costal erosion and extreme weather (UNEP, 2006). Weather-related events averaged $3 billion in insurance claims annually between 1970 and 1990, while the average between 1990 and 2004 was $16 billion (Kunreuther and Michel-Kerjan, 2009). These damages affect not only public safety and government spending, but also have an impact on local economies and business activities. With coastal shoreline counties contributing $6.6 trillion to US gross domestic product (GDP) and physical capital stocks along the coast being worth $1.2 trillion, it is crucial for policymakers to reduce climate vulnerability and enhance economic resilience to environmental change (NOAA, 2012; Nordhaus, 2006). Promotion of resilience requires identifying coastlines that are the most economic and socially vulnerable and considering an array of options for each

community's individual needs (Borchert, et al., 2017). When looking at options for protection and adaptation, differences in geology, climate, and bathymetry will play an important role in optimal design of adaptive strategies (Barbier, 2008).

In order to assess preferences and values for shoreline management strategies, this study analyzes a choice experiment for restoration of Jamaica Bay, New York, which was dramatically affected by Hurricane Sandy in 2012. Initially categorized as a Category 3 hurricane, the storm lost some of its ferocity as it travelled up the eastern seaboard and was eventually categorized as an extratropical cyclone when it struck the Northeast. Although no longer categorized as a hurricane, the size and duration of the storm, combined with its unusual path, occurrence at high-tide, and the deteriorated state of the Northeast's coastal marshes, lead to devastating effects in New York and New Jersey (O'Neill and Van, 2016). Following Hurricane Sandy, the Obama administration's Executive Order 13653 provided impetus to prepare the US for the impacts of climate change and to implement risk management strategies, including natural infrastructure for coastal protection (Sutton-Grier, 2015).

Protection of coastal development typically entails implementation of shoreline infrastructure to attenuate waves, prevent loss of sediment, and protect buildings and conventional infrastructure (transportation, utilities) from severe storms, flooding, and erosion. Historically, coastal protection was focused on shoreline armoring, which involves installing hard structures (seawalls, bulkheads, riprap) to shield human development from natural forces. For many decades, armoring was the most common form of coastal defense in the US, but there

has been criticism against this approach due to environmental concerns (Brandon, 2019). Shoreline armoring can cause passive erosion, alter shoreline habitat, and create sea floor removal over time (Griggs, 1998 and Griggs, 2005). An alternative approach, living shorelines or natural infrastructure, has garnered increasing attention in the interim. Living shoreline protections can be manmade or constructed of natural materials, such as dunes, native plants, and stones. This approach is designed to mimic natural features of the coastal fringe, providing protection to coastal development, while also enhancing the natural environment and creating recreation opportunities (Christiansen, 2000). Likewise, natural infrastructure is designed to use enhanced features of the natural environment to provide protective services, such as erosion control, floodwater conveyance, and ecological habitat. Hybrids of hard and natural infrastructure are also viable options in some areas, depending upon location-specific factors and desired outcomes (Sutton-Grier, 2015). By implementing coastal protection projects, storm surges can be reduced, erosion will occur less rapidly, and communities will be more resilient to the effects of extreme storms, flooding, and erosion. In this project, we evaluate household preferences for these different options for shoreline restoration and coastal protection to better understand community perspectives on resilience to future storms like Hurricane Sandy.

The North Oceanic and Atmospheric Association (NOAA) commissioned this study to assess perceptions and preferences of households in the Northeast region for restoration of natural areas affected by Sandy. Property protected by coastal habitats is worth more than $20 billion in Suffolk and Kings counties of New York alone (Arkema, 2013). Kings County is

directly adjacent to Jamaica Bay and Suffolk County is adjacent to Nassau County, which borders Jamaica Bay. A web-based survey was administered to households in New York, New Jersey, and Pennsylvania. The selected states were directly affected by Hurricane Sandy and were all located in the vicinity of our subject site, Jamaica Bay.

Jamaica Bay is located in the southeastern part of New York City, along the Atlantic Coast, and the highly urbanized estuary covers about 13,000 acres (Bennotti, 2007). Jamaica Bay is also known for its composition of wetlands, containing intricate ecosystems and natural defenses for storms and coastal erosion. Jamaica Bay Wildlife Refuge, which largely consists of shallow waters and salt-marsh small islands towards the center of the bay, encompasses almost 10,000 acres. The Refuge contrasts with the surrounding neighborhoods that include bustling cities and industrial areas in both the Bronx and Queens boroughs. A large amount of the 1,116,000 city residents living within 5m coastal flood level in New York reside in the Jamaica Bay area (Colle et al., 2015). New York is predicted to have about 350,000 people exposed to hazards with habitat loss from climate change or human impacts (Arkema et al., 2013). As wetlands are continuing to disappear throughout the country, coastal communities are more susceptible to increased damages from storms. The protective effects of wetlands from property damages were found to produce an average revenue of about \$1.8 million/km^2 every year for US coastal counties and a marginal value of up to \$2.4 million for counties in our survey(Sun and Carson, 2020). Since Hurricane Sandy, there have been active debates on the best ways to protect areas like Jamaica Bay from future storms, including extending efforts to restore wetlands in the

area. We analyze primary survey data to measure household-level effects of Hurricane Sandy, weather and climate risk perceptions, and the preferences for restoring Jamaica Bay. A choice experiment is used to evaluate the respondent's preferences and willingness-to-pay for shoreline restoration.

In addition to household collecting attributes, the survey presents individuals with three choices for coastal protection: two alternatives and a status quo option. The two restoration options that were given for the choice set consisted of living shorelines and shoreline armoring. The survey participants were given information on impacts and descriptions of both alternatives, each associated with a tax payment. The status quo option provides respondents the choice to leave things as they are in the current state and incur no additional taxes for restoration. We use McFadden's Choice model (1974) to analyze household preferences, controlling for protest respondents and perceived consequences. We find that the higher the tax, the less likely respondents will vote for a restoration option. When comparing both sea armoring and living shorelines to the status quo, we find significant effects for respondents who: perceived a high risk for future storms; preferred natural solutions opposed to man-made; or participated in outdoor activities. The coefficients are interpreted as changes in likelihood of voting for the alternative option relative to the status quo. We also compare the willingness-to-pay (WTP) between the two protection alternatives and find respondents were willing to pay an increase in taxes of $312.47 for living shorelines and $83.78 for shoreline armoring per year for a ten-year time period.

2 Background Information

Specifically, the subject site of Jamaica Bay is located at the southern end of the Boroughs of Brooklyn and Queens. The John F. Kennedy Airport borders the Bay on its northeastern edge, while the Rockaway Beach is situated along the southern border. Jamaica Bay also encompasses the Jamaica Bay Wildlife Refuge and consists of roughly 10,000 acres of woods, wetlands, harbors, and beaches (Hartig et al., 2002). In late October of 2012, Hurricane Sandy inflicted significant damage on the Northeast seaboard of the United States, including Jamaica Bay of New York City.

Hurricane Sandy formed over the Caribbean Sea as a tropical depression system and made its way up the eastern coast of the United States. Once rated as a Category 3 storm, the storm was downgraded to an extratropical cyclone by the time the storm hit the New York City area on October 29 (Blake et al, 2013). Northeast and Mid-Atlantic States, including New York, Connecticut, Maryland, Delaware, and New Jersey, experienced torrential rain, flooding, catastrophic winds, blackouts, and fatalities in the storms wake (Varlas et al., 2019). The effects of Hurricane Sandy on the area were vast, including wind gusts between 80 mph and 90 mph recorded in New York and northern New Jersey (Walling et al., 2016). Hurricane Sandy's large diameter winds, which stalled over the New York and New Jersey for days, resulted in extreme wave heights over the Mid-Atlantic and contributed to the storm surge inland. The unusual path

of the hurricane, long fetches of wind towards the coast, and the timing of landfall at high tide, under a full moon, created an extreme coastal surge of 13.88 feet (Hall and Sobel, 2013; Apsan, 2013). Following almost two years of above-normal temperatures in the region, increased sea surface temperatures did not allow the storm to weaken when it made landfall; although, it would have taken the same track despite temperature (Magnusson et al., 2014). The storm was one of the most devasting in the area's history and could be attributed to a one-foot increase in sea level in the last century (O'Neill and Van Abs, 2016). More than one-third of buildings damaged in the storm were in South Queens (New York City Special Initiative for Rebuilding and Resiliency (NYCSIRR): New York City Office of the Mayor, 2013). The storm cost the United States an estimated $71.4 billion in property damage and clean-up costs, making it the second costliest storm to hit the US (Apsan, 2013). High intensity storms caused 377 deaths and over $110 billion in damages in 2012, including damage from Hurricane Sandy (Sutton-Grier, 2015). After the storm, the city had to rebuild and consider how future preparations could decrease damages if a storm of this magnitude, or greater, were to strike again.

One of the options historically used along the coast as a shoreline defense system is shoreline armoring. Hard structures (including seawalls, rip rap, or bulkheads) are built to create a physical barrier to minimize storm surge and strong waves caused by coastal storms. An alternative to shoreline armoring is living shorelines consisting of dunes, reefs, and native plants to attenuate waves, while also providing additional habitat. When considering an alternative for Jamaica Bay, the local ecosystem must be considered into the costs and benefits of each

alternative. The natural wetlands of Jamaica Bay provide ecosystem services including wildlife habitat, water purification, recreation, and most importantly for this study, protection against coastal erosion (Meixler, 2017). The demolition of wetlands will affect economic certainty and safety for the Jamaica Bay area.

Wetlands in Jamaica Bay experienced a 75% decrease from the early 1900's to the early 1970's due to human urbanization and infrastructure development (Hartig et al., 2002). Since 1959, there has been a 12% decrease in salt marshes from the three main islands in Jamaica Bay, vegetation cover on smaller islands has been lost by up to 78%, and an 8% decrease in salt marshes since 1976 after federal and state wetland regulations were put into place. The degradation of the surrounding wetlands in the harbors was extensive and marshes suffered a lack of management in the area before Hurricane Sandy hit (O'Neill and Van Abs, 2016). The wetlands have been largely diminished from extensive dredging in the Bay, which has caused increased tidal erosion, trapped sediments that would have been deposited on the shorelines, and enhanced erosion (Hartig and Gornitz, 1981). Sea level rise has brought alterations to marsh and wetland habitat, such as change in accretion rates, change in marsh vegetation distributions, and an alteration in nutrient and sediment supply. In addition to many grass species, Jamaica Bay is a habitat to more than 300 species of birds: many of them being migratory birds (Burger, 1983). Loss of habitat from sea armoring was associated with 2 to 36-fold impacts on richness and abundance of foraging shorebirds, roosting gulls and seabirds, and macroinvertebrates on open coast beaches (Dugan et al., 2008). Seabird habitats have been altered from the decrease of upper

and mid-beach zones, increased water depths, and the available food supply. The consequences of sea armoring in Jamaica Bay could alter the local ecosystems and the beneficial services they provide.

The objective of this study is to determine which coastal management strategy the public prefers for coastal protection and their willingness-to-pay for each alternative. There are many studies contributing to the value of beach quality from residents and tourists, but there are gaps in assigned values for coastal erosion management strategies for the region. Possible policies for beach management can include shoreline armoring, living shorelines, beach replenishment, shoreline retreat, or leaving the coastline as is. Restoration options are not mutually exclusive and can be combined for efficient results. Participants may be local homeowners, local beach goers, or people that have likely been affected by Hurricane Sandy in some capacity, as most live in the vicinity of Jamaica Bay. As public funds typically finance shoreline defenses, the local community's response is critical in providing solutions amenable to the majority. We will determine the preferred alternative for residents living in the Northeast, as well as which qualities significantly affect their choices.

3 Literature Review

3.1 Non-Market Valuation Techniques

Non-market techniques measure the value of a good where there is no formal market to signal their demand and values cannot easily be monetized. The roots of environmental economics in the United States can be found in the 1950s when Resources for the Future (RFF) was established to address natural resource scarcity, mainly concerning water (Pearce, 2002). Environmental concerns were voiced by the public about the externalities large agriculture businesses were creating after Rachel Carson's 1962 novel, Silent Spring, was published. Environmental economics gained more serious consideration as a result (Pearce, 2002). A change in US policy was instated in 1970 with the National Environmental Policy Act (NEPA) and environmental economics began to be incorporated into national policy. NEPA required proposed federal projects to conduct an environmental assessment or an environmental impact statement to evaluate the potential environmental consequences of the project (Dubrick and Moser, 2011). The Council on Environmental Quality (CEQ) was established in the Executive Office to ensure Federal agencies met their obligations under NEPA and recommend policies to improve environmental quality. By incorporating non-market factors into environmental economics, the true benefits and costs of a policy were more accurately estimated. National Oceanic and Atmospheric Administration (NOAA) is a national agency of the United States Department of Commerce instated in 1970 and is specifically charged with protecting the

nation's coastal and marine ecosystems. The NOAA Blue Ribbon Panel began the modern era of non-market valuation for US coastal resources and will be further discussed later in this section. Before non-market valuation was incorporated into policy, cost-benefit analysis (excluding externalities) was often the method used for proposed projects.

Environmental economics introduced a new way of integrating the environmental impacts of projects and policies into cost-benefit analysis (Pearce, 2002). Cost-benefit analysis sums the benefits of a possible action and subtracts the costs associated with those actions. Ideally, benefits should outweigh costs for an efficient policy, including both market and non-market values. The idea of cost-benefit analysis was not new during the development of environmental economics, but the use of external effects was further explored. Old economic theory did not account for externalities and human welfare was often not maximized. Cost-benefit analysis in terms of human preferences and willingness-to-pay were first established by Dupuit (1844) and Kaldor-Hicks (1939). If the gainers from a policy can compensate the losers of a policy, so the losers are no worse-off and the gainers would keep a net benefit, Kaldor-Hicks compensation criteria is met. Nobody is actually worse off, assuming the compensation occurs, and Pareto improvement occurs with an overall improvement in welfare. Welfare economics continued to grow in the government water sector and provided analytical foundations for determining optima in economic systems. Economists have devised empirical tools for estimating ways to measure costs and benefits while considering the externalities in the estimation.

The current methods of environmental valuation are revealed preference and stated preference. Both methods use microeconomic choice theory as a framework. The initial idea to use surveys did not become widely applied until 25 years after its conception (Ciriacy-Wantrup, 1947). Revealed preference models use observations of consumer behavior in hopes of measuring preferences, including the methods of hedonic pricing and travel cost analysis. Changes in public policies are influenced by observing behaviors from changes in public goods. One of the first frameworks to measure environmental benefits was through travel cost analysis. Travel cost is a revealed preference method where preferences can be found through other markets (i.e. real estate transactions) or observed actions. A demand curve can be derived for recreational visits of consumers that have travelled various distances and incurred miscellaneous costs per trip (Hotelling, 1947). In the 1960's and 1970's, research was focused around valuing site access or per-trip values and turned to valuing quality changes of a site in the 1980's (Parsons, 2017). Travel cost continues to be a well-used method for valuation, but unavoidable issues of the method have led researchers to question if is best suited for their project.

Despite its ability to construct values from observation, revealed preference methods maintain a hypothesis about the structure of preferences which may or may not be testable. The revealed preference technique can have limited scope by using historically observed values and surveys which cannot measure passive use values (Simoes et al., 2013). The new environmental quality change may also be outside the current set of experiences. The measure of environmental quality is assuming choices are influenced by scientific measures or quality. Improvements in

quality are difficult to define from the change in recreation demands from a single site (Whitehead et al., 2000). Pooled data from multiple sites can better estimate the quality improvement or the use of the hedonic wage method (Clark and Kahn, 1989). Revealed preference methods also may suffer from collinearity issues in modelling of quality level characteristics in observed data, as there is no variation in at the same recreation site (Whitehead et al., 2000). Stated preference methods can address several issues of revealed preference and have become popular in the last 40 years as a valid estimation technique for policy implementation.

Stated preference methods address limitations in revealed preference studies to provide values beyond the range of historical quality variation (Whitehead, 2000). Contingent valuation and choice models may be used instead of revealed preference models if behavior is unobservable. Maler (1974) was one of the first to construct willingness-to-pay from questionnaires with stated preference techniques. After studies in 1958 and 1961 on the Delaware River Basin and the Maine woods, respectively, contingent valuation became more widely used (Pearce, 2002). Stated preference techniques can elicit value for nonusers of an asset by considering nonuse values, bequest values, existence values, and option values (Pearce and Morgan, 2013; Barbier, 1994; and Stevens et al., 1991). Stated preference can also gauge motivations for respondent's willingness-to-pay, such as altruism or concern for the future. Techniques can be used to analyze responses for attribute ranges which are not presently

available (Adamowicz, 1994). One of the first stated preference methods that became widely used in economics was contingent valuation.

Contingent valuation is a way of estimating the value a person places on a good or service by asking their willingness-to-pay or willingness-to-accept compensation for lack of the good. Contingent valuation research recognizes the need to integrate economic and psychological dimensions into creating and analyzing survey results (Smith, 1993). Although contingent valuation was once the most widely used method for stated preference, many economists had questions about the legitimacy of the method. The Blue Ribbon Panel concluded there is a meaningful component of welfare in passive use values, and contingent valuation can reveal the magnitude of losses or gains (Lipton, 2014). The Panel also established a design for contingent valuation surveys to address concerns about the method and its variations among studies. A few of the most notable suggestions from the Panel include: a binary option for willingness-to-pay instead of reporting one's own number, a "no answer" voting option, a ballot box to remove any peer or social pressures, and responses across time to account for inflation (Randall, 1997). The binary response or adjustment for inflation also did not affect probabilities of saying "yes" or willingness-to-pay (Carson et al., 1994). Implementing all the panel's standards leads to high costs for studies and solutions to issues addressed by the panel have been expanded upon since its formation.

In addition to the concerns addressed by the Panel, the embedding effect, first analyzed by Kahneman and Knetsch (1992), has been a leading issue for economists in accepting

contingent valuation. The embedding effect is thought to come from the nonexistence of individual preferences for public goods and a failure of survey takers in considering their budget constraints. Embedding effects allow variability from survey to survey for the stated willingness-to-pay for the same good. Diamond and Housman (1994) do not believe the true preferences of respondents are captured in surveys and altering the composition of surveys will not change the held values. Respondents may be feeling obligated to take a survey, could be supporting a good cause, or may be reacting to actions that have taken place instead of the state of the good being evaluated. The absence of preferences leads to inconsistencies in responses and implies survey responses are not satisfactory for creating policies. Despite criticism, contingent valuation surveys and revealed preference techniques have shown similar values for willingness-to-pay and consistent preference levels (Brookshire et al., 1982; Warman, 1988; Carson et al. 1996, Haab and McConnell, 2002; Ferrini et al., 2014). Many recent studies are combining the stated preference and revealed preference methods to improve parameter estimation and use the strengths of each method to compensate for their respective weaknesses.

The choice model is a method of stated preferences which addresses common concerns about contingent valuation. Discrete choice experiments began in 1927 with Thurstone's concepts of random utility. Louviere and Woodworth (1983) were choice experiment pioneers that provided design constructions for multiple choice options using McFadden's (1974) assumptions for the conditional logit model. The transportation and marketing fields have long histories using choice experiments and applied economics has been added as a large field for

study (Louviere, 1992). Survey methods that allow consumers to choose from multiple choice sets enable researchers to learn about consumer preferences and attribute preferences for goods that do not exist in real markets (Carson et al., 1994). Not all possible factors involved in the decision to maximize utility can be included in the analysis (Holmes et al., 2017). The analysis for the choice experiment often uses a random utility model (RUM) framework (Holmes et al., 2017). RUM is based on assuming people know their utility with certainty, but utility is unobservable. The random component from omitted or unobserved variables allows researchers to make probabilistic statements about behavior. A conditional indirect utility function is used because the utility is conditional on the choice of the alternative (Train, 2003). The respondent may have a higher utility for another option unincluded in the study, but instead must choose the option ranked with the highest utility among the options provided. The conditional logit model uses RUM framework and assumes the ratio of choice probabilities between two alternatives is unaffected by other alternatives in the choice set. The model also assumes the population has the same preference structure. We used a multinomial logistic regression in our analysis which allows the model to exhibit both choice-specific and household-specific information. Choice modelling continues to advance as more surveys are issued and as the technique is more widely used.

Advantages of choice modelling include: the control of stimuli in the experiment to gain control of the decisions made, the design matrix of the model eliminates collinearity, wider attribute ranges than what are found in the market can give more robust models, and the

introduction and removal of alternatives is easier (Adamowicz, 1998). Choice models are not a theory of behavior, but instead a means to generate behavioral data from consumers (Adamowicz, 1998). Stated preference methods will often permit the identification of parameters and richer specifications than revealed preference data can support because of the lack of variability or limited range. Choice models have a broader attribute-based perspective, instead of specific details of the case at hand, compared to contingent valuation (Adamowicz, 1998). Choice modelling also focuses on tradeoffs over several attributes instead of solely on price or repayment, as demonstrated in contingent valuation. Respondents are forced to repeatedly make decisions on multiple scenarios and can indicate consistency of responses throughout the survey. Similar to the contingent valuation method, careful experimental design is necessary for consistent and realistic results.

Non-market researchers attempt to construct surveys to generate consistency between studies by using similar strategies in estimating willingness-to-pay. The goal of external validity has been found in the stated preference approach, often using construct or convergent validity tests (Loomis, 1997; Whitehead et al, 2010, Carson et al., 1996). In order to produce external validity, results should be generalized to apply findings to other settings. Questionnaires should always be worded as simplistic and realistic as possible and a reasonable length. If any attributes or levels are unclear, questions prior to the choice set or explained text should clarify any difficulties (Carson, 1994). Providing warm up choice sets and specifying choice contexts can also help make sure the respondent understands the tasks. Lastly, Carson does not suggest

making a respondent's choice too simple by not including alternatives that dominate the others in every benefit and cost attribute (1994). Some researchers will minimize levels and attributes to simplify the task of taking a survey, but most participants are willing to do longer and more complex assessments with no hinderance of reliability (Louviere et al., 2008). Researchers need to be more transparent about their assumptions to improve consistency. Louviere (2010) recommends using a statistical design community to evaluate the optimal design of papers and the validity of assumptions made to keep studies across all fields consistent. Consistency and transparency can help contribute to the validation of stated preference methods in the economics community.

A large amount of research today is dedicated to combining the revealed preference and stated preference methods. The efficiency of benefit information can be improved and the consistency of the two types of data are tested when the methods are combined (Adamowicz, 1994; Englin and Cameron, 1996; Huang et al., 1997; Loomis, 1997; Whitehead, 2008; Landry and Liu, 2011; Simoes et al., 2013, Parsons et al. 2013). The combination of the methods would allow: the evaluation of a policy with a change in attributes or cost that is not currently observable; an experimental design to introduce hypothetical qualities to reduce multicollinearity; convergent validity testing (Simoes et al., 2013; Whitehead et al., 2010; Hanley et al., 2003). The combination of techniques requires a more complex survey than if only one of the methods were used, altering traditional survey designs. The overall goal of all non-

market valuation methods is to determine values for quality changes in scarce resources that do not have an established market where values are indicated.

3.2 Coastal Resources Valuation and Management

Climate change, habitat degradation, sea level rise, and pollution all threaten the existence and quality of coastal ecosystems. Non-market valuation methods attempt to quantify and manage the possible services the coastline provides. More than one-third of the world population lives along the coast or on small islands, causing coastal densities to be three times greater than inland densities (UN Environment Programme, 2006). In the last several decades, coastal ecosystems including mangroves, marshes, and reefs, have been degraded or lost by 30 to 50% (Millennium Ecosystem Assessment, Ecosystems and Human Well-Being: Current State and Trends, 2005). With a large population along the coast relying on the goods and services that coastal ecosystems provide, management solutions should be guided by preferences and values of the population.

Beach management in coastal areas can be a vital part of maintaining environmental, social, and economic viability. Beach nourishment is a common management strategy which involves pumping or trucking sand from another location onto the beach to replace sand that has been lost to erosion along the coastline (Landry et al., 2003). It is expensive and only a temporary solution until nourishment needs to occur again after further erosion processes (Gopalakrishnan et al., 2016). Shoreline armoring (which will be explained later in the review) tends to create narrower beaches and limits recreational activities (Gopalakrishnan et al., 2011;

Parsons et al., 2013). Many studies have been done using the travel cost method, stated preference method, hedonic pricing, and contingent valuation method to estimate the cost per trip or per person for variations of beach width (Bin and Landry, 2013; Landry and Hindsley, 2011). Beach characteristics, including beach width, presence and nature of engineering structure, and number of beach visitors, effects the magnitude of benefits for each beach goer (Silberman and Klock, 1988). Landry et al. (2003) examined the costs and benefits of three different beach management policies on Tybee Island. The three management alternatives were beach nourishment with shoreline armoring, beach nourishment without shoreline armoring, and shoreline retreat. The least favored alternative in the survey was beach nourishment with shoreline armoring with a mean marginal willingness-to-pay of $6.75 per day in 1996$. Wider beaches with minimal shoreline armoring had the highest willingness-to-pay for respondents ($8.45 per day).

More recent studies have attempted to value coastal erosion options and find households' willingness-to-pay for possible changes. Huang et al. (2011) estimated a willingness-to-pay of $22 to $42 per household per year for erosion control for the coasts of New Hampshire and Maine. Another study comparing coastal erosion management strategies for North Carolina households found beach nourishment willingness-to-pay ($7.45/year/household) was preferable to shoreline armoring ($0.09) (Landry et al., 2018). Shoreline retreat was most preferred with a willingness-to-pay of $22.20 per household. A study in New South Wales, Australia estimated household willingness-to-pay for management that prevents beach loss (Ardeshirir, 2019). The

study found willingness-to-pay was $100.58 for main beaches, $31.90 for surf beaches, and $15.66 for bays, all per household, per year (Ardeshiri, 2019). A study measuring the willingness-to-pay for beach management in Cadiz, Spain found respondents were more willing to pay for improved beach management (Alves et al., 2015). Factors including age, hometown, education, and beach preference were all significant variables. Those that were highly educated are expected to better understand necessary management alternatives and are more likely to support a beach visit tax. Although the aforementioned studies focus mainly on managing beaches for erosion control, they indicate there is value to shoreline management and a willingness-to-pay for taxpayers.

In a study to measure the value of coastal erosion protection, Gopalakrishnan et al. (2016) analyzed a survey asking if the respondent had a preferred beach management strategy between beach nourishment, a combination of shoreline armoring and beach replenishment, and shoreline retreat. A status quo option of no state program was included. The stated preference data measured the willingness-to-pay of $37 per household, per year, for beach erosion management. Using a probit model, they found those who own a beach house have a lower preference for shoreline armoring over replenishment. Agent-based modeling with spatially extended geophysical models shows that those who believe in future coastal erosion are more likely to invest in defensive expenditures and abandon the coastline as it reaches a tipping point (McNamara and Keeler, 2013). The management alternative coastal communities choose can vary based on the bathymetry and geography of the area for both beach nourishment as well as

other coastal defense systems. The spatial and temporal implications of local decisions must be considered by both the community and by surrounding communities.

Like many state, federal, or local issues, communities differ in dynamic ecosystems and preferences for coastal management. One of the first decisions a coastal community will make regarding management is the use or nonuse of nourishment (Gopalakrishnan et al., 2016). Stabilization of beaches with nourishment or hard structures can affect shoreline change for distance up to tens of kilometers (Ells & Murray, 2012). Early work, focused on economic decisions of a single community located along the shoreline, attempted to model the actions of a coastal manager to maximize benefits (Landry 2011; Smith et al., 2009). The single-community model ignores the spatial externalities that can affect surrounding communities, including the spatial effects of beach nourishment or hard structures. Each community's ecosystem varies linearly and will require a specific strategy to combat local coastal erosion.

Hard structures are no longer the obvious choice for management strategies along the coast, despite being the predominant option along the West Coast for many years. "Shoreline armoring" is a common restoration strategy in the form of a seawall, bulkhead, riprap, or groin that will provide a shield for buildings, utilities, and roads from storm surges and strong waves caused by coastal storms. The impacts of sea armoring are significant along the shoreline. Bulkheads or walls can create impoundment loss when the sediment and sand eroding down bluffs is not available to replenish beaches (Tait and Griggs, 1991). Sea walls can also hold back the natural flow of sediment, causing passive erosion and accelerating the rate of erosion

(Griggs, 1998). Passive erosion occurs by the shoreline on either side of the wall migrating landwards and a gradual loss of beach in front of the wall (Griggs, 2005). In addition to holding back sand for the area directly along the wall, the undersea slope does not allow sand to move along the coastline, depriving beaches in other communities (Griggs, 2009). The undersea slope can be caused by high energy waves hitting the wall and the energy strikes back on the sea floor. Typically, bays are often armored because they have lower energy waves and are less expensive to construct (Brandon, 2019). Sea walls are not the most aesthetically pleasing feature in a landscape despite attempts to disguise rocks as natural features along the coast (Griggs, 2005). Although there are many cons to sea armoring, there are also positive outcomes. After shoreline armor is built, there is immediate protection from coastal storms and cost-benefit analysis is simpler to construct; however, future maintenance and eventually a replacement will be necessary. If negative externalities from the seawall are measured, the overall welfare cost might indicate it is not the most cost-efficient option for protection. Another approach to protect an area from storm damage is to build living shorelines along the coast.

The natural materials and structures, including dunes, grasses, native plants, and stones, which compose living shorelines can both protect coastal areas, provide wildlife habitat, and create recreational opportunities for locals and tourists. The idea of shoreline protections from storms using marshes and mangroves was first hypothesized in 1971 after a catastrophic storm in Bangladesh (Fosberg, 1971). Living shorelines act as efficient protections due to plant stems and leaves slowing water velocity, reducing turbulence, and increasing deposition (Christiansen et al,

2000). Dunes can also attenuate wave energy and if large enough, can also repel the waves. Typically, less than 20-meter narrow fringe marshes are used instead of a meadow marsh system (Currin et al., 2008). Fringe marshes perform many ecological services, including nitrate removal from groundwater, wave attenuation, and sediment trapping (Bilkovic, 2016). The costs of both living shorelines and shoreline armoring have been compared and show the average construction costs were similar, with lower replacement costs associated with marsh-sills compared to bulkheads (Gittman et al., 2014). Living shorelines are more aesthetically pleasing to look at, but in extreme cases, large dunes can prevent ocean viewing. Living shorelines can be complex to install with most coastal states enforcing many regulations for management programs (O'Donnell, 2016). Long term maintenance and public acceptance provides obstacles when building living shorelines. The two restoration options are not necessarily mutually exclusive. Based on regional preferences, including physical, economic, spatial, and social factors, one option or a combination of alternatives may be best suited for the area. In addition to obvious dunes and rock constructions, researchers are developing shoreline alternatives to encourage options other than sea armoring.

One of the more recent living shoreline strategies communities are looking into is the implementation of oyster reefs. The value of oyster reefs has yet to be quantified, but the nonmarket ecosystem services they provide are well known. Oyster reefs reduce erosion by attenuating wave energy to stabilize sediments, act as natural filters, and can grow faster than sea levels are expected to rise to stabilize shorelines (Meyer et al., 1997). Oyster walls used to be

common features of bay areas, but their absence in the southeast has contributed to shallow water ecosystems and a shift from traditional benthic zones and fauna (Grabowski et al., 2012). They offer a balance between shoreline armoring and ecology (Scyphers, 2011). Habitats that would benefit from close proximity oyster reef locations would be perfect substitutes from human-made structures and estimated to provide $85,998 of annual revenue (Grabowski et al., 2012). Costs of oyster reef restoration are similar to those of seagrasses, salt marsh, and mangrove restoration.

In addition to oyster reefs, wetlands have been degraded along the East Coast and are vital to the protection of the coastline. Coastal wetlands decrease the area of open water (fetch) for the wind to form waves, directly absorbing wave energy, and increase drag on water motion (Costanza et al., 2008). When considering sea level rise, wetlands contribute to soil salinity and effect flood frequency (Morris et al., 2002). Another study comparing effects of bulkheads on wetlands compared to sills (an alternative to walls that can support oysters) found higher catch rates, greater species diversity, and a greater abundance and biodiversity at sites with a sill (Gittman et al., 2016). Bulkheads can cause coastal squeeze for wetlands and the high intertidal zone is held in a constant state while the low intertidal zone migrates landward (Pontee, 2013). Saltmarshes are unable to migrate landwards with the defense system in its way. The destruction of wetlands is occurring at astounding rates and negative ecological and monetary impacts will continue as a result. Costanza et al. (2008) found the value for wetlands was an average of $1,700 per hectare per year for Louisiana by using a regression model of 34 major hurricanes that hit the US since 1980. For a loss of 1-hectare, average storm damages increased by $33,000.

Since then, Sun and Carson (2020) have analyzed property damage caused by 88 tropical storms and hurricanes hitting the US between 1996 and 2006 found counties with more wetland coverage experienced significantly less damage. The expected economic value of wetlands across coastal counties averaged about $1.8 million/km^2. A 1% decrease in wetlands is associated with a 0.58% reduction in property damages and a 0.35% reduction for hurricanes ranging from a category 3 to 5. The marginal value of wetlands in the coastal counties we surveyed ranged from between $31,000 and $2,412,000 annually (Sun and Carson, 2020). The regression they developed can be used in other states to estimate the value of wetlands along a different coastline. It is vital for coastlines to restore and maintain their wetlands to decrease effects of windstorms, while determining the of costs of damages and of human lives.

Individual living shoreline strategies do not have to stand and perform alone. Manis et al. (2015) studied the effects of boating waves along a simulated living shoreline. They found half of the energy from the wake was absorbed by a combination of cordgrass and oysters, but both performed poorly when standing alone. The hardened vegetation helps with wave attenuation while roots and plants thwart soil erosion (Hervert et al., 2018). Shorelines may require multiple natural engineering options (oyster reefs, crepe myrtle branches) to allow waves to be absorbed before making landfall. These structures allow water to pass through them (opposed to hitting a wall or non-porous structure) and can reduce water velocities, increase sedimentation rates, and create an environment for entire ecological systems. Larger structures can be combined with seagrasses and salt marshes, which both attenuate waves, that reach the shoreline and stabilize

sediment to increase intertidal height and reduce storm surge (Barbier et al., 2011). Foredunes can also attenuate waves and form a protection barrier to the inland from erosion. Depending on the location and environment, different structures and shoreline options may be preferred.

Every coastline contains unique sediment contents, climates, benthic zones, and ecological systems. A single restoration or protection strategy will not be the most efficient for every coastline. Ecosystem-based management systems have been developed to maximize benefits while also considering conflicting conservation uses in each local community (Barbier et al., 2008). Assuming ecosystem services are linear and homogeneous would likely result in mismanagement decisions. The responses from the independent characteristics are highly dynamic and are non-linear across time and space, including seasonality or population growth (Koch et al, 2009). Coastal protection will vary based on the ecosystem along the coast and what it consists of, such as comparing a marsh fringe to a mangrove or a reef. Non-linear relationships exist between the habitat area and measurement of the ecosystem function, particularly in terms of wave attenuation (Barbier et al., 2008). Wave attenuation is based off the interactions of biotic and abiotic factors along with each individual coastal system's bathymetry and temperature. By looking at non-linearities of ecosystem services, a unique balance of restoration and economic profit can be attained.

3.3 Adaptation to Sea Level Rise

With 23 out of the 25 most densely populated counties in the United States located along the coast, immediate adaptation strategies need to be considered. Additional stress on coastal areas for their resources and increased vulnerability from higher global temperatures and glacial melting can have devastating effects on these densely populated counties (US EPA, 2009; Church, 2013). One of the major hurdles of adapting to sea level rise is the uncertainty of when or how much it may rise. The economic impact of sea level rise could have a potential cost between $20-$200 billion with a 50-centimeter rise and twice that amount with a 100-centimeter rise (Yohe et al., 1996, Newmann et al., 2000). A rise in sea level may increase salinity of freshwater, alter patterns of coastal chemical and microbiological contamination, alter real estate markets, increase the necessity of flood insurance, and force structural mitigation techniques (Scavia et al., 2002). Zhang et al. (2002) and Galgano (1998) find that regardless of the severity of the storm, they are not responsible for long term beach erosion for areas that are stable before the storm. Sea level rise is ultimately responsible for long term beach erosion on the US East Coast barrier beaches and possibly for sandy beaches globally. Human induced areas of coastal management get less attention than climate components in terms of mitigation because they are considered local issues (Nicholls and Cazenave, 2010). Appropriate human influence mitigation is considered an adaptation to sea level rise. Communities need to begin adapting to changes along the coast, beginning with homes located in the area.

Alterations in sea defense systems and weather pattern changes have created an evolving real estate market. Real estate prices along the coastlines are traditionally higher than inland prices. As coastlines are adapting to changes in hurricane damage and frequency, a positive feedback loop is occurring (Keeler, 2018). When public investments are made to "climate proof" qualifications, real estate markets take the opportunity to build more expensive homes in areas where they previously would not have if the risks were not reduced (Keeler, 2018). The new homes inflate the value of houses in the area and increase the investment in climate proofing of surrounding real estate to continue the cycle. Shoreline restoration and engineering exhibit a similar effect. Once a defense system (e.g. nourishment, dune, sea wall) is constructed, home prices can increase if buyers believe the structures are more protected. Taxes also increase for the protected home as they now require more maintenance of the defense system. In cases of nourishment, more wealthy parts of town are likely to use funds and allocation will not be equitable (McNamara et al., 2011). Poorer areas of the community will be at a higher risk for erosion and wealthy areas will continue the positive feedback loop. A consistent nourishment level would have to be set to inflate values of homes or encourage buyers to buy homes with more climate proofing (Keeler et al., 2018). As time goes on, engineering costs will be too high to maintain at risk neighborhoods and spontaneous abandonment/relocation will occur; bringing negative economic consequences to the region (Keeler et al., 2018). A possible solution to weaken the positive feedback loop effect is to limit the size and amount of coastal homes in low areas, requiring them to be moveable, focus on large scale planning, and have more financial

responsibility given to homeowners instead of the public. One of the ways responsibility can be delegated to homeowners is by encouraging the purchase of flood insurance.

After a lack of interest in private insurance programs, the federal government set up the National Flood Insurance Program (NFIP) in 1968 (Michel-Jerjan, 2010). As a response to Hurricane Betsy in 1965, the Southeast Hurricane Disaster Relief Act of 1965 provided federal relief to hurricane victims and initiated a study to explore flood protections. The NFIP creates flood maps, sets insurance premiums, and sets the deductible/limits for coverage. The NFIP does not offer compensation for land consumed by coastal erosion. Their rates do not reflect shoreline armoring and have a low claim limit for houses along the shore (Kriesel and Landry, 2004). They also manage the Community Rating System which monitors risk reduction efforts made by local communities. Mortgage lenders began requiring flood insurance in flood hazard areas in the 1970s due to Federal requirements, though they were loosely enforced. After FEMA campaigned for "Cover America" in 1995, there was another surge in the program's size and the amount of flood insurance to increase more value for protection. As sea level rises, more homes will need flood insurance; however, if homes are rebuilt on the same land, the positive feedback loop will continue to occur.

Economic and insured losses from natural catastrophes have significantly increased since 1950. Between 1970 and 2004, storms contributed to over 75% of insured losses (Kunreuther and Michel-Kerjan, 2009). Weather-related events averaged $3 billion annually between 1970 and 1990, while the average between 1990 and 2004 was $16 billion annually. New York was

second to Florida with about $2.38 trillion of insured exposure along coastal areas (Kunreuther and Michel-Kerjan, 2009). To encourage homeowners to purchase flood insurance, insurance companies can also lower premiums for homes that are taking the initiative to install/construct climate proofing strategies. However, most people would not want long term investments with so few short-term payoffs. Natural disaster syndrome is an underinvestment in protection for an area prior to a disaster, leading to worse consequences after the disaster because people do not believe the disaster will happen to them. Kydland and Prescott (1977) find individuals assume if enough people move there, the Army Corp of Engineers will be forced to invest in flood control projects, unless residents are prohibited from moving into a floodplain,

Communities can also encourage residents to pursue mitigation features by giving tax incentives. Kriesel and Landry (2004) found households located in the vicinity of artificial shorelines were 12 percent more likely to purchase flood insurance. Artificial barriers signal additional protection is needed in the area and encourage risk averse owners to buy more insurance (Kriesel and Landry, 2004). For a 1-in-100-year return period, mitigation would reduce potential losses in New York by 39 percent (Kunreuther and Michel-Kerjan, 2009). FEMA is currently modifying the flood map for New York City and will require many more homes to purchase flood insurance. About one-third of one-to-four family homes would be in the high-risk zone with the new policy and required to purchase insurance (Dixon et al., 2013). The requirements of the new policy can have major effects for poor neighborhoods in New York. Increasing hurricane intensity or frequency may lead to high risk insurance premiums and

mitigation strategies to lessen amounts insurers and government agencies must pay for restoration efforts.

Aside from insurance, an individual mitigation technique for an increase in sea level and hurricane frequency or intensity is altering construction requirements. As storm intensity and frequency increases, vulnerabilities in building construction should be addressed to lower damage costs. Traditional models have used stationary wind speeds in their risk assessments to predict damages. The model in Bjanadottir et al. (2011) uses a probabilistic framework to predict damages with an increase and decrease in wind speed over the next 50 years. Using a Monte Carlo Simulation, annual damage to housing units may be $120 million a year. Secondary building characteristics that contribute to debris during a hurricane, the leading cause of economic damages, can be advanced for better stability (Pinelli et al., 2011). By reducing vulnerability of newly built homes, retrofitting structures to current building standards, and enforcing building codes, damages can be decreased despite wind speed uncertainty. Adaptation and mitigation techniques for sea level rise will be critical in reducing costs of damages and longevity of buildings along the coast.

After Hurricane Sandy swept the east coast, unique coastal restoration strategies were considered for the effected states to better prepare for future storms. Our study attempts to gauge the willingness-to-pay for restoration alternatives and the core values of households in New York. We used a discrete choice model, a stated preference method to ask questions about household's perceptions of global climate change, storm frequency and intensity, and

recreational activities they typically enjoy. Analyzing local preferences can indicate to policy makers what management techniques communities would support with their tax money.

4 Data

4.1 Survey Description

The survey instrument was administered between August 7-13, 2015 with the Eastern Research Group, Inc. and was a web-based survey distributed through GfK Knowledge Networks. GfK used random digit dialing and address based sampling to send the survey to 1,103 respondents, receiving a 51% response rate. Internet surveys typically yield a higher response rate than phone or mail surveys. We identified any errors or clarity issues in the pretest, given in June 2015, and developed our final questionnaire. The survey will be attached in Appendix C. The necessary sample size, according to the rule of thumb developed by Johnson and Orme (1996), was 500 respondents. The survey was sent to a subset of respondents, all residents or visitors of the states of New Jersey, New York, and Pennsylvania, and were responding for their household. The data used for the analysis indicates all submissions were collected from nine counties in the state of New York. The highest number of respondents are from New York County (19.8%), followed by Queens County (16.3%), Kings County (14.8%), Suffolk County (12.8%), Nassau County (10.4%), Bronx County (10%), Westchester County (8.1%), Richmond County (4.3%), and Rockland County (3.5%). Jamaica Bay is along the coast of Kings, Queens, and Nassau County (as seen in Figure 1).

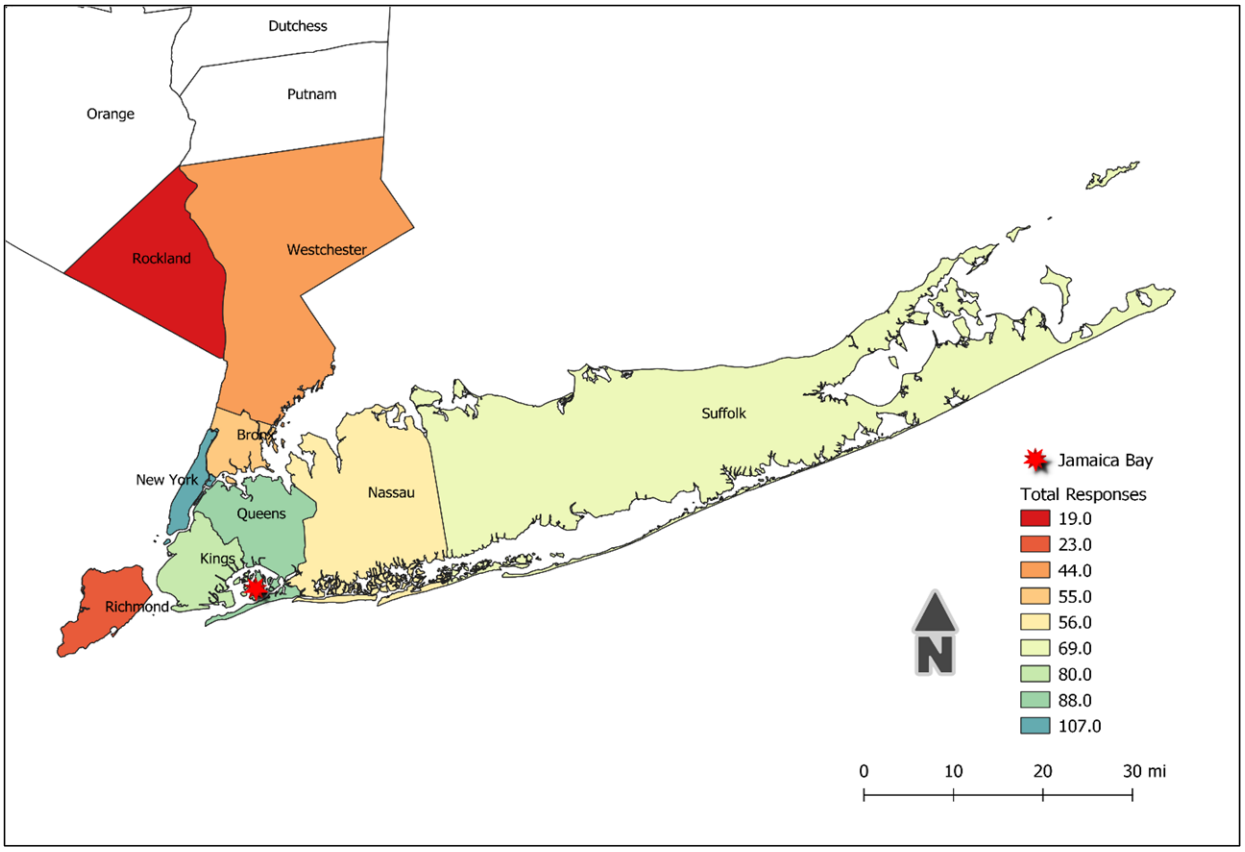

Figure 1: The county of map of New York with the number of survey responses received from each county

The instrument collects information on local beliefs in the future of climate change, preferences in quality shoreline defense systems, descriptive statistics, and the attitudes of those affected by Hurricane Sandy on federally funded projects. Before any questions are asked, respondents are given information about restoration alternatives. Table 1 shows the data the respondent is given to make a choice between sea armoring, living shorelines, or the status quo.

Table 1: Restoration Alternative Descriptions

	Sea walls (shoreline armoring)	**Living shorelines**
Amount of protection from storms	A sea wall offers significant protection from a storm. A sea wall repels most coastal storm waves which protects structures from damage. They can be designed to withstand certain storm "levels" (e.g., a 5-foot storm surge or a 50-year storm).	Dunes slow waves down and, if large enough, repel the waves. Living shorelines can also involve stone breakwaters that are placed offshore which slow down waves. Large waves, however, can wash over dunes and breakwaters.
Time it takes to get to full protection	Once it is installed, a sea wall offers immediate protection from coastal storms. Planning and design of the sea walls, however, could take one to three years.	A living shoreline can be built within a few months. If the design involves native plants (most do), then it may take a few years for those plants to fully mature and offer any benefits.
Longevity of protection	Over time, a sea wall will deteriorate and require maintenance and, eventually, replacement.	Living shorelines should last a long time. If built correctly, a living shoreline should improve in strength over time. Nevertheless, strong storms such as Sandy can damage living shorelines.
Beach erosion	Sea walls located in front of beaches will cause the beach to erode as waves bounce off of the wall and take sand with them back into the ocean.	Living shorelines will protect beaches from erosion by absorbing wave energy and providing sand to replace sand that is washed out to sea.
Aesthetics (how nice the feature looks)	Sea walls are just that, a wall, and are not necessarily considered pleasing to look at by some people.	Some may consider living shorelines more pleasant to look at compared to sea walls, but large dunes (which offer more storm protection) can block views of the ocean.
Benefits besides storm protection	None	Living shorelines provide habitat for birds and other wildlife. They also provide recreational opportunities such as wildlife watching and beach-going for people.

For the choice question, respondents are given three options for restoration: shoreline armoring, living shorelines, or an opt-out option. The payment vehicle is explained as an increase to household income tax annually for ten years. The randomly assigned bid values for the proposed restoration option are: $30, $70, $140, $240, per household, per year. The respondent is given a randomly chosen level, longevity, and tax for each restoration option and are asked to choose one of the options or the status quo. An example of the survey choice for a single restoration option can be seen in Table 2. Both shoreline armoring and shoreline armoring had randomly assigned values for each survey. For longevity and level, respondents are assigned a value of 1 or 2. For tax, a random value between 1 and 4 is assigned. The values are also presented in a paragraph explaining what their choices would indicate for each strategy, found in Appendix C. The respondent must then indicate their final restoration alternative or the status quo.

Table 2: Randomly Assigned Values for Restoration Alternatives

INSERTS FOR DOV_LEVEL, DOV_TIME, DOV_LONGEVITY, AND DOV_COST FOR EACH ALTERNATIVE	
DOV	Inserts
DOV_LEVEL	**1=**Category 2 hurricane (waves from the storm would be approximately 6-8 feet above high tide level) **2=**Category 4 hurricane (waves from the storm would be approximately 13-18 feet above high tide level)
DOV_LONGEVITY	**1=**10 years **2=**30 years
DOV_COST	**1=**$30 **2=**$70 **3=**$140 **4=**$240

Lastly, respondents are asked their level of agreement for questions regarding future storms in the area; their level of confidence in their choice; delegation of government funds; the likelihood the survey results would influence policy maker's decisions.

4.2 Descriptive Statistics

Table 3 includes the descriptive and household statistics of the survey respondents. Approximately 47% of respondents are familiar with Jamaica Bay and approximately 78% had never visited Jamaica Bay. Of those that visited Jamaica Bay, respondents visited an average of one time in the last year. About 97% of respondents were living in New York or New Jersey at the time of Hurricane Sandy. Nearly 45% of respondents were either very significantly or moderately impacted by Hurricane Sandy and another 36% experienced some impact. About 72% of respondents believe it is the federal government's responsibility to fund restoration efforts after Hurricane Sandy. Respondents are asked if they believe storms will be more destructive in the future than in the past; and 61% believe they are at higher risk than previous generations. About 20% of respondents agree that Hurricane Sandy was a rare event and a similar storm is unlikely to occur in their lifetime. The survey indicates 70% of respondents voted that natural features should be used as shoreline protection before any man-made features, if possible. Respondents are asked if they participate in outdoor activities to obtain information on how the aesthetic changes and available natural resources might affect the community. About

55% of respondents replied that they participate in outdoor activities (fishing, hiking, hunting, bird watching, etc).

Table 3: Descriptive Statistics

Variable	N	Mean	Std. Dev.
Income	503	78,451	56,963
Internet Access	503	0.962	0.191
Familiar with JB	503	0.473	0.499
Never Heard of JB	503	0.0795	0.271
Lives in JB	503	0.0795	0.271
Never Visited JB	503	0.773	0.419
Trips to JB/year	503	0.901	6.027
Living in NY/NJ during Sandy	503	0.968	0.176
Very Significant Impact of HS	503	0.155	0.362
Moderate Impact of HS	503	0.294	0.456
Some Impact of HS	503	0.364	0.481
Impacted from Sandy	503	0.449	0.498
Climate	503	0.793	0.405
Federal Funding	503	0.718	0.45
Low Risk	503	0.199	0.399
High Risk	503	0.616	0.486
Natural Restoration preferred	503	0.704	0.457
Fishing	503	0.163	0.37
Outdoors	503	0.545	0.498
Household Education (college or higher)	503	0.559	0.497
White	503	0.644	0.479
Hispanic	503	0.187	0.39
Black	503	0.111	0.315

(JB-Jamaica Bay, HS-Hurricane Sandy)

Demographically, 64.4% of respondents are white, 18.7% Hispanic, and 11.1% black. According to US Census Data 2010, the average race composition for the nine counties is 67% white, 25.5% Hispanic, and 19.7% black. Respondents are predominantly female at 54.9%, while the mean US Census 2010 is 53.7% female. The average income of respondents is $78,451 which is comparable to data gathered by the US Census 2015 showing a mean income of $71,473 for the nine New York counties surveyed. The per capita income for all of New York State was below that at $37,470 in 2018 (US Census Bureau). The survey income average is also above the national average of income of $56,516 in 2015$. On average, 56% of households have a college degree or higher, significantly above the New York state average of 35.9% (US Census 2010). Table 3 is not inclusive of all descriptive statistics from the survey, but instead are the statistics most relevant to this study.

4.3 Regression Attributes

In our primary choice model, we focus on several variables from the survey data. The program variable of the regression compares how likely the respondent is to choose either proposed alternative to the status quo. For the choice component of the regression, there are three attributes that influence the respondent's coastal protection selection. One attribute is the protection level the new options will provide from future storms (Category 2 or 4). Another attribute describes the longevity of the option before it must be replaced (10 or 30 years). The final attribute is the amount of tax increase the respondent would receive for the chosen option.

We separate the two restoration options and compare each to the status quo. We include the eight variables we assume will best represent significant household attributes. All variables are discrete. Train states it is impossible to include every factor in one's decision making process and the unmeasured factors will be accounted for in the error term (2003). The eight factors we consider to be most influential on selecting a restoration option are incorporated into the model and can be seen in Table 4.

Table 4: Variable Descriptions

Variable	Description
impact	Impacted very significantly or moderately by Hurricane Sandy
high_risk	Expects more destructive storms in the future
low_risk	A similar storm is unlikely in the future
nature	Prefer natural shoreline protections over man-made
fed	The federal government should fund restoration after Sandy
fishing	Engages in fresh or saltwater fishing
outdoors	Engages in outdoor activities
hedu	Household education level college and above
prot	Level of protection
longev	Longevity of the protection
tax	Amount of annual tax for 10 years

The first coefficient affecting the respondent's choice is impact. We assign a binary control to one for those who were very significantly or moderately impacted by Hurricane Sandy. For the high risk and low risk coefficients, we use a binary control of one if they responded with "strongly agree" or "agree" to questions asking if they expect storms to be more destructive or are likely to be rare in their lifetimes. If the respondent replied "strongly agree" or

"agree" to if they think natural options for shoreline protection are preferred over man-made options, we assign a binary control of one. The coefficient regarding if the respondent thought the restoration efforts for Hurricane Sandy should be funded by the government is assigned a binary control of one if they "strongly agree" or "agree." If the respondent stated they engaged in outdoor activities or specifically fishing, a binary control of one is assigned. Respondents who received a college degree are assigned a binary control of one.

When looking at descriptors for the model covariates, we see around 45% of respondents were significantly impacted by Hurricane Sandy and about 62% of respondents believed storms would increase in frequency in the future (Table 5). The average randomly assigned cost of restoration for the chosen alternative protection is $115.65. According to the questionnaire results, the sums for each option are totaled and 20.5% of respondents choose shoreline armoring, 54.1% choose living shorelines, and 25.4% choose the status quo as their preferred protection option.

Table 5: Descriptors for Model Covariates

Variables	Obs	Mean	Std. Dev.
Prot	503	0.485	0.5
Longev	503	0.481	0.5
Tax	503	115.65	78.09
Impact	503	0.449	0.498
high_risk	503	0.616	0.487
Hedu	503	0.559	0.497

5 Methods

5.1 Model Specification

McFadden's Choice Model (1974) allows for option and household specific variables, which is advantageous in our context, as we only have one response per household. Respondents chose either status quo (with no tax and no level or length of storm protection) or a restoration option (shoreline armoring or living shoreline) with high or low level and length of protection and a tax level (ranging from $30 - $240 per household, per year). The choice model defines utility for respondent *i* for choice *j* as:

$$u_{ij} = V_{ij} + \varepsilon_{ij} = x_j\beta + [y_i - tax_j]\gamma + \sum_{j\in 2,3} z_i\alpha_j + \varepsilon_{ij}$$

where x_j is a vector of alternative specific variables describing the level and length of protection for the shoreline armoring and living shoreline projects (=1 for high level/ length of protection; 0 otherwise); y_i is household income; tax_j is the level of randomly assigned tax payment associated with project *j*; z_i is a vector of household specific variables; binary indicators for higher education, moderate or significant impact from Hurricane Sandy, and perception of high future risk from climate change), and ε_{ij} is an unobserved random variable that is assumed to be independently distributed Type I extreme value. The vector β represents attribute-specific

variables; the vectors $\alpha_{j\in 2,3}$ represent household-specific parameters associated with shoreline armoring (j=3) or living shorelines (j=2) (relative to a baseline of status quo, j=1), and γ is the marginal utility of income.

5.2 Welfare Analysis

The economic value of restoration options for Jamaica Beach can be assessed using the parameters of the random utility model. Given the household choice data and our parametric assumptions, we estimate willingness-to-pay (WTP) for living shorelines and shoreline armoring (relative to the status quo) following Williams (1997), Small and Rosen (1981), and Train (2003). The expected value of consumer surplus associated with our choice model for household i is given by:

$$E(MaxU_i) = \frac{1}{\gamma}\ln\left(\sum_{j=1}^{J} e^{V_{ij}+\varepsilon_{ij}}\right) + C$$

where the expectation is taken over the domain of ε_{ij} , and C is a constant stemming from integration (reflecting the fact that the level of utility is relative). In this framework, household WTP for restoration policy n is given by:

$$WTP_{ni} = -\left(E(MaxU_i) - E\left[\frac{1}{\gamma}\ln\left(\sum_{j\neq n}^{J} e^{V_{ij}+\varepsilon_{ij}}\right) + C\right]\right)$$

where the second summation excludes restoration policy n. Confidence intervals for WTP are generated by the delta method.

6 Results

6.1 Conditional Logit Model

Using McFadden's Choice Model and after protest responses are dropped if the respondent did not support any kind of tax, we collected 503 observations. For the program characteristics, the level of protection and longevity of the protection are not significant from zero. The tax amount is significant at the p=0.05 level and is negative, indicating the higher the tax, the less likely the respondent would be willing to pay. The Wald Chi-Squared statistic of 140.19 and Chi-Squared number of 0 indicates at least one of the variables is significant (Moore, 1977). We use the choice model to compare the two alternatives (sea armoring and living shorelines) with the status quo. Results can be interpreted as estimates of probability that the respondent would be willing to pay the assigned bid value with their household attributes. Several variables prove to be significant.

Variables that prove to be significant in the regression are highlighted in Table 6. We first compare the significant factors when comparing the selection of living shorelines to the status quo by assessing relative probabilities. We find those who believe they are at high risk for future disasters are 74% more likely to choose living shorelines than those who do not believe there is a high risk of future storms. In accordance with those who had a high risk for future storms, those who do not anticipate an increase in storm frequency are less likely to choose the living shoreline

Table 6: Regression Results

Program Attributes							
Option	Coeff.		Std. Err.	z	P>|z|	[95% Conf.	Interval]
prot	-0.0161		0.0772888	-0.21	0.835	-0.16757	0.13539
longev	-0.00667		0.0074062	-0.9	0.369	-0.02118	-0.00786
tax	-0.00359***		0.0010416	-3.44	0.001	-0.00563	-0.00155
Household Attributes							
Status Quo (1)							
Base Alternative							
Living Shorelines (2)							
Variable	Coeff.	Odds Ratio	Std. Err.	z	P>|z|	[95% Conf.	Interval]
impact	0.393	1.480924	0.274	1.44	0.151	-0.143	0.929
high-risk	0.553**	1.738851	0.277	1.99	0.046	0.00946	1.097
low_risk	-0.802***	.448424	0.306	-2.62	0.009	-1.403	-0.201
nature	1.57***	4.804434	0.302	5.19	0	0.977	2.162
fed	0.562*	1.754552	0.287	1.96	0.05	-0.00115	1.126
fishing	0.448	1.564586	0.423	1.06	0.29	-0.381	1.276
outdoors	0.918***	2.503803	0.265	3.46	0.001	0.398	1.437
hedu	0.367	1.44325	0.257	1.43	0.153	-0.136	0.87
_cons	-1.01	.3628899	0.424	-2.39	0.017	-1.844	-0.183
Shoreline Armoring (3)							
Variable	Coeff.	Odds Ratio	Std. Err.	z	P>|z|	[95% Conf.	Interval]
impact	0.384	1.468229	0.309	1.24	0.214	-0.221	0.99
high-risk	0.728**	2.069687	0.32	2.28	0.023	0.101	1.354
low_risk	-0.036	.96421	0.358	-0.1	0.919	-0.739	0.666
nature	-0.982***	.3747362	0.322	-3.05	0.002	-1.61	-0.35
fed	0.797**	2.218228	0.333	2.39	0.017	0.145	1.449
fishing	0.956**	2.602311	0.446	2.15	0.032	0.0828	1.83
outdoors	0.605**	1.831892	0.303	2	0.046	0.012	1.2
hedu	0.209	1.231987	0.294	0.71	0.477	-0.367	0.784
_cons	-0.546	.5791553	0.437	-1.25	0.212	-1.403	0.311

*** p<0.01, ** p<0.05, * p<0.1

N=1,059

alternative than those who do not anticipate low storm frequency. There is a high level of significance (p=0.000) and respondents are 4.8 times more likely to choose living shorelines, if they preferred natural options over man-made options for coastal protection, over those who did not share this preference. Respondents who believe federal funding should be provided for Hurricane Sandy restoration are 75% more likely to choose living shorelines than those who do not believe restoration projects should be federally funded. Lastly, those participating in outdoor activities are 2.5 times more likely to choose the option of living shorelines than those who do not participate.

We also analyze the significant factors that affect the likelihood of respondents choosing sea armoring over the status quo. If respondents believe they are at high risk for being affected by future storms, they are two times more likely to choose sea armoring over the status quo than someone who does not assume high risk. The probability of choosing sea armoring rather than the status quo is 37% lower for those who preferred natural restoration options over man-made. Of those that participate in outdoor activities, 83% are more likely to choose sea armoring over the status quo, 2.6 times more likely if they fish, than those who do not perform outdoor activities. Those who voted in favor of federal funding for restoration are two times as likely to choose sea armoring than those who do not believe projects should be federally funded.

We calculate marginal effects of variables that displayed significance in Table 7 to gauge actual probability. When looking at marginal effects, we are determining how the predicted probabilities change as the binary independent variable changes from 0 to 1. All other variables

are assumed to be held constant while looking at the marginal effect of one variable. We first analyze those who choose the status quo and the variables that are proven significant.

Table 7: Marginal Effects of Significant Variables

Pr (choice =1|1 selected) =.20700825							
Variable	dp/dx	Std. Err.	z	P>|z|	95% Conf. Int.		X
impact	-.64101	.041886	-1.53	0.126	-.146196	.017993	.4493
high_risk	-.098041	.04224	-2.32	.020	-.180829	-.015253	.6163
low_risk	.099894	.046696	2.14	0.032	.008372	.191416	.19881
nature	-.151811	.045004	-3.37	0.001	-.240016	-.06305	.70378
fed	-.102019	.04427	-2.3	0.021	-.188787	-.015252	.71769
fishing	-.094588	.065427	-1.45	0.148	-.222822	.033647	.16302
outdoors	-.137701	.040418	-3.41	0.001	-.216919	-.058483	.54473
hedu	-.053662	.039331	-1.36	0.172	-.13075	.023425	.55865
Pr (choice =2|1 selected) =.5925757							
Variable	dp/dx	Std. Err.	z	P>|z|	95% Conf. Int.		X
impact	.04919	.053388	.92	.357	-.055449	.153829	.4493
high_risk	.047178	.055724	0.85	0.397	-.062039	.156395	.6163
low_risk	-.189302	.062611	-3.02	0.002	-.312018	-.066587	.19881
nature	.495502	.063897	7.75	0.000	.370266	.620738	.70378
fed	.041117	.060421	.68	0.496	-.077307	.159541	.71769
fishing	-.005515	.074005	-0.07	0.941	-.150561	.139532	.16302
outdoors	.149695	.053346	2.81	0.005	.045139	.25425	.54473
hedu	.063803	.051712	1.23	0.217	-.03755	.165156	.55865
Pr (choice=3|1 selected) = .20041605							
impact	.014911	.040456	0.37	.0712	-.064381	.094204	.4439
high_risk	.050863	.043172	1.18	0.239	-.033753	.13548	.6163
low_risk	.089408	.049158	1.82	0.069	-.006939	.185756	.19881
nature	-.343691	.045375	-7.57	0.000	-.432625	-.254757	.70378
fed	.060903	.046791	1.30	0.193	-.030806	.152612	.71769
fishing	.100102	.050615	1.98	0.048	.000899	.99306	.16302
outdoors	-.01194	.040815	-0.29	0.769	-.091989	.068001	.54473
hedu	-.010141	.039649	-0.26	0.798	-.087852	.06757	.55865

The marginal effect of those who exhibit a high risk for future storms, have a natural options preference, belief in federal funding, and participate in outdoor activity indicates there is a lower chance for a respondent to choose the status quo with a change in the discrete, significant variables. The predicted probability of choosing the status quo is slightly greater for a person that has a low risk for future storms. We also analyzed the marginal effects of choosing either restoration strategy over the status quo. Those who participate in outdoor activity have higher preferences for restoration options than the status quo. Specifically, we find respondents assuming they are at low risk for future storms are more likely to prefer the shoreline armoring option over the status quo but prefer the status quo over living shorelines. Respondents who prefer natural restoration options are more likely to prefer living shorelines over the status quo but do not prefer shoreline armoring over the status quo.

The level of protection and longevity of the respondent's choice does not prove to be significant at the 95% level. Another attribute that lacks significance in choosing living shorelines and sea armoring over the status quo is a dichotomous choice of if the respondent was impacted by Hurricane Sandy. Education is also not significant to the decision of the respondent for either alternative.

6.2 Willingness- to-Pay

We determine the WTP for both living shorelines and shoreline armoring compared to the status quo. The WTP for living shorelines is $312.47, with a confidence interval of $220.28 and

$404.66. The WTP for shoreline armoring is $83.78, with a confidence interval of $51.92 and $115.64. Households are willing to pay 3.73 times more for living shorelines than shoreline armoring. We confirm the confidence intervals by using the delta method. US Census data indicates the average number of households in New York between 2014-2018 was 7,316,537. Using an annual payment, the aggregate willingness-to-pay for a restoration alternative in the nine counties we surveyed is $1.4 billion for living shorelines and $376 million for shoreline armoring per household.

7 Discussion

The only program attribute we find to be significant is tax. The tax variable is significant in the choice between either alternative or the status quo and fits with the theory that the higher the given bid price, the lower the probability of the respondent choosing any restoration option. We expect the longevity variable to be significant and positive suggesting the greater the longevity of the restoration option, the more people would be willing to pay. We also expect the protection against the level of the storm to be positive and significant with a higher willingness-to-pay for greater protection from higher category storms.

When looking at the significant variables in the household characteristics, the nature variable (describing if respondents preferred natural options for shoreline protection) is positive for the living shoreline and negative for the sea armoring. We expect that those who prefer natural restoration options would choose the living shoreline, and those who prefer man-made options would choose sea armoring over the status quo. The impact variable is not significant in explaining the respondent's choice for either restoration option. Respondents who were impacted by the storm do not have a higher probability of choosing either restoration option over the status quo. We expect most respondents who were affected by Hurricane Sandy (about half of our sample being very significantly, moderately, or some impacted by Hurricane Sandy) would prefer protection measures that would lessen their odds of being impacted by a future storm. We attempted to drop responses that selected they did not think the survey would be likely to impact

future policies or if the respondents were not confident the in the choice they made. No changes in significance for any variables occurred if the responses were dropped.

For future studies, the income variable could be included in the regression analysis, rather than only in the descriptive statistics, in order to indicate if income has any effect on the alternative preferences. The living shoreline option is chosen more frequently amongst respondents, so we would expect a higher willingness-to-pay than in the case of shoreline armoring. When looking at future restoration efforts, decision-makers can use the ratio when comparing costs of project alternatives. A project involving living shorelines may exceed the cost of shoreline armoring, but if it is less than 3.73 times more, the government should seriously consider it as a restoration alternative. Although the willingness-to-pay estimates are high, the ratio of restoration alternatives can be used for benefit transfer.

We recognize there may be an upward bias in our willingness-to-pay estimates. The counties surveyed were in proximity to Jamaica Bay and experienced extreme damages from the storm. The survey was also issued directly after a "one in one-hundred-year storm," which could likely make respondents more risk averse than if they were asked many years after or before the storm. If the survey were better distributed throughout the state of New York, we would expect the willingness-to-pay to decrease as a large part of the state was not as severely affected. The average income for the counties in our survey ($78,451 in 2015$) is well above the average for the US ($56,516 in 2015$) and New York ($37,470 in 2018$), indicating respondents could

afford a higher tax with additional income. The household average of achieving a college degree or higher (56%) in our survey showed a difference of over 20% than the nine-county average (35.3%). We recognize our sample is above average in income, as well as level of education, and may not accurately represent the preferences of lower income communities, frequently located in the Queens and Brooklyn Boroughs. Although we detect the willingness-to-pay may have an upward bias, the projects taking place in New York City indicate the city is willing to spend extensive federal funds for future protections from coastal storms and erosion.

At the time of the survey, many restoration projects for the New York coastline were in the planning or beginning stages of construction. Since then, the city has spent billions on new strategies to combat intense storms and climate change. Project proposals include both living shorelines and shoreline armoring, proving a joint strategy could be key for community success. The Rockaway Beach Boardwalk was completed in 2017 and cost $341 million to construct the boardwalk atop of a retaining wall (New York City Special Initiative for Rebuilding and Resiliency (NYCSIRR), 2017). A T-groin project on Coney Island cost $28 million and was constructed to interrupt the flow of water, limit sediment movement, and includes beach replenishment every ten years (New York City Special Initiative for Rebuilding and Resiliency (NYCSIRR), 2016). Staten Island has installed an oyster reef south of the island, an elevated shoreline, and ten miles of sand dunes. Paul Greenburg in “American Catch” suggests the restoration of oyster reefs would likely cost around one billion dollars for the project. As mentioned in the literature review, oyster reef projects are continuing to be quantified for

installation and net benefits. The East Side Coastal Resiliency Project is expected to cost around $1.45 billion and would include parks and recreational fields along the coast. The director of the Mayor's Office of Recovery and Resiliency describes major projects are planned for the city to total $15 billion of Federal funds and $5 billion from city funds (Splvak, 2019). The high cost of projects New York has implemented and continues to fund indicates the importance of restoration and adaptation in the area. The high willingness-to-pay in our analysis supports the trend of large investments from the government of New York.

8 Conclusions

As coastal storms continue to intensify in frequency and intensity, coastal communities will be forced to adapt to changing conditions in order to minimize losses. One universal management plan for every community geared towards minimize damages is not efficient. We specifically analyze the community of Jamaica Bay and their preferences for restoration options after being devastated by Hurricane Sandy. Four attributes are statistically significant for both restoration options, with the expected effect on probability of choosing a restoration alternative. The four significant variables both restoration options exhibited are regarding: if the respondent believed storms were likely to worsen in the future; if federal funding was expected for disaster relief; if natural options were preferred over man-made options; and if they participated in outdoor activities. The higher the amount of a tax increase would make the respondent less likely to choose a restoration option and remain with the status quo. Respondents are willing to pay more for the living shoreline protection alternative and more likely to choose that alternative over shoreline armoring and the status quo. The effects of living shorelines continue to be researched to improve advancing coastal management plans by using more complete costs and benefits. The best alternative for a community may be a combination of living shorelines and shoreline armoring based on the ecosystem receiving the protection. Public support and awareness will be crucial in future decisions for coastline management and the installation of storm protection infrastructure.

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Apppendix A: Tables

Table 1: Restoration Alternative Descriptions

	Sea walls (shoreline armoring)	**Living shorelines**
Amount of protection from storms	A sea wall offers significant protection from a storm. A sea wall repels most coastal storm waves which protects structures from damage. They can be designed to withstand certain storm "levels" (e.g., a 5-foot storm surge or a 50-year storm).	Dunes slow waves down and, if large enough, repel the waves. Living shorelines can also involve stone breakwaters that are placed offshore which slow down waves. Large waves, however, can wash over dunes and breakwaters.
Time it takes to get to full protection	Once it is installed, a sea wall offers immediate protection from coastal storms. Planning and design of the sea walls, however, could take one to three years.	A living shoreline can be built within a few months. If the design involves native plants (most do), then it may take a few years for those plants to fully mature and offer any benefits.
Longevity of protection	Over time, a sea wall will deteriorate and require maintenance and, eventually, replacement.	Living shorelines should last a long time. If built correctly, a living shoreline should improve in strength over time. Nevertheless, strong storms such as Sandy can damage living shorelines.
Beach erosion	Sea walls located in front of beaches will cause the beach to erode as waves bounce off of the wall and take sand with them back into the ocean.	Living shorelines will protect beaches from erosion by absorbing wave energy and providing sand to replace sand that is washed out to sea.
Aesthetics (how nice the feature looks)	Sea walls are just that, a wall, and are not necessarily considered pleasing to look at by some people.	Some may consider living shorelines more pleasant to look at compared to sea walls, but large dunes (which offer more storm protection) can block views of the ocean.

Table 2: Randomly Assigned Values for Restoration Alternatives

INSERTS FOR DOV_LEVEL, DOV_TIME, DOV_LONGEVITY, AND DOV_COST FOR EACH ALTERNATIVE	
DOV	Inserts
DOV_LEVEL	**1=**Category 2 hurricane (waves from the storm would be approximately 6-8 feet above high tide level) **2=**Category 4 hurricane (waves from the storm would be approximately 13-18 feet above high tide level)
DOV_LONGEVITY	**1=**10 years **2=**30 years
DOV_COST	**1=**$30 **2=**$70 **3=**$140 **4=**$240

Table 3: Descriptive Statistics

Variable	N	Mean	Std. Dev.
Income	503	78,451	56,963
Internet Access	503	0.962	0.191
Familiar with JB	503	0.473	0.499
Never Heard of JB	503	0.0795	0.271
Lives in JB	503	0.0795	0.271
Never Visited JB	503	0.773	0.419
Trips to JB/year	503	0.901	6.027
Living in NY/NJ during Sandy	503	0.968	0.176
Very Significant Impact of HS	503	0.155	0.362
Moderate Impact of HS	503	0.294	0.456
Some Impact of HS	503	0.364	0.481
Impacted from Sandy	503	0.449	0.498
Climate	503	0.793	0.405
Federal Funding	503	0.718	0.45
Low Risk	503	0.199	0.399

High Risk	503	0.616	0.486
Natural Restoration	503	0.704	0.457
Fishing	503	0.163	0.37
Outdoors	503	0.545	0.498
Household Education	503	0.559	0.497
White	503	0.644	0.479
Hispanic	503	0.187	0.39
Black	503	0.111	0.315

(JB-Jamaica Bay, HS-Hurricane Sandy)

Table 4: Variable Descriptions

Variable	Description
impact	Impacted very significantly or moderately by Hurricane Sandy
high_risk	Expects more destructive storms in the future
low_risk	A similar storm is unlikely in the future
nature	Prefer natural shoreline protections over man-made
fed	The federal government should fund restoration after Sandy
fishing	Engages in fresh or saltwater fishing
outdoors	Engages in outdoor activities
hedu	Household education level college and above
prot	Level of protection
longev	Longevity of the protection
tax	Amount of annual tax for 10 years

Table 5: Descriptors for Model Covariates

Variables	Obs	Mean	Std. Dev.
prot	503	0.485	0.5
longev	503	0.481	0.5
tax	503	115.65	78.09
impact	503	0.449	0.498
high_risk	503	0.616	0.487
hedu	503	0.559	0.497

Table 6: McFadden's Choice Model Regression Results

Program Attributes						
Option	Coeff.	Std. Err.	Z	P>|z|	[95% Conf.	Interval]
prot	-0.0161	0.0772888	-0.21	0.835	-0.16757	0.13539
longev	-0.00667	0.0074062	-0.9	0.369	-0.02118	-0.00786
tax	-0.00359***	0.0010416	-3.44	0.001	-0.00563	-0.00155
Household Attributes						
Status Quo (1)						
Base Alternative						
Living Shorelines (2)						
Variable	Coeff.	Std. Err.	Z	P>|z|	[95% Conf.	Interval]
impact	0.393	0.274	1.44	0.151	-0.143	0.929
high-risk	0.553**	0.277	1.99	0.046	0.00946	1.097
low_risk	-0.802***	0.306	-2.62	0.009	-1.403	-0.201
nature	1.57***	0.302	5.19	0	0.977	2.162
fed	0.562*	0.287	1.96	0.05	-0.00115	1.126
fishing	0.448	0.423	1.06	0.29	-0.381	1.276
outdoors	0.918***	0.265	3.46	0.001	0.398	1.437

hedu	0.367	0.257	1.43	0.153	-0.136	0.87
_cons	-1.01	0.424	-2.39	0.017	-1.844	-0.183

Shoreline Armoring (3)

Variable	Coeff.	Std. Err.	Z	P>|z|	[95% Conf. Interval]	
impact	0.384	0.309	1.24	0.214	-0.221	0.99
high-risk	0.728**	0.32	2.28	0.023	0.101	1.354
low_risk	-0.036	0.358	-0.1	0.919	-0.739	0.666
nature	-0.982***	0.322	-3.05	0.002	-1.61	-0.35
fed	0.797**	0.333	2.39	0.017	0.145	1.449
fishing	0.956**	0.446	2.15	0.032	0.0828	1.83
outdoors	0.605**	0.303	2	0.046	0.012	1.2
hedu	0.209	0.294	0.71	0.477	-0.367	0.784
_cons	-0.546	0.437	-1.25	0.212	-1.403	0.311

*** p<0.01, ** p<0.05, * p<0.1
N=1,059

Table 7: Marginal Effects of Significant Variables

Pr (choice =1|1 selected) =.20700825							
Variable	dp/dx	Std. Err.	z	P>|z|	95% Conf. Int.		X
impact	-.64101	.041886	-1.53	0.126	-.146196	.017993	.4493
high_risk	-.098041	.04224	-2.32	.020	-.180829	-.015253	.6163
low_risk	.099894	.046696	2.14	0.032	.008372	.191416	.19881
nature	-.151811	.045004	-3.37	0.001	-.240016	-.06305	.70378
fed	-.102019	.04427	-2.3	0.021	-.188787	-.015252	.71769
fishing	-.094588	.065427	-1.45	0.148	-.222822	.033647	.16302
outdoors	-.137701	.040418	-3.41	0.001	-.216919	-.058483	.54473
hedu	-.053662	.039331	-1.36	0.172	-.13075	.023425	.55865
Pr (choice =2|1 selected) =.5925757							
Variable	dp/dx	Std. Err.	z	P>|z|	95% Conf. Int.		X
impact	.04919	.053388	.92	.357	-.055449	.153829	.4493
high_risk	.047178	.055724	0.85	0.397	-.062039	.156395	.6163
low_risk	-.189302	.062611	-3.02	0.002	-.312018	-.066587	.19881
nature	.495502	.063897	7.75	0.000	.370266	.620738	.70378

fed	.041117	.060421	.68	0.496	-.077307	.159541	.71769
fishing	-.005515	.074005	-0.07	0.941	-.150561	.139532	.16302
outdoors	.149695	.053346	2.81	0.005	.045139	.25425	.54473
hedu	.063803	.051712	1.23	0.217	-.03755	.165156	.55865
Pr (choice=3|1 selected) = .20041605							
impact	.014911	.040456	0.37	.0712	-.064381	.094204	.4439
high_risk	.050863	.043172	1.18	0.239	-.033753	.13548	.6163
low_risk	.089408	.049158	1.82	0.069	-.006939	.185756	.19881
nature	-.343691	.045375	-7.57	0.000	-.432625	-.254757	.70378
fed	.060903	.046791	1.30	0.193	-.030806	.152612	.71769
fishing	.100102	.050615	1.98	0.048	.000899	.99306	.16302
outdoors	-.01194	.040815	-0.29	0.769	-.091989	.068001	.54473
hedu	-.010141	.039649	-0.26	0.798	-.087852	.06757	.55865

Appendix B: Figures

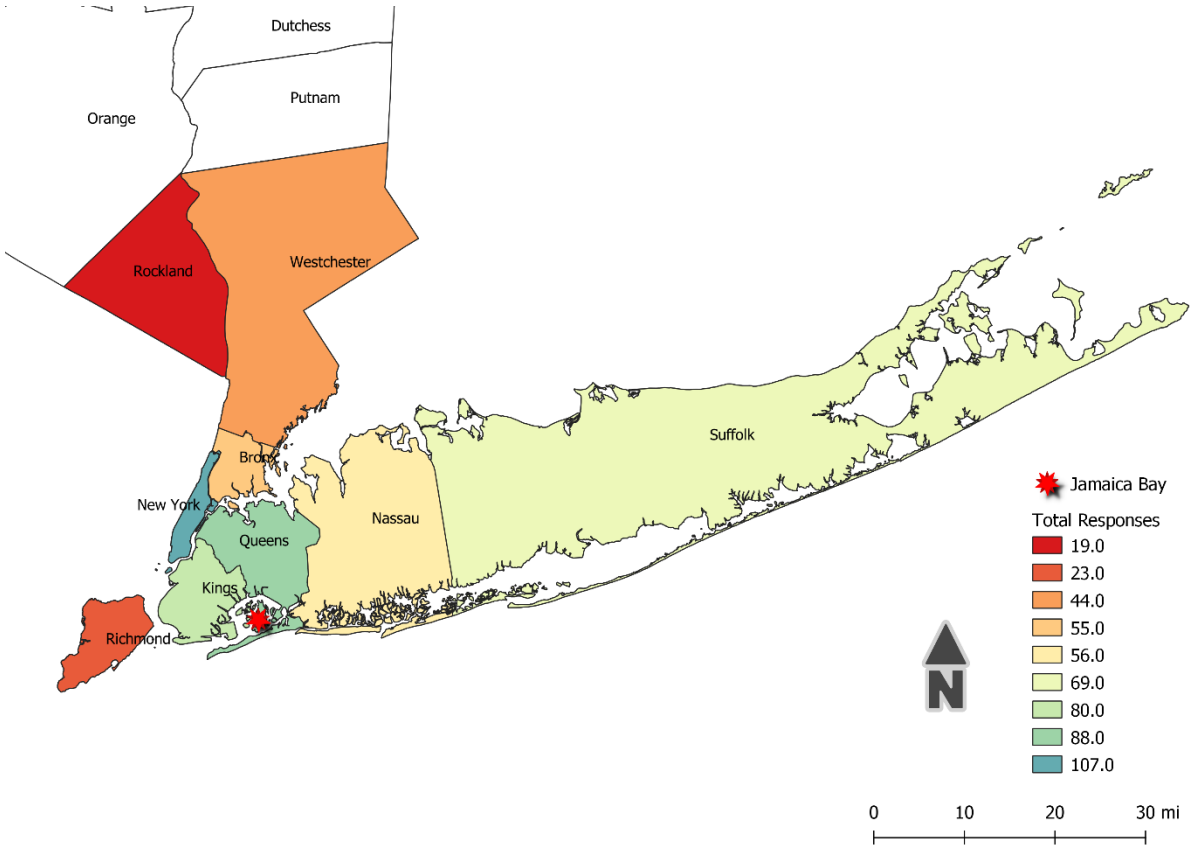

Figure 1: The county of map of New York with the number of survey responses received from each county

Appendix C: Final Questionnaire

Main-Jamaica Bay
July, 2015
- Questionnaire -

[SP; PROMPT ONCE]
QSTATE. In which state do you live?

New York 21
New Jersey 22
Pennsylvania 23
Some other state (not listed above) 99

[PROGRAMMING NOTE: TERMINATE IF QSTATE= -1 'REFUSED' OR IF QSTATE=22 'NEW JERSEY' OR IF QSTATE=23 'PENNSYLVANIA' OR IF QSTATE=99 'SOME OTHER STATE (NOT LISTED ABOVE)']

[SP; PROMPT ONCE]
QCOUNTY. In which of the following counties do you live?

Bronx County …1
Dutchess County …2
Kings County …3
Nassau County …4
New York County …5
Orange County …6
Putnam County …7
Queens County …8
Richmond County …9
Rockland County …10
Suffolk County …11
Westchester County …12
Some other county (not listed above)..... 99

[PROGRAMMING NOTE: TERMINATE IF QCOUNTY= -1 'REFUSED' OR IF QCOUNTY=99 'SOME OTHER COUNTY (NOT LISTED ABOVE) OR IF QCOUNTY=2 'DUTCHESS' OR QCOUNTY=6 'ORANGE COUNTY' OR QCOUNTY=7 'PUTNAM COUNTY']

[DISPLAY]
OMB Control #: 0648-0714

Expires May 31, 2018

- This research study is being conducted by Eastern Research Group, Inc. on behalf of the National Oceanic and Atmospheric Administration (NOAA).

- Your participation is absolutely voluntary and you may quit at any time.

- The survey will take approximately 25 minutes of your time to complete.

- You will not be individually identified and your responses will be used for statistical purposes only.

- If you have questions about your rights as a participant in this survey, or are dissatisfied at any time with any aspect of the survey, you may contact Melanie.Sands@erg.com.

Public reporting burden for this collection of information is estimated to average 25 minutes per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other suggestions for reducing this burden to Peter Wiley, NOAA Office for Coastal Management 1315 East-West Highway, Silver Spring, MD 20910 (Peter.Wiley@noaa.gov, 310- 563-1141).

Notwithstanding any other provisions of the law, no person is required to respond to, nor shall any person be subjected to a penalty for failure to comply with, a collection of information

subject to the requirements of the Paperwork Reduction Act, unless that collection of information displays a currently valid OMB Control Number.

[DISPLAY]
In October of 2012, Hurricane Sandy inflicted significant damage and loss of life along the eastern seaboard of the U.S. One of the areas significantly affected was the **Jamaica Bay** area of New York City.

Since Hurricane Sandy, there has been an active debate on the best ways to protect areas such as Jamaica Bay from storms like Sandy. One possible approach involves building sea walls (or flood walls) and other "hard" structures that shield buildings, roads, and utilities from storm surge and strong waves caused by coastal storms. This is often referred to as "**shoreline armoring**." A second approach is to use natural features, such as dunes, native plants, and stones that will protect coastal areas, while also providing wildlife habitat and recreational opportunities for people. This approach is sometimes referred to as "**living shorelines**." The two options are not "all-or-nothing". They can be combined as part of a region-wide strategy. Furthermore, some specific locations are better suited for one approach over the other (for various reasons). In many cases and at some locations, however, decision-makers will need to choose between the two options.

The purpose of this survey is to help NOAA better understand how and why people value the different shoreline protection options. In what follows, we'll provide some information on the pros

and cons of each approach and then ask you a series of questions, including a question about your willingness to pay for both types of storm protection.

As you are probably aware, significant work is underway to restore Jamaica Bay from the impacts of Sandy. There is still, however, much to be done to protect Jamaica Bay and other parts of NYC from future storms, and a good deal of thought has been given to what types of protective measures should be used. There are many options being considered, some of which involve **shoreline armoring** and some of which involve **living shorelines**.

The goal of this survey is to collect information from people like you to assist in better decision-making. We are interested in what you think of different storm protection options and the value you place on that protection.

[DISPLAY]
The choice between **shoreline armoring** and **living shorelines** is not a simple one; each offers pros and cons relative to the other. The following table describes some of these pros and cons for sea walls (a form of armoring) and living shorelines.

	Sea walls (shoreline armoring)	**Living shorelines**
Amount of protection from storms	A sea wall offers significant protection from a storm. A sea wall repels most coastal storm waves which protects structures from damage. They can be designed to withstand certain storm "levels" (e.g., a 5-foot storm surge or a 50-year storm).	Dunes slow waves down and, if large enough, repel the waves. Living shorelines can also involve stone breakwaters that are placed offshore which slow down waves. Large waves, however, can wash over dunes and breakwaters.

Time it takes to get to full protection	Once it is installed, a sea wall offers immediate protection from coastal storms. Planning and design of the sea walls, however, could take one to three years.	A living shoreline can be built within a few months. If the design involves native plants (most do), then it may take a few years for those plants to fully mature and offer any benefits.
Longevity of protection	Over time, a sea wall will deteriorate and require maintenance and, eventually, replacement.	Living shorelines should last a long time. If built correctly, a living shoreline should improve in strength over time. Nevertheless, strong storms such as Sandy can damage living shorelines.
Beach erosion	Sea walls located in front of beaches will cause the beach to erode as waves bounce off of the wall and take sand with them back into the ocean.	Living shorelines will protect beaches from erosion by absorbing wave energy and providing sand to replace sand that is washed out to sea.
Aesthetics (how nice the feature looks)	Sea walls are just that, a wall, and are not necessarily considered pleasing to look at by some people.	Some may consider living shorelines more pleasant to look at compared to sea walls, but large dunes (which offer more storm protection) can block views of the ocean.
Benefits besides storm protection	None	Living shorelines provide habitat for birds and other wildlife. They also provide recreational opportunities such as wildlife watching and beach-going for people.

[PROGRAMMING NOTE: IMAGES ARE PROVIDED IN DR UNDER THE FOLLOWING EXTENSIONS 'SEAWALL1.JPG,' 'SEAWALL2.JPG,' AND 'SEAWALL3.JPG;' PLEASE PLACE IMAGES ONE AFTER THE OTHER GOING DOWN THE LEFT SIDE OF THE SCREEN; PLEASE MAKE IMAGES OF EQUAL SIZE TO EACH OTHER]

[DISPLAY]

For reference, here are some examples of what sea walls (shoreline armoring) look like after installation.

[PROGRAMMING NOTE: IMAGES ARE PROVIDED IN DR UNDER THE FOLLOWING EXTENSIONS 'LIVINGSHORELINE1.JPG,' 'LIVINGSHORELINE2.JPG,' AND 'LIVINGSHORELINE3.JPG;' PLEASE PLACE IMAGES ONE AFTER THE OTHER GOING DOWN THE LEFT SIDE OF THE SCREEN; PLEASE MAKE IMAGES OF EQUAL SIZE TO EACH OTHER]

[DISPLAY]

For reference, these are some images of living shorelines …

[NUMBERBOX RANGE; 00000-99999]

ZIP. What is your ZIP code? (This will help us understand where you live in relation to Jamaica Bay)

[INSERT NUMBERBOX; RANGE 00000-99999] ZIP CODE

[SP]

Q1. How familiar are you with Jamaica Bay?

Very familiar 1
Somewhat familiar.....2
Not very familiar 3
Have never heard of it 4

[SP]

Q2. Do you live in one of the communities in and around Jamaica Bay?

Yes.....1
No 2

[IF Q2=2 'NO']
[SP]

Q3. How frequently do you visit Jamaica Bay?

Very often.....1
Often 2
Sometimes 3
Rarely.....4
Never 5

[IF Q2=2 'NO']
[NUMBERBOX; RANGE 0-100]

Q4. In the previous 12 months, how many trips did you take to the Jamaica Bay area for the purpose of performing some form of outdoor recreation such as going to the beach, hiking, or bird-watching?

[NUMBERBOX] trips

[SP]

Q5. Were you living in the New York/New Jersey area during Hurricane Sandy?

Yes.....1
No 2

[SP]

Q6. How would you describe the impact that Hurricane Sandy on you?

Very significant.....1
Moderate impact.....2
Small impact.....3
No impact at all.....4

[DISPLAY]

The results of this survey are *advisory.* In other words, they can be used to inform policymakers on the opinions and preferences of people, such as yourself, about different types of coastal protection measures. To provide information to policymakers, we will ask you to vote on

different options that involve **shoreline armoring** (sea walls) and **living shoreline** coastal protection measures. These projects are *not* currently proposed projects or ones that are being considered at this time. In fact, we have kept the details general in order to focus on the trade-offs between **shoreline armoring** and **living shoreline** options. In other words, the options we present are examples rather than specific projects.

Importantly, we'll also be asking whether you'd be willing to incur additional annual income tax to fund these coastal protection measures. As a voting taxpayer, you have an opportunity to provide feedback to policymakers regarding your support for – and willingness to pay for – coastal protection projects. Naturally, one alternative is to not invest in additional coastal protection, in which case no public money will be needed. If, however, the public values coastal protection, the results of this survey may be used to assess public preferences and how much people are willing to pay. This information may influence financing decisions, which can affect taxation policies.

Please think about your budget and keep in mind other things you might spend your money on instead of coastal protection projects. Honestly assess the tradeoffs involved with supporting a proposed project or not supporting it.

There are no right or wrong answers. We have found some people would support these kinds of projects and others would not support them. Both kinds of voters have good reasons for why they would vote one way or the other.

[CREATE DOV_LEVEL AND RANDOMLY ASSIGN R'S A VALUE OF 1-2]
[CREATE DOV_LONGEVITY AND RANDOMLY ASSIGN R'S A VALUE OF 1-2]
[CREATE DOV_COST AND RANDOMLY ASSIGN R'S A VALUE OF 1-4]

INSERTS FOR DOV_LEVEL, DOV_TIME, DOV_LONGEVITY, AND DOV_COST	
DOV	Inserts
DOV_LEVEL	**1=**Category 2 hurricane (waves from the storm would be approximately 6-8 feet above high tide level) **2=**Category 4 hurricane (waves from the storm would be approximately 13-18 feet above high tide level)
DOV_LONGEVITY	**1=**10 years **2=**30 years
DOV_COST	**1=**$30 **2=**$70 **3=**$140 **4=**$240

[CREATE DOV_LEVEL_2 AND RANDOMLY ASSIGN R'S A VALUE OF 1-2]
[CREATE DOV_LONGEVITY_2 AND RANDOMLY ASSIGN R'S A VALUE OF 1-2]
[CREATE DOV_COST_2 AND RANDOMLY ASSIGN R'S A VALUE OF 1-4]

INSERTS FOR DOV_LEVEL, DOV_TIME, DOV_LONGEVITY, AND DOV_COST	
DOV	Inserts
DOV_LEVEL_2	**1=**Category 2 hurricane (waves from the storm would be approximately 6-8 feet above high tide level) **2=**Category 4 hurricane (waves from the storm would be approximately 13-18 feet above high tide level)
DOV_LONGEVITY_2	**1=**10 years **2=**30 years
DOV_COST_2	**1=**$30 **2=**$70 **3=**$140 **4=**$240

[DISPLAY]

Below we provide two potential coastal protection options, one focused on shoreline armoring and one on living shorelines. We describe each option and the associated cost to taxpayers. You can choose to vote for one of the two options or choose to support neither one.

Shoreline armoring option. Under this option, sea walls would be built to protect coastal areas within Jamaica Bay. The walls would provide protection against a **[DOV_LEVEL INSERT]**. The walls would take two to three years to plan and build and, once completed, would provide immediate protection from storms. The walls would last approximately **[DOV_LONGEVITY INSERT]**, but would require some maintenance every year with more maintenance being required toward the end of the wall's lifetime. Any beaches in front of the sea walls would erode completely within 1-2 years after completion. Building these walls to protect coastal areas in Jamaica Bay would result in an increase of **[DOV_COST INSERT]** each year to your household income taxes over the next 10 years.

Living shorelines option. Under this option, living shorelines would be built in Jamaica Bay to provide coastal protection. The living shorelines would be built to provide protection against a **[DOV_LEVEL_2 INSERT]**. The living shorelines would take a year to plan and build and, once built, would provide immediate protection. The living shorelines would require little maintenance over time and, if built properly, would become stronger over time as they become "established". Large storms, however, can and will damage these areas. Under this

option, we would expect the living shorelines to last **[DOV_LONGEVITY_2 INSERT]** before being damaged by storms and needing repair. The living shorelines would also provide habitat for birds and other animals. Building living shorelines to protect coastal areas in Jamaica Bay would result in an increase of **[DOV_COST_2 INSERT**] each year to your household income taxes over the next 10 years.

[GRID, SP DOWN]

Q7. What option would you choose?
Please note, you can also choose to vote for neither option. Voting for neither option results in no additional cost to you, but no additional protection to the coastline is added.

Option	Increased annual household income tax you would have to pay	Vote
Shoreline armoring (sea walls)	$ **[DOV_COST INSERT]**	
Living shorelines	$ **[DOV_COST_2 INSERT]**	
Neither	$0	

[SP]

Q8. How confident were you in the choice you made?

Very confident 1
Somewhat confident.....2
Somewhat unsure 3
Not at all confident.....4

[SP]

Q9. When voting, what expectations, if any, did you have about how <u>others</u> might vote?

I thought most people would vote for the "neither approach" option.....1
I thought most people would vote for shoreline armoring.....2
I thought most people would vote for living shorelines.....3
I didn't really think about it.....4

[SP]

Q10. How likely do you think it is that the results of this survey will shape the direction of future policy in Jamaica Bay?

Very likely.....1
Somewhat likely.....2
Somewhat unlikely.....3
Very unlikely.....4
I don't know.....5

[IF Q7=3 'NEITHER']
[SP]

Q11. You chose to vote neither shoreline armoring nor living shorelines on the referendum. What was the primary reason for your decision?

I don't really have a specific reason why.....1
I'm interested, but I can't afford it.....2
I don't think the expected benefits are worth it.....3
Society has more important problems than coastal protection.....4
I do not support any kind of tax increases.....5
I do not live in the area – only people who live in the area should pay for the project.....6
Other, please specify: **[TEXTBOX]**.....7

[PROGRAMMING NOTE: CREATE DOV_BLOCK; RANDOMLY ASSIGN RESPONDENTS TO EITHER 1 'BLOCK A (ORIGINAL SCALE PATTERN)' OR 2 'BLOCK B (REVERSE SCALE PATTERN)'; IF RESPONDENTS ARE ASSIGNED TO 1 'BLOCK A (ORIGINAL SCALE PATTERN)' THEN PRESENT THE Q12_1 THROUGH Q12_5 SCALE IN THE INTEND ORDER OF 'STRONGLY DISAGREE TO STRONGLY AGREE'; IF RESPONDENTS ARE ASSIGNED TO 2 'BLOCK B (REVERSE SCALE PATTERN)' THEN

PRESENT ALL AGREEMENT SCALES IN REVERSE OF THE INTENDED ORDER 'STRONGLY DAGREE TO STRONGLY DISAGREE;' THIS SHOULD ONLY AFFECT THE VISUAL PRESENTATION THE GRID AND NOT THE ACTUAL DATA VALUES]

[GRID; SP ACROSS]

To what extent do you agree with the following statements?

Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
1	2	3	4	5

Q12_1. The climate is changing in ways that could be harmful to the coast.
Q12_2. It is the responsibility of the federal government to fund restoration efforts related to Hurricane Sandy.
Q12_3. Hurricane Sandy was a rare event and a similar storm is unlikely to occur again in my lifetime.
Q12_4. I expect coastal storms will be more destructive in the future than in the past.
Q12_5. Where possible, natural options for shoreline protection should be used before any man-made options.

[MP]

Q13. Which, if any, of the following outdoor activities do you engage in?

Freshwater fishing 1
Saltwater fishing 2
Boating/Canoeing 3
Hunting 4
Bird watching 5
Hiking/nature walking 6
Other, please specify: **[TEXTBOX]** 7
[SPACE]
I don't engage in any outdoor activities **[SP]** 8

[INSERT STANDARD CLOSE]