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Ex-Ante Economic Assessment of the Climate-Resilient Coastal Infrastructure and Management Program

BH-L1043

ECONOMIC ANALYSIS ANNEX

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Ex-Ante Economic Assessment of the Climate-Resilient Coastal Infrastructure and Management Program (BH-L1043)

I. Introduction

Pursuant to the requirements for project evaluation and approval put forth by the Inter-American Development Bank (IDB), this document presents methods and results for an *ex-ante* cost-benefit analysis for investments in the Climate-Resilient Coastal Infrastructure and Management Program (CRCIMP; BH-L1043) for the Commonwealth of The Bahamas. This endeavor is restricted by time, budget, information availability, and a paucity of relevant studies, and therefore must make use of readily available data, existing studies, and expert judgment to provide a basis for project evaluation and assessment. The *ex-ante* economic assessment draws heavily upon simulations of international tourism demand and storm damage (to explore the impacts of project effectiveness) and the practice of benefit transfer (BT) (Rosenberger and Loomis 2004), which has been shown to be defensible in application and empirically tractable in the presence of limited data (Griffiths et al. 2012).

IDB loan BH-L1043 for investments in CRCIMP consists of three components: 1) natural hazard risk-reduction and environmental enhancements stemming from investments in natural and man-made coastal infrastructure on New Providence, Grand Bahama, and Long Island; 2) environmental, social, and eco-tourism improvements on the island of Andros, engendered through implementation of a nature-based sustainable development plan; and 3) amelioration of storm, flooding, and erosion risk through design and implementation of a coastal risk management system, including improved governance and planning, institutional strengthening, and use of a web-based information and monitoring platform to improve access to data, technical capabilities, and inter-institutional coordination. Details of the possible investments in sustainable coastal protection infrastructure are laid out in individual Project Site Data Sheets, but are briefly summarized here.

Climate-resilient coastal investments for New Providence focus on the port of Nassau and nearby vicinity. From the perspective of stakeholders at the Ministry of Works and Urban Development (MOWUD), rehabilitation of breakwater infrastructure for the Port of Nassau and cruise terminal is a top project priority. The eastern breakwater is currently in a heavily degraded state, and the western breakwater has several breaches, complicating navigability of cruise ships and commercial freighters. By limiting the flow of imports and exports and inhibiting tourism arrivals, this situation threatens the viability of the Bahamian economy. Environmental enhancements for New Providence include replenishment of Junkanoo and the surrounding beaches to remediate erosion that has been intensified due to damage in the port breakwaters, as well as improvements in drainage to reduce flooding and improve water quality. Economic benefits of these *Sustainable Nassau* investments relate to maintenance of tourism flows, enhancements of natural resources that can improve tourism flows, protection of port capabilities (especially relevant for critical commodity imports), and improvements in beach and water quality for local residents.

Investments in East Grand Bahama will focus on excavation of derelict causeways that are impeding hydrological function and degrading ecological health, construction of a new bypass that will maintain the transportation network, new culverts to improve hydrology, and mangrove rehabilitation. Derelict causeways, constructed by logging companies, have restricted tidal flow, having an impact on salinity, hydrology, sedimentation, mangrove health, and fisheries. Removing causeways will have direct ecological benefits. The Bahamas National Trust has done preliminary work on environmental improvements in this area and has plans to establish a National Park and Marine Protected Area. Economic benefits for investments in East Grand Bahama include ecosystem service enhancements, better boat access to certain parts of the island, storm and flood-risk reduction, and improvements in fisheries—primarily bone fish, grouper, lobster, snapper, and conk.

Central Long Island will see investments in flood risk reduction (via drainage wells), storm surge protection, and shoreline erosion defense (seawalls, revetment, mangroves restoration, and vegetation planting). Local inhabitants have identified a number of places where they would like to see new drainage wells, to reduce flood likelihood and duration. Primary transit roads are located near the ocean and require enhanced protection to maintain viability, reduce erosion risk, and limit flooding. Many parts of the transportation network are inaccessible in times of flood. In addition, INVEST software identifies eastern mangroves on Central Long Island as some of the most productive and ecologically valuable resources in the area. These mangroves, however, are threatened by sedimentation and sea level rise. Economic benefits of these investments entail lower flood, erosion, and storm surge risk, which should lead to lower storm-related damages in the future; improved transportation and accessibility; and ecological improvements due to mangrove rehabilitation. Component one of BH-L1043, thus, makes focused infrastructure investments and environmental enhancements in locations that have been identified and vetted as areas of high vulnerability and with significant potential for effective mitigation and improved risk management.

Component two of BH-L1043 entails sustainable development initiatives for Andros Island. The *Andros Sustainable Development Plan* is an innovative effort to render the largest island in The Bahamas as an invigorated and sustainable natural and socio-economic system, with enhanced capacity to secure livelihoods, strengthen local institutions, and maintain nature-based tourism opportunities. The installation of small seawalls along Andros has led to mangrove degradation and heightened flooding, erosion, and storm risk. Given the low density of development and extensive ecological capital, many areas along the shore of Andros have been identifies as places where "hard" engineering structures can be removed and "soft" shoreline management options (mangroves, native vegetation, living shorelines) can be used in their place. Identified sites include Lowe Sound, Mastic Point, and Deep Creek, among others. Benefits of nature-based risk management solutions on Andros entail sustainable development of an ecologically unique destination that can promote eco-tourism and empower local communities to manage and maintain the natural capital for their own livelihoods and economic benefit.

Lastly, stakeholders and partners in the Bahamian Government desire greater capacity to manage coastal risk. Improved policy-making, expanded efforts in data collection, more clarity in responsibility for data collection, enhanced data and information management, building of institutional capacity, and integration of planning will provide for substantial benefits in coastal risk management, hazard mitigation, and better investment choices amongst developers, builders, and residents. This will entail the establishment of a Coastal Management Program Unit in the MOWUD; the collation, digitization, and geo-referencing of existing data; as well as baseline studies to fill critical data gaps for risk reduction and climate resilience in The Bahamas. Component three of BH-L1043 will provide for benefits in the form of institutional strengthening, capacity building, monitoring, and assessment to improve resilience, reduce risk, and enhance risk management capabilities, ultimately leading to reductions in expected storm damages and economic losses.

The organization of this document is as follows: We first lay out the motivation for considering investments in climate-resilient coastal infrastructure, then provide a detailed assessment of the conceptual framework, necessary assumptions, methodologies, and empirical foundations for analyzing the economic benefits of BH-L1043. Section three implements these methods and presents findings on net present value of benefits for BH-L1043 investments. Section four provides a summary of project costs, derived from engineers and other personnel in the production of project data sheets. The fifth section brings all of the information together to assess net returns to BH-L1043, which is subjected to sensitivity analysis in section six. The final section offers conclusions and recommendations.

II. Background, Assumptions, and Methods

Consisting of 700 low-lying islands, 80% of which are less than one meter above sea level (BEST 2001), the Commonwealth of The Bahamas is extremely vulnerable to sea level rise (SLR), tropical storms and hurricanes, coastal erosion, and extreme precipitation events causing widespread and persistent flooding. Including a vast maritime territory covering approximately 668,600 square kilometers (BEST 2001), the economy of The Bahamas is heavily dependent upon the natural resource base for tourism, fisheries, mining, and other sources of revenues. In 2015, direct tourist revenues generated an estimated US$2.5 billion

(BNGIS 2015); gross output of Bahamian fisheries was valued at US$103 million, while gross output of mining was valued at US$165 million (CTB 2015a). Revenues in these (and other) sectors create economic impact: tourist revenues, for example, create an estimated US$4.1 billion in direct, indirect, and induced economic impact (close to half of GDP) and account for induced employment amounting to 55,500 jobs (WTTC 2016).

While conventional wisdom suggests manufacturing is an engine for economic growth, tourism-based economies can also exhibit high economic growth rates (Algieri 2006). The Commonwealth of The Bahamas witnessed a 6.4% average annual growth rate between 1990 and 2003, arguably due to the human capital accumulation occurring from specialization in tourism (Algieri 2006). As such, the potential impacts of climate change on the natural resource base that supports tourism are a serious concern for future environmental, economic, and social sustainability in The Bahamas.

In defining assumptions and selecting methods to assess benefits of BH-L1043, we evaluate the implementation of all three investment-components roughly simultaneously (realizing they each have their different timelines, but ultimately should be in place contemporaneously for assessment purposes). To avoid double counting of economic benefits, we are careful to distinguish between beneficiary groups—tourists and residents—and to conceptualize project benefits relating to (roughly) independent ecosystem service flows for Bahamian residents—beach enhancement and recreation values, reduced storm damage, and enhancement of ecosystem services other than beaches and storm damage reduction.[1]

While components one and two consist of distinct investments on four Bahamian islands, component three entails additional capabilities for risk management that should have national level impacts. Moreover, beneficial aspects are not unique across investment areas, as many projects will provide for ecosystem service enhancements, risk reduction, and tourism benefits. As such, we apply a simple *with vs. without* approach to assess the net benefits of BH-L1043/CRCIMP. In doing so, we attempt to aggregate benefits across all project sites at which improvements are expected to occur. While it would be useful to evaluate individual projects in components one and two, the conceptualization of benefits is not refined enough to focus at this level. Assumptions and methods are briefly for each of the benefit and cost components that are to be evaluated.

Related Literature

Since our analysis utilizes limited primary data (relying mostly on simulations and BT), we provide a brief review of existing literature on economic benefits of risk-reduction and environmental enhancements for coastal systems, with a focus on the Caribbean, to provide context for simulations and BT and to gain some insight into economic values and impacts of tourism related to investments in climate-resilient coastal infrastructure. Edwards (2009) uses contingent behavior analysis (a stated preference approach) to estimate tourists' net

[1] While beaches do provide storm protection, Junkanoo and the surrounding beaches (788 meters in total length—see Figures 2 and 3 [pg. 34)]) are located behind navigation breakwaters and in front of seawalls. Thus, beach replenishment would have minimal effects on storm protection for a very small numbers of properties in Nassau.

economic value of visits to Jamaica; using a dichotomous choice (i.e. Yes/No) question format, he evaluates willingness to pay (WTP) an additional tax for visiting Jamaica (versus not visiting). Employing an experimental design, he segments the data so that the tax revenues in one version of the survey are allocated to a "general tourism development fund and are to be used to support management of the local tourist municipalities with activities such as General beautification and Human resource training." (pg. 380) Whereas in the other version of the survey, the tax is deemed an "environmental tax", with revenues allocated to primarily preserve and manage endangered coral reefs through funding of marine patrols, fisheries management, public education programs, but also address other environmental issues, like deforestation, river pollution, sustainable agricultural, and improved management of solid waste. Using a conservative (non-parametric) estimation procedure he finds an average WTP per person per day for the tourism tax was US$16.16 (2008), whereas the average WTP per person, per day for the environmental tax was US$20.52 (2008). Though the confidence intervals are wide, one can interpret the $4.36 difference in WTP as the value of investing in ecological services and preservation in the Caribbean.[2]

Loomis and Santiago (2013) use contingent valuation (CV) and choice experiments (CE) to assess residents' and tourists' values for improvements in Puerto Rican beaches. Of the characteristics wave height, crowding, beach debris, and water clarity, they find that absence of debris and water clarity each have significant and positive effects on the value of beach trips. They estimate WTP for beach cleanliness at US$98 per visitor day (95% confidence

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[2] Further, he uses his results to simulate the effects of an additional tax on tourists, estimate a $1 ($2) surcharge would decrease visits by 0.1% (0.2%), while raising additional revenues of $1,699,867 ($3,393,326) per year.

interval $83 - $131) from CV data, and US$103 per visitor day (95% confidence interval $77 - $126) from CE data. For improvements in water clarity, they find WTP of US$54 per visitor day (95% confidence interval $39 - $73) from CV data, and US$51 per visitor day (95% confidence interval $34 - $70) from CE data.[3] (All estimates in 2011 dollars.)

Beharry-Borg and Scarpa (2010) use CE to estimate WTP for improvements in water quality for snorkelers (70% of their sample) and non-snorkels in Tobago. Their data include 11% (64%) residents of Trinidad for the snorkelers (non-snorkelers) group, so it represents a mix of residents and tourists. They find evidence of two latent classes of snorkelers, with largest sub-group (61% of the sample of snorkelers) having larger WTP for high levels of fish (TT$35 per trip to see up to 60 fish), coral cover (TT$50 per trip for up to 45% coral cover on the ocean bottom), vertical visibility (TT$40 per trip to be able to see 10 meters underwater), and marine protected parks (TT$33 -$34 for marine protected areas). The second class (39% of the sample of snorkelers) exhibited lower economic values—TT$5 per trip to see up to 60 fish, TT$10 per trip for up to 45% coral cover on the ocean bottom, TT$10 per trip to be able to see 10 meters underwater, and TT$7 -$10 for marine protected areas. Their results also include WTP for reductions in plastic trash fragments, low chance of an ear infection, and low levels of urban development, though these attributes seem less relevant. Non-snorkelers were WTP TT$8 per trip to be able to see 10 meters underwater, and TT$7 for marine protected areas.[4]

Other studies have examined economic value of coastal-resilient infrastructure

[3] The overlap of estimates derived from different methods is evidence of convergent validity of SP approaches (i.e. different approaches produce similar answers).
[4] During the period of study TT$10 = US$1.40.

outside of the Caribbean. Alexandrakis et al. (2015) use a revealed preference technique called hedonic property price regression to estimate the relationship between beach width and land values at a vacation destination on the island of Crete in Greece. They aggregate all land uses adjacent to the beach (within a 200 meter buffer) into a single index of market value and regress that value on geophysical and tourism characteristics. Their unit of analysis is beach cross sections within the resort town of Rethymnon. Controlling for potential endogeneity, they estimate beach width price elasticities of 1.5 and 1.6. This implies that a one percent increase in the width of the beach increases land values within 200m by 1.5 to 1.6%. Using an unconventional "Value of Enjoyment" SP approach, Polomé et al. (2005) estimate the value of a beach day on the Italian Lido de Dante at €32.28 per person per day (2002) for tourists. This value decreases to €15.51 per person per day when the beach erodes.

Tourism Benefits

Sea arrivals accounted for 77.2% of the 6.11 million foreign tourist arrivals to the Bahamas in 2015, the majority of which (47.8%) occur at the Port of Nassau/ Paradise Island in New Providence (CTB 2015b). Stakeholders at MOWUD indicate that maintenance of navigation infrastructure at the port and cruise terminal in Nassau are critical for maintaining tourism and commodity flows. The breakwaters, in particular, are of primary importance for viability of navigation within the harbor, but they are currently in very poor shape, with numerous breaches in the eastern section and weaknesses in the western section. Investments in coastal infrastructure can include upgrading and augmenting the current breakwaters to provide for enhanced serviceability and sustainability for the Port of Nassau and cruise terminal.

Aside from navigation and the ability of cruise ships to access Nassau/ Paradise Island, tourism flows to The Bahamas are also contingent upon demand among international tourists. Demand for visits to the Bahamas depends upon individual households' preferences for vacation holidays, disposable incomes, and aspects of weather and climate, such as temperature, humidity, precipitation, sunshine, wind speed, and hurricane risk, which can influence the relative attractiveness of a destination (Moore 2010; Forster et al. 2012). Also relevant to tourist demand, negative impacts on natural resources—such as coral bleaching and beach erosion—can significantly decrease the likelihood of tourist returning to a destination (Uyara, et al. 2005).

As such, investments in BH-L1043 can benefit tourism in The Bahamas in at least three ways. First, climate-resilient coastal infrastructure can improve the quality of the international tourism destination, augmenting demand for visits to The Bahamas. For this to occur, visitors and potential visitors must perceive an improvement in the quality of the destination; this evolving perception can stem from experience, marketing, media reporting, or word-of-mouth. Augmented demand for international tourist trips to The Bahamas would create increases in net economic value (i.e. "consumer surplus") accruing to tourists and would increase the economic impact of tourism, through more trips taken, even under the conservative assumption of no increase in expenditures per trip.

Secondly, and related, investments that enhance climate resilience and improve the quality of environment and natural resources increase resilience and promote local self-sufficiency, bolstering The Bahamas' *destination image*. According to Chon (1990):

The central postulates of the destination image studies are that a destination

> *image has a crucial role in an individual's travel purchase related decision making and that the individual traveler's satisfaction/ dissatisfaction with a travel purchase largely depends on a comparison of his expectation about the destination, or a previously held destination image, and his perceived performance of the destination* (p. 3).

Pike (2002) offers a review of 142 studies on destination image, finding only a few studies on the Caribbean. Understanding formation and influence of destination image for The Bahamas could be useful for long-term marketing and management decisions and may reap benefits of bolstered tourism over a longer time horizon.

Lastly, enhancing resiliency to chronic natural hazards (like beach erosion and nuisance flooding) and acute disturbances (like catastrophic flooding and storm surge) in The Bahamas will help minimize tourism business interruption, protect the viability of the tourism product, limit bad publicity related to adversely affected tourist experiences, and may partially mitigate some tourists' concerns over hurricane risk. The majority of Caribbean tourism development is located in the highly vulnerable coastal zone; as such, beaches and coastal systems are a critical part of the Caribbean tourist economy (Phillips and Jones 2006). Currently, beaches in the Caribbean are eroding at an average rate of 0.3-0.5 meters per year (Phillips and Jones 2006, Cambers 2009). These trends could accelerate with SLR and greater storm intensities. Hurricanes can disrupt the tourism trade, forcing cancellations and inhibiting trips taken in the aftermath of a storm. While storms cannot be prevented, climate-resilient infrastructure investments can enhance the ability to protect natural resource systems during a hurricane and enable the local economy to withstand storms with minimal disruption of basic services due to damages. This should benefit both locals and tourists.

Overall, if The Bahamas is able to respond effectively to the occurrence of storms and manage their aftermath, international tourism should benefit.

Without BH-L1043

To assess the tourism benefits of BH-L1043, we calculate The Bahamas' market share of Caribbean tourism using recent years of arrival data, and we use this benchmark to assess potential changes in tourism flows. Engineers at MOWUD indicate that negative impacts on navigation due to depreciation and damage of the breakwaters at the Port of Nassau could have adverse effects on tourism and commerce in the port.[5] We estimate *without-BH-L1043* flows under the assumptions of diminished market share attributable to reduced navigability at Cruise Terminal, reductions in natural resource quality, and heightened threat of business interruption due to unmitigated storm risks.

Tourist arrivals at Cruise Terminal in Nassau comprise 47.8% of sea arrivals and 37.0% of total tourist arrivals. To gauge the magnitude of the baseline effect, we turn to the tourism literature. Uyara et al. (2005) analyze tourist questionnaire data to assess the potential impact of climate-related depreciation in natural resources on future visitation to Caribbean islands. Focusing on natural resources that are identified as being of primary importance to visitors, their data indicate that 81% of visitors to Barbados would be unwilling to return for another vacation holiday (at the same price) if "beaches largely disappeared because of climate change". Similarly, for Bonaire, 77% of visitors would be unwilling to return if "corals were more severely bleached as a result of climate change" (Uyara et al. 2015).[6] Even

[5] Unfortunately, there are no data on cruise or port interruption problems.
[6] Their sample includes repeat visitors (43% for Bonaire and 39% for Barbados).

changes in natural resources that are not identified as primarily important to visitors are projected to have substantial impacts on tourist demand—a 42% reduction of visitors to Barbados stemming for coral bleaching and a 26% decline for visits to Bonaire if beaches were heavily eroded. To put these numbers in perspective, they correspond with a decrease of almost one million tourist trips to Barbados due to beach erosion, or almost 500,000 trips due to coral bleaching. Such effects on tourist visits have, in fact, been documented—for example, diving tourism at a popular resort in the Philippines was significantly lower following a mass coral-bleaching event in1998 (Cesar 2000).

The tourism impacts estimated by Uyara et al. (2005) are quite large; they relate to drastic scenarios of negative environmental change, and they could be upward biased due to focusing illusions (i.e. placing undue attention on negative aspects of environmental change within the context of a sterile survey questionnaire that could be otherwise mitigated under more natural circumstances). Substitution patterns related to environmental change are also important, as other Caribbean destinations may become more desirable if negative change occurs in a single destination. Overall impacts on Caribbean tourism, however, could be more muted if negative environmental change were more widespread (which is likely). Realizing these limitations, we benchmark Bahamas market share of Caribbean tourism on historical data (2011-2014), and assume a modest decline in *market share* occurring over the construction period (5 years) and project life (50 years). Our approach is conservative; total international tourist arrival impacts amount to about an aggregate of a one-percent decrease from the benchmark over 55 years. Economic effects of declining tourism are calculated as lost expenditures and lower economic impact accruing from decreased tourist visits. A 12%

discount rate is used to calculate net present value of changes in tourist expenditures and economic impacts.

With BH-L1043

To assess tourist benefits associated with investments in BH-L1043, we again turn to the literature. Time-series modeling of aggregate tourism flows to Caribbean countries provide some insight, producing estimates of substitution elasticities, income effects, and the influence of seasonality, weather, and climate. Rosensweig (1988) analyzes tourism flows from the United States and Europe to Mexico, the Caribbean, and Mediterranean destinations. Focusing on U.S. visitors to the Caribbean, he estimates a constant elasticity of substitution of 1.33, indicating that, for example, a one-percent increase in the travel price for Puerto Rico relative to Bahamas leads to a 1.33% increase in the number of trips take to The Bahamas relative to Puerto Rico. In this case, trips to Bahamas and Puerto Rico are gross substitutes, but the effect is not very strong. Expanding the model to United States and European tourists, Rosensweig estimates an intra-Caribbean substitution elasticity of 2.45, and a foreign tourism income elasticity of 1.5. The latter indicates that a one-percent increase in foreign visitor income increases Caribbean tourism demand by 1.5%.

Moore (2009) examines the impact of climate on tourism demand using a dynamic panel data approach. Employing a Tourism Climate Index that accounts various measures of temperature, humidity, precipitation, and wind, he finds that the value of climate index at destination relative to origin increases tourism to Barbados; this implies that relative values of desirable climate characteristics enhance demand for Caribbean tourism. Moore explores the impact of climate change scenarios on Caribbean tourism (2071 – 2100) via changes in the

Tourism Climate Index, finding positive impacts for Inter-governmental Panel on Climate Chance (IPCC) scenarios A1 and A2—*increasing* average tourist trips by 3.22 and 3.26 percent respectively, and negative impacts for IPCC scenarios B1 and B2—*decreasing* average trips by 1.18 and 1.28 percent, respectively. The main factor driving the decline in tourist arrivals under the B1 and B2 scenarios is the projected rise in temperature that would make normal tourist activities difficult to do during the day (Moore 2009). While we do not possess detailed data to make such forecasts, the magnitudes are instructive in scenario development. For example, applying these magnitudes to historical Bahamas international tourism suggests scenarios that improved tourism could increase aggregate trips by as much as 200,000 trips, while reductions in tourism can have aggregate impacts as high as 79,000 trips.

Figure 1: Shares of International Tourism Arrivals by Island: The Bahamas (2015)

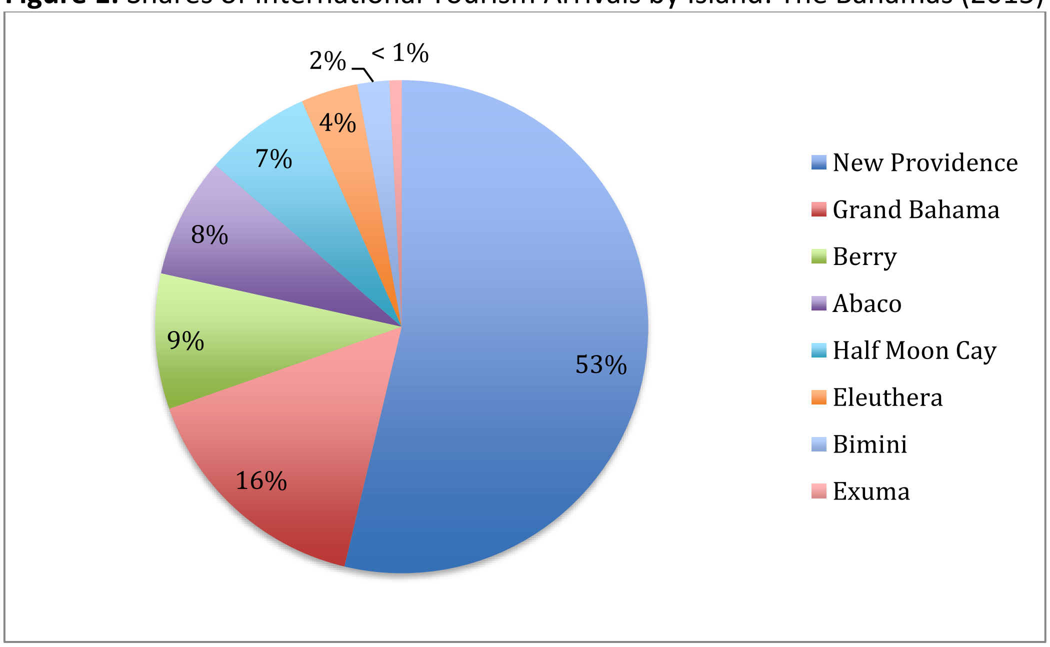


Figure 1 provides a breakdown of total visits to individual islands within The Bahamas for the year 2015. Two of the islands being considered for investments in BH-L1043—New Providence and Grand Bahama— share the majority of tourism arrivals to The Bahamas, 69.2% of the total international arrivals. These data do not reveal, however, the degree of intra-island visitation that occurs during tourist trips. This will depend upon transportation infrastructure, commercial options for travel, and marketing of alternative destinations within The Bahamas. Of note, Andros Island currently receives very little air/sea arrivals, amounting to less than one percent (0.1%) of the total (8,144 arrivals in 2015).

Our scenarios for tourist behavior with BH-L1043 build on these results within the context of historical Bahamas tourism data. Improvements in the quality of environmental and natural resources and mitigation projects to deal with problems stemming from climate change can augment future international tourism demand (Braun et al. 1999, Uyara et al. 2005, Moore 2010, Forster et al. 2012). Sustainable development of Andros Island as an eco-tourism destination (Component 2), in particular, could create a unique and highly desirable experience for many international tourists. Demand analysis of Caribbean tourism indicates that international tourists see the Caribbean islands as gross substitutes (Rosensweig 1988), but elasticity of substitution estimates are not very large—especially for United States visitors, the majority (65%) of international visitors to The Bahamas—so we should not expect excessive site substitutions with the Caribbean. Given improvements in climatic conditions relative to tourists' point of origin, Moore (2010) estimates improvements in tourism leading roughly 3.2% increase in international trips for 2071 to 2100.

Using the same benchmark market share as the baseline scenario we assume a modest increase in *market share* of Bahamas relative to other Caribbean destinations. As with the baseline scenario, this approach is conservative, amounting to about an aggregate of a one percent increase from the benchmark over construction and project life years. Economic effects are calculated as increased expenditures accruing from increased tourist visits. A 12% discount rate is used to calculate net present value of changes in tourist expenditures.

Resident Benefits

Benefits accruing directly to residents of The Bahamas include improvements in local beach conditions (primarily in the vicinity of Junkanoo beach associated with Component 1: Nassau/Paradise Island, but possibly elsewhere); reductions in erosion, flood, and SLR risk due to investments in protective infrastructure and rehabilitation of mangroves and other natural vegetation (associated with Component 1: East Grand Bahama and Central Long Island, Component 2, and Component 3); enhancements of other ecosystem services (Component 1: East Grand Bahama and Central Long Island and Component 2); and improvements in transportation infrastructure (Component 1: East Grand Bahama and Central Long Island). Other less tangible benefits will be identified in the section III.

Enhancements at Junkanoo Beach and the Surrounding Vicinity

Junkanoo Beach (see Figure 3 in Section III) and the surrounding beaches between *The Pointe* and Arawak Cay (see Figure 4 in Section III) (heretofore referred to generally as "Junkanoo") have been degraded in recent decades, due to damage to Nassau Port breakwaters (and possibly other factors). Junkanoo is a primary tourist attraction for cruise ship passengers and is also utilized by Nassau locals. Tourist benefits are captured under the tourism analysis. For assessment of local benefits associated with replenishing Junkanoo beach, the *without-BH-L1043* conditions are defined by current beach length and width (detailed in Section III). *With-BH-L1043* conditions assume general improvements in beach area that can be specified with appropriate data.

Benefits to local resident are measured using the process of Benefit Transfer (BT) (Rosenberger and Loomis 2004), which involves scouring the valuation literature for empirical estimates of the economic value of beach improvements and attempting to find studies that are similar to the project we are analyzing. If suitable estimates are found, one can attempt to adjust the BT estimate for differences in the study and application sites, magnitude of change in the natural resource, the population under study, inflation, etc.

In addition, while working on a preliminary draft of this analysis it was discovered that potentially relevant primary data exist. Dr. Peter Schuhmann of University of North Carolina-Wilmington has done extensive work in the Caribbean, particularly in Barbados. Dr. Schuhmann shared data so that empirical estimates for improving beach width for a sub-set of respondents that are Barbados nationals could be derived. The survey instrument and stated preference scenario, however, are not entirely appropriate; the payment vehicle entails a weeklong trip to Barbados, for which beach width and other site characteristics are attributes of the choice. The data are analyzed under the Random Utility Maximization framework using a multinomial logit model. Assessment of local benefits associated with beach enhancements is informed by benefit transfer and analysis of these primary data, the results for which are included in the Appendix.

Storm Damage Reduction

Reductions of damages due to natural hazards are a common focus of public investment. Large-scale projects that aim to control flood waters, limit coastal erosion, forecast earthquakes, warm of tsunamis, and track adverse weather patterns exhibit key aspects of public goods (non-exclusivity and non-rivalry). As such, they are often undertaken by public agencies. In applied economics, this sort of investment is assessed by the replacement cost method, which seeks to estimate the "value of an existing service that can be protected from loss by public effort" (Brown 2017).

Climate-resilient coastal infrastructure investments can thus be valued by the damage-avoidance that they support. In order to provide an estimate of benefit, an *ex ante* storm risk analysis is performed. We use historical storm occurrence and damage data (obtained from The International Disaster Database (EM-DAT) at http://www.emdat.be and augmented with ancillary data as necessary and possible) for The Bahamas to estimate a storm damage probability density function. Converting historical damages to USD of 2015 and expressing in rounded $10,000,000s, we estimate zero-inflated negative binomial regression models that permit empirical analysis of historical storm damage. The output of these models provides an estimate of the probability of zero damage in any given year, as well as probabilities associated with positive storm damages ranging from USD 10 million to USD 1 billion in USD 10 million increments. We attempt to include time trends to approximate the historical likelihood and rate of change in storm damage probabilities, but these parameters are never statistically significant. This three-parameter count data model is a parsimonious and effective way to forecast storm occurrence based on historical data.[7] We use the zero-inflated negative binomial results in a Monte Carlo procedure to repeatedly simulate 50-years of storm activity in The Bahamas *with* and *without BH-L1043* investments.

Mechler (2016) provides a systematic review of studies on assessment of disaster risk reduction, focusing on effectiveness of structural methods of risk mitigation, preparedness, and risk financing (to transfer income across states of nature). Of 39 studies providing risk-based assessment, whether ex-post evaluation of risk-reduction and ex-ante appraisals, the most common catastrophe analyzed is flood risk (both riverine and coastal), with an average disaster risk reduction benefit-cost ratio of 4.6 (range: 0.1 – 30); this result is based on 21 studies of flood risk—far more evidence than available for other hazards (e.g. earthquake, drought). Most of the studies focused on structural and preparedness interventions (as opposed to risk financing); the disaster risk-reduction studies include a number of Caribbean countries (St. Lucia, Jamaica, Dominican Republic), countries in Central and South America, as well as the United States. The assessment of average risk-reduction in Mechler is similar to the estimate from another synthesis in the literate, which finds an average disaster risk reduction benefit-cost ratio to be 5.0 (MMC 2005). We use the 4.6 B/C ratio estimate to be conservative, and we subject this assumption to sensitivity analysis (in Section VI).

The Mechler study did not identify what cost components were included in benefit-cost comparisons in the existing literature. Some project costs go directly towards risk

[7] Other possible approaches, including the Tobit model and extreme value distributions (Pareto and Generalized EV) ran into problems. The Tobit model exhibited a poor find and extreme value distributions defined in maximum likelihood estimation would not converge.

mitigation, while others go towards supporting and administrative activities. In order to maintain a conservative approach to benefit estimation, we include only project expenditures that directly target hazard mitigation (identified in Table 7 by "Y" under Mitigant). Focusing exclusively on disaster risk mitigation and ecosystem rehabilitation projects (that should provide for risk mitigation) associated with BH-L1043, investments total USD 26 million, or about 74% of the USD 35 million investment. Assuming a 4.6 multiplier for damage reduction, average storm damages should decrease by USD 120 million per event. This is our estimate of the *with-BH-L1043* effect. To incorporate potential changes in storm intensity due to climate change, we assume storm probabilities could increase 15% (IDB 2014). We, thus, move probability from no-storm outcome to storm outcomes and apportion them equally among the storm damage categories. The Monte Carlo simulations are run in @Risk™ (produced by Palisades Corporation), which operates as an add-in with *Microsoft Excel* spreadsheets. The output of the zero-inflated negative binomial models is used to define discrete probability distributions with specific damage levels.

Ecosystem Services

Components 1 and 2 of BH-L1043 will produce other ecosystem service benefits in The Bahamas. Excavation of derelict causeways in East Grand Bahama will improve hydrological function and ecological health in the region, improving fish stocks and increasing catch rates of commercial and recreational fisheries, including bone fish, grouper, spiny lobster, conch, and snapper (Cushion and Sullivan-Sealy 2007). Establishment of a new Marine Protected Area in East Grand Bahama should provide for ecological benefits (improved aquatic habitat, bolstered biodiversity) and recreational opportunities (swimming, snorkeling, and diving)

(Beharry-Borg and Scarpa 2010). Investments in East Grand Bahama, Central Long Island, and Andros include rehabilitation of mangroves, which will provide for ecosystem services, such as water quality maintenance (via biofilter function) (Walters et al. 2008).

The 1995 Census of The Bahamas reports approximately 9,300 persons in the labor force employed in the fisheries industry, with 95% being fishermen and the remainder engaged in processing or distribution (Buchan 2000). The literature provides some estimates of the value of commercial and artisanal fishing in The Bahamas, but we lack detailed quantity change data to apply these estimates in assessment of BH-L1043. There is also some potential for double-counting give that we do assess the value of a marine protected area and extensive mangrove restoration (each of which should have a positive impact on fish populations. The Appendix includes a brief discussion of existing catch values for The Bahamas.

Beharry-Borg & Scarpa (2010) use choice experiments to estimate WTP for marine protected areas in Tobago, incorporating heterogeneity of survey respondents. One of their sub-samples, which they identify as "Non-snorkelers" was comprised of 70% Tobago nationals, permitting us to analyze preference of Caribbean residents. They find that this group of respondents is willing to pay 7.12 Trinidad and Tobago dollars (TTD) for a new marine protected area that allows recreational access, but no fishing. Controlling for inflation and income differences across Tobago and Bahamas, this estimate can be transferred to estimate the economic benefits of a marine protected area in East Grand Bahama associated with investments in BH-L1043.

While the linkage of mangroves to fisheries production in strong (Barbier 2000), catch rates and market prices (or recreational values) can be used to directly assess improvements in fisheries. In addition to allowing for direct exploitation of outputs, like fish, food, water, wood, and wildlife, mangroves and other wetland ecosystems provide a flow of services to society, such as storm protection, flood control, water transport, and nutrient and waste absorption (Barbier 1993). Such regulatory ecological functions provide indirect use values and non-use values, which can be valued by measuring avoided damages, defensive expenditures, changes in productivity, replacement costs or stated preference analysis (Barbier 1994). For example, mangroves adjacent to urban sewage sources can provide biofilter functions to remove nutrient from waste waters, providing a service equivalent to a sewage treatment plant, saving USD 1,193 per hectare/year (USD of 1998) (Walter et al. 2008). Other studies value mangroves in the range of USD 239 to USD 4,185 per hectare/year in South east Asia (Brander et al. 2012), USD3,800-4,100 per hectare/year in Sri Lanka (Emerton et al. 2016), and as large as USD 10,000 per hectare/year in Thailand (Das 2009; Das and Crepin 2013; Barbier et al. 2011). Some of these estimates include multiple ecological services, such as storm protection, water purification, and habitat support. Such per-unit values can be transferred to appropriate contexts in The Bahamas to estimate economics benefits of mangrove rehabilitation associated with investments in BH-L1043.

Project Costs

Details of economic costs for Components 1 – 3 are provided by project personnel in the Project Data Sheets and other documents. Initial planning, design, and construction cost estimates are allocated across the construction time horizon of six years based upon the Pluri-annual Execution Plan (PEP) document. Based on input from personnel at MOWUD, we estimate maintenance costs through the project life to be close to zero or zero, but we include salary cost ($95,000) each year to fund engineering personnel to support the coastal risk management initiative. Net present value of construction costs is calculated using a 12% discount rate.

III. Economic Benefits

This section presents pertinent data and results for estimation of economic benefits of BH-L1043 using the methods outlined above.

Tourist Benefits

To assess tourism benefits associated with BH-L1043 investments, we estimate international tourist visits *without* and *with BH-L1043*. Table 1 provides details on the Caribbean, Bahamas totals, and Bahamas share of the total international tourist arrivals for 2003 – 2015 (except for 2010, for which data were not available). The Bahamas consistently comprises almost 7 – 9.5% of air-sea arrivals and 15.5 – 22% of cruise arrivals of total Caribbean international tourism. The exceptions are the recession years of 2008 and 2009, which were down slightly from the overall percentages.

Based on the most recent data (2011 – 2015), we benchmark the market share of international tourism for the Bahamas at 14.78%. (Were we to use the entire time-series of shares, the market share would be 13.39%.) Based on the assumptions put forth in the previous section, we assume a 2% decline in *market share* apportioned out over years 1 – 20, but continuing at the same implicit rate of change through the project life (55 years). To account for infrastructure depreciation at the Port of Nassau, we utilize a decreasing market share of 3% for Nassau/Paradise Island sea arrivals (applied in the same manner, but only to roughly 37.0% of total international arrivals).

This approach is conservative: total international tourist arrival impacts amount to about an aggregate of a one-percent decrease from the benchmark over 55 years. The loss of over an aggregate of 77,000 tourist visits is considerably less that the magnitude of estimates in the literature—an implied decrease of almost one million tourist trips to Barbados due to beach erosion, and half a million due to coral bleaching based on stated preference responses (Uyara et al. 2005). Revealed preference data generally support these types of impacts (coral-bleaching event in the Philippines in 1998) (Cesar 2000).

Table 1: Bahamas and Rest of Caribbean tourist arrivals 2003-2015.

	Caribbean Total		**The Bahamas**		**Bahamas Share**	
Year	**Air Arrivals**	**Sea-landed and Cruise Arrivals**	**Air Arrivals**	**Sea-landed and Cruise Arrivals**	**Air Arrivals**	**Sea-landed and Cruise Arrivals**
2003	16,982,147	17,062,671	1,623,868	2,970,174	9.56%	17.41%
2004	18,609,084	19,464,389	1,643,955	3,360,012	8.83%	17.26%
2005	18,882,812	18,503,599	1,700,708	3,078,709	9.01%	16.64%
2006	18,454,065	18,415,675	1,652,073	3,078,534	8.95%	16.72%
2007	19,207,648	19,058,892	1,630,679	2,970,659	8.49%	15.59%
2008	19,415,216	19,889,100	1,532,432	2,861,140	7.89%	14.39%
2009	18,499,072	18,090,227	1,389,335	3,255,780	7.51%	18.00%
2010	NA	NA	1,252,393	3,392,722	NA	NA
2011	18,090,000	20,616,701	1,267,542	4,320,046	7.01%	20.95%
2012	18,189,000	21,187,378	1,357,431	4,582,739	7.46%	21.63%
2013	18,203,000	21,998,631	1,280,736	4,870,048	7.04%	22.14%
2014	19,512,000	24,737,188	1,343,093	4,977,095	6.88%	20.12%
2015	20,283,000	NA	1,391,782	4,722,555	6.86%	NA

Source: Caribbean Tourism Organization

Tourism benefits stemming from BH-L1043 include: 1) improved navigation and arrival ability at the Nassau Cruise Terminal; 2) enhanced environmental quality of The Bahamas as a tourist destination; 3) sustainable redevelopment of Andros Island as an eco-tourism site; and 4) enhancing resiliency to chronic natural hazards (like beach erosion and nuisance flooding) and acute disturbances (like catastrophic flooding and storm surge) to minimize business interruption and promote sustainability and adaptation in tourism.

Using the same benchmark market share as the baseline scenario (14.78%) we assume a modest 2% increase in *market share* apportioned out over years 6 – 26 (allowing time for construction and project completion), but continuing at the same implicit rate of change through the project life (55 years). As with the baseline scenario, this approach is conservative, amounting to about an aggregate of a one percent increase from the benchmark over 55 years. The aggregate increase in trips over 55 years amounts to just over 45,000 trips, which is consistent with, but conservative relative to, estimates from the literature—favorable changes in climate are estimated to effect Caribbean tourism demand on the order of 3.25% (which would correspond with around 200,000 trips for The Bahamas) (Moore 2009).

Economic effects of BH-L1043 on tourism are calculated as the change in tourist expenditures. A 12% discount rate is used to calculate net present value of changes in tourist expenditures.

Assuming a 2% decline in *market share* apportioned out over years 1 – 20 (and a slightly larger rate of 3% for Nassau Cruise Terminal arrivals), but continuing at the same implicit rate of change through the project life (55 years), the net present value of lost tourism revenues over 55 years are USD 40.978 million. (See Table 2.) At the end of 55 years, total arrivals will have decreased by 77,567 trips, or about 1.3% of the arrivals in 2015.

Table 2: Baseline Changes in Tourism Expenditures in The Bahamas over 55 Years (12% discount rate)

Year	Air Arrivals	Sea Arrivals	Change Air	Change Sea	Total Change	Change in Tourist Expenditures	NPV
0	7.05%	21.21%	0	0	0	$0	$0
1	7.04%	21.18%	-215	-1197	-1412	-$534,926	-$477,612
2	7.04%	21.16%	-430	-2394	-2824	-$1,069,852	-$852,879
3	7.03%	21.13%	-645	-3591	-4236	-$1,604,778	-$1,142,249
4	7.02%	21.10%	-860	-4788	-5648	-$2,139,703	-$1,359,820
5	7.01%	21.08%	-1075	-5985	-7060	-$2,674,629	-$1,517,656
6	7.01%	21.05%	-1290	-7182	-8472	-$3,209,555	-$1,626,061
7	7.00%	21.03%	-1505	-8379	-9884	-$3,744,481	-$1,693,813
8	6.99%	21.00%	-1720	-9576	-11296	-$4,279,407	-$1,728,381
9	6.99%	20.97%	-1935	-10773	-12708	-$4,814,333	-$1,736,097
10	6.98%	20.95%	-2150	-11969	-14119	-$5,348,880	-$1,722,196
11	6.97%	20.92%	-2366	-13165	-15531	-$5,883,806	-$1,691,454
12	6.97%	20.89%	-2582	-14361	-16943	-$6,418,731	-$1,647,528
13	6.96%	20.87%	-2798	-15557	-18355	-$6,953,657	-$1,593,599
14	6.95%	20.84%	-3014	-16753	-19767	-$7,488,583	-$1,532,312
15	6.94%	20.82%	-3230	-17949	-21179	-$8,023,509	-$1,465,865
16	6.94%	20.79%	-3446	-19145	-22591	-$8,558,435	-$1,396,066
17	6.93%	20.76%	-3662	-20341	-24003	-$9,093,361	-$1,324,397
18	6.92%	20.74%	-3878	-21536	-25414	-$9,627,908	-$1,252,009
19	6.92%	20.71%	-4094	-22731	-26825	-$10,162,455	-$1,179,930
20	6.91%	20.68%	-4310	-23926	-28236	-$10,697,002	-$1,108,924
21	6.90%	20.66%	-4526	-25121	-29647	-$11,231,549	-$1,039,588
22	6.89%	20.63%	-4742	-26316	-31058	-$11,766,096	-$972,380
23	6.89%	20.61%	-4958	-27511	-32469	-$12,300,643	-$907,639

24	6.88%	20.58%	-5174	-28706	-33880	-$12,835,190	-$845,609
25	6.87%	20.55%	-5390	-29901	-35291	-$13,369,737	-$786,452
26	6.87%	20.53%	-5606	-31095	-36701	-$13,903,905	-$730,244
27	6.86%	20.50%	-5822	-32289	-38111	-$14,438,073	-$677,053
28	6.85%	20.47%	-6038	-33483	-39521	-$14,972,241	-$626,877
29	6.85%	20.45%	-6254	-34677	-40931	-$15,506,410	-$579,680
30	6.84%	20.42%	-6470	-35871	-42341	-$16,040,578	-$535,401
31	6.83%	20.40%	-6686	-37065	-43751	-$16,574,746	-$493,956
32	6.82%	20.37%	-6902	-38259	-45161	-$17,108,914	-$455,246
33	6.82%	20.34%	-7118	-39453	-46571	-$17,643,082	-$419,160
34	6.81%	20.32%	-7334	-40646	-47980	-$18,176,872	-$385,573
35	6.80%	20.29%	-7550	-41839	-49389	-$18,710,661	-$354,371
36	6.80%	20.26%	-7767	-43032	-50799	-$19,244,829	-$325,436
37	6.79%	20.24%	-7984	-44225	-52209	-$19,778,997	-$298,633
38	6.78%	20.21%	-8201	-45418	-53619	-$20,313,165	-$273,837
39	6.78%	20.19%	-8418	-46611	-55029	-$20,847,334	-$250,927
40	6.77%	20.16%	-8635	-47804	-56439	-$21,381,502	-$229,783
41	6.76%	20.13%	-8852	-48996	-57848	-$21,915,291	-$210,285
42	6.75%	20.11%	-9069	-50188	-59257	-$22,449,080	-$192,328
43	6.75%	20.08%	-9286	-51380	-60666	-$22,982,870	-$175,804
44	6.74%	20.05%	-9503	-52572	-62075	-$23,516,659	-$160,614
45	6.73%	20.03%	-9720	-53764	-63484	-$24,050,448	-$146,660
46	6.73%	20.00%	-9937	-54956	-64893	-$24,584,238	-$133,853
47	6.72%	19.97%	-10154	-56148	-66302	-$25,118,027	-$122,106
48	6.71%	19.95%	-10371	-57340	-67711	-$25,651,816	-$111,340
49	6.70%	19.92%	-10588	-58531	-69119	-$26,185,227	-$101,478
50	6.70%	19.90%	-10805	-59722	-70527	-$26,718,637	-$92,451
51	6.69%	19.87%	-11022	-60913	-71935	-$27,252,048	-$84,194
52	6.68%	19.84%	-11239	-62104	-73343	-$27,785,458	-$76,644
53	6.68%	19.82%	-11456	-63295	-74751	-$28,318,869	-$69,746
54	6.67%	19.79%	-11673	-64486	-76159	-$28,852,279	-$63,446
55	6.66%	19.76%	-11890	-65677	-77567	-$29,385,690	-$57,696
						NPV =	-$40,977,644

We turn next to the BH-L1043 investment scenario. Assuming a modest 2% increase in *market share* apportioned out over years 6 – 26, but continuing at the same implicit rate of change through the project life (55 years), we estimate a net present value of increases in international tourism revenue of USD 14.780 million. The details are presented in Table 3.

Taken together, the difference between *without BH-L1043* and *with BH-L1043* amounts to USD 55.758 million. These estimates will be subjected to a sensitivity analysis in Section VI.

Table 3: BH-L1043 Improvements in Tourism in The Bahamas over 55 Years (12% discount rate)

Year	Bahamas Tourism Share	Change International Visitors	Change in Tourist Expenditures	NPV
1	14.78%	0	$0	$0
2	14.78%	0	$0	$0
3	14.78%	0	$0	$0
4	14.78%	0	$0	$0
5	14.78%	0	$0	$0
6	14.794780%	904	$342,474	$173,508
7	14.809560%	1807	$684,569	$309,664
8	14.824340%	2711	$1,027,042	$414,805
9	14.839120%	3615	$1,369,516	$493,861
10	14.853900%	4519	$1,711,990	$551,215
11	14.868680%	5423	$2,054,464	$590,609
12	14.883460%	6327	$2,396,938	$615,234
13	14.898240%	7231	$2,739,411	$627,802
14	14.913020%	8135	$3,081,885	$630,615
15	14.927800%	9039	$3,424,359	$625,618
16	14.942580%	9943	$3,766,833	$614,452
17	14.957360%	10847	$4,109,306	$598,497
18	14.972140%	11751	$4,451,780	$578,908
19	14.986920%	12655	$4,794,254	$556,645
20	15.001700%	13559	$5,136,728	$532,508
21	15.016480%	14463	$5,479,202	$507,153
22	15.031260%	15367	$5,821,675	$481,118
23	15.046040%	16271	$6,164,149	$454,840
24	15.060820%	17175	$6,506,623	$428,670
25	15.075600%	18079	$6,849,097	$402,887
26	15.090380%	18983	$7,191,571	$377,707
27	15.105160%	19887	$7,534,044	$353,298
28	15.119940%	20791	$7,876,518	$329,784
29	15.134720%	21695	$8,218,992	$307,253
30	15.149500%	22599	$8,561,466	$285,764
31	15.164280%	23503	$8,903,939	$265,353
32	15.179060%	24407	$9,246,413	$246,035
33	15.193840%	25311	$9,588,887	$227,810

34	15.208620%	26215	$9,931,361	$210,667
35	15.223400%	27119	$10,273,835	$194,582
36	15.238180%	28023	$10,616,308	$179,525
37	15.252960%	28927	$10,958,782	$165,461
38	15.267740%	29831	$11,301,256	$152,350
39	15.282520%	30735	$11,643,730	$140,149
40	15.297300%	31639	$11,986,203	$128,813
41	15.312080%	32543	$12,328,677	$118,298
42	15.326860%	33447	$12,671,151	$108,557
43	15.341640%	34351	$13,013,625	$99,546
44	15.356420%	35255	$13,356,099	$91,219
45	15.371200%	36159	$13,698,572	$83,534
46	15.385980%	37063	$14,041,046	$76,449
47	15.400760%	37967	$14,383,520	$69,923
48	15.415540%	38871	$14,725,994	$63,917
49	15.430320%	39775	$15,068,467	$58,396
50	15.445100%	40679	$15,410,941	$53,325
51	15.459880%	41583	$15,753,415	$48,669
52	15.474660%	42487	$16,095,889	$44,399
53	15.489440%	43391	$16,438,363	$40,486
54	15.504220%	44295	$16,780,836	$36,901
55	15.519000%	45199	$17,123,310	$33,620
			NPV =	$14,780,400

Beach Enhancements and Resident Benefits

While the tourism analysis captures the effect of beach enhancements on tourists, it fails to account for the value this can create for Bahamian residents. We first outline specific details of the Junkanoo beach enhancements. We then review the literature on valuing beach improvements, before turning to empirical analysis of primary data from Barbados.

Figure 2: Junkanoo Beach, Nassau (adapted from *GoogleEarth®*)

Figures 2 and 3 provide details on the current status of Junkanoo Beach in Nassau. The primary part of Junkanoo (adjacent to the Nassau Courtyard by Marriott Hotel – see Figure 2) comprises two beach sections between groins. The eastward section is about 90.47m long and 42.26m wide; the westward section is about 159.42m long and 37.3m wide. This section (Junkanoo Beach proper) offers commercial services (food, drink, arts and crafts), and has bathrooms, showers, and lifeguards. Carrying capacity depends on beach area, which is currently 9,769 m^2.

Figure 3: Beaches Surrounding Junkanoo, Nassau (adapted from *GoogleEarth®*)

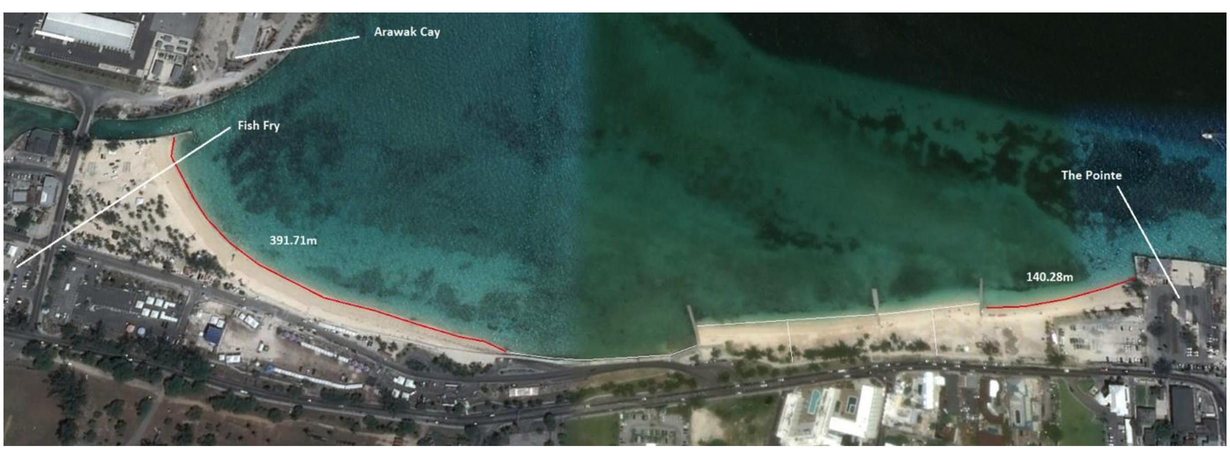
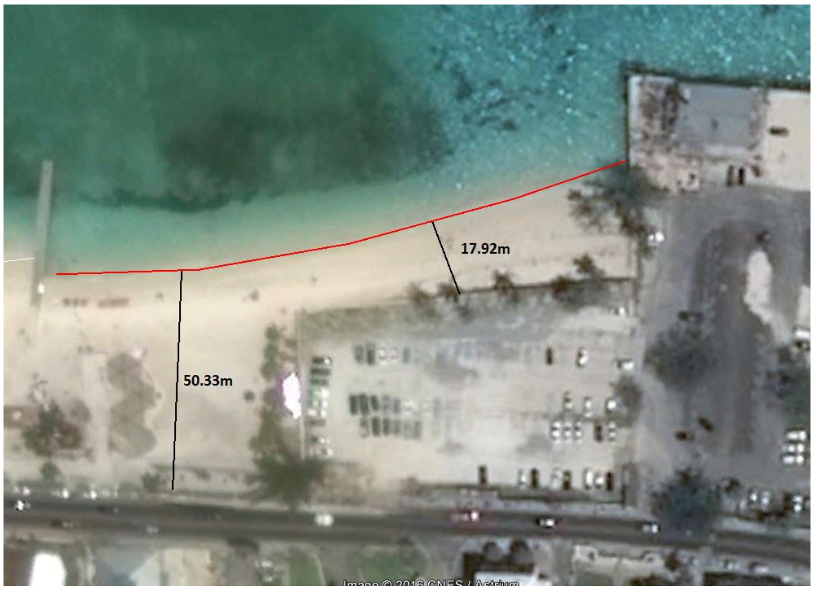


Figure 3 depicts the larger beach area surrounding Junkanoo. To the east, going towards *The Pointe*, the beach is 140.28m long. The widest portion—adjacent to Junkanoo—is 50.33m wide, and the remainder—seaward of a large parking lot—is 17.92m wide. See Figure 4.

Figure 4: Eastern Beach Adjacent to Junkanoo, Nassau (adapted from *GoogleEarth®*)



The westward beach, between Junkanoo and Arawak Cay, is heavily eroded on the eastern flank. This erosion is alleged to have occurred due to damages in the eastern breakwater, which has increased wave energy at Junknaoo. The eroded section is about 160m in length. Where there is beach, it is very long (391.72m), but rather narrow (around 20m, on average). See Figure 5.

Taken together, the surrounding beaches adjacent to Junkanoo comprise about 11,863m^2. Thus, total beach area in Junkanoo and the surrounding vicinity is around 21,632 m^2. Employing an estimate of optimal congestion from the literature—10.68 m^2/ person (Bell 1986)—the current carrying capacity of Junkanoo beach is around 2,025 persons.

Figure 5: Western Beach Adjacent to Junkanoo, Nassau (adapted from *GoogleEarth®*)

Economic Values of Beach Erosion Control

There are a number of studies that examine the impact of improving beach quality on local users or residents of the state/nation in which the beaches are located. Saengsupavanich et al. (2008) explore local users' WTP to preserve a beach that is eroding due to construction of a large commercial port in Thailand. Using contingent valuation (CV), they find that beachgoers were willing to donate an average of USD24.80 (USD of 2006) for preserving 500 meters of Nam Rin beach. Huang et al. (2007) use choice experiments (CE) to evaluate the benefits and costs of erosion control programs in New Hampshire and Maine. They estimate WTP of USD 10.94 for females and USD 4.28 for males (USD of 2000) per mile of preserved beach.

Focusing on day-users (those within 120 miles of the coast) of North Carolina beaches, Whitehead et al. (2008) combine revealed and stated preference approaches (contingent behavior) to evaluate the impacts of beach nourishment on recreation demand. They estimate WTP of USD 6.36 per household (USD of 2003; standard error of USD 1.78) for a beach nourishment policy that would last 50 years and increase average beach width from 75 feet to 175 feet. Parsons et al. (2013) use combined RP/SP (CB) data to estimate household WTP to preserve and increase beach width at seven Delaware Bay beaches. They find welfare losses of USD 4.72 per day (USD of 2010/2011) for reductions in beach width from 50 – 100 feet to 12.5 – 25 feet, and gains of USD 2.60 per day for doubling beach width from 50 – 100 feet to 100 – 200 feet.

Specific to the Caribbean, Dharmaratne and Brathwaite (1998) estimate the economic value of beaches in Barbados, but their focus is on tourists. They use an unconventional travel-cost demand specification and have very little data; as such, their results are not likely to be appropriate or reliable for benefit transfer. Banarjee et al. (2016) analyze beach improvements in Barbados, focusing on tourist, residents, and local businesses as beneficiaries. Their retrospective stated preference analysis evaluates project characteristics very similar to BH-L1043 investments, but their resident valuation scenario employs an unconventional payment vehicle. Realizing the difficulties in utilizing a more typical tax-increase vehicle, the investigators specify payments for beach maintenance as a reallocation from “taxes you already pay” (pg. 17) to maintain beaches depicted in photographs provided within the survey. Since these payments are not coming out of the respondents’ budgets, it is unclear what the opportunity costs of this reallocation could be. For example, if residents perceive the government as being inefficient and corrupt, the opportunity cost could be zero. For those that think the reallocation would affect other vital services, however, the opportunity cost could be significant. In the latter case, the payment would equate with the value of other services sacrificed by the reallocation (e.g. less frequent trash collection). As the researchers do not investigate this opportunity cost, it is difficult to interpret and apply the results for Barbados residents.

Schuhmann et al. (2016) conduct a choice experiment in Barbados to assess preferences for proximity of lodging to beaches, marine debris cleanup on beaches, and beach width. While the focus of their analysis is on international tourists, they find that tourists are willing to pay USD 5.50 for an additional meter of beach width, with the payment vehicle being the price of lodging that tourists utilize during their vacation. In a follow-up study, Dr. Peter Schuhmann (of University of North Carolina-Wilmington) conducts a similar kind of analysis, but these data include a substantial number of responses from Barbados nationals.[8]

Table 4: WTP for Improved Beach Width from Existing Studies

Study	Location	Beach Enhancement	Method	WTP (US$ 2015)	Details
Huang, et al. (2007)	New Hampshire and Maine, USA	Erosion Control per mile of beach	CE	$15.06	one-time compulsory tax; males
				$5.89	one-time compulsory tax; females
Saengsupavanich, et al. (2008)	Nam Rin Beach, Thailand	Protect 500 meters of threatened local beach	CV	$29.16	one-time donation; protect local beach from erosion caused by port
Whitehead, et al. (2008)	North Carolina, USA	Erosion Control; widen beaches	RP/CB	$8.19	50-year project; SE(WTP) = $1.78

[8] Dr. Schuhmann was kind enough to share the data with us; no results from this study have been published at this point. Thus, we explore Random Utility Models that permit an assessment of preferences of Barbados nationals in the Appendix. The results are not ideal for our purposes, however, as the payment vehicle in the CE scenario is the price of travel and lodging; Barbados national living abroad would only need to purchase lodging if they had no family members or friends to stay with.

		from 75 to 175 feet			
Parsons, et al. (2013)	Delaware Bay, USA	Prevent erosion	RP/CB	$4.97	WTP per day-trip; Erosion would reduce beach width from average of 75 to 18.75 ft
	Delaware Bay, USA	Increase beach width	RP/CB	$2.70	WTP per day-trip; Nourishment would increase beach width from average of 75 to 175 ft
Schuhmann, et al. (2016)	Barbados	WTP for lodging adjacent to beach	CE	$6.29	Tourists' WTP for a marginal change in beach width (m)

Table 4 summarizes the results of the aforementioned studies, converting economic values to USD of 2015. These studies analyze primarily soft engineering approaches (i.e. beach replenishment) to control beach erosion and improve beach width. A synthesis of the results is enlightening: Huang et al. (2007) and Whitehead et al. (2008) focus on single or multi-state-level beach erosion control programs, and their samples include residents from the relevant states. WTP estimates are on the order of USD 6 to USD 15 per household for a long-term program to control coastal erosion. Parsons et al. (2013) focus on a small region of beaches along the Delaware Bay (not as a high-profile as the Delaware ocean coast). Local users of these beaches are willing to pay more to prevent erosion (around USD 5 per day) than to produce a substantial increase in beach width (USD 2.70/day). Scaling these estimates by the total number of day-trips would produce an estimate of total WTP, though number of trips is not reported in the Parsons et al. (2013) paper. If trip frequency were 2 – 4 times per year, value estimates are on the order of or greater than those of Huang et al. and Whitehead et al. While the beaches studied by Parsons et al. are a small sub-set of Delaware beaches, the local users could exhibit greater value, on average, for their preservation.

The largest estimate from Table 4 is derived from Saengsupavanich et al. (2008), which is also a local beach (Nam Rin Beach) in Thailand. Their sample also corresponds with local beach users (similar to Parsons et al.) Lastly, the estimates from Saengsupavanich et al. relates to preservation of a local beach in close proximity to a port, which corresponds well with local benefits of Junkanoo. The downside of this estimate for benefit transfer is the potential heterogeneity of preferences across the Caribbean and Southeast Asia. The last estimate from Table 4, from Shuhmann et al. (2016), corresponds with Caribbean beaches (Barbados), but relates to WTP for wider beaches through payments for lodging on a weeklong vacation for tourists. The payment vehicle (lodging) and the population (tourists) are not appropriate for benefit transfer.

From the above studies, Saengsupavanich et al. seems best suited for benefit transfer to Junkanoo Beach. The Huang et al. study considers the entire coastline of two U.S. states, and the Parsons et al. estimates are expressed in per-day units, which would require knowledge of locals visits to Junkanoo Beach. GDP per capita for Thailand relative to The Bahamas is 0.25, so the household WTP estimate from Saengsupavanich et al. would need to be re-scaled by 3.92, producing a benefit transfer estimate of USD 114.42 per beach-user household. Transferring these estimates to the 2,640 households in the Fort Charlotte Supervisory District[9] (where Junkanoo Beach is located), we employ figures from The National Census of Population and Housing (Department of Statistics of The Bahamas 2012). Our Benefit Transfer estimates are: Total WTP for improvements in Junkanoo Beach = USD 114×2,640 households = USD 300,960. The Appendix includes additional results for an

[9] The supervisory district is the jurisdictional unit for which the most disaggregated household data are available.

empirical analysis of data from Barbados that provides ancillary evidence on the value of beaches.

Benefits from Storm Damage Reduction

Natural disaster data were obtained from The International Disaster Database (EM-DAT) at http://www.emdat.be (ancillary data appended when possible). Since 1988, The Bahamas has been affected by 14 storms and one large-scale flood event. Table 5 indicates the occurrence of natural disasters since 1900. Total damages are listed in thousands of USD of 2015. Since 1992, there have been 13 meteorological disasters for which damage data are available, an additional two without damage data (and that appear to have caused only minimal damage), and one hydrological flood disaster. On average over that 25-year period, the annual storm damage was USD 200.6 million, with a conditional mean of USD 394.8 million per storm and a conditional median of USD 393.4 million per storm.

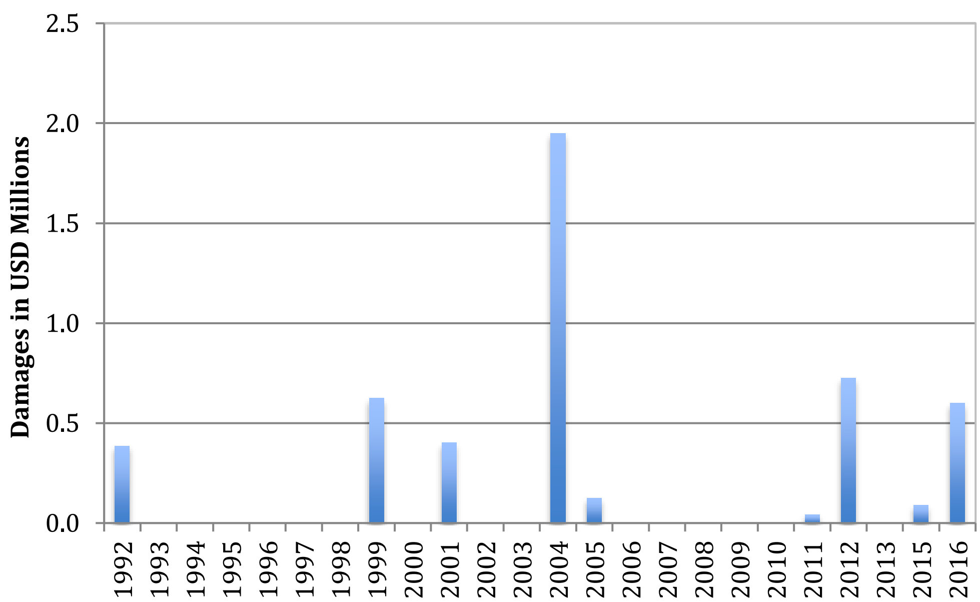
Table 5: Natural Disasters in The Bahamas (1926 – 2016)

Year	Disaster	Total deaths	Affected	Storm Damage (USD 1,000 of 2015)
1926	Storm			
1929	Storm			$8,979
1935	Storm	14		$124,524
1945	Storm	22		
1963	Storm			$11,732
1965	Storm		1200	$5,475
1966	Storm	5		$121,233
1990	Storm			$0
1992	H Andrew			$385,517
1995	H Erin	4		$580
1999	H Floyd			$624,084
2001	H Michelle	1		$401,273
2004	H Charley			$503,841
2004	H Frances	12	9000	$1,258,326
2004	H Jeanne	1	1500	$692,079

2005	H Wilma	1	7000	$123,861
2007	H Noel		3000	
2008	H Ike		10000	$225,914
2011	TS Bret, H Irene	1		$42,329
2012	H Sandy		1000	$726,335
2015	H Kate, H Joaquin	33	6710	$104,800
2016	H Matthew			$438,600

The time series of storm damage data are depicted in Figure 2. These data suggest that The Bahamas exhibits high exposure to natural hazard risk. The other important dimension in determining overall risk level is vulnerability of the population, built environment, and natural resource systems. BH-L1043 seeks to mitigate the vulnerability by investing in protective measures that reduce vulnerability to storms.

Figure 2: Meteorological Disasters in The Bahamas since 1992 (USD millions of 2015)



To parameterize historic storm activty and damage in The Bahamas, we express damage data in USD 10 million dollar increments, rendering the dependent variable in our analysis within the ranges of 1 to 100. We analyze all existing damage data, spanning 1926 to

2016. The large number of zeros necessitates a regression model that can account for a data spike at zero. We employ the zero-inflated negative binomial model to analyze the storm damage data. The negative binomial specification permits analysis of count data with a mean that need not equal (typically exceeds) the variance. (The standard Poisson count data model imposes equality of mean and variance.) This is particularly important for storm damage data, which is not well behaved, due to “fat tails”. The zero-inflated negative binomial permits a probability spike at zero (no damage outcome) to account for a large preponderance of zero outcomes that need not be distributed negative binomial function. Under the assumptions of zero-inflated negative binomial, the probabilities of damage outcomes (*d*) depicted in Figure 2 are:

$$\text{Prob}(d_i = 0) = \sigma + (1 - \sigma)(1/(1 + \alpha e^{\lambda})^{1/\alpha}$$

$$\text{Prob}((d_i = 1, 2, 3, \ldots) = (1 - \sigma)\left(\frac{\Gamma(\frac{1}{\alpha}+d_i)(\frac{1}{1+\alpha e^{\lambda}})^{1/\alpha}\left(\frac{\alpha e^{\lambda}}{1+\alpha e^{\lambda}}\right)^{d_i}}{\Gamma(d_i+1)\Gamma(1/\alpha)}\right) \text{ for } d_i > 0$$

where e^{λ} is the conditional mean of damage (d_i), for $d_i > 0$; α is the dispersion parameter that permits variance to be greater than mean; Γ is the gamma function, and σ is a parameter that allows for inflating zero outcomes (relative to the standard negative binomial weight on zeros). The model is estimated by Maximum Likelihood Method, where the likelihood function is sum of the natural log of Prob(d_i = 0) or Prob((d_i = 1, 2, 3, …) for each damage observation in the dataset (N=119). The results of the zero-inflated negative binomial model are presented in Table 6.

Table 6: Zero-inflated Negative Binomial Regression Results: Bahamas Storm Damage

Variable	Coefficient	Standard Error
σ (logit)	3.421235***	0.2329493
λ (location NB)	1.534319***	0.2643343
ln(α) (dispersion NB)	0.2173438	0.546576
Observations 119: 99 zeros; 20 non-zeros; Log pseudolikelihood = -142.9332		

Results indicate statistically significant coefficients for the zero inflation logit portion of the model (σ) and the location parameter (λ) for the negative binomial distribution. While the natural log of the dispersion parameter of the negative binomial (α) is not precisely estimated, the point estimate of the converted dispersion parameter is 1.2, with a standard error of 0.7, producing a 95% confidence interval of 0.4 - 3.6. Moreover, the predicted probabilities associated with the fitted negative binomial model exhibit much better match to the historical data.

Figure 3: Fitted Storm Damage Probabilities for The Bahamas based on Historic Data

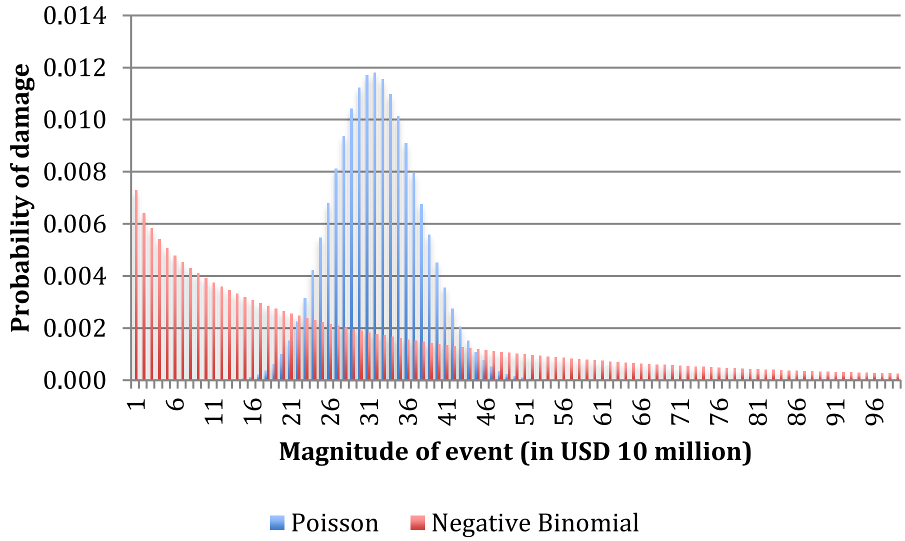


Figure 3 depicts the storm damage probabilities for the zero-inflated Poisson regression (which imposes α = 0) and the zero-inflated Negative Binomial model. Due to the restrictive nature of the Poisson distribution (i.e. variance = mean), the posterior probabilities stemming from the Poisson model are bunched around a $310 million storm event. The posterior probabilities from the negative binomial model, by comparison, are distributed across the entire range of damage outcomes, with greater probability on lower damage outcomes. For each model, the annual probablity of zero outcome (no storm damage) was 0.83.

To assess economic benefits of storm damage reduction, Monte Carlo analysis is performed to simulate damages *with* and *without BH-L1043*. The Monte Carlo analysis utilizes the zero-inflated negative binomial storm damage probability estimates to simulate storm occurences over a 50-year time period. The historical damage occurences define *without BH-*

L1043 outcomes, while literature guides our assessment of damage reduction *with BH-L1043*. Based on numerous studies, Mechler (2016) estimates that storm damage reduction attributable to mitigation investments are on the order of USD 4.6 to USD 5 per dollar spent on mitigation. Thus, we assume risk-reducing investments associated with BH-L1043 (totaling $26 million) will reduce storm damages by USD 120 million per event. To implement this within the Monte Carlo analysis, we subtract this magnitude of damage from each possible storm damage outcome, reducing the damages to a range of USD 0 – USD 880 million. Lastly, to incorporate potential changes in storm intensity due to climate change, we assume, based on a previous study by IDB (2014) that storm probabilities could increase 15%. This is implemented by scaling up the probability of storm to 0.1933 (=0.1681×1.15), implying a no-storm probability of 0.8067. The increase in storm probability is distributed equally to all storm damage outcomes. Economic benefits of enhanced storm protection are estimated by comparing damages *with* and *without* investments in *BH-L1043*, and net present values are calculated using a 12% discount rate.

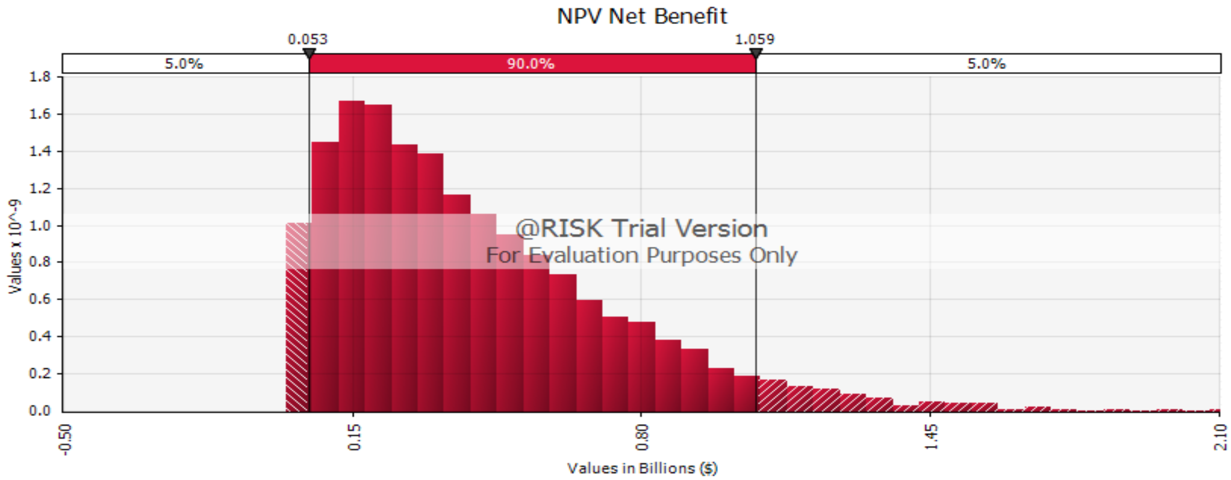
Figure 4.1 presents the baseline storm damage distribution for The Bahamas (*without BH-L1043*), under historical storm conditions as parameterized by the zero-inflated negative binomial model. The net present value of expected storm damages over 50 years are USD 427.01 million. The minimum damages are USD 613,000 and the maximum damages are USD 2.13 billion.

Figure 4.2 indicates the storm damage distribution *with BH-L1043*, assuming each dollar invested in risk-reducing mitigation projects will reduce storm damages by USD 4.60.

The net present value of storm damage reduction decreases to USD 284.903 million. Thus, BH-L1043 investments are estimated to decrease the net present value of storm damages by USD 142.108 million.

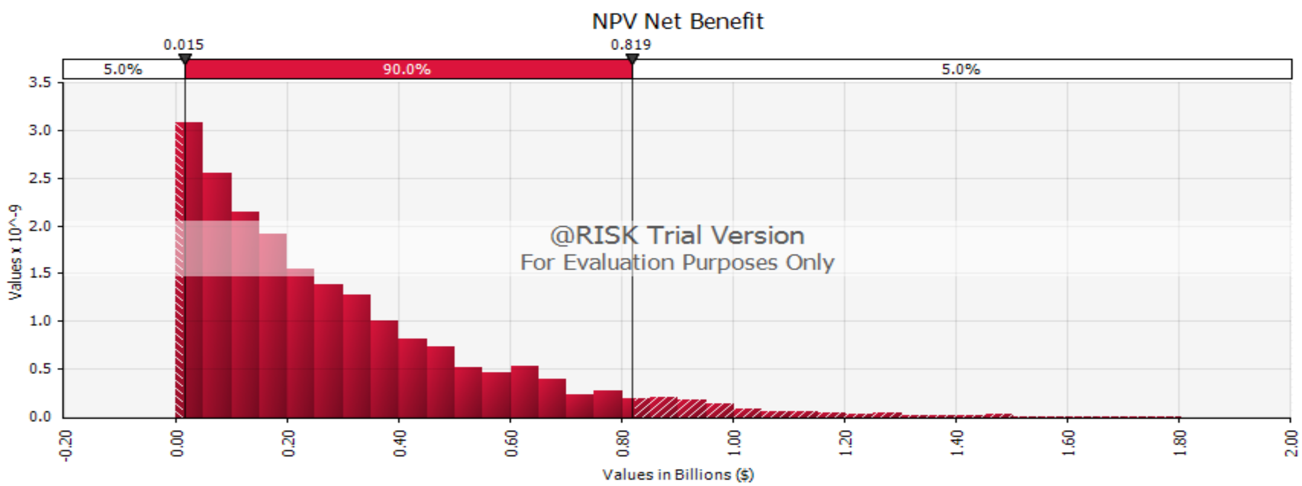
The case of increasing storm damages due to climate change is considered next. Figures 4.3 presents the baseline storm damage distribution for The Bahamas (*without BH-L1043*), under the assumption of a 15% increase in storm damage probabilities. The net present discounted value of storm damages *without BH-L1043* under this scenario is USD 581.121 million. *With BH-L1043*, the mean of net present value of storm damages decreases to USD 414.462 million (Figure 4.4). The expected reduction in storm damages under this scenario is USD 166.659 million. Sensitivity analysis is conducted in section VI.

Figure 4.1: Baseline Storm Damages under Historical Storm Conditions (*without BH-L1043*)



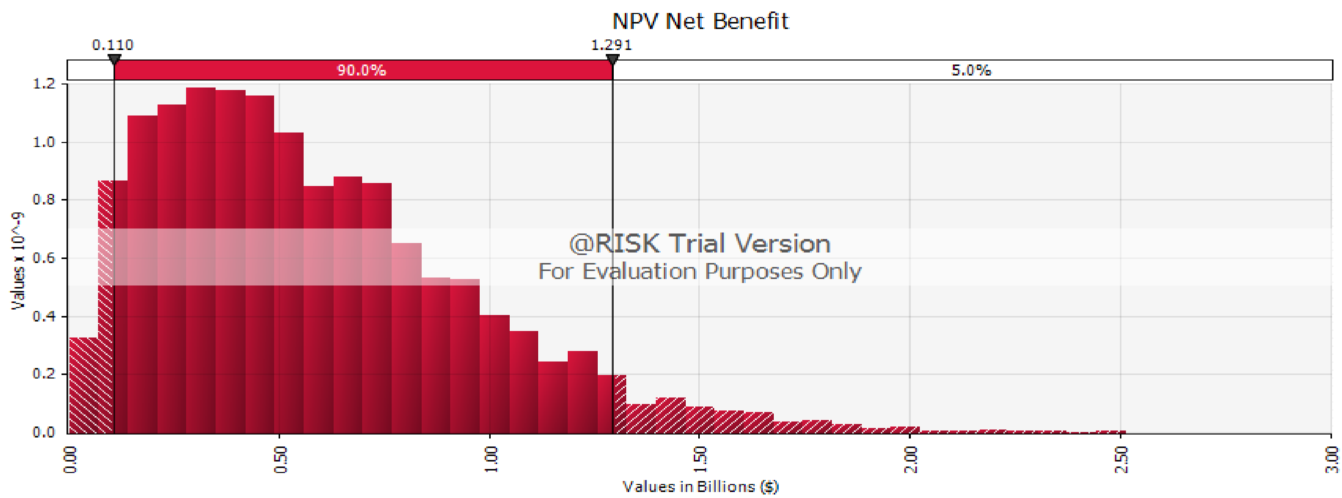
	NPV Net Benefit
Cell	S0!D3
Minimum	$613,640.78
Maximum	$2.137E+009
Mean	$427,010,924.31
90% CI	± $7,473,913.23
Mode	$179,147,444.14
Median	$347,781,152.34
Std Dev	$321,236,824.77
Skewness	1.2332
Kurtosis	4.7603
Values	5000
Errors	0
Filtered	0
Left X	$52,541,803.27
Left P	5.0%
Right X	$1.059E+009
Right P	95.0%
Dif. X	$1.006E+009
Dif. P	90.0%

Figure 4.2: Storm Damages under Historical Storm Conditions (*with BH-L1043*)



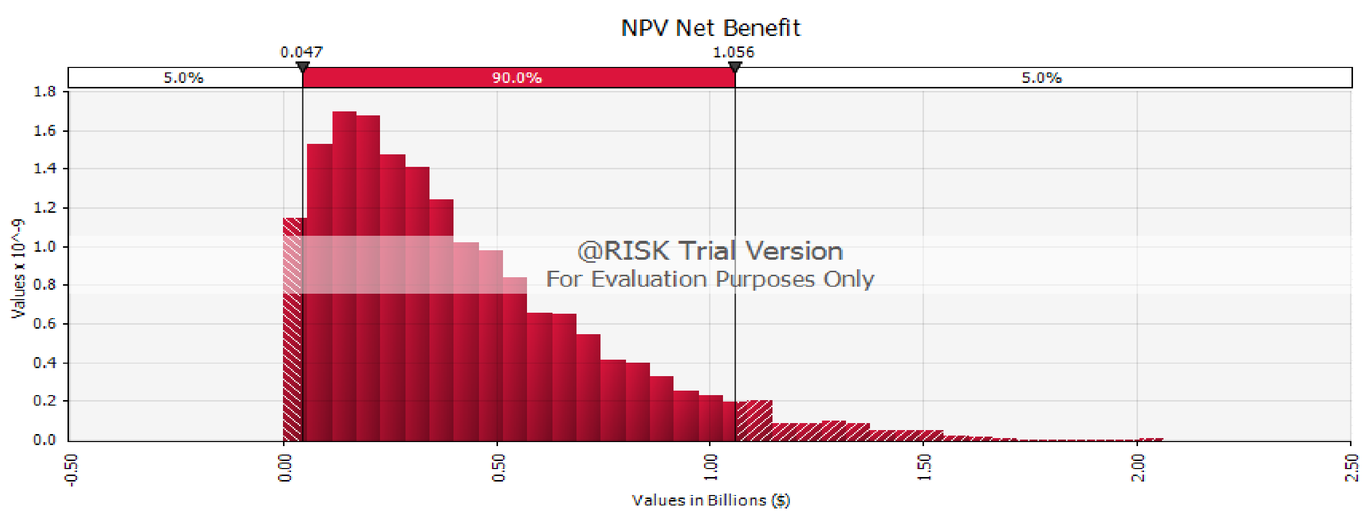
	NPV Net Benefit
Cell	S0(2)!F3
Minimum	$0.00
Maximum	$1.805E+009
Mean	$284,902,900.61
90% CI	± $6,052,587.12
Mode	$0.00
Median	$209,060,949.22
Std Dev	$260,146,700.77
Skewness	1.4524
Kurtosis	5.3688
Values	5000
Errors	0
Filtered	0
Left X	$15,299,222.55
Left P	5.0%
Right X	$819,456,833.93
Right P	95.0%
Dif. X	$804,157,611.38
Dif. P	90.0%

Figure 4.3: Baseline Storm Damages, 15% Increase in Storm Probabilities (*without BH-L1043*)



	NPV Net Benefit
Cell	S15!D3
Minimum	$2,984,356.52
Maximum	$2.513E+009
Mean	$581,121,149.16
90% CI	± $8,775,082.55
Mode	$255,826,499.29
Median	$505,531,125.80
Std Dev	$377,162,480.82
Skewness	1.0219
Kurtosis	4.1614
Values	5000
Errors	0
Filtered	0
Left X	$110,134,152.84
Left P	5.0%
Right X	$1.291E+009
Right P	95.0%
Dif. X	$1.181E+009
Dif. P	90.0%

Figure 4.4: Storm Damages, 15% Increase in Storm Probabilities (*with BH-L1043*)



	NPV Net Benefit
Cell	S15(2)!F3
Minimum	$0.00
Maximum	$2.065E+009
Mean	$414,462,060.50
90% CI	± $7,440,439.84
Mode	$201,963,839.58
Median	$335,411,215.88
Std Dev	$319,798,102.39
Skewness	1.2061
Kurtosis	4.4532
Values	5000
Errors	0
Filtered	0
Left X	$47,301,687.81
Left P	5.0%
Right X	$1.056E+009
Right P	95.0%
Dif. X	$1.009E+009
Dif. P	90.0%

Other Ecosystem Services

Additional benefits related to provision of ecosystem services associated with BH-L1043 include i) improving fish stocks and increasing catch rates of commercial and recreational fisheries; ii) expanding aquatic habitat, bolstering biodiversity, and enhancing recreational opportunities associated with establishment of a new Marine Protected Area in East Grand Bahama; and iii) increasing water quality and other environmental benefits associated with mangrove rehabilitation. While market prices for fisheries catch are available from the literature, estimates of changes in fish stocks and improvements in catch rates associated with BH-L1043 are not available.

In accounting for other benefits of ecological services associated with BH-L1043, we consider environmental improvements stemming from a new marine protected area in East Grand Bahama and water quality improvements associated with mangrove restoration. We use benefit transfer for these purposes. Estimates from Beharry-Borg and Scarpa's (2010) choice experiments in Tobago produce a transfer estimate of USD 1.40 per household. According to Bahamian Census data, there are 3,387 households in Grand Bahama, producing an estimate of economic value of USD 4,472 per year. To assess water purification values, we use the estimate of Walters et al. (2008), which found mangroves valued at USD 1,193 of 1998 per hectare per year. Adjusting for income level and inflation, the value of a hectare of mangrove in The Bahamas is USD 1,193×0.455×1.404 =USD 762 per year.[10] BH-L1043 entails restoration of 120 hectares on Grand Bahama and Long Island (part of Component 1) and 200 hectares on

[10] The rescaling factor for transferring from US to The Bahamas is $US22,817/US$50,159=0.455; the inflation factor for 1998 to 2015 is 1.404.

Andros. Thus, benefit transfer suggests aggregate benefits of mangrove restoration of USD 244,003 per year.

Intangible Benefits

As with many investments in climate resilience and enhancement of ecological systems, there can be a slew of intangible and ancillary benefits, many of which cannot be quantified. Improved hydrological flow in East Grand Bahama is likely to produce ancillary ecosystem services related to biodiversity and ecosystem health; this can generate (non-use) *existence values* among residents of and visitors to The Bahamas. These values are difficult to measure and likely to be rather small, but could aggregate to a substantial magnitude if they are widespread in the population. Improvements in the general quality of coastal resources could entail recreation and aesthetic values for residents of The Bahamas. Exploration of these potential benefits would require interviews, literature review, and focus groups, which could then lead to empirical assessment with model formulation, data collection, and analysis.

Sustainable development of Andros could create a host of economic benefits for Bahamian residents, including new employment opportunities, greater household income, and lower income inequality. By providing new opportunities, eco-tourism development of Andros can promote self-sufficiency of Bahamian households. Components of Central Long Island flood risk mitigation, establishment of a risk management system, and sustainable development of Andros will involve students and citizens in monitoring, data collection, and maintenance projects. Through investments in enhancing ecological services and fostering improvements in risk management, BH-L1043 will entail benefits in education, outreach, and sustainability.

Project components on East Grand Bahama and Central Long Island will provide for improvements in transportation and accessibility. Construction of a Bypass on East Grand Bahama will improve transportation reliability and reduce uncertainty regarding transit time. Installation of drainage wells in Central Long Island will reduce flooding, the extent of floodwaters, and the duration of nuisance flood events. The changes will improve transportation and accessibility, reduce travel times, and provide for human welfare.

Investments in a risk management system not only help to reduce storm damage and facilitate adaptation to climate change. Through enhanced data acquisition and management, improved modeling capabilities, and investments in institutional capacity, the risk management program will permit efficient assessment and design of new building codes, which will allow informed tradeoffs in risk reduction and construction costs. This should lead to cost effective risk management and lower hazard insurance rates for Bahamian households.

IV. Economic Costs

Details of the projected economic costs for Components 1 – 3 have been provided by IDB personnel in the Project Data Sheets, and costs are apportioned out to planning and construction years (Y1 – Y6) in the Pluri-annual Execution Plan (PEP). The PEP also includes additional management costs for audits, evaluation, supervision, and contingencies. Table 7 presents the estimates of project costs for each of the three projects in component 1, as well as component 2 and component 3, and the additional management costs (last group). By far, the most costly component of BH-L1043 involves investments in transportation and beach erosion control infrastructure in the Port of Nassau. The other projects in Component 1 and in components 2 and 3 each are projected to cost between USD 2.5 million to 3.5 million. An additional USD 5 million is included for project management. The last column in Table 7 is an indicator of whether the input is a direct hazard mitigant (e.g. seawall as opposed to ecological survey).

Table 7: Cost Estimates for BH-L1043

Component; Project	**Input**	**Cost (1,000s)**	**Mitigant**
Grand Bahama	*Hydrodynamic/ Baseline surveys*	$267	N
	Ecological Suvey	$70	N
	Environmental Impact, BCA	$100	N
	Detailed Designs	$50	N
	Mangrove Rehabilitation	$60	Y
	Raised Road	$60	Y
	Causeway excavation	$1,130	Y
	Upgraded causeway	$400	Y
	Supervision (6%)	$99	N
	Construction Contingency (15%)	$239	Y
	Stakeholder consultation	$10	N
	Maintenance	$16	Y
	SUBTOTAL 1.1 =	$2,500	
Nassau	*Hydrodynamic/ Baseline surveys*	$1,001	N
	Environmental Impact, BCA	$151	N
	Detailed Design	$400	N
	Breakwaters	$10,000	Y
	Drainage outlet	$30	Y
	Seawalls	$30	Y
	Beach Replenishment	$708	Y
	Beach control structures	$2,800	Y

	Supervision (6%)	$814	N
	Construction Contingency (15%)	$2,035	Y
	Stakeholder consultation	$10	N
	Maintenance	$21	Y
	SUBTOTAL 1.2 =	$18,000	
Long Island	*Hydrodynamic/ Baseline surveys*	$280	N
	Surge modeling (west coast)	$280	N
	Environmental Impact, BCA	$180	N
	Detailed Designs	$100	N
	Mangrove rehabilitation	$400	Y
	Drainage wells	$151	Y
	Bypass road with land purchase	$1,000	Y
	Revetment	$100	Y
	Flood Gate	$100	Y
	Supervision (6%)	$105	N
	Construction Contingency (15%)	$203	Y
	Stakeholder consultation	$20	N
	Maintenance	$81	Y
	SUBTOTAL 1.3 =	$3,000	
Andros	*Baseline studies*	$200	N
	Stakeholder consultation	$10	N
	Advise on nature-based solutions	$50	N
	Diagnostics/pilot	$700	Y
	Conservation/restoration	$2,000	Y
	Communication	$40	N
	SUBTOTAL 2 =	$3,000	
Coastal Zone Management	*Establishment*	$1,400	Y
	Travel	$50	Y
	Training	$250	Y
	Equipment/ software	$500	Y
	Technical Assistance	$80	Y
	Action Plan	$100	Y
	Updated Building Codes	$100	Y
	Shoreline MGMT Plans	$450	Y
	Sustainable Finance	$70	Y
	Pilot monitoring/ info MGMT	$500	Y
	SUBTOTAL 3 =	$3,500	
Management	*Audits*	$200	N
	Evaluation	$300	N

	Supervision	$1,500	N
	Contingencies	$3,000	N
	SUBTOTAL 4 =	$5,000	
	TOTAL =	$35,000	

Project costs also include salary dollars ($95,000) for engineering personnel to support the Coastal Risk Management Program. To calculate net present value of costs, a 12% discount rate is utilized. *Intangible costs* associated with the project include sedimentation, erosion impacts, and turbidity of coastal waters during construction. In addition, BH-L1043 will likely cause congestion and traffic problems during construction.

V. Economic Returns

In this section we calculate the net present value and internal rate of return on BH-L1043 using the benefit and cost estimates presented in the previous two sections. Table 8 presents details of the calculation of net present value of net benefits based on historical storm occurrences in the storm damage data, where: *Ben(T)* presents the tourism benefits (from Tables 2 and 3 in Section III, but including indirect and induced economic impacts); *Ben(R)* presents the storm damage reduction benefits as a current-value, annualized flow; *Ben(B)* is the benefit of beach enhancement at Junkanoo (a one-time benefit of over USD 300,000 that reflects the capitalized value of future beach recreation benefits to households in the near vicinity (see Section III) of Junkanoo Beach); *Ben(M)* represents the annual benefits of establishment of a marine protected area on Grand Bahama ($4,472 per year) and restoration of mangroves on Grand Bahama and Long Island (just over $244,000 per year); and Costs are the projected investment costs allocated to the appropriate time horizon, including salary costs for the Coastal Risk Management Program. The negative tourism effects depicted in Table 3 for periods 1 – 5 are not included in this calculation, as they are projected to occur both *with* and *without BH-L1043*.

Table 8: Net Present Value of BH-L1043 for The Bahamas (USD 1,000s)

Period	Ben(T)	Ben(D)	Ben(B)	Ben(M)	Costs	Net Benefits
1	$0	$0	$0	$0	$6,305	-$6,305
2	$0	$0	$0	$0	$5,675	-$5,675
3	$0	$0	$0	$0	$9,890	-$9,890
4	$0	$0	$0	$0	$9,137	-$9,137
5	$0	$0	$0	$0	$2,044	-$2,044
6	$3,552	$17,112	$301	$248	$1,949	$19,264
7	$4,429	$17,112	$0	$248	$95	$21,694
8	$5,306	$17,112	$0	$248	$95	$22,572
9	$6,184	$17,112	$0	$248	$95	$23,449
10	$7,061	$17,112	$0	$248	$95	$24,326
11	$7,938	$17,112	$0	$248	$95	$25,203
12	$8,816	$17,112	$0	$248	$95	$26,081
13	$9,693	$17,112	$0	$248	$95	$26,958
14	$10,570	$17,112	$0	$248	$95	$27,836
15	$11,448	$17,112	$0	$248	$95	$28,713
16	$12,325	$17,112	$0	$248	$95	$29,590
17	$13,203	$17,112	$0	$248	$95	$30,468
18	$14,080	$17,112	$0	$248	$95	$31,345
19	$14,957	$17,112	$0	$248	$95	$32,222
20	$15,834	$17,112	$0	$248	$95	$33,099
21	$16,711	$17,112	$0	$248	$95	$33,976
22	$17,588	$17,112	$0	$248	$95	$34,853
23	$18,465	$17,112	$0	$248	$95	$35,730
24	$19,342	$17,112	$0	$248	$95	$36,607
25	$20,219	$17,112	$0	$248	$95	$37,484
26	$21,095	$17,112	$0	$248	$95	$38,361
27	$21,972	$17,112	$0	$248	$95	$39,237
28	$22,849	$17,112	$0	$248	$95	$40,114
29	$23,725	$17,112	$0	$248	$95	$40,991
30	$24,602	$17,112	$0	$248	$95	$41,867
31	$25,479	$17,112	$0	$248	$95	$42,744
32	$26,355	$17,112	$0	$248	$95	$43,620
33	$27,232	$17,112	$0	$248	$95	$44,497

34	$28,108	$17,112	$0	$248	$95	$45,373
35	$28,984	$17,112	$0	$248	$95	$46,250
36	$29,861	$17,112	$0	$248	$95	$47,126
37	$30,738	$17,112	$0	$248	$95	$48,003
38	$31,614	$17,112	$0	$248	$95	$48,880
39	$32,491	$17,112	$0	$248	$95	$49,756
40	$33,368	$17,112	$0	$248	$95	$50,633
41	$34,244	$17,112	$0	$248	$95	$51,509
42	$35,120	$17,112	$0	$248	$95	$52,385
43	$35,996	$17,112	$0	$248	$95	$53,262
44	$36,873	$17,112	$0	$248	$95	$54,138
45	$37,749	$17,112	$0	$248	$95	$55,014
46	$38,625	$17,112	$0	$248	$95	$55,890
47	$39,502	$17,112	$0	$248	$95	$56,767
48	$40,378	$17,112	$0	$248	$95	$57,643
49	$41,254	$17,112	$0	$248	$95	$58,519
50	$42,130	$17,112	$0	$248	$95	$59,395
51	$43,005	$17,112	$0	$248	$95	$60,271
52	$43,881	$17,112	$0	$248	$95	$61,147
53	$44,757	$17,112	$0	$248	$95	$62,022
54	$45,633	$17,112	$0	$248	$95	$62,898
55	$46,509	$17,112	$0	$248	$95	$63,774
NPV	$50,466	$80,636	$152	$1,169	$25,546	$106,876

Net present value of BH-L1043 amounts to USD 106.876 million, and the internal rate of return (IRR) is 20%. Other benefits of the investments include improvements in fisheries (which can be valued by increased catch and market prices), other recreational and aesthetic values for residents of The Bahamas, local economic benefits and impacts of sustainable development of Andros, improvements in transportation and accessibility, and intangibles, such as existence values, cost effective risk management, and lower hazard insurance rates for Bahamian households. Intangible costs include sedimentation, erosion, turbidity, and traffic congestion impacts, primarily occurring during construction.

On balance, BH-L1043 is on solid economic grounds. The present value of net benefits is greater than $106 million, with an internal rate of return of 20%. While the costs are projected based on engineering estimates of necessary resources and investment expenditures, the benefits have been estimated using fairly conservative approaches.

Assessment of tourism benefits assumed minor changes in market share; benefits of beach enhancements were assumed to accrue to only households in the near vicinity of Junkanoo beach, and only the economic benefits of marine protected areas and mangrove restoration are included for East Grand Bahama and Long Island. Analysis of BH-L1043 under a climate change scenario—increasing storm frequencies and damage by 15%—indicates NPV of almost USD 120.807 million with an IRR of 22% (table A3 presented in Appendix). Differences in net benefits related to different scenarios of climate change and alternative effectiveness of risk-mitigation measures are explored in sensitivity analysis (below).

VI. Sensitivity analysis

In this section we conduct sensitivity analysis to the following assumptions: 1) the 2% decline in market share (Y1 – Y20, and continuing at the same implicit rate of change through the project life [Y55]) occurring due to natural resource depreciation, enhanced climate risk, and transportation infrastructure problems; 2) the 2% increase in market share (Y6 – Y25, and continuing at the same implicit rate of change through the project life [Y55]) occurring due to improvements in transportation infrastructure, natural resource quality, and climate risk; 3) the effectiveness of climate-resilient infrastructure investments in reducing storm damages; 4) climate-change induced evolutions in storm frequency; and 5) the existence of particular economic benefits accruing to Bahamians (the potential of double-counting of benefits when assessing *Ben(T)* and *Ben(D)* simultaneously, as well as the existence of *Ben(B)* and *Ben(M)*.

Assuming a more modest 1% decline in market share apportioned out over years 1 – 20 (and a slightly larger rate of 1.5% for Nassau Cruise Terminal arrivals), but continuing at the same implicit rate of change through the project life (55 years), the net present value of lost tourism revenues over 55 years are USD 20.512 million. At the end of 55 years, total arrivals will have decreased by 38,827 trips, or about 0.63% of the arrivals in 2015. A more modest 1% increase in market share due to BH-L1043 results in net present value of gains in tourism revenue of USD 7.391 million over 55 years. The total change in arrivals in this case is 22,600 (about 0.37% of 2015 arrivals). Using these estimates of tourism benefit (see column 2 in Table A4 in Appendix), the net present value of BH-L1043 amounts to USD 81.664 million, and the Internal Rate of Return (IRR) is 18%.

Reducing the effectiveness of storm damage mitigation from USD 120 million to USD 90 million results in a decrease in net present value of storm damages of USD 108.8 million (decreasing expected damages from USD 427.011 million to USD 318.211 million). In this case, present value of net benefits for BH-L1043 is USD 87.976 million with an IRR of 17%. (See Table A5 in Appendix.)

Considering different changes in storm intensity has a rather small impact on net benefits of BH-L1043: a 10% increase in storm frequency leads to a net present value of USD 115.007 million (IRR 21%), while a 20% increase in storm frequency would increase the net benefits to USD 136.285 million (IRR 24%) (see Tables A6 and A7 in Appendix, respectively).

Furthermore, a relevant consideration when analyzing a range of impacts in a cost-benefit analysis is the preclusion of double-counting without losing all relevant benefits derived from a project. Ignoring local benefits associated with enhancement of Junkanoo Beach, establishment of a marine protected area on East Grand Bahama, and mangrove restoration in Grand Bahama and Long Island has only a minimal impact on net benefits, which are still considerable at USD 105.555 million (20% IRR) (see Table A8 in Appendix).

Along the same vein, one of the fundamental distinctions recognized in economics is between stocks and flows. A controversial subject is the appropriateness of including both stock and flow measures in the case of natural hazards. Stocks refer to a quantity at a single point in time, whereas flows refer to the services or outputs of stocks over time. In our case, infrastructure damage represents a decline in stock value that is likely to lead to a decrease in service flows, such as tourism. However, tourism interruption losses are a flow measure that may emanate only in part from infrastructure damage. Disentangling the stock/flow overlap is an extremely complex endeavor, given the quite diverse attributes of goods and services and because most goods and services cannot yield all of these attributes to their maximum simultaneously, and that only one or the other, or some balance of the two, should only be counted. We believe, based on previous work by Rose (2004) and others, that including both stock damage and flow losses is a reasonable assumption if one interprets the output (flow) losses as ’‘opportunity costs of delays in restoring production,” however, we acknowledge that potential double-counting issues may arise when accounting for both tourism and avoided damages benefits simultaneously. To mitigate this risk, we present results excluding tourism benefits in Table A9. Even without including tourism benefits, the NPV of BH-L1043 is USD 56.411, with an internal rate of return of 15%.

Lastly, we consider a worst-case scenario for project performance within the parameter values we used in sensitivity analysis. For this case, we assume more modest impacts on tourism (1% change in market share rather than 2%), lower effectiveness of damage reduction (USD 90 million rather than USD 120 million, and no local economic benefits associated with Junkanoo, marine protected area, or mangrove restoration. These results are presented in Table A10 in the Appendix. Under this worst-case scenario for project performance of BH-L1043, net present value is over USD 61 million, with an internal rate of return of 14%.

VII. Conclusions

IDB loan BH-L1043 for investments in climate-resilient coastal infrastructure and Management Program for the Commonwealth of the Bahamas consists of: investments in natural and man-made coastal infrastructure on New Providence, Grand Bahama, and Long Island; environmental, social, and eco-tourism improvements on the island of Andros; and amelioration of storm, flooding, and erosion risk through design and implementation of a coastal risk management system. The economic benefits that are projected arise from these investments include maintenance of tourism flows (through improvements in natural resources, protection of critical port capabilities, and reducing business interruption during disaster), reductions in expected storm damages (under historical storm regimes and potential increases in storm frequency due to climate change), and improvements in environmental quality (beaches, mangroves, fish, water quality) and infrastructure services (transportation, flood control) for Bahamian residents.

Utilizing estimates from existing literature, baseline data to conduct simulations, and limited primary empirical analysis, we conducted an *ex-ante* benefit-cost analysis of these investments. On balance, BH-L1043 is on solid economic grounds. The present value of net benefits is greater than $106 million, with an internal rate of return of 20%. Similarly, based on a range of plausible alternative scenarios that hold up to scrutiny in sensitivity analysis, the Present Value of Net Benefits attributable to these projects is consistently in the range of USD 82 million to USD 136 million. The internal rate of return is typically around 18-24%. Even in a worst-case scenario, in which all benefits tend to be in the lower range of assumed effects, or when excluding tourism benefits for potential double-counting net present value is in the range of USD 56-61 million, with an internal rate of return of 14-15%. BH-L1043 appears to be a good investment for IDB from an economic standpoint.

References

Agnew, D. & Viner, D. (2001) Potential impacts of climate change on international tourism. *Tourism and Hospitality Research* **3**: 37–59.

Alexandrakis, G., C. Manasakis, N.A. Kampanis. 2015. "Valuating the effects of beach erosion to tourism revenue. A management perspective" *Ocean & Coastal Management* 111: 1-11.

Algieri, B. 2006. "International Tourism Specialization of Small Countries" *International Journal of Tourism Research* 8: 1-12.

Beharry-Borg, N. and R. Scarpa. 2010. "Valuing quality changes in Caribbean coastal waters for heterogeneous beach visitors" *Ecological Economics* 69: 1124–1139.

Banerjee, O., K. Boyle, C. Rogers, J. Cumberbatch, B. Kanninen, M. Lemay, and M. Schling. 2016. "A Retrospective Stated Preference Approach to Assessment of Coastal Infrastructure Investments" IDB Working Paper Series No. 727: Washington, DC.

Barbier, E.B. 1993. "Sustainable Use of Wetlands Valuing Tropical Wetland Benefits: Economic Methodologies and Applications" *The Geographic Journal* 159(1): 22-32.

Barbier, E.B. 1994. "Valuing Environmental Functions: Tropical Wetlands" *Land Economics* 70(2): 155-173.

Barbier, E.B. 2000. "Valuing the Environment as Input: Review of Applications to Mangrove-fishery Linkages" *Ecological Economics* 35: 47-61.

Barbier et al. 2011. The value of estuarine and coastal ecosystem services. Volume 81, Issue 2. Pages 169–193

Bell, F.W. 1986. "Economic Policy Issues Associated with Beach Nourishment", *Policy Studies Review* 6(2): 374-381.

Braun, O.L., Lohmann, M., Maksimovic, O., Meyer, M., Merkovic,A., Messerschmidt, E., Brander et al. 2012. Vegetation's Role in Coastal Protection. Science 320.

Riedel, A. & Turner, M. (1999) Potential impacts of climate change effects on preferences for tourism destinations. A psychological pilot study. *Climate Research* 11: 247–254.

Brown, T.C. 2017. "Substitution Methods" Chapter 9 in A Primer on Non-Market Valuation, 2nd Edition, Champ, P., K. Boyle, and T. Brown (Eds), Springer: New York, NY.

Buchan, K. 2000. "The Bahamas" *Marine Pollution Bulletin* 41(1-6): 94-111.

Cesar, H. (2000) Impacts of the 1998 coral bleaching event on tourism in El Nido, Philippines. Report for Coastal Resources Center, University of Rhode Island, Narragansett, RI, USA: 21 pp.

Cambers, G. 2009. "Caribbean Beach Changes and Climate Change Adaptation." *Aquatic Ecosystem Health & Management* 12.2: 168–176.

Carey, K. 1991. "Estimation of Caribbean Tourism Demand" *Atlantic Economic Journal* 19(3): 32-40.

Chon, K. 1990. "The role of destination image in tourism: A review and discussion" *The Tourist Review* 45(2): 2–9.

Corral, L., M. Schling, C. Rogers, J. Cumberbatch, F. Hinds, N. Zhou, and M. Lemay. 2016. "The Impact of Coastal Infrastructure: Improvements in Economic Growth" IDB Working Paper Series No. 729: Washington, DC.

Cushion N.M. and K. Sullivan-Sealey. 2007. "Landings, Effort, and Socio-economics of a Small

Scale Commercial Fishery in The Bahamas" *Proceedings of the 60th Gulf and Caribbean Fisheries Institute* (November 5 – 9): Punta Cana, Dominican Republic.

Das, S. (2009) Can Mangroves Minimize Property Loss during Big Storms? An Analysis of House Damage due to the Super Cyclone in Orissa. SANDEE working papers, 42-09. Kathmandu: SANDEE.

Das and Crepin. 2013. Mangroves can provide protection against wind damage during storms. Estuarine, Coastal and Shelf Science. Volume 134. Pages 98–107.

Department of Statistics of The Bahamas. 2012. "Census of Population and Housing 2010." The Commonwealth of The Bahamas. Retrieved on March 5, 2017 from http://www.soencouragement.org/forms/CENSUS2010084903300.pdf

Dharmaratne, G.S. and A.E. Brathwaite. 1998. "Economic Valuation of the Coastline for Tourism in Barbados" *Journal of Travel Research* 37 (Nov): 138- 44.

Edwards, P.E.T. 2009. "Sustainable financing for ocean and coastal management in Jamaica: The potential for revenues from tourist user fees" *Marine Policy* 33: 376–385.

Emerton et al. 2016. Investing in Natural Infrastructure: the economic value of Indonesia's marine protected areas & coastal ecosystems. The Nature Conservancy. DOI: 10.13140/2.1.2420.3844

Forster, J., Schuhmann, P.W., Lake, I. R., Watkinson, A.R., and Gill, J.A., 2012. "The Influence of Hurricane Risk on Tourist Destination Choice in the Caribbean" *Climatic Change* 114 (3-4): 745- 768.

Greenidge, K. 2001. "Forecasting Tourism Demand: An STM Approach" Annals of Tourism Research" 28(1): 98-112.

Griffiths, C., H. Klemick, M. Massey, C. Moore, S. Newbold, D. Simpson, P. Walsh, and W. Wheeler. 2012. "U.S. Environmental Protection Agency Valuation of Surface Water Quality Improvements" *Review of Environmental Economics and Policy* 6: 130-146.

Huang, J., P.J. Poor, and M.Q. Zhao 2007. "Economic Valuation of Beach Erosion Control" *Marine Resource Economics* 22(3): 221-238.

Inter-American Development Bank. 2014. "Estimación de la amenaza y el riesgo probabilista por huracán en Guatemala incorporando el impacto asociado al cambio climático." Technical Note IDB-TN-667. Retrieved from https://publications.iadb.org/handle/11319/6641#sthash.sI3rZMhl.dpuf

Koslow, J., K. Aiken, K., S. Auil, S., and A.Clementson. 1994. "Catch and effort analysis of the reef fisheries of Jamaica and Belize" *Fishery Bulletin* 92:737-747.

Loomis, J. and L. Santiago. 2013. "Economic Valuation of Beach Quality Improvements: Comparing Incremental Attribute Values Estimated from Two Stated Preference Valuation Methods" *Coastal Management* 41(1): 75-86.

Maritime Limits and Boundaries Services Ltd. (BNGIS) 2015. "Desktop Study Report prepared by Maritime Limits and Boundaries Services Ltd for the Commonwealth Secretariat": London.

Mechler, R. 2016. "Reviewing estimates of the economic efficiency of disaster risk management: opportunities and limitations of using risk-based cost–benefit analysis" *Natural Hazards* 81: 2121–2147.

MMC. 2005. "Natural hazard mitigation saves: an independent study to assess the future savings from mitigation activities". Volume 2—study documentation. Multihazard

Mitigation Council, Washington, DC.
Moore, W.R. 2010. “The Impact of Climate Change on Caribbean Tourism Demand” *Current Issues in Tourism* 13(5): 495–505.
Parsons, G.R. Z. Chen, M.K. Hidrue, N. Standing, J. Lilley. 2013. “Valuing Beach Width for Recreational Use: Combining Revealed and Stated Preference Data” *Marine Resource Economics* 28(3): 221-241.
Phillips, M.R. and A.L. Jones. 2006. “Erosion and Tourism Infrastructure in the Coastal Zone: Problems, Consequences, and Management” *Tourism Management* 27: 517-24.
Pike, S. 2002. “Destination Image Analysis—A Review of 142 Papers from 1973 to 2000” Research Note, *Tourism Management* 23: 541–549.
Polome´, P., S. Marzetti, and A. van der Veen. 2005. “Economic and social demands for coastal protection” *Coastal Engineering* 52: 819–840.
Rose, A. 2004. Economic Principles, Issues, and Research Priorities in Hazard Loss Estimation. Springer, NewYork.
Rosenberger, R.S. and J.B. Loomis. 2004. “Benefit Transfer”, Chapter 12 in A Primer on Non-Market Valuation (Eds. P.A. Champ, K.J. Boyle, and T.C. Brown), Kluwer: The Netherlands.
Rosensweig, J.A. 1988. “Elasticities of Substitution in Caribbean Tourism” *Journal of Development Economics* 29: 89-100.
Saengsupavanich, C., U. Seenprachawong, W.G. Gallardo, and G.P. Shivakoti. 2008. “Port-induced erosion prediction and valuation of a local recreational beach” *Ecological Economics* 67: 93–103.
Schuhmann, P.W., B.E. Bass, J.F. Casey, and D.A. Gill. 2016. “Visitor Preferences and Willingness To Pay For Coastal Attributes In Barbados” *Ocean and Coastal Management* 134: 240-50.
The Bahamas Environment, Science and Technology Commission (BEST). 2001.“First National Communication on Climate Change”: Nassau.
The Commonwealth of the Bahamas (CTB). 2015a. “National Accounts Report”, Ministry of Finance, Department of Statistics: Nassau.
The Commonwealth of the Bahamas (CTB). 2015b. “Total Foreign Arrivals To The Bahamas By Air & Sea 1971 – 2015”, The Bahamas Ministry Of Tourism Visitor Statistics: Nassau
Uyarra, M.C., I.M. Côté, J.A. Gill, R. TInch, D. Viner, and A.R. Watkinson. 2005. “Implications of Climate Change for Tourism-dependent States” *Environmental Conservation* 32 (1): 11–19.
Walters, B.B., P. Rönnbäck, J.M. Kovacs, B. Crona, S.A. Hussain, R. Badola, J.H. Primavera, E. Barbier, F. Dahdouh-Guebas. 2008. “Ethnobiology, Socio-economics, and Management of Mangrove Forests: A Review” *Aquatic Botany* 89: 220-236.
Whitehead, J.C., C.F. Dumas, J. Herstine, J. Hill, and B. Buerger. 2008. “Valuing Beach Access and Width with Revealed and Stated Preference Data” *Marine Resource Economics* 23: 119–135.
World Travel and Tourism Council (WTTC). 2016. “Travel and Tourism Economic Impact 2016: Bahamas”: London.

Appendix

A1. Value Estimates for Commercial and Artisanal Fishing in The Bahamas

Finfish landings for export in 1998 were 444,335 kgs, valued at $5,825,962 (USD of 1998), or $13.11/kg (Buchan 2000). There is also considerable effort in small-scale fisheries that serve the national Bahamian market (households, restaurants, etc.), primarily focused on reef fishing. These artisanal fisheries contribute significantly to the local economies of the Caribbean (Koslow et al. 1994). Focusing on the Montagu artisanal fish market on New Providence, Cushion and Sullivan-Sealy (2007) estimate (conservatively) 54,000 fish landed by approximate 30 fishers working an average of 3 days per week during a 6-month period. Prices during this time averaged USD 35 for a 4.5 kg Nassau grouper and USD 13.50 for a 3–4.5 kg hind—around USD 7.78/kg for grouper and USD 3.60/kg for hinds (USD of 2007). Since the fisheries on East Grand Bahama are a small proportion of Bahamian output, projected changes in fisheries catch could be valued using these estimates.

A2. Empirical Analysis of Primary Data from Barbados

Dr. Peter Schuhmann provided primary data from Barbados (collected in 2015) that contain 242 responses from Barbados nationals. The choice experiment was designed to assess the relative importance and economic value of natural resource attributes in Barbados from the perspective of international tourists. As such, the payment vehicle is bundled travel/accommodations price, which ranges from USD 750 – USD 4,000 for a weeklong vacation. Natural resource attributes assessed include beach width, seawater quality (probability of getting an infection from swimming/bathing), storm risk, and coral reef quality. See Table 5 for a summary of choice experiment attributes and levels.

Table A1: Destination choice attributes and levels (2015 CE)

Attributes	Levels
Price for airfare and one week lodging ($US)	$750, $1,500, $2,500, $4,000
Beach Width (meters)	2-4 meters, 6-10 meters, 12-16 meters, 18-20 meters
Seawater Quality (% chance of an infection from swimming/bathing)	Poor (> 10% chance), Moderate (5 - 10% chance), Good (1 - 5% chance), Excellent (< 1% chance of an infection)
Storm Risk (days out of 100 interrupted by hurricane or tropical storm)	Virtually none (< 1 day out of 100 interrupted), Low (1 day), Moderate (5 days), High (10 days)
Coral Reef Quality (images)	Low (Image A), Good for coral viewing (Image B), Good for fish viewing (Image C), Excellent (Image D)

Since the payment vehicle is bundled travel/accommodations price for a weeklong vacation, the choice experiment is clearly not ideal for our purposes. Most Bahamian nationals would not be considered conventional tourists that require air travel and hotel accommodations to visit their own country, especially considering that the majority live on the island where the beach improvements are occurring. While providing data on Caribbean nationals, the stated preference scenario is not well suited to assessment of residents' economic value of improving a local beach. Nonetheless, we estimate conditional (multinomial) logit models with these data to assess WTP of Barbados nationals for changes in beach width. Table 6 presents results from a conditional logit model for two utility specifications: 1) effects-coded (dummy variables for attribute levels [relative to an excluded category]); and 2) a linear model with beach attributes coded at their midpoint (e.g. the attribute "6-10m beach width" is coded as 8 meters wide).

Table A2: Conditional Logit Discrete Choice Models for Barbados Nationals

Variable	**Model 1: Effects-code**	**Model 2: Linear**

Price	-0.00036*** (0.000094)	-0.00034*** (0.00009)
beach_w1	-0.57089*** (0.19965)	
beach_w3	0.09588 (0.17595)	
beach_w4	0.47392** (0.18428)	
beach_w		0.05464*** (0.01776)
sea_water1	-0.77678*** (0.20067)	
sea_water3	0.33309* (0.18253)	
sea_water4	0.72068*** (0.17959)	
sea_water		-0.14994*** (0.02770)
snorkel1	-.18254 (0.18959)	-0.18126 (0.18368)
snorkel3	.31205* (0.17807)	-0.26370 (0.17454)
snorkel4	-.03759 (0.17688)	-0.04715 (0.17480)
storm_risk1	.60123*** (0.17546)	
storm_risk3	-.20356 (0.18683)	
storm_risk4	-.38432** (0.19171)	
storm_risk		-0.08416*** (0.02894)
ln(L)	-224.98573	-228.28372
LRT (p-value)	81.32375 (<0.00001)	74.72778(<0.00001)
Obs	242	242
Note: ***, **, * ==> Significance at 1%, 5%, 10% level.		

Empirical results indicate a negative effect on vacation choice for low-beach width (2-4m) and a positive effect on vacation choice for increasing beach (18-20m) in model 1 (each relative to the excluded category of 6-10m). Transformations of the model parameters reveal the following household economic value for changes in beach width: WTP (avoid beach width of 2-4m) = -$1,567; WTP (increase beach width to 18-20m) = $1,301. These figures correspond with marginal changes in WTP for a weeklong Barbados related to changes in the quality of the local beach. To put the estimates in context, WTP to avoid eroded beaches amounts to $224 per day; WTP for wider beaches (18-20m) is $186 per day. For the widening scenario, the increase to roughly 19 meters (midpoint of 18-20m range) from a baseline of 8 meters (midpoint of 6-10m) implies an approximate and average value of USD16.90 per additional meter of beach width per day. Results from the linear model imply a marginal WTP of USD 161 per additional meter of beach width. Normalizing by the length of stay, this corresponds with USD 23 per meter per day. These results are useful only in as much as they convey a legitimate preference of Caribbean residents for improvements in beach width (and an aversion to erosion).

A3. Results of Sensitivity Analyses

Table A3: Net Present Value of BH-L1043 for The Bahamas (USD 1,000s): 15% increase in storm probabilities due to climate change

Period	Ben(T)	Ben(D)	Ben(B)	Ben(M)	Costs	Net Benefits
1	$0	$0	$0	$0	$6,305	-$5,629
2	$0	$0	$0	$0	$5,675	-$4,524
3	$0	$0	$0	$0	$9,890	-$7,040
4	$0	$0	$0	$0	$9,137	-$5,807
5	$0	$0	$0	$0	$2,044	-$1,160
6	$3,552	$20,069	$301	$248	$1,949	$11,257
7	$4,429	$20,069	$0	$248	$95	$11,151
8	$5,306	$20,069	$0	$248	$95	$10,310
9	$6,184	$20,069	$0	$248	$95	$9,522
10	$7,061	$20,069	$0	$248	$95	$8,784
11	$7,938	$20,069	$0	$248	$95	$8,095
12	$8,816	$20,069	$0	$248	$95	$7,453
13	$9,693	$20,069	$0	$248	$95	$6,856
14	$10,570	$20,069	$0	$248	$95	$6,301
15	$11,448	$20,069	$0	$248	$95	$5,786
16	$12,325	$20,069	$0	$248	$95	$5,309
17	$13,203	$20,069	$0	$248	$95	$4,868
18	$14,080	$20,069	$0	$248	$95	$4,461
19	$14,957	$20,069	$0	$248	$95	$4,084
20	$15,834	$20,069	$0	$248	$95	$3,738
21	$16,711	$20,069	$0	$248	$95	$3,418
22	$17,588	$20,069	$0	$248	$95	$3,125
23	$18,465	$20,069	$0	$248	$95	$2,855
24	$19,342	$20,069	$0	$248	$95	$2,607
25	$20,219	$20,069	$0	$248	$95	$2,379
26	$21,095	$20,069	$0	$248	$95	$2,170
27	$21,972	$20,069	$0	$248	$95	$1,979
28	$22,849	$20,069	$0	$248	$95	$1,803
29	$23,725	$20,069	$0	$248	$95	$1,643
30	$24,602	$20,069	$0	$248	$95	$1,496
31	$25,479	$20,069	$0	$248	$95	$1,362
32	$26,355	$20,069	$0	$248	$95	$1,239
33	$27,232	$20,069	$0	$248	$95	$1,127
34	$28,108	$20,069	$0	$248	$95	$1,025
35	$28,984	$20,069	$0	$248	$95	$932

36	$29,861	$20,069	$0	$248	$95	$847
37	$30,738	$20,069	$0	$248	$95	$769
38	$31,614	$20,069	$0	$248	$95	$699
39	$32,491	$20,069	$0	$248	$95	$634
40	$33,368	$20,069	$0	$248	$95	$576
41	$34,244	$20,069	$0	$248	$95	$523
42	$35,120	$20,069	$0	$248	$95	$474
43	$35,996	$20,069	$0	$248	$95	$430
44	$36,873	$20,069	$0	$248	$95	$390
45	$37,749	$20,069	$0	$248	$95	$354
46	$38,625	$20,069	$0	$248	$95	$320
47	$39,502	$20,069	$0	$248	$95	$290
48	$40,378	$20,069	$0	$248	$95	$263
49	$41,254	$20,069	$0	$248	$95	$238
50	$42,130	$20,069	$0	$248	$95	$216
51	$43,005	$20,069	$0	$248	$95	$195
52	$43,881	$20,069	$0	$248	$95	$177
53	$44,757	$20,069	$0	$248	$95	$160
54	$45,633	$20,069	$0	$248	$95	$145
55	$46,509	$20,069	$0	$248	$95	$131
NPV	$50,466	$94,567	$152	$1,169	$25,546	$120,807

Table A4: Net Present Value of BH-L1043 for The Bahamas (USD 1,000s): More Moderate Impact on Tourist Arrivals (50% lower than primary results)

Period	Ben(T)	Ben(D)	Ben(B)	Ben(M)	Costs	Net Benefits
1	$0	$0	$0	$0	$6,305	-$6,305
2	$0	$0	$0	$0	$5,675	-$5,675
3	$0	$0	$0	$0	$9,890	-$9,890
4	$0	$0	$0	$0	$9,137	-$9,137
5	$0	$0	$0	$0	$2,044	-$2,044
6	$1,778	$17,112	$301	$248	$1,949	$17,490
7	$2,217	$17,112	$0	$248	$95	$19,483
8	$2,656	$17,112	$0	$248	$95	$19,922
9	$3,096	$17,112	$0	$248	$95	$20,361
10	$3,535	$17,112	$0	$248	$95	$20,800
11	$3,973	$17,112	$0	$248	$95	$21,238
12	$4,412	$17,112	$0	$248	$95	$21,677
13	$4,851	$17,112	$0	$248	$95	$22,116
14	$5,289	$17,112	$0	$248	$95	$22,555
15	$5,728	$17,112	$0	$248	$95	$22,993
16	$6,167	$17,112	$0	$248	$95	$23,432
17	$6,606	$17,112	$0	$248	$95	$23,871
18	$7,044	$17,112	$0	$248	$95	$24,309
19	$7,483	$17,112	$0	$248	$95	$24,748
20	$7,922	$17,112	$0	$248	$95	$25,187
21	$8,360	$17,112	$0	$248	$95	$25,625
22	$8,799	$17,112	$0	$248	$95	$26,064
23	$9,238	$17,112	$0	$248	$95	$26,503
24	$9,676	$17,112	$0	$248	$95	$26,942
25	$10,115	$17,112	$0	$248	$95	$27,380
26	$10,554	$17,112	$0	$248	$95	$27,819
27	$10,992	$17,112	$0	$248	$95	$28,258
28	$11,431	$17,112	$0	$248	$95	$28,696
29	$11,870	$17,112	$0	$248	$95	$29,135
30	$12,309	$17,112	$0	$248	$95	$29,574
31	$12,747	$17,112	$0	$248	$95	$30,012
32	$13,186	$17,112	$0	$248	$95	$30,451
33	$13,625	$17,112	$0	$248	$95	$30,890
34	$14,063	$17,112	$0	$248	$95	$31,329
35	$14,502	$17,112	$0	$248	$95	$31,767
36	$14,941	$17,112	$0	$248	$95	$32,206
37	$15,379	$17,112	$0	$248	$95	$32,645
38	$15,818	$17,112	$0	$248	$95	$33,083

39	$16,257	$17,112	$0	$248	$95	$33,522
40	$16,696	$17,112	$0	$248	$95	$33,961
41	$17,134	$17,112	$0	$248	$95	$34,399
42	$17,573	$17,112	$0	$248	$95	$34,838
43	$18,011	$17,112	$0	$248	$95	$35,276
44	$18,450	$17,112	$0	$248	$95	$35,715
45	$18,888	$17,112	$0	$248	$95	$36,153
46	$19,326	$17,112	$0	$248	$95	$36,591
47	$19,765	$17,112	$0	$248	$95	$37,030
48	$20,203	$17,112	$0	$248	$95	$37,468
49	$20,641	$17,112	$0	$248	$95	$37,906
50	$21,080	$17,112	$0	$248	$95	$38,345
51	$21,518	$17,112	$0	$248	$95	$38,783
52	$21,956	$17,112	$0	$248	$95	$39,221
53	$22,395	$17,112	$0	$248	$95	$39,660
54	$22,833	$17,112	$0	$248	$95	$40,098
55	$23,271	$17,112	$0	$248	$95	$40,536
NPV	$25,253	$80,636	$152	$1,169	$25,546	$81,664

Table A5: Net Present Value of BH-L1043 for The Bahamas (USD 1,000s): Lower Effectiveness of Storm Damage Reduction (USD 90 million)

Period	Ben(T)	Ben(D)	Ben(B)	Ben(M)	Costs	Net Benefits
1	$0	$0	$0	$0	$6,305	-$6,305
2	$0	$0	$0	$0	$5,675	-$5,675
3	$0	$0	$0	$0	$9,890	-$9,890
4	$0	$0	$0	$0	$9,137	-$9,137
5	$0	$0	$0	$0	$2,044	-$2,044
6	$3,552	$13,101	$301	$248	$1,949	$15,253
7	$4,429	$13,101	$0	$248	$95	$17,683
8	$5,306	$13,101	$0	$248	$95	$18,561
9	$6,184	$13,101	$0	$248	$95	$19,438
10	$7,061	$13,101	$0	$248	$95	$20,315
11	$7,938	$13,101	$0	$248	$95	$21,193
12	$8,816	$13,101	$0	$248	$95	$22,070
13	$9,693	$13,101	$0	$248	$95	$22,947
14	$10,570	$13,101	$0	$248	$95	$23,825
15	$11,448	$13,101	$0	$248	$95	$24,702
16	$12,325	$13,101	$0	$248	$95	$25,580
17	$13,203	$13,101	$0	$248	$95	$26,457
18	$14,080	$13,101	$0	$248	$95	$27,334
19	$14,957	$13,101	$0	$248	$95	$28,211
20	$15,834	$13,101	$0	$248	$95	$29,088
21	$16,711	$13,101	$0	$248	$95	$29,965
22	$17,588	$13,101	$0	$248	$95	$30,842
23	$18,465	$13,101	$0	$248	$95	$31,719
24	$19,342	$13,101	$0	$248	$95	$32,596
25	$20,219	$13,101	$0	$248	$95	$33,473
26	$21,095	$13,101	$0	$248	$95	$34,350
27	$21,972	$13,101	$0	$248	$95	$35,226
28	$22,849	$13,101	$0	$248	$95	$36,103
29	$23,725	$13,101	$0	$248	$95	$36,980
30	$24,602	$13,101	$0	$248	$95	$37,856
31	$25,479	$13,101	$0	$248	$95	$38,733
32	$26,355	$13,101	$0	$248	$95	$39,610
33	$27,232	$13,101	$0	$248	$95	$40,486
34	$28,108	$13,101	$0	$248	$95	$41,363
35	$28,984	$13,101	$0	$248	$95	$42,239
36	$29,861	$13,101	$0	$248	$95	$43,115
37	$30,738	$13,101	$0	$248	$95	$43,992
38	$31,614	$13,101	$0	$248	$95	$44,869

39	$32,491	$13,101	$0	$248	$95	$45,745
40	$33,368	$13,101	$0	$248	$95	$46,622
41	$34,244	$13,101	$0	$248	$95	$47,498
42	$35,120	$13,101	$0	$248	$95	$48,375
43	$35,996	$13,101	$0	$248	$95	$49,251
44	$36,873	$13,101	$0	$248	$95	$50,127
45	$37,749	$13,101	$0	$248	$95	$51,003
46	$38,625	$13,101	$0	$248	$95	$51,880
47	$39,502	$13,101	$0	$248	$95	$52,756
48	$40,378	$13,101	$0	$248	$95	$53,632
49	$41,254	$13,101	$0	$248	$95	$54,508
50	$42,130	$13,101	$0	$248	$95	$55,384
51	$43,005	$13,101	$0	$248	$95	$56,260
52	$43,881	$13,101	$0	$248	$95	$57,136
53	$44,757	$13,101	$0	$248	$95	$58,012
54	$45,633	$13,101	$0	$248	$95	$58,887
55	$46,509	$13,101	$0	$248	$95	$59,763
NPV	$50,466	$61,736	$152	$1,169	$25,546	$87,976

Table A6: Net Present Value of BH-L1043 for The Bahamas (USD 1,000s): 10% increase in storm probabilities due to climate change

Period	Ben(T)	Ben(D)	Ben(B)	Ben(M)	Costs	Net Benefits
1	$0	$0	$0	$0	$6,305	-$6,305
2	$0	$0	$0	$0	$5,675	-$5,675
3	$0	$0	$0	$0	$9,890	-$9,890
4	$0	$0	$0	$0	$9,137	-$9,137
5	$0	$0	$0	$0	$2,044	-$2,044
6	$3,552	$18,838	$301	$248	$1,949	$20,989
7	$4,429	$18,838	$0	$248	$95	$23,420
8	$5,306	$18,838	$0	$248	$95	$24,297
9	$6,184	$18,838	$0	$248	$95	$25,174
10	$7,061	$18,838	$0	$248	$95	$26,051
11	$7,938	$18,838	$0	$248	$95	$26,929
12	$8,816	$18,838	$0	$248	$95	$27,806
13	$9,693	$18,838	$0	$248	$95	$28,684
14	$10,570	$18,838	$0	$248	$95	$29,561
15	$11,448	$18,838	$0	$248	$95	$30,438
16	$12,325	$18,838	$0	$248	$95	$31,316
17	$13,203	$18,838	$0	$248	$95	$32,193
18	$14,080	$18,838	$0	$248	$95	$33,070
19	$14,957	$18,838	$0	$248	$95	$33,947
20	$15,834	$18,838	$0	$248	$95	$34,824
21	$16,711	$18,838	$0	$248	$95	$35,701
22	$17,588	$18,838	$0	$248	$95	$36,578
23	$18,465	$18,838	$0	$248	$95	$37,455
24	$19,342	$18,838	$0	$248	$95	$38,332
25	$20,219	$18,838	$0	$248	$95	$39,209
26	$21,095	$18,838	$0	$248	$95	$40,086
27	$21,972	$18,838	$0	$248	$95	$40,963
28	$22,849	$18,838	$0	$248	$95	$41,839
29	$23,725	$18,838	$0	$248	$95	$42,716
30	$24,602	$18,838	$0	$248	$95	$43,593
31	$25,479	$18,838	$0	$248	$95	$44,469
32	$26,355	$18,838	$0	$248	$95	$45,346
33	$27,232	$18,838	$0	$248	$95	$46,223
34	$28,108	$18,838	$0	$248	$95	$47,099
35	$28,984	$18,838	$0	$248	$95	$47,975
36	$29,861	$18,838	$0	$248	$95	$48,852
37	$30,738	$18,838	$0	$248	$95	$49,728
38	$31,614	$18,838	$0	$248	$95	$50,605

39	$32,491	$18,838	$0	$248	$95	$51,482
40	$33,368	$18,838	$0	$248	$95	$52,358
41	$34,244	$18,838	$0	$248	$95	$53,235
42	$35,120	$18,838	$0	$248	$95	$54,111
43	$35,996	$18,838	$0	$248	$95	$54,987
44	$36,873	$18,838	$0	$248	$95	$55,863
45	$37,749	$18,838	$0	$248	$95	$56,740
46	$38,625	$18,838	$0	$248	$95	$57,616
47	$39,502	$18,838	$0	$248	$95	$58,492
48	$40,378	$18,838	$0	$248	$95	$59,368
49	$41,254	$18,838	$0	$248	$95	$60,244
50	$42,130	$18,838	$0	$248	$95	$61,120
51	$43,005	$18,838	$0	$248	$95	$61,996
52	$43,881	$18,838	$0	$248	$95	$62,872
53	$44,757	$18,838	$0	$248	$95	$63,748
54	$45,633	$18,838	$0	$248	$95	$64,624
55	$46,509	$18,838	$0	$248	$95	$65,500
NPV	$50,466	$88,767	$152	$1,169	$25,546	$115,007

Table A7: Net Present Value of BH-L1043 for The Bahamas (USD 1,000s): 20% increase in storm probabilities due to climate change

Period	Ben(T)	Ben(D)	Ben(B)	Ben(M)	Costs	Net Benefits
1	$0	$0	$0	$0	$6,305	-$6,305
2	$0	$0	$0	$0	$5,675	-$5,675
3	$0	$0	$0	$0	$9,890	-$9,890
4	$0	$0	$0	$0	$9,137	-$9,137
5	$0	$0	$0	$0	$2,044	-$2,044
6	$3,552	$23,353	$301	$248	$1,949	$25,505
7	$4,429	$23,353	$0	$248	$95	$27,935
8	$5,306	$23,353	$0	$248	$95	$28,813
9	$6,184	$23,353	$0	$248	$95	$29,690
10	$7,061	$23,353	$0	$248	$95	$30,567
11	$7,938	$23,353	$0	$248	$95	$31,445
12	$8,816	$23,353	$0	$248	$95	$32,322
13	$9,693	$23,353	$0	$248	$95	$33,199
14	$10,570	$23,353	$0	$248	$95	$34,077
15	$11,448	$23,353	$0	$248	$95	$34,954
16	$12,325	$23,353	$0	$248	$95	$35,832
17	$13,203	$23,353	$0	$248	$95	$36,709
18	$14,080	$23,353	$0	$248	$95	$37,586
19	$14,957	$23,353	$0	$248	$95	$38,463
20	$15,834	$23,353	$0	$248	$95	$39,340
21	$16,711	$23,353	$0	$248	$95	$40,217
22	$17,588	$23,353	$0	$248	$95	$41,094
23	$18,465	$23,353	$0	$248	$95	$41,971
24	$19,342	$23,353	$0	$248	$95	$42,848
25	$20,219	$23,353	$0	$248	$95	$43,725
26	$21,095	$23,353	$0	$248	$95	$44,602
27	$21,972	$23,353	$0	$248	$95	$45,478
28	$22,849	$23,353	$0	$248	$95	$46,355
29	$23,725	$23,353	$0	$248	$95	$47,232
30	$24,602	$23,353	$0	$248	$95	$48,108
31	$25,479	$23,353	$0	$248	$95	$48,985
32	$26,355	$23,353	$0	$248	$95	$49,862
33	$27,232	$23,353	$0	$248	$95	$50,738
34	$28,108	$23,353	$0	$248	$95	$51,614
35	$28,984	$23,353	$0	$248	$95	$52,491
36	$29,861	$23,353	$0	$248	$95	$53,367
37	$30,738	$23,353	$0	$248	$95	$54,244
38	$31,614	$23,353	$0	$248	$95	$55,121

39	$32,491	$23,353	$0	$248	$95	$55,997
40	$33,368	$23,353	$0	$248	$95	$56,874
41	$34,244	$23,353	$0	$248	$95	$57,750
42	$35,120	$23,353	$0	$248	$95	$58,626
43	$35,996	$23,353	$0	$248	$95	$59,503
44	$36,873	$23,353	$0	$248	$95	$60,379
45	$37,749	$23,353	$0	$248	$95	$61,255
46	$38,625	$23,353	$0	$248	$95	$62,132
47	$39,502	$23,353	$0	$248	$95	$63,008
48	$40,378	$23,353	$0	$248	$95	$63,884
49	$41,254	$23,353	$0	$248	$95	$64,760
50	$42,130	$23,353	$0	$248	$95	$65,636
51	$43,005	$23,353	$0	$248	$95	$66,512
52	$43,881	$23,353	$0	$248	$95	$67,388
53	$44,757	$23,353	$0	$248	$95	$68,263
54	$45,633	$23,353	$0	$248	$95	$69,139
55	$46,509	$23,353	$0	$248	$95	$70,015
NPV	$50,466	$110,045	$152	$1,169	$25,546	$136,285

Table A8: Net Present Value of BH-L1043 for The Bahamas (USD 1,000s): Not Including Local Economic Benefits (Junkanoo Beach Enhancements, Marine Protected Area, Mangrove Restoration)

Period	Ben(T)	Ben(D)	Ben(B)	Ben(M)	Costs	Net Benefits
1	$0	$0	$0	$0	$6,305	-$6,305
2	$0	$0	$0	$0	$5,675	-$5,675
3	$0	$0	$0	$0	$9,890	-$9,890
4	$0	$0	$0	$0	$9,137	-$9,137
5	$0	$0	$0	$0	$2,044	-$2,044
6	$3,552	$17,112	$0	$0	$1,949	$18,715
7	$4,429	$17,112	$0	$0	$95	$21,446
8	$5,306	$17,112	$0	$0	$95	$22,324
9	$6,184	$17,112	$0	$0	$95	$23,201
10	$7,061	$17,112	$0	$0	$95	$24,078
11	$7,938	$17,112	$0	$0	$95	$24,955
12	$8,816	$17,112	$0	$0	$95	$25,833
13	$9,693	$17,112	$0	$0	$95	$26,710
14	$10,570	$17,112	$0	$0	$95	$27,588
15	$11,448	$17,112	$0	$0	$95	$28,465
16	$12,325	$17,112	$0	$0	$95	$29,342
17	$13,203	$17,112	$0	$0	$95	$30,220
18	$14,080	$17,112	$0	$0	$95	$31,097
19	$14,957	$17,112	$0	$0	$95	$31,974
20	$15,834	$17,112	$0	$0	$95	$32,851
21	$16,711	$17,112	$0	$0	$95	$33,728
22	$17,588	$17,112	$0	$0	$95	$34,605
23	$18,465	$17,112	$0	$0	$95	$35,482
24	$19,342	$17,112	$0	$0	$95	$36,359
25	$20,219	$17,112	$0	$0	$95	$37,236
26	$21,095	$17,112	$0	$0	$95	$38,113
27	$21,972	$17,112	$0	$0	$95	$38,989
28	$22,849	$17,112	$0	$0	$95	$39,866
29	$23,725	$17,112	$0	$0	$95	$40,743
30	$24,602	$17,112	$0	$0	$95	$41,619
31	$25,479	$17,112	$0	$0	$95	$42,496
32	$26,355	$17,112	$0	$0	$95	$43,372
33	$27,232	$17,112	$0	$0	$95	$44,249
34	$28,108	$17,112	$0	$0	$95	$45,125
35	$28,984	$17,112	$0	$0	$95	$46,002
36	$29,861	$17,112	$0	$0	$95	$46,878
37	$30,738	$17,112	$0	$0	$95	$47,755

38	$31,614	$17,112	$0	$0	$95	$48,632
39	$32,491	$17,112	$0	$0	$95	$49,508
40	$33,368	$17,112	$0	$0	$95	$50,385
41	$34,244	$17,112	$0	$0	$95	$51,261
42	$35,120	$17,112	$0	$0	$95	$52,137
43	$35,996	$17,112	$0	$0	$95	$53,014
44	$36,873	$17,112	$0	$0	$95	$53,890
45	$37,749	$17,112	$0	$0	$95	$54,766
46	$38,625	$17,112	$0	$0	$95	$55,642
47	$39,502	$17,112	$0	$0	$95	$56,519
48	$40,378	$17,112	$0	$0	$95	$57,395
49	$41,254	$17,112	$0	$0	$95	$58,271
50	$42,130	$17,112	$0	$0	$95	$59,147
51	$43,005	$17,112	$0	$0	$95	$60,023
52	$43,881	$17,112	$0	$0	$95	$60,899
53	$44,757	$17,112	$0	$0	$95	$61,774
54	$45,633	$17,112	$0	$0	$95	$62,650
55	$46,509	$17,112	$0	$0	$95	$63,526
NPV	$50,466	$80,636	$0	$0	$25,546	$105,555

Table A9: Net Present Value of BH-L1043 for The Bahamas (USD 1,000s): Tourism Benefits Excluded

Period	Ben(T)	Ben(D)	Ben(B)	Ben(M)	Costs	Net Benefits
1	$0	$0	$0	$0	$6,305	-$6,305
2	$0	$0	$0	$0	$5,675	-$5,675
3	$0	$0	$0	$0	$9,890	-$9,890
4	$0	$0	$0	$0	$9,137	-$9,137
5	$0	$0	$0	$0	$2,044	-$2,044
6	$0	$17,112	$301	$248	$1,949	$15,712
7	$0	$17,112	$0	$248	$95	$17,265
8	$0	$17,112	$0	$248	$95	$17,265
9	$0	$17,112	$0	$248	$95	$17,265
10	$0	$17,112	$0	$248	$95	$17,265
11	$0	$17,112	$0	$248	$95	$17,265
12	$0	$17,112	$0	$248	$95	$17,265
13	$0	$17,112	$0	$248	$95	$17,265
14	$0	$17,112	$0	$248	$95	$17,265
15	$0	$17,112	$0	$248	$95	$17,265
16	$0	$17,112	$0	$248	$95	$17,265
17	$0	$17,112	$0	$248	$95	$17,265
18	$0	$17,112	$0	$248	$95	$17,265
19	$0	$17,112	$0	$248	$95	$17,265
20	$0	$17,112	$0	$248	$95	$17,265
21	$0	$17,112	$0	$248	$95	$17,265
22	$0	$17,112	$0	$248	$95	$17,265
23	$0	$17,112	$0	$248	$95	$17,265
24	$0	$17,112	$0	$248	$95	$17,265
25	$0	$17,112	$0	$248	$95	$17,265
26	$0	$17,112	$0	$248	$95	$17,265
27	$0	$17,112	$0	$248	$95	$17,265
28	$0	$17,112	$0	$248	$95	$17,265
29	$0	$17,112	$0	$248	$95	$17,265
30	$0	$17,112	$0	$248	$95	$17,265
31	$0	$17,112	$0	$248	$95	$17,265
32	$0	$17,112	$0	$248	$95	$17,265
33	$0	$17,112	$0	$248	$95	$17,265
34	$0	$17,112	$0	$248	$95	$17,265
35	$0	$17,112	$0	$248	$95	$17,265
36	$0	$17,112	$0	$248	$95	$17,265
37	$0	$17,112	$0	$248	$95	$17,265

38	$0	$17,112	$0	$248	$95	$17,265
39	$0	$17,112	$0	$248	$95	$17,265
40	$0	$17,112	$0	$248	$95	$17,265
41	$0	$17,112	$0	$248	$95	$17,265
42	$0	$17,112	$0	$248	$95	$17,265
43	$0	$17,112	$0	$248	$95	$17,265
44	$0	$17,112	$0	$248	$95	$17,265
45	$0	$17,112	$0	$248	$95	$17,265
46	$0	$17,112	$0	$248	$95	$17,265
47	$0	$17,112	$0	$248	$95	$17,265
48	$0	$17,112	$0	$248	$95	$17,265
49	$0	$17,112	$0	$248	$95	$17,265
50	$0	$17,112	$0	$248	$95	$17,265
51	$0	$17,112	$0	$248	$95	$17,265
52	$0	$17,112	$0	$248	$95	$17,265
53	$0	$17,112	$0	$248	$95	$17,265
54	$0	$17,112	$0	$248	$95	$17,265
55	$0	$17,112	$0	$248	$95	$17,265
NPV	$0	$80,636	$152	$1,169	$25,546	$56,411

Table A10: Net Present Value of BH-L1043 for The Bahamas (USD 1,000s): More Moderate Impact on Tourist Arrivals (50% lower than primary results), Lower Effectiveness of Storm Damage Reduction (USD 90 million)**,** and Excluding Local Economic Benefits (Junkanoo Beach Enhancements, Marine Protected Area, Mangrove Restoration)

Period	Ben(T)	Ben(D)	Ben(B)	Ben(M)	Costs	Net Benefits
1	$0	$0	$0	$0	$6,305	-$6,305
2	$0	$0	$0	$0	$5,675	-$5,675
3	$0	$0	$0	$0	$9,890	-$9,890
4	$0	$0	$0	$0	$9,137	-$9,137
5	$0	$0	$0	$0	$2,044	-$2,044
6	$1,778	$13,101	$0	$0	$1,949	$12,930
7	$2,217	$13,101	$0	$0	$95	$15,224
8	$2,656	$13,101	$0	$0	$95	$15,663
9	$3,096	$13,101	$0	$0	$95	$16,102
10	$3,535	$13,101	$0	$0	$95	$16,541
11	$3,973	$13,101	$0	$0	$95	$16,980
12	$4,412	$13,101	$0	$0	$95	$17,418
13	$4,851	$13,101	$0	$0	$95	$17,857
14	$5,289	$13,101	$0	$0	$95	$18,296
15	$5,728	$13,101	$0	$0	$95	$18,734
16	$6,167	$13,101	$0	$0	$95	$19,173
17	$6,606	$13,101	$0	$0	$95	$19,612
18	$7,044	$13,101	$0	$0	$95	$20,051
19	$7,483	$13,101	$0	$0	$95	$20,489
20	$7,922	$13,101	$0	$0	$95	$20,928
21	$8,360	$13,101	$0	$0	$95	$21,367
22	$8,799	$13,101	$0	$0	$95	$21,805
23	$9,238	$13,101	$0	$0	$95	$22,244
24	$9,676	$13,101	$0	$0	$95	$22,683
25	$10,115	$13,101	$0	$0	$95	$23,121
26	$10,554	$13,101	$0	$0	$95	$23,560
27	$10,992	$13,101	$0	$0	$95	$23,999
28	$11,431	$13,101	$0	$0	$95	$24,438
29	$11,870	$13,101	$0	$0	$95	$24,876
30	$12,309	$13,101	$0	$0	$95	$25,315
31	$12,747	$13,101	$0	$0	$95	$25,754
32	$13,186	$13,101	$0	$0	$95	$26,192
33	$13,625	$13,101	$0	$0	$95	$26,631
34	$14,063	$13,101	$0	$0	$95	$27,070
35	$14,502	$13,101	$0	$0	$95	$27,508

36	$14,941	$13,101	$0	$0	$95	$27,947
37	$15,379	$13,101	$0	$0	$95	$28,386
38	$15,818	$13,101	$0	$0	$95	$28,825
39	$16,257	$13,101	$0	$0	$95	$29,263
40	$16,696	$13,101	$0	$0	$95	$29,702
41	$17,134	$13,101	$0	$0	$95	$30,141
42	$17,573	$13,101	$0	$0	$95	$30,579
43	$18,011	$13,101	$0	$0	$95	$31,018
44	$18,450	$13,101	$0	$0	$95	$31,456
45	$18,888	$13,101	$0	$0	$95	$31,894
46	$19,326	$13,101	$0	$0	$95	$32,333
47	$19,765	$13,101	$0	$0	$95	$32,771
48	$20,203	$13,101	$0	$0	$95	$33,209
49	$20,641	$13,101	$0	$0	$95	$33,648
50	$21,080	$13,101	$0	$0	$95	$34,086
51	$21,518	$13,101	$0	$0	$95	$34,524
52	$21,956	$13,101	$0	$0	$95	$34,963
53	$22,395	$13,101	$0	$0	$95	$35,401
54	$22,833	$13,101	$0	$0	$95	$35,839
55	$23,271	$13,101	$0	$0	$95	$36,278
NPV	$25,253	$61,736	$0	$0	$25,546	$61,443