APPENDIX M

UNDERSTANDING COST AND BENEFITS

Appendix M: 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, and retreat all 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 may 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 farther 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.

2.0 Limitations

The purpose of this appendix is to review the extant literature regarding economic considerations that are pertinent to the proposed management alternatives for the Holden Beach Inlet and Terminal Groin 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 appendix and accompanying discussion in the EIS should be taken as a framework for understanding the potential scope of economic impacts associated with the range of project alternatives evaluated in the 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 real 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 value estimates. 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. Non-market values pertain to changes in human wellbeing and may be associated with active uses of resources (e.g. recreation), passive uses of resources (e.g. aesthetics) or not associated with any tangible use (e.g. concern for the condition of the natural environment). Non-market valuation techniques for estimating the associated benefits to people 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 not be the most accurate 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. Some notable results can be gleaned from prior work in the literature and applied to North Carolina coastlines.

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[1] 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[2] (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

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[1] 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.

[2] 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.

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

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 farther 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.[3]

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

[3] 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.

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