Valuation of the Ecosystem Services Provided by Oak Bluffs' Public Coastal Resources

Salt Marsh across from Farm Pond *Liz Durkee*

Final

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Acronyms and Abbreviations

EPA	Environmental Protection Agency
GDP	Gross domestic product
GIS	Geographic information system
IAM	Integrated assessment model
IWG	Interagency Working Group
MDFW	Massachusetts Division of Fisheries and Wildlife
MESA	Massachusetts Endangered Species Act
MOEEA	Massachusetts Office of Energy and Environmental Affairs
MOTT	Massachusetts Office of Travel and Tourism
MRLC	Multi-Resolution Land Characteristics
MVC	Martha's Vineyard Commission
NCLD	National Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
NORE	National Ocean Recreational Expenditure
PES	Peconic Estuary system
SCC	Social cost of carbon
UMass	University of Massachusetts
TPV	Total present value
USFWS	U.S. Fish and Wildlife Service
VCS	Vineyard Conservation Society
WTP	Willingness to pay

Executive Summary

Overview

Oak Bluffs is a town on the island of Martha's Vineyard in Massachusetts. This island town is known for its pristine natural environment, bustling arts and culture, and abundance of recreational opportunities. Oak Bluffs' shorelines are in large part responsible for these notable qualities.

Beaches, wetlands, and coastal ponds support the unspoiled landscape of Oak Bluffs by providing habitat for locally important species and by protecting the natural environment through carbon sequestration, storm protection, and erosion control. Furthermore, the arts and culture scene in Oak Bluffs is intricately linked to the coast; many artists use the water as a source of inspiration or subject for their art, and many festivals and cultural celebrations in town are tied to the coast. Additionally, Oak Bluffs' beaches and other seaside elements provide a plethora of recreation activities for town residents and visitors alike. Beach recreation activities—including swimming, sailing, recreational fishing and shellfishing, and aquatic sports—are among the most popular activities in Oak Bluffs. Other recreational opportunities, such as hiking, biking, and sightseeing, also rely heavily on the coastal geography for the scenic vistas it provides. Finally, Oak Bluffs' waters support a thriving shellfishing and finfishing industry, contributing to a significant source of commerce for the town.

The ecosystem services supplied by Oak Bluffs' coastal resources provide economic value regionally and beyond. Some types of ecosystem goods and services are valued because they directly affect human welfare and contribute to human well-being (goods with "use" value), such as fish and shellfishing. Other types of ecosystem goods and services are valuable independently of any observable human use ("non-use" goods), such as existence of productive and attractive wildlife habitat along the coast, even if the resident never uses coastal waters for fishing or other recreation activities.

This study has several objectives: (1) identify and characterize the ecosystem service flows of Oak Bluffs' coastal resources; (2) calculate the dollar value of natural goods and services provided by these resources; and (3) help community members in assessing the relative importance of coastal resources when considering future development, land use policies, and conservation or restoration actions.

Methods

To show the diversity of natural capital benefits derived from Oak Bluffs' coastal resources, this study characterizes the ecosystem services that these resources provide. To the extent possible, this study quantifies and monetizes ecosystem goods and services provided by Oak Bluffs' coastal resources. Where quantification or monetization are not possible, we narratively describe the goods and services provided by the coast to provide insight into their values.

We have chosen 2016 as the baseline year for our analysis to assume "current" conditions. We assume that the stream of ecosystem services provided by coastal resources will continue through 2050, resulting in a 34-year analysis period. The total present value (TPV) of preservation is the sum of benefits in all years of the analysis, which captures the long-term benefits of preserving coastal resources in Oak Bluffs.

Throughout this report, we use a mix of quantitative and qualitative methods to assess ecological conditions and economic benefits derived from the current status (as of 2016) of Oak Bluffs' coastal resources. The value of some of the ecosystem services provided by Oak Bluffs' coastal waters can be estimated in dollars based on market value (e.g., shellfish). However, most of the ecosystem services provided by natural resources are goods and services that cannot be bought or sold in the market ("non-market good and services"). Our approaches therefore rely on the implicit value of these goods by examining behaviors related to the service, such as travel distance and household expenditures for a day of outdoor recreation.

Because conducting a primary resource valuation study of ecosystem services provided by Oak Bluffs public coastal resources is not within the scope or resources of this project, we apply benefit transfers from existing resource valuation studies. This is a common and accepted approach to adapting benefit values first estimated in one context to a second context that is similar, but for which time or data prevent a new, from-the-ground-up economic study (Freeman, 2003; U.S. Environmental Protection Agency (U.S. EPA), 2010; U.S. Office of Management and Budget, 2003).

Summary of Results

This study focuses on estimating the monetary value of four categories of ecosystem service benefits provided by Oak Bluffs' public coastal resources: provisioning services, cultural services, supporting services, and regulating services. Chapters 3 through 6 provide qualitative discussion of these services and detail quantitative assessment of each service category. The estimated total economic value of the ecosystem services provided by Oak Bluffs' public coastal resources ranges from $133.13 million to $168.45 million per year; TPV ranges from $4.52 billion to $5.71 billion from 2016 to 2050. These estimates are likely to be biased downward because we did not monetize all of the economic benefits provided by Oak Bluffs' public coastal resources (*Table 1-1*). For example, modeling storm protection and sea-level rise mitigation provided by these resources was outside of the scope of this study. The estimates provided in *Table 1-1* are subject to uncertainty and limitations due to availability of local data and analytic methods used in the analysis. The most significant limitation is the omission of some ecosystem services provided by Oak Bluffs' public coastal resources from the monetary estimates due to the lack of data (e.g., educational opportunities, support of threatened and endangered species, and aquaculture).

Table 1-1. Estimated Economic Value of Ecosystem Services Provided by Oak Bluffs' Public Coastal Resources (Millions 2016$)

Ecosystem Service	Annualized Value[1]	TPV[2] (2016-2050)
Provisioning Services	$0.48	$10.51
Cultural Services	$132.44 - $167.17	$4,503.04 - $5,683.61
Supporting Services	$0.05 - $0.06	$1.83 - $1.88
Regulating Services	$0.16 - $0.74	$3.77 - $16.59
Total	**$133.13 - $168.45**	**$4,519.15 - $5,712.59**

[1] Annualized value is estimated using a 3% discount rate.
[2] TPV is estimated using a 3% discount rate.

To put the economic value of Oak Bluffs' public coastal resources into perspective, we would ideally compare our estimates to the Oak Bluffs' gross domestic product (GDP), which accounts for the total value of everything produced by all companies and people in Oak Bluffs. Because no estimate of GDP is available for Oak Bluffs or Martha's Vineyard, we compared our results to total annual payroll for all economic sectors in Oak Bluffs to the estimated value of ecosystem services provided by Oak Bluffs' public coastal resources.

The total annualized value of ecosystem services provided by Oak Bluffs' public coastal resources ($133.13 million to $168.45 million) is greater than the value of the total annual payroll for all sectors in Oak Bluffs in 2015 ($87.77 million; 2016$; U.S. Census Bureau, 2017). This comparison suggests that Oak Bluffs' public coastal resources are a key contributor to the thriving local economy. Recognizing this value and incorporating it into resource management decisions is necessary for ensuring resilient communities and a sustainable future economy.

Coastal recreation and flow-on impacts from recreation account for nearly the entire estimated value of Oak Bluffs' coastal resources. Direct expenditures ($31.36 million), one of three outdoor recreational benefit categories, account for 18.6% to 23.6% of the estimated annualized value of ecosystem services provided by Oak Bluffs' public coastal resources. To ensure that our estimate is within the correct range, we compared our estimate of direct expenditures from outdoor recreation to the total estimated expenditure estimate for Oak Bluffs (Massachusetts Office of Travel and Tourism (MOTT), 2016; Martha's Vineyard Commission (MVC), 2011; Town of Oak Bluffs et al., 2015). Based on our estimate, direct expenditures from outdoor recreation account for 33% of total estimated expenditures in Oak Bluffs.

Butterfly Weed, Town Beach *Liz Durkee*

1. Introduction

Martha's Vineyard, an island located in Dukes County, Massachusetts, is known for its scenic vistas; pristine natural environment; vibrant culture; and small-town, New England charm. This truly distinctive island combines isolated geography with a bustling population to create a magnetic appeal. Tourists from around the world flock to Martha's Vineyard to experience all that the island has to offer. In 2015, 2.2 million people visited Martha's Vineyard (Nancy Gardella, Martha's Vineyard Chamber of Commerce and Tourism Executive Director, personal communication). The summer months are a particularly popular time to visit the island for its scenic beaches and abundance of recreational opportunities.

Oak Bluffs is a gateway to the rest of Martha's Vineyard as one of the island's principal points of arrival—ferries carry tourists from Woods Hole, Falmouth, Hyannis, Nantucket, New Bedford, and Rhode Island (Town of Oak Bluffs, 2015). Oak Bluffs has many publicly accessible beaches, which help make the town one of the most popular destinations for tourists visiting the island. Additionally, many tourists visit Oak Bluffs for its scenic coastline views and ample coastal recreation opportunities, including biking, fishing, and hiking. Oak Bluffs' coastal resources also provide a variety of services beyond attracting tourists, and these services are the focus of this study. In addition to their natural beauty, Oak Bluffs' coastal resources provide a wide range of ecosystem services that benefit local communities, including flood control, erosion protection, recreation, carbon sequestration, commercial and recreational fisheries' production, and water quality regulation.

The objectives of this study are to: (1) identify and enumerate relevant ecosystem goods and services provided by the town's public, coastal natural resources; (2) estimate the monetary value of benefits provided by these resources to local communities, town visitors, and other affected populations; and (3) help community members better assess the relative importance of Oak Bluffs' coastal resources when considering future restoration and conservation actions.

1.1 Population

Oak Bluffs is one of six towns on the island of Martha's Vineyard, neighboring the towns of Edgartown to the south and Tisbury and West Tisbury to the west (*Figure 1-1*). Although Oak Bluffs occupies only 7.3% of Martha's Vineyard's landmass, it is home to 26% of the island's population with 4,527 year-round residents (Town of Oak Bluffs, 2015). Because Oak Bluffs is a popular tourist destination, the seasonal population increases to approximately 22,432 each summer (Town of Oak Bluffs, 2015).

Figure 1-1. Map of Oak Bluffs

1.2 Economy

Tourism is a cornerstone of Oak Bluffs’ economy and the island’s economy as a whole. Second homeowners and seasonal residents subsidize 70% of the island’s tax base (Town of Oak Bluffs, 2015). According to the Massachusetts Office of Travel and Tourism, tourist spending in Martha’s Vineyard totaled $160.17 million in 2015 (2016$), supporting 1,400 jobs (MOTT, 2016). Tourist-related sectors, which include retail, accommodation and food service, arts, recreation, and entertainment, represent 37% of employment on Martha’s Vineyard (MVC, 2017) and 27% of employment in Oak Bluffs (U.S. Census Bureau, 2015). Other important industries in Oak Bluffs include construction and real estate (Town of Oak Bluffs, 2015).

Approximately 4% of the employed population in Oak Bluffs is employed in farming, fishing, and forestry occupations (U.S. Census Bureau, 2015). Additional breakdowns are not available due to confidentiality concerns, but we expect most are employed in the fishing industry. Oak Bluffs has only 40 acres of active farmland, including Island Alpaca and the Bayes Norton Farm on the Oak Bluffs/Tisbury town line (MVC, 2010). Commercial forestry is not present in the area.

1.3 Coastal Resources

The Oak Bluffs Harbor, beaches, coastal ponds, and the Nantucket Sound surround Oak Bluffs, placing the town’s coastal resources among its best-known and most valuable features. Over 40% of Oak Bluffs’ coastal wetlands are publicly owned, including 73 acres of barrier beaches and 25 acres of salt marshes (*Figure 1-2*; Appendix A), and are thus open to public recreation and use.

Within Oak Bluffs' collection of coastal waters, Oak Bluffs Harbor is one of the town's most iconic water bodies. With an area of 30 acres, Oak Bluffs Harbor is the largest marina on the island. It serves as a hub of activity for Oak Bluffs and Martha's Vineyard as a whole and provides residents and visitors alike with a destination for boating and fishing. Oak Bluffs Harbor is also home to one of the most popular festivals on the island: the annual Harborfest (Town of Oak Bluffs, 2015).

Similarly, the beaches of Oak Bluffs are some of its most iconic geographic features. These beaches support a variety of recreation, and many are free and easily accessible to the public (Town of Oak Bluffs, 2015). Oak Bluffs' coastline prominently features barrier beaches, which make up 80% of public coastal resources in Oak Bluffs by area (*Figure 1-2*). Two of Oak Bluffs' most popular coastal attractions, Jetty Beach and Joseph Sylvia State Beach, are part of barrier beach systems. Joseph Sylvia State Beach separates the Nantucket Sound and Sengekontacket Pond and provides opportunities for swimming, walking, and fishing. The gradually sloping water depth and small waves draw many families to State Beach (Dukes County, 2017). Likewise, coastal beaches draw many recreational beach users. Points of interest include Eastville Point Beach and Oak Bluffs Town Beach (Inkwell), as well as scenic bluffs like East Chop Bluff and North Bluff bank and beach. Eastville Point Beach and Oak Bluffs Town Beach are popular swimming and recreation locations for families, and the bluffs are popular scenic locations (Town of Oak Bluffs, 2015). Finally, beaches and dunes provide valuable habitat to wildlife and coastal protection.

Sengekontacket Pond *Liz Durkee*

Figure 1-2. Map of Public Coastal Resources in Oak Bluffs

Source: MVC (2016)

Oak Bluffs' coastal ponds include Sengekontacket Pond, Lagoon Pond, Farm Pond, and Sunset Lake (Town of Oak Bluffs, 2015). Coastal ponds provide a wide array of ecosystem services directly to people (e.g., recreation opportunities) as well as important habitat to aquatic and avian species. Shellfishing and wildlife observation are particularly popular recreational activities at coastal ponds.

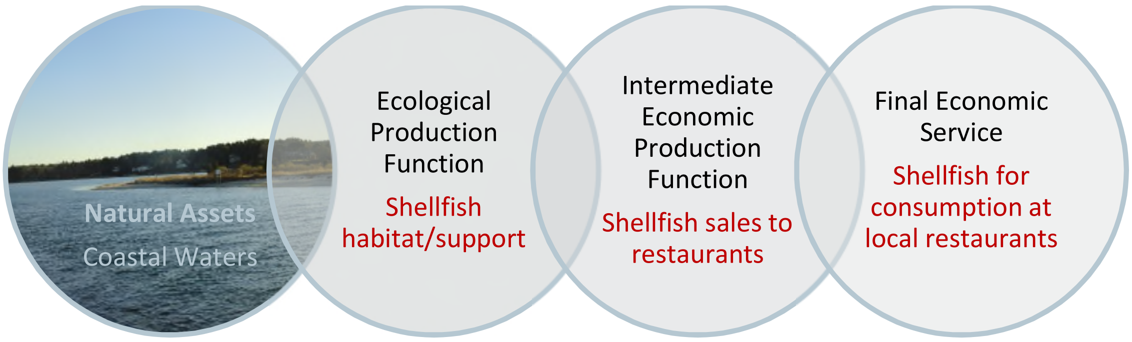
Salt marshes and eelgrass are additional notable elements of Oak Bluffs' water resources. Salt marshes, which comprise parts of Brush Pond and Farm Pond in Oak Bluffs (Town of Oak Bluffs, 2015), provide a wide range of ecosystem services that benefit wildlife and people, including ecological support for local wildlife, opportunities for wildlife viewing and photography, carbon sequestration, storm protection, and erosion control. Eelgrass, the dominant seagrass in the Oak Bluffs region, provides critical habitat for fish, shellfish, and birds (MOEEA, n.d.). Eelgrass also provides storm protection benefits by reducing wave energy and reducing the likelihood of wave damage (Möller et al., 2014).

Sunrise, Town Beaches *Liz Durkee*

2. Ecosystem Services

The natural assets within Oak Bluffs' coastal resources (i.e., coastal wetlands, beaches, trees and other vegetation, minerals, and animals) provide local communities with a diverse flow of goods and services. These ecosystem goods and services can be defined as the benefits people derive from nature (Millennium Ecosystem Assessment, 2005). For example, wetlands within Oak Bluffs' public coastal resources provide coastal protection through wave attenuation and shoreline stabilization (Shepard et al., 2011). *Figure 2-1* provides an example of the relationship between natural assets (coastal waters), coastal ecosystem functions, and final ecosystem services and goods contributing to human well-being.

Figure 2-1. Example Relationship between Natural Assets, Coastal Ecosystem Functions, and Ecosystem Goods and Services



2.1 Ecosystem Services Classification

To communicate and value the ecosystem services and benefits provided by Oak Bluffs' coastal resources, we used the Millennium Ecosystem Assessment (2005) framework that categorizes ecosystem services into four broad groups:

- ***Provisioning services*** are the goods that ecosystems provide to people, including food, timber, raw materials, water, and biochemicals.
- ***Cultural services*** include all non-material benefits obtained from ecosystems and can include recreational, educational, and spiritual benefits; preservation values (bequest, existence); and aesthetic beauty.
- ***Supporting services*** are necessary for the production of ecosystem services and include nutrient cycling and soil formation.
- ***Regulating services*** provide people with benefits such as carbon sequestration, flood regulation, and detoxification from the regulation of ecosystem processes.

Table 2-1 expands on the classification of ecosystem services and goods by identifying 21 ecosystem services corresponding to the four groups described above.

Table 2-1. Classification of Ecosystem Services and Goods Provided by Coastal Resources

Provisioning	Cultural	Supporting	Regulating
• Energy and raw materials • Food • Water supply • Medicinal resources • Ornamental resources	• Recreation and tourism • Science and education • Natural beauty • Spiritual and historic • Artistic and cultural information	• Habitat and nursery • Genetic resources	• Climate stability • Air quality • Flood control • Soil formation • Soil retention • Biological control • Pollination • Waste treatment • Water regulation

2.2 Key Ecosystem Services Provided by Oak Bluffs' Coastal Resources

The coastal resources in Oak Bluffs provide a variety of ecosystem services and goods to the local community, including recreational, commercial, and cultural opportunities, as well as wildlife protection and environmental services. This chapter introduces each ecosystem service category. Subsequent chapters provide detailed descriptions and the estimated value of each service category.

2.2.1 Provisioning Services

Oak Bluffs' coastal resources support fish and shellfish populations that drive the local commercial fishing and shellfishing industries. Bay scallops, quahogs, and soft-shell clams are all commercially harvested in Oak Bluffs, providing employment and income to local residents. In 2016, Oak Bluffs issued 17 commercial shellfishing licenses. According to the Oak Bluffs Shellfish Constable (David Grunden, personal communication), 27,333 pounds of shellfish were caught commercially in Oak Bluffs in 2016. To encourage more commercial shellfishing in Oak Bluffs, the Martha's Vineyard Shellfish group has co-opted the former state lobster hatchery in Lagoon Pond to grow out shellfish seed. In particular, the group spawns quahogs, oysters, and scallops (Wells, 2011). Additionally, Oak Bluffs Harbor supports much of the town's commercial fishing by serving as the home base for six commercial fishing vessels and supporting a commercial quahog fishery in the winter months (Town of Oak Bluffs, 2015).

Scallops from Lagoon Pond *Sam Moore*

2.2.2 Cultural Services

Tourism and Recreation

Oak Bluffs and its coastal resources provide a variety of recreational activities for island residents and visitors alike. Oak Bluffs is known for its many acres of free, public beaches with calm water. Town residents enjoy unrestricted access to beaches, many of which are easily accessible from downtown. As a result, Oak Bluffs is a popular location for beach recreation. Popular swimming areas include Joseph Sylvia State Beach, Oak Bluffs Town Beach, Eastville Point Beach, Lagoon Pond, and Sengekontacket Pond (Town of Oak Bluffs, 2015).

Oak Bluffs is also a popular location for recreational fishing and shellfishing, as it houses a variety of aquatic species that are popular among recreational and commercial fishers. Available species include quahogs, bay scallops, striped bass, bluefish, oyster, and eel, among other species (O'Higgins et al., 2010; Town of Oak Bluffs, 2015). Certain species—such as periwinkles, slipper shells/sweet meats, razor clams, and mussels—are solely fished recreationally (Town of Oak Bluffs, 2015). Further attracting recreational fishers to Oak Bluffs is the Oak Bluffs Fishing Pier, the largest recreational fishing pier in Massachusetts (Sigelman, 2014). Oak Bluffs also hosts several fishing competitions, including the annual Oak Bluffs Bluewater Classic, the annual Martha's Vineyard Striped Bass and Bluefish Derby on a rotating basis with the other Martha's Vineyard towns, and the annual Kids Fishing Derby. The Oak Bluffs Bluewater Classic is a 3-day overnight tournament at Oak Bluffs Marina that welcomed 35 participating vessels in 2016 (Oak Bluffs Bluewater Classic, 2017). The Martha's Vineyard Striped Bass and Bluefish Derby is a month-long fall derby that has attracted over 3,200 participants for the past several years (Elizabeth Durkee, personal communication). The Annual Kids Fishing Derby is a two-hour annual event with more than 300 child participants that takes place at the Oak Bluffs Steamship Authority wharf (Ewing, 2016).

Boating and sailing are other popular activities supported by Oak Bluffs' coastal resources. Oak Bluffs Harbor sees upwards of 10,000 boats visiting per year (Elizabeth Durkee, personal communication). The Harbor supports boating through private piers, boat slips, transient moorings, and private moorings. Additionally, Lagoon Pond is a favored location for sailors, with sailboat rentals available at the pond. Children can take part in a free sailing program at the town-owned Sailing Camp Park. Sengekontacket Pond also has a public boat ramp, increasing public access to water-based recreation (Town of Oak Bluffs, 2015). Other popular water-based recreational activities supported include water sports (e.g., kayaking, windsurfing, stand-up paddling, parasailing), wildlife viewing, and sightseeing along scenic roadways. Lagoon Pond offers equipment rentals for various water sports.

More than 300 species of birds inhabit and visit Martha's Vineyard, drawing birding enthusiasts from around the world (Martha's Vineyard Chamber of Commerce, n.d.). Beaches, salt ponds, and marshes are hotspots for watching and photographic shorebirds and waterfowls and birds of prey (e.g., nesting ospreys). Bird-watching enthusiasts can use many miles of hiking trails for self-guided tours or take a personalized guided tour to learn about birds' identification, their behavior, and where to find them.

Heritage and Education

As an island town, Oak Bluffs has extensive cultural ties to the coasts. Oak Bluffs' public coastal spaces host many popular events each year, including community festivals such as the annual Harborfest and the Grand Illumination. In 2016, the Grand Illumination attracted approximately 6,500 visitors (Elizabeth Durkee, Conservation Agent, personal communication). Additionally, arts and music utilize Oak Bluffs' unique coastal resources. The annual Martha's Vineyard Sound Festival, a popular music festival, is held at Waban Park across from the Oak Bluffs Town Beach each July (Martha's Vineyard Sound Series, 2016). Band concerts occur every other Sunday night during the summer at Ocean Park, also located across from Oak Bluffs Town Beach (Elizabeth Durkee, Conservation Agent, personal communication). Many artists use the coast as inspiration, producing photographs, paintings, and other types of art that represent Oak Bluffs' coastline. Finally, cultural landmarks such as the East Chop Lighthouse are inextricably tied to the coast. The East Chop Lighthouse and town beaches are often used as sites for weddings and other special events (Town of Oak Bluffs, 2015).

2013 Oak Bluffs Harborfest *Michelle Gross*

2.2.3 Supporting Services

The coastal resources of Oak Bluffs provide habitat to a variety of important wildlife species, including commercially and recreationally valuable shellfish. As filter feeders, shellfish provide environmental benefits by improving water quality in coastal ponds. Coastal ponds also support many bird species, several of which are endangered, threatened, or species of special concern, such as piping plovers and roseate terns (see Appendix B for a list of all 27 species of concern under the Massachusetts Endangered Species Act with habitat in Oak Bluffs).

2.2.4 Regulating Services

Oak Bluffs' coastal resources provide a wide range of regulating services. According to a U.S. Fish and Wildlife Service (USFWS) study on wetlands of Cape Cod and the islands of Massachusetts, wetlands on Martha's Vineyard provide the following services: surface water retention; sediment and other particulate retention; coastal storm surge retention; shoreline stabilization; carbon sequestration; and nutrient transformation (Tiner, 2010).

Storm surge protection is one of the most important environmental services provided to Oak Bluffs by its coastal resources, including barrier beaches and wetlands. Barrier beaches and wetlands protect Oak Bluffs from storm surge and sea-level rise and provide the most natural and least expensive storm buffer available. Wetlands are able to store water and slowly release it, which reduces flood heights. These services are important because floodwaters can cause property damage and loss of life (MOEEA, 2017).

Wetlands also protect shorelines and stream banks against erosion. They buffer storm surges that can lead to coastal erosion, and wetland plants hold soil in place with their roots while absorbing the energy of waves and currents (MOEEA, 2017). Erosion control is a particularly important environmental service for Oak Bluffs, whose many valuable shorelines have wetlands at their margins.

Oak Bluffs' coastal resources also play in important role in removing air pollutants. Wetland plants in particular sequester large amounts of carbon dioxide, a greenhouse gas, in order to grow. Carbon is stored in wetland soils for long periods of time because it decomposes very slowly in anaerobic conditions (National Oceanic and Atmospheric Administration (NOAA), 2017). By sequestering and storing carbon dioxide rather than releasing it into the atmosphere, wetlands help mitigate against climate change. Terrestrial plants located in non-wetland coastal areas —including trees, shrubs, and herbaceous vegetation—also reduce carbon dioxide levels by sequestering carbon dioxide in their biomass or in the soil.

Salt Marsh at Sengekontacket Pond *Jeanna Shepard*

2.3 Valuation Methods

The ecosystem services supplied by Oak Bluffs' coastal resources provide economic value regionally and beyond. Some types of ecosystem goods and services are valued because they directly affect human welfare and contribute to human well-being (goods with "use" value), such as fish and shellfishing. Other types of ecosystem goods and services are valuable independently of any observable human use ("non-use" goods), such as a resident's desire to improve wildlife habitat along the coast, even if the resident never uses coastal waters for fishing or other recreation activities.

To show the diversity of natural capital benefits derived from Oak Bluffs' coastal resources, we evaluated each ecosystem service category individually. To avoid double-counting, we first determined which benefit categories we could analyze, and evaluated overlaps. We used a mix of quantitative and qualitative descriptions to demonstrate the extent and value of environmental services within Oak Bluffs' public coastal resources. *Table 2-2* shows the ecosystem services provided by the coastal resources and indicates whether we estimated a monetary value for a given service category.

Table 2-2. Ecosystem Services Provided by Oak Bluffs' Coastal Resources			
Service	**Aquatic Resources**	**Terrestrial Resources**	**Assessed Services**
Provisioning	Commercial fishing and shellfishing Aquaculture Kelp farming		Commercial shellfishing
Cultural	Water-Based Recreation Fishing Shellfishing Boating Swimming Other recreation (e.g., water skiing) Aesthetic (water clarity/color) Property values Scenic vistas Non-use Aquatic biodiversity Education and outreach Education and outreach activities	Land-Based Recreation Beach going Birdwatching Wildlife viewing Hiking/nature enjoyment Other recreation (e.g., camping) Aesthetic (landscape effects) Property values Scenic vistas Non-use Wildlife and plant biodiversity Regional character Education and outreach Forest education and outreach activities	Services assessed in monetary terms: Fishing Shellfishing Boating Beach going Wildlife viewing
Supporting	Wetland habitat Seagrass habitat Beaches & sand dunes Threatened & endangered species	Habitat and Nursery Genetic Resources	Wetland habitat Seagrass habitat
Regulating	Hydrology Shoreline stabilization Wave attenuation Floodwater attenuation Water Quality Filtration/nutrient removal from oyster and quahog fisheries	Air Air pollutant removal Carbon storage and sequestration Reduction in air temperature volatility Soil Erosion control Sediment retention	Services assessed in monetary terms: Air pollutant removal Carbon storage Carbon sequestration Nitrogen and carbon sequestration from oyster and quahog fisheries

Notes: This study assesses the value of the ecosystem services and goods provided by Oak Bluffs' public coastal resources. Additional management efforts could improve the total value of environmental services.

We use a mix of valuation approaches to estimate the monetary values of ecosystem goods and services. Some ecosystem goods, such as commercial shellfishing, are valued and sold in markets. We valued these services using market data. Ecosystem services that cannot be measured in terms of market values because no direct exchange of money takes place have a non-market value (Bateman et al., 2010; Freeman, 2003). Our approaches to estimating a monetary value of non-market goods and services reveal the implicit value of these goods by examining behaviors related to the service or by using values elicited based on stated preferences. For example, economists may conduct a survey that asks how much households would agree to pay to protect coastal wetland habitat or recreational beach access. An alternative approach to valuing non-market services is to examine the expenditures associated with relevant activities. In this report, we use results from stated preference studies to value habitat support services in coastal wetlands and eelgrass beds, and we derive the implied value of recreation (e.g., fishing, beach going) based on travel costs incurred by consumers of recreation activities to enjoy services provided Oak Bluffs' coastal resources.

Because conducting a primary resource valuation study of ecosystem services provided by Oak Bluffs public coastal resources is not within the scope or resources of this project, we apply benefit transfers from existing resource valuation studies. This is a common and accepted approach to adapting benefit values first estimated in one context to a second context that is similar, but for which time or data prevent a new, from-the-ground-up economic study (Freeman, 2003; U.S. EPA, 2010; U.S. Office of Management and Budget, 2003). Benefit transfer can generate reasonable estimates faster and at a fraction of the cost of conducting site-specific primary studies.

In developing the benefit transfer approach for this study, we followed three key steps recommended in U.S. EPA's Guidelines for Economic Analysis, including: (1) detailing the policy case (coastal resource protection) for which value estimates are desired, (2) selecting studies from existing economic research that match the policy case, and (3) transferring values. Subsequent chapters of this report detail valuation methods for key ecosystem services analyzed in this study (i.e., provisioning, cultural, supporting, and regulating).

2.4 Main Elements of the Analysis

Our analysis assesses coastal resource benefits under baseline conditions in the year 2016. *Figure 2-2* summarizes the main elements and key assumptions of our analysis. We report all estimated economic values as of 2016, accounting for discounting and the passage of time until the flow of ecosystem services occurs.

Figure 2-2. Main Analysis Elements and Key Assumptions

Time Frame

We analyze the value of ecosystem services provided by Oak Bluffs' coastal resources under "current" conditions (as of 2016). We assume that the stream of ecosystem services provided by coastal resources will continue through 2050, resulting in a 34-year analysis period. The present value of preservation is the sum of benefits in all years of the analysis (discounted to reflect the timing of the production of benefits as discussed below).

Dollar Year

For comparability across time, we present all monetary values in present-day currency (2016 dollar value). Where necessary, we convert value estimates to 2016 dollars using the GDP deflator. Implicit price deflators "are calculated as the ratio of the current-dollar to the corresponding chained-dollar value, multiplied by 100" (U.S. Bureau of Economic Analysis, 2012, p. 2-14).

Discounting Benefits Over Time

When asked if one wants to receive a certain benefit today versus tomorrow, many say they would prefer to have the benefit today. These people "discount" the value of future benefits. Benefits occurring farther in the future are less valuable from today's perspective.

We account for society's time preferences by discounting future value of ecosystem services. To properly express—in today's dollars (2016$)—the total value of ecosystem services occurring decades from now, we apply a *discount rate* to future benefits.

Following the conventions of economic analyses concerned primarily with social benefits, we discount future benefits at 3% per year. Discounting benefits at 3% means that $1 to be received in 2017 is worth $0.97 today (in 2016).

Following standard practices (U.S. EPA, 2010), we annualize the present value of benefits using the equation:

$$AB = PV \cdot \frac{d * (1+d)^n}{(1+d)^n - 1} \qquad \text{(Eq. 2-1)}$$

where:

AB = Annualized benefit,

PV = Present value of the benefit stream (estimated for each service),

d = Discount rate (3%), and

n = Number of years in the analysis period (34 years).

3. Provisioning Services

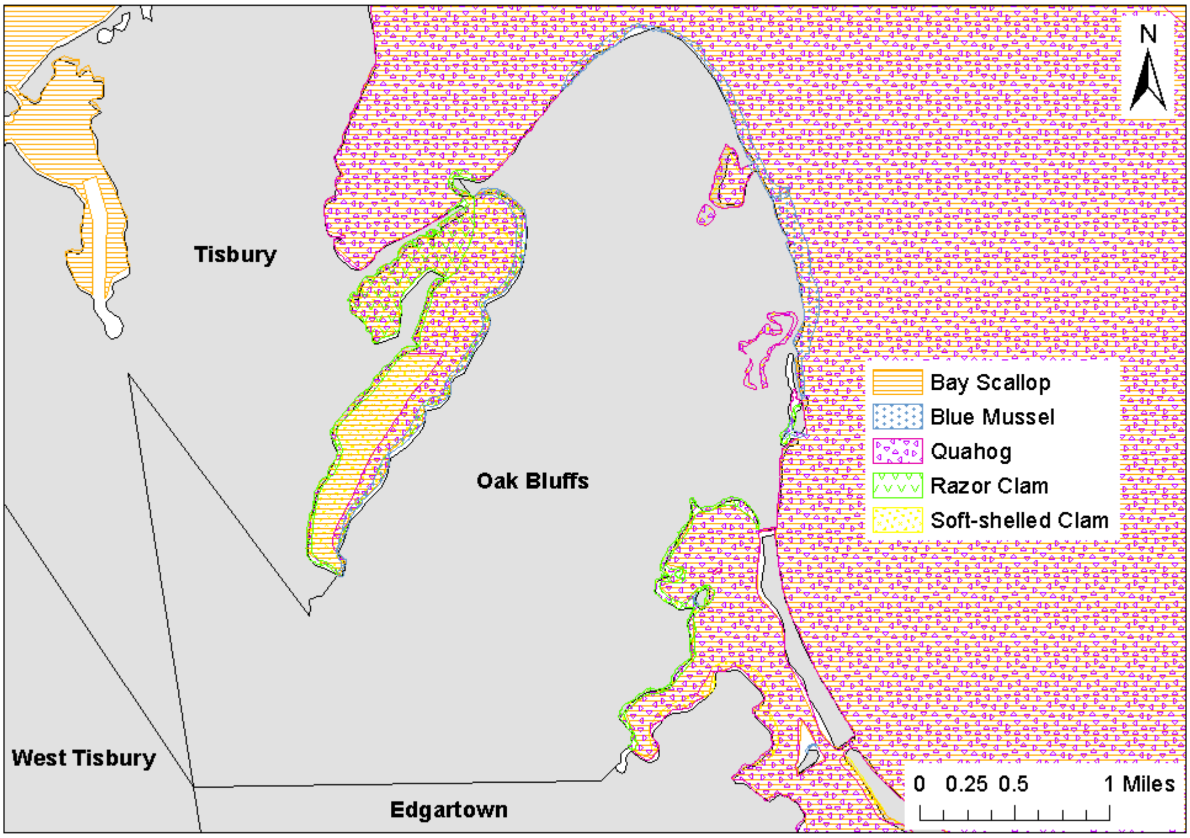
Oak Bluffs' public coastal resources support provisioning services for commercial shellfishing, fishing, and aquaculture that lead to food production. Because these provisioning services can be bought and sold in the marketplace, we valued them based on their market value. Below, we provide separate descriptions of (1) shellfish, (2) finfish, (3) aquaculture, and (4) kelp farming provisioning services. Due to data limitations, we were able to provide an estimate of the economic value only of shellfish production; we provide only qualitative information about the remaining services.

3.1 Shellfish

Commercial Shellfishing in Lagoon Pond *Mark Lovewell*

Coastal resources in Oak Bluffs support fisheries for several different types of shellfish, including bay scallops, quahogs, and soft-shell clams. All coastal waters in Oak Bluffs are classified as Designated Shellfish Growing Areas by the Division of Marine Fisheries (MassGIS, 2017). The harvest of shellfish for direct human consumption is allowed in all coastal waters surrounding Oak Bluffs as long as temporary closures are not in effect. Currently, no shellfish take is allowed from Farm Pond and Brush Pond due to their "prohibited" classification status from the Massachusetts Division of Marine Fisheries. *Figure 3-1* shows Shellfish Suitability Areas, or potential habitat areas for shellfish, around Oak Bluffs. The map depicts areas that are believed to be suitable for shellfish based on the expertise of the Massachusetts Division of Marine Fisheries and local shellfish constables, input from commercial fishermen, and information contained in maps and studies of shellfish in Massachusetts. The map includes sites where shellfish have been observed since the mid-1970s, but these sites may no longer support any shellfish (MassGIS, 2011).

Figure 3-1. Map of Shellfish Suitability Areas in Oak Bluffs



Source: MassGIS (2011)

In the state of Massachusetts, each town with shellfish resources is tasked with managing the fishery, even though shellfish are considered a state resource (Lagoon Pond Association, n.d.). The majority of commercial shellfishing occurs in Sengekontacket Pond, where commercial diving for bay scallops is permitted (Town of Oak Bluffs, 2015). Recreational shellfishing is also popular in Sengekontacket Pond. Common shellfish species in Sengekontacket Pond include quahogs, soft-shell clams, oysters, bay scallops, blue claw crabs, blue mussels, and ribbed mussels (Friends of Sengekontacket, n.d.).

Lagoon Pond and Oak Bluffs Harbor are also popular shellfishing locations. Oak Bluffs Harbor is exclusively used for commercial shellfishing, while Lagoon Pond is popular for recreational shellfishing. Quahogs and soft-shell clams are available year-round, though most shellfishing activity occurs during the warmer months. Bay scallops, another common species in Lagoon Pond, are available in the winter starting at the end of October to early November (Lagoon Pond Association, n.d.).

The Oak Bluffs Shellfish Department recently started managing an oyster fishery in Sengekontacket Pond that is open only to recreational shellfishing. In 2016, the recreational shellfish harvest included 213 bushels of bay scallops, 448 bushels of quahogs, 52 bushels of soft-shell clams, and 36 bushels of oysters. Oak Bluffs sold 699 recreational shellfishing licenses in 2016, including residential and non-residential, generating $14,000 from license fees (David Grunden, Shellfish Constable, personal communication). In this chapter, we do not monetize recreational catch because the recreational analysis (see Chapter 4) accounts for the value of recreational shellfishing.

Below, we estimate the monetary value of commercial shellfish operations, which comprises (1) the revenue from commercial shellfishing licenses, (2) dockside revenue generated through the sale of commercial shellfish, and (3) the "flow-on" benefits of shellfishing that result from investments of shellfishing profits into the local economy.

3.1.1 Revenue from Commercial Shellfish Licenses

Oak Bluffs sold 17 commercial shellfishing licenses in 2016, generating $5,950 from license fees ($350 each). The number of commercial licenses sold has declined slowly over time. We estimated commercial license revenue over time by assuming that the number of commercial licenses sold declines by 2.5% each year throughout the 2016-2050 study period (rounding to the nearest whole number). We estimate that the total present value of commercial shellfish license revenue is $95,478.

3.1.2 Dockside Revenue from Commercial Shellfish Catch

Commercial catch in 2016 included 599 bushels of bay scallops, 278 bushels of quahogs, and 12 bushels of soft-shell clams. The estimated value of Oak Bluffs' commercial shellfish catch in 2016 is $138,448, including $115,308for bay scallops, $22,240for quahogs, and $900 for soft-shell clams (David Grunden, Shellfish Constable, personal communication).

To determine the TPV of commercial shellfish catch, we assume that commercial catch will remain relatively stable throughout the 2016-2050 study period. The annual bay scallop catch in Oak Bluffs has fluctuated over the past couple of decades (David Grunden, Shellfish Constable, personal communication). We thus anticipate that some years in the study period will have higher catch while other years will have lower catch, and we assume that the variations will balance out. The quahog fishery has been relatively stable, with increasing recreational catch. Commercial soft-shell clam catch is typically small since the fishery is primarily recreational (David Grunden, Shellfish Constable, personal communication). We calculated the TPV using a 3% discount rate. We estimate that the total present value of commercial shellfish catch supported by Oak Bluffs' coastal resources is $3.06 million ($0.14 million annually; *Table 3-1*).

Table 3-1. Value of Shellfish Catch in Oak Bluffs (2016$)

Type of Shellfishing	Lbs. Harvested[1]	Annual Value[2]	TPV[3] (2016-2050, Millions $)
Commercial	27,333	$138,448	$3.06
Bay Scallops	4,193	$115,308	$2.55
Quahogs	22,240	$22,240	$0.49
Soft-Shell Clams	900	$900	$0.02
Recreational[4]	43,391	NA	NA
Bay Scallops	1,491	NA	NA
Quahogs	35,840	NA	NA

Table 3-1. Value of Shellfish Catch in Oak Bluffs (2016$)			
Type of Shellfishing	**Lbs. Harvested[1]**	**Annual Value[2]**	**TPV[3] (2016-2050, Millions $)**
Soft-Shell Clams	3,900	NA	NA
Oysters	2,160	NA	NA
Total	**70,724**	**$138,448**	**$3.06**

[1] Pounds of harvested bay scallops based on shucked meats.
[2] Based on 2016 catch.
[3] TPV estimated using a 3% discount rate.
[4] Annual and total present value of recreational harvest not provided because recreational analysis includes value of recreational shellfishing (see Chapter 4).

3.1.3 Flow-On Impacts

Dockside revenue from shellfish catch only covers the first-order impacts. Local shellfishers reinvest money earned from harvesting shellfish into the local economy. Flow-on impacts to the region can be estimated using either an input-output model or an economic multiplier. For this analysis, we used an economic multiplier of 2.4 from Abt Associates (2016a) to estimate flow-on impacts from commercial shellfish catch in Oak Bluffs. We applied this multiplier to the estimated value of commercial shellfish catch to determine the flow-on economic impacts of commercial shellfishing within Oak Bluffs' public coastal resources. Commercial shellfishing accounts for $332,275 in annual flow-on impacts ($7.35 million TPV) in addition to the dockside harvest revenue, assuming relatively stable commercial shellfish catch throughout the 2016-2050 study period.

3.1.4 Total Value for Commercial Shellfishing

We estimated the total annual value of commercial shellfishing in Oak Bluffs at $476,673 (*Table 3-2*). This estimate includes $5,950in commercial shellfishing license fees, $138,448 in shellfish catch revenue, and $332,275 in flow-on impacts. Using a 3% discount rate, the TPV of commercial shellfishing in Oak Bluffs is $10.51 million.

Table 3-2. Total Economic Value of Commercial Shellfishing in Oak Bluffs' Public Coastal Resources (2016$)		
Valuation Method	**Annual Value[1]**	**TPV[2] (2016-2050, Millions $)**
License Revenue	$5,950	$0.10
Shellfish Catch	$138,448	$3.06
Flow-on Impacts	$332,275	$7.35
Total	$476,673	$10.51

[1] Based on the number of commercial shellfishing licenses sold and commercial shellfish catch in 2016.
[2] TPV is estimated using a 3% discount rate.

3.2 Finfish

Only a portion of finfish landings can be attributed to Oak Bluffs' coastal resources. A good portion of commercial catch is taken from the deep ocean, far from the coast. Because very little commercial fishing is done within the boundaries of Oak Bluffs' coastal resources, we do not estimate a monetary value of commercial fisheries in this report. Oak Bluffs' coastal resources indirectly support commercial fisheries by providing nursery habitat for game fish and their prey (see Chapter 5). Commercial fish landings in Oak Bluffs include both finfish and shellfish. Separate finfish estimates are not available due to confidentiality concerns. The amount of commercial fish and shellfish landed in Oak Bluffs has consistently declined over the past few years (*Table 3-3*).

Table 3-3. Total Oak Bluffs Commercial Fish and Shellfish Landings (2016$)

Year	Landings (Lbs.)	Annual Value
2013	310,227	$ 744,545
2014	229,729	$ 616,700
2015	206,369	$ 555,422
2016	170,097	$ 504,970
Source: Massachusetts Division of Marine Fisheries (2017a)		

Recreational fishing along the coast is a common and economically valuable activity in Oak Bluffs. Popular finfish species include striped bass, bluefish, Spanish mackerel, and bonito (O'Higgins et al., 2010; Town of Oak Bluffs, 2015). The monetary value of recreational opportunities, including fishing, is presented in Chapter 4.

Oak Bluffs Harbor *Timothy Johnson*

3.3 Aquaculture

Oak Bluffs supports "orderly development of Aquaculture that is complementary to the continued development of the Town's fisheries" (Town of Oak Bluffs, 2016). Aquaculture applicants must pay a non-renewable application fee of $100.00 and an annual renewal application fee of $25.00. Accepted licenses require a reasonable amount of production, defined at no less than $1,500 per acre based on current market value (Town of Oak Bluffs, 2016). We were unable to estimate the monetary value of aquaculture due to data confidentiality issues. Instead, this section qualitatively discusses oyster farming in Oak Bluffs.

Cottage City Oysters runs a two-acre offshore oyster farm in Oak Bluffs off the Eastville Beach coast (Elvin, 2016). The operation is run by two brothers, Dan and Greg Martino. In 2015, the farm's first year of operation, the Martino brothers tested different densities in mesh bags that hold the oysters to ensure optimal growth. After determining optimal densities, Dan and Greg Martino cultivated approximately 50,000 oysters in 2016. Since the crop quickly sold out, the Martino brothers plan to expand their operation to meet demand. The Cottage City Oysters' mission statement states that their oysters get their good looks and taste from the cold, clean, swift-moving currents of the Vineyard Sound (Cottage City Oysters, n.d.). Cottage City Oysters is Martha's Vineyard only offshore oyster farm (Elvin, 2016).

3.4 Kelp Farming

In addition to the offshore oyster farm, Dan and Greg Martino from Cottage City Oysters also hold a permit for a commercial kelp farm (Brown, 2017). Kelp is touted as a super food that can be added to smoothies or salads. Kelp is also used in beauty products and could possibly serve as a biofuel alternative. Additionally, kelp growth may have nitrogen removal benefits (Brown, 2017). Cottage City Oysters is working with the Martha's Vineyard Shellfish Group to test kelp farming in the area, learning how to seed, grow, harvest, and process the kelp as well as how to market it to local businesses and Martha's Vineyard residents. The Martino brothers plan to connect with local chefs to learn how to prepare the kelp properly (Berlow, 2016). We were unable to estimate monetary value of kelp farming due to data limitations. The remainder of this section qualitatively discusses this new initiative.

Dan and Greg Martino and Chilmark shellfisher Stanley Larsen are the first to hold commercial kelp permits in the state of Massachusetts (Brown, 2017). State permitters are currently using shellfish regulations as guidelines and are monitoring the testing efforts to work out any regulatory kinks. Despite many remaining questions, the state of Massachusetts is supportive of early kelp farming efforts. Christopher Schillaci, a state fisheries biologist, said kelp farms "join shellfish in the sense that if properly managed [they] can provide benefits to the environment, which is very different than most crops" (Brown, 2017).

Although commercial kelp farming is still in its initial stages, growing kelp helps Cottage City Oysters diversify their crop. Kelp is a cold-water crop that grows in the winter months. Dan and Greg Martino plant the kelp crop in December and harvest at the end of March to early April. The oyster seed arrives in early April, completing the full-year growing cycle for a farmer (Berlow, 2016).

3.5 Limitations and Uncertainty

Table 3-4 summarizes key limitations and uncertainties in the analysis of benefits associated with provisioning services in Oak Bluffs' public coastal resources and indicates the direction of any potential bias.

Table 3-4. Limitations and Uncertainties in the Analysis of Provisioning Services Benefits

Issue	Effect on Benefits Estimate	Notes
Uncertainties in future commercial shellfish catch and license revenue	Uncertain	To calculate total present value of commercial shellfish catch for the entire study period (2016-2050), we assumed that shellfish catch will remain relatively constant and that any annual fluctuations will balance out. Actual commercial catch in future years may be higher or lower than our estimates. Our projections do not account for potential climate change impacts on commercial shellfish harvest, which could cause significant declines in bay scallops and soft-shell clams (Abt Associates, 2016a). We also assumed that commercial license sales decline slowly throughout the study period based on recent trends. Actual sales may be higher or lower than our estimates.

4. Cultural Services

4.1 Recreation

Americans spend an estimated $887 billion per year[1] on outdoor recreation trips (Outdoor Industry Association, 2017). Recreational boating activity in Massachusetts' coastal and ocean waters generates an estimated $883 million each year for the local economy (2016$; Hellin et al., 2011). Among Massachusetts' 2.2 million residents in the year 2011, 532,000 (24%) fished, 56,000 (3%) hunted, and 1.8 million (83%) participated in wildlife-watching activities, which includes observing, feeding, and photographing wildlife (U.S. Department of the Interior et al., 2011). In 1995, 61.5% of Massachusetts residents had visited Massachusetts' coastal beaches and shorelines within the last year for a projected usage of nearly 111 million person-trips annually (Commonwealth of Massachusetts, 2006).

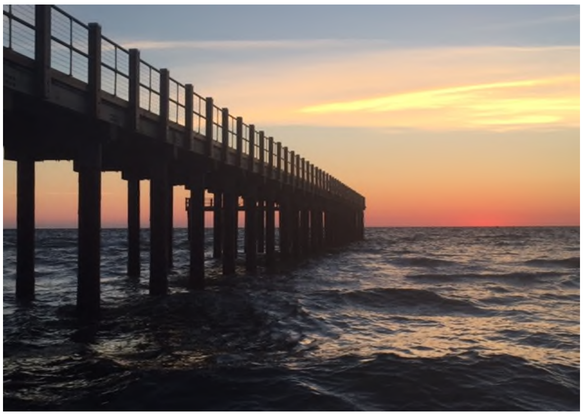
Martha's Vineyard is one of coastal Massachusetts' iconic recreation destinations. The population during peak summer tourism is nearly five times greater than the year-round population (MVC, 2011). Oak Bluffs and Edgartown, two of the six towns on Martha's Vineyard, attract the highest number of tourists during the summer season due to their public beaches, scenic views, restaurants and shops, and proximity to the ferry. Tisbury also attracts a large tourist population and has the third highest average summer population average (MVC, 2011), partly because of the year-round ferry service to Vineyard Haven, one of Tisbury's communities (Steamship Authority, 2017).

Oak Bluffs' coastline is surrounded by many acres of public beaches, salt marshes, and coastal ponds that provide excellent recreation opportunities. Both residents and visitors utilize these resources for swimming, beach going, fishing, shellfishing, boating, and wildlife viewing. In particular, Oak Bluffs offers exceptional fishing opportunities for town residents and guests. Popular fishing locations include Eastville Point Beach, Joseph Sylvia State Beach, Upper Lagoon Pond, and Sengekontacket Pond. Common recreational fishing and shellfishing species include striped bass, bluefish, bay scallops, quahogs, soft-shell clams, and oysters (Town of Oak Bluffs, 2015). Oak Bluffs contains the largest recreational fishing pier in Massachusetts (Sigelman, 2014) and hosts several fishing competitions, including the annual Oak Bluffs Bluewater Classic and the annual Kids Fishing Derby (Town of Oak Bluffs, 2015). Oak Bluffs also hosts the annual Martha's Vineyard Striped Bass and Bluefish Derby on a rotating basis with the other Martha's Vineyard towns (Town of Oak Bluffs, 2015; Elizabeth Durkee, Conservation Agent, personal communication). Water sports—including kayaking, windsurfing, stand-up paddling, and parasailing—are also popular activities that are supported by equipment rental businesses along Lagoon Pond, Sengekontacket Pond, and Oak Bluffs Harbor (Town of Oak Bluffs, 2015).

[1] Estimate is based on a compilation of national surveys about annual recreation trips and typical spending on outdoor recreation products (gear, apparel, footwear, equipment, services and vehicle purchases) and trip and travel expenses (Outdoor Industry Association, 2017).

Kayakers on Sengekontacket Pond — *Timothy Johnson*

Inkwell Beach — *Ralph Stewart*



Fishing Pier — *Liz Durkee*

Bikers Along State Beach — *Timothy Johnson*

Wildlife viewing, photography, and sightseeing are well supported by more than 16 miles of spectacular coastline in Oak Bluffs. Birdwatching at Sengekontacket Pond and Lagoon Pond is popular, as many species of birds use the pond shores and islands for nesting and foraging (Town of Oak Bluffs, 2015). Bird species present include endangered and threatened birds such as least terns, roseate terns, common terns, and piping plovers, as well as common birds such as Canada geese, mute swans, and cormorants. Upper Lagoon Pond is also popular for wildlife viewing because it is home to many varieties of turtles, as well as river otters and muskrats. Furthermore, Sea View Avenue, East Chop Drive, and East Chop Bluff provide beautiful scenic views for sightseers, recreational walkers, runners, and bicyclists (Town of Oak Bluffs, 2015; Elizabeth Durkee, Conservation Agent, personal communication). Several road races occur along the scenic East Chop bluffs, including the annual 5K Sullivan Run, the Oak Bluffs Memorial 5K, and the Columbus Day 5K (Stewart, 2017; Rupolo, 2016).

Residents' and visitors' appreciation for the outdoor opportunities offered by the Oak Bluffs coastal resources is reflected in the non-market value of coastal recreation and contribution of tourism spending to the local economy. This chapter estimates economic benefits of recreation opportunities offered by Oak Bluffs' public coastal resources. We estimate total value of public coastal resources, using the number of recreation trips that Oak Bluffs residents and visitors take each year, and the monetary value of these visits using benefit transfer from existing studies of willingness to pay (WTP) for coastal recreation. We then estimate the economic impact of tourism and recreation on Oak Bluffs' economy using direct expenditures and flow-on impacts. Finally, we calculate the total value of social benefits from the recreational opportunities provided by the coastal resources.

4.1.1 Total Recreational Value of Oak Bluffs' Public Coastal Resources

To estimate the total recreational value of public coastal resources, we first estimated the number of use-days of those resources in each year, by both residents and non-residents. Next, we multiplied those use-days by the per-day value of recreational trips. For the first step, estimating the number of participation days for outdoor recreation in Oak Bluffs, we used four primary data sources:

- NOAA's National Ocean Recreational Expenditure (NORE) (NOAA, 2012)
- Summer population estimate for Martha's Vineyard (MVC, 2011)
- Martha's Vineyard visitor survey (MVC, 2006)
- Recreational fishing and shellfishing license data (Massachusetts Division of Marine Fisheries, 2017b)

We provide more details about each step of the analysis in the sections below.

Estimating Residential Participation in Outdoor Recreation

To estimate the number of residential participation days in outdoor recreational activities, we used the NORE survey's ocean recreation participation rates for coastal residents in New England and average number of trips for each activity (NOAA, 2012). NORE provides participation percentages for many different coastal activities. For our analysis, we used the participation percentages for beachcombing (beach going), fishing,[2] boating, wildlife viewing, and outdoor activities not involving water contact (i.e., biking and hiking).

We based the participation percentage for shellfishing on the number of residential shellfishing licenses in 2016. The recreational shellfishing participation rate in Oak Bluffs was much higher in 2016 (15.8%) than the NORE participation rate for New England coastal counties (5.4%), and the number of recreational shellfishing licenses sold in Oak Bluffs has been steadily rising over the past few years (David Grunden, Shellfish Constable, personal communication). We thus used the NORE participation rate to estimate recreational fishing participants throughout the study period (2016-2050). We assumed that the participation percentages and average number of recreational days for each activity remained constant throughout the study period.

To estimate the number of participants for each activity, we multiplied the residential participation rate by the number of Massachusetts residents who are 18 years or older. To estimate the number of recreational trips, we multiplied the number of residential participants for each activity by the average number of

[2] We compared the estimated number of fishing participants in 2016 derived using the NORE participation rate to the actual number of residential fishing licenses sold in 2015, the most recent year available. For recreational fishing, the number of residential participants in 2016 derived using the NORE participation rate (428) was identical to the number of recreational fishing licenses sold in 2015 (Massachusetts Division of Marine Fisheries, 2017b), the latest year available.

recreational days for residents in the Northeast region in 2012. We accounted for population changes by using population projections for Oak Bluffs from 2015 to 2035 (University of Massachusetts (UMass) Donahue Institute, 2015). Because the 2015, 2020, 2025, 2030, and 2035 population estimates are almost linear as a function of year, we interpolated population estimates for the intermediate years (e.g., between 2015 and 2020) and extrapolated values for the years 2036 through 2050 linearly.

Table 4-1 presents the participation percentages, estimated number of recreational participants for each activity in 2016, average number of recreational days per participant, and the estimated number of participation days for each activity in 2016. The estimated number of participation days varies for each year in the study period based on population projections.

Table 4-1. Residential Participation Days in 2016

Activity	NORE Participation % for Coastal Residents in New England	# Residential Participants (2016)	NORE Average Annual Number of Recreation Days in Northeast Region	Residential Participation Days (2016)
Beachcombing	26.9%	1,030	12.69	13,074
Fishing	11.2%	428	11.47	4,911
Shellfishing[1]	15.8%	604	7.15	4,320
Boating	16.6%	633	8.37	5,299
Wildlife Viewing	39.4%	1,506	16.43	24,741
Non-water contact	25.0%	956	16.37	15,653
Total		**5,157**		**67,998**

Source: NOAA (2012).

[1] Shellfishing participation rate is based on the number of residential shellfishing licenses sold in 2016.

Estimating Non-Resident Participation in Outdoor Recreation

To estimate the number of non-residential participation days in outdoor recreational activities, we used the Martha's Vineyard Commission's (MVC, 2011) estimated average summer population for Oak Bluffs. The summer population estimate is divided into several categories: year-round residents, guests of year-round residents, seasonal/vacationers (on island for a week or more), transients (on island for less than a week), and day trip participants. We used the daily peak summer estimate for mid-June through Labor Day (81 days). For early and late season, we apportioned the peak population estimate based on the number of visitor booth check-ins during these times relative to the peak summer period. We estimate that the non-resident population is approximately 40% of the summer peak in late May and early October (30 days total) and 55% of the summer peak in early June and post-Labor Day September (41 days total).

When estimating the number of recreational participation days for each activity, we assumed that visitors would participate in non-outdoor activities on rainy days. We calculated 5-year average precipitation days (precipitation greater than 0.20 inches) for each summer month using historical precipitation measurements for Edgartown, MA, the town closest to Oak Bluffs with available data (U.S. Climate Data, 2017), and subtracted rainy day visitation from our calculations. On average, Oak Bluffs experiences rain during approximately 18 days of the 152-day tourist season. We then multiplied the number of non-rainy day visitors by the expected participation percentages for each activity. Survey results (MVC, 2006) provided weekly participation rates for seasonal residents and visitors in addition to daily rates for day trip participants. To avoid overestimating participation days, we combined similar activities when possible. For example, we combined walking/hiking with nature viewing and used the participation rates for walking/hiking, the more common activity. We also combined boat-based fishing with recreational boating and used the participation rates for boating. Based on national survey data (U.S. Department of the Interior et al., 2011), 65% of saltwater anglers fish from boats and 35% fish from shore. We thus multiplied the fishing participation percentages by 0.35 to calculate the participation rate for shore-based fishing only. We then apportioned the participation rates across all activities to sum to 100% among the included outdoor activities (*Table 4-2*). Lastly, we summed the participation day estimates from late May to early October to obtain the annual number of non-resident participation days for each activity.

Some visitors may participate in more than one outdoor recreation activity on a given day, but our analysis only accounts for one outdoor activity per person per non-rainy day. Our analysis also does not account for non-resident participation days from late October through early May.

Table 4-2. Non-Resident Outdoor Recreation Participation Rates

Visitor Category	Beach Use	Fishing	Boating	Wildlife Viewing	Biking	Total
Guests of Year-Round Residents	37%	4%	14%	26%	19%	100%
Seasonal/Vacationers	37%	4%	14%	26%	19%	100%
Transients	38%	2%	8%	36%	16%	100%
Day Trip Participants[1]	36%	0%	3%	49%	12%	91%

[1] The participation rates for day trip participants do not sum to 100%. Survey results (MVC, 2006) indicate that some day trip participants do not engage in outdoor recreation and instead participate in activities such as shopping and dining.

To account for visitation changes over time, we modified the number of guests of year-round residents and seasonal/vacationers using population projections for Oak Bluffs from 2015 to 2035 (UMass Donahue Institute, 2015) and household estimates from the U.S. Census (average number of people per household, percentage of year-round occupied housing units). We interpolated population estimates for the intermediate years (e.g., between 2015 and 2020) and extrapolated values for the years 2036 through 2050 linearly. Following the methods used in the original summer population estimate (MVC, 2011), we calculated the number of guests of year-round residents as 0.7 persons per year-round household and the number of seasonal/vacationers as 4.77 persons per seasonal household. To account for changes in the number of day trip participants, we used weighted population growth rates for Massachusetts and Rhode Island (UMass Donahue Institute, 2015; Rhode Island Statewide Planning Program, 2013). We assumed that the participation percentages, average number of people per household, and ratio of year-round to seasonal housing remain constant throughout the study period. We also assumed that the number of transients remains constant throughout the analysis but recognize that Airbnb and other house-sharing programs could have a substantial impact on the number of transients (Christine Flynn, Martha's Vineyard Commission, personal communication).

Table 4-3 presents the daily peak summer population numbers for each visitor category in 2016 and the estimated number of participation days for each recreational activity in 2016. The estimated number of participation days varies for each year in the study period based on population and housing projections.

Table 4-3. Non-Residential Participation Days in 2016						
Visitor Category	**Daily Peak Summer Population**	**Beach Use Days[1]**	**Fishing Days[1]**	**Boating Days[1]**	**Wildlife Viewing Days[1]**	**Biking Days[1]**
Guests of Year-Round Residents	1,247	47,223	51,04	17,868	33,184	24,249
Seasonal/Vacationers	12,745	482,647	25,158	88,056	339,157	119,502
Transients	1,290	50,172	2,640	10,563	47,530	20,801
Day Trip Participants	3,039	83,984	0	9,331	152,415	37,327
Total	18,321	664,026	32,902	125,818	572,286	201,879

Sources: MVC (2006), MVC (2011), and UMass Donahue Institute (2015)

[1] The 2016 participation days estimates are based on the number of non-rainy days during the tourist season (134), including 72 days during peak summer, 25 days in late May and early October (40% peak summer population), and 37 days in early June and post-Labor Day September (55% peak summer population).

Non-Market Value of Recreation Supported by Oak Bluffs' Public Coastal Resources

To estimate the per-day value of the many recreation activities supported by Oak Bluffs' public coastal resources, we utilized local and national studies of WTP values for participating in beach going, fishing, shellfishing, boating, wildlife viewing, and biking.[3] To estimate the total value of recreation activities to recreational users, we multiplied WTP values by the estimated number of participation days in Oak Bluffs' public coastal resources. For each activity, we aimed to find a low and high WTP estimate for the Northeast region. We used a range to account for variability in literature WTP estimates and methodology, including both revealed and stated preference values. For beach going, we followed the methods used in Restore America's Estuaries (2006) by using a low estimate of $6.03 and a high estimate of $24.12 (2016$).

For recreational saltwater fishing, we used the mean WTP value for the Northeast region reported by Moeltner and Rosenberger (2014) for the low estimate ($42.62; 2016$) and Opaluch et al.'s (1999) value for the Peconic Estuary for the high estimate ($59.29; 2016$). For shellfishing, we used WTP estimates for eight Massachusetts towns (English, 2010), using the lowest town value for the low estimate ($7.47; 2016$) and the highest town estimate as the high value ($13.21; 2016$). The literature values for recreational boating were fairly constant when converted into 2016$, but we still used a low and high estimate to remain consistent. We used Opaluch et al.'s (1999) value for the Peconic Estuary ($28.32; 2016$) for the low boating WTP estimate and a national-level estimate (Bergstrom and Cordell, 1991) for the high estimate ($30.24). For wildlife viewing, we used a national-level estimate (Bergstrom and Cordell, 1991) for the low estimate ($23.86; 2016$) and a Northeast region estimate (Moeltner and Rosenberger, 2014) for the high estimate ($58.61; 2016$). For biking, we used the low ($25.47; 2016$) and high ($90.96; 2016$) ends of the range reported by Rosenberger and Loomis (2000).

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[3] WTP for a recreation day is typically derived from observed recreation choice behavior using the travel cost method (Phaneuf & Smith, 2005; Parsons, 2014). Individuals' decisions as to where to recreate are based on choosing the alternative that gives the highest utility and thus reveal their value for recreation site attributes.

Table 4-4 provides the low and high WTP values per recreation day, the number of participation days, and the WTP values for each activity in Oak Bluffs' public coastal resources. The estimated total WTP for outdoor recreation for residents and non-residents ranges from $21.10 million to $55.82 million annually, or $717 million to $1.9 billion as total present value (TPV; 3% discount rate).

Table 4-4. Value of Recreational Activities in Oak Bluffs' Public Coastal Resources (2016$)

	Activity	Low Per Day WTP ($)	High Per Day WTP ($)	# Participation Days (2016)	Annualized WTP (Millions $)	TPV[1], 2016-2050 (Millions $)
Resident	Beach Use	$6.03	$24.12	13,074	$0.06 - $0.23	$1.98 - $7.92
	Fishing	$42.62	$59.29	4,911	$0.15 - $0.21	$5.25 - $7.30
	Shellfishing	$7.47	$13.21	4,320	$0.02 - $0.04	$0.81 - $1.43
	Boating	$28.32	$30.24	5,299	$0.11 - $0.12	$3.77 - $4.03
	Wildlife Viewing	$23.86	$58.61	24,741	$0.44 - $1.07	$14.83 - $36.42
	Non-water (i.e., biking)	$25.47	$90.96	15,653	$0.29 - $1.05	$10.01 - $35.75
Non-Resident	Beach Use	$6.03	$24.12	664,026	$2.90 - $11.62	$98.74 - $394.97
	Fishing	$42.62	$59.29	32,902	$1.03 - $1.43	$34.87 - $48.50
	Boating	$28.32	$30.24	125,818	$2.59 - $2.77	$88.11 - $94.06
	Wildlife Viewing	$23.86	$58.61	572,286	$9.80 - $24.06	$333.10 - $818.11
	Biking	$25.47	$90.96	201,879	$3.70 - $13.22	$125.86 - $449.39
			Total	**1,664,909**	**$21.10 - $55.82**	**$717.32 - $1,897.90**

Sources: Bergstrom and Cordell (1991), Opaluch et al. (1999), Restore America's Estuaries (2006), English (2010), Moeltner and Rosenberger (2014), Rosenberger and Loomis (2000).

[1] TPV estimated using a 3% discount rate.

4.1.2 Impacts of Recreation on Oak Bluffs' Economy

While the above section focuses on estimating the non-market value of recreational opportunities in Oak Bluffs, here we focus on the direct impact of recreation on the Oak Bluffs economy. The Martha's Vineyard economy is largely driven by vacationers, including second home owners and visitors. Four tourism-driven industries—hospitality (food and accommodations), retail, construction, and real estate—make up more than half of the island's economy (Ryan, 2008). Oak Bluffs is one of the most popular tourist destinations on Martha's Vineyard. Tourism is thus a significant contributor to Oak Bluffs' local economy.

The total economic impact of recreation includes both direct recreation expenditures and subsequent flow-on impacts to the region (e.g., spending by employees providing services to visitors and employee compensation). Recreation expenditures account for the direct costs of participating in recreation activities, such as fishing licenses, outdoor gear, transportation, and food. For this analysis, we used the 2012 NORE survey data on average trip expenditures for coastal recreation in the Northeast region (NOAA, 2012). Average expenditure values are available for each activity and for residents and non-residents. We multiplied the average trip expenditure by the estimated number of participation days for each activity and resident class.

Direct expenditures only cover the first-order impacts on the local economy. Subsequent flow-on impacts to the region can be estimated using either an input-output model or an economic multiplier. For this analysis we used an economic multiplier from Chang (2001) to estimate flow-on impacts from recreational expenditures in Oak Bluffs. Chang (2001) investigated recreation and tourism multipliers throughout the United States. For recreation in rural areas, such as Martha's Vineyard, Chang determined that the multiplier was 2.55. We applied this multiplier to our direct expenditure estimates for outdoor recreation to determine the flow-on economic impacts of recreational activity within Oak Bluffs' public coastal resources. *Table 4-5* provides the average expenditures per trip, estimated number of participation days, direct expenditures, and flow-on expenditures for residential and non-residential outdoor recreation.

In summary, many residents and visitors participate in outdoor recreation in Oak Bluffs' public coastal resources. These activities account for approximately $31.36 million in annual direct expenditures and $79.98 million in flow-on impacts. The TPV for direct expenditures and flow-on impacts throughout the study period (2016-2050) are $1.07 billion and $2.72 billion, respectively, using a 3% discount rate.

Table 4-5. Direct Expenditure and Flow-on Impact Estimates for Outdoor Recreation in Oak Bluffs' Public Coastal Resources (2016$).

	Activity	Per-Day Expenditure ($)	# Days (2016)	Direct Expenditures (Millions $)		Flow-on Impacts (Millions $)	
				Annualized	TPV[1] (2016-2050)	Annualized	TPV[1] (2016-2050)
Resident	Beach Use	$21.91	13,074	$0.21	$7.19	$0.54	$18.34
	Fishing	$54.24	4,911	$0.20	$6.68	$0.50	$17.04
	Shellfish-ing	$85.92	4,320	$0.27	$9.32	$0.70	$23.77
	Boating	$70.49	5,299	$0.28	$9.38	$0.70	$23.93
	Wildlife Viewing	$24.22	24,741	$0.42	$14.27	$1.07	$36.39
	Biking	$14.74	15,653	$0.17	$5.80	$0.43	$14.78
Non-Resident	Beach Going	$30.80	664,026	$14.83	$504.21	$37.82	$1,285.73
	Fishing	$18.67	32,902	$0.45	$15.28	$1.15	$38.95
	Boating	$58.12	125,818	$5.32	$180.78	$13.56	$461.00
	Wildlife Viewing	$13.95	572,286	$5.43	$184.71	$13.85	$471.00
	Biking	$26.06	201,879	$3.79	$128.77	$9.66	$328.38
		Total	**1,664,909**	**$31.36**	**$1,066.40**	**$79.98**	**$2,719.32**

Sources: NOAA (2012) and Chang (2001)
[1] TPV estimated using a 3% discount rate

4.1.3 Total Recreational Value

We estimated the annualized value of the recreation opportunities provided by Oak Bluffs' coastal resources at $132.4 million to $167.2 million (*Table 4-6*). This estimate includes $21.1 million to $55.8 million in benefits to recreational users (WTP for recreation opportunities), $31.4 million in direct expenditures, and $80.0 million in flow-on impacts. Assuming that recreational users' preferences remain constant over time and using a 3% discount rate, the TPV of recreation provided by Oak Bluffs' coastal resources is $4.5 billion to $5.7 billion.

Table 4-6. Total Economic Value of Outdoor Recreation in Oak Bluffs' Public Coastal Resources (Millions 2016$)

Valuation Method	Annualized Value[1]	TPV[2] (2016-2050)
Non-market Values[3]	$21.10 - $55.82	$717.32 - $1,897.90
Direct Expenditures	$31.36	$1,066.40
Flow-on Impacts	$79.98	$2,719.32
Total	**$132.44 - $167.17**	**$4,503.04 - $5,683.61**

[1] Annual value is estimated using a 3% discount rate.
[2] TPV is estimated using a 3% discount rate.
[3] Estimated based on WTP values.

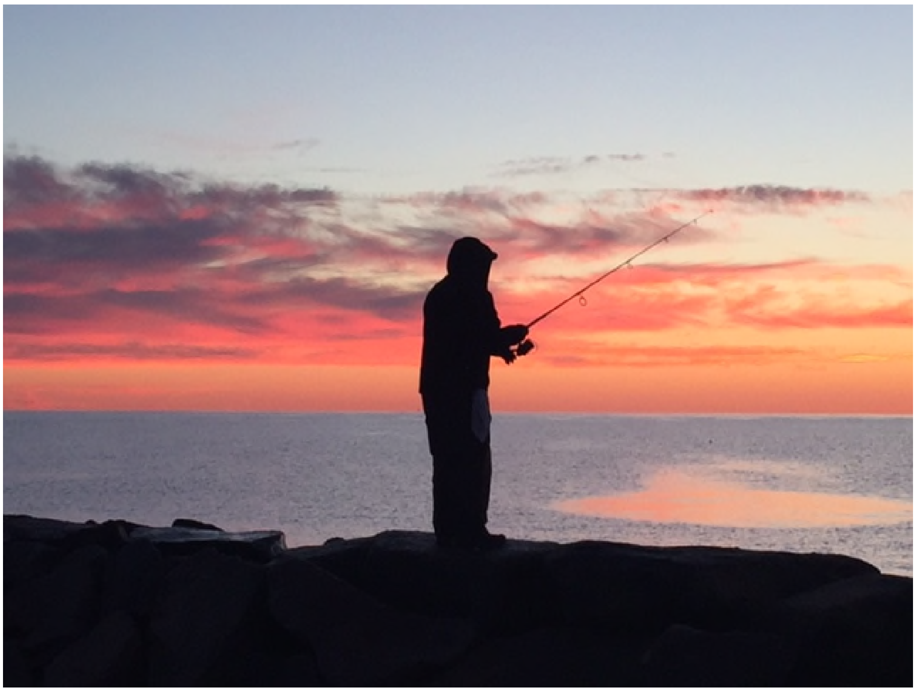
4.2 Fishing Tournaments

Oak Bluffs also hosts several fishing competitions, including two annual events: Oak Bluffs Bluewater Classic and the Kids Fishing Derby. The six Martha's Vineyard towns, including Oak Bluffs, take turns hosting the annual Martha's Vineyard Striped Bass and Bluefish Derby. We were unable to estimate the impact of fishing competitions on the local economy due to data limitations. However, existing studies of fishing competitions at different locations suggest that the economic impact of these events is not trivial. Below we discuss public participation in these events and their contribution to non-profit organizations.

- The **Oak Bluffs Bluewater Classic** is a 3-day overnight tournament at Oak Bluffs Marina that is open to the public. In 2016, 35 vessels participated in the tournament. The Oak Bluffs Bluewater Classic enriches the island community beyond the cultural value that it provides. In 2016, the tournament raised $20,000 for the Island Autism Group of Martha's Vineyard and $14,000 for the Massachusetts General Hospital (MGH) Colon Cancer Research Fund. In 2017, 10% of tournament proceeds will be donated to the Island Autism Group. The tournament also features entertainment and education on pelagic species. (Oak Bluffs Bluewater Classic, 2017).
- The **Martha's Vineyard Striped Bass and Bluefish Derby** is a month-long fall derby that has attracted over 3,200 participants for the past several years (Elizabeth Durkee, Conservation Agent, personal communication). The Derby is a local institution with more than 70 years of history. The Martha's Vineyard Striped Bass and Bluefish Derby committee emphasizes that the tournament is a time to focus on the natural beauty of Martha's Vineyard. The Derby has the distinction of being a not-for-profit fishing tournament, and the Derby president speculates that it may have been the first fishing tournament to be designated a 501(c)(3) tax-exempt non-profit by the IRS. This event contributes to the community that hosts it by awarding annual scholarships to the island's graduating

high school seniors. In 2016, the Derby awarded $30,000 in scholarships to students graduating from Martha's Vineyard Regional High School (MV Derby, 2015).

- The **Annual Kids Fishing Derby**, part of the Martha's Vineyard Striped Bass and Bluefish Derby, is located at the Oak Bluffs Steamship Authority wharf. This 2-hour annual event attracts over 300 child participants each year and has been a hallmark of Oak Bluffs' culture for more than 30 years (Sigelman, 2016; Ewing, 2016).



Participant in the Striped Bass and Bluefish Derby — *Liz Durkee*

4.3 Local Art

On the island of Martha's Vineyard, arts and culture are an important aspect of the economy. According to a study by the Martha's Vineyard Commission, arts and culture have a direct economic impact of $21.64 million, or 4.2% of the Vineyard's overall economy. In 2012, the arts and culture industry constituted 3.37% of island employment with 263 employees (Martha's Vineyard Arts and Culture Collaborative, 2012).[4] The U.S. Census Bureau's American Community Survey estimates that 191 people are employed in the arts, entertainment, and recreation industry in Oak Bluffs, which is 8.13% of the employed population (U.S. Census Bureau, 2015). Although we were not able to estimate the local

[4] The Martha's Vineyard Arts and Culture Collaborative (2012) figures include valuations for all art and culture industries in the six Martha's Vineyard towns. Values for only coastal-related art and culture in Oak Bluffs are uncertain.

economic contribution of coastal resource-related arts and entertainment due to the lack of data, the qualitative discussion provided below demonstrates that Oak Bluff's coastal resources are an integral part of local arts and culture.

Much of the art sold in Oak Bluffs is heavily inspired by the coast. While formal estimates of the amount of coastal art sold in Oak Bluffs are not available, several Oak Bluffs artists and artisans report that the vast majority of art they sell has a coastal subject. One well-known gallery on the island, Alison Shaw Gallery, estimates that 85% of the images they sell depict coastlines (Sue Dawson, Alison Shaw Gallery Owner, personal communication). While these images are not always specific to the coastal resources of Oak Bluffs, artists report that the demand for coastal artwork in general is high, especially for day visitors who are inclined toward island themes. Artist Judith Drew Schubert of Periwinkle Studio has also built her artistic identity on shoreline art. She uses her walks around Oak Bluffs as inspiration for her artwork, and much of her art depicts coastal scenes (Schubert, 2015). Furthermore, many popular and iconic coastal resources are featured prominently in art produced in Oak Bluffs, including lighthouses, popular beaches and scenic walking areas, cliffs and bluffs, boats, and docks and ports. The revenue that artists receive for coastal art varies by medium and artist. Some prints and posters can be purchased for as little as $20, while fine art can be sold for more than $1,000 (Sue Dawson, Alison Shaw Gallery Owner, personal communication).

Art galleries in Oak Bluffs provide an avenue for local artists to sell their work. Circuit Avenue is a hotspot for local artists, with three art galleries—Cousen Rose, Island Images, and Crossroads Gallery—and Driftwood Jewelry, a jewelry store that sells only island-made jewelry. The Oak Bluffs Arts District also contains several prominent art galleries, including Alison Shaw Gallery, the Martha's Vineyard Center for the Visual Arts' ART GALLERY, Dragonfly Gallery, Periwinkle Studio, and Gallery Josephine (Robards, 2012; Martha's Vineyard Times, 2017). While none of these art galleries exclusively feature coastal art, they contribute to the vibrant arts culture in Oak Bluffs that fosters coastally focused artists, such as Alison Shaw, Judith Drew Schubert, and many others.

Oak Bluffs also hosts several art festivals each year, including the All-Island Art Show and the Oak Bluffs Art District Stroll, and many Oak Bluffs artists participate in other art festivals on the island. According to the organizers of the Vineyard Artisan Festivals, which are a series of shows based in West Tisbury for local artisans, 90 Martha's Vineyard artists participate on average, and approximately one-third of participating artists are based in Oak Bluffs. Finally, Oak Bluffs hosts an open market on Sundays from May to October and the Featherstone Flea and Fine Arts Market on Tuesdays from July to August, where local artists can sell their work (Martha's Vineyard Online, 2017; Featherstone Center for the Arts, 2017). Many of the art pieces showcased relate to coastal resources; artists sell wampum shell jewelry, use seaweed in art, or capture the coast in paintings and photographs. These events attract many tourists; attendance at the two largest shows—Thanksgiving weekend and Labor Day weekend—is consistently in the thousands (Andrea Rogers, Vineyard Artisans Festivals Founder, personal communication).

4.4 Festivals

Each year, Oak Bluffs hosts many festivals that celebrate the culture, and town and island heritage. Many of these events utilize Oak Bluffs' unique geography by taking place on the coast. Oak Bluffs begins the summer season with two very popular events on the same day: Harborfest and the Midsummer Faerie Festival. In the past, the event also included a Summer Solstice Celebration at the conclusion of Harborfest, with an outdoor street fair and a fireworks display over Nantucket Sound (Schlossberg, 2011).

Harborfest and the Midsummer Faerie Festival both make use of Oak Bluffs' location on the water. While we are unable to monetize the value of these festivals to the local economy due to a lack of relevant data, we provide a qualitative description of their contributions to the local community below.

- The annual Oak Bluffs **Harborfest** occurs along the Oak Bluffs Harbor, where there is live music, island artisans selling their arts and crafts, antiques, native seafood, and raffles. Harborfest also has an educational component: non-profit organizations use the event to provide attendees with information about their causes, and, in past years, the Coast Guard has performed a search and rescue demonstration on the Harbor. Harborfest draws many attendees and over 40 vendors to Oak Bluffs Harbor (Roriz, 2011; Vineyard Gazette, 2013).
- The **Midsummer Faerie Festival**, once a separate event, has joined with Harborfest in recent years to celebrate the summer solstice. The Faerie Festival takes place in Washington Park, overlooking the water. Entertainment at the Faerie Festival includes music, art, performances, a parade, and children's activities (Vineyard Gazette, 2012).

Many other festivals incorporate the coast into the celebrations:

- The **Martha's Vineyard Wind Festival** utilizes the breezy nature of the coast in its Ocean Park location for kite flying and model sailboat racing (Martha's Vineyard Wind Festival, 2017). This event draws people from all over the country. Between 600 and 800 people attended the festival in 2016 (Holly Alaimo, Festival Contact, personal communication).
- The annual **Oak Bluffs fireworks** show also takes place in Ocean Park. This popular event celebrates the peak of the summer with fireworks over Nantucket Sound (Vineyard Gazette, 2016). Approximately 15,000 to 18,000 people attend this event each year (Suzanne Cioffi, Oak Bluffs Police Department, personal communication).
- The **Martha's Vineyard Sound Festival**—an annual festival of music, food, and the arts—takes place at Waban Park across from the town beach each year. This event permits re-entry for attendees so they can swim at the town beach in between sets, a policy uniquely attributed to the festival's location on the coast (Omer, 2015).
- The **Martha's Vineyard Oar and Paddle Regatta** takes place on Sengekontacket Pond in Oak Bluffs each summer and is a race benefiting the Friends of Sengekontacket, an environmental non-profit organization. The event includes races for rowboats, canoes, kayaks, and stand-up paddleboards and also features a kayaking race where participants paddle with their dogs (Friends of Sengekontacket, 2017).
- The **Portuguese Holy Ghost Feast and Parade** includes food, music, and dancing in celebration of the Azorean people. The Holy Ghost Association of Martha's Vineyard holds its annual feast in mid-July and has been doing so since the 1920s. The annual parade begins at the Steamship Ferry and concludes at the Portuguese-American Club (Vineyard Gazette, 2017; Holy Ghost Association of Martha's Vineyard, 2017).

Martha's Vineyard Oar and Paddle Regatta *Timothy Johnson*

4.5 Educational Events

Oak Bluffs' coastal resources also serve as an educational resource for both residents and visitors. Several nature centers and camps primarily focus on Oak Bluffs' coastal geography. While insufficient data are available to estimate the impact of educational activities on the local economy, these activities are a key cultural resource for local communities, and we describe the most important of them in more detail below.

The Massachusetts Audubon Felix Neck Wildlife Sanctuary—located along Sengekontacket Pond in Edgartown— is a key educational resource. It hosts approximately 10,000 people each year in the form of program participants, campers, students, and visitors. The center offers more than 150 school programs and 320 public and group programs, as well as 35 weeks of camp (Suzan Bellincampi, Felix Neck Wildlife Sanctuary Director, personal communication). Programs and activities offered at the sanctuary include kayak tours, salt marsh ecology education, and birding and other wildlife viewing, all of which are specific to the sanctuary's wetland ecology (Mass Audubon, 2017).

Felix Neck camp children at Sengekontacket Pond *Timothy Johnson*

Many children also establish ties to the coast in Oak Bluffs at an early age through summer camps. In addition to the educational camps run by the Massachusetts Audubon Felix Neck Wildlife Sanctuary, many children attend camps that are fully or partially based on Oak Bluffs beaches. At Sailing Camp Park, children can participate in a free sailing program on Lagoon Pond (Town of Oak Bluffs, 2015). Island Spirit Kayak in Oak Bluffs also introduces children to water-based recreation. Island Spirit Kayak has weeklong programs in the summer called Kids Kayak Adventures that allow children to explore canals and learn about shellfish, endangered birds, and local history while also learning kayaking skills (Island Spirit Kayak, 2017). Another camp, Camp Jabberwocky, enriches its program with beach visits. Camp Jabberwocky is a summer camp for children and adults with disabilities where campers and their families only pay what they can. Part of this program includes almost daily camp trips to State Beach in Oak Bluffs (Camp Jabberwocky, 2017; Elizabeth Durkee, Conservation Agent, personal communication). These summer camps enrich the lives of children by helping them develop lifelong skills and hobbies. Oak Bluffs' coastal resources are integral in the missions of these camps.

Several environmental organizations incorporate the coastal geography of Oak Bluffs in their education initiatives. One of these groups is the Vineyard Conservation Society (VCS), a non-profit environmental organization dedicated to preserving Martha's Vineyard's land and water. One of the primary mechanisms through which the VCS seeks to achieve these objectives is through public education. The VCS's public education events often incorporate Oak Bluffs' water resources. For example, the VCS hosted an interpretive walk at Oak Bluffs' Eastville Point beach in December 2012 where community attendees learned about the history and future of conservation initiatives at the beach. VCS has also hosted interpretive walks along Sea View Avenue and the East Chop Bluff (Elizabeth Durkee, Conservation Agent, personal communication). Additionally, for Earth Day the VCS organizes annual beach cleanups, several of which occur at Oak Bluffs beaches. These citizen cleanups contribute to a sense of community and environmental stewardship in Oak Bluffs (Vineyard Conservation Society, 2017).

Another group providing education about Oak Bluffs' coastal resources is the Friends of Sengekontacket, a non-profit organization dedicated to protecting Sengekontacket Pond and its barrier beach, the Joseph Sylvia State Beach. The organization's education initiatives include Saturdays on Sengekontacket and the Carry In/Carry Out poster contest. Saturdays on Sengekontacket, which occur on seven Saturdays in July and August, are free events that allow children to explore wildlife around Sengekontacket Pond with a Felix Neck naturalist. The Carry In/Carry Out poster conference is a competition for students in Edgartown and Oak Bluffs schools where students submit a poster illustrating the concept of Carry In/Carry Out. This contest corresponds to a science curriculum where students learn about the effect of litter on marine mammals and sea birds (Friends of Sengekontacket, 2017). Activities like these instill in children a connection to the environment and the community.

4.6 Cultural Landmarks

Many of Oak Bluffs' most notable cultural landmarks are inextricably linked to the coast. These landmarks allow residents to cultivate a sense of history and pride for their community. According to a research report on the valuation of cultural heritage (Getty Conservation Institute, 2002), heritage sites have many different sociocultural values, including historical, cultural/symbolic, social, and aesthetic values. Heritage sites that have the ability to convey, embody, or stimulate a relation or reaction to the past have *historical value.* Heritage sites are associated with *cultural/symbolic values* because their shared nature builds culture in the present and stimulates positive behavior that builds civil society. *Social values* for heritage sites include community and social connections, such as use for social gatherings and celebrations, as well as place attachment. Finally, *aesthetic values* for heritage sites include sensory experiences that strongly contribute to a sense of personal well-being (Getty Conservation Institute, 2002).

The connection between Oak Bluffs' cultural landmarks and coastal resources helps create these types of sociocultural values. One example of this is the East Chop Lighthouse, which is an active federal aid to navigation (National Parks Service, 2017). The East Chop Lighthouse has a storied history that attracts visitors locally and internationally. A private citizen built the lighthouse in 1869 when federal officials refused to fund it. It is the only privately financed and independently built lighthouse on Martha's Vineyard, and the Martha's Vineyard Museum now manages the site (Dunlop, 2011). This lighthouse provides historic value from its age and uniqueness, cultural/symbolic value as a museum property open for tours and as a functional beacon, social value as a site for weddings and other special events, and aesthetic value with its sunset tours and visually arresting views of the Nantucket Sound.

Another heritage landmark closely connected to the coast is the Ocean Park Bandstand. The Bandstand's historical value and corresponding cultural value derives from its centuries-long existence: it was built in the 1870s to provide a space for a band of Civil War veterans to play their music for then-President Ulysses S. Grant during a visit to Martha's Vineyard. To this day, the band, which is no longer composed of Civil War veterans, plays concerts at the Bandstand overlooking the Nantucket Sound (Berg, 2011). The Bandstand, along with the East Chop Lighthouse and many beaches in Oak Bluffs, provides social value by serving as a popular location for weddings and other special events, such as clambakes and festivals.

Ocean Park Bandstand *Liz Durkee*

Wesleyan Grove, a 34-acre National Historic Landmark District near Oak Bluffs Harbor, also serves as a historically and culturally significant landmark and contributes to coastline appeal. Wesleyan Grove is home to the gingerbread cottages, famous for their Victorian style, bright colors, and gingerbread trim (Horrocks, 2016). Wesleyan Grove served as a Methodist summer camp starting in 1835. Initially, New England Methodists pitched tents during their stay at the summer camp. Starting in 1859, the first wooden cottages were built with designs inspired by the tents they replaced. Today, church services are held weekly in the Tabernacle, the physical and spiritual center of Wesleyan Grove, during the months of July and August. The graduation ceremony for Martha's Vineyard Regional High School is the first event held in Wesleyan Grove each year. The Martha's Vineyard Camp Meeting Association also hosts many public events at the gingerbread cottages, including campground walking tours, family movie nights, and weekly singing events. One of the cottages has been converted into a museum, allowing the public to view the inside of a cottage for a nominal fee. The Grand Illumination, an annual event typically held on the third Wednesday of August, serves as the crowning event of the season. During the event, paper lanterns adorn the cottages and nearby landscape. Attendees, a handful of whom wear Victorian garments, gather for a community singing event and band concert at the Tabernacle (Horrocks, 2016).

In addition to providing sociocultural values, cultural landmarks raise revenue for the Town of Oak Bluffs. For all events hosted at coastal cultural landmarks, the Town of Oak Bluffs receives a small fee (Town of Oak Bluffs, 2017).

4.7 Limitations and Uncertainty in Recreation Valuation

While we used sound methodologies to estimate the economic value of coastal recreation in Oak Bluffs (the only service we were able to monetize), key limitations and uncertainties remain in our analysis. We summarize the most important of these in *Table 4-7*.

Table 4-7. Limitations and Uncertainties in the Analysis of Economic Values of Recreational Opportunities Provided by Public Coastal Resources in Oak Bluffs

Issue	Effect on Benefits Estimate	Notes
Estimating the number of recreational users of public coastal resources and number of recreational days	Uncertain/Underestimate	Because site-specific recreational participation data are not available, we estimated total recreational participation days using NORE survey data for Northeastern coastal county residents, a summer population estimate, visitor recreation survey results, and population projections for the years 2015-2035. The actual number of participation days may be lower or higher than our estimates. In particular, we expect that recreational participation rates for Oak Bluffs residents are higher than average rates for the Northeast. Additionally, our estimates did not account for multi-activity recreation days and non-resident participation days outside the summer season.
Omission of some recreational activities	Underestimate	Due to data limitations, the estimated total value of recreation does not include economic impacts and WTP for participation in fishing tournaments and other outdoor recreation activities, such as picnicking and photography. The estimated total value also excludes WTP value for other water-based recreation (e.g., water skiing and jet skiing) due to data limitations.
Transfer error	Uncertain	We selected recreational valuation studies from the available literature that match characteristics of the user population and recreational activities in Oak Bluffs. While widely accepted, benefit transfers are always subject to the inherent uncertainty in applying models developed for one site and purpose to a different site and purpose. Transferring values across sites introduces an unknown bias in resulting estimates.

Table 4-7. Limitations and Uncertainties in the Analysis of Economic Values of Recreational Opportunities Provided by Public Coastal Resources in Oak Bluffs		
Issue	**Effect on Benefits Estimate**	**Notes**
Future participation in coastal zone recreation	Uncertain	To calculate the TPV of recreational services provided by public coastal resources for the entire study period (2016-2050), we assumed that NORE participation rates and average number of participation days remain constant throughout the study period. We assumed that participation rates for non-residents (MVC, 2006) remain constant throughout the study period and that the apportioned rates apply for daily participation. Daily participation rates may decline for longer-term visitors if they engage in alternative activities.

5. Supporting Services

The coastal ecosystems of Oak Bluffs not only provide an array of ecosystem services directly to people, as described in earlier sections of this report; they are also crucial for maintaining a wide range of species that depend on the habitat those ecosystems provide. Below, we describe the ecosystem support services provided by the three main types of coastal habitat found in Oak Bluffs: (1) coastal wetlands, (2) seagrass, and (3) beaches and sand dunes. For each of these types of habitat, we first provide a qualitative description of the overall ecological support Oak Bluffs' coastal resources. We follow this discussion with analyses that provide estimates of the economic value provided to people through the support services the habitats provide. We end this chapter with a discussion of key threatened and endangered species that may benefit from the existence and preservation of coastal ecosystems in Oak Bluffs.

5.1 Coastal Wetlands

Wetlands provide an array of ecological services that benefit both wildlife and people. Below, we first describe the ecological support that wetlands provide to local wildlife. Second, we estimate the economic value provided by these habitats through their impact on local commercial and recreational fishing. Finally, we conclude with an analysis of the potential societal value of the support services provided by wetlands to local communities.

5.1.1 Wildlife Support

Coastal wetlands are a central feature of Oak Bluffs, having provided scenic beauty, recreational, and commercial opportunities for residents over the past 100 years. However, they also provide critical habitat for wildlife and support ecological processes that are essential to the maintaining the structure and function of coastal ecosystems over time. One of the most important ecological services that wetlands provide to wildlife is the provisioning of habitat. Many fish, shellfish, and birds are particularly dependent on coastal wetland habitat.

For fish and shellfish, wetland vegetation provides important spawning and/or nursery habitat. Common wetland-associated fish and shellfish in the Oak Bluffs area include bluefish, seabass, eel, hard-shelled clams, soft-shelled clams, and scallops (Town of Oak Bluffs, 2015). Vegetative surfaces in wetlands offer secure places for fish and shellfish to lay their eggs, and the vegetation provides protection from predators for young fish and shellfish as they mature (Graff & Middleton, 2001). In the Oak Bluffs area, juvenile scallops, bluefish and seabass in particular may benefit from wetland habitat (NOAA, 1999; Hart and Chute, 2004; MDFW, 2017). Adult fish and shellfish also find refuge from predators in wetland vegetation. Wetlands are an important source of food for fish and shellfish—highly productive wetlands produce a substantial amount of detritus, or dead vegetation (Graff & Middleton, 2001). Detritus can either directly feed fish, or support small fish or invertebrates upon which fish prey. Coastal wetland plants and soils also help maintain water quality by absorbing and processing nutrients or harmful substances that would otherwise contaminate coastal waters and make it difficult for fish, shellfish, and other organisms to survive (Graff & Middleton, 2001).

Shellfish beds, specifically of oysters and soft-shell clams, also stabilize sediments and provide habitat for other organisms, including worms, juvenile crabs, snails, and sea stars (Massachusetts Bay Program, 2011). Shellfish are also filter feeders, improving water quality in the estuaries in which they reside (Rice, 2008). An individual oyster alone can filter between 15 and 55 liters of seawater per day on average (Rice, 2008).

Many birds also depend on coastal wetlands throughout the year. As with fish, coastal wetlands provide important breeding habitat for many marsh-dependent birds that hide nests and newly fledged young from predators among dense vegetation. In Oak Bluffs, birds found locally known to breed in wetlands include the red-winged blackbird, salt marsh sharp-tailed sparrow, swamp sparrow, and willet (Mass Audubon, n.d.; Vineyard Gazette, n.d.). Wetlands also provide needed sustenance for birds throughout the year. Breeding waterbirds, such as great egrets, depend on fish and invertebrates found among wetland vegetation and soils for sustenance and feeding their young (USFWS, 2008; Culbert, 2016b). And a wide variety of migrating waterfowl and shorebirds depend on wetlands for refueling on their long migrations to and from their breeding grounds during spring and winter, respectively (USFWS, 2008). Common species found in the wetlands of Martha's Vineyard during migration and the winter include greater scaup, red-breasted mergansers, and bufflehead (Pelikan, 2015).

Great Blue Heron at Farm Pond *Timothy Johnson*

While the above functions can benefit the wildlife residing in or passing through Oak Bluffs, major wetland habitats in Oak Bluffs are under serious threat of habitat degradation, primarily from eutrophication, an excess of nitrogen stemming primarily from private residential septic systems (Howes, Eichner, et al., 2010; Howes, Ramsey, et al., 2010; Howes, Ramsey, et al., 2013). Excess nitrogen in nutrient-limited estuaries stimulates the growth of algae. This additional productivity leads to lower light levels, which can shade out seagrass, another critical habitat for fish and birds (see Section 5.2.1). The increase in algal blooms can also lead to depleted oxygen over time as decaying algae decomposes. That said, three major wetlands in Oak Bluffs (i.e., Oak Harbor, Farm Pond, and Sengekontacket Pond) are now part of the Massachusetts Estuaries Project, which works with municipalities to restore key coastal wetland habitats (Howes, Eichner, et al., 2010; Howes, Ramsey, et al., 2010; Howes, Ramsey, et al., 2013). Restoring and maintaining these habitats over time will be critical to maintaining the support they provide to a wide range of organisms.

Algae at Lagoon Pond *Jeanna Shepard*

5.1.2 Productivity-Based Support of Commercial and Recreational Fishing

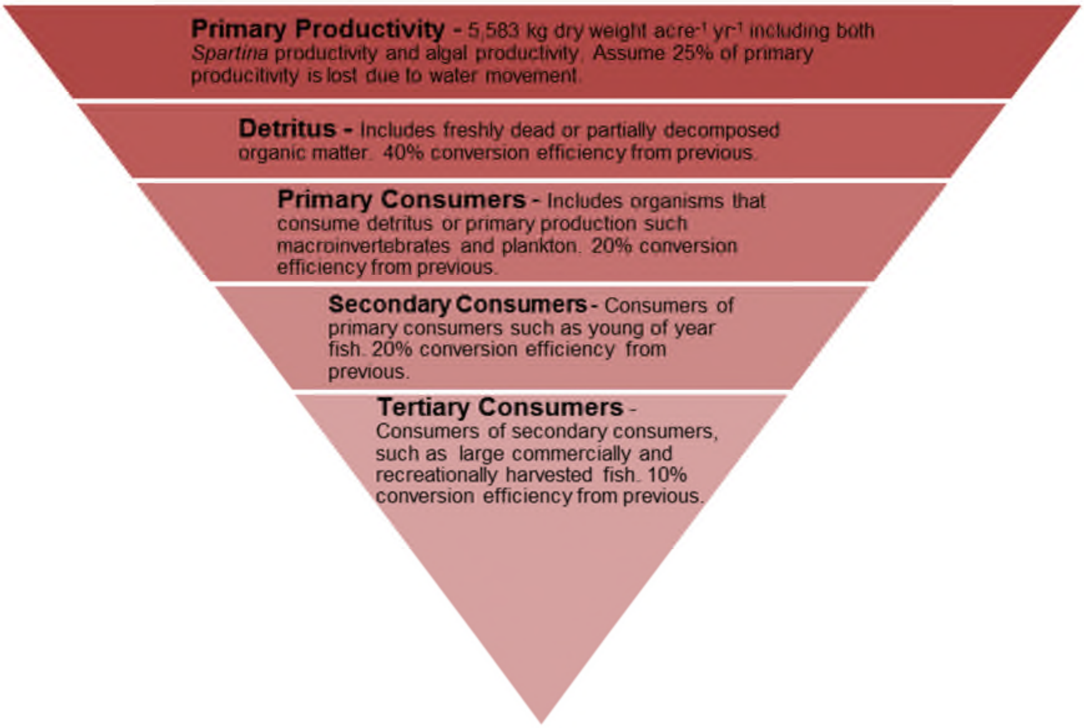
While the direct benefits of fisheries are provided in the Provisioning Services chapter (Chapter 3), coastal wetlands also provide indirect support to commercial and recreational fishing through primary production. That is, wetland plants help produce or sustain the local fish upon which commercial and recreational fisheries depend. Below, we describe how we estimated the economic value of the wetland primary productivity to fisheries in Oak Bluffs.

Methods

We used a trophic transfer approach to approximate the potential commercial and recreational fishing benefits of wetland primary production in Oak Bluffs. To do this, we used a "trophic transfer" approach, which is based on the relationship between wetland primary production and the production of resident and transient fish (Kneib, 2003; McCay & Rowe, 2003). We recognize that there are significant uncertainties associated with this approach. Nonetheless, it provides a simplified method to approximate potential commercial and recreational fishing benefits given that local information about the primary production of coastal wetlands and its support of resident fish is lacking.

We calculated fish production per acre of wetland habitat created by tracking biomass through four trophic levels as summarized in *Figure 5-1*. A trophic conversion occurs between each step because energy is lost due to metabolic processes, and only a fraction of production transfers to the subsequent level.

Figure 5-1. Trophic Transfer Calculation



Inputs for this trophic analysis were drawn from EPA's habitat-based valuation approach for the proposed 316(b) rulemaking (U.S. EPA, 2011). Assuming that dry weight is 22% of wet weight, tertiary production is 30.5 kg wet weight per acre per year.

This analysis focuses on tertiary consumers because these species tend to constitute a vast majority of commercial and recreational benefits. Because the precise mix of tertiary species enhanced is unknown, we calculated a range of benefits per acre of coastal wetland based on three illustrative species or groups of fish (henceforth, simply "fish"): Atlantic menhaden, bluefish, and winter flounder. In each case, benefits calculations incorporate fish-specific rates of growth, natural mortality, and fishing mortality. Commercial and recreational benefits are realized when this tertiary production is harvested either in the year of conversion or subsequent years as dictated by mortality rates.

We monetized harvest following the approach used for EPA's proposed 316(b) rule (U.S. EPA, 2011):

- Harvest was allocated to commercial and recreational based on the ratio of regional commercial and recreational harvest for the fish.
- The value of commercial harvest in each year of the analysis was calculated by multiplying harvest by the dockside price in Massachusetts in 2015 (the most recent year available; 2016$). Commercial benefits were calculated in terms of producer surplus, by multiplying dockside value by a specific net benefit ratio.
- The benefits of recreational harvest were calculated by multiplying the number of fish caught by the estimated (WTP per fish caught per trip).

Results

Total commercial and recreational fishery benefits for three illustrative Oak Bluffs region fishes range from $2.99 to $82.73 per wetland acre per year (*Table 5-1*). Total annualized fishery benefits would range from $229/year to $6,333/year. The estimated present value of these benefits ranges from $7,788 - $215,322.

As mentioned, we consider this a rough approximation of potential fishing benefits of coastal wetlands. Additional site-specific data are necessary to conduct a more rigorous analysis. Fish production benefit values are not included in the total value of supporting services to avoid potential double counting with the wetland support values calculated in Section 5.1.3.

Table 5-1. Annualized Commercial and Recreational Fish Production Benefits from Wetland Restoration (2016$)

Illustrative Species	Fishery Characterization	Annual Productivity ($/acre/year)	Annualized Value	TPV (2016-2050, Millions $)
Atlantic Menhaden[1]	8-year average lifespan. 0% recreational and 100% commercial.	$2.99	$229	<$0.01
Bluefish	14-year average lifespan. 89% recreational and 11% commercial.	$41.45	$3,173	$0.11
Winter Flounder	16-year average lifespan. 50% recreational; 50% commercial.	$82.73	$6,333	$0.22

[1] TPV of wetland fish production benefits for Atlantic Menhaden is $7,788.

5.1.3 Valuation of the Support Services Provided by Wetlands

While we have qualitatively described some of the habitat support services provided by wetlands in Section 5.1.1, it is also possible to provide a quantitative estimate of the value that people place on these types of services. We provide an analysis of the value of wetlands supporting services below, in three key steps. First, we describe how we identified the value that households on average place on the supporting services provided by wetlands. Second, we describe the households in Oak Bluffs that likely value these services. Finally, we develop a final estimate of household value by multiplying household values for wetland support services by the relevant number of households that value Oak Bluffs wetlands.

Household Values

Benefit transfer accuracy depends on a close match between original study site and policy site characteristics, including ecological changes, geographic location, uniqueness, demographic characteristics of the affected population, and other considerations. We thus focused our search on WTP studies for coastal wetlands in the New England area to be compatible with characteristics of Oak Bluffs' coastal wetlands. We also selected studies that focused on wildlife support values of coastal wetlands. Ultimately, we selected two functions that provided the best match to Oak Bluffs (*Table 5-2*):

- **Johnston et al. (2002)** present an original valuation function[5] estimating New York residents' WTP for different types of coastal habitat restoration in the Peconic Estuary system (PES). The valuation

[5] Based on Mazzotta's (1996) dissertation. Mazzotta (1996) provides full details on the survey.

function is estimated based on results of a survey that provided background information on coastal wetlands and related ecosystem services—including fish and wildlife habitat, storm buffering, and aesthetics—in the PES. Values from Johnston et al. (2002) provide a good match to coastal wetland services in Oak Bluffs and enable us to estimate the total value of preserving habitat support services of coastal wetlands. To focus the valuation on habitat support values, we use findings from U.S. EPA (2004) that 73% of the WTP estimate is attributable to fish, bird, and shellfish habitat.

- **Bauer et al. (2004)** present an original valuation function estimating Rhode Island residents' WTP for coastal wetland protection in Rhode Island. While demographic and geographic differences between Rhode Island and Massachusetts will likely result in some transfer error, Bauer et al.'s study is valuable because it estimates values for types of wetlands that are similar to those in Oak Bluffs. Coefficients in the valuation function allowed us to tailor estimates of total WTP per household based on the guidance from economic literature, available data on Oak Bluffs site characteristics, and best professional judgment.

Table 5-2. Transfer Functions Used in Calculating Total WTP for Coastal Wetlands

	Johnston et al. (2002)	Bauer et al. (2004)
Study Description	Contingent-choice survey designed to evaluate public WTP for coastal wetlands and eelgrass	Contingent-choice survey designed to evaluate public preferences for wetland preservation or restoration projects
Key Variables	Acres of preserved coastal wetlands and eelgrass Ecological improvements relative to other potential restoration projects. Fish and shellfish habitat	Acres of preserved salt marsh Public access via viewing platform or trails Endangered species habitat
Wetland Services Valued	Acres of coastal wetlands and eelgrass preserved Fish and shellfish habitat for eelgrass Fish and wildlife habitat, storm buffering, and aesthetics for coastal wetlands	Size of wetland area preserved Presence of recreational amenities (i.e., boardwalks and/or viewing towers) Endangered species habitat Preservation vs. restoration

We estimated per-household annual WTP for preserving coastal wetlands using the two different study values. Johnston et al. (2002) estimated annual household WTP per acre of coastal wetland ($0.073/acre, 2016$). This value includes several wetland services, including fish and shellfish habitat, bird habitat, mosquito control, storm buffering, and coastal erosion control. To focus the valuation on habitat support services, we utilized findings from U.S. EPA (2004) that approximately 73% of the value estimates are attributed to fish, bird, and shellfish habitat (U.S. EPA, 2004). We multiplied the per-acre, per-household WTP value by the proportion attributable to habitat support services (0.73) and the acres of public coastal wetlands in Oak Bluffs (117.6) to obtain an annual household WTP value for Oak Bluffs. To estimate per-household WTP for wetland preservation based on Bauer et al. (2004), we set key variables to reflect characteristics of Oak Bluffs' coastal wetlands (Appendix C). We also used demographic characteristics (median income, educational attainment, and gender) from Dukes County, MA, to calibrate Bauer et al.'s (2004) transfer function. Next, we estimated total annual household WTP values for habitat support services provided by Oak Bluffs' coastal wetlands by multiplying per-household WTP by the number of benefitting households.

Benefitting Households

Households both near to and distant from Oak Bluffs' coasts may hold values, including use and non-use values, for ecosystem services provided by coastal wetlands. Data on the number of households that use (e.g., view, recreate in, fish in) and do not use, but value these habitats (i.e., valuing wetlands purely because they exist) were unavailable. Johnston et al.'s (2002) original valuation function estimated WTP of year-round and seasonal residents in the five towns surrounding the Peconic Estuary. In keeping with this scope, we applied per-household benefits to the 6,160 households residing in Dukes County, which includes the six Martha's Vineyard towns. We accounted for population changes during the study period using population projections for Dukes County from 2015 to 2035 (UMass Donahue Institute, 2015) divided by the average number of people per household (U.S. Census Bureau, 2015; *Table 5-3*). Other households beyond Dukes County may value habitat support services provided by Oak Bluffs' coastal wetlands. Thus, our estimate may understate the values of these services.

Table 5-3. Estimated Number of Households in Dukes County, MA

Year	Projected Population	Average # People Per Household	Estimated # Households
2015	17,291	2.79	6,197
2020	17,305	2.79	6,203
2025	17.604	2.79	6,310
2030	17,972	2.79	6,442
2035	18,453	2.79	6,614

Source: UMass Donahue Institute (2015) and U.S. Census (2015)

Estimated Household Values for Coastal Wetlands

Assuming the coastal wetlands persist throughout the study period (2016-2050), we estimate that the total non-market value of coastal wetlands (117.56 acres) in Oak Bluffs is $26,360-$27,853 per year when annualized over the 34-year timeframe. The TPV of these benefits ranges from $896,231 to $946,993. This range incorporates WTP values for Dukes County households using per-household WTP estimates from two different studies (*Table 5-4*). Our analysis quantifies coastal wetland habitat benefits in Oak Bluffs' public coastal resources only. Private coastal wetlands likely provide additional benefits.

Table 5-4. Total Economic Value of Public Coastal Wetlands in Oak Bluffs (2016$)

Study	$HH/Year	# Households (2016)	Annualized Value	TPV (2016-2050, Millions $)
Johnston et al. (2002)[1]	$6.27	6,160	$26,360	$0.90
Bauer et al. (2004)	$6.62	6,160	$27,853	$0.95

[1] WTP value adjusted to include only wildlife support values (based on the U.S. EPA (2004) analysis; 73% of original WTP value).

5.2 Seagrass

Seagrass is widely recognized for the critical support services it provides to both wildlife and people. Below, we first describe the ecological support that seagrass provide to local wildlife. Second, we provide an estimate of the economic value of the support services provided by seagrass through its impacts on local fish and bird populations. Finally, we conclude with an analysis of the potential societal value of the support services provided by seagrass.

5.2.1 Wildlife Support

Seagrass is another important habitat for the wildlife and invertebrates that reside in the Oak Bluffs area; in this region, the habitat is dominated by eelgrass (*Zostera marina*; Hempy & Wilcox, 1998). As with wetlands, seagrass can provide critical habitat for fish, shellfish and birds (Massachusetts Office of Energy and Environmental Affairs (MOEEA), n.d.). For fish, seagrass provides shelter from predators for juvenile and adult fish. Fish also depend on seagrass for food, whether the blades of the grass itself, the detritus the grass produces, or the small fish and invertebrates that reside among the vegetation (Graff & Middleton, 2001). The fish species in Oak Bluffs that may benefit from eelgrass are similar to those that benefit from wetland habitat, as they can utilize eelgrass for feeding and protection from predators as they do in salt marshes; these are striped bass, bluefish, alewife, seabass, and eel (Town of Oak Bluffs, 2015). This habitat is also critical for the bay scallop (Environmental Data Center, n.d.), a regionally scarce species that is being increasingly introduced into various estuaries on Martha’s Vineyard, including Sengekontacket and Lagoon Ponds (Walthers, 2010). Seagrass also represents a critical foraging habitat for waterfowl, particularly in the breeding and migration seasons (MOEEA, n.d.; USFWS, 2008). Specific waterfowl that are known to forage in the wetlands of Martha’s Vineyard include greater scaup, red-breasted mergansers, and bufflehead (Pelikan, 2015). Seagrass also helps consolidate and stabilize sediments, which can help maintain water quality and clarity (MOEEA, n.d.)

As with wetlands, seagrass habitat in Oak Bluffs is under threat from eutrophication, and its habitat has declined significantly over the past several decades; seagrass is absent from Oak Bluffs Harbor, and only remnant patches remain in Sengekontacket Pond habitats (Howes, Eichner, et al., 2010; Howes, Ramsey, et al., 2013). Excess nitrogen from septic systems has led to algal blooms, which have shaded out eelgrass and led to its decline. The loss of seagrass further degrades water quality because fewer particulates are trapped among its leaves and roots, and sediments are less stable. This in turn leads to a further loss of seagrass habitat. Restoring estuaries through a reduction in nutrient inputs or increasing tidal flushing will likely be essential to maintaining or increasing this critical habitat.

Eelgrass *Friends of Sengekontacket*

5.2.2 Valuation of Eelgrass Primary Productivity

Eelgrass beds provide excellent habitat and food sources for a variety of marine and estuarine species, including birds and many juvenile fish and shellfish species (bay scallops, crabs) of ecological, commercial, and recreational importance. Protection of eelgrass habitat thus provides substantial benefits in the production of finfish, shellfish, birds, and other wildlife. These species may then be commercially harvested or used for viewing and hunting.

The immense habitat productivity benefits of eelgrass are especially noticeable in areas experiencing eelgrass habitat loss. Hughes et al. (2002) conducted a long-term study in 15 estuaries in Buzzards Bay and Waquoit Bay, MA, to assess the impacts of eelgrass habitat loss on estuarine fish. They determined that fish abundance, biomass, species richness, and fish community integrity decline significantly as eelgrass habitat complexity decreases. Additionally, all but two common fish species in these estuaries declined in abundance and biomass when eelgrass habitat was completely lost (Hughes et al., 2002). A Swedish study also determined that the loss of one hectare of eelgrass habitat results in the loss of 626 kg of cod fishes and 7,535 wrasse fish (Cole and Moksnes, 2016), and the study measured impacts for only 5 of the 41 fish species that rely on eelgrass beds on the Swedish northwest coast.

We valued the potential total per-acre value of habitat preservation to a general assemblage of species that are likely to use the preserved areas, following Johnston et al. (2002)'s habitat productivity model.

Johnston et al. (2002):

- Estimated the average per-acre value of restoring Peconic Estuary (Long Island, NY) eelgrass habitat for species that preferentially use or depend on the habitat and are valued for human uses, including the abundance of wading birds and the expected yield of bay scallops and blue crabs.

- Based the benefits from changes in these populations on the end value of each species or type/group of animal: bird values are based on recreational hunting and viewing, and specific fish and shellfish species values are based on commercial landings data.
- Summed all food web and habitat values for a single year and estimated a marginal annual value of healthy eelgrass habitat at $1,569/acre (2016$).

We applied this per-acre point estimate to the total acreage of eelgrass habitat in Oak Bluffs, assuming that habitat productivity values persist through 2050. We estimate that the annualized habitat productivity value to fish, birds, scallops, and crabs is $78,703, and the TPV is $2.75 million. Given the high degree of overlap across services included in TPV estimates of eelgrass habitat productivity and TPV based on WTP, benefits estimates in this section are recommended as an *alternative* estimate, and not an additive estimate.

5.2.3 Valuation of the Support Services Provided by Eelgrass

While we have qualitatively described some of the habitat support services provided by eelgrass in Section 5.2.1, it is also possible to provide a quantitative estimate of the value that people place on these types of services. We provide an analysis of the value of eelgrass supporting services below, in three key steps. First, we describe how we identified the value that households on average place on the supporting services provided by eelgrass. Second, we describe the households in Oak Bluffs that likely value these services. Finally, we develop a final estimate of household value by multiplying household values for eelgrass support services by the relevant number of households that value Oak Bluffs eelgrass.

Household Values

While eelgrass provides a diversity of ecosystem goods and services, there have been few studies of household WTP for eelgrass or other seagrass habitat (Barbier et al., 2011). We use results from a study of eelgrass value in the Peconic Estuary system (PES; Johnston et al., 2002)[6] to estimate a monetary value of eelgrass habitat in Oak Bluffs because eelgrass is the dominate seagrass in Massachusetts and Oak Bluffs. Aquatic species found in eelgrass bed in Massachusetts and New York are similar.

The valuation function in Johnston et al. (2002) is estimated based on results of a survey that provided background information on eelgrass in the PES, including its function as habitat for fish and shellfish species, and estimated WTP for the area of eelgrass restored or protected from further degradation. Thus, values from Johnston et al. (2002) provide a good match to the Oak Bluffs scenario and enable us to estimate the habitat support value of protected eelgrass. The authors estimated average annual household WTP at $0.082/acre (2016$). To obtain an annual household WTP value for Oak Bluffs, we multiplied the per-acre value by the acres of eelgrass within the Oak Bluffs town boundary (79.33 acres). Next, we scaled annual household WTP values to account for the size and the extent of ecological services provided by Oak Bluffs' eelgrass beds using the number of benefitting households.

Benefitting Households

Households likely to hold values for eelgrass habitat include all households in Dukes County, MA. Section 5.1.3 provides detail on the approach used for estimating the number of affected households.

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6 Based on Mazzotta's (1996) dissertation. Mazzotta (1996) provides full details on the survey.

Estimated Household Values for Eelgrass

Assuming Oak Bluffs' eelgrass beds persist throughout the study period (2016-2050), we estimate that the WTP value among Dukes County households for eelgrass habitat support services is approximately $27,412 per year when annualized over the 34-year study period (*Table 5-5*). The TPV of these benefits is $932,006.

Table 5-5. Total Economic Value of Eelgrass Habitat in Oak Bluffs (2016$)				
Study	$HH/Year	# Households (2016)	Annualized Value	TPV (2016-2050, Millions $)
Johnston et al. (2002)	$6.52	6,160	$27,412	$0.93

5.3 Beaches and Sand Dunes

Beaches and sand dunes are already valued for their contribution to human well-being, but they are also valuable habitats for wildlife. Here, we describe the ecological support that beaches and sand dunes provide to local wildlife.

Beaches and sand dunes are a critical component of the coastal ecosystem in Oak Bluffs, providing habitat for wildlife as well as protection for inland ecosystems. Many organisms benefit from the presence of beach and dune ecosystems in Oak Bluffs, including plants and birds. Beaches in Oak Bluffs include unvegetated beach and berm areas, sparsely vegetated dunes that are dominated by beach grass, and more densely vegetated inner dunes with bayberry, saltspray rose, poison ivy, and winged sumac (USFWS, 1991). The beaches at the periphery of Oak Bluffs provide potential breeding and nesting habitat for shorebirds, including the federally and state threatened piping plover as well as common and least terns, both species of concern for the state of Massachusetts (USFWS, 1991; MDFW & the Nature Conservancy, 2012). Beaches and dunes also provide protection to inland ecosystems from damage during coastal storms, just as they provide protection for nearby human communities. More specifically, beaches protect back-barrier wetlands from wind and wave damage during storms, which protect critical habitat and prevent the accelerated coastal erosion that often accompanies wetland degradation.

While beaches and dunes provide important habitat for plants and birds, the value of the habitat is strongly influenced by human use of the habitats that are present. For example, all the shorebirds mentioned above that use beach habitat for breeding are very sensitive to human disturbance, and birds abandon nesting areas when human foot traffic, stray animals, or vehicles are present (USFWS, 2008). Beach erosion can also be accelerated through vehicular use during the off-season or from coastal armoring, which can amplify wave energy and prevent natural beach migration (MDFW, 2016).

5.4 Threatened and Endangered Species

In this section, we provide information on the threatened and endangered species that may benefit from the coastal habitats found in Oak Bluffs. Overall, Oak Bluffs harbors nine species that are threatened or endangered at the federal or state level and have been observed on the island within the past two decades (http://www.mass.gov/eea/scripts/dfg/species-viewer.html). Three of these species depend on one or more of the coastal habitats described above, and we provide more information on each of them below. We begin with an overall description of each species and its habitat requirements, and conclude with a discussion of how the habitats found in Oak Bluffs may support the conservation of that species.

5.4.1 Piping Plover *(Charadrius melodus)*

The piping plover is a small, stocky shorebird with brown, white, and black coloring that provides excellent camouflage in the beach habitat in which it breeds. Piping plovers are listed as threatened both federally and in the state of Massachusetts (MDFW, 2015a), and the state released a habitat conservation plan for the piping plover in 2016 (MDFW, 2016).

Piping plovers prefer to breed on beaches and sand dunes that are relatively free of vegetation, which typically is between the high-tide water line and the foot of the dunes (MDFW, 2015a; MDFW, 2016). Territories on beaches are established by males in the early spring (March and April), and nests are typically around 200 feet apart (MDFW, 2015a; MDFW, 2016). It takes 26-28 days for eggs to hatch, and young typically stay with their parents for 25-35 days before they fledge. Piping plovers typically forage along the intertidal area of either ocean-facing or bay-side beaches, where they consume marine worms, mollusks, crustaceans, and insects (MDFW, 2016). The birds migrate between July and early September, and adults often return to the site to breed every year (MDFW, 2015a). Piping plovers are extremely sensitive to human activity, pets, and vehicles, and will abandon sites either seasonally or permanently if too much human disturbance is present (MDFW, 2016). However, recent conservation efforts have shown that actively managing nesting areas (e.g., by fencing off breeding areas) can re-establish breeding piping plovers in areas that had been previously abandoned (MDFW & the Nature Conservancy, 2012; MDFW, 2016).

In Oak Bluffs, piping plover may use relatively undisturbed beaches (e.g., Sengekontacket Pond) to breed. In fact, this species can be found breeding in various locations on Martha's Vineyard, typically in the least disturbed habitats of the island in the south (Seccombe, 2008). Piping plover, either during breeding or migration, are also able to utilize the mudflats of the town's coastal wetlands and salt ponds. In fact, recent bird sightings indicate the presence of piping plover on John Sylvia State Beach as recently as July 2015 (https://ebird.org/ebird/map).

Piping Plover on Martha's Vineyard — *Lanny McDowell*

5.4.2 Roseate Tern *(Sterna dougallii)*

The roseate tern is a medium-sized, gull-like tern with silvery and white body feathers and a distinctive black cap during the breeding season (USFWS, 2011). Hunting related to the hat trade, along with displacement in breeding areas by gulls, led to its decline over the 19th century (MDFW, 2015b). It is currently endangered both in Massachusetts and at the federal level.

The roseate tern tends to nest on sandy, gravelly, or rocky islands, isolated from human disturbance and land predators, but it occasionally nests at the ends of long barrier beaches (USFWS, 2011). It prefers sites with vegetation (e.g., beach pea or goldenrod), which also provides cover for young chicks (MDFW, 2015b). Nests are simple scrapes in the ground to which vegetation may be added throughout the incubation period (MDFW, 2015b). The tern arrives in late April to early May to breed, and typically nests in large colonies along with common terns, a more aggressive tern that serves to protect the colony (MDFW, 2015b). Eggs take about 3 weeks to hatch, and nestlings are reared for about 4 weeks before they fledge. The roseate tern feeds in shallow sandbars, inlets, and offshore, up to 30 km from nesting sites (MDFW, 2015b). This tern depends almost exclusively on small fish, such as lance, herring, bluefish, mackerel, silversides, and anchovies (MDFW, 2015b). In early fall, the birds concentrate in "staging" areas before migration, where they feed and prepare for the long flight (MDFW, 2015b). Migration occurs in mid- to late September.

In Oak Bluffs, roseate terns may use some of the more remote sections of barrier beaches to breed, though as noted above the species prefers to nest on more remote islands that support larger colonies. However, roseate terns may use habitat in the wetlands, eelgrass, and near-shore habitats surrounding Oak Bluffs for feeding. This may be particularly important just prior to migration, as roseate terns tend to congregate in the region prior to migration (USFWS, 2011). Birders have observed roseate terns in Oak Bluffs as recently as May of 2017 on John Sylvia State Beach (https://ebird.org/ebird/map; Culbert, 2017).

Roseate Terns on Martha's Vineyard — *Lanny McDowell*

5.4.3 Northern Gama-Grass (*Trypsacum dactyloides*)

Northern gama-grass is listed as endangered in Massachusetts, though it is more abundant south of New England with a range that extends to Florida in the south and Michigan to the west (MDFW, 2015c). It is a perennial plant that prefers sandy and rocky substrates, and can grow from 1 to 4 meters in height (MDFW, 2015c). Northern gama-grass is found in maritime areas near the edges of salt ponds, salt marshes, and wet beach strands (MDFW, 2015c). It is typically located just above the spring high-tide mark, and is often exposed to, and can tolerate, significant winds and storm surge (MDFW, 2015c).

The coastal ecosystems of Oak Bluffs harbor a critical population of northern gama-grass in Massachusetts. However, while the species can tolerate natural disturbance well, it is sensitive to trampling and vehicular damage and thus needs to be protected from human disturbance. It may also suffer from the establishment of *Phragmites australis*, a non-native species that can outcompete native vegetation in the peripheries of salt marshes and salt ponds (MDFW, 2015c).

5.5 Total Value of Supporting Services

The estimated total present value (2016-2050) of supporting services provided by Oak Bluffs' public coastal resources is $1.83 million to $1.8 million (*Table 5-6*). This total includes $896,231 to $946,993 in coastal wetland habitat support benefits and $932,006 in eelgrass habitat support benefits. Our analysis quantifies supporting services in Oak Bluffs' public coastal resources only. Private coastal resources may provide additional supporting service benefits.

Table 5-6. Total Economic Value of Supporting Services in Oak Bluffs' Coastal Resources (2016$)

Ecosystem Service	Annualized Value[1]	TPV[2] (2016-2050, Millions $)
Coastal Wetlands	$26,360 - $27,853	$0.90 - $0.95
Eelgrass	$27,412	$0.93
Beaches and Sand Dunes	Positive Qualitative Benefit	
Threatened and Endangered Species	Positive Qualitative Benefit	
Total	$53,772 - $55,265	$1.83 - $1.88

[1] Annualized value is estimated using a 3% discount rate.
[2] TPV is estimated using a 3% discount rate.

5.6 Limitations and Uncertainty

Table 4-7 summarizes key limitations and uncertainties in the benefits analysis for cultural services in Oak Bluffs' public coastal resources and indicates the direction of any potential bias.

Table 5-7. Limitations and Uncertainties in the Analysis of Cultural Services Benefits

Issue	Effect on Benefits Estimate	Notes
Transfer error	Uncertain	We used benefit transfer values from Johnston et al. (2002) and Bauer et al. (2004) to value wetland and eelgrass habitat benefits. While widely accepted, benefit transfers are always subject to the inherent uncertainty in applying models developed for one site and purpose, to a different site and purpose. Transferring values across sites introduces an unknown bias in resulting estimates.
Limitations of the geographic information system (GIS) datasets	Uncertain	We obtained acreage estimates for coastal wetlands and eelgrass using MassGIS layers and the MVC's public coastal resources GIS layer. Any inaccuracies in these GIS layers can cause over- or underestimates of public coastal wetland and eelgrass acreage.
Uncertainties in future wetland and eelgrass acreage	Uncertain	We assumed that coastal wetland and eelgrass acreage remains constant throughout the study area. Since our analysis focuses on public coastal resources that are largely protected, we believe coastal wetland and eelgrass acreage will NOT decrease substantially. However, natural factors, such as coastal storms, can influence eelgrass populations. Eelgrass beds may also grow and expand during the study period.
Benefitting households for wetland and eelgrass analysis	Uncertain	The number of households that value coastal wetlands and eelgrass in Oak Bluffs is uncertain. The chosen number of benefitting households can have a substantial impact on the benefit estimate. We attempted to control for this uncertainty by providing a benefits range, with a conservative estimate (Dukes County households) and a high estimate (all households within 50 miles of Oak Bluffs).

6. Regulating Services

The coastal ecosystems of Oak Bluffs provide an array of ecosystem services that reduce atmospheric pollutants and protect coastal land from storms. Below, we describe the regulating ecosystem support services provided by the coastal habitat found in Oak Bluffs: (1) vegetation-related carbon sequestration and storage, (2) air pollution removal, (3) oyster-driven carbon and nitrogen sequestration, and (4) storm protection and erosion control. For each of these services, we first provide a qualitative description of the overall coastal ecological systems that provide regulating services in Oak Bluffs. We follow this discussion with analyses that estimate the economic value provided to people through the regulatory services the habitats provide.

Farm Pond *Timothy Johnson*

6.1 Vegetation-Driven Carbon Sequestration and Storage

Climate change presents a long-term threat to the global environment. Carbon dioxide (CO_2) and other greenhouse gases (CH_4 and N_2O) contribute to climate change by absorbing outgoing terrestrial radiation (Jo and McPherson, 2001). The relationship between land use and greenhouse gas levels is complex (Andrews, 2008; Lu et al., 2015). Trees and other vegetation sequester carbon in their biomass or in the soil, removing it from the atmosphere and preventing it from contributing to climate change. Above-ground herbaceous biomass tends to die annually, whereas the woody portions of plants can store carbon for many years prior to dying and decomposing (Gorte, 2009). Carbon accumulates in the upper soil layers as dead vegetation is added to the surface and decomposes. Carbon can also enter the soil through root growth and decomposition. Long-term storage of carbon (e.g., 100 years) is of particular interest for climate change mitigation compared to carbon that is released back into the atmosphere in the short term through decomposition. This analysis focuses on the direct carbon sequestration and storage provided by vegetated areas of Oak Bluffs' coastal areas.

We quantified carbon sequestration and storage rates using data from existing studies and geographic databases and applying rates per unit area of vegetation to the coastal resources landscape. This analysis entails four main steps, described in this section:

1. *Estimate vegetation cover in Oak Bluffs' public coastal resources;*

2. *Estimate carbon sequestration for major vegetation types;*
3. *Estimate carbon storage for forests (data for other vegetation types were lacking); and*
4. *Estimate the monetary value of carbon sequestration and storage services provided by coastal resources based on the social cost of carbon (SCC).*

6.1.1 Estimate Vegetation Cover

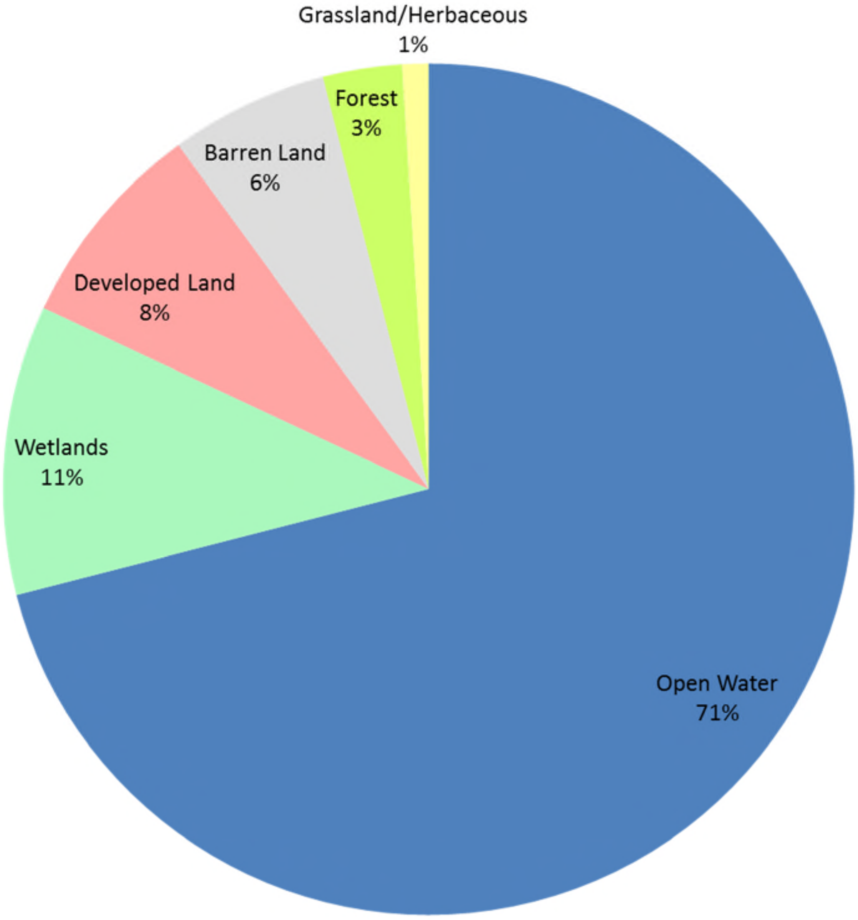
The analysis of vegetative cover relied on four key data sources:

1. *NLCD 2011*– The National Land Cover Database (NLCD) provides a detailed, geographic database of land cover throughout the United States (Homer et al., 2015). The NLCD is produced by the Multi-Resolution Land Characteristics (MRLC) consortium, a group of federal agencies that collaboratively develop land cover information at a national scale for various uses (U.S. Geological Survey, 2015).
2. *Public Coastal Resources* – GIS layer provided by Martha's Vineyard Commission and MassGIS. They layer designates which coastal resources are open to the public (not private land).
3. *Wetlands* – GIS layer provided by MassGIS. The layer provides locations and classifications for all coastal wetlands.
4. *Eelgrass* – GIS layer provided by MassGIS. The layer provides locations of eelgrass beds throughout Massachusetts. We used the offshore boundary for Oak Bluffs to determine which eelgrass beds are located within Oak Bluffs.

The majority of land cover within Oak Bluffs' public coastal resources (82%) is classified as open water and wetlands. *Figure 6-1* summarizes dominant vegetation.

We quantified carbon sequestration benefits for four different cover categories: forest, grassland, wetland (divided into salt marsh and freshwater wetlands), and eelgrass (which is a small subset of the open water cover category). We measured forests, grassland, and wetland cover by intersecting the NLCD data layer with the coastal resources shapefile. We assessed eelgrass cover using the MassDEP Eelgrass Mapping Project shapefile and the offshore town boundary for Oak Bluffs.

Figure 6-1. Distribution of Dominant Vegetation or Land Use Categories within Oak Bluffs' Public Coastal Resources



Source: Homer et al. (2015)

6.1.2 Estimate Carbon Sequestration for Major Vegetation Types

Carbon sequestration refers to the net amount of carbon removed from the atmosphere over a given period of time; in this section we focus on carbon sequestration provided by vegetation. Not all ecosystems actively sequester more carbon over time; mature forests, for example, may store a lot of carbon, but not be actively accumulating it over time. After storms, when vegetation and soils are disturbed, ecosystems can even lose carbon rather than sequester it. However, wetland ecosystems, disturbed or young forests, or habitats that are growing in otherwise bare/degraded areas do tend to sequester carbon. Below, we provide estimates of annual carbon sequestration for the vegetation types found in Oak Bluff's coastal ecosystems.

Forests. For forested areas, we used state-level sequestration values from the U.S. Forestry Service's analysis of *Carbon Storage and Sequestration by Trees in Urban and Community Areas of the United States* (Nowak, Greenfield, et al., 2013). State values reflect the distribution of tree species, size, age, health condition, and length of growing season observed in samples. The estimated net sequestration rate for Massachusetts is 0.188 kg C per square meter per year based on the ratio of the average length of growing season in each state to sample average length of growing season. We applied the net sequestration rate to all forest cover in Oak Bluffs' coastal resources, assuming that the rate remained constant through the analysis period. By using net sequestration rates, we implicitly accounted for changes in tree condition and death over time.

Grasslands. Grasslands have been shown to sequester carbon over long periods of time, up to 45 years, with rates greatest in the first 25 to 30 years after establishment of grass cover (Post & Kwon, 2000; Pouyat et al., 2009; Qian and Follett, 2002). The net change in carbon accumulation within soils depends, in part, on initial levels of soil organic carbon in the native soil (Pickett et al., 2008). For this analysis, we applied a mean net sequestration value of 0.56 kg C per square meter per year based on a review of the scientific literature for grass cover (Appendix D). We held the sequestration rate for grasslands constant for the duration of the analysis period.

Eelgrass. Two species of seagrass are found in Massachusetts—*Zostera marina* (eelgrass) and *Ruppia maritime* (widgeon grass), but eelgrass is more common. Only eelgrass is present within the Oak Bluffs offshore boundary. In our analysis, we used the Commission for Environmental Cooperation's (2016) carbon sequestration rate of 0.083 kg C per square meter per year.

We calculated the carbon sequestration for each year of the analysis by multiplying the area of the wetlands, forests, grasslands, and eelgrass land by the carbon sequestration rates provided above.

Carbon sequestration is calculated as follows:

$$C_t = \sum LC_t \times \left(\frac{\text{SeqR} \times 4{,}046.86}{1{,}000}\right) \quad \textbf{(Eq. 6-1)}$$

where:

C	=	Carbon sequestered by vegetation
LC	=	Land cover (trees, grasses, wetlands, eelgrass) acreage
t	=	Year within the analysis period
SeqR	=	Net sequestration rate for each land cover (kg C per square meter per year)

For this analysis, net sequestration rates per square meter were converted to a per-acre basis by multiplying by 4,048.86 m^2 per acre and converted from kilograms to metric tons by dividing by 1,000.

6.1.3 Estimate Carbon Storage for Forests

Carbon storage refers to the amount of carbon residing in an ecosystem (as opposed to the amount of additional carbon entering that system each year via sequestration). In our carbon storage analysis, we focused on forest cover only. We used an average carbon storage amount (7.24 kg C/m^2) derived from managed forest in the United States (Heath et al., 2011). Because carbon storage represents a standing "stock" instead of an annual rate (i.e., the carbon is stored as long as the forest is standing), we calculated carbon storage only for the current year (2016).

Carbon storage is calculated as follows:

$$CS = forest\ acres \times \frac{7.24 \times 4{,}046.86}{1{,}000} \quad \textbf{(Eq. 6-2)}$$

where:

CS = Carbon stored by forest cover
7.24 = Carbon storage amount for forest cover (kg C per square meter)

For this analysis, the carbon storage amount per square meter was converted to a per-acre basis by multiplying by 4,048.86 m^2 per acre and converted from kilograms to metric tons by dividing by 1,000.

6.1.4 Monetary Value of Vegetation-Related Carbon Sequestration and Storage Services

We estimated the monetary value of vegetation-related carbon sequestration and storage by multiplying the estimate of annual carbon sequestration by the SCC. The SCC is "… an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year" (Interagency Working Group (IWG), 2013). The SCC intends to reflect the value of the various effects of climate change, such as changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services affected by climate change. It is typically expressed as dollars per metric ton of carbon dioxide (CO_2) removed from the atmosphere or alternatively as dollars per metric ton of carbon (C). The SCC increases over time as incremental damages associated with carbon dioxide emissions grow (IWG, 2010, 2013).

The economic literature includes many SCC values estimated using various models and assumptions. SCC is often estimated based on outputs from integrated assessment models (IAMs), which tie climate changes to economic damages. Beginning in 2009, various agencies participated in a U.S. government Interagency Working Group to develop SCC values for use in regulatory analysis (IWG, 2010).[7] The working group developed a set of recommended SCC values for use in U.S. regulatory analyses based on the average from original runs of three IAMs—the Dynamic Integrated Climate and Economy model (DICE), the Policy Analysis of the Greenhouse Effects model (PAGE), and the Climate Framework for Uncertainty, Negotiation, and Distribution (FUND) model (IWG, 2010). A technical update to the SCC values was released in 2013 (IWG, 2013). In keeping with the U.S. government's standards for policy analysis, this study used the IWG's SCC estimates.[8]

We assumed, as is standard in economic analyses of the present value of future benefits, that society holds a positive rate of time preference. Because people generally feel that receiving benefits now is preferable to receiving benefits in the future, society discounts the value of future benefits relative to current benefits (Conrad, 2010). The discounting of SCC values requires special consideration because of the discount

[7] Participants included the U.S. Environmental Protection Agency, Council of Economic Advisers, Council on Environmental Quality, Department of Agriculture, Department of Commerce, Department of Energy, Department of Transportation, National Economic Council, Office of Energy and Climate Change, Office of Management and Budget, Office of Science and Technology Policy, and the Department of the Treasury.

[8] These SCC estimates assume that climate change does not slow economic growth. Alternative estimates are available and suggest that the 2015 SCC approaches $220/ton (Moore & Diaz, 2015). We do not use them here, to maintain consistency with U.S. federal government guidelines for economic analysis in place at the time of this report.

rate assumptions included within their estimation. That is, an SCC value estimated for a given year reflects costs in later years that are discounted back to the year when the carbon dioxide is emitted. The IWG selected four sets of SCC values for use in regulatory analysis, using 2.5%, 3%, and 5% discount rates. The fourth set of SCC values reflects the 95th percentile SCC values across all models using a 3% discount rate. *Table 6-1* presents the SCC values used for each year of the analysis period, expressed in 2016$ per metric ton of C removed from the atmosphere. These values reflect *global* SCC. The IWG recommends the use of global values in lieu of "domestic SCC" for policy analyses due to the global nature of the climate change problem.[9] We used these data to develop year-specific SCC estimates for each year in our analysis period, interpolating within the 5-year periods (*Table 6-1)*.

We discounted future values using a 3% discount rate (U.S. EPA, 2010; U.S. Office of Management and Budget, 2003). All present and annualized values are reported in present-day currency (U.S. dollars, in the 2016 dollar year), and where necessary were converted using the GDP Index.

Table 6-1. Social Cost of Carbon, 2015-2050 (2016$/metric ton of CO_2)

Year	SCC[1] by Discount Rate			
	5.0% Average	3.0% Average	2.5% Average	3.0% 95th Percentile
2015	$13	$41	$64	$120
2020	$14	$48	$71	$140
2025	$16	$52	$78	$157
2030	$18	$57	$83	$173
2035	$21	$63	$89	$191
2040	$24	$68	$96	$209
2045	$26	$73	$101	$225
2050	$30	$79	$108	$242

[1] SCC values reported by IWG (2016) were converted to 2016$ using the GDP deflator.

We calculated annual benefits in each year of the analysis period by applying the SCC values for that year to the mass of carbon sequestered, following the equation below.

$$B_{i,t} = C_{i,t} \times SCC_{t,d} \times 3.67 \qquad \textbf{(Eq. 6-3)}$$

where:

B = Benefits in year *t* of the analysis
C = Carbon sequestered (metric tons)
i = Land use *i*,
t = Year within the analysis period

[9] Some analysts of SCC have included "equity weights" to account for differences in consumption and relative reductions in wealth across different regions of the world. The argument is that a monetary loss in a poor country results in a greater loss of utility than the same amount of money in a wealthy country. The Interagency Working Group concluded that this approach is not appropriate when estimating SCC values for domestic regulations (IWG, 2010), therefore, global SCC values without equity weights are applied here.

SCC = Social cost of carbon (2016$ per metric ton of CO_2)
d = Discount rate (set to 3% average)
3.67 = the molecular weight of CO_2 divided by the molecular weight of C (44/12)

We calculated the *TPV* of carbon sequestration benefits as follows:

$$TPV = \sum_i \sum_{t=2016}^{2050} \left(\frac{B_t}{(1+d)^{(t-2016)}} \right) \quad \textbf{(Eq. 6-4)}$$

where:

t = Year within the analysis period
B = Benefits in year t of the analysis
d = Discount rate (3%).

Using the 3% average SCC values, we estimated that Oak Bluffs' coastal resources generate a TPV of $245,946 in carbon sequestration benefits, with annualized benefits of $7,234 (*Table 6-2*).

Table 6-2. Summary of Carbon Sequestration Benefits from 2016 to 2050.

Total carbon sequestered (mt C)	2,353
Average annual carbon sequestration (mt C)	67
Annualized value of carbon sequestration benefits (3% discount, 2016$)	$7,234
TPV of carbon sequestration benefits (3% discount, Millions 2016$)	$0.25

6.1.5 Monetary Value of Carbon Storage Services

We estimated the monetary value of carbon storage by multiplying the estimate of total carbon storage by modified SCC values provided by Mills et al. (2014; *Table 6-3*). The value modifications are related to the permanence of carbon storage. A reduction in CO_2 emissions is assumed to be permanent, but carbon storage may be temporary due to tree removal or death over time (e.g., land clearing during land development). The U.S. government SCC estimates represent a net present value of damages avoided from each analysis year through 2300. Use of these values would therefore overestimate the value of carbon storage if any CO_2 is released before 2300. The adjusted values reported by Mills et al. (2014) better account for the timeline of carbon storage benefits. *Table 6-3* shows the social cost of carbon values used to estimate carbon storage values.

Table 6-3. Social Cost of Carbon Values Used to Estimate Carbon Storage Values (2016$/metric ton of CO2, discounted to 2016)

Year	SCC[1] by Discount Rate			
	5.0% Average	3.0% Average	2.5% Average	3.0% 95th Percentile
2016	$12	$42	$65	$124

[1] Values reported by Mills et al. (2014; 2005$) were converted to 2016$ using the GDP deflator.

We calculated total carbon storage benefits for current conditions (2016) by applying the modified SCC values for that year to the mass of carbon stored, following the equation below.

$$B = C \times SCC_d \times 3.67$$ **(Eq. 6-5)**

where:

B	=	Benefits
C	=	Carbon stored (metric tons)
SCC	=	Social cost of carbon (2016$ per metric ton of CO_2)
d	=	Discount rate (set to 3% average)
3.67	=	The molecular weight of CO_2 divided by the molecular weight of C (44/12)

Using 3% average SCC values, we estimated that Oak Bluffs' coastal resources generate a TPV of $133,775 in carbon storage benefits.

Table 6-4. Summary of Carbon Storage Benefits in 2016	
Total carbon stored (mt C)	863
TPV of carbon storage benefits (3% discount, Millions 2016$)	$0.13

6.2 Air Pollution Removal by Forests

In addition to carbon storage and sequestration, forests growing in the Oak Bluffs coastal area also reduce ambient concentrations of air pollutants in two ways: directly, by removing pollutants from the air, and indirectly, by reducing air emissions associated with energy use for building cooling and heating (Akbari and Konopacki, 2003; McPherson et al., 1999; Simpson, 2002).

Trees can act as a sink for ambient pollutants through dry deposition due to the surface area and roughness of vegetation and uptake through leaf stomata (Beckett et al., 2000; Nowak, Crane, & Stephens, 2006; Nowak, Hirabayashi, et al., 2013b; Yang et al., 2008). Gaseous pollutants are primarily removed by uptake through leaf stomata, and particulate pollutants are primarily captured by plant surfaces (Nowak, McHale, et al., 1998; Nowak, Crane, & Stephens, 2006). Vegetation is typically only a temporary retention site for particulate pollutants. Intercepted particles are re-suspended into the atmosphere; washed off by precipitation; or deposited on the ground with leaves, twigs, and other plant debris (Nowak, McHale, et al., 1998). The mass of pollutant removed by vegetation tends to represent a small fraction of total ambient pollution (Nowak, Crane, & Stephens, 2006; Nowak, Hirabayashi, et al., 2013). For example, annual percentage reductions in ambient $PM_{2.5}$ range from 0.05% to 0.24% for 10 cities examined by Nowak, Hirabayashi, et al. (2013). However, the human health benefits of even small percentage changes in air quality can be substantial (Nowak, Hirabayashi, et al., 2013).

This chapter describes our analysis of direct removal of pollutants by forests only, as data regarding the air pollution benefits of wetland vegetation were insufficient to conduct a rigorous analysis. Our approach specifically estimates tree-driven net reductions in atmospheric pollutant concentrations of four pollutants (NO_2, SO_2, $PM_{2.5}$, and O_3). These pollutants are common throughout the United States and are detrimental to human welfare (U.S. EPA, 2013). Health effects related to these pollutants include impacts on pulmonary, cardiac, vascular, and neurological systems (Pope et al., 2002; Nowak, Hirabayashi, Bodine, & Greenfield, 2014). We multiply pollution reduction estimates by health benefit per ton estimates to obtain a monetized estimate of the air pollution benefits of coastal forest cover.

Our analysis of atmospheric pollutant removal involved three main steps:

1. *Estimate forest cover;*
2. *Estimate reductions in atmospheric pollutant concentrations by forests; and*
3. *Estimate health benefits from reductions in pollution concentrations.*

6.2.1 Estimate Tree Canopy Cover

For the air pollution reduction analysis, we used forest cover estimates only (see Section 6.1.2 for methodology).

6.2.2 Estimate Reductions in Atmospheric Pollutant Concentrations

Nowak, Hirabayashi, Bodine, and Greenfield (2014) estimated air pollution removal rates of forests for each state in the United States. We used the total pollution removal rate for Massachusetts and divided the total into removal rates for four pollutants—NO_2, O_3, $PM_{2.5}$, and SO_2—based on the national proportions for each pollutant to obtain removal rates per acre. We multiplied these per acre estimates by the number of forest acres in Oak Bluffs' coastal resources to obtain estimates of total removal for each pollutant.

Table 6-5. Air Pollution Removal Rates for NO_2, O_3, SO_2, and $PM_{2.5}$ (g/m2) for Massachusetts

Pollutant	Air Pollutant Removal Rate (g/m^2)
NO_2	0.362
O_3	3.611
$PM_{2.5}$	0.178
SO_2	0.230
Source: Nowak, Hirabayashi, Bodine, and Greenfield (2014)	

6.2.3 Estimate Monetary Value of Air Pollution Removal

To analyze the benefits of air pollution reduction, we relied on a screening-level approach based on the estimated values of health benefits per ton of air pollution reduction. These values represent the total monetized human health co-benefits, premature mortality and premature morbidity, from the reduction in one ton of O_3 or $PM_{2.5}$ (or $PM_{2.5}$ precursors such as NO_2 or SO_2) (Nowak, Hirabayashi, Bodine, & Greenfield, 2014).

To be consistent with the rest of the analysis of benefits from Oak Bluffs' coastal resources, we developed estimates of health benefits per ton of pollutant for each year of the analysis from 2016 through 2050. We estimated changes in population density during that period based on population projections for Massachusetts towns from 2015 to 2035 (UMass Donahue Institute, 2015). Because the 2015, 2020, 2025, 2030, and 2035 population estimates are almost linear as a function of year, we interpolated population estimates for the intermediate years (e.g., between 2015 and 2020) and extrapolated values for the years from 2036 through 2050 linearly. *Table 6-6* presents health benefits per ton for each pollutant for select years. We obtained estimates of benefits per ton of pollutant for the years 2016-2050 using a 3% discount rate and discounting back to 2016.

Table 6-6. Estimates of Health Benefits per Ton Estimates of NO_2, SO_2, $PM_{2.5}$, and O_3 Emissions (2016$) for Massachusetts

Year	Benefit Per Ton (2016$)			
	NO_2	O_3	$PM_{2.5}$	SO_2
2015	$197	$1,109	$38,616	$47
2020	$204	$1,150	$40,047	$49
2025	$213	$1,201	$41,808	$51
2030	$223	$1,258	$43,777	$53
2035	$234	$1,320	$45,923	$56
2040	$245	$1,378	$47,937	$58
2045	$255	$1,435	$49,942	$61
2050	$265	$1,493	$51,948	$63
Note: These estimates were derived from Nowak, Hirabayashi, Bodine, and Greenfield's (2014) regression equations using population projections from the UMass Donahue Institute (2015).				

We calculated the monetized air-related benefits in any given year (discounted back to the year 2016) by (1) multiplying the tons of pollutant reductions for a given air pollutant in that year by the appropriate benefits per ton value, and then (2) summing the benefits across all pollutants. The total benefit for year *y*, then, is calculated using (Eq. 6-6):

$$\sum_{j=1}^{4} (\text{Tons removed})_{y,j} \times \text{BPT}_{y,j}^{2016} \qquad \textbf{(Eq. 6-6)}$$

where:

j = 1, 2, 3, and 4 denote NO_2, O_3, $PM_{2.5}$, and SO_2, respectively

y = Year

$BPT_{y,j}^{2016}$ = present discounted value, discounted to the year 2016, of the benefits per ton for the *j*th pollutant

The TPV of benefits, discounted to the year 2016, TPV_{2016}, is calculated using (Eq. 6-7).

$$\text{TPV}_{2016} = \sum_{y=2016}^{2050} \sum_{j=1}^{4} (\text{Tons removed})_{y,j} \times \text{BPT}_{y,j}^{2016} \qquad \textbf{(Eq. 6-7)}$$

6.2.4 Total Air Pollutant Reduction Benefits of Forests

We estimated that Oak Bluffs' coastal forests generate a TPV of $30,731 in air pollution removal benefits, with annualized benefits of $1,412 (*Table 6-7*).

Table 6-7. Air Pollution Reduction Benefits from 2016 to 2050		
Pollutant	**Annualized Value (2016$, 3% discount)**	**TPV (Millions 2016$, 3% discount)**
Total (NO_2, O_3, $PM_{2.5}$, SO_2)	$1,412	$0.03

6.3 Nitrogen and Carbon Sequestration from Oyster and Quahog Fisheries

A Massachusetts Estuaries Project analysis (Howes, Eichner et al., 2010) determined that nitrogen levels exceed state standards in Sengekontacket Pond, which lies within the jurisdiction of two Martha's Vineyard towns, Oak Bluffs and Edgartown. Recognizing the potential for oysters to help mitigate nitrogen pollution in local wetlands, the Oak Bluffs and Edgartown Shellfish Departments obtained funding to create a put and take oyster (*Crassotrea virginica*) fishery as one strategy for reducing nitrogen levels in Sengekontacket Pond (Grunden, 2016). Oysters are suspension-feeders, and remove N from the water column when consuming organisms and plankton. Some consumed N is sequestered in oyster shells and tissue.

After a few years of testing, the Oak Bluffs and Edgartown Shellfish Departments cultured 500,000 oysters each in 2016, yielding approximately 525,000 adults to be harvested annually. Both towns plan to continue with this level in future years. For this analysis, we assume that the town continues creating the put-and-take oyster fishery through 2050. The towns grow the seeds in tidal upwellers until they attain a large enough size to be placed in bottom cages. This methodology allows the towns to capture hard survival numbers as opposed to estimates based on survival rates. Knowing the number of oysters that are raised to market allows for calculations of nitrogen attenuation and carbon sequestration (Grunden, 2016). Recreational shellfishers are encouraged to remove all market-sized oysters to ensure the removal of nitrogen from Sengekontacket Pond.

The Oak Bluffs Shellfish Department also rears other types of shellfish, including quahogs since the late 1970s, bay scallops since the early 1980s, and softshell clams since 2002 (David Grunden, Oak Bluffs Shellfish Constable, personal communication). These shellfish species support both commercial and recreational species and can be found in Sengekontacket Pond, Lagoon Pond, and Oak Bluffs Harbor. Although the Oak Bluffs Shellfish Department did not begin rearing these shellfish for the primary purpose of removing nitrogen, the rearing of these three species nonetheless generates nitrogen removal benefits. While these shellfish are also likely providing some carbon sequestration benefits as well, we were unable to identify studies that would allow us to estimate such a benefit.

For the carbon and nitrogen sequestration analyses, we only monetized benefits associated with annual oyster and quahog harvest. Unharvested shellfish provide additional benefits by excreting carbon and nitrogen into sediment. Some carbon and nitrogen will remain locked in the sediment and can persist indefinitely. However, these processes are highly variable and more difficult to quantify than harvest removals (Elvin, 2017).

6.3.1 Carbon Sequestration Benefits from the Oyster Fishery

Climate change may pose significant long-term threats to the global environment. Although shellfish do not play a large role in the global carbon cycle, they can contribute to climate change mitigation by sequestering carbon in their shells and tissues (National Research Council, 2010). Calcifying organisms sequester carbon from a mix of sources. Carbon sequestration from biogenic sources in the ocean is carbon-neutral, whereas carbon storage from atmospheric sources is a true removal of carbon from the marine environment. Shells that are harvested and removed from the water and ultimately buried in landfills offer a relatively permanent form of atmospheric carbon storage, as they are unlikely to decompose rapidly and re-release the carbon (Fry, 2010; National Research Council, 2010).

To estimate the carbon storage capacity of the Oak Bluffs' oyster fishery, we modified carbon storage estimates from a life-cycle analysis of shellfish populations in Scotland. While carbon sequestration is likely to vary widely between Massachusetts and Scotland, at the time of our study this was the only identifiable estimate of carbon sequestration rates (Fry, 2010). Fry (2010) estimated that 1 ton of oysters permanently removed from the environment can sequester 441 kg of CO_2 per year (Fry, 2010). We multiplied this approximated sequestration value by the number of tons of oysters removed from Sengekontacket Pond each year (525,000 oysters equals approximately 105 tons). We estimate that the Oak Bluffs' oyster fishery is capable of removing a total of 46.3 metric tons of CO_2 annually. Valued over the 34-year period at 3% SCC values, the annualized value of carbon storage is $1,737 (TPV $59,052; *Table 6-8*).

Table 6-8. Summary of Oyster Carbon Sequestration Benefits from 2016 to 2050	
Total carbon sequestered (mt CO_2)	1,621
Annualized Value of carbon sequestration benefits (3% discount, 2016$)	$1,737
TPV of carbon sequestration benefits (3% discount, Millions 2016$)	**$0.06**

6.3.2 Nitrogen Sequestration Benefits from the Oyster and Quahog Fisheries

The primary goal of the oyster fishery is to mitigate the impacts of nitrogen loading in Sengekontacket Pond. The Oak Bluffs and Edgartown Shellfish Departments are working with the Martha's Vineyard Commission to monitor water quality in Sengekontacket Pond. Early monitoring results showed a small decease in nitrogen levels, but measurements in 2016 indicated that nitrogen levels were approximately the same as before implementation of the oyster fishery. Both towns will continue to monitor and grow oysters to see if the oyster fishery provides any long-term nitrogen removal benefits (Grunden, 2016).

Additional years of data are needed to evaluate nitrogen removal rates from the Sengekontacket Pond oyster fishery. Therefore, we estimate nitrogen removal benefits of the oyster fishery using published literature values. There is considerable variation in the timing and amount of nutrients removed by oysters and oyster reefs. Nonetheless, nitrogen removal measurements from existing studies in the same region can be used to approximate the potential nitrogen removal at a given site (Cape Cod Cooperative Extension, 2014; Grabowski et al., 2012; Piehler & Smyth, 2011; U.S. Department of Agriculture Natural Resources Conservation Service, 2012). From the available studies, we selected Cape Cod Cooperative Extension (2014) because it provides clear documentation, is based on a geographically close reference site (Cape Cod), and provides nitrogen removal rates based on nitrogen content stored in tissues for cage-grown oysters (representing a net removal from a waterbody when the oysters are harvested). Cape Cod

Cooperative Extension (2014) also provides a nitrogen removal rate for quahogs, allowing us to assess nitrogen removal from two shellfish fisheries in Oak Bluffs.

Cape Cod Cooperative Extension (2014) determined that, on average, each cage-grown oyster removes 0.255 grams of nitrogen. Based on this removal rate and an annual yield of 525,000 oysters, the Oak Bluffs oyster fishery is expected to remove 133.88 kg of nitrogen annually. Additionally, each cultured quahog removes 0.21 g of nitrogen (Cape Cod Cooperative Extension, 2014). In 2016, shellfishers removed 726 bushels of quahogs from waterbodies in Oak Bluffs, or approximately 72,600 quahogs (David Grunden, Oak Bluffs Shellfish Constable, personal communication). Assuming the quahog catch is approximately the same each year, the quahog fishery results in the removal of approximately 15.25 kg of nitrogen annually.

To translate these values into monetary terms, we applied Grabowski et al.'s (2012) method of using the average trading price per kilogram of nitrogen removal in the North Carolina Nutrient Offset Credit Program ($28.23/year at the time of Grabowski et al.'s [2012] study; $30.32 in 2016$). These monetary estimates are a rough approximation since region-specific values are not available and thus should be interpreted with caution. Applying Grabowski et al.'s dollar benefits to Oak Bluffs' oyster and quahog fisheries, we estimate an annualized value of nitrogen removal benefits through 2050 of $2,642 for oysters and $301 for quahogs. The TPV associated with these values is $89,826 for oysters and $10,230 for quahogs (*Table 6-9*).

Table 6-9. Oyster and Quahog Nitrogen Removal Benefits from 2016 to 2050

Result	Oysters	Quahogs
Total nitrogen sequestered (kg N)	4,686	534
Average annual nitrogen sequestration (kg N)	134	15
Annualized value of nitrogen sequestration benefits (3% discount, 2016$)	$2,642	$301
TPV of nitrogen sequestration benefits (3% discount, Millions 2016$)	**$0.09**	**$0.01**

6.4 Storm Protection and Erosion Control

Field evidence indicates that estuarine and coastal ecosystems—including coastal wetlands, seagrass beds, and sand beaches and dunes—provide protection against storms and flooding by attenuating waves and buffering winds (Barbier et al., 2011; Bouma et al., 2010; Gedan et al., 2011; Shepard et al., 2011). Coastal ecosystems thus reduce the impacts of storm to upland areas, including valuable residential and commercial property. Coastal wetlands can also prevent coastline erosion by absorbing the energy created by ocean currents, which have the potential to degrade shorelines and associated development (Carter, 1997). Coastal marshes provide wave attenuation and shoreline stabilization benefits across a range of geographic and hydrodynamic settings (Shepard et al., 2011).

Existing valuation studies suggest that storm protection benefits may be one of the most significant benefits lost when coastal habitats are degraded (Barbier, 2015). However, few valuation studies have properly accounted for spatial and temporal variability. For instance, past coastal wetland valuation studies have not taken into account that storm surge attenuation benefits depend on properties of the storm as well as location, type, extent, and condition of the wetlands (Engle, 2011). Additionally, valuation studies are not available for all habitats. No valuation studies are currently available for storm protection services from seagrass meadows and sand dunes (Barbier, 2015), although a recent experiment found that 60% of the reduction in wave energy by salt marshes can be attributed to the vegetation (Möller et al., 2014). Seagrass storm protection benefits likely fluctuate in temperate regions from seasonal changes in plant biomass and density (Koch et al., 2009; Paul & Amos, 2011). Economic value of storm protection services also depends on the proximity of people, homes, or infrastructure to the coastal ecosystems.

Many past studies valued storm prevention and flood mitigation services of estuarine and coastal ecosystems using estimated costs of replacing coastal habitat with human-made barriers to provide the same services (Barbier et al., 2011; Barbier, 2007; Freeman, 2003). However, economists recommend treating any valuations based on the replacement cost approach with caution because a human-built alternative is rarely the most cost-effective means of providing the service. Other studies focus on WTP for restoration (e.g., Louisiana wetlands; Petrolia et al., 2014) rather than valuations for existing estuarine and coastal ecosystems.

The many factors that contribute to storm protection and erosion control benefits make these services difficult to quantify with reasonable certainty. To derive approximate storm risk reduction benefit values the Oak Bluffs region, we calculated property value effects from a change in flood risk. We assumed that Oak Bluffs' coastal resources reduce the baseline flood risk by approximately 1% but do not change the extent of the floodplain (and thus, the number of houses affected by floods). A site specific assessment of Oak Bluffs' coastal resources could help determine whether this assumption holds, but such an analysis is beyond the scope of this study.

6.4.1 Monetary Value of Storm Risk Reduction Benefits

Available hedonic property valuation studies (*Table 6-10*) suggest a 1% reduction in flood risk translates to about 0.5% - 5% improvement in property values (e.g., Braden & Johnston, 2004; Daniel et al., 2009). A one-percent reduction in flood risk is equivalent to removing properties from the 100 year flood plain. Studies suggest that even a less-than-1% reduction in flooding would result in a small increase in value. In this analysis, we illustrate the property value benefits of marginally reducing the frequency flooding (but not its spatial extent).

Table 6-10. Flood Risk Reduction Benefit Transfer Functions

Study	Study Description	% Change in Property Value from Reducing Flood Risk	
		Low Bound	High Bound
Streiner & Loomis (1995)	Flood damage reduction, stream stabilization and re-vegetation, debris removal, improvements in fish habitat, and additional buffer land around the stream corridor all together affect mean residential property values. This also includes aesthetic, recreational, and educational features. As reported in Braden & Johnston (2004).	3%	5%
Braden & Johnston (2004)	Conducted a categorical synthesis of estimates reported in 6 studies. Properties that remain exposed to "frequent profound" flooding would gain the "low" benefit. Those which are removed from the 100-year flood plain and thus federal insurance would gain the "high" benefit. Values are converted to the percent change using an approximate housing value of $134,000.	≤ 2%	2.5% to 5%

Table 6-10. Flood Risk Reduction Benefit Transfer Functions

Study	Study Description	% Change in Property Value from Reducing Flood Risk	
		Low Bound	High Bound
Daniel et al. (2009)	Conducted a meta-analysis of 19 US-based studies of the property value effects of a change in flood risk. The value at left represents the one-time transaction price differential of reducing the probability of flood risk in a year by 1%. The authors note there may be a confounding effect of coastal amenity values and increased flood risk observed in the coastal zone, making the effect of flooding unclear.	0.60%	

We used two GIS layers provided by the Martha's Vineyard Commission in our analysis: the 100 year flood zone and Oak Bluffs housing parcels. Merging the 100 year flood zone layer with the Oak Bluffs housing parcel layer, we identified the households in areas at risk of inundation or shallow flooding by a 1-percent-annual-chance flood event. The Oak Bluffs parcel layer contains values for each property, which we used in the valuation scenario. Property values were not available for 10 parcels within the 100 year flood zone. For these parcels, we used the median property value of the remaining properties within the 100 year flood zone.

Results of the spatial flood zone analysis suggest approximately 883 properties in Oak Bluffs are subject to 100-year flood risks (*Table 6-11*). Using assessed property values for each parcel, the identified flood risk reduction benefit estimates suggest that small (i.e., <1%) reductions in flood severity or risk may provide benefits between $3.2 and $16.0 million in TPV. The wide range in benefits estimates may be due to the differences in ecosystem services included in each estimate: Daniel et al. (2009) limit their analysis to only flood reduction values, while Streiner & Loomis (1995) also include co-benefits of flood reduction such as aesthetic, recreational, and educational features. Given the coarse nature of the flood risk reduction analysis and our underlying assumption that the restoration would affect flood risk for all properties in the flood plain, we suggest cautious interpretation of these results.

Table 6-11. Flood Risk Reduction Benefit Transfer Results (2016$)[1]			
Study	**% Change In Property Value**	**Annualized Value[2]**	**TPV[3] (2016-2050, Millions $)**
Daniel et al. (2009)	0.6%	$144,746	$3.20
Braden & Johnston (2004)	2.0%	$482,486	$10.68
Streiner & Loomis (1995)	3.0%	$723,729	$16.02

[1] This table of final benefit estimates omits results based on Braden & Johnston's (2004) upper bound estimate because we are assuming that the number of houses in the floodplain remains the same with or without the presence of coastal resources. These values also omit Streiner & Loomis' (1995) upper bound, since their benefits values also incorporate aesthetic, recreational, and educational features of flood risk reductions and stream bank stabilization.

[2] Annualized benefit divides the per-household total benefit by the 3% discount rate to provide estimates of the annual value to homes each year in perpetuity, rather than the one-time benefit from selling a house for more money.

[3] TPV is estimated using a 3% discount rate.

6.5 Total Value of Regulating Services

The estimated TPV (2016-2050) of regulating services provided by Oak Bluffs' public coastal resources is $3.8 million to $16.6 million (*Table 6-12*). This total includes $245,946 in carbon sequestration benefits, $133,775 in carbon storage benefits, $30,731 in air pollution removal benefits, $59,052 in oyster carbon sequestration, $100,056 in shellfish nitrogen removal, and $3.2 million to $16.0 million in storm risk reduction benefits. With the exception of storm risk reduction benefits, our analysis quantifies regulating services in Oak Bluffs' public coastal resources only. Private coastal resources provide additional benefits, particularly carbon sequestration, carbon storage, and air pollution removal benefits.

Table 6-12. Total Economic Value of Regulating Services in Oak Bluffs' Coastal Resources (2016$)		
Ecosystem Service	**Annualized Value[1]**	**TPV[2] (2016-2050, Millions $)**
Carbon Sequestration	$7,234	$0.25
Carbon Storage	-	$0.13
Air Pollution Removal	$1,412	$0.03
Oyster Carbon Sequestration	$1,737	$0.06
Shellfish Nitrogen Removal	$2,943	$0.10
Storm Protection and Erosion Control	$144,746 - $723,729	$3.20 - $16.02
Total	**$158,072 - $737,055**	**$3.77 - $16.59**

[1] Annualized value is estimated using a 3% discount rate.

[2] TPV is estimated using a 3% discount rate.

6.6 Limitations and Uncertainty

This analysis is subject to the sources of uncertainty found in any regulating services benefits analysis—uncertainties surrounding the estimated land cover changes, the estimated changes in carbon and air pollutant concentrations resulting from land cover changes, the estimated concentration-response relationships between the air pollutant and various health effects in the exposed population, and the estimated value of each health effect avoided. There is additional uncertainty in the SCC estimates, which reflect the projection of future harm from climate change, and the benefits per ton estimates. More details about the limitations and uncertainties associated with the air-benefit analysis are discussed in *Table 6-13.*

Table 6-13. Limitations and Uncertainties in the Analysis of Cultural Services Benefits

Issue	Effect on Benefits Estimate	Notes
Limitations of the NLCD dataset	Uncertain	For example, one study has found that the NLCD data tend to underestimate tree canopy cover within NLCD-developed land classes by an average of 13.7% (Nowak & Greenfield, 2010). We did not adjust the forest cover data in this analysis to account for this potential under-prediction.
Uncertainty and geographic variability in carbon storage and sequestration rates	Uncertain	We simplified the analysis by using average per unit sequestration values for four vegetation groups (forests, grass, wetlands, and eelgrass) that implicitly incorporate vegetation growth, time to maturity, mortality, and decomposition rather than tracking these processes explicitly. Actual sequestration rates vary based on local conditions. For example, net carbon accumulation to soil depends in part, on native levels of soil organic carbon in the soil (Pickett et al., 2008). Use of average values could potentially result in underestimation or overestimation of benefits if local conditions differ significantly from average values.
Uncertainty in air pollution removal rates	Uncertain	We obtained air pollution removal rates for Massachusetts for Nowak, Hirabayashi, Bodine, and Greenfield (2014) and assumed that the same rate continues for the entire study period. This assumption introduces an unknown amount of error into the estimates.
Uncertainty in nitrogen removal rates	Uncertain	We obtained nitrogen removal rates for oysters and quahogs from Cape Cod Cooperative Extension (2014). We assumed that average shellfish size and nitrogen removal rates would be the same in Oak Bluffs as in the Cape Cod region, and we assumed the rates would remain constant for the entire study period. This assumption introduces an unknown amount of error into the estimates.

Table 6-13. Limitations and Uncertainties in the Analysis of Cultural Services Benefits		
Issue	**Effect on Benefits Estimate**	**Notes**
Uncertainty in projecting the future harm from climate change	Uncertain	The SCC values used in this analysis are considered best estimates for the purposes of regulatory analysis. However, there are uncertainties and limitations associated with treatment of non-catastrophic damages, treatment of potential catastrophic damages, extrapolation of damages to high temperatures, treatment of adaptation and technological change, and risk aversion, among others. See IWG (2010, 2013) for additional information.
Uncertainties in benefit per ton values	Underestimate	We derived benefit per ton values for the entire study period using Nowak, Hirabayashi, Bodine, and Greenfield's (2014) regressions and the UMass Donahue Institute's (2015) population projections. Actual benefit per ton values may differ from the values derived using the regressions, and future population changes may differ from the population projections.
Uncertainties in reduced flood risk reduction levels	Uncertain	To approximate flood risk reduction benefits, we assumed that Oak Bluffs' coastal resources reduce the baseline flood risk by approximately 1% but do not change the extent of the floodplain. A site specific assessment would help determine if this assumption holds.
Transfer error	Uncertain	We translated reduced baseline flood risk into monetary values using published values from Daniel et al. (2009), Braden & Johnston (2004), and Streiner & Loomis (1995). While widely accepted, benefit transfers are always subject to the inherent uncertainty in applying models developed for one site and purpose to a different site and purpose. Transferring values across sites introduces an unknown bias in resulting estimates.

7. Summary of the Results

This study focuses on estimating the monetary value of four categories of ecosystem service benefits provided by Oak Bluffs' public coastal resources: provisioning services, cultural services, supporting services, and regulating services. Chapters 3 through 6 provide qualitative discussion of these services and detail quantitative assessment of each service category. The estimated total economic value of the ecosystem services provided by Oak Bluffs' public coastal resources ranges from $133.13 million to $168.45 million per year; TPV ranges from $4.52 billion to $5.71 billion from 2016 to 2050. The estimates provided in *Table 7-1* are subject to uncertainty and limitations due to availability of local data and analytic methods used in the analysis. The most significant limitation is the omission of some ecosystem services provided by Oak Bluffs' public coastal resources from the monetary estimates due to the lack of data (e.g., educational opportunities, support of threatened and endangered species, aquaculture). Chapters 3 through 6 detail limitations and uncertainty inherent in the analysis of each ecosystem service category analyzed in this report.

Table 7-1. Estimated Economic Value of Ecosystem Services Provided by Oak Bluffs' Public Coastal Resources (Millions 2016$)

Ecosystem Service	Annualized Value[1]	TPV[2] (2016-2050)
Provisioning Services	$0.48	$10.51
Cultural Services	$132.44 - $167.17	$4,503.04 - $5,683.61
Supporting Services	$0.05 - $0.06	$1.83 - $1.88
Regulating Services	$0.16 - $0.74	$3.77 - $16.59
Total	**$133.13 - $168.45**	**$4,519.15 - $5,712.59**

[1] Annualized value is estimated using a 3% discount rate.
[2] TPV is estimated using a 3% discount rate.

To put the economic value of Oak Bluffs' public coastal resources into perspective, we would ideally compare our estimates to Oak Bluffs' GDP, which accounts for the total value of everything produced by all companies and people in Oak Bluffs. Because no estimate of GDP is available for Oak Bluffs or Martha's Vineyard, we compared our results to total annual payroll for all economic sectors in Oak Bluffs to the estimated value of ecosystem services provided by Oak Bluffs' public coastal resources.

The total annualized value of ecosystem services provided by Oak Bluffs' public coastal resources ($133.13 million to $168.45 million) is greater than the value of the total annual payroll for all sectors in Oak Bluffs in 2015 ($87.77 million; 2016$; U.S. Census Bureau, 2017). This comparison suggests that Oak Bluffs' public coastal resources are a key contributor to the thriving local economy. Recognizing this value and incorporating it into resource management decisions is necessary for ensuring resilient communities and a sustainable future economy.

Coastal recreation and flow-on impacts from recreation account for nearly the entire estimated value of Oak Bluffs' coastal resources. Direct expenditures from outdoor recreation ($31.36 million) account for 18.6% to 23.6% of the estimated annualized value of ecosystem services provided by Oak Bluffs' public coastal resources. To ensure that our estimate is within the correct range, we compared our direct expenditures from outdoor recreation estimate to the total estimated expenditure estimate for Oak Bluffs

(MOTT, 2016; MVC, 2011; Town of Oak Bluffs et al., 2015).[10] Based on our estimate, direct expenditures from outdoor recreation account for 33% of total estimated expenditures in Oak Bluffs.

Sunrise from Ocean Park *Liz Durkee*

[10] The total estimated expenditure estimate for Oak Bluffs is based on calculations using MOTT (2016) tourism expenditure estimates for 2015 ($160.2 million; 2016$) and the proportion of the Martha's Vineyard summer tourist population that stays in Oak Bluffs (27.5%; MVC, 2011). Tourism expenditures in Oak Bluffs in 2015 were thus approximately $44.0 million (2016$). Expenditures by seasonal residents and tourists account for 46% of total estimated expenditures in Oak Bluffs, while year-round expenditures account for 54% (Town of Oak Bluffs et al., 2015). Accounting for year-round resident expenditures brings the total estimated expenditure estimate for Oak Bluffs in 2015 to $95.8 million (2016$).

8. References

Abt Associates. (2016a). Economic Impacts of Ocean Acidification and Climate Change on Shellfish. Prepared for U.S. Environmental Protection Agency, National Center for Environmental Economics.

Abt Associates Inc. (2016b). Greenhouse Gas Budget for Select Wetlands and River Restoration Projects. Massachusetts and Clean Energy Plan.

Akbari, H., and Konopacki, S. J. (2003). Streamlined energy-savings calculations for heat-island reduction strategies. Lawrence Berkeley National Laboratory.

Andrews, C. J. (2008). Greenhouse gas emissions along the rural-urban gradient. Journal of environmental planning and management 51(6), 847-870.

Barbier, E. B. (2015). Valuing the storm protection service of estuarine and coastal ecosystems. Ecosystem Services, 11, 32-38.

Barbier, E.B., Hacker, S.D., Kennedy, C., Koch, E.W., Stier, A.C., and Silliman, B.R. (2011). The value of estuarine and coastal ecosystem services. *Ecological Monographs*, 81(2), 169-193.

Bateman, I., Mace, G., Fezzi, C., Atkinson, G., and Turner, K. (2010). Economic Analysis for Ecosystem Service Assessments. Environmental and Resource Economics: 1-42.

Bauer, D., Cyr, N.E., and Swallow, S.K. (2004). Public preferences for compensatory mitigation of salt marsh losses: a contingent choice of alternatives. *Conservation Biology, 18*(2), 401-411.

Beckett, K. P., Freer-Smith, P. H., and Taylor, G. (2000). Particulate pollution capture by urban trees: effect of species and windspeed. Global Change Biology, 6(8), 995-1003.

Berg, M. (2011). Outdoor entertainment on Martha’s Vineyard. Martha’s Vineyard Times. 7 July 2011. Retrieved from http://www.mvtimes.com/2011/07/13/outdoor-entertainment-marthas-vineyard-6551/

Bergstrom, J. C., and Cordell, H. K. (1991). An analysis of the demand for and value of outdoor recreation in the United States. Journal of Leisure Research 23(1): 67-86.

Berlow, A. (2016). From Growing Oysters to Growing Kelp on Martha's Vineyard. WCAI. 31 March 2016. Retrieved from http://capeandislands.org/post/growing-oysters-growing-kelp-marthas-vineyard#stream/0

Bouma, T.J., DeVries, M.B., and Herman, P.M.J. (2010). Comparing ecosystem engineering efficiency of two plant species with contrasting growth strategies. Ecology 91, 2696–2704.

Braden, J. B., and Johnston, D. M. (2004). Downstream economic benefits from storm-water management. *Journal of Water Resources Planning and Management*, 130(6), 498-505.

Brown, S. (2017). Shellfish Farmers Look to Kelp as Possible New Business. Vineyard Gazette. 07 Feb 2017. Retrieved from https://vineyardgazette.com/news/2017/02/06/kelp

Camp Jabberwocky. (2017). *Summer Residential Camp*. Retrieved from http://campjabberwocky.org/summer-camp/

Cape Cod Cooperative Extension. (2014). Shellfish Nitrogen Content from Coastal Waters of Southeastern Massachusetts. January 2014.

Carter, V. (1997). Technical Aspects of Wetlands: Wetland Hydrology, Water Quality, and Associated Functions. United States Geological Survey Water Supply Paper 2425.

Chang, W. H. (2001). Variations in Multipliers and Related Economic Ratios for Recreation and Tourism Impact Analysis, Michigan State University.

Cole, S. G., and Moksnes, P. O. (2016). Valuing multiple eelgrass ecosystem services in Sweden: fish production and uptake of carbon and nitrogen. *Frontiers in Marine Science*, 2, 121.

Commission for Environmental Cooperation (CEC). (2016). North America's Blue Carbon: Assessing Seagrass, Salt Marsh and Mangrove Distribuition and Carbon Sinks. Montreal, Canada: Commission for Environmental Cooperation.

Commonwealth of Massachusetts. (2006). Massachusetts Outdoors 2006: Statewide Comprehensive Outdoor Recreation Plan.

Conrad, J. M. (2010). *Resource Economics* (2nd ed.). New York: Cambridge University Press.

Cottage City Oysters. (n.d.). Mission Statement. Retrieved from https://cottagecityoysters.com/about-us/

Culbert, R.A. (2016a). Buffleheads and Mergansers Make Their Arrival. Vineyard Gazette. 16 Nov 2016. Retrieved from https://vineyardgazette.com/news/2016/11/16/baffling-buffleheads

Culbert, R.A. (2016b). Eyes peeled for nesting crows, herons. Vineyard Gazette. 20 April 2016. Retrieved from https://vineyardgazette.com/news/2016/04/20/eyes-peeled-nesting-crows-herons

Culbert, R.A. (2017). Return of the roseate terns, cattle egret sighting. Vineyard Gazette. 25 May 2017. Retrieved from https://vineyardgazette.com/news/2017/05/25/return-roseate-terns-and-cattle-egret-sighting

Daniel, V. E., Florax, R. J., and Rietveld, P. (2009). Flooding risk and housing values: an economic assessment of environmental hazard. *Ecological Economics*, 69(2), 355-365.

Duke's County. (2017). Joseph Sylvia State Beach. Retrieved from http://www.dukescounty.org/pages/dukescountyma_naturalresources/Sylvia

Dunlop, T. (2011). Illuminating Lighthouses: East Chop Light. Martha's Vineyard Magazine. 1 Aug 2011. Retrieved from http://www.mvmagazine.com/news/2011/08/01/illuminating-lighthouses

Elvin, A. (2016). Brotherhood of Oysters Is Delicious. Vineyard Gazette. 30 June 2016. Retrieved from https://vineyardgazette.com/news/2016/06/30/brotherhood-oysters-delicious

Elvin, A. (2017). Study Bolsters Theory that Shellfish Remove Nitrogen from Ponds. Vineyard Gazette. 10 Feb 2017. Retrieved from https://vineyardgazette.com/news/2017/02/10/study-bolsters-theory-shellfish-remove-nitrogen

Engle, V.D. (2011). Estimating the provision of ecosystem services by Gulf of Mexico Coastal Wetlands. Wetlands 31, 179–193.

English, E. P. (2010). Discrete Choice, Recreation Demand, and Consumer Surplus. Cornell University. PhD Thesis.

Environmental Data Center. (n.d.). Bay Scallop *(Argopecten irradians)*. University of Rhode Island. Retrieved from https://www.edc.uri.edu/restoration/html/gallery/invert/bay.htm

Ewing, V. (2016). Casting Lines at First Light at Annual Kids Fishing Derby. Vineyard Gazette. 18 Sep 2016. Retrieved from https://vineyardgazette.com/news/2016/09/18/casting-lines-first-light-annual-kids-fishing-derby

Featherstone Center for the Arts. (2017). Featherstone Flea and Fine Art Market. Retrieved from http://www.featherstoneart.org/Home/featherstone-fleamarket

Freeman, A.M. (2003). The Measurement of Environmental and Resource Values: Theory and Methods. Washington, DC: Resources for the Future.

Friends of Sengekontacket. (n.d.). Shellfishing. Retrieved from http://www.sengekontacket.org/activities/#/shellfishing/

Friends of Sengekontacket. (2017). Activities. Retrieved from http://www.sengekontacket.org/activities/

Fry, J. M. (2010). Carbon Footprint of Scottish Suspended Mussels And Intertidal Oysters: Scottish Aquaculture Research Forum.

Gedan, K.B., Kirwan, M.L., Wolanski, E., Barbier, E.B., and Silliman, B.R. (2011). The present and future role of coastal wetland vegetation in protecting shorelines: answering recent challenges to the paradigm. Climate Change 106, 7–29.

Getty Conservation Institute. (2002). Assessing the Values of Cultural Heritage: Research Report. Los Angeles, CA: De la Torre, M. (Ed.). Retrieved from http://www.getty.edu/conservation/publications_resources/pdf_publications/pdf/assessing.pdf

Gorte, R. W. (2009). Carbon Sequestration in Forests. Congressional Research Service (CRS) report to Congress, 7-5700, August 6, 2009.

Grabowski, J. H., Brumbaugh, R. D., Conrad, R. F., Keeler, A. G., Opaluch, J. J., Peterson, C. H., . . . Smyth, A. R. (2012). Economic valuation of ecosystem services provided by oyster reefs. BioScience, 62(10), 900 - 909.

Graff, L., and Middleton, J. (2001). Wetlands and fish: Catch the link. National Oceanic and Atmospheric Administration. Retrieved from http://www.habitat.noaa.gov/pdf/fishandwetlands.pdf

Grunden, D. (2016). Nitrogen Mitigation by Oyster Culture; Striving to Comply with the Clean Water Act. Presentation at the 8th National Summit on Coastal and Estuarine Restoration.

Hart, D.R., and Chute, A. S. (2004). Sea scallop, *Placopecten magellanicus*, life history and habitat characteristics. Retrieved from https://www.nefsc.noaa.gov/publications/tm/tm189/tm189.pdf

Heath, L. S., Smith, J. E., Skog, K. E., Nowak, D. J., and Woodall, C. W. (2011). Managed Forest Carbon Estimates for the US Greenhouse Gas Inventory, 1990-2008. Journal of Forestry, 109(3), 167-173.

Hellin, D., Starbuck, K., Terkla, D., Roman, A., and Watson, C. (2011). 2010 Massachusetts Recreational Boater Survey (03.uhi.11). Boston: Massachusetts Ocean Partnership.

Hempy, K. and Wilcox, W. (1998). A survey of the eelgrass beds of Sengekontacket and Farm Ponds, Edgartown and Oak Bluffs, Massachusetts. A study funded by the Massachusetts Department of Environmental Management Lakes and Ponds Program and the Martha's Vineyard Commission. Retrieved from http://www.mvcommission.org/sites/default/files/docs/Senge_Eelgrass_Chapter1.pdf

Holy Ghost Association of Martha's Vineyard. (2017). History of the Feast. Retrieved from http://holyghostassociation.com/history-of-the-feast/

Homer, C. G., Dewitz, J. A., Yang, L., Jin, S., Danielson, P., Xian, G., Coulston, J., Herold, N. D., Wickham, J. D., and Megown, K. (2015). Completion of the 2011 National Land Cover Database for the conterminous United States-Representing a decade of land cover change information. Photogrammetric Engineering and Remote Sensing, v. 81, no. 5, p. 345-354.

Horrocks, A. (2016). Gingerbread Cottages at Oak Bluffs Campground. New England Today Travel. 18 Aug 2017. Retrieved from https://newengland.com/today/travel/massachusetts/gingerbread-cottages-at-oak-bluffs-campground/

Howes, B.L., E.M. Eichner, T. Ruthven, J.S. Ramsey, and D.R. Schlezinger. (2010). Linked watershed-embayment model to determine the critical nitrogen loading threshold for the Sengekontacket Pond system, Oak Bluffs and Edgartown, Massachusetts. SMAST/DEP Estuaries Project, Massachusetts Department of Environmental Protection. Boston, MA.

Howes, B.L., Ramsey, J.S., Samimy, R.I., Schlezinger, D.R., and Eichner, E.M. (2010). Linked watershed-embayment model to determine the critical nitrogen loading threshold for the Farm Pond system, Oak Bluffs, Massachusetts. SMAST/DEP Estuaries Project, Massachusetts Department of Environmental Protection. Boston, MA.

Howes, B.L., Ramsey, J.S., Samimy, R.I., Schlezinger, D.R., Eichner, E.M., Kelly, S., Ruthven, T., Ramsey, J., and Detjens, P. (2013). Linked watershed-embayment model to determine the critical nitrogen loading threshold for the Oak Bluffs Harbor system, Oak Bluffs, Massachusetts. SMAST/DEP Estuaries Project, Massachusetts Department of Environmental Protection. Boston, MA.

Hughes, J. E., Deegan, L. A., Wyda, J. C., Weaver, M. J., & Wright, A. (2002). The effects of eelgrass habitat loss on estuarine fish communities of southern New England. *Estuaries and Coasts*, 25(2), 235-249.

Interagency Working Group (IWG). (2010). Technical Support Document – Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866: Interagency Working Group on Social Cost of Carbon, United States Government, with participation by Council of Economic Advisors, Council on Environmental Quality, Department of Agriculture, Department of Commerce, Department of Energy, Department of Transportation, Environmental Protection Agency, National Economic Council, Office of Energy and Climate Change, Office of Management and Budget, Office of Science and Technology Policy, Department of the Treasury.

Interagency Working Group (IWG). (2013; revised 2016). Technical Support Document - Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866: Interagency Working Group on Social Cost of Carbon, United States Government, with participation by Council of Economic Advisors, Council on Environmental Quality, Department of Agriculture, Department of Commerce, Department of Energy, Department of Transportation, Environmental Protection Agency, National Economic Council, Office of Management and Budget, Office of Science and Technology Policy, Department of the Treasury.

Island Spirit Kayak. (2017). Kid's Adventures!. Retrieved from http://www.islandspiritkayak.com/kids-kayak-sup-adventures

Jo, H. K., and McPherson, E. G. (2001). Indirect carbon reduction by residential vegetation and planting strategies in Chicago, USA. Journal of Environmental Management, 61(2), 165-177.

Johnston, R.J., Grigalunas, T.A., Opaluch, J.J., Mazzotta, M., & Diamantedes, J. (2002). Valuing estuarine resource services using economic and ecological models: the Peconic Estuary System study. *Coastal Management*, 30(1), 47-65.

Kneib, R. (2003). Bioenergetic and landscape considerations for scaling expectations of nekton production from intertidal marshes. *Marine Ecology Progress Series*, *264*, 279-296.

Koch, E.W., Barbier, E.B., Silliman, B.R., Reed, D.J., Perillo, G.M.E., Hacker, S.D., Granek, E.F., Primavera, J.H., Muthiga, N., Polasky, S., Halpern, B.S., Kennedy, C.J., Kappel, C.V., Wolanski, E. (2009). Non-linearity in ecosystem services: temporal and spatial variability in coastal protection. Front. Ecol. Environ.7, 29–37.

Lagoon Pond Association (n.d.). Shellfishing on the Lagoon. Retrieved from http://lagoonpondassoc.org/shellfishing-on-the-lagoon/

Lu, X., Kicklighter, D. W., Melillo, J. M., Reilly, J. M., and Xu, L. (2015). Land carbon sequestration within the conterminous United States: Regional- and state-level analyses. Journal of Geophysical Research: Biogeosciences, 120(2), 379-398. doi: 10.1002/2014jg002818

Martha's Vineyard Arts and Culture Collaborative. (2012). Fostering Arts and Culture on Martha's Vineyard: Planning Report. Oak Bluffs, MA. January 2012.

Martha's Vineyard Chamber of Commerce. (n.d.). Hiking and Birding. Retrieved from http://www.mvy.com/play-here/hiking-birding.aspx

Martha's Vineyard Commission (MVC). (2006). Results of Recent Surveys of Martha's Vineyard Residents and Visitors. January 2006. Oak Bluffs, MA.

Martha's Vineyard Commission (MVC). (2010). Agricultural Self-Sufficiency on Martha's Vineyard. Oak Bluffs, MA. March 2010.

Martha's Vineyard Commission (MVC). (2011). Estimated Average Summer Population – 2010. Updated December 2011. Oak Bluffs, MA.

Martha's Vineyard Commission (MVC). (2016). Public Coastal Natural Resources: Oak Bluffs, MA. Compiled by C.L. Seidel. September 2016.

Martha's Vineyard Commission (MVC). (2017). Economic Profile of Martha's Vineyard. Retrieved from http://www.mvcommission.org/economic-profile-marthas-vineyard

Martha's Vineyard Land Bank Commission. (N.D.a). Farm Pond Preserve. Retrieved from http://mvlandbank.com/17farm_pond.shtml

Martha's Vineyard Land Bank Commission. (N.D.b). Doug's Cove. Retrieved from http://mvlandbank.com/68dougs_cove.shtml

Martha's Vineyard Land Bank Commission. (N.D.c). Pecoy Point. Retrieved from http://mvlandbank.com/31pecoy.shtml

Martha's Vineyard Online. (2017). Oak Bluffs Open Market. Retrieved from http://mvol.com/events/oak-bluffs-open-market-2014-06-01/

Martha's Vineyard Sound Series. (2016). About the MV Sound Series/Festival. Retrieved from http://www.marthasvineyardsound.com/about/

Martha's Vineyard Times. (2017). Oak Bluffs Arts District stroll returns on Saturday. 5 July 2017.. Retrieved from http://www.mvtimes.com/2017/07/05/take-arts-district-stroll-dukes-county-avenue/

Martha's Vineyard Wind Festival. (2017). About Martha's Vineyard Wind Festival. Retrieved from https://www.mvwindfestival.com/about-us-1

Mass Audubon. (n.d.). Bird check list, Felix Neck Wildlife Sanctuary. Retrieved from http://www.massaudubon.org/content/download/2651/28429/file/checklist_Felixneck.pdf

Mass Audubon. (2017). Felix Neck Wildlife Sanctuary. Retrieved from http://www.massaudubon.org/get-outdoors/wildlife-sanctuaries/felix-neck/about

Massachusetts Bay Program. (2011). Shellfish beds. Retrieved from http://www.mass.gov/envir/massbays/bhha_shellfish.htm

Massachusetts Division of Fisheries and Wildlife (MDFW). (2015a). Piping plover *(Charadrius melodus)*. Retrieved from http://www.mass.gov/eea/docs/dfg/nhesp/species-and-conservation/nhfacts/charadrius-melodus.pdf

Massachusetts Division of Fisheries and Wildlife (MDFW). (2015b). Roseate tern *(Sterna dougallii)*. Retrieved from http://www.mass.gov/eea/docs/dfg/nhesp/species-and-conservation/nhfacts/roseate-tern.pdf

Massachusetts Division of Fisheries and Wildlife (MDFW). (2015c). Northern gama-grass *(Tripsacum dactyloides).* Retrieved from http://www.mass.gov/eea/docs/dfg/nhesp/species-and-conservation/nhfacts/tripsacum-dactyloides.pdf

Massachusetts Division of Fisheries and Wildlife (MDFW). (2016). Massachusetts Division of Fisheries and Wildlife habitat conservation plan for piping plover. 173 pages. Retrieved from http://www.mass.gov/eea/docs/dfg/nhesp/species-and-conservation/masswildlife-final-piping-plover-hcp.pdf

Massachusetts Division of Fisheries and Wildlife (MDFW). (2017). Black sea bass. Retrieved from http://www.mass.gov/eea/agencies/dfg/dmf/recreational-fishing/black-sea-bass.html

Massachusetts Division of Fisheries and Wildlife (MDFW) and the Nature Conservancy. (2012). Biomap 2: conserving the biodiversity of Massachusetts in a changing world; Oak Bluffs. 26 pages. Retrieved from http://maps.massgis.state.ma.us/dfg/biomap/pdf/town_core/Oak%20Bluffs.pdf

Massachusetts Division of Marine Fisheries. (2017a). Total Oak Bluffs Landings and Value by Year, 2013-2016. Data compiled by E. Druskat, Data Analyst, from the Massachusetts Recreational Permitting Database.

Massachusetts Division of Marine Fisheries. (2017b). Oak Bluffs and Statewide Recreational Permit Counts, 2015. Data compiled by E. Druskat, Data Analyst, from the Massachusetts Recreational Permitting Database.

Massachusetts Office of Energy and Environmental Affairs (MOEEA). (2017). Massachusetts Wetlands: Types, Ecology and Functions, and Loss and Degradation. Retrieved from http://www.mass.gov/eea/agencies/czm/program-areas/coastal-habitat/coastal-wetlands/massachusetts-wetlands.html

Massachusetts Office of Energy and Environmental Affairs (MOEEA). (n.d.). Eelgrass mapping project. Retrieved from http://www.mass.gov/eea/agencies/massdep/water/watersheds/eelgrass-mapping-project.html

Massachusetts Office of Travel and Tourism (MOTT). (2016). FY 2015 Tourism Impacts for Cape Cod and the Islands.

MassGIS. (2009). MassDep Wetlands. Retrieved from http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/depwetlands112000.html

MassGIS. (2011). Shellfish Suitability Areas. Retrieved from http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/shlfshsuit.html

MassGIS. (2017). Designated Shellfish Growing Areas. Retrieved from http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/dsga.html

Mazzotta, M.J. (1996). Measuring public values and priorities for natural resources: an application to the Peconic Estuary Program. Doctor of Philosophy, University of Rhode Island.

McCay, D. F., & Rowe, J. J. (2003). Habitat restoration as mitigation for lost production at multiple trophic levels. *Marine Ecology Progress Series, 264*, 233-247.

McPherson, E., Gregory, E., and Simpson, J. R. (1999). Carbon dioxide reduction through urban forestry: guidelines for professional and volunteer tree planters: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station.

Millennium Ecosystem Assessment. (2005). Current State & Trends Assessment: MA Conceptual Framework. Vol. 1 Ch. 1. 12 pp.

Mills, D., Jones, R., Carney, K., Juliana, A. S., Ready, R., Crimmins, A., Martinich, J., Shouse, K., BeAngelo, B., and Monier, E. (2014). Quantifying and monetizing potential climate change policy impacts on terrestrial ecosystem carbon storage and wildfires in the United States. Climatic Change, 1-16.

Moeltner, K., and Rosenberger, R. S. (2014). Cross-context benefit transfer: A Bayesian search for information pools. American Journal of Agricultural Economics, 1-20.

Möller, I., Kudella, M., Rupprecth, F., Spencer, T., Paul, M., van Wesenbeeck, B.K., & Schimmels, S. (2014). Wave attenuation over coastal salt marshes under storm surge conditions. Nature Geoscience, 7: 727–731.

Moore, F.C., and Diaz, D.B. (2015). Temperature impacts on economic growth warrant stringent mitigation policy. Nature Clim. Change, 5(2), 127-131. doi: 10.1038/nclimate2481

MV Derby. (2015). About. Retrieved from http://www.mvderby.com/~mvderby/about/index.php

National Oceanic and Atmospheric Administration (NOAA). (1999). Bluefish, *Pomatomus saltatrix*, life history and habitat characteristics. NOAA technical memorandum NMFS-NE-144. Retrieved from https://www.nefsc.noaa.gov/publications/tm/tm144/tm144.pdf

National Oceanic and Atmospheric Administration (NOAA). (2012). National Ocean Recreation Expenditure Survey (unpublished data).

National Oceanic and Atmospheric Administration (NOAA). (2017). Carbon Sequestration 101. Retrieved from http://www.habitat.noaa.gov/coastalcarbonsequestration.html

National Parks Service. (2017). East Chop (Telegraph Hill) Light. Retrieved from https://www.nps.gov/nr/travel/maritime/ech.htm

National Research Council. (2010). Ecosystem Concepts for Sustainable Bivalve Mariculture: The National Academies Press.

Nowak, D. J., McHale, P. J., Ibarra, M., Crane, D. E., Stevens, J. C., & Luley, C. J. (1998). Modeling the Effects of Urban Vegetation on Air Pollution. In S. E. Gryning and N. Chaumerliac (Eds.), Air Pollution Modeling and Its Application XII. New York, NY: Plenum Press.

Nowak, D. J., Crane, D. E., & Stevens, J. C. (2006). Air pollution removal by urban trees and shrubs in the United States. Urban Forestry & Urban Greening, 4(3-4), 115-123.

Nowak, D. J., & Greenfield, E. J. (2010). Evaluating the National Land Cover Database Tree Canopy and Impervious Cover Estimates Across the Conterminous United States: A Comparison with Photo-Interpreted Estimates. Environmental Management, 46(3), 378-390.

Nowak, D. J., Greenfield, E. J., Hoehn, R. E., & Lapoint, E. (2013). Carbon storage and sequestration by trees in urban and community areas of the United States. Environmental Pollution, 178, 229-236.

Nowak, D., Hirabayashi, S., Bodine, A., & Hoehn, R. (2013). Modeled PM2.5 removal by trees in ten U.S. cities and associated health effects. Environmental Pollution, 178, 395-402.

Nowak, D. J., Hirabayashi, S., Bodine, A., and Greenfield, E. (2014). Tree and forest effects on air quality and human health in the United States. Environmental Pollution, 193, 119-129.

Oak Bluffs Bluewater Classic. (2017). 2017 Oak Bluffs Bluewater Classic. Retrieved from http://www.obbclassic.com/index.htm

O'Higgins, T., Ferraro, S., Dantin, D., Jordan, S., & Chintala, M. (2010). Habitat scale mapping of fisheries ecosystem service values in estuaries. Ecology and Society, 15(4).

Omer, T. (2015). M.V. Sound Festival gets ready to rock. Martha's Vineyard Times. 8 July 2015. Retrieved from http://www.mvtimes.com/2015/07/08/m-v-sound-festival-gets-ready-to-rock/

Opaluch, J.J., Grigalunas, T.A., Mazzotta, M., Johnston, R.J., & Diamantedes, J. (1999). Recreational and resource economic values for the Peconic Estuary. Prepared for the Peconic Estuary Program. Peace Dale, RI: Economic Analysis Inc.

Outdoor Industry Association. (2017). The Outdoor Recreation Economy. Boulder, CO.

Parsons, George R. (2014). Travel Cost. *Selected Works of George Parsons*. University of Delaware.

Paul, M., and Amos, C. L. (2011). Spatial and seasonal variation in wave attenuation over *Zostera noltii*. Journal of Geophysical Research: Oceans, 116(C8).

Pelikan, M. (2015). Martha's Vineyard provides a winter home for sea ducks of all varieties. Martha's Vineyard Times. 24 Feb 2015. Retrieved from http://www.mvtimes.com/2015/02/24/wild-side-marthas-vineyard-provides-winter-home-sea-ducks-varieties/

Petrolia, D. R., Interis, M. G., & Hwang, J. (2014). America's wetland? A national survey of willingness to pay for restoration of Louisiana's coastal wetlands. Marine Resource Economics, 29(1), 17-37.

Phaneuf, D.J., and Smith, V.K. (2005). Recreation demand models. *Handbook of Environmental Economics*, 671-761.

Pickett, S. T. A., Cadenasso, M. L., Grove, J. M., Groffman, P. M., Band, L. E., Boone, C. G., and Wilson, M. A. (2008). Beyond Urban Legends: An Emerging Framework of Urban Ecology, as Illustrated by the Baltimore Ecosystem Study. BioScience, 58(2), 139-150.

Piehler, M. F., & Smyth, A. (2011). Habitat-specific distinctions in estuarine denitrification affect both ecosystem function and services. Ecosphere, 2(1).

Pope, C. A., Burnett, R. T., Thun, M. J., Calle, E. E., Krewski, D., Ito, K., and Thurston, G. D. (2002). Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution. J. Am. Med. Assoc. 287(9), 1132-1141.

Post, W. M., and Kwon, K. C. (2000). Soil carbon sequestration and land-use change: processes and potential. Global Change Biology, 6(3), 317-327.

Pouyat, R., Yesilonis, I., and Golubiewski, N. (2009). A comparison of soil organic carbon stocks between residential turf grass and native soil. Urban Ecosystems, 12(1), 45-62.

Qian, Y. I., and Follett, R. F. (2002). Assessing Soil Carbon Sequestration in Turfgrass Systems Using Long-Term Soil Testing Data. Agron. J., 94, 930–935.

Restore America's Estuaries. (2006). The Economic and Market Value of Coasts and Estuaries: What's At Stake? Ed. Pendleton, L. H. Arlington, VA.

Rhode Island Statewide Planning Program. (2013). Rhode Island Population Projections Summary Tables. April 2013.

Rice, M.A. (2008). Environmental Effects of Shellfish Aquaculture in the Northeast (NRAC Publication No. 105-2008).College Park, Maryland: Northeastern Regional Aquaculture Center. Retrieved from https://agresearch.umd.edu/sites/agresearch.umd.edu/files/_docs/105-2008%20Environmental%20effects.pdf

Robards, B. (2012). Time to stroll over to Oak Bluffs Arts District. Martha's Vineyard Times. 11 July 2012. Retrieved from http://www.mvtimes.com/2012/07/11/time-stroll-over-oak-bluffs-arts-district-11471/

Roriz, E. (2011). Harborfest & Summer Solstice in Oak Bluffs June 18. Martha's Vineyard Times. 15 June 2011. Retrieved from http://www.mvtimes.com/2011/06/15/harborfest-summer-solstice-oak-bluffs-june-18-6085/

Rosenberger, R.S., & Loomis, J.B. (2000). Panel stratification in meta-analysis of economic studies: an investigation of its effects in the recreation valuation literature. Journal of Agricultural and Applied Economics, 32(3), 459-470.

Rupolo, S. (2016). Islanders dominate Oak Bluffs Columbus Day 5k. Martha's Vineyard Times. 9 Oct 2016. Retrieved from http://www.mvtimes.com/2016/10/09/islanders-dominate-columbus-day-5k/

Ryan, J.J. (2008). Martha's Vineyard Economic Profile. Prepared for the Martha's Vineyard Commission and the Island Plan Livelihood and Commerce Work Group. January 2008. Amherst, MA.

Schlossberg, T. (2011). Oak Bluffs' Big Harborfest Hello Only Part of Its Enduring Charm. Vineyard Gazette. 16 June 2011. Retrieved from https://vineyardgazette.com/news/2011/06/16/oak-bluffs-big-harborfest-hello-only-part-its-enduring-charm

Schubert, J.D. (2015). About the Artist. Retrieved from http://www.judithdrewschubert.com/about-judith-drew-schubert

Seccombe, M. (2008). Against odds, piping plovers rebound. Vineyard Gazette. 5 June 2008. Retrieved from https://vineyardgazette.com/news/2008/06/05/against-odds-piping-plovers-rebound

Shepard, C.C., Crain, C.M., and Beck, M. W. (2011). The protective role of coastal marshes: a systematic review and meta-analysis. PloS One, 6(11), e27374.

Sigelman, N. (2014). Oak Bluffs fishing pier is bathed in praise. Martha's Vineyard Times. 19 June 2014. Retrieved from http://www.mvtimes.com/2014/06/19/oak-bluff-fishing-pier-bathed-praise/

Sigelman, N. (2016). Gone Fishin': At Derby Kids' Day, 'little fishies' become 'big fishies'. Martha's Vineyard Times. 21 Sep 2016. Retrieved from http://www.mvtimes.com/2016/09/21/gone-fishin-derby-kids-day-little-fishies-become-big-fishies/

Simpson, J. R. (2002). Improved estimates of tree-shade effects on residential energy use. Energy and Buildings, 34(10), 1067-1076.

Steamship Authority. (2017). 2017 Year-Round Schedule for Martha's Vineyard and Nantucket. Retrieved from https://www.steamshipauthority.com/schedules

Stewart, R. (2017). Michael Schroeder wins 24th Oak Bluffs Memorial Day 5K. Martha's Vineyard Times. 30 May 2017. Retrieved from http://www.mvtimes.com/2017/05/30/michael-schroeder-wins-24th-oak-bluffs-memorial-day-5k/

Streiner, C., and Loomis, J. (1995). Estimating the Benefits of the Urban Stream Restoration Program. Department of Agricultural and Resource Economics, Colorado State University, Fort Collins, Col. Photocopy.

Tiner, R.W. (2010). Wetlands of Cape Cod and the Islands, Massachusetts: Results of the National Wetlands Inventory and Landscape-level Functional Assessment. U.S. Fish and Wildlife Service (USFWS). Retrieved from https://www.fws.gov/northeast/wetlands/publications/Wetlands%20of%20Cape%20Cod_Final_Report.pdf

Town of Oak Bluffs. (2015). Town of Oak Bluffs Open Space and Recreation Plan. Oak Bluffs, MA.

Town of Oak Bluffs. (2016). Aquaculture License Regulations.

Town of Oak Bluffs. (2017). Parks & Recreation. Retrieved from http://www.oakbluffsma.gov/157/Parks-Recreation

Town of Oak Bluffs, Horsely Witten Group, Carr, Lynch and Sandell, ConsultEcon, and SurfaceMatterDesign. (2015). Oak Bluffs Streetscape Master Plan. Oak Bluffs, MA. July 2015.

U.S. Bureau of Economic Analysis. (2012). Concepts and Methods of the U.S. National Income and Product Accounts. Chapters 1-20 and 13.

U.S. Census Bureau. (2015). 2011-2015 American Community Survey 5-Year Estimates [data file]. Retrieved from https://factfinder.census.gov/faces/nav/jsf/pages/community_facts.xhtml

U.S. Census Bureau. (2017). Geography Area Series: County Business Patterns: 2015. Data released 20 April 2017.

U.S. Climate Data. (2017). Weather History: Edgartown, MA. Retrieved from http://www.usclimatedata.com/climate/edgartown/massachusetts/united-states/usma0132

U.S. Department of Agriculture Natural Resources Conservation Service. (2012). Oyster Reef Restoration Project 2012/USDA Report. Retrieved from http://www.wellfleetma.org/public_documents/WellfleetMA_Wastewater/Wellfleet%20Oyster%20Project%20and%20Water%20Quality%202012%20Results.pdf.

U.S. Department of the Interior, U.S. Fish and Wildlife Service (USFWS), U.S. Department of Commerce (U.S. DOC), & U.S. Census Bureau. (2011). National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.

U.S. Environmental Protection Agency (U.S. EPA). (2004). Section 316(b) Phase II Final Rule – Regional Studies, Part A: Evaluation Methods. Chapter A15: Habitat Based Methodology for Estimating Non-use Values.

U.S. Environmental Protection Agency (U.S. EPA). (2010). Guidelines for Preparing Economic Analyses. (EPA 240-R-10-001).

U.S. Environmental Protection Agency (U.S. EPA). (2011). Environmental and Economic Benefits Analysis for Proposed Section 316(b) Existing Facilities Rule. EPA 821-R-11-002.

U.S. Environmental Protection Agency (U.S. EPA). (2013). National Ambient Air Quality Standards (NAAQS). Retrieved from http://www.epa.gov/air/criteria.html

U.S. Fish and Wildlife Service (USFWS). (1991). Northeast coastal areas study: significant coastal habitats of southern New England and portions of Long Island, New York. A report submitted to Submitted to the U.S. House of Representatives, Committee on Appropriations and the U.S. Senate, Committee on Appropriations. Retrieved from http://buzzardsbay.org/bbpreports/significant_coastal_habitats.pdf

U.S. Fish and Wildlife Service (USFWS). (2008). New England/Mid-Atlantic coast bird conservation region (BCR30) implementation plan. 251 pages. Retrieved from http://www.acjv.org/BCR_30/BCR30_June_23_2008_final.pdf

U.S. Fish and Wildlife Service (USFWS). (2011). Roseate tern: North American subspecies *(Sterna dougallii dougallii).* Retrieved from https://www.fws.gov/northeast/pdf/Roseatetern0511.pdf

U.S. Geological Survey. (2015). About Multi-Resolution Land Characteristics Consortium Retrieved from http://www.mrlc.gov/about.php

U.S. Office of Management and Budget. (2003). Circular A-4, September 17. Retrieved from http://www.whitehouse.gov/OMB/circulars/a004/a-4.pdf

University of Massachusetts (UMass) Donahue Institute. (2015). Vintage 2015 Population Projections. March 2015.

Vineyard Conservation Society. (2017). Connect • Reflect • Protect. Retrieved from http://www.vineyardconservation.org/httpssitesgooglecomavineyardconservationorgvineyard-conservation-societyHome

Vineyard Gazette. (n.d.). Coastal ponds under pressure. Retrieved from https://vineyardgazette.com/ponds/pond-life

Vineyard Gazette. (2012). Oak Bluffs Harbor Festival, Faeries Too. 14 June 2012. Retrieved from https://vineyardgazette.com/news/2012/06/14/oak-bluffs-harbor-festival-faeries-too

Vineyard Gazette. (2013). Oak Bluffs Harbor Festival. 20 June 2013. Retrieved from https://vineyardgazette.com/news/2013/06/20/oak-bluffs-harbor-festival

Vineyard Gazette. (2016). Oak Bluffs Fireworks Blasts Off on Friday. 18 Aug 2016. Retrieved from https://vineyardgazette.com/news/2016/08/18/oak-bluffs-fireworks-blasts-friday

Vineyard Gazette. (2017). Portuguese Holy Ghost Feast and Parade. 13 July 2017. Retrieved from https://vineyardgazette.com/news/2017/07/13/portuguese-holy-ghost-feast-and-parade

Walthers, C. (2010). All about shellfish. Martha's Vineyard Magazine. 1 July 2010. Retrieved from http://www.mvmagazine.com/news/2010/07/01/all-about-shellfish

Wells, J. (2011). Lobstery Hatchery Rehab is Approved. Vineyard Gazette. 30 June 2011. Retrieved from https://vineyardgazette.com/news/2011/06/30/lobster-hatchery-rehab-approved

Yang, J., Yu, Q., and Gong, P. (2008). Quantifying air pollution removal by green roofs in Chicago. Atmospheric Environment, 42, 7266-7273.

Appendix A – Public Coastal Resource Details

Table A-1. Oak Bluffs Wetland Sizes		
Wetland Type	**Coastal Acres**	**Public Acres**
Barrier Beach – Coastal Beach	41.756	23.955
Barrier Beach – Coastal Dune	66.822	43.456
Barrier Beach – Salt Marsh	1.055	-
Barrier Beach System	24.135	5.644
Coastal Bank Bluff or Sea Cliff	13.412	6.764
Coastal Beach	20.650	8.277
Coastal Dune	3.400	0.368
Deep Marsh	3.149	-
Rocky Intertidal Shore	1.525	0.436
Salt Marsh	71.772	24.606
Shallow Marsh Meadow or Fen	14.944	0.370
Shrub Swamp	21.634	1.247
Tidal Flat	5.697	2.433
Wooded Swamp Deciduous	1.790	-
Total	**291.742**	**117.558**

Table A-2. Oak Bluffs' Public Coastal Areas					
Resource	**Type**	**Size (Acres)[1]**	**Use**	**Wildlife[2]**	**Conservation Concern[3]**
Lagoon Pond	Saltwater Pond	593	Shellfishing, swimming, boating, water sports	Quahogs, clams, scallops	Tern foraging area
Brush Pond/Hatchery	Tidal Pond/Salt Marsh	14	Birdwatching, wildlife/nature viewing[4]	Various bird species	Tern foraging area
Crystal Lake	Freshwater Pond/Barrier Beach System	12	Not generally used for recreation	Snapping turtles, migratory waterfowl, muskrat, otter	Tern foraging area
Oak Bluffs Harbor	Harbor	30	Boating, fishing, water sports	No notable species	Tern foraging area
Sunset Lake	Brackish Pond	5	Wildlife/nature viewing	No notable species	Not a significant conservation area
Farm Pond[5]	Coastal Pond/Salt Marsh	35	Wildlife/nature viewing, hiking	No notable species	Tern foraging area
Upper Lagoon Pond	Freshwater Pond	12	Fishing, bird watching	Turtles, songbirds, herrings, juvenile eels, trout, otters, muskrats	Not a significant conservation area
Sengekontacket Pond	Saltwater Pond	691	Shellfishing, water sports, swimming, boating	Herring, juvenile eels, birds	Barn Owl, Common Tern, and Roseate Tern habitat
Eastville Point Beach	Coastal Beach	7.76	Swimming	No notable species	Least Tern and Piping Plover habitat
Doug's Cove Preserve[6]	Brackish Pond	4.4	Fishing, boating, hiking, wildlife/nature viewing	No notable species	Tern foraging area
Sailing Camp Park	Coastal Beach	15	Boating	No notable species	Tern foraging area
Lighthouse Park	Coastal Beach	1.38	Sightseeing	No notable species	Not a significant conservation area

Table A-2. Oak Bluffs' Public Coastal Areas					
Resource	**Type**	**Size (Acres)**[1]	**Use**	**Wildlife**[2]	**Conservation Concern**[3]
East Chop Bluff	Coastal Beach	15	Sightseeing	No notable species	Not a significant conservation area
North Bluff bank and beach	Coastal Beach		Swimming, fishing	No notable species	Tern foraging area
Town (Inkwell) Beach/ Pay Beach	Coastal Beach	7.45	Beach recreation, swimming	No notable species	Tern foraging area
Jetty Beach (Marinelli Beach)	Barrier Beach	3	Beach recreation, swimming	No notable species	Tern foraging area
Joseph Sylvia State Beach	Barrier Beach	54.45	Beach recreation, swimming, fishing	Various birds[4]	Barn Owl, Common Tern, Least Tern, and Piping Plover habitat
Pecoy Point[7]	Salt Marsh	17	Wildlife/nature viewing, hiking, fishing, boating, duck and geese hunting	River otters, ducks, geese	Tern foraging area

All information from the Town of Oak Bluffs Open Space and Recreation Plan unless otherwise noted.
[1] Acreage is town specific and based on the public coastal resources GIS layer (MassGIS, 2009)
[2] Excludes species with Massachusetts Endangered Species Act (MESA) status
[3] BioMap2 Oak Bluffs (MDFW & the Nature Conservancy, 2012)
[4](Culbert, 2016a)
[5](Martha's Vineyard Land Bank Commission, N.D.a)
[6](Martha's Vineyard Land Bank Commission, N.D.b)
[7](Martha's Vineyard Land Bank Commission, N.D.c)

Appendix B – Species of Concern under the Massachusetts Endangered Species Act with Habitat in Oak Bluffs

Table B-1. Species with MESA Status Observed in Oak Bluffs	
Name	**MESA Status**
Coastal Heathland Cutworm	Special Concern
Barrens Daggermoth	Threatened
Gerhard's Underwing	Special Concern
Imperial Moth	Threatened
Barrens Buckmoth	Special Concern
Pink Sallow Moth	Special Concern
Pine Barrens Zale	Special Concern
Barrens Metarranthis	Endangered
Dune Noctuid Moth	Special Concern
Faded Gray Geometer	Threatened
Sandplain Euchlaena	Special Concern
Unexpected Cycnia	Threatened
Oak Hairstreak	Special Concern
Purple Tiger Beetle	Special Concern
Piping Plover	Threatened
Common Tern	Special Concern
Roseate Tern	Endangered
Least Tern	Special Concern
Barn Owl	Special Concern
Eastern Whip-poor-will	Special Concern
Purple Needlegrass	Threatened
Sanplain Flax	Special Concern
Papillose Nut-sedge	Endangered
Bristly Foxtail	Special Concern
Saindplain Blue-eyed Grass	Special Concern
Lion's Foot	Endangered
North Gama-grass	Endangered

Appendix C – Benefit Transfer Function used to Estimate Household WTP for Coastal Wetlands

Table C-1. Benefit Transfer Function from Bauer et al. (2004) Used to Calculate WTP for Coastal Wetlands				
Variable	**Description**	**Coefficient**	**Attribute Value**	**Rationale**
cost	cost of the mitigation alternative	-0.01893	n/a	n/a
acre	acres preserved or restored	0.00913	117.558	Acres of public coastal wetlands in Oak Bluffs
boardwalk	public access via boardwalk	1.02814	1	Boardwalks present in public coastal wetlands
viewing tower	public access via viewing tower	0.82109	0	No viewing towers in Oak Bluffs
endangered species	endangered species present at mitigation site	0.47982	1	Relative to salt ponds, coastal wetlands increase habitat for and observed counts of threatened and endangered species.
no action	no-action alternative	-1.03780	0	Oak Bluffs scenario implies preservation rather than no action.
preserve	preservation alternative (as opposed to restoration)	-0.17227	1	Oak Bluffs scenario implies preservation rather than restoration.
no action*female	Interaction: Tailors WTP for no-action scenario to female respondents.	1.03514	0	Not used; no action is not relevant to the policy context.
preserve*female	Interaction: Tailors WTP for preservation to female respondents.	0.64152	0.505	Set to female population percentage in Dukes County, MA
no action*high income	Interaction: Tailors WTP for no-action scenario to high-income (>$60,000) households.	0.69527	0	Not used; no action is not relevant to the policy context.
preserve*high income	Interaction: Tailors WTP for preservation to high-income households.	0.58691	0.5	Set to 0.5. Median household income in Dukes County, MA is about $64,000.
no action*graduate	Interaction: Tailors WTP for no-action scenario to respondents with a graduate degree.	-0.34986	0	Not used; no action is not relevant to the policy context.
preserve*graduate	Interaction: Tailors WTP for preservation to respondents with a graduate degree.	-0.57284	0.152	Set to percent of Dukes County population 25 years and over with a graduate or professional degree

Appendix D – Literature Sources for Grass Carbon Sequestration Rates

Table D-1. Literature Sources for Grass Carbon Sequestration Rates

Type of Grass Cover	Study	Net Carbon Sequestration Rate (kg C per square meter per year)
Cultivated land converted to perennial grasses with management	Gebhart et al. (1994)	0.11
Cultivated reseeded to grass	Bruce et al. (1999)	0.08
Cultivated to abandoned grassland	Burke et al. (1995) as reported by Zirkle et al. (2011)	0.0031
Agricultural land converted to perennial grasses	Post and Kwon (2000)	0.033
Low-high grassland management	Conant (2001)	0.054
	Average	0.056