II. Executive Summary

WHY ESTUARIES MATTER

Estuaries have always been an essential feature of the economy. Even before European settlement, Native Americans lived either permanently or seasonally in estuary regions because of food supply. European settlement, and the population and economic growth following it, were centered in the estuary regions where North America could most easily connect with Europe. That history established a pattern of economic importance which continues today.

The counties in the estuary regions of the continental U.S.1 comprise 4% of the land area of the U.S. but on that 4% sits 47% of the output of the U.S. economy, 39% of the employment, population, and housing (in 2018). Eight of the ten largest cities are located on estuaries. Estuaries, in other words, are geographically small and economically mighty.

Insert similar map with the estuary regions, but not the focus estuaries

With 37% of the poulution on just 4% of the land, the concentration of people, as year-round or seasonal residents or as employees in the estuary regions, helps drive the national economy. But that same concentration puts enormous pressure on the natural and environmental resources of the estuaries, manifested in loss of wetlands, degraded water quality, and impaired access for economic uses such as recreation and fishing. This updated study is meant to remind us that this place that so many people call home is at risk, and the risk to this sensitive ecosystem in turns puts our property, our health, our special places and our economy at risk.

In 2009, NOAA, Restore America's Estuaries and The Ocean Foundation released "The Economic and Market Value of America's Coasts and Estuaries: What's at Stake" providing a compendium of economic information related to the oceans and coasts. The 2009 report examined economic impacts to gross state and domestic product in twenty-one regions across the continental U.S. It also reviewed the benefits provided by five major sectors of the U.S. economy: fisheries, energy infrastructure, marine transportation, real estate, and recreation.

Since that time, much research has been completed to advance this knowledge, however, there have also been substantial changes in the way economists, coastal resource managers and policy makers think about economics in the last decade. New sectors and ecosystem services have emerged that have garnered a lot of attention from coastal managers and policy makers,

[1] For this study, Alaska and Hawaii are excluded.

however the economic understanding of those sectors and services has not kept pace. Some of the big changes include:

- Recognition that the climate is changing, and changing faster than we understood in 2009;
- Better understanding of the the economic benefits provided by natural infrastructure along the coast;
- Increased awareness that blue carbon sequestered in estuarine ecosystems are a critical missing piece in policy decisions.

This project builds on the work completed in "What's at Stake" and provides an update of some of the key national economic indicators previously assessed. The need for studies like this one is supported by the need for a more accurate picture of America's estuary regions, how they impact the U.S. economy, and how that relationship is changing over time.

This project also assesses the values of two services (natural coastal infrastructure and coastal blue carbon storage[2])—which provide coastal resilience benefits and opportunities for mitigating the impacts of climate change—through a series of case studies at six estuaries across the nation that have natural infrastructure or stocks of coastal blue carbon at risk. The six estuaries chosen were:

- Great Egg Harbor, New Jersey
- Pamlico Sound and the Lower Neuse River, North Carolina
- Tampa Bay, Florida
- Terrebonne Basin, Louisiana
- San Pablo Bay, California
- Snohomish River Estuary, Washington

Research and data on the five economic sectors covered in the 2009 report is much more widely available than it was a decade ago. However, there are still substantial gaps in our understanding of the benefits provided by coastal natural infrastructure and blue carbon. The intent is to expand our understanding of the economic values of estuarine wetlands by examining the values provided by reduction in flood damages (the natural infrastructure function) and by storing carbon dioxide that would exacerbate climate change if released to the atmosphere (the coastal blue carbon function).

REGIONAL ANALYSIS

The twenty-one regions examined are comprised of 380 counties bordering the Atlantic, Gulf of Mexico, Pacific, and Great Lakes (See Figure II-1). These regions together comprised 4% of the

[2] This report uses the term "coastal blue carbon" to differentiate carbon sequestration and storage in estuary habitats, including salt marshes, mangroves and sea grass beds, from those in the open ocean.

land area of the U.S. but from that 4% come 47% of the output of the U.S. economy ($8.8 trillion in gross domestic product), 39% of the employment (59.4 million jobs) and 40% of the population (130 million people) in 2018. Eight of the ten largest metropolitan areas are located in estuary regions. This concentration of economic activity and population in a small land area makes estuaries among the most economically valuable areas of the country, but that concentration also implies the potential for significant stresses on the environmental quality and ecosystem health of estuaries.

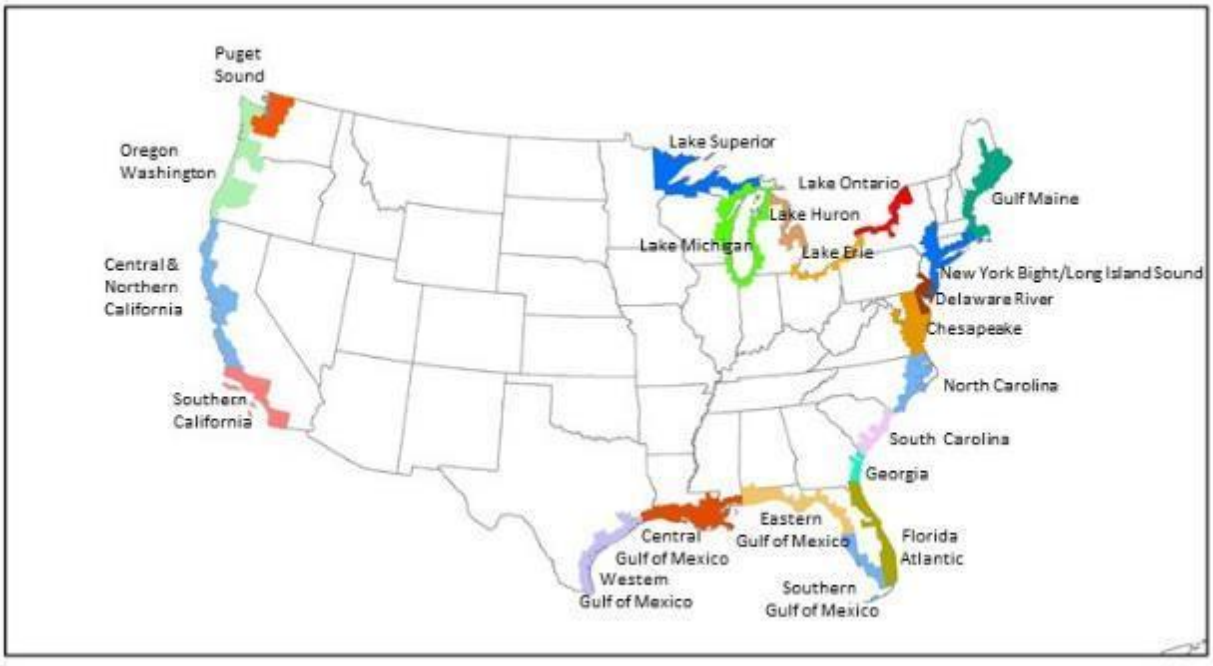

Figure II-1. Estuary Regions for Regional Economic Analysis

This review of the economic and demographic characteristics of America's estuary regions is at a relatively high level in terms of geographic scale. Conclusions from this analysis are more suggestive of key features and require more detailed analysis within each region to support efforts to manage, conserve, and restore key estuarine natural capital. But the following summary, arising from the data, may be useful:

- Estuary regions grew faster in both employment and GDP and at the same rates in population and housing from 2009-2018 compared to the US as a whole, indicating that the primary driver of change was economic rather than demographic growth. This pattern of faster economic growth compared with demographic change is present in all the estuary regions except for Lake Huron and Lake Erie.
- The pace and location of economic and demographic changes within estuary regions are important long-term drivers of natural resource change. Employment growth rates over 2009-2018 were fastest in the estuary regions on the Pacific and South Atlantic

coasts. Population and housing growth were fastest in the Carolinas, the Western Gulf of Mexico, and Puget Sound.

- A key component of the estuary regions' economy are those sectors directly connected to the oceans and Great Lakes, which provided 3.1 million jobs in 2018 and contributed $301.9 billion to the U.S. economy. These sectors tend to be largest in the major urban areas such as the New York Bight (598,000 jobs, 5.6% of regional employment) and Southern California (330,000 jobs and 4.0% of regional employment). But water dependent industries are more important in less urban areas such as the coastal areas of South Carolina (81,900 jobs but 15.3% of regional employment) and North Carolina (45,000 jobs but 12.4% of employment).
- The largest Ocean-Great Lakes economic activity as measured by employment in this report is tourism and recreation, which is a labor-intensive sector. Comparisons of employment among regions tend to be dominated by tourism & recreation employment, and this sector is also closely tied to the environmental and ecological health of estuaries.
- Where growth occurs within a region matters. Faster growth near the ocean or Great Lake can affect coastal and marine ecosystems, while faster growth in the upstream parts of estuary regions have cumulative effects from runoff that magnify as they travel down the rivers and streams of estuaries. Population changes within the regions were relatively small over 2009-2018, but Georgia and South Carolina saw increased populations in their near shore areas. Employment changes shifted towards the shore in the Gulf of Mexico regions but towards inland parts of the estuaries in the major urban areas such as New York, Chicago, and Los Angeles.

ESTUARY CASE STUDIES

This analysis also examined the role of specific types of wetlands in reducing damages from flooding in estuaries (natural infrastructure) and storing carbon in the soils that could offset carbon releases from other sources (coastal blue carbon). Vlaues for the two ecosystem services are calculated on a present value basis over 30 years..

There are two important features to values of natural infrastructure and blue carbon:

- Natural infrastructure are stocks of value derived from the ability of wetlands to avoid future economic damages to property. The value is based on ecosystem services produced by the wetlands. This value is a form of natural capital, and derived from a future flow of benefits and expressed as a present value estimated for a future period.
- Blue Carbon value reflects that that wetlands both store and sequester carbon, i.e., remove it from the atmosphere, however this study only assesses the storage values of wetlands and does not include sequestration benefits.

Secondly, and importantl, tThe present value of natural infrastrure and blue carbon is entirely dependent upon keeping existing wetlands intact, and thereby preventing or reducing economic losses. The reduction or elimination of flood losses and the avoided release of carbon stores into the atmosphere are what determine the basic values.

We do not know exactly how much climate will change or how much, or how severe future flooding may be. Therefore, any estimates of these values contain uncertainty, and can ultimately only be expressed as lying with a range defined by the optimistic and pessimistic assumptions about future impacts of climate change. These ranges are shown in the analysis through the use of "low" and "high" estimates as in the table below. Table II-1 summarizes the results from the six case studies. Estuaries are listed geographically from the Northeast, clockwise to the Northwest. The rank ordering by size and value is indicated by the colors of the cells. Yellow cells show the highest values in each column, the light green and dark green cells the middle and lower values, respectively. This allows easy comparison across the categories.

Table II-1. Summary of Natural Infrastructure and Blue Carbon Benefits by Case Study

	Wetlands Area (Hectares)		Natural Infrastructure		Coastal Blue Carbon		Total Natural Infrastructure and Blue Carbon	
	Natural Infrastructure	Coastal Blue Carbon	Lowest Estimate	Highest Estimate	Lowest Estimate	Highest Estimate	Lowest Estimate	Highest Estimate
			Dollars Per Hectare					
Great Egg Harbor	3,600	24,439	$9,483	$42,669	$2,602	$15,014	$12,085	$57,683
Pamlico	62,153	37,000	$739	$3,321	$3,374	$19,465	$4,113	$22,786
Tampa Bay	34,377	6,652	$35,774	$121,599	$1,152	$6,643	$36,926	$128,242
Terrebonne	N/A[3]	133,462			$3,224	$18,601	$3,224	$18,601
San Pablo	29,872	8,451	$512	$2,302	$1,877	$10,829	$2,389	$13,131
Snohomish	906	189	$773	$3,753	$1,301	$7507	$2,074	$11,260
TOTAL	**130,908**	**210,193**					**$60,811**	**$251,703**
			Total (Million Dollars)					
Great Egg Harbor	3,600	24,439	$34.1	$153.6	$63.6	$367.0	$97.7	$520.6

[3] Because the estuarine wetlands are located in the southern portion of the hydrologic unit, and are generally quite distant from the developed areas around the cities of Houma and Morgan City, it is not possible to estimate the value of natural infrastructure flood resilience for this case study in the same manner as the other case studies. See Section IX. Terrebonne Basin Case Study for more information.

Pamlico	62,153	37,000	$45.9	$206.4	$124.8	$720.1	$170.7	$926.5
Tampa Bay	34,377	6,652	$1,229.8	$4,180.2	$7.7	$44.2	$1,237.5	$4,224.4
Terrebonne	N/A	133,462			$408.0	$2,282.1	$408.0	$2,282.1
San Pablo	29,872	8,451	$15.3	$68.8	$15.9	$91.5	$31.2	$160.3
Snohomish	906	189	$0.7	$3.4	$0.2	$1.4	$0.9	$4.8
TOTAL	**130,908**	**210,193**					**$1,946.0**	**$8,118.7**

Allowing for the assumptions and simplified methods used in the analysis, it is clear that natural infrastructure and coastal blue carbon values in these six estuaries are quite significant, ranging in total (across all six estuaries studied) from a low estimate of approximately $1.9 billion to a high estimate of approximately $8.0 billion over a 30-year period, and from $60,811 to $251,703 per hectare. Whether the natural infrastructure or blue carbon values are higher varies across the six estuaries studied.

Hilary – I think this may be stretch, but using the EPA data on where wetlands in the US are, can we go ahead and extrapolate? https://www.epa.gov/wetlands/about-coastal-wetlands

Low value $1946 X 40,000,000 = $77.8B
High value $8118 X 40,000,000 = $324.7B

I think an important call out is that (1) blue carbon potential is highest in warmer climates which also are apt to have more storm surges (right?). (2) The natural infrastructure value is depended upon the density of residences?

It is important to note differences between low and high estimates between the two values, and to look at both per hectare and total values for each estuary. Values (high and low) for coastal blue carbon generally exceed those for natural infrastructure, except for Great Egg Harbor and Tampa Bay.[4] But when total values are examined, natural infrastructure values for both San Pablo and Snohomish become greater because there are more wetlands protecting assets than storing carbon. These differences are primarily driven by the extent and location of development within the estuaries. Highly developed estuary regions will tend to have larger flood benefits either because the value of protected assets is high, as is the case with Great Egg Harbor, or more economic assets located behind wetlands, as is the case with San Pablo and

[4] As discussed above, natural infrastructure benefits were not estimated for Terrebonne because of the unique features of that estuary.

Snohomish. While less developed regions tend to have more functional wetlands sequestering and storing carbon.

In addition to estimating the coastal blue carbon and natural infrastructure benefits, each of the case studies summarized past efforts at restoring wetlands. Data was primarily drawn from the NOAA Restoration Atlas, supplemented by local sources of data. Projects covered the period from 1970 to 2020. Only projects shown as completed were included in the analysis; projects listed in planning or in permitting were not included.

There are a total of 545 projects reported. The largest number of projects are shown in San Pablo Bay, followed by Tampa Bay. San Pablo Bay has the largest area restored at nearly 1,800 hectares (4,300 acres), though in combined restored and protected hectares, Terrebonne is clearly the leader, with projects covering 13,500 hectares.

CONCLUSIONS

The six case studies included as part of this report used a consistent methodology to assess the values of natural infrastructure flood resilience and coastal blue carbon. Using a consistent methodology has benefits and presents challenges. Benefits include the ability to look across the case studies and begin to discern similar patterns across the different analyses, this information can be used to support national strategies for the future management of U.S. estuaries. More work is needed before this can effectively drive sustainable policy, as the sample size is too small to make any broad characterizations. However it does provide a basis to start thinking about what criteria in estuaries needs to be present to drive certain types of value and why measuring and monitoring that value is important.

The challenges with using a consistent methodology include limitations on understanding details that are needed for project-siting and management decisions. For instance, the method used to value natural infrastructure benefits could not be used in Terrebonne Basin because the type of wetlands that were examined did not abut any houses or commercial assets. Notably, this study is not intended to drive on the ground, project-level, or siting decisions. Several of the estuaries that were selected for case studies already have assessments of varying degrees of their benefits, developed at a much more local and usable scale. Concerns that the existence of different values for the same service are warranted, however this project explicitly recognizes those concerns, while also recognizing there is room and use for both approaches.

The coastal blue carbon values can provide needed context and insights into emerging efforts to develop carbon markets, integrate blue carbon values into the Nationally Determined Contributions (NDCs) required by the Paris Agreement, to which the U.S. has recently become a party. While the NDCs require a much more stringent approach to assessing the stocks of carbon in coastal soils, this report provides a first look, an indication on whether or not undertaking the more comprehensive assessment is worthwhile. It also sheds insights on the social cost of carbon. In every case study, in almost all scenarios, the cost of purchasing the

right to release the stream of carbon by converting wetlands is much less than the social cost of the released carbon. Achieving a socially optimal solution requires that emission caps be set at a level where the market price of carbon equals the social cost of carbon.

The case studies also shed light on where to look to find certain types of benefits that estuaries provide. The natural infrastructure flood resilience benefits are greatest in the areas that contain the highest levels of economic assets, but placement of the wetlands is key. To maximize the benefits the estuaries must be conserved or restored between those economic assets and the oncoming wind and water. Conversely, natural infrastructure flood resilience benefits are relatively low in the absence of concentrations of economic assets. Terrebonne basin estuary did not have enough potentially impacted parcels that bordered buildings or homes to measure, yet it was by far the richest source of blue carbon benefits in terms of total value, second only to Pamlico Sound in terms of blue carbon benefits per hectare.

To those experienced in assessing and understanding the value of the benefits provided by coastal habitats like estuaries these concepts may seem obvious. However, they are often overlooked in broader planning and budgeting processes. Restoration investment decisions should not be driven by the potential for economic return, but it should be considered as part of the equation. Continued investment in the assessment and monitoring of the ecosystem services provided by our nation's estuaries can improve decisions and allow for future potential benefits to be included in current efforts to restore America's estuaries.

While the overall report updates and expands many of the features of the 201X report, especially around blue carbon, there remains a number outstanding issues for future research. Future research should address and account for some of the following factors:

- The report does not address the human cost of storms in terms of loss of life, injuries, social disruptions and physical stress. Since over X% of Americans live in these communities and there are an increasing number of storm events (FEMA), this human impact should not just be acknowledged, but a key driver in creating resilient coasts.
- The report focused on avoided property damaged due to flooding and storms. However, the report does not model the disruption to business due to storms. Given that estuaries represent 47% of the US economy a distruption to a single port or major economic sector can have severe ripple effects.
- The forward looking models of property damanage over 30 years assumes a stagnant housing supply and constant prices. A more dynamic model, quite likely, would lead to an even higher value around avoided destruction.
- Due project limitations this study does not cover Alaska or Hawaii which are states with a heavy reliance on nature-based tourism, and are on the front lines of climate change.
- While imbedded in many of the arguments underpinning the need to sequester and store carbon, there is a not a full account of the social cost of carbon.

- This report begins to address blue carbon from coastal wetlands and mangroves, it does not touch on the sequestration value of sea grass. While the sequestration value of sea grass is still an emerging topic, a future report should cover this.
- Additionally, the report does not focus on the multiple roles of seagrass such as for habitat and wave attenuation, whose health is heavily depend upon functioning wetland and is an integral part of our estuaries..