APPENDIX G

ECONOMICS

Potential Scope of Economic Costs and Benefits Associated with Alternative Actions Related to the Figure Eight Island Inlet and Shoreline Management Project

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1.0 Introduction

Alternative actions for the Figure Eight Island Inlet and Shoreline Management Project each create a unique array of costs and benefits. These include market costs, such as any construction or engineering costs associated with active mitigation, potential economic losses associated with upland damage to coastal real estate and infrastructure, as well as non-market costs and benefits, such as those associated with effects on the natural environment, aesthetic appeal, habitats and species.

The purpose of this section is to describe the potential scope of these values for each of the six alternative actions under consideration for the Figure Eight Island Inlet and Shoreline Management Project. We provide monetary measures for values that are readily identifiable and measurable based on existing data, such as construction and maintenance costs for the alternatives that involve nourishment or a terminal groin as well as assessed tax values of at-risk properties. These values should not be considered definitive and should not be used as the sole basis for choice or ranking of alternatives.

It is important to note that this section should not be considered a formal cost-benefit analysis. We do not attempt to monetize all aspects of the range of non-market costs and benefits that are associated with alternative actions such as those associated with aesthetics, opportunities for recreation or services provided by the natural environment. Based on results in the literature, these values are known to be substantial. However, in the absence of formal valuation efforts, their precise magnitude remains unknown. As such, the select monetary values that are provided herein should not be considered to be a representation of the true economic worth associated with the alternatives. Given the lack of formal valuation and the inherent uncertainties regarding specific performance of alternatives over a 30-year project horizon, providing an estimate of total costs, total benefits or net gains is not possible. Further, ranking of the alternatives based on their relative economic values is not possible.

In many cases, the benefits associated with alternatives that mitigate the effects of erosion can be considered costs of alternatives that do not mitigate erosion. For example, the benefits of shoreline stabilization via nourishment or hardened structures include maintaining the integrity of the Figure Eight Island shoreline and the associated real estate. These economic values may be partially or wholly sacrificed in the absence of active mitigation. Hence, the costs of no action or retreat should account for declinations in the economic value of associated real estate due to lost shoreline integrity as well as losses associated with effects on use and non-use values associated with recreation and tourism on Figure Eight Island. It is important to note that in the case of Figure Eight Island, it is likely that inaction or retreat may have the greatest effect on environmental conditions. That is, strategies that do not protect the shoreline from continued erosion are not expected to maintain environmental conditions in the study area.

Cost and benefit values described below include explicit and implicit values. Affected stakeholders include property owners, business owners, visitors, taxpayers of North Carolina and individuals who value coastal species and ecosystems and the existence of the current character of Figure Eight Island. The incidence of costs and benefits across these stakeholder groups will vary across the alternatives. As noted in Landry and Hindsley (2011), stakeholders can be expected to have different perceptions of the effectiveness of natural and man-made storm and erosion buffers and variable evaluations of beach characteristics in terms of aesthetics, recreation, and leisure. Hence, the alternative actions can be expected to convey net economic gains to some user groups and impose economic losses on others.

Explicit costs associated with alternative actions include physical construction costs associated with shoreline nourishment activities, construction of a terminal groin, and costs associated with destruction and/or removal of existing properties and infrastructure. Implicit costs include losses to the economic value to coastal property and public infrastructure associated with degradation of the character of the shoreline and proximate coastal and marine ecosystems, as well as reductions in use and non-use values associated with recreation, aesthetics and changes in the quantity and quality of habitats and species. These estimates are based on modeling of shoreline change under project alternatives provided by Tom Jarrett of Coastal Planning and Engineering, Inc.

Construction and maintenance costs detailed herein are those incurred by Figure Eight Island Home Owners Association and are based on estimates provided by Tom Jarrett of Coastal

Planning and Engineering, Inc. as part of an engineering analysis of project alternatives (Appendix B). These estimates were constructed using a 30-year time horizon beginning in year 2015. Discounting is applied to current dollar value expenditures in order to provide cost estimates in present value terms. The discount rate used in analyzing public projects should reflect the opportunity cost of public funds. Lower discount rates result in higher estimated present values for future expenditures, and cause alternatives that involve higher future expenses to appear less favorable. Likewise, higher discount rates result in lower present values for future expenditures. At the time of this writing, long-term rates on U.S. Treasury Bills were approximately 2.5 percent. Because the public is generally risk-averse with regard to spending on projects with uncertain outcomes, it can be argued that higher discount rates are more appropriate. For this analysis, the present value of future expenditures associated with the alternatives are examined using discount rates of 2.5 percent, 4.125 percent and 6 percent.

Applying a 4.125 percent discount rate is standard practice for civil works projects by the USACE; hence by using rates above and below 4.125 we provide sensitivity analysis for this important parameter. Shoreline management alternatives that include the construction of a terminal groin involve large initial costs associated with construction, but considerably lower costs associated with future beach nourishment. This future cost saving is due to smaller quantities of sand that would be placed during each episode, a decreased frequency of nourishment episodes or both. Because these alternatives involve larger up-front costs and lower future costs, they will appear more favorable when lower discount rates are employed. For the range of estimates for the present value of future expenditures associated with the project alternatives higher estimates correspond to a 2 percent discount rate and lower estimates correspond to a 6 percent discount rate.

In the case of alternatives that are projected to provide some level of shoreline stabilization relative to the status quo (i.e. Alternative Nos. 3, 4, 5C and 5D), economic benefits include the maintenance/protection or enhancement of coastal real estate, which may include values associated with residential, commercial and infrastructure assets. These values can also be interpreted as representing potential costs of Alternative 2, which involves a projection of upland losses to erosion.

To understand the relative scope of potential impacts on coastal property, we use most recent (2012) assessed tax values for at-risk properties. It is important to note that the current assessed tax values may not be reflective of current market values. To the extent that risk of future erosion is known to market participants, market values could be considerably lower than assessed tax value. Given the dynamic nature of the shoreline in recent years and uncertainty regarding the potential for mitigating action, it seems logical that current market values for at-risk properties on Figure Eight Island, especially those protected by sandbag revetments, will have capitalized a sense of future risk. Whether or not such risks are incorporated into value assessments is unknown. More generally, changes in the real estate market that have transpired since the most recent assessment may affect market values. These changes include general market trends as well as modifications to insurance rates specific to properties in the coastal zone. While the general real estate market trend since 2012 seems upward, such enhancements are not homogenous across locations and may not be conferred upon properties at risk to erosion. Recent trends in insurance rates as part of the N.C. Beach Plan have been generally unfavorable for properties in the coastal zone. Expected or realized additional costs may decrease demand for coastal properties offsetting some of the general market improvements experienced in recent months. Moreover, it can be argued that the appropriate values to be used in understanding the possible effects of alternative shoreline management actions are the values that exist at the time of the associated environmental change. As noted above, and with the important exception of acute change due to damage from storms, anticipated changes in coastal environments are likely to be capitalized into the market value of real estate far in advance of actual change (Landry and Hindsley, 2011; Landry, 2011).

In the absence of contemporaneous sales data for at risk properties and without a formal hedonic pricing analysis for the properties in the subject area, we lack an appropriate means of determining the true market value of at-risk real estate or the changes in value that might result from changes to the shoreline. The assessed tax values of at-risk properties should therefore be used only as a means of appreciating the relative magnitude of the management alternatives, rather than the absolute value that is at risk. Even in terms of relative magnitudes, these values should be used with caution. As noted in Landry and Hindsley (2011), if active mitigation creates an expectation of improved conditions over time, value estimates should be interpreted as lower bounds on true value. If instead, conditions are expected to degrade, value estimates should be interpreted as upper bounds on true value.

It should also be noted that impending property loss due to erosion may result in some structures being demolished and some being moved further inland. We do not attempt to monetize the value of the transition losses associated with destruction or location of property, nor do we attempt to monetize the gains in value that will be realized by currently unimproved parcels that are subsequently improved when structures are relocated. While it is important to acknowledge that such effects are very likely to transpire in the case of some alternatives, forecasting the magnitude, timing and location of such transitions is beyond the scope of this report.

The direct cost to demolish a structure, as determined by CPE, was computed as \$12/square foot while relocation cost were computed at \$50/square foot plus \$50,000 for new foundation piles, utilities, driveways, permits, etc.

To the extent that the alternatives also induce long term enhancements to beach width, volume or quality, there will be additional benefits associated with tourism, recreation and aesthetics conferred upon residents and visitors of Figure Eight Island. Stabilized shorelines may also convey additional use and non-use values associated with protecting coastal habitats and species. Such values may be conferred upon the public at large, regardless of past or present experience with the study site. Existence values, option values and bequest values (see Sub-Appendix A for discussion) may also accrue to past and potential visitors to Figure Eight Island who derive benefits from maintenance of favorable conditions at the site. Actions that involve the construction of a terminal groin (i.e. Alternatives 5C and 5D) may create economic benefits in terms of enhanced recreational fishing opportunities, though these gains may be more than offset by diminished aesthetic appeal and/or any unforeseen environmental effects produced by permanent physical alteration of the shoreline. Alternatives that maintain the existing sand bag revetments (i.e. Alternatives 1, 3, and 4) are also likely to involve loss of aesthetic appeal as well as diminished recreation value due to the physical constraints that the structures impose on beach activities, especially at high tide. However, there is a possibility the sandbags could be ordered removed by NC DCM. If implementation of Alternative 3 or 4 results in semi-permanent improvement of the shoreline, DCM could order their removal.

Alternative 2 (retreat) may produce economic benefits to a set of individuals who place economic value on unimpeded ecosystem function and change. These values are probably best described as non-use values, though some use value losses may also transpire, and can be expected to accrue to some portion of the general public. A critical assumption with regard to these values is that baseline environmental conditions are naturally occurring, which may not be the case for Figure Eight Island given the lengthy history of shoreline protection projects. Without formal valuation studies directed at estimating these values, it is not possible to form conclusions regarding net gains or losses in economic value.

2.0 Costs and Benefits of Alternative Actions

2.1 No Action (Alternative 1)

Under the "No Action" alternative, the Figure Eight Island HOA and individual home owners would continue to respond to erosion threats through the creation or repair of damaged dunes via beach scraping and/or bulldozing, intermittent sand placement, and maintenance and/or placement of sandbag revetments. The resultant condition at the north end of Figure Eight Island can be characterized as a narrow and unstable beach profile prone to continued shoreline recession and acute episodic sand losses. There are currently 20 properties in this area that are protected by sandbag revetments, 19 of which are improved. The home that was built on the remaining property (13 Comber Rd.) was removed in 2010. The most recent (2012) assessed tax values for the improved properties (land and structure only) range from $520,300 to $1.53 million, with an average value of approximately $744,000. The one unimproved parcel is currently valued for tax purposes at $50,100. The total assessed value of all properties currently protected by sandbags is roughly $14.185 million. Detailed information on these properties is shown in Table 1. Because the sandbag revetments have been in place for over 10 years (Cleary & Jackson, 2004), it seems reasonable to assume that the current tax values for these properties includes a substantial amount of capitalized risk, though the extent to which assessed values differ from market values with regard to perceived or anticipated risk it is not known.

To model the potential conditions and impacts of this alternative, Delft3D modeling results from Alternative 2 were adjusted for beach nourishment activities at the northern end of Figure Eight Island. Shorelines of Figure Eight Island and Hutaff Island are expected to behave as in the past, which involves losses of up to 16.8 feet per year at the northern end of Figure Eight fronting the current sandbag revetments, and erratic movement with a tendency toward accretion at the southern portion of Hutaff Island.

2.1.1 Costs

The timing of when sandbags would be installed was based on when the erosion scarp would come within 20 feet of the front of the structure. Demolishing or removing the structure was assumed to occur 2 years after the installation of the sandbags. Given the current condition on the north end of Figure Eight Island in which the bar channel of Rich Inlet has assumed an alignment toward Figure Eight resulting in some shoreline accretion, the minimum amount of time that would elapse before some action would be taken was assumed to be 5 years.

Under Alternative 1, Delft3D modeling results suggest that 11 homes currently protected by sandbag revetments would have to be demolished or relocated within 5 years. Another home is expected to be impacted in such a manner within 8 years. The average 2012 assessed value for these homes is approximately $590,900 and their combined assessed value is approximately $7.68 million. The remaining 7 homes currently protected by sandbags would have to be demolished or relocated within 10 to 17 years.[1] The average 2012 assessed value for these homes is approximately $.93 million and their combined assessed value is approximately $6.50 million. Assuming the main channel of Rich Inlet will assume an alignment back toward Hutaff Island within the next 5 years, this alternative is expected to affect the market value of several other properties near the north end of Figure Eight Island. Up to 5 improved parcels are projected to be threatened within 11 years (numbers 4, 5, 7, 8 and 9 Surf Court) to such an extent that the installation of sandbag revetments will be required. An additional 16 improved parcels projected to be similarly threatened within 12 to 26 years. With regard to the properties that are expected to be threatened within 11 years, most recent (2012) assessed tax values for these properties range from approximately $1.43 million to $2.82 million with an average assessed value of $219 million. The total assessed tax value of these four properties is approximately $10.97 million. With regard to the properties that are expected to be threatened to a condition requiring sandbag protection within 12 to 26 years, most recent (2012) assessed tax values for these properties range from approximately $1.41 million to $3.23 million with an average assessed value of $1.96 million. The total assessed tax value of these four properties is approximately $31.29 million. Details of these properties are shown in Table 2. It is important to note that the actual timing prior to demolition or removal may be shorter for these properties, as 5 years was the minimum value permitted for this parameter in the modeling exercise given the current condition of the inlet and shoreline on the north end of Figure Eight Island.

We do not attempt to estimate the monetary value of the transition costs associated with the relocation or demolition and removal of existing properties. While it may seem reasonable to assume that the timing of such transition costs for each structure will be coincident with imminent acute loss to erosion, the actual timing of transition will be determined by individual property owners and may occur well in advance of impending losses. Likewise, some property owners may relocate threatened structures to other locations on Figure Eight Island while others will opt for demolition. In either case, these costs will be nontrivial, given the size and value of the properties in question and the associated difficulties with either demolition or relocation. In addition to physical costs associated with the removal and transport of materials, costs will also be associated with loss of aesthetic appeal due to noise, equipment and congestion during the transition process. These additional costs will temporarily impact specific locations, largely concentrated around the northern segment of Figure Eight Island, as individual structures are removed. Generally, these effects can be expected to persist for the duration of the landward shift of the shoreline.

As the Figure Eight Island shoreline recedes landward, a portion of the market value of threatened properties can be expected to transfer to properties currently located further inland as newly beachfront properties realize improvements in market value. However, to the extent that this alternative conveys a sense of future erosion risk to market participants, this value transfer may be limited to temporary proximity value rather than long term improvements in market value. Even with partial or complete relocation of all physical property, the loss or degradation of these parcels can be expected to have an effect on the tax base of the Island, *all else equal*.

Construction and maintenance costs associated with sand placement of this alternative are expected to total $29.04 million over a 30-year planning horizon. Assuming continued nourishment of the area north of Bridge Road with approximately 300,000 cubic yards every 3 years, the discounted present values of these expenditures are approximately $14.16 million under a 6 percent discount rate, $17.03 million using a 4.125 percent discount rate and $20.61 million using a 2.5 percent discount rate.

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The installation of sandbag revetments associated with future protection needs under this alternative will involve costs of approximately $41,500 per home or roughly $461 per linear foot of protected shoreline (Yogi Harper, owner, Erosion Control Specialist of NC Inc. personal communication, 2013). Given the nature and timing of the anticipated need for protection via sandbag revetments and assuming that sandbags are not installed until the associated coastal assets are threatened, over the 30-year planning period the discounted present value of future costs associated with the installation of sandbag revetments is approximately $1.05 million assuming a 6 percent discount rate, approximately $1.28 million using a 4.125 percent discount rate and $1.60 million using a 2.5 percent discount rate. Details of anticipated sandbag revetment installation are shown in Table 3.

Assuming that sandbag revetment permits expire after 5 years, the anticipated landward shift of the shoreline associated with Alternative 1 may also result in loss of existing subgrade infrastructure, including roadways, water lines, sewer lines, fire suppression, power and communications. Modeling of the affected shorelines suggests that approximately 4,275 linear feet of road, water, sewer and power lines (including portions of Comber Road, Inlet Hook Road, Surf Court and Beach Road North) will be lost over the 30 year planning period. It is reasonable to assume that a portion of the economic value associated with this infrastructure has been capitalized into the value of the properties that rely on it for support. As such, providing a separate estimate of the value of at risk infrastructure independent of the value of adjacent properties creates the possibility for double counting. Some of the infrastructure value, however, accrues to the public that uses the roads to gain access to beaches and other properties. Moreover, the at-risk infrastructure that runs below Beach Road North provides utility service that is distributed throughout other areas of the Island. Hence, relocation of the physical capital that provides these service flows may be necessary in the case of loss as predicted under this alternative. A lower bound[2] on the value of this infrastructure can be provided using the

[2] We consider such estimates a lower bound on value. First, as noted in Sub-Appendix A, the cost associated with new construction will be lower than the discounted present value of the benefits flowing from intact infrastructure over its lifetime. Second, additional costs associated with the physical removed and off-site transport of the materials that comprise the at-risk infrastructure will create additional transition costs.

replacement cost method.[3] We follow the estimation used by NCCRC (2010), and value at risk infrastructure using construction costs of $568 per foot for roads, $55 per foot for water lines and $150 per foot for sewer lines, assuming that the length of affected water and sewer lines is coincident with affected length of road.[4] Applying these values to the 4,275 linear feet of anticipated infrastructure impact under Alternative 1, and accounting for the expecting timing of impact, the discounted present value of the expected infrastructure replacement cost ranges from approximately $1.48 million assuming a 6 percent discount rate to $2.32 million assuming a 2.5 percent discount rate. This estimate does not include infrastructure associated with power and communications and does not include costs associated with land acquisition for ROW. Details of anticipated costs associated with infrastructure loss are shown in Table 4.

Continued near term losses of beach volume near the northern end of Figure Eight Island and the preventative actions taken by homeowners and the Figure Eight Island HOA will continue to have an impact on aesthetics and recreation opportunities in the area. Given that these conditions have existed for many years, the total welfare derived from recreationists under Alternative 1 might be described as status quo conditions. It is important to note that these conditions can be characterized as limited and degrading, especially during high tides, with the exception of time periods immediately following nourishment events, when conditions are relatively stable and improved. The "status quo" situation is therefore not a steady state condition, which hinders straightforward comparison. Additional potential loss of beach width and/or volume in the case of progressive sandbag revetment failure or expiration of existing permits complicates matters further; as such events would induce additional losses of recreation and aesthetic values.

[3] As discussed in Sub-Appendix B, using the replacement cost method to estimate the value of assets that have no prospect for being replaced is counterintuitive. The economic damages associated with losing existing assets that have no potential for recovery are probably best characterized as unrecoverable sunk costs. Estimating the extent to which new infrastructure will be constructed to replace damaged roads and subgrade utilities on Figure Eight Island is beyond the scope of this report. As such, the values presented here should only be used as a proxy for the potential scope of damage.

[4] The replacement cost estimate for roads is based North Carolina Department of Transportation Construction Cost Estimates for 2008. Water and sewer construction costs are based on estimates from the Cape Fear Public Utility Authority and Wrightsville Beach public works department (NCCRC, 2011). It is not known whether acquisition, engineering, permitting costs are accounted for in the NCCRC estimation.

In terms of environmental values, active mitigation measures notwithstanding, Alternative 1 is expected to have continued (status quo) impacts on dry beach, dunes and interdunal wetland habitats. In addition to a reduction in the storm protection function of dunes, several federally and state listed species that utilize these habitats may be affected, including sea turtles and seabeach amaranth. Understanding the economic value of these changes is beyond the scope of this report, but it should be noted that use and non-use values associated with species preservation have been shown to be large, as highlighted in Sub-Appendix A.

2.1.2 Benefits

The benefits of Alternative 1 can be construed as maintenance of the current stock and flow of market and non-market goods and services, subject to multiple caveats noted above.

2.2 Retreat (Alternative 2)

The “Retreat” alternative involves no action by the Figure Eight HOA or individual property owners to slow erosion or pursue a long-term beach nourishment project or inlet channel relocation project. The timing of when property owners would either move or demolish their structures was based on the time the erosion scarp would reach a point 10 feet past the front of the structure or following the removal of existing sandbags. In this regard, existing sandbag revetments would eventually fail or be removed, at which point coastal properties at imminent risk to erosion damage would be demolished or moved to new locations. Under this alternative, shoreline recession is expected to occur at a more rapid pace, with an expected loss of 66,000 cubic yards per year along the 12,500 feet of Figure Eight Island situated between Bridge Road and Rich Inlet based on the 5-year simulation period. Specifically, the volume changes include 18,000 cubic yards/year of accretion between stations F90+00 and 60+00 and a loss of 84,000 cubic yards/year between stations 60+00 and 105+00. Dune habitat losses are expected in the northern segment (See Table 5.2). In contrast to losses of beach volume and width along the northern reaches of Figure Eight Island, the southern portion of Hutaff Island is expected to accrete at a rate of 53,000 cubic yards per year.

2.2.1 Costs

Excluding transition costs associated with relocation of structures and infrastructure (discussed below), construction and maintenance costs associated with this alternative are expected to be negligible, as there will be no active mitigation by the Figure Eight Island HOA or individual homeowners. Near term costs associated with removal of the sandbag revetments are expected to be nominal.

The expected reconfiguration of Figure Eight Island's northern shorefront associated with this alternative involves a shift landward, with upland impacts on existing properties and infrastructure. Specifically, based on Delft3D model simulations and assuming current rates of erosion, twenty-one (21) oceanfront homes (located on Surf Court, Comber Road, and Inlet Hook Road) would have to be demolished or moved within five (5) years. The current (2012) assessed tax values for these properties range from approximately $520,000 to $2.83 million, with an average value of $0.994 million and a total value of approximately $20.88 million.

An additional nine (8) homes (located on Beach Road North immediately south of Surf Court) will be threatened within the next eleven (11) to fifteen (15) years and eight (8) homes (located on Beach Road North) are expected to be threatened within 25 years. The current (2012) assessed tax values for these properties range from approximately $1.41 million to $3.23 million. The average value of these 16 homes is approximately $1.96 million and their combined value is roughly $29.84 million. Details of these properties are shown in Table 2.

As noted in Landry (2011), as the market capitalizes the expectation of continued shoreline erosion into the value of these properties, market values may be driven toward zero. Inland relocation of structures may offset some of these losses but will involve transition costs. Again, it is reasonable to expect that a portion of the lost market value will transfer to properties currently located further inland. However, a strategy of retreat is likely to convey an expectation of risk from future erosion losses to shoreline properties. Newly beachfront properties might reasonably be considered newly at-risk properties. The market capitalization of this additional risk may offset gains in amenity value. While proximity benefits associated with recreation and aesthetics will likely accrue to some property owners in the near term, it seems unlikely that such values will be capitalized into market values due to long term uncertainty and risk of future losses.

As with Alternative 1, we do not attempt to estimate the monetary value of the transition costs associated with the relocation or demolition and removal of existing properties as the timing and nature of the transition will be determined by individual property owners and may occur in advance of imminent loss. In addition to physical transition costs, this alternative can be expected to generate loss of aesthetic appeal due to noise, equipment and congestion during the transition process, which can be expected to persist for the duration of the landward shift of the shoreline.

As with Alternative 1, the landward shift of the Figure Eight Island shoreline associated with Alternative 2 will result in loss of existing Island subgrade infrastructure, including roadways, water lines, sewer lines, fire suppression, power and communications. Modeling of the affected shorelines suggests that approximately 6,105 linear feet of road, water, sewer and power lines will be lost. It is reasonable to assume that a portion of the economic value associated with this infrastructure has been capitalized into the value of the properties that rely on it for support. Some of the infrastructure value, however, accrues to the public that uses the roads to gain access to beaches and other properties. Moreover, the at-risk infrastructure that runs below Beach Road North provides utility service that is distributed throughout other areas of the Island. Hence, relocation of the physical capital that provides these service flows will be necessary in the case of loss as predicted under this alternative. Applying the replacement cost values detailed in the description of losses associated with Alternative 1 above to the anticipated timing of infrastructure impact under Alternative 2 suggests a discounted present value of total replacement costs ranging from approximately $1.91 million using a 6 percent discount rate to $3.11 million using a 2.5 percent discount rate. This estimate does not include infrastructure associated with power and communications and does not include costs associated with land acquisition for ROW. Details of anticipated costs associated with infrastructure loss are shown in Table 5.

As a result of the extent of shoreline recession and deflation associated with this alternative, effects on natural habitats are expected. These include effects on inlet dunes, oceanfront dunes, intertidal flats and dry beach. Existing oceanfront dune habitat in the area from Surf Court north to Rich Inlet is expected to be impacted. Because this area is currently covered by sandbag revetments, change from existing degraded conditions may be considered marginal. It is important to again note that this area of dune habitat is not expected to naturally relocate or regenerate in the near term under this alternative. In addition to delayed regeneration of dune habitat function, the protection service provided by dunes will also be delayed under Alternative 2.

In addition to receding shorelines in the area adjacent to existing properties, Delft3D model simulations indicate that the spit area projecting off the north end of Figure Eight Island into Rich Inlet would be eroded and converted to a submerged sand flat by the end of the 5-year simulation period. This loss of accessible beach area may have an effect on recreation on the northernmost segment of Figure Eight Island.

Market losses expected under this alternative include land loss, capital (structure) loss, proximity loss, and transition loss affecting privately held real estate as well as reduction of the municipal tax base. Non-market losses include the use and non-use values associated with affected species and habitats, non-use value losses to those who hold the existence of Figure Eight Island in high regard, as well as declinations in aesthetic appeal and recreation opportunities to residents and visitors.

2.2.2 Benefits

The retreat alternative can be construed as the alternative where "natural processes" are permitted to continue unimpeded by human activity or intervention. As noted in Judge, Osborne and Smith (1995), some individuals have preference for non-intervention approaches that allow unimpeded erosion to take place. These individuals may derive real economic value from the existence of unfettered coastal ecosystems. As noted above, a critical assumption with regard to these values is that baseline environmental conditions are naturally occurring. This assumption seems unlikely in this case, given the modified conditions of the study area that have resulted from long-term maintenance of the northern section of the Figure Eight shoreline and adjacent channel. Without a thorough (non-market) valuation study directed at understanding the scope and magnitude of these benefits it is difficult to characterize their nature or extent. We do note that in a sample of North Carolina beachgoers, Whitehead et al. (2008) found that a majority of respondents favored beach nourishment as a means of maintaining beach width, and 18 percent felt that beach width should not be altered by people.

Under this alternative, the southern portion of Hutaff Island is predicted to accrete at a rate potentially in excess of 53,000 cubic yards per year. This additional beach volume and width may provide additional recreational benefits to boaters who utilize the area. Because this alternative involves the removal of existing sandbag revetments, improved aesthetic appeal as well as enhanced recreation value may also be generated on Figure Eight Island after transition losses to coastal properties have run their course and the shoreline has returned to a natural state. However, it is unknown whether removal of the aesthetic disamenity and physical constraints associated with the sandbag revetments will be offset by losses associated with reduced beach width.

2.3 Rich Inlet Management with Beach Fill (Alternative 3)

Alternative 3 entails relocation of the main bar (entrance) channel of Rich Inlet from its current location immediately adjacent to the south end of Hutaff Island to a position closer to the north end of Figure Eight Island and perpendicular to the adjacent shorelines. The relocation of the main channel would be accompanied by the creation of two new channels connecting the main ebb channel with Nixon Channel and Green Channel as described in Chapter 3 and shown in Figure 3.2. Material removed for channel relocation and construction would be used to construct a closure dike across the existing ebb channel, provide beach fill along 1,400 feet of the Nixon Channel shoreline on the backside of Figure Eight Island just south of Rich Inlet, and nourish 12,500 feet of ocean shoreline extending from Rich Inlet south to Bridge Road. The purpose of the closure dike would be to concentrate most of the tidal flow through the new channel. This alternative also involves periodic entrance channel dredging and beach nourishment, projected to take place every five years.

Delft3D model simulations of the associated effects over a 5-year period suggest that Over the southern 8,000 feet of the fill (stations F90+00 to 60+00) almost 98% of the initial fill volume remained at the end of the 5-year simulation as losses were shown to be only 2,000 cubic yards/year (Table 5.4). For the area between stations 60+00 and 105+00, losses were shown to be 99,000 cubic yards/year. At the end of the 5-year simulation, 24.5% of the fill remained in this beach segment. Approximately 43% of the fill remained in this area after 4 years but with the migration of the channel back to a position closer to Hutaff Island indicated by the model results between years 4 and 5 of the simulation, erosion of the fill accelerated.

Delft3D model results for this alternative also suggest growth of the sand spit off the north end of Figure Eight Island, toward Rich Inlet. The new bar channel is expected to experience shoaling of up to 60 percent and migrate toward the southwest with notable build-up of the ebb tide delta off the north end of Figure Eight Island within the first four years. The bar channel is expected to migrate back toward Hutaff Island by the fifth year, which suggests that bar channel dredging will be required every five years. As a result of the shifting location of the ebb tide delta, the model indicated that the south end of Hutaff Island would experience a net loss in volume.

Within the first two years of the project, the constructed sand dike is projected to erode and evolve into a sand spit projecting off the south end of Hutaff Island, the majority of which will become sub tidal. Shoaling of the Green Channel connector is expected to be associated with this erosion, but is anticipated to stabilize by the third year. The Nixon Channel connector is also expected to experience shoaling, especially during the first year of the project, with relative stabilization following in subsequent years. Subsequent maintenance of Nixon and Green Channel connectors is not projected to be necessary unless future monitoring surveys find that maintenance is required to restore flow volumes or divert flow from eroding shorelines.

2.3.1 Costs

Alternative No. 3 is expected to involve initial (first year) construction costs totaling \$17.25 million, which includes roughly \$13.19 million associated with channel dredging and beach fill activities \$3.79million associated with dike construction. Channel dredging and beach nourishment activities are expected to involve \$7.705 million in costs every five years, or \$63.50 million over a 30-year planning horizon. The discounted present value of these dredging and beach nourishment costs is approximately \$36.06 million assuming a 6 percent discount rate, \$41.42 million assuming a 4.125 percent discount rate and \$47.93 million using a 2.5% discount rate.

Public recreational values will be affected under this alternative to the extent that the activities associated with channel relocation and maintenance physically impede and diminish the aesthetic appeal of the channel area and southern end of Hutaff Island. These effects can be expected to be temporary, occurring during the period channel maintenance. Recreation opportunities are also expected to be similarly impacted on the northern end of Figure Eight Island. Associated impacts should be expected for approximately two and a half months in year one and for similar durations during dredging and nourishment events every subsequent five years. The net loss of beach volume on the southern end of Hutaff Island is also expected to negatively impact beach recreation by boaters who utilize in the area, though these costs may be offset by improved channel navigation through and around area inlets.

Dredging associated with obtaining sand for nourishment events may result in effects on habitats as well as direct mortality to benthic species at the borrow site. These effects may result in economic losses associated with diminished use and non-use values and may have effects on ecosystem service values in terms of provisioning and regulating services provided by the affected species and habitats.

2.3.2 Benefits

The principle benefit of Alternative 3 is the stabilization of the northern sections of the Figure Eight Island shoreline. Such stabilization is expected to confer benefits in the form of improved property values in the immediate vicinity. Improvements in property values can be expected for properties that would otherwise be imminently threatened. The Figure Eight Island tax base should improve as a result. We do not attempt to monetize the magnitude of these effects.

The reduced frequency of nourishment required under this alternative is expected to result in less frequent environmental disturbance at dredge sites and nourishment sites. Estimating the economic value of associated impacts on commercial and recreational fisheries, ecosystem services or non-use values is beyond the scope of this report. Improved navigation through and around area channels may also confer benefits on commercial and recreational boaters as dredging activities are projected to allow for wider and deeper navigation channels relative to current conditions. These benefits are likely to be most apparent in Nixon and Green Channels after the initial shoaling subsides and the character of these channels is relatively stable and predictable. Improved boating conditions in the entrance channel are likely to be most apparent in years immediately following its maintenance (i.e. years 1, 5, 10, etc.).

2.4 Beach Nourishment without Inlet Management (Alternative 4)

Alternative 4 involves the placement of fill material along the oceanfront and Nixon Channel shorelines. Because this alternative does not include accompanying inlet management measures, other borrow sites will be used as beach fill sources. Due to high rates of projected loss of fill particularly in the area between stations 80+00 and 105+00, the beach fill design for Alternative 4 includes periodic nourishment of 788,000 cubic yards that would occur every 4 years.

Potential borrow sources for this alternative include a previously permitted site in Nixon Channel (with an estimated minimum of 400,000 cubic yards available for initial construction and subsequent periodic nourishment), three sources located between 3 and 4 miles directly offshore of Figure Eight Island and three upland dredged material disposal sites located adjacent to the AIWW behind Figure Eight Island near the confluence of Nixon Channel with the AIWW. The relatively high rate of periodic nourishment required under this alternative would necessitate the continued use of the offshore borrow sites as shoaling of the previously permitted area in Nixon Channel would not satisfy periodic beach nourishment requirements under Alternative 4. The AIWW disposal sites contain substantially less fill material and would be used only for periodic nourishment in emergency situations such as following coastal storms. These upland sites could also be used if the volume of material available from the previously permitted area within Nixon Channel is insufficient.

The Alternative 4 beach fill performed better compared to Alternative 3 between F90 and 60, actually gaining 58% more material than was initially placed. However, between stations 60+00 and 105+00, the Alternative 4 fill performed poorly losing essentially all of the fill placed in this segment by the end of year 4 of the simulation. The difference of the performance of the fills between Alternatives 3 and 4 in the area from station 60+00 to 105+00 can be attributed to the changes in the configuration of the ebb tide delta induced by the repositioned channel associated with Alternative 3. In this regard, the model indicated changes in Rich Inlet under Alternative 4 were very similar to the model results for Alternative 2 hence the shoreline responses on both Figure Eight Island south of station 60+00 and on Hutaff Island for Alternative 4 were also similar to Alternative 2.

The simulated performance of the fill between 60+00 and 105+00 mimics what has been observed following 6 pervious beach nourishment attempts on the north end of Figure Eight Island since 1993-94, some of which are documented by Dr. Cleary in Sub-Appendix A of Appendix B. While the 6 previous beach fills were relatively small (less than 300,000 cy) compared to the beach fill volume simulated for Alternative 4, all of the fill material included in these 6 beach fills was lost from the area fronting the sandbag revetments within a matter of months following placement.

Given the loss of all of the fill material between stations 60+00 and 105+00 by the end of year 4, periodic nourishment under Alternative 4 would need to be accomplished every 4 years in order to prevent encroachment into the pre-nourished beach profile.

Because this alternative does not involve modifications to Rich Inlet or the connecting channels, the south end of Hutaff Island is expected to accrete at a rate comparable to existing conditions (i.e. roughly 86,000 cubic yards per year on average).

2.4.1 Costs

Costs associated with this alternative pertain to construction and maintenance of periodic beach nourishment, risk to property owners associated with unstable shorelines, loss of recreation opportunities due to beach erosion and environmental impacts caused by dredging activities at offshore and channel borrow sites.

Alternative 4 is expected to involve initial construction cost of $13.69 million associated with beach nourishment and disposal along Nixon channel and the northern ocean front of sections of Figure Eight Island, $1.0 million for geotechnical investigations and permitting offshore borrow area, and additional costs of approximately $10.94 million associated with nourishment that will be incurred every four years. Total costs are therefore approximately $90.30 million for the 30-year planning horizon. The discounted present value of the total costs associated with this alternative is $47.21 million, $55.92 million and $66.28 million using discount rates of 6 percent, 4.125 percent and 2.5 percent respectively.

A strategy involving nourishment without channel maintenance is likely to convey an expectation of additional future risk of loss from erosion. To the extent that projected future shoreline erosion is anticipated by market participants, the near term market value of properties on the northern segments of Figure Eight Island is likely to be affected. This is especially true for properties north of station 80+00, which are expected to experience reduced beach width and volume within two years after nourishment events. Because erosion of shorelines adjacent to these properties is not expected to be of sufficient magnitude to necessitate destruction or relocation of these homes, it is not anticipated that any of the lost market value will transfer to properties located further inland. Indeed, the lack of a perceived long-term strategy to control erosion on the northern end of Figure Eight Island may confer risk on properties that are not threatened in the short term.

Beyond direct effects to the market value of shoreline real estate, the loss of fill in the years subsequent to nourishment events is also expected to have an impact on recreation opportunities and aesthetics on the northern sections of Figure Eight Island. The sand spit on the north end of Figure Eight Island is expected to disappear and be converted into a submerged sand flat prior to the next scheduled nourishment event. Monetizing the timing and extent of the associated losses in economic value is beyond the scope of this report, and would require appraisal via non-market valuation methods such as the travel cost method and/or hedonics (Sub-Appendix A has more information on these methods as well as estimates of their potential economic value in other locations).

Public recreational values will also be affected under this alternative to the extent that the activities associated with beach nourishment activities physically impede and diminish the aesthetic appeal of the north Figure Eight area and southern end of Hutaff Island. Associated impacts should be expected for approximately two and a half months in year one and for similar durations during dredging and nourishment events every subsequent three years.

In terms of costs associated with impacts on natural habitats, this alternative is expected to affect dry beach, wet beach, dunes and soft bottom habitats. In addition to the potential reduction in the storm protection function of dunes, several federally and state listed species that utilize these habitats may be affected, including sea turtles and seabeach amaranth. The frequency of nourishment events necessitated by this alternative is expected to have additional effects at nourishment borrow sites. These effects are likely to reduce economic values associated with direct and indirect uses as well as non-use values associated with these species and habitats. Dredging associated with obtaining sand for nourishment events may result in habitat effects as well as direct mortality to benthic species at the offshore borrow sites. These effects may result in economic losses associated with diminished use and non-use values and may have effects on ecosystem service values in terms of provisioning and regulating services provided by the affected species and habitats. Understanding the economic value of these changes is beyond the scope of this report, but it should be noted that use and non-use values associated with species preservation have been shown to be large, as highlighted in Sub-Appendix A.

2.4.2 Benefits

The principle benefit of Alternative 4 is the stabilization of the northern sections of the Figure Eight Island shoreline, as well as continued accretion on the southern portion of Hutaff Island. Such stabilization is expected to confer benefits in the form of improved property values in the immediate vicinity. Improvements in property values can be expected for properties that would otherwise be imminently threatened. The Figure Eight Island tax base should improve, however we do not attempt to monetize the magnitude of these effects.

Under this alternative, the southern portion of Hutaff Island is predicted to continue to accrete as under existing conditions. This additional beach volume and width may provide additional recreational benefits to boaters who utilize the area via reduced crowding effects and/or ease of access to Hutaff Island.

2.5 Modified Terminal Groin (more northerly position) with Beach Fill from Maintenance of the Nixon Channel Navigation Channel and Connector Channel (Alternative 5C)

Alternative 5C includes a 1,300-foot long terminal groin, 305 feet of which would extend seaward of the 2007 mean high water shoreline, constructed at the extreme north end of Figure Eight Island. The terminal groin would include a 995-foot shore anchorage section. The purpose of the seaward section of the terminal groin is to stabilize the shoreline immediately south of Rich Inlet by reorienting it to an alignment comparable to the shoreline further south. The purpose of the anchorage section is to protect against flanking of water around the landward "dry" end of the terminal groin. This alternative also involves the construction of a 600 foot wide channel connector between the previously permitted area within Nixon Channel with the inlet gorge, which should serve to concentrate flows away from the eroding portion of the Nixon Channel shoreline. This construction would involve the excavation of 1,077,100 cubic yards of material, including 375,200 cubic yards from the previously permitted area in Nixon Channel and 701,900 cubic yards excavated to construct the connector.

Under this alternative, nourishment of the oceanfront side of Figure Eight Island and the Nixon Channel shorefront would take place every five years, with material derived from maintenance of the previously permitted area in Nixon Channel and the new channel connecting Nixon Channel to the inlet gorge. Assuming maintenance of the previously permitted area in Nixon Channel and the proposed connecting channel every five years, the nourishment requirements would be 495,000 cubic yards, with 465,000 cubic yards for the ocean shoreline and 30,000 cubic yards for the Nixon Channel fill area. It is expected that maintenance of the channels in Nixon Channel will provide sufficient fill to satisfy periodic beach nourishment requirements for this alternative. Indeed, the beach fill design associated with Alternative 5C was based on the optimal utilization of the material removed to construct the new channel connector from the inlet gorge into Nixon Channel, rather than the beach fill volume needed to protect against shoreline erosion.

Analysis of the Delft3D model results for Alternative 5C suggest that the initial beach fill may be excessive, particularly along the segment of the oceanfront shoreline south of station 80+00. Delft3D model five-year simulation results for this alternative also suggest a steady rate of shoaling in the previously permitted area of Nixon Channel. Rapid shoaling of the proposed channel connector is predicted over the first two years, with moderation of the rate of shoaling between years 3 and 4. Simulation results suggest that the Rich Inlet ocean bar channel is expected to migrate toward Hutaff Island. The south end of Hutaff Island is expected to elongate. A portion of the sand spit projecting off the north end of Figure Eight Island is also expected to erode and convert to a submerged sand flat within five years. The northernmost 1,500 feet of the sand fillet south of the terminal groin is expected to experience initial losses and stabilize by the end of year 5. The shoreline area immediately south of the terminal groin is expected to be characterized by a seaward bulge of dry sand beach that is expected to provide a wide and stable protective beach on the northern section of Figure Eight Island.

With regard to individual beach segments, the beach area between F90+00 and 60+00 is expected to accrete and would not require periodic nourishment. Volume losses averaging 93,000 cubic yards per year are indicated between stations 60+00 and 105+00.

2.5.1 Costs

Initial (first year) costs associated with Alternative 5C are expected to total approximately $13.03 million, which includes $9.62 million for channel dredging and nourishment of the ocean and Nixon Channel shorefronts and $3.41 million for construction of the terminal groin. This latter cost estimate includes expenses associated with engineering and design and construction oversight. Additional costs associated with channel maintenance and nourishment activities are expected to be approximately $5.16 million every five years. Maintenance of the terminal groin would average $15,000 per year. Over a 30 year planning horizon, construction and maintenance costs associated with Alternative 5C are expected to total approximately $44.43 million. The discounted present values of these costs are $25.63 million using a 6 percent discount rate, $29.22 million using a 4.125 percent discount rate and $33.58 million using a 2.5 percent discount rate.

4.5 The initial construction of Alternative 5C is expected to take approximately 6 to 6.5 months. Construction of the terminal groin would require about 2 to 3 months, however, removal the material from Nixon Channel and the new channel connector and distributing the material along the Nixon Channel shoreline and the ocean shoreline would require about 4 months. In this regard, construction of portions of the terminal groin could occur concurrently with the dredging operation.

Construction activities are expected to take place on existing dry sand beaches and near shore waters for the former of these two periods. During construction of the structure, reduced recreation value and aesthetic appeal on the northern segments of Figure Eight Island is anticipated due to the presence of construction equipment and associated noise and disruption. To the extent that the terminal structure itself may be viewed as aesthetically lacking, properties with views of the associated area may have reduced amenity value. In the case of Figure Eight Island, it seems logical that an aesthetically lacking but stable shoreline will be seen as preferable relative to an unstable shoreline. Further, to the extent that the structure serves to attract recreationists (i.e. fishers) or inhibits movement along the shoreline, property owners in the vicinity may suffer economic losses due to inconvenience, crowding and reduced aesthetic appeal. Shoreward-facing visual impacts should also be anticipated.

Construction of the terminal groin and accompanying nourishment has the potential to create short-term and long-term impacts on the natural environment, including effects caused by dredging, sediment transfer, physical contact, physical barriers and placement of material (NCCRC, 2010). Negative effects are to be expected for some species and habitats, while other species and habitats may be promoted or restored. Negative impacts will include those induced by volumetric losses to beaches north of the structure and benthic habitat losses in the footprint of the structure and from the introduction of rocky bottom material (NCCRC, 2010). Disturbance to the nesting habitat of sea turtles may result during construction of the groin. Groin Installation is also expected to temporarily influence the behavior of foraging birds, including federally and state-listed species. Dredging associated with obtaining sand for nourishment events may result in habitat effects as well as direct mortality to benthic species at the borrow sites. These effects may result in economic losses associated with diminished use and non-use values as well as ecosystem service values.

The use of a hardened structure to mitigate erosion will confer economic losses on the segment of the population that values unfettered ecosystem function. Even if harmful effects on proximate or adjacent coastlines are never realized, it is safe to conclude that some people may remain opposed to the use of hardened structures for shoreline erosion control. In the case of the proposed terminal groin on Figure Eight Island, such sentiments may be partially mitigated by the understanding that the projected need to engage in beach nourishment will be reduced, resulting in fewer of the environmental consequences associated with dredging and sand placement in general.

With regard to potential effects on proximate shorelines, it is important to note that while such effects are suggested as possible by NCCRC (2010), their analysis of terminal groins in North Carolina found that shorelines on the side of the inlet opposite a terminal groin did not display a clear trend (i.e. mixed accretion and erosion) after construction of the terminal groin. Shorelines on the structure side of the inlet were found to be generally accreting. Delft3D model results do not support the notion that the adjacent Figure Eight or Hutaff Island shorelines would be negatively impacted in the case of the proposed Figure Eight Island terminal groin. Model results indicate that reorienting and stabilizing the shoreline on the north end of the island with the proposed terminal groin would reduce erosion rates south of station 60+00 to Bridge Road obviating the need for beach nourishment for this area in the near future. Model results also indicate that the south end of Hutaff Island could experience some erosion under Alternative 5C.

In the event of unanticipated negative impacts to the coastal and marine environment, removal of the groin structure may be necessary. Initial estimates for the physical costs associated with groin removal are $2.0 million. In this event, additional costs will include reduced recreation, diminished aesthetic appeal and habitat disturbance during the removal process. It should be noted that 100 percent removal of the proposed rock structure may not be feasible given the nature of the marine environment and substrate (NCCRC, 2010).

2.5.2 Benefits

As noted in NCCRC (2010) the use of a terminal groin in concert with a shoreline protection plan may provide a host of benefits, including long-term infrastructure protection, enhanced beach width and volume, and enhanced recreation opportunities for the public. The principle benefit associated with Alternative 5C is the anticipated stability and reduced erosion potential along the ocean and Nixon Channel shorelines located on the northern sections of Figure Eight Island.

To the extent that the public views the terminal structure as reducing the risk of future erosion, this added stability should serve to enhance property values along these stretches of Figure Eight Island. We do not attempt to estimate the magnitude of these benefits, but based on the associated literature it is reasonable to expect that properties as far as 300 meters inland from the shoreline will realize improvements in market value. Associated benefits are likely to include increased rental revenues (when applicable) and higher municipal tax revenues.

As noted in Parsons and Powell (2001), active mitigation efforts such as beach armoring may also serve to encourage additional use and/or development. Such additional development can reasonably be anticipated in the case of the 93 undeveloped residential lots on the island, especially the 31 lots that are oceanfront. Provided that such development does not compromise the integrity and value of the adjacent beaches, it is expected to generate additional economic impacts in the form of increased municipal tax revenues as well as temporary construction employment and spending.

The terminal groin may create enhanced recreation values as a result of (predicted) gains in beach width and stability on the northern stretches of Figure Eight Island as well as the creation of rocky bottom area that may increase species diversity and enhance the quality of recreational fishing near the structure. Because dune and beach habitats in the project area will not be subject to loss from erosion, indirect and non-use values may also be created, enhanced or preserved. In particular, the more stable dry beach habitat southward of the groin would be expected to create conditions considered more favorable for sea turtle nesting (footprint of the structure notwithstanding). It is important to note that the effects on the proposed terminal groin on the approach of nesting female turtles or the egress (or predation) of hatchlings are unknown at this time.

2.6 Terminal Groin at a More Northerly Location with Beach Fill from the Previously Permitted Area in Nixon Channel and Other Sources (Alternative 5D)

Alternative 5D also includes the same beach fill along the Nixon Channel as Alternative 5C but would provide a much smaller beach fill along the ocean shoreline. In this regard, the ocean shoreline beach fill for Alternative 5D would begin at the terminal groin and extend south to station 60+00, effectively filling the area generally referred to as the accretion fillet. Based on the modeled shoreline behavior for Alternative 5C as well as the fill performance associated with Alternatives 3 and 4, no initial beach fill would be needed south of station 60+00 to Bridge Road. However, this area would be included in the shoreline monitoring program and could be nourished in the future should conditions warrant.

Based on the results of the Delft3D simulation of Alternative 5D, between Years 4 and 5 of the simulation, essentially all of the fill out to the depth of closure (-24 feet NAVD) would be lost and would need to be nourished. A closer inspection of the fill performance, however, found 27.5% of the fill placed above the -6-foot NAVD contour remained on the beach after 5 years. That is, the terminal groin appeared to be effective in retaining the fill placed on the upper portions of the beach profile. The fill retained above -6 feet NAVD would continue to prevent encroachment into the pre-nourished upland areas in this segment. Under this alternative it is expected that the most of the sand spit on the north end of Figure Eight Island would be converted to a submerged sand flat within 5 years. The southern portion of Hutaff Island is expected to accrete in a manner similar to Alternative 2.

2.6.1 Costs

Initial (first year) costs associated with Alternative 5D are expected to total approximately $7.44 million, which includes approximately $2.88 million for channel dredging and nourishment of the ocean and Nixon Channel shorefronts and $4.56 million for construction of the terminal groin. This latter cost estimate includes expenses associated with engineering and design and construction oversight. Additional costs associated with channel maintenance and nourishment activities are expected to be approximately $2.99 million every five years. Over a

30 year planning horizon, construction and maintenance costs associated with Alternative 5D are expected to total approximately $26.07 million. The discounted present values of these costs are $14.73 million using a 6 percent discount rate, $16.80 million using a 4.125 percent discount rate and $19.33 million using a 2.5 percent discount rate.

The construction associated with Alternative 5D is expected to take approximately 4 to 5 months, with 2 months required for construction of the shore anchorage section and an additional 4 months for the construction of the rubblemound section. Reduced recreation value and aesthetic appeal is anticipated on the northern segments of Figure Eight Island during this period. Properties with views of the associated area may have reduced amenity value relative to that which would exist with a natural and stable shoreline to the extent that the terminal structure itself may be viewed as aesthetically lacking. In the case of Figure Eight Island, it seems logical that an aesthetically lacking but stable shoreline will be seen as highly preferable relative to status quo conditions. Crowding around the structure associated with recreational fishing may impose economic costs on property owners in the vicinity. Shoreward-facing visual impacts should also be anticipated.

Environmental impacts of this alternative are expected to include those caused by dredging, sediment transfer, physical contact, physical barriers and placement of material (NCCRC, 2010). Negative effects are to be expected for some species and habitats, while other species and habitats may be promoted or restored. Impacts will include those induced by volumetric losses to beaches north of the structure and benthic habitat losses in the footprint of the structure and from the introduction of rocky bottom material (NCCRC, 2010). Disturbance to the nesting habitat of sea turtles may result during construction of the groin. Groin installation is also expected to temporarily influence the behavior of foraging birds, including federally and state-listed species. Dredging associated with obtaining sand for nourishment events may result in habitat effects as well as direct mortality to benthic species at the borrow site. These effects may result in economic losses associated with diminished use and non-use values.

The use of a hardened structure to mitigate erosion may confer economic losses on the segment of the population that values unfettered ecosystem function. Even if harmful effects on proximate or adjacent coastlines are never realized, it is safe to conclude that some people may remain opposed to the use of hardened structures for shoreline erosion control. In the case of the proposed terminal groin on Figure Eight Island, such sentiments may be partially mitigated by the understanding that the projected need to engage in beach nourishment will be reduced, resulting in fewer of the environmental consequences associated with dredging and sand placement in general.

If unanticipated impacts to the coastal and marine environment necessitate groin removal, physical costs will total approximately $3.2 million. Additional temporary costs due to reduced recreation and aesthetic appeal should also be anticipated.

2.6.2 Benefits

The use of a terminal groin coupled with a shoreline nourishment plan is expected to provide long-term infrastructure protection, enhanced beach width and volume, enhanced recreation opportunities, and increased tax revenues. The principle benefit associated with Alternative 5D is the anticipated stability and reduced erosion potential along the ocean and Nixon Channel shorelines located on the northern sections of Figure Eight Island.

To the extent that the public views the terminal structure as reducing the risk of future erosion, this added stability should serve to enhance property values along these stretches of Figure Eight Island. We do not attempt to estimate the magnitude of these benefits, but based on the associated literature it is reasonable to expect that properties as far as 300 meters inland from the shoreline will realize improvements in market value. Associated benefits are likely to include increased rental revenues (when applicable) and higher municipal tax revenues.

Active mitigation efforts such as beach armoring may also serve to encourage additional use and/or development (Parsons and Powell, 2001). Such additional development can reasonably be anticipated in the case of the 93 undeveloped residential lots on the island, especially the 31 lots that are oceanfront. Provided that such development does not seriously compromise the integrity and value of the adjacent beaches, it is expected to generate additional economic impacts in the form of increased municipal tax revenues as well as temporary construction employment and spending.

The terminal groin may create enhanced recreation values as a result of (indicated) gains in beach width and stability on the northern stretches of Figure Eight Island as well as the creation of rocky bottom area that may increase species diversity and enhance the quality of recreational fishing near the structure. Because dune and beach habitats in the project area will not be subject to loss from erosion, indirect and non-use values may also be created, enhanced or preserved. In particular, the more stable dry beach habitat southward of the groin would be expected to create conditions considered more favorable for sea turtle nesting (footprint of the structure notwithstanding). It is important to note that the effects on the proposed terminal groin on the approach of nesting female turtles or the egress (or predation) of hatchlings are unknown at this time.

3.0 Conclusion

This report has outlined the nature, scope and complexities associated with the costs and benefits of the proposed alternatives for the Figure Eight Island Inlet and Shoreline Management Project. Table 6 below provides a conceptual framework for understanding the scope of the costs and benefits of the alternatives and a general assessment of their relative magnitudes.

Each alternative action creates a unique set of costs and benefits. Consideration of these values conveys an obvious sense that no matter which alternative is chosen, tradeoffs are unavoidable. Complicating the analysis of the available alternatives is the fact that many important outcomes are uncertain and inherently unpredictable.

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Table 1: Properties currently protected by sandbag revetments

Address	station	2012 assessed value	stories	square ft
3 Comber Road	88+20	$582,000	2.0	3635
4 Comber Road	89+10	$690,100	2.0	3090
9 Comber Road	80+00	$587,100	2.0	2758
10 Comber Road	81+00	$682,700	2.0	3548
11 Comber Road	81+90	$738,300	2.0	3336
12 Comber Road	82+80	$676,500	1.7	3234
13 Comber Road	83+70	$50,100	2.0	5379
14 Comber Road	84+60	$655,500	2.0	3260
15 Comber Road	85+50	$563,500	2.0	2848
16 Comber Road	86+40	$645,500	3.0	2638
17 Comber Road	87+30	$520,300	2.0	2432
5 Inlet Hook Rd	90+00	$700,900	2.0	3156
6 Inlet Hook Rd	91+00	$709,000	2.0	3635
7 Inlet Hook Rd	92+00	$718,800	2.0	2816
8 Inlet Hook Rd	93+00	$733,400	2.0	2820
9 Inlet Hook Rd	94+00	$1,291,100	2.2	3761
5 Surf Court	76+40	$707,500	3.0	3838
6 Surf Court	77+30	$813,300	2.0	2503
8 Surf Court	79+10	$589,000	2.0	2592
11 Surf Court	74+60	$1,531,100	2.0	3044
Average		**$709,285**		
Total		**$14,185,700**		

Table 2: Properties at risk within 30 year planning horizon under Alternatives 1 and 2

Address	Approx. station	Years until sandbags (Alt 1)	Years until relocation or demolition		2012 Assessed value
			Alt 1	Alt 2	
13 Comber Road	83+70	existing	5	5	$50,100
17 Comber Road	87+30	existing	5	5	$520,300
15 Comber Road	85+50	existing	5	5	$563,500
3 Inlet Hook Rd	88+20	existing	5	5	$582,000
9 Comber Road	80+00	existing	5	5	$587,100
8 Comber Road	79+10	existing	5	5	$589,000
16 Comber Road	86+40	existing	5	5	$645,500
14 Comber Road	84+60	existing	5	5	$655,500
12 Comber Road	82+80	existing	5	5	$676,500
10 Comber Road	81+00	existing	5	5	$682,700
4 Inlet Hook Rd	89+10	existing	5	5	$690,100
5 Inlet Hook Rd	90+00	existing	8	5	$700,900
5 Comber Road	76+40	existing	10	5	$707,500
6 Inlet Hook Rd	91+00	existing	11	5	$709,000
7 Inlet Hook Rd	92+00	existing	14	8	$718,800
8 Inlet Hook Rd	93+00	existing	14	8	$733,400
11 Comber Road	81+90	existing	5	5	$738,300
6 Comber Road	77+30	existing	10	5	$813,300
9 Inlet Hook Rd	94+00	existing	17	11	$1,291,100
11 Surf Court	74+60	existing	14	7	$1,531,100
9 Surf Court	72+80	3	11	5	$1,980,500
8 Surf Court	71+90	3	11	5	$2,537,900
7 Surf Court	71+00	3	11	5	$2,827,700
5 Surf Court	70+00	3	11	5	$2,198,200
4 Surf Court	69+10	7	11	5	$1,425,600
3 Surf Court	68+20	9	12	11	$1,517,900
2 Surf Court	67+30	9	12	11	$1,928,800
1 Surf Court	66+40	10	14	12	$2,776,300
332 North Beach Road	64+60	11	14	13	$1,889,800
330 North Beach Road	63+70	11	14	13	$1,570,900
328 North Beach Road	62+80	11	14	13	$2,206,600
324 North Beach Road	61+00	12	16	14	$1,900,100
326 North Beach Road	61+90	13	16	15	$1,886,800
314 North Beach Road	56+00	18	22	21	$1,992,400
316 North Beach Road	57+00	19	23	22	$1,407,600

312 North Beach Road	55+00	19	23	22	$3,229,400
318 North Beach Road	58+00	19	23	22	$1,558,000
304 North Beach Road	51+00	20	24	23	$1,827,200
302 North Beach Road	50+00	20	24	23	$2,076,800
310 North Beach Road	54+00	21	25	24	$2,073,800
308 North Beach Road	53+00	22	26	25	$1,452,100
Average					$1,376,832
Total					**$56,450,100**

Table 3: Expected costs associated with sandbag revetments under Alternative 1

Road & Lot Numbers	Year sandbags installed[1]	Sandbag cost	Present Value Sandbag Cost 6%	Present Value Sandbag Cost 4.125%	Present Value Sandbag Cost 2.5%
Inlet Hook 3 to 9	7	$179,800	$90,780	$102,860	$114,833
Beach Rd N behind Inlet Hook 3 to 9	17	$230,500	$64,989	$88,024	$115,009
Comber Rd. 4 to 16	2	$610,800	$412,780	$427,780	$441,452
Beach Rd N behind Comber Rd 4 to 16	14	$610,800	$205,139	$263,367	$328,208
Surf Court 1 to 11	13	$338,800	$120,632	$152,133	$186,614
Beach Rd N behind Surf Court 1 to 11	29	$537,100	$75,262	$126,285	$199,252
Beach Rd N 322 to 334	26	$461,000	$76,934	$122,359	$184,182
Total		**$2,254,200**	**$1,046,517**	**$1,282,809**	**$1,569,550**

[1]Bags installed when scarp comes within 20 feet of the road.

Table 4: Expected costs associated with infrastructure loss under Alternative 1

Road & Lot Numbers	Length of road (ft)	Year Road Lost[1]	Infrastructure replacement cost	Present Value Infrastructure replacement cost (6%)	Present Value Infrastructure replacement cost (4.125%)	Present Value Infrastructure replacement cost (2.5%)
Inlet Hook 3 to 9	390	12	$301,470	$149,821	$185,603	$224,160
Beach Rd N behind Inlet Hook 3 to 9	500	22	$386,500	$107,256	$158,832	$224,504
Comber Rd. 4 to 16	1325	7	$1,024,225	$681,168	$771,810	$861,645
Beach Rd N behind Comber Rd 4 to 16	1325	19	$1,024,225	$338,520	$475,171	$640,681
Surf Court 1 to 11	735	18	$568,155	$199,050	$274,458	$364,282
Total	**4275**		**$3,304,575**	**$1,475,814**	**$1,865,874**	**$2,315,272**

[1]Assumes sandbag permit good for 5 years.

Table 5: Expected costs associated with infrastructure loss under Alternative 2

Road	Lot Numbers	Length (ft)	Year Road Lost[(1)]	Infrastructure replacement cost	Present Value Infrastructure replacement cost (6%)	Present Value Infrastructure replacement cost (4.125%)	Present Value Infrastructure replacement cost (2.5%)
Inlet Hook	3 to 9	320	8	$247,360	$155,197	$179,015	$203,020
Beach Rd N behind Inlet Hook	3 to 9	500	18	$386,500	$135,408	$186,706	$247,811
Comber Rd.	4 to 16	1,087	5	$840,251	$705,491	$744,293	$780,257
Beach Rd N behind Comber Rd	4 to 16	1,310	15	$1,012,630	$422,535	$552,237	$699,186
Surf Court	1 to 11	723	14	$558,879	$247,193	$317,357	$395,534
Beach Rd N behind Surf Court	1 to 11	1,165	30	$900,545	$156,794	$267,827	$429,328
Beach Rd N	322 to 334	1,000	27	$773,000	$160,295	$259,534	$396,858
Total		6105		$4,719,165	$1,905,306	$2,449,166	$3,114,396

Table 6: Scope of Costs and Benefits by Alternative

Costs (*ceteris paribus*)						
Alternative	1	2	3	4	5C	5D
Construction and Maintenance (NPV)	$16.58 M - $24.53 M	$1.98 M - $3.15 M	$36.06 M - $47.93 M	$47.21 M - $66.28 M	$25.63 M - $33.58 M	$14.73 M - $19.33 M
Potential reduction in tax base	High	Highest	Intermediate	Intermediate	None	None
Parcels affected	41	41	0	0	0	0
Transition costs	High	Highest	Low	Low	None	None
Diminished recreation value	High[a]	Highest[b]	Intermediate[a,c]	High[b]	Low	Low
Diminished aesthetic value	Intermediate[d]	High	Intermediate[d]	High[b]	Intermediate[e]	Intermediate[e]
Environmental damage						
Public non-use value losses (nature)	Low	Low	Intermediate	High	High	High
Public non-use value losses (Figure Eight Island)	High	Highest	Intermediate	Intermediate	Low	Low
Benefits (*ceteris paribus*)						
Alternative	1	2	3	4	5	5B
Reduction in future nourishment expense	Intermediate	N/A	Intermediate	Low	High	High
Enhanced property value	None	None	Intermediate	Intermediate	High	High
Enhanced Recreation value	Low[f]	Moderate[f]	Moderate	Moderate[f]	High	High
Environmental improvement	See Chapter 5 of EIS					
Public non-use value (nature)	Intermediate	Highest	Intermediate	High	Low	Low
Public non-use value (Figure Eight Island)	Low	None	Intermediate	Intermediate	High	High

[a] Recreation losses are associated with the presence of the sandbag revetments.
[b] Some losses are expected to be temporary, and associated with the presence of construction equipment.
[c] Erosion of southern end of Hutaff Island
[d] Aesthetic losses associated with sandbag revetments.
[e] Aesthetic losses associated with terminal groin.
[f] Accretion at Hutaff Island

Sub-Appendix A: Understanding the Costs and Benefits of Shoreline Change

1.0 Introduction

Actions associated with mitigating the effects of shoreline change are expected to create an array of costs and benefits. These include market costs, such as any physical or engineering costs associated with active mitigation, as well as non-market costs and benefits, such as those associated with changes in the quality of recreational experiences and effects on the natural environment. Shoreline nourishment, armoring via hardened structures, or retreat each entail costs and benefits that accrue to different groups of stakeholders and over different time periods. As noted in Landry (2011), nourishing shorelines by adding sand may protect coastal habitats and real estate as well as the possibilities for recreation, but without maintenance, the duration of such benefits can be expected to be temporary. Armoring the shoreline may likewise protect coastal property, but may have adverse impacts on habitats and proximate shorelines. Shoreline retreat will involve relocation or demolition of existing buildings and infrastructure and can be expected to impose substantial costs and burdens on coastal property owners. Local governments may also be opposed to shoreline retreat for reasons related to the potential infrastructure losses, diminished property tax revenues, and impacts on coastal tourism, or real estate sales (Landry, 2011).

As a result of these disparate costs and benefits, alternative efforts to mitigate shoreline erosion can be expected to be valued differently by different groups of people. Direct and indirect economic impacts from alternative shoreline management strategies will vary across a given population, as will preferences for maintaining, preserving or allowing natural change (Judge, Osborne and Smith, 1995). As noted in Judge, Osborne and Smith (1995), some individuals will have preference for non-interventionist approaches that allow natural erosion to take place. These individuals may derive real economic value from the existence of unfettered coastal ecosystems. While such "retreat" options will likely have an adverse impact on the value of beaches and beach front property at eroding sites, they may also induce positive or negative value changes at proximate sites via changes in crowding or changes in aesthetic appeal. For example, as noted in Parsons and Powell (2001), the amenity value of beachfront properties lost to erosion may not be lost in the aggregate, but rather transferred to properties further inland. Further, in the absence of land use controls active mitigation efforts such as beach armoring or renourishment may serve to encourage additional use and/or development, which may in turn compromise the integrity and value of the beach that such efforts were designed to protect or create a situation where continued mitigation is necessary to protect value. With regard to this latter point, Gopalakrishnan et al. (2011) find that beach replenishment activities are likely to occur more frequently in communities where baseline property values are higher.

Finally, certain groups of stakeholders may have different and contrasting values related to natural or anthropogenic changes to the shoreline. For example, as noted in Landry, Keeler and Kriesel (2003), property owners may desire shoreline proximity for recreational and aesthetic reasons and also value shoreline distance for protection from erosion. Huang et al. (2007) also note that anthropogenic modifications to beaches involve multiple positive and negative impacts on individual stakeholders. They find that erosion control measures are less valued when there are adverse impacts on wildlife, water quality and erosion at neighboring beaches.

In light of diverse impacts and preferences, economic analysis of the potential gains and losses from proposed shoreline management actions can be a useful input for policy makers who are confronted with the need to balance conflicting objectives while conforming to budgetary limitations. However, as alluded to above, understanding the economic values associated with shoreline management alternatives is a complex and multifaceted undertaking. Determining which strategy makes the most economic sense for a given coastal community is an empirical question, requiring detailed consideration of an array of natural, physical and socioeconomic characteristics (Parsons and Powell, 2001) and forecasting potential impacts into the future. Coupling these complexities with the inherently dynamic nature of marine coastlines suggests that the effects of shoreline management alternatives will vary according to myriad factors such as preferences for recreation, the degree of shoreline development, the characteristics of proximate and substitute sites and the bio-physical character of affected coastal ecosystems. As such, quantitative forecasting of the economic impacts of shoreline management alternatives is fraught with difficulty. Such analysis is beyond the scope of this report.

2.0 Limitations

The purpose of this report is to review the extant literature regarding economic considerations that are pertinent to the proposed management alternatives for the Figure Eight

Island Inlet and Shoreline Management Project and to summarize available evidence in the literature so as to frame and characterize the potential scope of economic costs and benefits associated with the proposed alternatives. This report does not provide an itemization or explicit estimation of economic values associated with the management alternatives, nor does this report provide a ranking of alternatives based on relative economic values or any other criteria. This report should not be considered a substitute for a monetary cost-benefit analysis, but rather should be taken as a framework for understanding the potential scope of economic impacts associated with the range of project alternatives evaluated in the Environmental Impact Statement (EIS).

3.0 Economic Value and Valuation

Economists define the value of a particular good or service as what it is *worth* to people, in terms of the contribution of the good or service to well-being (Bockstael et al., 2000). Value is best measured by what people are *willing and able to pay* (WTP) for a good or service. Value should not be confused with the *cost* or expenditure required to obtain a good or service, because cost may differ greatly from what something is worth. For example, a beach renourishment project may involve $5 million in physical and engineering costs, but may generate considerably more (or less) in actual economic value.

It should also be recognized that economic value extends to goods and services that are not explicitly traded in markets such as clean beaches and healthy habitats, and may include benefits not directly associated with use such as the benefits resulting from the knowledge that particular species or ecosystems exist (“existence values), are available for potential future use (“option values”) or are available for future generations (“bequest values”). The measurement of non-market values is detailed in later sections of this report. Evidence in support of “non-use values” includes the willingness of people to give up time and other resources (including money) for goods and services that they never interact with in any tangible fashion. While relatively unknown outside the economics profession, the consideration of non-use values is germane to any analysis of beach management alternatives due to their explicit mention in the Water Resource Council Principles and Guidelines (P&G) for federal projects (USACE, 2000 as noted in Landry, 2011).

More generally, it is clear that coastal ecosystems provide a variety of goods and services that create economic value via contributions to human well-being. These include services that affect the value of goods that are traded in markets such as the protection of coastal real estate and tourism as well as services that impact non-market goods and services such as aesthetics, habitat provision and opportunities for recreation. Quantifying the associated benefits to people from these goods and services is the domain of economic valuation. Valuation simply means empirical estimation of what something is worth, typically in monetary terms.

3.1 Valuation Methods

Because humans interact with the environment in many ways, approaches to valuation take a variety of forms. The choice of method is most often a function of what is being valued and the intended use or policy purpose of the values. A common point of demarcation for valuation methods pertains to whether the economic values in question are market-based or "non-market" values. Market values are often readily observed using applicable prices and quantities. Measuring and monetizing the costs and benefits associated with changes that are not revealed in market transactions requires the application of empirical techniques that fall under the category of non-market valuation. Examples of non-market values include changes in human wellbeing associated with aesthetics, opportunities for recreation and changes to the natural environment. Non-market valuation techniques are well-established in the academic and practitioner literature.

Examples of market-based valuation methods include the market price method, the replacement cost method and the damage avoidance method. Non-market valuation methods include the travel cost method, hedonic pricing and the contingent valuation method. A variety of sources are available for detailed reviews of these methods (e.g. Smith, 1996; Bockstael, et al., 2000; Schuhmann, 2012). For the purposes of this report, we only review those methods that are pertinent to the valuation of changes to coastal systems. Much of the review below is based upon Schuhmann (2012).

3.1.1 The Replacement Cost Approach

Some goods and services provided by the natural environment can be replaced by manmade goods and services. This basic idea is the foundation of the *replacement cost approach*

(RC) to valuation, which uses the *costs* associated with providing replacement services as the value of the associated natural services. As such, this approach fits into the category of market-based valuation methods. As an example, artificial breakwaters may provide some of the shoreline protection services afforded by barrier islands or reefs. The costs of constructing breakwaters may therefore be used as an estimate of the economic value that stands to be lost if the natural service was to be degraded. The replacement cost approach is appealing in its ease of calculation and interpretation – the method typically relies on readily available market data and represents the opportunity costs associated with the degradation of natural assets in terms of costs that would have to be incurred in the absence of protection.

The replacement cost approach should be used with caution, however, as it does not deliver a true measure of the value of natural goods and services in the sense of net gains to society. In short, the replacement cost method provides a measurement of *costs*, which may not reflect the benefits gained from natural resources. For example, the cost of widening a beach via sand management may be entirely unrelated to the benefits derived from naturally wide beaches. Moreover, this method should only be applied when certain conditions are met (Bockstael et al., 2000; EPA, 2009; WRI, 2009). First, the manmade alternatives must provide an effective replacement for natural services. While it is unlikely that manmade alternatives can provide the full range of benefits provided by natural assets, there must be at least some service flows that can be attained via substitution of manmade alternatives. Further, the costs of that substitute must be known or estimable and must represent the least-cost means of providing the service in question. Finally, society must be willing and able to incur the costs associated with the replacement. These latter two points may require extensive research to confirm, as the scope of economic costs associated with habitat modification likely extends beyond monetary or market-based expenses. Only when these non-market costs are understood, measured and conveyed to the public can society's willingness to accept them be established.

3.1.2 The Cost (Damage) Avoidance Approach

Related to the replacement cost approach, the *cost (damage) avoidance approach* (CA) is based on the idea that manmade services may be able to offset or prevent harm caused by natural or anthropogenic change. The cost avoidance approach relies on market-based estimates of the costs associated with potential damage to manmade assets as an estimate of the value of the natural services that prevent those damages from occurring. For example, the cost of replacing coastal property may be used as an estimate of the benefits derived from beach nourishment activities that mitigate damage from storms. As noted in Landry (2011), this is the approach employed by the US Army Corps of Engineers when defining benefits in P&G. As is the case with the replacement cost approach, this method ascribes estimates of *costs* to notions of *value*, which may be an inherently flawed means of understanding the *benefits* derived from changes in natural resources. Using the value of coastal real estate as an estimate for the value of beach width may lead to the conclusion that highly developed beaches are worth more than undeveloped beaches. While this may seem logical from a private landowner's perspective, the opposite may be true from the perspective of society. That is, undeveloped beaches may confer larger economic gains to society than developed ones. Landry (2011) provides additional discussion of this important issue.

3.1.3 Revealed Preference Methods

In terms of understanding the economic value of beach width and shoreline amenities, the most commonly employed non-market valuation methods are the revealed preference approaches of *hedonic pricing* method and the *travel cost method*. These approaches are based on establishing empirical links between changes in natural resources and market behaviors. For example, beach width may affect sales prices of coastal real estate or influence the number of tourists that visit a particular destination. By collecting data on real estate sales or travel to the coast, the associated value of beach width can be estimated. Specifically, the hedonic pricing method uses data on house characteristics (size, age, neighborhood characteristics, etc.), associated environmental amenities (e.g. proximity to the coast or beach width near the house) and selling prices. To estimate the contribution of those environmental amenities to the market value of the house, regression analysis is used where price serves as the dependent variable and independent variables are house characteristics, including environmental amenities. The estimated regression coefficient on the environmental characteristic represents the marginal change in average selling price for a change in that characteristic, and can be interpreted as the implicit price of the characteristic. Because this method relies on actual transactions, value results are difficult to critique, provided that proper methodology was employed and that the environmental characteristics of interest were accurately quantified and have not undergone meaningful change since the time of the real estate transactions. The literature contains several applications of the hedonic pricing method to value coastal attributes, many of which are reviewed herein.

The travel cost method is another revealed preference approach that is commonly employed to value natural resources associated with recreation. Site visitation data, including travel costs and the number of trips taken to a particular destination are collected and used to estimate a trip demand curve, where explicit and implicit travel expenses serve as a proxy for price. The net benefits of a particular site or the value of the resources within each site can then be estimated by integrating under the estimated demand curve at a particular price point (e.g. mean or median price). Numerous examples of recreation demand models applied to value beach visitation appear in the published literature. Pertinent applications are reviewed later in this report.

3.1.4 Stated Preference Methods

The above methods are useful for understanding the economic value associated with property and recreation aspects of coastal quality and amenities, but they are not amenable to the valuation of benefits that are not associated with direct use. When people derive values from simply knowing that natural resources are preserved or maintained in a particular state, s*tated preference methods* such as the Contingent Valuation Method (CVM) and Choice Modeling (CM) must be employed. These methods, which rely on surveys to elicit values, are well-accepted approaches for valuing non-market goods and services. CVM has been adopted by the U.S. Department of Interior to measure non-market values associated with damages under CERCLA 1980 (US DOI 1986), while NOAA has endorsed the use of this method for damage assessment under the Oil Pollution Act of 1990 (Arrow et al. 1993). The CM approach appears to be gaining favor in the economics literature as it avoids many of the difficulties associated with CVM and allows multidimensional attribute changes to be valued simultaneously (Huybers, 2004). As is the case with all valuation approaches, estimates of value are subject to an array of biases and caveats, hence care must be taken with regard to proper methodology and interpretation.

3.1.4 Economic Impact Analysis

In addition to estimating changes in economic value to users, property owners and other direct stakeholders, analysts may be interested in understanding the effects of changes in natural resource quantity or quality on the broader economy. Such impacts might include additional revenues, incomes and employment realized by local, regional and national economies. *Economic impact analysis* is the process concerned with such estimation, and recognizes that a portion of each dollar spent by a consumer or producer represents revenue earned by someone else in the economy. As the new revenue earner spends that income, each transaction creates additional income that ripples through businesses and households creating "economic multiplier effects". These impacts are estimable, and are typically categorized into *direct* effects, *indirect* effects and *induced* effects. *Direct effects* are market contributions to the economy, and are typically measured by gross total revenues, total employment or gross incomes. *Indirect effects* are impacts on the incomes and wages of the suppliers of inputs used in the industry in question when those earnings are subsequently spent on other goods and services. *Induced effects* are the economic impacts of spending of generated income by households who are either directly or indirectly employed in the industry. Indirect and induced effects taken together are often referred to as *value added effects* (Fedler, 2010).

Economic impact analysis relies on the use of input-output models which delineate forward and backward linkages in earnings and spending between economic sectors of interest and the rest of the economy. An empirical understanding of these linkages allows for the estimation of *multipliers* which quantify the extent to which a given economic activity (direct effect) generates other economic activity. Value added multipliers convert direct expenditures into total economic impact (Fedler, 2010). For example, if the estimated value added multiplier for tourism spending is 1.5, then each $1 of direct spending by tourists results in an additional $1.50 of indirect and induced effects, for a total economic impact of $2.50. Because economic impact analysis does not calculate net economic gains to market participants and does not account for non-market values, economic impact analysis and the use of input-output models should be considered a complement rather than a substitute for the calculation of economic value using other methods described above (Hoagland, et al, 2005).

4.0 Beach Nourishment as a Dynamic Optimization Problem

A recent branch of economics research has examined beach management decisions as a dynamic optimization problem where the timing and rate of renourishment that maximizes the discounted present value of net gains (benefits less costs) is derived (Landry, 2011). Required inputs for such modeling efforts include a rate of natural erosion or decay, the economic costs of beach nourishment, a parameter that converts sand volume to beach width, and a function representing aggregate benefits from beach width. The principle outputs are an optimal schedule of renourishment, the optimal quantity of sand that should be applied during each operation, and a measurement of how these values are affected by changes in the inputs (Landry, 2011). An obvious benefit of this approach is the ability to determine, *a priori*, the potential economic value of beach management actions under a range of hypothetical conditions. A downside is the time, effort and expertise required to conduct the modeling. While it is beyond the scope of this report to apply dynamic optimization models for coastlines in North Carolina, some notable results can be gleaned from prior work in the literature.

5.0 Categories of Potential Impacts from Coastal Management Alternatives

The economic costs and benefits associated with shoreline management projects will include changes in market values and non-market values. Affected market values may include with the physical costs of active mitigation efforts (e.g. construction and maintenance costs associated with hardened structures, acquisition of beach nourishment material, destruction and/or relocation of coastal real estate), and the change in economic value to coastal property and public infrastructure. Non-market values include those associated with changes to the size and integrity of beaches and dunes, inlets and their associated functions, including provision of public recreational opportunities, aesthetics and wildlife habitat. Effects on coastal property values will materialize in market values, and likely entail elements of both market and non-market values. These include changes in the storm protection benefits from beaches and dunes as well as values associated with recreation and aesthetics.

When comparing management alternatives, it is important to note that in many cases the benefits of active mitigation efforts can be considered costs of inaction. For example, the benefits of shoreline stabilization via nourishment or hardened structures include maintaining the integrity of the shoreline and the associated real estate. These economic values are likely to be partially or wholly sacrificed in the absence of active mitigation. Hence, an analysis of the costs of inaction (e.g. retreat) would include lost shoreline integrity and declinations in the economic value of associated real estate. Likewise, the benefits of inaction may include the value associated with maintaining natural environmental conditions in a state unaltered by active mitigation.

A deep body of literature exists examining the nature, scope and measurement of these economic values. Below, we provide a brief overview of this literature so as to provide a context for the potential scope of changes in economic value that might be associated with alternative shoreline management projects under consideration in North Carolina.

5.1 Values Associated with Coastal Property and Physical Capital

Natural and anthropogenic changes to shorelines can be expected to affect the value of coastal real estate. The value of at-risk property can be viewed as a potential economic cost associated with inaction (e.g. retreat) or an economic benefit of protection via active management (e.g. nourishment, armoring). Hence, an appraisal of coastal property values and/or derivation of the effect of beach characteristics on property values via the hedonic pricing method can serve as a valuable input in terms of understanding the costs and benefits of management alternatives.

However, caution must be exercised when conducting such appraisals for a number of reasons. First, property values can fluctuate with local and national economic conditions. Available sales, tax assessment or appraisal data may be reflective of market that may no longer be applicable to contemporaneous or future valuations. Further, natural characteristics of coastlines the associated economic benefits are inherently dynamic, which may create empirical difficulties when attempting to quantify the association between those characteristics and property values. For example, even with periodic renourishment, sand volume and beach width can be expected to vary over time. As such, explorations of the relationship between beach characteristics and property values that rely on measurements of those characteristics at a particular point in time may not properly account for anticipated future change or the flow of benefits from average quality metrics (Gopalakrishnan et al., 2011). Indeed, market participants' understanding of shoreline dynamics and expectations regarding shoreline management interventions will likely be capitalized into market values (Landry and Hindsley, 2011; Landry, 2011). For example, if a strategy of retreat is reasonably anticipated, the value of threatened properties could be driven toward zero (Landry, 2011). Likewise, uncertainty regarding legislative or budgetary conditions may confer a perception of investment risk, which can also be expected to be capitalized into market values. To the extent that shoreline characteristics at the time and location of data collection do not reflect those expectations, value estimates will be compromised.

An additional complication arises from the potential endogeneity between property values and shoreline characteristics. While it is clear that property values will depend on the characteristics of proximate shorelines (additional discussion below), shoreline characteristics may also depend on property values. As noted in Gopalakrishnan et al. (2011), shoreline management decisions may depend on the benefits from changing the natural character of the shoreline. For example, beach nourishment might occur on a larger scale or more frequent interval where beaches protect valuable real estate. This bi-directional causality may confound empirical estimation of the effect of beach width on property values.

To summarize, the value of at-risk property and assets that stand to be lost or protected can and should be considered when appraising the costs and benefits associated with alternative actions for shoreline management. The hedonic pricing method is the most commonly employed approach to understanding the relationship between shoreline characteristics and the market value of such assets, but such analysis should be exercised with careful consideration of the above cautions and caveats.

5.1.1 Categories of Value

Parsons and Powell (2001) categorize the costs of shoreline retreat as land loss, capital (structure) loss, proximity loss, and transition loss. The economic value of land loss is the difference between the value of affected land in the absence of beach erosion and the value of the same land with beach erosion. Because there will always be a given area of land that is beach front, value lost to erosion is associated with diminished land availability inshore rather than the loss of beachfront land. Capital loss is the difference between the asset value of housing, commercial buildings, and public infrastructure in the absence of beach erosion and the value of those same assets with beach erosion, including any loss of use and additional maintenance costs associated with retreat.

Proximity loss is the decrease in human welfare associated with adjusting the pattern of coastal development in response to an unstable shoreline. For example, Parsons and Powell (2001) note that in the face of an unstable shoreline, permanent structures may be rebuilt further from the shore or temporary structures may be built close to the shore. Either case confers less economic welfare associated with proximity than permanent structures built close to the shore, which is the presumed pattern of coastal development when shorelines are stable. Finally, transition loss is the economic costs associated with removal of housing, commercial buildings, and public infrastructure and includes costs of labor, capital and materials. It is important to note that the costs associated with replacing coastal real estate may not be an appropriate proxy for the benefits of avoiding replacement, as the latter entails the value associated with occupying a property, which may or may not be related to construction costs (Landry, 2011).

5.1.2 Examples from the literature

A deep body of literature examines the relationship between the value of coastal real estate and environmental amenities such as views, distance to shorelines, beach width and water quality. Each of these amenities is found to enhance property values as reflected in market prices. The contribution of amenities such as views and beach width is found to diminish with distance from the ocean.

With regard to ocean views, Benson et al. (1997) and Benson et al. (1998) use the Hedonic Pricing approach to estimate the value of scenic views to single family homes in Washington. Both studies find that homes with ocean views are associated with statistically significant price premiums. The 1997 study suggests that ocean frontage adds up to 147 percent to the market price of a home. Views of the ocean add between 10 and 32 percent to market prices, with lower values corresponding to partial views. The richer dataset used in the 1998 study allows for detailed characterization of view quality and distance from the water, and suggests that prices of homes with high quality (unobstructed) views of the ocean are 59 percent higher than prices of otherwise comparable homes on average. Lower quality ocean views convey lower price premiums, ranging between 8 and 31 percent. Not unexpectedly, while controlling for the quality of view, the value of ocean views is found to be inversely related to distance from the water. Prices of homes that are a very short distance from the water with unobstructed views may be more than 68 percent higher than otherwise similar homes.

Pompe and Rinehart (1999) also find that property buyers value ocean views. These authors apply the hedonic pricing approach to home sales in South Carolina and find that views of the ocean add approximately 45 percent to the value of developed lots and 83 percent to the value of vacant (undeveloped) lots.

Numerous studies explore the economic value of beach width to property owners. Pompe and Rinehart (1995) and Pompe and Rinehart (1999) find that property buyers value wider beaches. These two studies - applications of the Hedonic Pricing approach to data from coastal property sales in South Carolina – show that the marginal value of beach width varies with distance from the beach and differs for developed and undeveloped lots. Specifically, Pompe and Rinehart (1995) find that an additional foot of beach width is estimated to increase the value of developed and undeveloped oceanfront lots by $554 and $754 respectively. At a distance of one-half mile from the beach, the price premium for an additional foot of width is found to be considerably lower, roughly $254 and $165 for developed and undeveloped lots respectively. In Pompe and Rinehart (1999), an additional foot of beach width is found to add $194.09 and $310.84 to the market value of developed and undeveloped oceanfront lots, respectively. The authors caution that these latter estimates are based on a relatively small number of oceanfront parcels. Smaller price premiums are found for properties that are not oceanfront with ocean views, and even smaller (but still statistically significant) premiums are found for properties near the beach, but without ocean views.

With regard to loss of beach width to erosion, Parsons and Powell (2001) use a hedonic price regression to estimate the costs of shoreline retreat in Delaware. Specifically, using a range of estimates for average erosion rates at seven different beach communities along the Delaware coast, they approximate the expected location of the shoreline in the absence of active management actions and predict which specific houses would be lost as the shoreline migrates. For each structure that is predicted to be lost, value is predicted using a hedonic price regression based on market data. It is important to note the reason why the hedonic approach is employed rather than simply relying on market values of at-risk real estate: The hedonic approach allows the estimation of the coastal amenity value associated with each structure. This coastal amenity value is subtracted from this anticipated loss under the assumption that such value is simply transferred to other structures that are now closer to the shoreline. The costs associated with removal of the structure (i.e. the transition loss) are assumed to be $25,000 per structure and are added to create an estimate of the total loss associated with losing that property to retreat. Commercial structure losses are approximated using Marshall and Swift's property appraisal method. It is important to note that the authors assume that the majority of the value associated with infrastructure is capitalized into the value of residential structures, and as such the associated losses are captured in the hedonic estimation. To the extent that such infrastructure conveys economic benefits to the public at large (e.g. tourists, or nearby residents), this assumption results in an underestimate of the true costs of retreat. Further, while the authors mention the costs of infrastructure removal and/or relocation, it is not clear that these costs are explicitly accounted for. The authors also do not attempt to estimate proximity losses, which are assumed to be small. Finally, the authors do not account for unstable beach conditions and the effect of such future risk on values of homes that are now closer to the shoreline.

Their results suggest that over a 50-year period, the costs of active beach renourishment are expected to be substantially less than the lost value associated with retreat. The authors suggest that the costs of renourishment would have to increase by a factor of four for retreat to be an economically preferable alternative, though they caution that cost estimates may vary greatly with assumed rates of erosion. Because of the characteristics of the study area, the majority of losses from retreat are those associated with residential real estate. Transition losses and losses associated with commercial structures are found to account for about 15% of total losses. Importantly, the coastal amenity value is found to be a statistically significant component of the economic value of at-risk property. For example, for an ocean-front house valued at $300,000, the ocean-front amenity is found to account for nearly $132,000 of the value. A bay-front house of similar value would owe $24,000 to its proximity to water and canal frontage appears to be worth $63,000. The authors also suggest that for houses less than a half-mile from the beach, each 25 feet of distance from the coast is worth about $1200 for a representative $300,000 house. Because these amenity values can be assumed to transfer to properties further inland as a result of retreat, these results suggest that a simple subtraction of the current market value of at-risk real estate will grossly overestimate the costs of retreat and unimpeded shoreline recession. That is, while retreat can be expected to diminish or eliminate the market value of beachfront properties, the beachfront itself will always exist. Hence, properties that were once "one row back" will now be beachfront, and can be expected to increase in value. Nonetheless, given the current costs and technology associated with shoreline renourishment, retreat appears to be an unfavorable option from a market costs perspective.

Landry, Keeler and Kriesel (2003) explore the desirability of shoreline management alternatives by quantifying the economic impacts on coastal property owners who face risk of economic loss from erosion, the change in value of recreational uses of coastal areas that may be impacted by shoreline management and the costs of management. Effects on the natural environment (e.g. habitat loss or change) are not considered. Specifically, the incremental value of improved beach widths for coastal residents is estimated using hedonic analysis applied to a sample of 318 property sales on Tybee Island, GA. Including among the set of sales price determinants in the hedonic regression are beach width, distance from the beach, erosion risk, and the presence of erosion control structures. The measure of erosion risk was an indicator variable for property proximity to known high risk areas on the island. Beach width is found to be a statistically significant determinant of property value, with each one-meter increase adding $233 to property value. Ocean-front and inlet-front amenity values are estimated to be of $34,068 and $87,620 respectively. Property values in high risk areas were estimated to be reduced by $9,269.

Landry and Hindsley (2011) also apply the hedonic pricing method to real estate transactions for single-family residences in Tybee Island, GA, and measure the value of high- and low-tide beach and dune widths at nearby beaches, adjusted for changes in beach width due to sand replenishment activities. They find that beach and dune width have a statistically significant influence property value for properties located within 300 meters from the shore, but find no relationship for properties located further from the shore. Specifically, Landry and Hindsley estimate marginal willingness-to-pay for beach width for houses within 300 meters from the beach ranges from $421 to $487 for an additional meter of high-tide beach, or $272 to $465 for an additional meter of low-tide beach. The incremental value of dune width ranges from $212 to $383 per meter for houses within the 300 meter distance. When the estimation is extended to properties beyond the 300 meter distance, marginal values decrease. These authors also find that the value of ocean frontage is estimated to be between $39,000 and $75,000 and between $121,000 and $128,000 inlet frontage.

Gopalakrishnan et al. (2011) estimate the value of beach width to coastal property in ten coastal towns in North Carolina[5] using hedonic pricing models. When beach width is treated as an exogenous characteristic, the average increase in oceanfront property value is approximately $1,440 per additional foot of beach width. This value approaches zero for properties that are located more than 330 feet from the beach. When beach width is treated as endogenously determined[6] (i.e. property values are function of beach width and beach width, via nourishment activity, is a function of property value), the authors find that beach width likely accounts for a larger portion of coastal property value. Specifically, the coefficient on the (fitted) beach width variable is five times larger than in the exogenous specification, suggesting that the average increase in oceanfront property value is approximately $8,800 per additional foot of beach width, or a roughly 0.5 percent increase in value per 1 percent increase in beach width. The authors suggest that their results indicate that property values will be more sensitive to beach width when there is severe erosion and beach replenishment is used to stabilize the shoreline. Notably, unlike Landry and Hindsley (2011), Gopalakrishnan et al. (2011) find that the presence of dunes does not impact property values.

5.1.3 Summary

There is a preponderance of evidence that property owners place considerable economic value on beach width. This value declines with distance from the shore. While some literature suggests that the existence of dunes has a positive impact on property values, the evidence to date is not clear. It is important to note, as articulated by Landry and Hindsley (2011), interpretation of specific value estimates such as those detailed above depends on individual perceptions of future resource quality. If conditions are expected to improve over time, value estimates should be interpreted as lower bounds on true value. If instead, conditions are expected to degrade, value estimates should be interpreted as upper bounds on true value.

5.2 Coastal Infrastructure

[5] The sample of towns includes Carolina Beach, Kure Beach and Wrightsville Beach in New Hanover County. All other towns in the sample are in Carteret County or Dare County.

[6] This model is estimated via two-stage least squares, where geomorphological variables are used to instrument for beach width in the first stage, and fitted values of beach width are used in the price hedonic in the second stage.

In addition to privately owned residential properties, coastal areas also contain physical capital in the form of public infrastructure (e.g. roads, water, electric, sewer). As with privately held capital, this public capital conveys economic benefits to society. Again, the value of these benefits to society can be considered a benefit of erosion control measures, or a cost associated with the failure to control erosion. It is important to note, as expressed in Parsons and Powell (2001), that some of the benefits associated with public capital accrue directly to property owners and will be capitalized into market values for associated real estate (e.g. water and sewer services), and thus included as part of damage avoidance estimates if the value of privately held coastal property is assessed. Yet, other aspects of value for these public assets are not amenable to market valuation, because the benefits derived from their use are not for sale (e.g. the value of public roads adjacent to public beaches). The only readily available market measure of value is that pertaining to new construction costs. That is, while there is no observable market value of what infrastructure is worth in terms of benefits conveyed to the public, we can observe or estimate the cost associated with its construction. As a case in point, in order to measure the potential value of terminal groins in terms of protecting public assets, the cost of constructing public infrastructure was used in NCCRC (2010).

While the procedural endorsement of the RC and CA approaches is understandable in light of the lack of an alternative proxy for value, as noted in the discussion above, the monetary estimates derived from these approaches should not be used without careful consideration. In particular, infrastructure replacement costs seem a tenuous measure of the value of protecting in-situ infrastructure in situations where a lack of protection induces sufficient erosion to eliminate any possibility of replacing that infrastructure. In circumstances where inundation (conversion of land habitat to water) removes the possibility of replacement, the cost of constructing infrastructure might best be considered an unrecoverable sunk cost. Costs that are germane to these situations would include expenses associated with physical removal of the infrastructure. However, when inundation necessitates replacement of lost infrastructure at an alternative location services in order to maintain service flows to properties that remain unaffected by erosion, replacement costs may be an appropriate estimate of at-risk value provided that they account for costs associated with right-of-way acquisition, engineering, permitting, and construction costs (in addition to removal of infrastructure).

5.3 Values Associated with Recreation and Tourism

5.3.1 Categories of value

Alternative actions for mitigating the effects of shoreline change are expected to impact the quantity and quality of recreation and tourism opportunities at the site of interest. Management action or inaction may also create effects on proximate sites or sites that are considered substitutes. These effects may include changes in beach area, the quality of sand, ease of access, the quality of the marine environment, the quality of scenery and the quantity or quality of habitats and species. Changes in economic values will be manifested in changes in the quantity or quality of extractive direct uses (e.g. catch-and-keep fishing), non-extractive direct uses (e.g. sunbathing, bird watching, walking/running, surfing, catch-and-release fishing), and passive uses (e.g. enjoying the aesthetics of a coastal area). In the case of beach nourishment and/or armoring, perhaps the most obvious of these changes is that associated with the amount of physical space available for recreation. Landry (2011) categorizes the economic value of changes in beach area as associated with improvements in scenery and aesthetics, allowing space for more users and decreasing congestion for existing users.

These categories of value are not mutually exclusive. Indeed, a single user can derive economic value from all of the above activities. Further, due to the non-rival and non-excludable characteristics of many of these uses, value derived by one individual does not preclude others from enjoying benefits as well. The most widely applied methodology for estimation of the economic value of changes in coastal quality as it pertains to recreation is the travel cost method, or its close cousin, random utility modeling. Applications of these revealed preference approaches are detailed in an extensive body of literature, some of which is reviewed below. Stated preference approaches such as the contingent valuation method and choice modeling may be appropriate in cases where benefits extend to aspects of value associated with more passive uses.

In addition to value accruing to direct users, additional economic impacts from changes in coastal quality may be realized by local businesses via changes in tourism demand and by governments via changes in tax revenues. Estimation of such economic impacts requires the use of economic impact analysis (input-output models) described earlier in this report. While the estimation of tourism multipliers and the economic impacts of discrete tourism-related events have received attention in the literature (e.g Dwyer et al., 2004; Frechtling and Horvath, 1999;

Hodur and Leistritz, 2007), a recent review of the economics of coastal erosion by Landry (2011) finds a dearth of research regarding the economic benefits accruing to local businesses from beach management.

Finally, it is important to note that management alternatives involving shoreline retreat may not create losses in terms of foregone recreation and tourism opportunities. As discussed in Parsons and Powell (2001), if the shoreline is simply relocated further inland, with no changes to other beach characteristics, the welfare derived from recreationists can be assumed to be unchanged. More generally, to the extent that shoreline change does have an adverse effect on the quantity or quality of recreational opportunities, the degree of economic loss to users and associated businesses will depend upon the availability of substitute locations for such activities (Landry, 2011). If alternative sites are available, proximate and of similar quality, the economic losses associated with diminished quality at one site may be mitigated via substitution.

Clearly, the economic value from coastal recreation and tourism is multi-faceted and involves numerous user groups. A comprehensive empirical estimation of quality-induced changes in values associated with recreation is not straightforward, and should be site-specific entailing multiple valuation approaches.

5.3.2 Examples from the literature

The literature pertaining to the economic value of coastal recreation is vast. This literature includes estimates of the value of access, typically addressed via revealed preference methods, as well as the value associated with changes in site quality, which is more commonly assessed via stated preference techniques. We do not attempt to provide a comprehensive review of this literature, but rather try to highlight particular studies that may be germane to the issues at hand.

Bin et al. (2005) apply the travel cost method to estimate the economic value of beach recreation in North Carolina. Data were collected at seven beach sites in the state, including Topsail Island and Wrightsville Beach. Value estimates range from $11 to $80 for day trips and between $11 and $41 for overnight trips. There is notable variation in value estimates across sites, with higher values found for beaches that are inaccessible by automobile or are not as well-known as other beaches in the sample. The authors speculate that the perception of exclusivity may influence the recreational value of beaches and suggest that unique site characteristics and user preferences for different types of experiences are important determinants of value.

In a contingent valuation analysis of beach renourishment in the Cape Hatteras National Seashore, N.C., Judge, Osborne and Smith (1995) find that average willingness to pay for beach renourishment is approximately $178 per person per year. This value was a positive function of anticipated future visitation and is inversely related to prior experience at the site. Willingness to pay also decreases with distance from the site for those users with no prior experience visiting Cape Hatteras and is a positive function of education level and the attitude that beach towns suffering from storm erosion should receive additional federal assistance.

Whitehead et al. (2008) use the travel cost method and a combination of revealed preference and stated preference data to estimate changes in recreation demand at 17 beaches in southeastern North Carolina that would occur with improved parking and beach nourishment. The study area included numerous beaches in Carteret, Pender, Onslow, New Hanover and Brunswick Counties. Regarding beach nourishment, respondents were informed that beach nourishment projects would be performed at least once every 3 to 5 years for a 50-year term for the purpose of shore protection and enhanced recreation opportunities, and average beach width would increase by 100 feet. A majority of respondents (58%) expressed support for the beach nourishment policy, and most respondents (85%) felt that the stated beach nourishment policy would be effective in maintaining beach width. Yet, some respondents (21%) were satisfied with current beach widths and some (18%) felt that beach width should not be altered by people. Enhanced beach width was found to increase total net gains to beach visitors by approximately $7 per person per trip and roughly $68 per person per year.

5.4 Values Associated with Coastal Species and Habitats

As is the case with empirical explorations regarding the economic value associated with coastal recreation, the literature on the economic value of species and habitats is extensive. Howarth and Farber (2002) provide important background reading regarding the economic valuation of ecosystem services, and note the importance of constructing monetary measures of economic wellbeing that account for non-market values held by people. These non-market values include existence values pertaining to species and ecosystems. The authors also highlight the importance of accounting for values held by a range of stakeholder groups rather than value held by a “representative” individual. A review of the literature provided by Spurgeon (1999) suggests that use and non-use benefits derived from coastal ecosystems are substantial. These ecosystems provide an array of valuable services that result in economic benefits to the public at large. Barbier et al. (2008) note the importance of considering nonlinearities when accounting for changes in coastal ecosystem service flows. Specifically, they note that changes in coastal ecosystem services do not necessarily respond linearly to changes in habitat size. This implies that valuation of coastal ecosystem services should not be based on simple linear extrapolations of lost habitat to point estimates of monetary value.

In the case of wetlands, ecosystem services include filtration, storage, and detoxification of residential and agricultural wastes and mitigation of pollution and nutrient-laden runoff into receiving water bodies (Stedman and Dahl, 2008). Wetland preservation can be viewed as a cost-saving measure for communities as these water-quality services can involve considerably lower costs than community or municipal water treatment alternatives (US EPA, 2006). By absorbing and storing flood waters, wetlands can also serve as a natural buffer protecting adjacent real estate from the effects of rising surface waters during storms. Similarly, dune habitats provide important storm-protection services for coastal land and property. Wetlands and dunes also provide important transitional habitat between aquatic and terrestrial environments for resident and migratory wildlife. Wetlands serve as critical nursing areas for marine organisms, including the majority of fish and shellfish species harvested in the U.S. (US EPA, 2006). The quality and abundance of coastal ecosystems are therefore directly related to the health of fish and wildlife stocks (Stedman and Dahl, 2008).

The existence of dunes and wetlands in a community may enhance property values for storm protection benefits, aesthetics and through improved opportunities for recreation activities such as hiking, bird watching, and photography. Wetlands may be considered a disamenity if they are associated with odors, insects or undesirable wildlife interactions.

Several studies have attempted to estimate the economic impact of proximate wetlands on land values using the hedonic pricing method. Generally, these studies suggest that the effect of wetlands on property values depends on the type and character of the wetland. For example, in an examination of property values in rural Florida, Reynolds and Regalado (1998) find that proximity to scrub-shrub and shallow pond wetlands has a positive impact on property values, while proximity to emergent palustrine wetlands may have an adverse effect. In mainland North

Carolina, Bin and Polasky (2003) find that the open and sparsely vegetated nature of coastal wetlands provide a value-enhancing amenity while more densely forested inland wetlands do not, and may in fact decrease property values.

Numerous studies employing stated preference methods find substantial economic value associated with recreation, wildlife habitat, flood control, and improved water quality from wetland services (McConnell and Walls, 2005). Woodward and Wui (2001) review the results from 39 empirical studies, and find that type of wetland and method of analysis has substantial effect on estimated wetland values, noting that only imprecise estimates of wetland values can be garnered from the literature. Hence, it is reasonable to conclude that wetlands are an important source of economic value to surrounding areas, but without case-specific empirical analysis, a reasonable approximate of the magnitude or distribution of that value is not feasible.

Spurgeon (1999) provides an overview of the economics associated with coastal habitat rehabilitation and creation, including a review of the relevant literature. The author notes that the costs associated with habitat rehabilitation or creation costs vary widely between and within ecosystems. The two studies that pertain to dune habitats suggest that rehabilitation costs may range from approximately $19,000 to $25,000 per hectare.[7]

Numerous studies are available that pertain to the economic value of species and species protection. Shogren et al. (1999) provide useful background reading. Loomis and White (1996) provide results from a meta-analysis of the economic benefits of rare and endangered species. Whitehead (1993) estimates willingness to pay for preservation of coastal non-game habitat and loggerhead sea turtle nesting habitat in North Carolina using the contingent valuation method and a sample of 600 North Carolina residents. Average annual willingness to pay is approximately $11 for the loggerhead sea turtle program and $15 for the coastal nongame wildlife program. In addition to generating estimates of the economic value of coastal habitat associated with species protection, this work highlights the importance of accounting for uncertainty when estimating the economic value associated with threatened or endangered wildlife populations. The author notes that failure to account for uncertainty with regard to the

[7] The latter value pertains to a 2.5 ha dune rehabilitation project in Scotland and includes costs associated with replanting dune grass, providing fencing for trapping sand and installing gabion revetments. Additional maintenance costs for the project are noted as less than $1,000 per year. The former value pertains to a 17.8 ha dune rehabilitation project in Monterey, CA.

continued existence of the resource as well as uncertainty pertaining to demand and preferences may result in inappropriate benefits estimates.

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