Advancing Preparedness of Climate Change Impacts on Coastal Communities in the Mid-Atlantic

MARCO Climate Preparedness and Hazard Resilience Capacity

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1. Executive Summary

The Governors of New York, New Jersey, Delaware, Maryland, and Virginia formed the Mid-Atlantic Regional Council on the Ocean (MARCO) in 2009 to address shared regional priorities to improve ocean health, quality of life, and the economic vitality of the Mid-Atlantic region and provide a collective voice. MARCO priorities, in addition to adapting to climate change, include protecting marine habitats, improving water quality and supporting development for offshore renewable energy. This report provides the results of the MARCO Climate Change Adaptation Team's (CCAT) assessment of regional assets within MARCO's geographic boundaries. The four assets, beaches, nearshore habitat, offshore habitat and marine terminals, were selected based on an analysis of MARCO's mission priorities, geographic scope of governance, and potential transboundary impacts. A research team, including members of Rutgers University, Georgetown Climate Center and Monmouth University, worked with the CCAT to categorize trans-boundary impacts (i.e. where climate change impacts on assets have the potential to create affects across two or more state boundaries) in three ways: economic Impacts, ecological Impacts, and social/cultural impacts.

The full range of priority assets included:

1. **Beaches**, including public access, habitat, tourism, local economies, dunes, availability of appropriate resources for beach management
2. **Near shore habitat**, including estuarine, tidal wetlands, SAV, and aquaculture that support a healthy ocean species and ecological communities
3. **Offshore habitat**, including deep water and coral habitat, and ocean habitat
4. **Marine terminals**, including supporting built infrastructure (e.g. rail, road, bridges, etc.)

After the CCAT team confirmed the priority assets and range of activities, the research team began to create a strategic planning framework to help the CCAT move forward. The framework document provides a focused discussion of each priority asset, including:

1. the climate stressors and dynamics most likely to affect the asset,
2. the impacts that may result from those affects, and
3. examples of current efforts organizations are undertaking in each state to adapt the asset to the changing climate.

The CCAT agreed on four (4) viable categories of potential actions and related initiatives, based on the resources required and the level of coordination needed between each of the states.

1. **Common understanding** efforts should focus on documenting and connecting projects from disparate scales and funding sources to assess baseline understanding of science and implementation of different adaptation practices across areas. Doing so will likely require investment in observation equipment and data collection in the Mid-Atlantic region to enhance physical and biological modeling. Both initiatives are necessary steps for informing strategic investments related to state coordination, federal advocacy, or regional action.
2. **Coordination of state policies** should focus on investigations of consistency among states and the observed or perceived effects of any inconsistencies from the regional perspective related to adaptation impacts.

3. **Federal policy advocacy** reviews should identify opportunities for modification to enable states to better work together to implement regional governance strategies, or to enable states to share and coordinate resources through federal grant programs.
4. **Regional actions** for the four priority assets should be reviewed in light of existing example partnerships at the federal and state levels for fisheries management and bay commissions related to water quality and health.

The CCAT team should reassess their strategic direction on an annual basis, reviewing the projects completed with reference to the framework to determine further efforts and advance goals that move from understanding to action at the appropriate level of governance.

This report documents that process and context of the CCAT decision making, materials, and methods used to arrive at the recommendations for priority assets. However, CCAT recognizes the need to consider opportunities related to other assets in different organizations' climate adaptation efforts. Such efforts could include participation in surface transportation resilience efforts or vulnerability assessments of federal, state and local preserved lands. The frameworks and findings herein will serve as a tool for evaluating MARCO participation in such initiatives and facilitating discussions around investments of time and resources related to most opportunities presented to CCAT.

2. Introduction

The Governors of New York, New Jersey, Delaware, Maryland, and Virginia formed the Mid-Atlantic Regional Council on the Ocean (MARCO) in 2009 to address regional priorities to improve ocean health, quality of life, and the economic vitality of the Mid-Atlantic region and provide a collective voice. Climate Change Adaptation is a shared priority area among the states, along with conservation of marine habitat, establishment of offshore renewable energy, and the improvement of coastal water quality. The Climate Change Adaptation team's efforts should support regional strategies to mitigate the economic, environmental, and social risks of climate change in the MARCO member states.

Mid-Atlantic Ocean Economy

NOAA's Office for Coastal Management in coordination with the Bureau of Economic Analysis has created the Economics National Ocean Watch (ENOW) tool which delivers time-series data (2005-2012) on the ocean and Great Lakes economy in six sectors: 1) Living Resources, 2) Marine Construction, 3) Marine Transportation, 4) Offshore Mineral Extraction, 5) Ship and Boat Building, and 5) Tourism and Recreation. The data incorporates eight regions, thirty coastal states and approximately four hundred coastal counties.

The ocean economy accounts for 682,167 employees, $22.8 billion in wages and $45.2 billion in goods and services (Table 1). Tourism and Recreation (58%) and the Marine Transportation (27%) sectors make up 85 percent of total GDP for the Mid-Atlantic. The Marine Transportation sector makes up a large part of the GDP but also has low employment illustrating the capital-intensive infrastructure that is essential in the Mid-Atlantic. New York and New Jersey have the highest share in business establishments and number of employed in the Tourism and Recreation sector. The Tourism sector in Delaware represents 74 percent of

GDP for the state. In addition, Virginia is the only state that Ship and Boat Building sector represents more GDP than Tourism and Marine Transportation. In Maryland even though the Tourism and Recreation sector has the larger share of establishments and employees, Marine Transportation brings in a billion more in GDP with over 3,000 less establishments and 40,000 less employees. Climate change impacts will affect each of these water dependent industries, affecting both local residents and those in neighboring states reliant on such industries for employment or recreation.

Table 1: ENOW Mid-Atlantic Analysis

Sectors	Business Establishments (#)	Employment (#)	Wages ($M)	GDP ($M)
Marine Construction	628	9,322	595	1,100
Living Resources	1,037	13,926	268	1,100
Offshore Mineral Extraction	322	2,655	169	453
Ship and Boat Building	172	37,993	2,500	3,500
Tourism and Recreation	33,734	517,226	12,300	26,400
Marine Transportation	2,122	101,045	7,000	12,400
All Ocean Sectors	38,015	682,167	22,800	45,200

Source: ENOW Explorer Tool 2012

Hurricane Sandy is a recent example of an extreme storm that dramatically affected the region. Flooding from the storm damaged many areas of residential, commercial development, airports and subway lines (USACE, 2015). Historical data suggests that property values can fluctuate after a natural disaster. In some cases, homes in affected areas see dramatic decreases in their market values, while post-Sandy research suggests that some affected areas have seen increases in property values (Bin and Polasky, 2004; Dawsey, 2013). Increases in values are likely due to original homeowners selling their damaged homes, unable to rebuild or keep up with insurance premiums, to buyers who are building larger and more expensive homes (Dawsey, 2013). From an insurer's perspective, projected sea level rise will increase average annual property losses from hurricanes and other coastal storms by $6 billion to $11 billion over the course of the next century in the Northeast alone (covering all of the MARCO states except Virginia). In addition, potential changes in hurricane activity, caused by atmospheric warming, would potentially raise these regional estimates from $11 billion to $22 billion (Risky Businesses Report, 2015). The measures taken by communities to adapt and limit exposures to capital stock and business disruption for the benefit of local residents and regionally dependent businesses and individuals will affect the economy of the Mid-Atlantic region.

Mid-Atlantic Ocean and Terrestrial Ecology

Ocean and near-shore habitats are critical for the functioning of Mid-Atlantic ecological systems. Scientists have identified over 2000 benthic invertebrate species in the Northeast U.S.

Continental Shelf Large Marine Ecosystem (NEFSC, 2011). In addition to their role as important contributors to the regional food web, some are economically valuable such as clams, oysters, scallops, lobsters, crabs, and sea urchins. Climate change can negatively affect sensitive species, some of whom are already existing in environmentally impaired habitat. Rising ocean temperatures and ocean acidification are the most hazardous to calcifying (shelled) organisms. Additionally, seasonal changes in water temperature often begin fish migration and any changes in this system can manipulate the growth rate of eggs and juveniles. This phenomenon can affect fish replacement numbers and other species impacted by the decrease in the food web system (TNC, 2014).

The Mid-Atlantic region also contains large drowned river estuaries and extensive narrow strips of elongated barrier beaches, typically separated from the mainland by bays and marshes. These coastal ecosystems contain interrelated coastal habitats that support many priority fish, wildlife and plant species. Climate change will also stress freshwater ecosystems, which are home to high priority species like bog turtle, bog asphodel, swamp pink, and American black duck, all which require inland wetlands for habitat. The marine zones that lie offshore are becoming more vulnerable as temperatures rise and decreased snowmelt causes droughts and low-flow river conditions. The decline in estuarine and riverine ecosystems has already seen the decline in herring, lobster, mollusks, perches, smelts and cod (North Atlantic LCC, 2009).

Changing climatic conditions may also adversely affect terrestrial ecosystems, such as conifer forests. These forests are home to a diversity of species, including many species of continental concern such as olive-sided flycatcher, bay-breasted warbler and Canada warbler. Many of the same bird species have about 25 percent of their global breeding population in the North Atlantic region, further illustrating the vulnerability of species' habitats (North Atlantic LCC, 2009). Saltwater intrusion presents another issue for the terrestrial ecology of the Mid-Atlantic. The increase in sea-level rise and hurricane incidence and intensity under climate change may accelerate the decease of coastal forests from saltwater intrusion. In other regions along the gulf coast and southeastern United States, scientists have attributed declines in cypress and pine populations to saltwater intrusion (USGS, 2005).

Mid-Atlantic Social / Cultural

The Mid-Atlantic has long rich history of fishing and shipping, which has shaped the social and cultural aspects of the region. Early European settlers learned from Native Americans how to harvest resources from the coastal waters, later turning harvested oysters into a cash crop for the region. Shipping and ship-building was centered in New York and Baltimore, which helped launch fishing and agriculture industries that still exist. Early tourism in the region came from waterfowl guides who would lead hunters through the local marshes and wetlands (Smithsonian, 2014).

Historic preservation activities are occurring throughout the Mid-Atlantic region to save many heritage assets. Historic shipwrecks and submerged prehistoric sites can and have been impacted by fishing, farming, and energy development, but are also predicted to experience further deterioration as a result of climate change (NOAA, 2013). The National Park Service is working to survey climate-vulnerable areas, develop appropriate preservation and documentation techniques, and learn from the history and prehistory these resources contain.

In Annapolis, stakeholders are working to minimize the negative effects of climate change on historical buildings and seaports in the Chesapeake Bay. The historic bridges and roads in New York and New Jersey are also under greater stress by flooding and increased precipitation. Climate change has already begun to impact archaeological sites in Delaware (Preserve America, 2012; Clarke, 2011; NPS, 2015).

The Mid Atlantic coastal areas have several unique economic ecological and social attributes. Yet, historic industrial development related to maritime industries or beach tourism and recreation driven by natural assets in the region also demonstrate the dependence of economy, environment, and culture. Therefore, while CCAT views each of these impacts as separate but related vulnerabilities, that when viewed collectively, may indicate a broader impact than each individual area alone. The purpose of this analysis was to help MARCO focus efforts, with the CCAT identifying the niche for a regional organization focused on the ocean and helping to shape the focal points for a regional vulnerability assessment.

3. Methods

The research team performed quantitative and qualitative analyses, and facilitated two in person workshops for CCAT to review analyses and agree on the definition of assets for investigation, the evaluation framework for prioritization, and the current selection of priority assets. Analyses consisted primarily of literature review, with qualitative assessments to address queries related to the presence of assets in the coastal areas and the compilation of other supporting economic and demographic statistics.

The evaluation framework for asset prioritization included:

1. Locations of each asset relative to United States marine jurisdictions and MARCO focus
2. Occurrence or potential for trans-boundary impacts
3. Potential to coordinate with MARCO shared priority areas
4. Capability for MARCO initiatives to be effective

The research team reviewed asset locations with the CCAT based on available federal, state and local data sources to facilitate a discussion of the typical location of each asset in relationship to marine environments. MARCO priorities, in addition to adapting to climate change, include protecting marine habitats, improving water quality and supporting development for offshore renewable energy. The research team categorized trans-boundary impacts (i.e. where climate change impacts on assets have the potential to create affects across two or more state boundaries) in three ways:

1. Economic Impacts,
2. Ecological Impacts, and
3. Social/Cultural Impacts

Economic impacts include activities involving the flow of money into the economy through a variety of venues such as tax revenues, property values, personal income, and jobs. Ecological impacts are ones that have an effect on living organisms and their environment. Finally, social/cultural impacts include factors that contribute to the quality of life of the people living in an area and assets that encourage communal activities that bind people together to a place.

Subsequently, the CCAT discussed their current perception of areas in each state where they felt their organizations could provide the most meaningful contributions to advancing adaptation practices. These discussions resulted in the prioritization of the four assets for additional investigation and strategic planning.

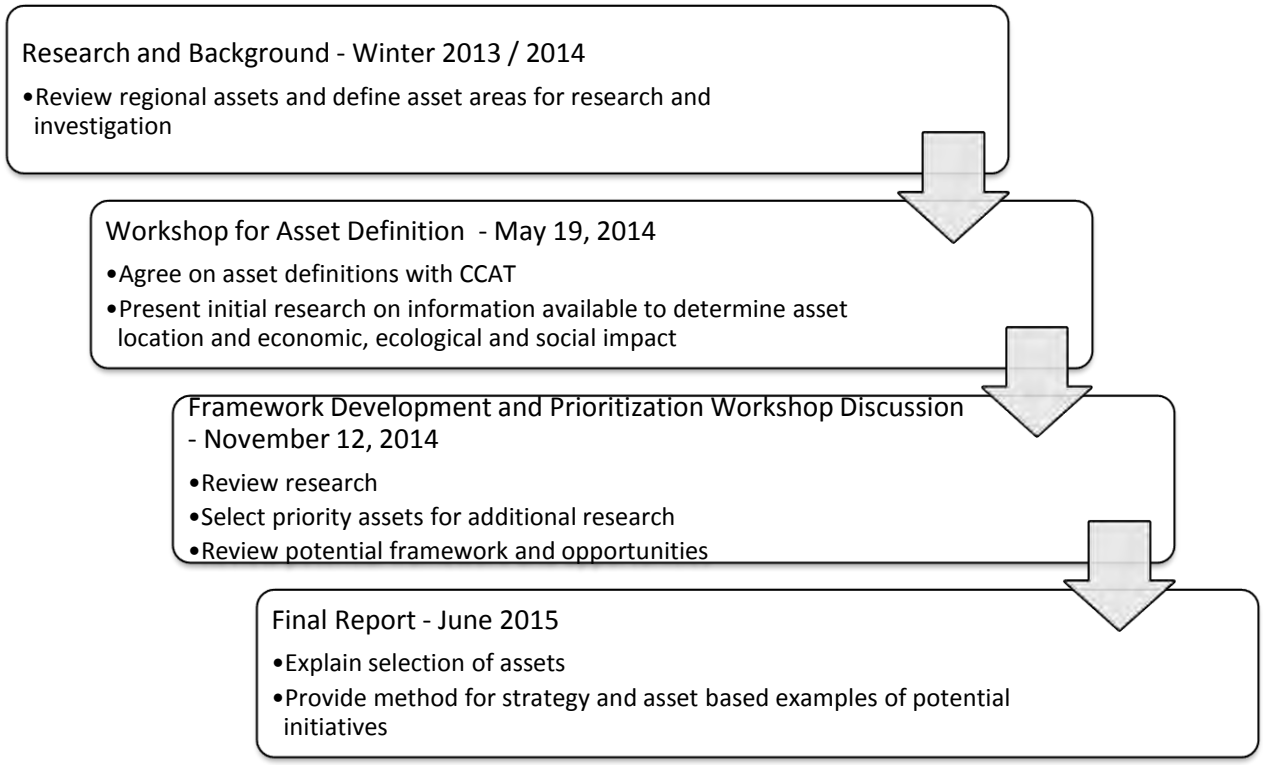


Figure 1: Overview and Project Timeline

While discussing the prioritization of assets for strategic focus, the CCAT also discussed strategies that MARCO could take to advance climate change adaptation among the five states related to each asset. The CCAT agreed on four (4) categories of potential actions, based on the resources required and the level of coordination needed between each of the states:

- Increase common understanding, including having states help each other to understand gaps in current knowledge
- Inform consistent state policy by sharing best practices across the states
- Advocating for and influencing federal policies
- Opportunities for true regional action

4. Mid-Atlantic Assets

The research team undertook an analysis to prioritize asset areas for discussion by the CCAT. Over the past year, the research team has worked in conjunction with CCAT members to identify categories of assets in order to prioritize addressing adaptation efforts related to those assets (See Table 2). Assets were grouped into "built" and "natural" categories. Built categories include grey infrastructure and manufactured systems such as transportation and utility infrastructure and facilities. Natural assets include species, habitats and other items that occur through natural processes. CCAT reviewed the asset categories and agreed with the definitions for the purposes of the analysis for this project.

Table 2. Asset Categories and Definitions for Evaluation

	Resource Type	Resource Definition
Built Infrastructure Resources	Public Coastal Roads and Highways	Paved road infrastructure including county and state roads and federal highways
	Rail	Passenger and transit systems, including stations, rights of way and supporting infrastructure
	Marine Terminals	Large industrial and transportation terminals
	Waterways and Channels	Maintained navigable waterways and channels for commercial or recreational purposes
	Bridge and Tunnel	Bridges and tunnels associated with roads and highways as defined herein
	Airports	Large and municipal airport terminals and associated infrastructure
	Water Infrastructure	Water treatment facilities, water distribution infrastructure, sewer and storm water infrastructure
	Coastal Development (Residential and Commercial Business)	Built assets that are not water dependent, but are located on or near the waterfront. Examples including housing, commercial, hospitality and other structures
	Working Waterfronts / Public Access	Water dependent businesses and uses include recreational fishing, commercial fishing, tourism, public access, and other commercial waterfront businesses. A particular focus will be placed on potentially hazardous industrial facilities and brownfield sites (where feasible and information is readily available)
	Utility Transmission	Electricity, water, natural gas, and telecommunication infrastructure associated with service delivery
	Energy Generation	Power plants and associated infrastructure used for generation purposes
	Historic Structures	Assets of significance that qualify for state or federal historic preservation protections
	Resource Type	Resource Definition
Natural Resources	Commercial Fisheries	Ocean and bay commercial fishing resources (Blue Crab, Striped Bass, Oyster, Conch, American Eel, Hard Clam)
	Shellfisheries	Oyster beds and other near shore harvesting uses
	Anadromous Fish Species	Fish species which migrate from the sea into fresh water to spawn; or, ones which stay entirely in sea water and migrate upstream to spawn. (Atlantic sturgeon, Striped Bass, American Shad)
	Protected Aquatic Species	Endangered or protected species as defined by federal and/or state agencies (Atlantic sturgeon, Short nose sturgeon, Sea Turtles (Kemp's, Green, Loggerhead, hawksbill, leatherback), Whales (finback, humpback, right), Mussels)
	Protected Terrestrial Species	Endangered or protected species as defined by federal and/or state agencies (Bats, Birds)
	Aquatic Habitat	Corals, vegetation, and other aquatic flora and structures
	Terrestrial Habitat	Forests and other natural habitats
	Estuarine Habitat	Tidal, Tidal Freshwater, and Non-Tidal habitats
	Avian Species	Birds
	Beaches	Coastal and bay beaches
	Dredging / Sand Mining / Ocean Resources	Sand, wind energy, oil and gas, and other resource based ocean uses
	Vulnerable Waters	Pollutants, sedimentation, changes to PH, increasing salinity and other potential impacts
	Protected / Preserved Lands	Lands protected under federal and state programs including preserves, farmland, and other areas.

Source: Authors

5. Asset Prioritization

The research team set out to assist MARCO CCAT in prioritizing the assets by evaluating four different criteria:

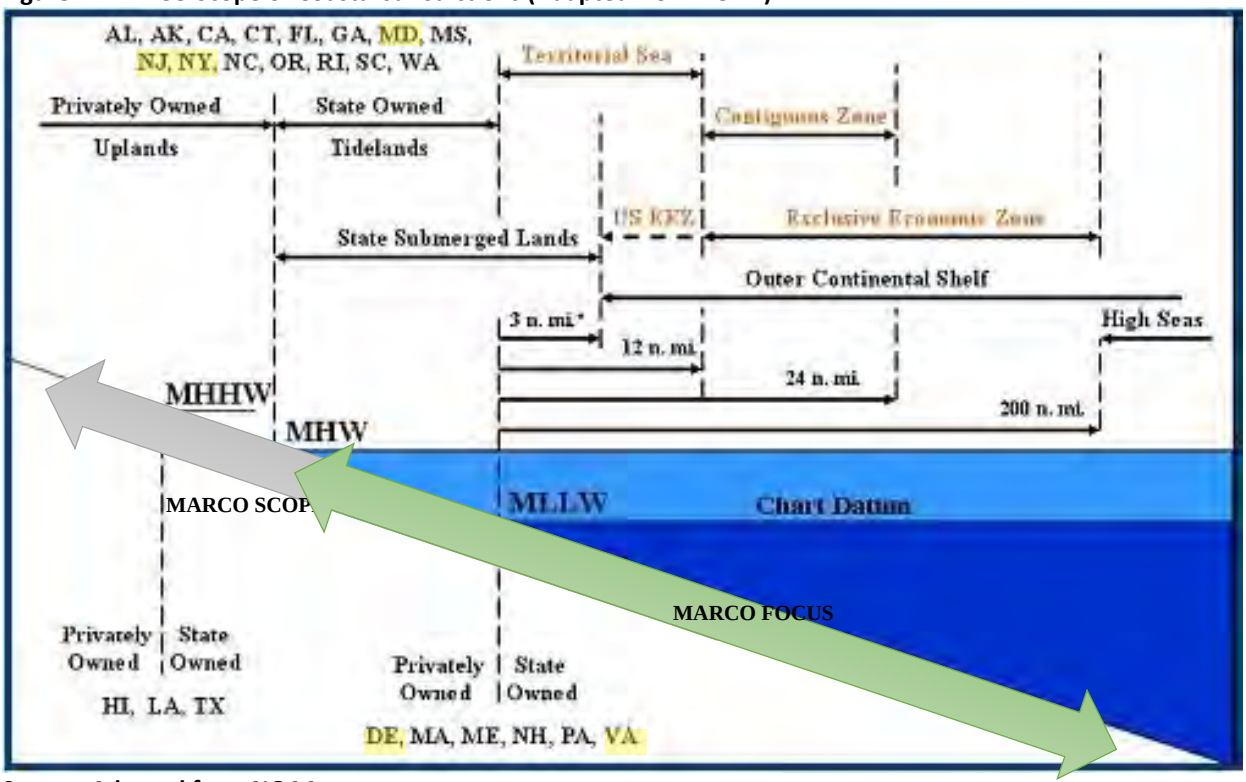
1. Locations of each asset relative to United States marine jurisdictions and MARCO focus
2. Extent of trans-boundary impacts
3. Potential to meet MARCO strategic goals
4. Capability for MARCO initiatives to be effective given existing governance structure

Asset Location

"While our focus is on addressing emerging challenges in the ocean environment, to be successful we will need to address the connections between upland, near shore, and offshore areas. The actions contemplated under this approach will provide opportunities for the States to collaborate across the region, from the watersheds to the offshore areas, and to address economic, social, and other factors, "(Mid-Atlantic Governor's Agreement on Ocean Conservation, 2009).

Figure 2 represents the different jurisdictions that are relevant for maritime governance in the United States. The green arrow represents the focus of MARCO in the "ocean environment" while the grey arrow represents the scope of assets with connection to the health of the ocean environment, including uplands and near shore areas.

Figure 2: MARCO Scope of Coastal Jurisdictions (Adapted from NOAA)

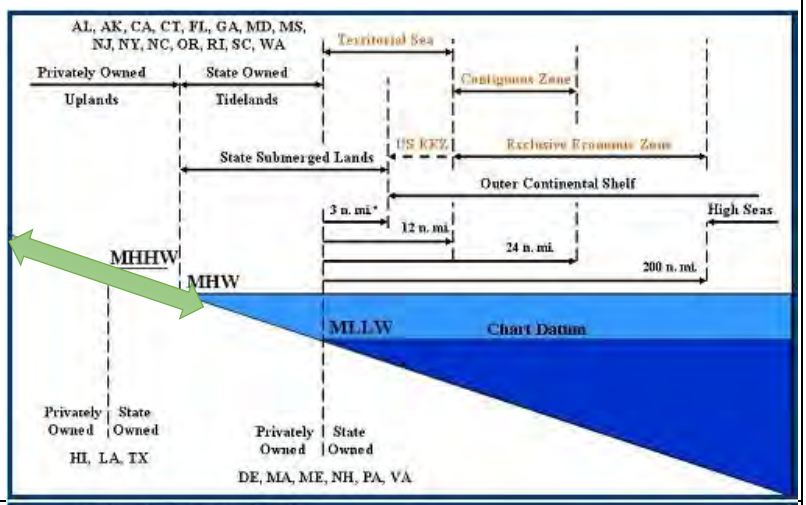
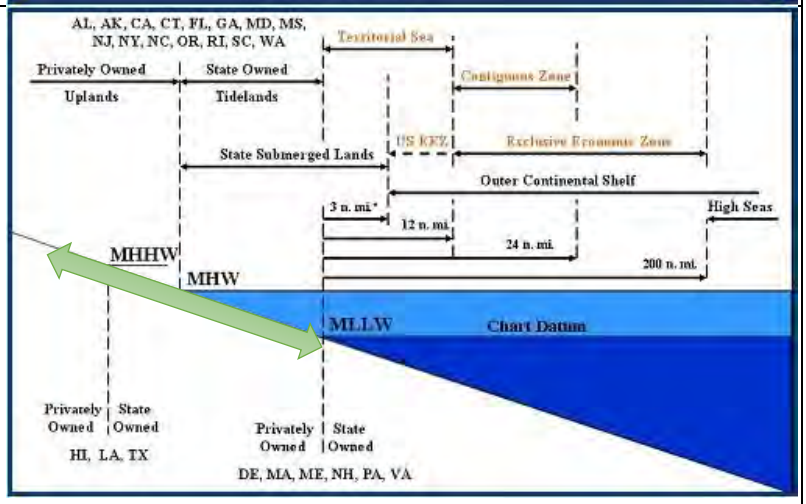


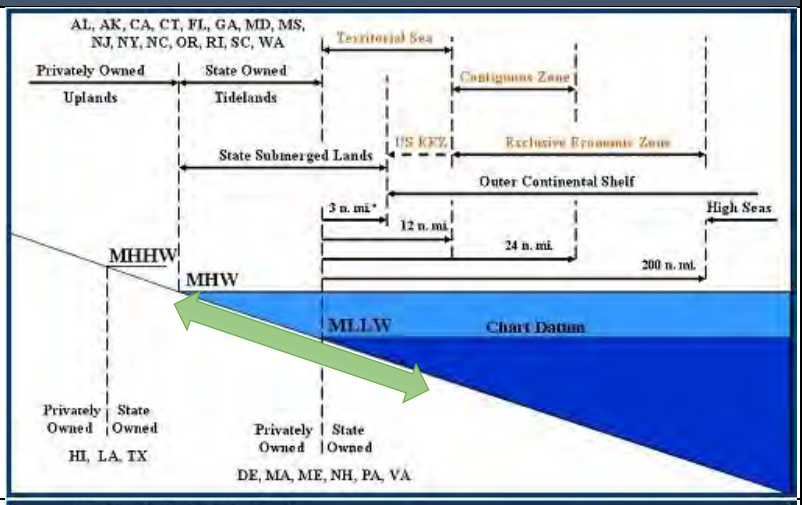
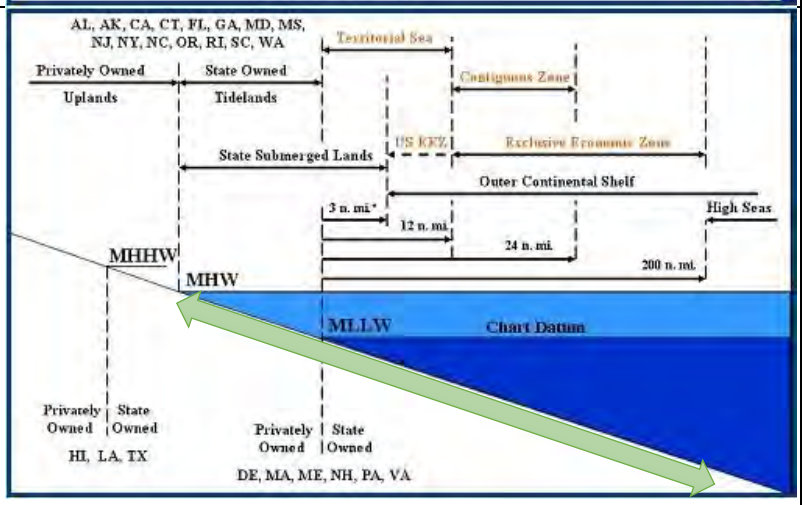
Source: Adapted from NOAA

The research team assessed the geographic distribution of the assets of concern based on available academic literature, ocean data portals, and other tools and data sets available in order to better understand MARCO's role in addressing climate change impacts to the selected assets. Assets located from the high seas to state submerged lands were consistent with the geographic focus of

MARCO were considered. Assets that were located in both terrestrial and near shore habitats are still within the scope of MAROC's responsibilities, however they may only be so on a case-by-case basis. CCAT and the research team considered those assets that are located primarily in terrestrial areas as part of the MARCO scope, but not necessarily within the focus of MARCO. These terrestrial assets ensure that the assets within the scope of the MARCO organization function most effectively.

Table 3: Location Scope Summary

Scope Assessment	Applicable Assets	Asset Location
Primarily Terrestrial: Assets that are located above the mean high water line in the uplands of the coastal zone	**Built Infrastructure** 1. Public Coastal Roads and Highways 2. Rail 3. Airports 4. Coastal Development **Natural Resources** 1. Protected Terrestrial Species 2. Terrestrial Habitat	
Assets that are located on land, but often extend into water, particularly in channels and harbors	**Built Infrastructure** 1. Marine Terminals 2. Bridge and Tunnel 3. Utility Transmission 4. Working Waterfronts / Public Access 5. Energy Generation\ **Natural Resources** 1. Protected preserved lands	

Scope Assessment	Applicable Assets	Asset Location
Assets that are located in water, but often near shore or in tidal waters	**Built Infrastructure** 1. Waterways and Channels 2. Historic Structures* **Natural Resources** 1. Shellfisheries 2. Anadromous Fish Species 3. Estuarine Habitat 4. Beaches 5. Avian Species	
Assets that are located in ocean waters and may include tidally influenced bodies of water	**Natural Resources** 1. Commercial Fisheries 2. Protected Aquatic Species 3. Aquatic Habitat 4. Vulnerable Waters 5. Dredging / Sand Mining / Ocean Resources	

Source: Authors

Asset Location CCAT Discussion Summary:

Only one type of infrastructure, waterways and channels, sits entirely within the MARCO area of focus. All other infrastructure assets are located in coastal land areas or upland terrestrial areas. Of those built infrastructure assets that are located in near shore areas, marine terminals and bridges and tunnels are most always located nearest to the maritime environment because of the functions that they perform in supporting coastal infrastructure systems. Power generation infrastructure is also often located near water because of needs for cooling infrastructure. The remaining built infrastructure assets are sometimes affected by the ocean environment, but are not inherently dependent on accessibility to water. It is not a requirement for airports and other different types of infrastructure to perform using the ocean as a direct input. On the other hand, most of the natural resource areas that were analyzed for locations have at least some maritime presence or dependency based on either their habitat needs or the functions that they provide (e.g. habitat).

Assessment of Trans-boundary Impacts

Trans-boundary impacts are defined as changes to assets in one jurisdiction that affect the economic, ecological, or socio-cultural conditions in other jurisdictions. The most often cited trans-boundary impacts include river or air pollution, where the affected parties cannot implement an effective mitigation strategy without cooperation among all parties involved. Although the bilateral cases can be resolved by negotiations between two jurisdictions, there are cases (such as air pollution) that require coordinating across several jurisdictions in order to resolve them (Castells, 1998).

For example, State A is home to an estuary that supports the spawning habits of a particular harvestable fish species. Scientists expect that sea level rise will endanger the health of the estuary, thereby limiting the potential of a commercial fishing industry that depends on the species. While the estuary is located in State A, the loss in commercial fishing capability may extend to States B, C, and D. Alternatively, State A has several brownfield sites that future sea-level rise may expose to increase flooding, with commensurate community pollution concerns. Though the pollution would affect communities in State A, the impacts may not result in significant consequences to States B, C, or D. States, B, C, and D may have similar situations related to brownfields; however, trans-boundary impacts would only be considered when the pollution from one (or more) sites in a given state affected resources of one or more states in the region.

After collecting and reviewing literature associated with each of the assets, the research team scored each based on the level of Trans-boundary impacts (as opposed to potentially significant, but ultimately local impacts). The assessments for each are indicated to the right of each description (See Table 4).

1. **High (H)** – The impacts of climate change on this asset in my state will more often than not affect the economy, ecology, or socio-cultural conditions in more than one Mid-Atlantic State.
2. **Medium (M)** – The impacts of climate change on this asset in my state will often affect the economy, ecology, or socio-cultural conditions of a neighboring state and sometimes affect several states in the Mid-Atlantic region.
3. **Low (L)** – The impacts of climate change on this asset in my state will often affect the economy, ecology, or socio-cultural conditions of local or regional areas in my state, only affecting other states under unique or extreme circumstances.

Table 4: Results of Transboundary Impact Research and Workshop Discussions

	Resource Type	Trans-boundary Impacts		
		Economic (H,M,L)	Ecological Rank (H,M,L)	Social/Cultural Rank (H,M,L)
Built Infrastructure Resources	Public Coastal Roads and Highways	Medium	Low	Low
	Rail	High	Low	Medium
	Marine Terminals	High	Low	High
	Waterways and Channels	High	Medium	Medium
	Bridge and Tunnel	Medium	Low	Medium
	Airports	High	Low	Low
	Water Infrastructure (Fresh / Storm / Sewerage)	Medium	Medium	Medium
	Coastal Development (Residential and Commercial Business)	Medium	Medium	Medium
	Working Waterfronts / Public Access	High	High	High
	Utility Transmission	High	Medium	Medium
	Energy Generation	Medium	Medium	Medium
	Historic Structures	High	Medium	High
Natural Resources	Commercial Fisheries	High	High	High
	Shellfisheries	Medium	High	Medium
	Anadromous Fish Species	Low	High	Medium
	Protected Aquatic Species	Low	High	Medium
	Protected Terrestrial Species	Low	High	Medium
	Aquatic Habitat	Medium	High	Medium
	Terrestrial Habitat	Low	Medium	Low
	Estuarine Habitat	High	High	Medium
	Avian Species	Low	Medium	Low
	Beaches	Medium	Medium	Medium
	Dredging / Sand Mining / Ocean Resources	High	High	High
	Vulnerable Waters	Medium	High	Medium
	Protected / Preserved Lands	High	High	High

Notes: **High (H)** – The impacts of climate change on this asset in my state will more often than not affect the economy, ecology, or socio-cultural conditions in more than one Mid-Atlantic State.
Medium (M) – The impacts of climate change on this asset in my state will often affect the economy, ecology, or socio-cultural conditions of a neighboring state and sometimes affect several states in the Mid-Atlantic region.
Low (L) – The impacts of climate change on this asset in my state will often affect the economy, ecology, or socio-cultural conditions of local or regional areas in my state, only affecting other states under unique or extreme circumstances.

Trans-boundary Impacts CCAT Discussion Summary

Assets that are vulnerable to sea level rise, extreme events, and ocean acidification (as a function of increased greenhouse gas emissions) are priorities for the CCAT because these are directly related to supporting Mid-Atlantic Ocean resources and human and ecological uses.

- Transportation infrastructure can have significant trans-boundary economic impacts, to the extent that it effects the movement of goods, commuting patterns, or tourism. GHG reductions can mitigate direct ecological impacts resulting from climate change in conjunction with adaptation strategies. Socio-cultural trans-boundary impacts are related to regional evacuation needs and existing historic infrastructure in some coastal locations.
- Water infrastructure is at risk as sea level rises. Storms that are more frequent can damage treatment facilities and the likelihood of spills into the ecosystem is more likely, which poses a risk to human health.
- Working waterfronts face pressure from increasing sea level rise, temperature changes and extreme events. These changes can affect tourism and local waterfront businesses. This will likely impact coastal communities both locally and regionally.
- Commercial fisheries and shellfisheries are vulnerable to increases in temperature, precipitation changes and GHG emissions. The economic impacts are potential job loss; this will result in damage to the social cohesion of many coastal communities in the MARCO states. As the climate warms and fish species change their patterns, this will affect the ecology of the region.
- Anadromous fish species may affect the commercial fishing industries in other states as their ideal habitat moves further north. This will locally affect jobs and food web dynamics all along the MARCO states.
- Beaches represent both an economic and ecological vulnerability for coastal areas. Several critical habitats for migratory birds and tourism economies for in-state and out-of-state visitors.

MARCO Shared Priority Areas

In order to understand MARCO's role in addressing climate change impacts to the selected assets better, CCAT and the research team designed a template to analyze and clarify the roles that addressing the impacts of climate change would have on other MARCO shared priorities. According to the founding documents and strategic planning efforts of the Mid-Atlantic Regional Council on the Ocean, there are three other shared priorities of the organization, in addition to addressing impacts from a changing climate:

1. Marine Habitats: marine areas that provide a home to a variety of protected species and other species that support commercial and recreational economic activities
2. Coastal Water Quality: problems with water quality that include beach closures, contaminated seafood, invasive species, and ocean acidification threaten human health, local economies, recreation, and marine life
3. Offshore Renewable Energy: wind energy development offshore provides an opportunity for sustainable energy supply, but requires planning and foresight to consider environmental impacts and safety for human uses and ecological systems

After collecting and reviewing literature associated with each of the assets, the research team scored each of shared priorities based on whether or not the team felt that efforts related to a particular asset would also be supportive of efforts to drive other strategic missions of MARCO. The assessments for each are indicated to the right of each description.

1. **High (H)** – Addressing the impacts of climate change on this asset would strongly support MARCO shared priorities related to this goal (e.g. Marine Habitat, Coastal Water Quality, Offshore Renewable Energy)

2. **Medium (M)** – Addressing the impacts of climate change on this asset could indirectly support MARCO shared priorities related to this goal (e.g. Marine Habitat, Coastal Water Quality, Offshore Renewable Energy)
3. **Low (L)** – Addressing the impacts of climate change on this asset would have little to no impact in supporting MARCO shared priorities related to this goal (e.g. Marine Habitat, Coastal Water Quality, Offshore Renewable Energy)

Summary of How Assets Coincide with MARCO Priorities

- Utility transmission, energy generation, and ocean resources ranked highly in terms of addressing the impacts of climate change that could indirectly support MARCO shared priorities related to offshore renewable energy.
- Initiatives related to coastal infrastructure development and land use, in addition to vulnerable water and habitat initiatives are supportive of the coastal water quality shared priority.
- Many of the species related natural assets affect marine habitat conservation and protection activities and support commercial and recreational economic activities.
- Ocean Resources, working waterfronts, habitat, and protected aquatic species initiatives were perceived to be most supportive of all shared priorities, with at least a medium score for each and at least one high score.

Table 5: How Assets Coincide with MARCO Priorities

	Marine Habitats	Coastal Water Quality	Offshore Renewable Energy
Public Coastal Roads and Highways	Low	Low	Low
Rail	Low	Low	Low
Marine Terminals	Medium	Medium	Medium
Waterways and Channels	Medium	Medium	Medium
Bridge and Tunnel	Medium	Low	Low
Airports	Low	Low	Low
Water Infrastructure	Medium	Medium	Low
Coastal Development (Residential and Commercial Business)	Medium	High	Low
Working Waterfronts / Public Access	Medium	High	Medium
Utility Transmission	Low	Low	High
Energy Generation	Low	Low	High
Historic Structures	Medium	Low	Low
Commercial Fisheries	High	Low	Medium
Shellfisheries	High	Medium	Low
Anadromous Fish Species	High	Medium	Low
Protected Aquatic Species	High	Medium	Medium
Protected Terrestrial Species	High	Low	Low
Aquatic Habitat	High	High	Medium
Terrestrial Habitat	Low	Low	Low
Estuarine Habitat	High	High	Low
Avian Species	Low	Low	Medium
Beaches	Medium	Low	Low
Dredging / Sand Mining / Ocean Resources	Medium	Medium	High
Vulnerable Waters	Medium	High	Low
Protected / Preserved Lands	Low	Low	Low

Source: Authors

Table 6: Summary of CCAT Evaluation from Workshop

	Resource Type	Location	Transboundary Impacts			MARCO's Mission		
		(H,M,L,NS)	Economic Rank (H,M,L,NS)	Ecological Rank (H,M,L,NS)	Social/Cultural Rank (H,M,L,NS)	Marine Habitats	Coastal Water Quality	Offshore Renewable Energy
Built Infrastructure Resources	Public Coastal Roads and Highways	Low	Medium	Low	Medium	Low	Low	Low
	Rail	Low	High	Low	High	Low	Low	Low
	Marine Terminals	Medium	High	Medium	High	Medium	Medium	Medium
	Waterways and Channels	High	High	Medium	Medium	Medium	Medium	Medium
	Bridge and Tunnel	Low	Medium	Low	Medium	Medium	Low	Low
	Airports	Low	High	Low	Low	Low	Low	Low
	Water Infrastructure	Medium	Medium	Medium	Medium	Medium	Medium	Low
	Coastal Development (Residential and Commercial Business)	Low	Medium	Medium	Medium	Medium	High	Low
	Working Waterfronts / Public Access	Medium	High	High	High	Medium	High	Medium
	Utility Transmission	Low	High	Medium	Medium	Low	Low	High
	Energy Generation	Low	Medium	Medium	Medium	Low	Low	High
	Historic Structures	Medium	High	Medium	High	Medium	Low	Low
Natural Resources	Commercial Fisheries	High	High	High	High	High	Low	Medium
	Shellfisheries	Medium	Medium	High	Medium	High	Medium	Low
	Anadromous Fish Species	Medium	Low	High	Medium	High	Medium	Low
	Protected Aquatic Species	High	Low	High	Medium	High	Medium	Medium
	Protected Terrestrial Species	Low	Low	High	Medium	High	Low	Low
	Aquatic Habitat	High	Medium	High	Medium	High	High	Medium
	Terrestrial Habitat	Low	Low	Medium	Low	Low	Low	Low
	Estuarine Habitat	Medium	High	High	Medium	High	High	Low
	Avian Species	Medium	Low	Medium	Low	Low	Low	Medium
	Beaches	Medium	Medium	Medium	Medium	Medium	Low	Low
	Dredging / Sand Mining / Ocean Resources	High	High	High	High	Medium	Medium	High
	Vulnerable Waters	High	Medium	High	Medium	Low	High	Low
	Protected / Preserved Lands	Medium	High	High	High	Low	Low	Low

Source: CCAT as recorded by Authors

6. Climate Adaptation Efforts in MARCO States

There are multiple actors currently working to help adapt these assets to changing climatic conditions at the federal, state and local levels. This section summarizes some of the climate adaptation efforts that are underway in the MARCO region. This summary includes efforts at the state, regional, and federal levels. The Georgetown Climate Center's state adaptation progress tracking tool and Adaptation Clearinghouse maintain a continually updated catalogue of efforts underway. The information below represents a summary of information and events to provide context for understanding efforts in each state.

New York

- The New York State Climate Action Council was established in August 2009 by Governor David Patterson. The Council developed a climate action plan that included a chapter on how the state could adapt to climate change. The adaptation goals covered a number of sectors, including coastal, ecosystems, and water.
- In 2010, the New York Energy Research and Development Authority (NYSERDA) published an assessment of the state's vulnerability to climate change: Responding to Climate Change in New York State: ClimAID Integrated Assessment for Effective Climate Change Adaptation - Synthesis Report. NYSERDA is also administering the $40 million New York State competition program NY Prize, which challenges communities and entrepreneurs to design microgrid projects, making them more resilient to power outages caused by extreme weather.
- After Hurricane Sandy, Governor Andrew Cuomo convened the NYS 2100 Commission, which developed a report with recommendations to improve the resilience of the state's critical infrastructure systems: NYS 2100 Commission: Recommendations to Improve the Strength and Resilience of the Empire State's Infrastructure
- Operating under the umbrella of New York Rising, the Governor's Office of Storm Recovery (GOSR) utilizes approximately $4.4 billion in flexible funding made available by the U.S. Department of Housing & Urban Development's (HUD) Community Development Block Grant Disaster Recovery (CDBG-DR) program to concentrate aid to four main areas (housing, small businesses, community reconstruction, and infrastructure). The NY Rising Community Reconstruction (NYRCR) Program is a participatory recovery and resiliency initiative established to provide assistance to 124 communities severely damaged by Superstorm Sandy, Hurricane Irene, and Tropical Storm Lee. Communities are eligible to receive awards ranging from $3 million to $25 million, as they implement strategies that will support local recovery and resiliency efforts.
- In 2014, the state legislature enacted the Community Risk and Resilience Act (CRRA), which calls on state agencies to consider sea-level rise and other climate change impacts in state permitting and funding programs. The NY-DEC has until January 2016 to adopt a set of sea-level projections, which will then need to be updated every 5 years. The legislation also directs the NY-DOS to work with NY-DEC to develop model climate change adaptation zoning laws for use by municipalities, and guidance on the use of natural resources and natural processes to reduce risk. Once adopted, future climate change risks will need to be considered in a variety of state permitting and funding programs, including the following relevant provisions of the NY Code:
    - Smart growth public infrastructure criteria (ECL Art. 6);
    - Water pollution revolving loan fund (ECL Art. 17, title 19);
    - Siting of hazardous waste facilities (ECL Art. 27, title 11) and bulk storage of hazardous substances (ECL Art. 40);

    - Land acquisition for preservation of open space; recreation; and natural, cultural and historic resources (ECL Art. 49, title 2andArt. 54, title 3);
    - State assistance for local waterfront revitalization programs and coastal rehabilitation projects (ECL Art. 54 title 11);
    - Uniform procedures for major permits (ECL Art. 70); and
    - Drinking water revolving fund (Public Health Law Art. 11, Title 4);
- The state is also implementing several of the winning Rebuild by Design projects including projects in New York City, Hunt's Point, Staten Island, and Nassau County.
- As part of the Hurricane Sandy recovery effort NYDEC conducted an assessment of water quality threats posed by climate change and sea-level rise in Nassau and Suffolk counties, Coastal Resiliency and Water Quality in Nassau and Suffolk Counties: Recommended Actions and a Proposed Path Forward.

New Jersey

- Under the administration of Governor Jon Corzine, the New Jersey Department of Environmental Protection (NJDEP) recommended the development of a state-wide adaptation plan in the state's greenhouse gas mitigation report. However, no formal state-wide plan has been adopted.
- In 2013, the Rutgers Climate Institute published an assessment, titled State of the Climate: New Jersey, which provides an overview of recent climate events and trends, their impacts, and their implications for the future of New Jersey.
- In June 2014, the New Jersey Adaptation Alliance (a network for 30 non-profit, government, academic, and business organizations) released a report recommending a number of strategies the state could implement to prepare for climate change: Resilience. Preparing New Jersey for Climate Change: Policy Considerations from the New Jersey Climate Adaptation Alliance.
- NJADAPT (a collaborative of academics, government, non-profits, and the private sector) provides a repository of climate data, flood mapping tools, and assessments to help New Jersey communities prepare for climate change.
- NJDEP has worked with the non-profit Sustainable Jersey to help communities increase their sustainability in the face of climate change, including natural habitat conservation.[1]
- The state is also implementing several of the winning Rebuild by Design projects including projects in the Meadowlands and Hoboken.

Delaware

- The Delaware Coastal Programs Section of DNREC has led a multi-year Sea Level Rise Initiative to help assess and prepare for the potential impacts of sea-level rise in the state. Delaware's Sea Level Rise Advisory Committee (SLRAC)[2] was established by DNREC in 2010 to support the Initiative and help the state assess and plan for sea-level rise. The SLRAC has developed both an assessment of the state's vulnerability to future sea-level rise and a series of recommendations for policy improvements and best management practices, Preparing for Tomorrow's High Tide: Sea Level Rise Vulnerability Assessment for the State of Delaware, which was released in July 2012.
- In September 2013, Governor Jack Markell issued Executive Order 41 establishing the Governor's Committee on Climate and Resiliency, and requiring state agencies to incorporate

[1] see also http://www.state.nj.us/dep/sage/sustain.html

[2] The Delaware's Sea-Level Rise Advisory Committee (SLRAC) is comprised of a representative from each cabinet-level department and representatives from municipal governments, and business and citizen advocacy organizations.

measures for adapting to increased flooding and sea-level rise in the siting and design of state-funded projects.

- The Delaware Department of Natural Resources and Environmental Control (DNREC) developed a statewide climate change vulnerability and risk assessment, The Delaware Climate Change Impact Assessment.
- In March 2015, the Governor released a Climate Framework for Delaware describing the actions that state agencies have already taken to adapt to impacts and outlining recommendations for future action.

Maryland

- In an April 2007 Executive Order,[3] Governor Martin O'Malley established the Maryland Commission on Climate Change (MCCC)and directed the Commission to create a Climate Action Plan including recommendations for how the state can prepare for the impacts of climate change. The Adaptation and Response Working Group within the MCCC developed the adaptation portions of the state's Climate Action Plan. In 2014, the membership of the MCCC was expanded and the state legislature passed legislation in 2015 codifying the Commission.
- Maryland's Climate Action Plan includes two adaptation plans: (1) the Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change, Phase I: Sea-level rise and coastal storms, which was published on September 12, 2008, and includes recommendations for how the state can adapt to impacts from sea-level rise and coastal storms; and (2) the Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change, Phase II: building societal, economic, and ecological resilience, which was published on January 24, 2011 and provides recommendations for adapting to changes in precipitation patterns and increased temperature. The Maryland Department of Environment (MDE) issued detailed information through the recent Greenhouse Gas Emission Reduction Act Plan Update (2015), including implementation efforts to date, along with short, medium and long-term priorities for future action.[4]
- In 2012 Governor O'Malley directed all state agencies to consider the risk of sea-level rise, flooding and extreme weather in the construction or reconstruction of state buildings and facilities (Executive Order 01.01.2012.29, Climate Change and "Coast Smart" Construction). The 2012 executive order also calls for new and reconstructed state-owned structures to be elevated two or more feet above the 100-year base flood elevation. The state legislature codified these requirements and created the Coast Smart Council in May 2014 through House Bill 615. The Coast Smart Council (within MD-DNR) developed guidelines for the siting and design of state capital projects in consideration of future sea-level rise and coastal flooding, State of Maryland Climate Change and Coast Smart Construction Infrastructure Siting and Design Guidelines, that were approved on June 26, 2015.
- Maryland's *CoastSmart* Communities Program provides financial and technical assistance to vulnerable coastal communities to help them identify, prepare for and reduce their risk to coastal and climate related impacts. Since 2009, CCS has supported more than 50 state-local government partnership efforts throughout the coastal zone and has awarded over $600,000 to support projects in six coastal counties and 19 municipalities.

[3] O'Malley signed an additional Executive Order in 2015, which superseded the 2007 EO and updated the priorities of the Commission.

[4] http://climatechange.maryland.gov/wp-content/uploads/sites/16/2014/11/GGRA_Report_Final_11-2-15.pdf

Virginia

- In 2007, Governor Tim Kaine established the Governor's Commission on Climate Change and directed the Commission to develop a Climate Action Plan. The Commission released its plan, A Final Report: A Climate Change Action Plan, in 2008.
- In September 2014, the Recurrent Flooding Subpanel of the legislature's Secure Commonwealth Panel made a series of recommendations for how the state can respond and adapt to the threat of recurrent flooding and sea-level rise, Recommendations to the Secure Commonwealth Panel on the Issue of Sea Level Rise and Recurrent Flooding in Coastal Virginia.
- Virginia's Coastal Zone Management Program funded twelve pilot projects related to climate change adaptation between 2008 and 2011.
- In July 2014, Virginia Governor Terry McAuliffe issued an Executive Order creating a new Governor's Climate Change and Resiliency Update Commission to conduct an assessment of Virginia's vulnerability to climate change impacts and to develop recommendations and update the state's 2008 plan. The Commissions updated report and recommendations are scheduled to be released by the end of 2015.

Federal

- In January 2015, the Army Corps of Engineers released its North Atlantic Coast Comprehensive Study, which detailed strategies for reducing risks from coastal storms and flooding due to sea-level rise in the North Atlantic region from Maine to North Carolina. The study was called for in the Disaster Relief Appropriations Act of 2013,[5] which was signed into law to assist recovery in the states and communities affected by Hurricane Sandy.
- In January 2015, President Obama signed an executive order directing federal agencies to adopt new flood risk management standards for the siting, design, and construction of federal projects and projects funded with federal dollars (Federal Flood Risk Management Standards or Standards). Agencies have three options for establishing the flood elevations for projects and the hazard areas where the Standards will apply; they can: use the best-available climate science, build two feet above the 100-year flood elevation for standard projects and 3-feet for critical facilities, or they can build to the 500-year flood elevation. The Standards also call on agencies to avoid, preserve and enhance natural flood plains and to use natural systems, ecosystem processes, and nature-based approaches where possible. The Federal Emergency Management Agency (FEMA) was charged with drafting guidelines to assist agencies in implementing the Standards, and once adopted the agencies will need to develop their own implementation plans.
- Beginning in 2016, FEMA will require states to consider climate change in their Hazard Mitigation Plans, which are required as a condition of receiving disaster recovery assistance under the Hazard Mitigation Grant Program (HMGP) authorized by Section 404 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act.

In summarizing the efforts, it is apparent that several of the projects and initiatives across all levels of governance are related to generating data and sharing knowledge among stakeholders within the region. State approaches and initiatives to climate change differ, with varying efforts underway to create state level advisory boards and climate governance structures. Maryland has succeeded in integrating climate change into policy decisions. Recent developments at the federal level are also helping to integrate climate change into federal agency decisions.

[5] Pub. Law 113-2, Chapter 4.

However, federal initiatives often deal with securing built infrastructure and communities, with few programs focusing on natural resources.

Summary Results and Workshop Discussion

After analyzing how an initial list of 25 assets coincided with MARCO's shared priorities, geographic scope of governance, and potential transboundary impacts, the CCAT selected the following focus areas for analysis:

1. Beaches, including public access, habitat, tourism, local economies, dunes, availability of appropriate resources for beach management and associated tradeoffs
2. Near shore habitat, including estuarine, tidal wetlands, SAV, and aquaculture
3. Offshore habitat, including deep water and coral habitat, and ocean habitat
4. Marine terminals, including supporting built infrastructure

In some cases, such as sand mining, there were discussions regarding the feasibility of MARCO being able to lead or participate in those discussions. Therefore, though some areas may have had more high ratings for location and trans-boundary impacts than the assets selected for further action, the CCAT team discussion centered on assets for which the team's experience and knowledge of potential opportunities to make a difference on MARCO priorities was more certain.

7. Priority Assets and Adaptation Strategy

Following the identification of the priority assets, the research team developed more detailed asset definitions, and in partnership with the Georgetown Climate Center, reviewed the authorities under which some of the efforts might take place. In addition, a more thorough review of vulnerabilities and impacts was conducted for each of the focus asset areas.

MARCO shared priority areas include water quality, offshore wind, and marine habitat. A number of different climate stressors affects each of these priorities. Ocean acidification, warming temperatures, and changes in exposure from coastal storms and rising sea levels degrade water quality. Offshore renewable energy efforts mitigate carbon emissions, but are potentially vulnerable to coastal storms and other climate change impacts that might cause damage or inundation to the infrastructure investments made. Climate impacts on marine habitat are numerous and include changes in species and migratory behavior from changing temperatures and currents, and habitat degradation from ocean acidification. Adaptation efforts can address these priorities individually, or can address several of the priorities indirectly by improving adaptation of related assets.

Initiatives identified center around gathering a better understanding of the different perceptions of impacts and vulnerabilities within the region. These first steps fall primarily within MARCO's role as creating common knowledge among stakeholders. Subsequently there are different strategies for exercising that knowledge through federal state or regional authorities that are dependent on the asset in question. In some cases, it may require a continuous evolution from state to federal authorities, whereas other options may require a specific action unique to a level of governance. In all cases, generating a common understanding and baseline for action is the most critical need among each of the focus asset areas.

Beaches

A beach is the zone of unconsolidated material that extends landward from the low water line to the place where there is marked changes in material such as rock or sand (NOAA, 2014). Mid-Atlantic States rely on beaches for ecological functions, recreation, tourism revenues and employment opportunities, especially during the summer tourism season. The continued management of these areas plays a critical role for local, national, and international visitors. In addition, beaches clearly have important cultural meanings. Residents and tourists spend money in beach destinations and often return to them year after year.

Beaches also serve many important ecological functions, which are distinctly transboundary since beaches do not have official ends at state lines but are a continuous habitat from Maine to Florida. For example, crabs, insects, and migratory birds feed on material left by the waves and small animals dig into the sand to obtain their food. In certain areas, birds use beaches to nest and sea turtles lay their eggs on ocean beaches. Sea grasses and many other beach plants grow on the different areas of beaches and dunes.

The relationship between the economy (recreation) and health of beaches is evident. The US Army Corps of Engineers (USACE) often conducts beach replenishment and other strategies to maintain coastal properties and protect beaches. While studies suggest that beach nourishment projects have little systematic effect on recreational use (Blackwell et al., 2010), decreases in width (from sea level rise or extreme events) are associated with decreases in use for certain recreational activities (Whitehead et al., 2009). The long-term effects of beach replenishment on natural systems are uncertain and this uncertainty is complicated by sea level rise.

Structurally, USACE encourages the use of Natural and Nature-based features (NNBF) to enhance coastal resilience. Beaches are natural features that can provide coastal storm risk reduction where their sloping nearshore bottom causes waves to break dissipating wave energy over the surf zone (Gedan et al., 2011; Lopez 2009; NACCS, 2015). Structural measures to protect coastal property such as revetments, bulkheads and seawalls share disadvantages such as loss of sediment transport and the potential to reflect waves that can erode beaches.

The Coastal Zone Management Act of 1972 (administered by NOAA) outlines three national programs for the management of coastal resources; the National Coastal Zone Management Program, the National Estuarine Research Reserve System, and the Coastal and Estuarine Land Conservation Program. According to the 2014 Funding Summary for the National Coastal Zone Management Program, in 2014 NOAA invested in approximately $66 million for coastal management programs with the majority of funding used to protect and restore coastal habitat. NOAA also has performance measures that cover: coastal habitat, coastal hazards, coastal community development, public access, coordination and public involvement in order to evaluate the success of the programs (NOAA, 2014).

Each Mid-Atlantic state has a costal management program. In New York, the inland coastal zone boundary is generally 1,000 feet from the shoreline in non-urbanized areas, 500 feet or less in urbanized areas with the boundary possibly extending inland up to 10,000 feet to incorporate significant coastal resources. The New Jersey coastal zone includes 1,800 miles of tidal coastline and ranges in width from 100 feet to 24 miles inland. All of Delaware is within the federal coastal zone, but the “coastal strip” (approximately four miles in width) receives special protection from industrial development. In Maryland, the coastal zone follows the

inland boundary of the counties and Baltimore City bordering the Atlantic Ocean, Chesapeake Bay, and the Potomac River to the municipal limits of Washington, D.C. The Virginia coastal zone contains the state's 29 coastal counties, 17 cities, and 42 incorporated towns.

Figure 3 demonstrates the geographical representation of land coverage where beaches are located. In this context, functions addressed in this section include public access, species habitat, tourism, local economies, and dunes.

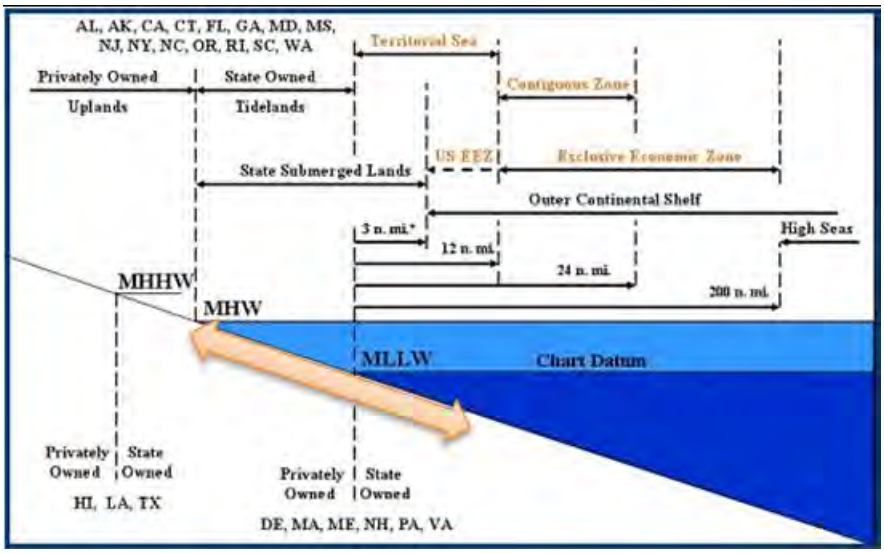


Figure 3: Geographical representation for beaches as defined in this report

Stressors

Stressors are factors that reduce the health or productivity of an asset. The climate change stressors that affect beaches are sea level rise, changes in precipitation, increased temperature, and extreme events. Beaches are naturally vulnerable to erosion due to changing wave patterns and coastal storms. The intensity of extreme storms is likely to increase because of climate change, which may increase damage to beaches from erosion (USGCRP, 2009). Research suggests that 50 to 100 feet of beach width will be lost for every foot of sea level rise in Mid-Atlantic States (Kyper and Sorensen 1985). Both state and federal climate change reports recognize that beach and dune erosion due to rising sea level is a major issue in the Northeast (Buonaiuto et al. 2011; Gornitz et al. 2001).

In addition, increases in precipitation could expand the risk of landslides on coastal bluffs. The combination of saturated soils and sea level rise could increase the number and severity of landslides, especially in areas with high development or already unstable slopes (USGCRP, 2009). Beach ecosystems are highly vulnerable to rising temperatures, which can affect species that use sandy beaches as nesting grounds. This may change the tolerance and survival of organisms, change the geographical range in species and increase invasive species in the region (Stillman, 2003; Harley et al., 2006; Ricciardi, 2007).

Impacts

Based on literature reviews from state climate change adaptation plans, federal climate change adaptation sources and academic literature, transboundary impacts can be divided into three categories, (1) Economic, (2) Ecologic, and (3) Social/Cultural. Economically, impacts to

beaches have significant local impacts related to paying for beach replenishment after coastal storms. Coastal storms also cause considerable damage to beaches and dunes, which local/state governments must pay to repair. For example, the total estimated first construction cost for beach restoration project (beach fill, dune creation) cost $3,500 per square foot (NACCS, 2015). Also, reactive responses to impacts can involve structural solutions such as coastal armoring (sea walls) which have high associated costs, can increase flooding in neighboring areas, and can damage beaches (Grannis, 2011). In addition, regional tourism impacts are likely. An increase in sea level, leads to greater erosion of beaches, which could be devastating to one of the Mid-Atlantic's biggest tourist destination. Tourism brings in over $26 billion in GDP for the Mid-Atlantic, and with over half a million employees, impacts to this sector will have vast economic impacts in the region.

Ecologically, beaches provide habitat for species and are important for turtle and bird nesting grounds. The impact is mostly local (individual beaches) but impacts to migratory species which can also have regional impacts. Barrier islands and beach restoration projects are highly vulnerable to flooding and wave attenuation and erosion (NACCS, 2015).

Beaches have social and cultural importance, as many people across the mid-Atlantic travel to beaches in other states. Sea level rise may affect public access by causing the loss (inundation) of some of these beach areas. Portions of what is currently sandy beach used by the public will be covered with water and no longer useable for recreation.

In New York State, in conjunction with the U.S. Army Corps of Engineers, beach nourishment projects have been implemented to protect the coast, along with applications of both hard and soft shoreline protection. According to the Army Corps, 3.5 million cubic yards of sand in the Rockaway Peninsula and 679,000 cubic yards of sand in Coney Island alone were lost during Hurricane Sandy (NYCHMP, 2014). Like many states, losses in beach habitat also result in the loss of tourism dollars, a reduction of the biologic diversity in the ecosystem, and impacts to already vulnerable communities (USACE, 2015).

New Jersey consists of many coastal beach communities that depend highly on tourism in the summer months for economic activity. Tourists often travel from neighboring states to visit these beaches. In addition to creating tourism demand, New Jersey beaches are important for bird migration routes that extend from South America to the Artic, especially for the Red Knots (USGS, 2012). However, due to the increases in beach erosion from sea level rise and extreme events, beach replenishment and coastline sand flux evaluation will be required for future emergency preparedness (NJGWRAR, 2009). A USGS model estimated that 21 percent of the New Jersey shoreline had more than a 90 percent chance of experiencing inundation, which was observed during the Nor'easter that followed Hurricane Sandy by only 10 days (USGS, 2012).

Delaware has invested in beach replenishment to offset sand loss and to protect structures (Love, Arndt & Ellwood, 2013). For decades, the state has routinely replenished publicly accessible beaches on the Atlantic Ocean and Delaware Bay coasts. Delaware sees beaches and dunes as a high concern resource. Residents in New Jersey, Maryland, and other mid-Atlantic states often travel to Delaware's beaches in the summer months. Due to the economic value, natural resource value and significant state investment in sand replenishment, beaches are an area of high concern in Delaware's state adaptation plan (Love, Arndt & Ellwood, 2013).

In Maryland, tourism along the eastern shore, and particularly Ocean City, represent a significant portion of the overall state economy. Worcester County, where Ocean City is located, generated more than $42.7 million in tourism taxes in 2015.[6] To protect these assets, the state has participated in a decade's long beach replenishment and protection program that was estimated to have prevented $717 million in property damage as of 2013.[7]In addition to the value generated through tourism and protective functions of the beaches, several critical ecological habitats (e.g. Assateague Island) and species are endangered by rising sea levels and other changes in climate.[8] .

Virginia Beach is the 10th largest coastal city in the world in terms of assets exposed to increased flooding from sea level rise (CCAP, 2008). Future hurricanes could cause serious damage especially to the beaches. Tourism is especially important here where over 3 million people travel to this area each year. Virginia Beach gained $1.1 million from traveler spending in 2007 (Yochum & Agarwal, 2009).

Table 7: Climate Change Stressors and Impacts on Beaches

Stressors	• Sea level rise • Changes in precipitation • Increased temperatures • Extreme events.				
State Impacts	• Cost associated with beach replenishment	• Vulnerable populations in coastal communities.	• Habitat depletion	• Decrease in water quality, resulting in beach closures	• Potential tourism impacts

Source: Literature Review, see Bibliography

Near Shore Habitat

Estuaries are bodies of water found where rivers meet the ocean (NOAA, 2014). Many animals rely on estuaries for food, places to breed, and migration stopovers. The CCAT team has decided to focus on Near Shore habitats, which include estuaries, tidal wetlands and submerged aquatic vegetation (SAV). Aquaculture is another important asset in this resource area. Wetlands are complicated and unique ecosystems that are on the edge of aquatic or terrestrial systems that include swamps, marshes, bogs, and similar areas (NOAA, 2003). In addition, wetlands are characterized by certain hydrologic and soil conditions. Wetlands have substantial capacities for carbon storage, water filtration, wave and storm surge buffering, and resource extraction, plus tourism benefits. In this case, the wetlands under this asset are tidal salt and brackish marshes, which include salt tolerant grasses. This asset does not include infrastructure but is mainly concerned with the habitat.

Nearshore habitats are economically, ecologically and culturally important to the Mid-Atlantic States. Economically, wetlands and estuaries provide the habitat for many harvested

[6] https://dl.dropboxusercontent.com/u/30917966/Industry/PDFs/Research/Annual%20Reports/annual-report-2015.pdf

[7] http://news.maryland.gov/dnr/2013/08/17/governor-omalley-federal-state-and-local-officials-celebrate-25th-anniversary-of-ocean-city-beach-replenishment-program/

[8] http://www.nps.gov/articles/assateaguelandscape.htm

fish species. Commercially harvested fish and shellfish are dependent on estuaries and their wetlands. All freshwater species of fish are dependent to some degree on wetlands, often spawning in marshes adjacent to lakes or in riparian forests during spring flooding (NOAA, 2003). Similar to beaches, wetlands can be used to dissipate wave energy. The USACE has implemented wetlands or "living shorelines" for coastal storm risk management (NACCS, 2015).

In addition, many recreational activities take place in and around wetlands, which are important to the social and cultural character of many Mid-Atlantic communities. Hunting and fishing are popular activities associated with wetlands and other recreational activities in wetlands include hiking, nature observation and photography, canoeing, and boating. Properties bordering wetlands often have higher values than those that do not (NOAA, 2003). Nearshore habitats such as wetlands and estuaries intercept runoff and store storm water, which slows down rapid and high peak flows to reduce flooding impacts to surrounding communities. Additionally, by dissipating wave energy and stabilizing shorelines, wetland vegetation buffers the adjacent upland from wave action and intensive erosion (NOAA, 2003).

In addition, near shore habitats are important ecologically as essential habitat for waterfowl species and aquatic species. Some have referred to estuaries as the "nurseries of the sea" (EPA, 2012). Many marine organisms, including most commercially important species of fish, depend on estuaries at some point during their development. Eighty percent of the domestic breeding bird population and more than 50 percent of the 800 species of protected migratory birds rely on wetlands and estuaries (NOAA, 2003). Therefore, connectivity between different habitats in near shore areas must also be maintained to support different developmental stages of species and allow for natural migration patterns.

The federal government protects wetlands and estuaries through the Clean Water Act. The EPA established The National Estuary Program (NEP) under Section 320 of the 1987 Clean Water Act (EPA, 2014), which protects and restores the water quality and ecological integrity of estuaries of national significance. Each NEP develops and implements a Comprehensive Conservation and Management Plan, a long-term plan that contains specific targeted actions designed to address water quality, habitat, and living resource challenges in its estuarine watershed (EPA, 2014). The Mid-Atlantic States each have regulatory and non-regulatory programs of varying jurisdictions that help to protect and enhance both freshwater and tidal wetlands.

There are currently 28 estuaries located along the Atlantic, Gulf, and Pacific coasts and in Puerto Rico designated as estuaries of national significance. In the Mid-Atlantic, there is the Long Island Sound Study (NY), New York-New Jersey Harbor Estuary Program (NY/NJ), Barnegat Bay Partnership (NJ), Delaware Center for the Inland Bays (DE), Partnership for the Delaware Estuary (DE), Maryland Coastal Bays Program (MD/VA), Chesapeake Bay Program (MD/VA) and the Albemarle-Pamlico National Estuary Program (VA). Along with these programs, the US Fish and Wildlife Service maintains a National Wetlands Inventory, which divides the US into eight regions. Each region inventories threatened and endangered species habitat and important sites for bird nesting and feeding areas, shoreline types, and historic sites and national monuments, among others to assess resource exposure (NACCS, 2015). Figure 4 below outlines the geographic extent of nearshore habitat.

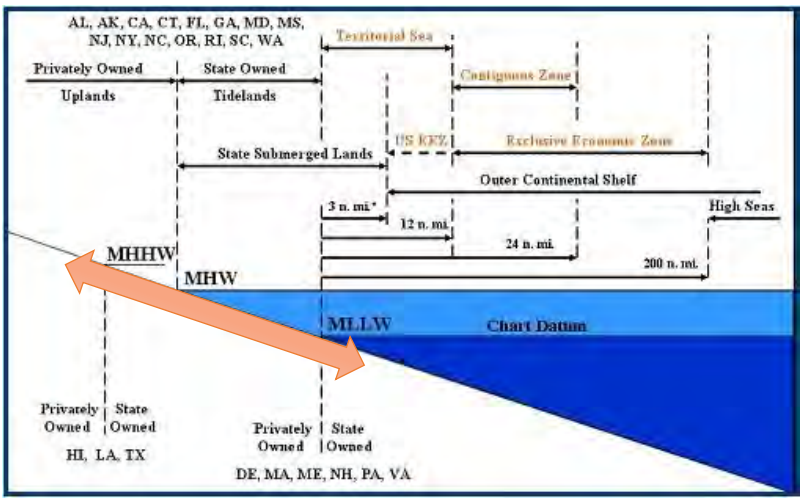


Figure 4: Geographical representation for near shore habitats as defined in this report

Stressors

The climate change stressors that affect near shore habitats are sea level rise, changes in precipitation, increased temperature, extreme events, and ocean acidification. Many coastal wetlands in the United States are in decline, and threatened by increasing coastal development and sea level rise (NOAA, 2014; CCSP, 2009). Protective measures and shoreline hardening, while protecting physical infrastructure, can harm habitat quality and species in near shore areas by enhancing erosion and other damaging impacts (Gittman et al., 2015). Due to sea level rise, increases in flooded wetlands are highly likely (EPA, 2013). Decreases in precipitation may affect the salinity of coastal waters particularly affecting estuaries. Intense storms negatively affect wetlands from erosion, stripped vegetation, and salinity burn, all of which can decrease long-term productivity (NACCS, 2015). In addition, droughts reduce fresh water input into tidal rivers and bays, which raises salinity in estuaries, and enables salt water to mix farther upstream (CCSP, 2009). As temperatures increase, headwater streams will be increasingly dry. Species that are susceptible to higher temperatures or lower dissolved oxygen levels will lose viable habitat (EPA, 2013).

Impacts

Since near shore habitats do not have political boundaries, this asset has many transboundary impacts. Sea level rise will result in retreating of shorelines and flooded wetlands (EPA, 2013). Economically, to the extent that estuaries and other near shore habitats provide habitat for commercially harvestable species or recreation opportunities, there may be transboundary effects related to loss of such revenues. Natural features, such as coastal wetlands provide environmental and social benefits and can contribute to coastal storm risk management or resilience (NACCS, 2015). Natural infrastructure assets such as living shorelines, artificial reefs, submerged aquatic vegetation and wetlands can generate costly repair obligations for state and local governments. For example, the cost of creating an artificial reef is approximately $4,800 per square foot and wetlands cost about $565,000/acre for the first construction cost (NACCS, 2015). However, structural measures aimed at reducing erosion and stabilizing uplands can also have negative impacts and impose costly repair and maintenance obligations on state and local governments wishing to protect nearshore habitats.

Ecologically, estuaries and wetland habitats provide important ecological roles for habitat migration. Since wetlands cross multiple states, this fragile resource offers habitat for a variety of species that are already seeing decline from climate change stresses. In addition, decreases in precipitation could also affect the salinity of coastal waters. Droughts reduce fresh water input into tidal rivers and bays, which raises salinity in estuaries, and enables salt water to mix farther upstream (CCSP, 2009). In addition, this asset serves many social and cultural functions within the Mid-Atlantic.

Tourism and other cultural activities take place in and near these areas. Wetlands provide critical protection from hurricanes and flooding, and recreational opportunities, as well as removing pollutants from water systems and recharging groundwater supplies.

Scientists expect annual precipitation for coastal regions in New York State to increase from zero to 5 percent by the 2020s (NYSERDA, 2011). This increased precipitation and sea level rise is already affecting tidal marshes and coastal ecosystems in the area. New York and New Jersey share oyster reefs and many habitats for fish, crabs, and lobsters. Impacts in New York will have clear transboundary impacts particularly in New York and New Jersey but not necessarily including the other MARCO states. Headwater streams will also be increasingly dry during summer months as drought conditions occur more often and evapotranspiration increases. This will have an effect on estuarine ecosystems because species that are susceptible to higher temperatures or lower dissolved oxygen levels, such as freshwater trout fisheries in New Jersey, they will lose viable habitat (EPA, 2013) which will also impact New York's near shore resources.

In Delaware, freshwater tidal wetlands occur at the upper reaches of estuaries and are home to unique plant and animal communities. Sea level rise could affect between 84 percent and 98 percent of the total freshwater tidal wetland acreage statewide by the year 2100, replacing freshwater tidal marshes with brackish marshes or open water and causing major shifts in species composition (Love, Arndt & Ellwood, 2013). Because of the unique habitats contained within freshwater tidal wetlands and because the majority of the resource within the state could be affected, this resource was ranked as a high concern in Delaware (Love, Arndt & Ellwood, 2013). The Delaware Bay lies between estuaries in New Jersey and Maryland.

Summary Table 8: Climate Change Stressors and Impacts on Near Shore Habitats (Estuaries)

Stressors	• Sea level rise • Changes in precipitation • Increased temperatures • Extreme events • Ocean acidification				
State Impacts	• Negative impacts in tidal marshes	• Habitat loss • Changes in habitat suitability for certain species	• Freshwater tidal wetland habitats will be impacted which will change ecosystem dynamics	• Tidal marshes will begin to disappear	• Wetlands will be harmed by salt water intrusion

Source: Literature Review, see Bibliography

Climate change impacts such as rising temperatures, shifting precipitation regimes, and sea level rise will likely result in many tidal marshes disappearing. In Maryland, scientists project that subsiding land in the Chesapeake Bay area will worsen the effects of relative sea level rise and increase the risk of flooding tidal wetlands (Nicholls et al, 2007). Coastal wetlands are critical habitat for many of the Chesapeake Bay's plants and animals, however, they are being lost as sea levels rise, and saltwater intrusion threatens freshwater coastal wetlands (Bryant, 2008).

Offshore Habitat

Offshore waters extend from about ten miles beyond the coast to the edge of the continental shelf (NOAA, 2013). Depths vary from 50 feet to well over 600 feet, providing habitat for free-swimming and well as bottom- dwelling organisms. Offshore waters maintain a constant temperature and salinity with little turbidity (NOAA, 2013). The warm surface water and abundant sunlight allow production of algae and other phytoplankton. Larger predatory animals, including dolphins and whales as well as many fishes feed on smaller organisms. Species that spend much of the spring and summer in inshore waters as well as juveniles that have matured in estuaries move to deeper, and often warmer, more stable offshore waters during the late fall and winter, making this habitat vital to many organisms.

The offshore assets that the CCAT has decided to focus on include coral habitat and deep ocean habitats. Another focus is ocean acidification issues. Ocean acidification refers to a reduction in the pH of the ocean over an extended period, caused primarily by uptake of carbon dioxide from the atmosphere. Deep ocean corals and habitats are important because they provide habitat for a diverse array of species, including commercially important ones (Hourigan & Cope, 2008; NOAA, 2014). Figure 5 outlines the geographic location for where this resource is located. This shows that no land is included in this resources but from offshore to the deep ocean habitats.

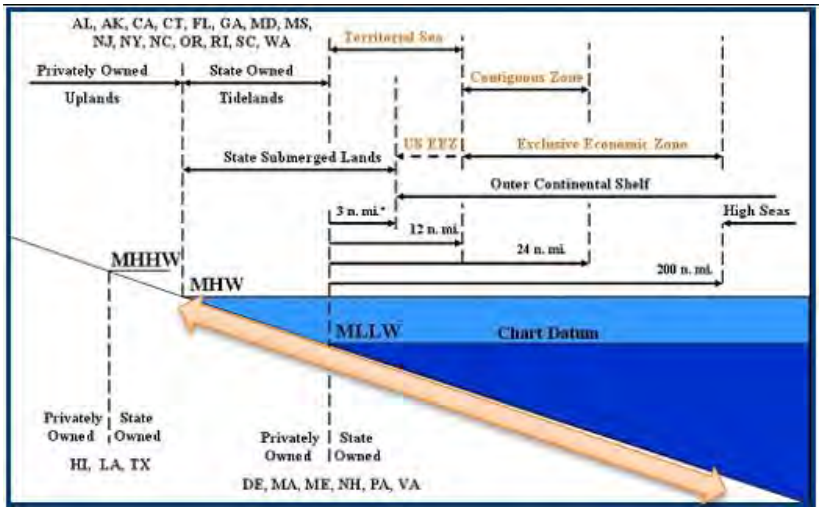


Figure 5: Geographical representation for deep ocean habitat as defined in this report

Stressors

Extreme events such as hurricanes and storm surges can cause massive, though usually temporary, disruptions in the life cycles of ocean plants and animals (NOAA, 2013). In addition, as temperatures increase the ocean absorbs the extra heat, which can negatively affect species with temperature sensitivity such as corals. In addition, high levels of atmospheric carbon dioxide, caused mainly by the burning of fossil fuels, are absorbed by the oceans, where the gas dissolves into carbonic acid. This leads to ocean acidification.

Impacts

Regionally, aquatic habitats provide an important ecological function for habitat migration. However, local habitats will likely see impacts sooner. For the Atlantic Ocean, climate change will have a varying impacts ranging from temperature impacts on cold-water species to the loss of tidal marshes unable to keep pace with sea level rise.

As ocean temperatures rise due to increased global temperatures, this can cause excess melting of ice caps and glaciers, which will raise sea levels and flood estuaries. In addition, small temperature changes can have far-reaching effects on the life cycles of marine animals from corals to whales. For example, deep-sea organisms are largely reliant for food on plankton sinking from surface waters. Increases in the annual flux of detrital food reaching the deep-sea bed can trigger population explosions of some benthic invertebrate species (Hughes & Narayanaswamy, 2013).

Table 9: Climate Change Stressors and Impacts on Offshore Habitat

Stressors	• Temperature • Extreme events • Ocean acidification	
State Impacts	• Food web dynamics will likely be impacted as rising temperatures may destroy some species (coral) and increase the rates in others (plankton)	• Coral and habitats

Source: Literature Review, see Bibliography

Elevated ocean acidity inhibits the ability of marine animals, including many plankton organisms, to create shells, disrupting life within the ocean's food web from carbonate-based phytoplankton up to higher trophic levels. (Kleypas et al., 2006). Ocean acidification poses a major long-term threat to deep-sea corals and other calcifying organisms. However, there is very little data on this to base predictions of future impacts. (Hughes & Narayanaswamy, 2013).

Marine Terminals (and supporting built infrastructure)

Marine terminals are defined as the actual port facility and the infrastructure that supports this infrastructure because ports are highly dependent on other sources of infrastructure. Dependent infrastructures include regional transportation networks (i.e. road, rail, etc.) that are also vulnerable to impacts from climate change as a result of serving the freight and passenger terminals.

Marine terminals are important economically, ecologically and culturally to the Mid-Atlantic States. Economically, marine terminals bring millions of dollars to the states each year.

For example, the value of imports going through US ports in 2011 was valued at $1.16 trillion (US Census, 2012). Regionally, limited access to marine terminals from changes in channel infrastructure can make goods more expensive or limited. Locally, the states will have to take on the cost of adjusting port facilities to adapt to the changing climate. There are no real ecological impacts here due to the focus on built infrastructure. However, socially and culturally, some of the MARCO states see their maritime history as an important cultural resource to the area which needs to be protected. In addition, marine terminals regionally affect jobs and locally affect residents that live directly near the ports. For example, 13 million Americans have jobs that rely on commercial ports (AAPA, 2009). Figure 6 outlines the geographic location for where this resource is located. This represents only the small amount of land that the marine terminal sits on and near shore but not the deep ocean.

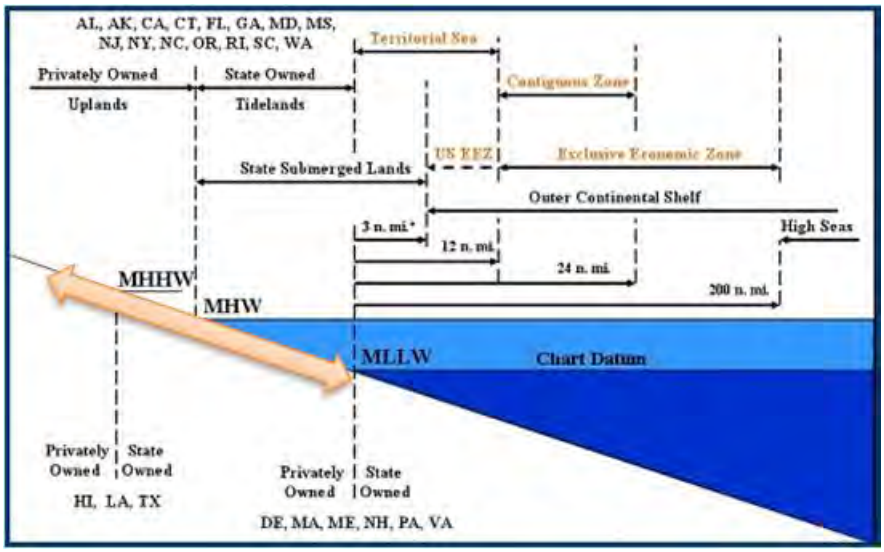


Figure 6: Geographical representation for marine terminals as defined in this report

Stressors

The climate change stressors that affect marine terminals and supporting infrastructure are sea level rise, changes in precipitation and extreme events. Climate-related hazards, including sea level rise and coastal flooding, and intense precipitation events will increasingly compromise port infrastructure. Changes in precipitation will also negatively affect marine terminals. In areas experiencing increasing drought, water levels could periodically decrease, limiting inland shipping on rivers (NRC, 2008; USGCRP, 2009). However, areas where rainfall increases may allow ports to accommodate larger ships but lower clearance under bridges coming into the terminal. In addition, extreme events can damage equipment leading to significant disruptions and damage (NRC, 2008; USGCRP, 2009).

Impacts

Since ports bring large amounts of goods and provide jobs for many people across the US, the economic climate change impacts will be great. Similar to other coastal infrastructure, owners may need to raise harbor facilities, including docks and bridges to accommodate higher tides and storm surges, as sea levels rise (NRC, 2008; USGCRP, 2009). Ecological impacts from ballast water, sediment movement and other marine dynamics will also affect near shore areas. Social

and cultural impacts will come from disruptions to services provided by public and private infrastructure in the Northeast will likely interrupt commerce and threaten public health and safety.

The Port of New York and New Jersey is the largest port on the east coast, moving over 33.3 million metric tons of general cargo and 48.2 million metric tons of bulk cargo in 2011 (PANYNJ, 2012). According to the NYSERDA document, sea level rise may affect pier heights, base elevation of loading cranes, power supply substations, access roads and rail tracks, open air storage (for containers or automobiles), and warehouse facilities located at low elevations along all shores subject to tides. In particular, the frequency of the 1-in-10-year coastal flood may triple over the next century, depending on the rate of sea level rise. In addition, this area is particularly vulnerable to damage from many invasive species from ballast water. According to the New Jersey Global Warming Response Act Recommendations Report (2009), the Port Authority recognizes the threat of climate change to the region. To deal with this threat, the Port Authority is implementing a comprehensive sustainability policy that calls for mitigation, carbon neutrality, and the development of adaptive strategies. Specifically, the Port Authority is committed to reducing GHG emissions from its facility activities by 80 percent from 2006 levels by 2050. Since New Jersey and New York share a port, the transboundary impacts affect both of these states but also many other states that rely on goods that come into this port.

Between 36 percent and 73 percent of the Port of Wilmington's property is within an area that sea level rise could inundate by 2100. The port has regional economic implications for the Mid-Atlantic and beyond, as one of the largest fresh produce import locations in the country, and is a high concern asset for Delaware (Love, Arndt, Ellwood; 2013). Port facilities in Maryland (primarily Baltimore) are also vulnerable to increased flooding, with 298 acres or 32 percent of the overall port facilities in the state impacted by 2100. These impacts have potentially significant economic ramifications. For example, in 2006 alone the Port of Baltimore generated more than 50,200 jobs, $3.6 billion in personal income, $1.9 billion in business revenues, and $388 million in state, county, and municipal tax (DOT, 2008). Changes in runoff may also affect coastal transportation and shipping due to the specific depth required to maintain Maryland's ports and coastal shipping channels (Dominici et al, 2006).

According to Virginia state climate change action plan (2008), climate changes such as sea level rise pose serious and growing threats to Virginia's roads, railways, ports, utility systems, and other critical infrastructure. According to an economic impact study conducted by the Mason School of Business at the College of William & Mary, 343,000 Virginia jobs – nearly ten percent of the state's resident workforce – are linked to port activity across our six terminals. Those jobs generate $13.5 billion in annual compensation and $1.2 billion in state and local taxes (POV, 2014). For the Port of Virginia, 34 percent of cargo arrives and departs the port by rail, the largest percentage of any U.S. East Coast port (POV, 2014). Impacts to this port will affect many other states that rely on the Port of Virginia for goods and other products.

Table 10: Climate Change Stressors and Impacts on Marine Terminals (and supporting infrastructure)

Stressors	• Sea level rise • Changes in precipitation • Extreme events
State Impacts	• Damage to • Ecological • Economic • Ports and

	infrastructure which will need to be raised or moved to accommodate the rising seas	impacts from ballast water and sediment movement	impacts from the damage to marine terminals	channels may be able to house larger ships

Source: Literature Review, see Bibliography

8. Agency Authorities for Priority Assets and Climate Adaptation Planning

Many of the efforts undertaken in the region are because of grant activities or other single instance measures. This section provides an overarching description of the authorities of the key agencies that will be needed to adapt priority resources over the long term.

New York

- The NY Dept. of Environmental Conservation (NYDEC) is the primary agency charged with administering state laws to protect and enhance the environment. NYDEC regulates water quality, fisheries, and development affecting coasts and wetlands. NYDEC also has authority to protect and preserve lands with ecological significance.
- NY Department of State (NY-DOS) administers New York's coastal management program (the Waterfront Revitalization and Coastal Resources Act) in conjunction with local governments; facilitates local government planning; and has authority to review federal decisions for consistency with the state's coastal management program.
- NY Department of Transportation (NYDOT) develops and operates transportation facilities and systems for the state's highways, railroads, ports, waterways, aviation facilities, mass transit systems, and public transit systems. NYDOT maintains a state-wide master plan for the development of public transportation, commuter resources, and general transportation facilities.[9] NYDOT also develops and operates transportation facilities and systems for the state's waterways, including canals, cruise terminals, ferries, and shipping ports.[10]
- The Metropolitan Transportation Authority operates much of the public transportation system in the New York area, including the Long Island Railway; the Metro North Railroad; the Triborough, Whitestone, Throgs Neck, Verrazano Narrows and Henry Hudson bridges; the Hugh Carey Brooklyn-Battery Tunnel and the Queens-Midtown Tunnel.
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New Jersey

- The New Jersey Department of Environmental Protection (NJDEP) is charged with developing policies for the conservation of the state's natural resources, the promotion of environmental protection, the prevention of pollution, and programs to promote ecosystem-based management.[11]
- The New Jersey Department of Transportation (NJDOT) plans, designs, maintains, and operates the state's freight, air, water, and surface transportation systems and infrastructure.[12] It

[9] McKinney's Transportation Law § 14. https://www.dot.ny.gov/index

[10] McKinney's Transportation Law § 14. https://www.dot.ny.gov/index

[11] N.J.S.A. 13:1D-9. Ecosystem-based management is defined as "an integrated approach to management that integrates biological, social, and economic factors into a comprehensive strategy aimed at protecting, restoring and enhancing the sustainability, diversity and productivity of ecosystems." N.J.S.A. 13:19-35.

[12] N.J.S.A. 27:1B-6. http://www.nj.gov/transportation/

maintains the container-handling network for freight, including ports and docks in marine terminals such as the Port of Newark.[13]

Delaware

- The Delaware Department of Natural Resources and Environmental Control (DNREC) is charged with managing the state's natural resources, including fish and wildlife. DNREC administers the state's coastal management program, and has authority to acquire and develop recreational lands.
- The Delaware Department of Transportation (DelDOT) has the power to construct and maintain transportation facilities, designate locations for highways, accept gifts or grants of funds or property, grant easements, and more; this includes the Port of Wilmington deepwater port and marine terminal.[14]

Maryland

- The Maryland Department of the Environment (MDE) implements programs for land redevelopment, drinking water protection, fish safety, and general environmental protection.[15] MDE also administers stormwater management, wetland protection, and erosion and sediment control programs.[16]
- The Maryland Department of Natural Resources (MD-DNR) is charged with reviewing, coordinating, and promulgating policies for the conservation and development of the state's natural resources.[17] MD-DNR manages state parks and may purchase and manage lands suitable for conservation (i.e. watershed protection, State parks, and scenic preserves).[18] MD-DNR issues fishing licenses and defines boundaries for state fisheries and administers the state's coastal management program.
- The Maryland Department of Transportation (MDOT) is responsible for integrated transportation planning activities for the state. MDOT's Port Administration is responsible for the development, maintenance and administration of the state's ports. This includes the Port of Baltimore's public marine terminals.[19] MDOT also is charged with administering the state's Sustainable Communities initiative.[20]
- Maryland Department of Planning (MDP) helps counties and cities incorporate sustainability and smart growth into land use and resource planning. MDP is an advisory and coordinating agency that is charged with developing an integrated program for the effective use of the natural and other resources of the state and is charged with preparing the State Development Plan with recommendations for directing state major public works (flood control, water reservoirs, and pollution control facilities).[21] MDP staffs the Maryland Sustainable Growth Commission that makes recommendations on how to align the state's planning and investments with the state's economic growth, resource protection and planning policies.

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13 N.J.S.A. 27:1B-6. http://www.nj.gov/transportation/
14 2 Del.C. § 1309; http://www.deldot.gov/index.shtml
15 http://www.mde.state.md.us/Pages/Home.aspx
16 http://www.mde.state.md.us/PROGRAMS/WATER/Pages/index.aspx
17 Md. Code Ann., Nat. Res. § 1-101.
18 Md. Code, Natural Resources, § 5-207.
19 Md. Code, Transportation, § 2-103.
20 Md. Code, Transportation, § 6-103; MD Code, Transportation, § 6-702.
21 Md. Code, State Finance and Procurement, §§ 5-303, 5-602, 5-613.

Virginia

- Virginia Department of Environmental Quality (VDEQ) implements programs to protect Virginia water resources. VDEQ administers and oversees the state's coastal management program, environmental impact reviews, remediation of contaminated lands, pollution prevention activities, and stormwater and wastewater management.[22]
- The Virginia Department of Conservation and Recreation (VA-DCR) manages state parks and conservation lands, and implements the states non-point source pollution management program. VA-DCR is charged with developing a flood-protection plan for the Commonwealth identifying flood-prone areas and developing strategies to mitigate flood damage.[23] VA-DCR is also charged with coordinating shore erosion control programs of all state agencies and implementing solutions for shoreline erosion.[24]
- The Virginia Marine Resources Commission (VMRC) has jurisdiction over the Commonwealth's territorial seas inland to the fall line of tidal rivers and streams. VMRC has jurisdiction over commercial fishing and all marine fish, shellfish, marine organisms, and habitat; and can develop fisheries management plans. VMRC administers the states Wetlands Act and Coastal Primary Sand Dune Protection Act; it has authority to regulate structures and improvements built or proposed by riparian property owners, develop guidelines for coastal management, and issue permits for living shorelines or development activities that could affect sand dune systems.
- The Virginia Department of Game and Inland Fisheries (VDGIF) manages wildlife and inland fish populations, and enforces the laws pertaining to hunting and fishing licenses.[25]
- The Virginia Port Authority (VPA) develops policies pertaining to the acquisition of goods in ports, has police powers, and can acquire property for the operation of port facilities.[26]

Regional

- The Atlantic States Marine Fisheries Commission (ASMFC) was established by interstate compact to manage the shared fisheries resources of the Atlantic states (from Maine to Florida). ASMFC develops fisheries management plans and designates essential fish habitat (EFH) for Atlantic fisheries pursuant to the Magnuson-Stevens Fishery Conservation and Management Act.[27]
- The Chesapeake Bay Program (CBP) is a regional partnership to lead bay restoration and protection between PA, DC, VA and MD) was formed in 1983 pursuant to the Chesapeake Bay Agreement with the goal of reducing pollution and restoring the Chesapeake Bay. In 2014, a specific goal for Climate Resiliency was included in the Bay Agreement.
- The Port Authority of New York and New Jersey (PANYNJ) is a bi-state agency that builds, operates, and maintains infrastructure critical to the New York/New Jersey region's trade and transportation network. These facilities include airport systems, marine terminals and ports, the rail transit systems and six tunnels and bridges between New York and New Jersey. PANYNJ was created by an interstate compact between the states of NY and NJ to collectively manage, maintain and operate marine terminal and transportation facilities within the port districts created by the compact agreement. The port district centers on NY Harbor and includes 1,500 square miles between NY and NJ including the Port of New York, Port Newark, and Elizabeth-Port Authority Marine Terminal. PANYNJ has developed several tools to green and increase the

[22] http://www.deq.virginia.gov/
[23] Va. Code Ann. § 10.1-602
[24] Va. Code Ann. § 10.1-701
[25] http://www.dgif.virginia.gov/
[26] Va. Code Ann. § 62.1-132.11, § 62.1-132.1, § 62.1-132.18.
[27] 16 U.S.C. §§ 1801-1883.

sustainability of their projects and facilities. The Port Authority of New York and New Jersey operates the main harbor facilities in the region as well as the Holland and Lincoln Tunnels to New Jersey; the George Washington Bridge to New Jersey; Kennedy, LaGuardia, Newark, Teterboro, Stewart and Atlantic City airports; and other transportation assets.

- The Delaware River and Bay Authority (DRBA) was created by interstate compact between the states of NJ and DE with the purpose of financing, developing, constructing, operating and maintaining transportation and marine terminal facilities. DRBA operates the Delaware Memorial Bridge, the Cape May-Lewes Ferry, and the Delaware City-Salem Ferry.

Federal

- The Bureau of Ocean Energy Management (BOEM) within the Department of the Interior coveys the right to sand in the Outer Continental Shelf for beach nourishment projects and also regulates the leasing of Outer Continental Shelf lands for offshore wind development and oil and gas exploration and production.
- The US Army Corps of Engineers (Corps) has regulatory authority over land-disturbing activities and activities that could obstruct navigation in navigable waters pursuant to Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act. The Corps also undertakes beach nourishment and other civil works projects to reduce flood risks pursuant to Water Resources Development Acts (WRDA).
- The Corps has ecosystem restoration authorities under section 206 (aquatic restoration), section 1135 (project modifications), and section 204 (beneficial reuse) WRDA, among other restoration authorities. The Corps must consult with the US Fish and Wildlife Service for potential impacts to protected endangered species or marine mammals, and with the National Marine Fisheries Service for potential impacts to fishery resources under Magnuson-Stevens, the Endangered Species Act and the Marine Mammals Protection Act.
- The National Oceanic and Atmospheric Administration (NOAA), within the Department of Commerce, is charged with protecting, managing, restoring and enhancing the nation's coastal and ocean resources and ecosystems. NOAA works with states to encourage management of coastal resources and development through the Coastal Zone Management Program. NOAA provides technical assistance to states and localities through the Office for Coastal Management. NOAA also provides the data and information states and localities need to understand climate change, weather, and ocean health; it implements the Integrated Ocean Observing System (IOOS) to monitors ocean water quality, meteorology, temperatures, and other data using buoys, tidal stations and satellite measurements.[28] NOAA manages the National Marine Sanctuaries, a network of 13 sanctuaries designated for preservation because of the ecological and cultural values.[29] NOAA also works to protect coral reef systems through its Coral Reef Conservation Program.[30]
- The US Environmental Protection Agency (EPA) administers the water quality provisions of the Clean Water Act and provides funding through the State Revolving Loan funds to help states and utilities upgrade wastewater treatment facilities and reduce runoff of polluted stormwater.[31] EPA also supports the National Estuaries Programs, which was created by the Clean Water Act to protect and restore the water and ecological quality of estuaries of national significance. NEPs are managed pursuant to Comprehensive Conservation and Management Plans (CCMPs), which

[28] http://www.ioos.noaa.gov/
[29] http://sanctuaries.noaa.gov/welcome.html
[30] http://coralreef.noaa.gov/
[31] http://www2.epa.gov/science-and-technology/water-science

are required to define plans to improve water quality and habitat in estuaries.[32] EPA administers the Climate Ready Estuaries (CRE) program to help estuaries assess climate change impacts and develop adaptive responses.[33]The MARCO states have several NEPs including, Barnegat Bay, Buzzards Bay, the Delaware Estuary, Long Island Sound, and the Maryland Coastal Bays, New York-New Jersey Harbor, and Peconic Bay.

The most common agency authorities related to priority assets across states in this study are those that exist under the departments of environmental quality and or protection. In addition, state departments of transportation work closely with environmental agencies to regulate and plan for maritime facilities of all sizes in coastal areas. In addition to state agencies, authorities exist in either quasi-public or bi-state efforts through bay commissions and port authorities in the region. In the case of bay commissions, authorities relate to water quality and habitat, whereas port authorities are concerned with capital investments and environmental impacts of facility operations. In some cases, there are executive directives that create multi-agency task forces to address climate change; however, their composition is not consistent across the states in the Mid-Atlantic region.

There are several levels of authorities and programs that MARCO may seek to work through in order to share or implement practices. These authorities, given the assets selected, primarily lie within coastal zone management and water quality governance. However, some governance methods are common, the approaches in each state, and the coordinating agencies for each state, can be vastly different. This suggests that developing a common understanding of responsibilities across states is feasible. In some cases, agencies can accomplish these objectives through coordinated approaches to federal programs and participation in grant processes.

9. Potential Regional Adaptation Approaches

Four (4) categories of potential actions were discussed among the CCAT meeting participants:

1. Common Understanding: Increase common understanding, including having states help each other to understand gaps in current knowledge
2. Inform Consistent State Policy: sharing best practices across the states
3. Advocating for Federal Policies
4. Regional Action: Opportunities for true regional action

Each of the strategies will generate specific outcomes that will lead toward integration with other strategic actions. Developing a common understanding of particular asset vulnerabilities or approaches to adaptation will result from conferences to gather groups working and researching climate change and adaptation strategies. Governing stakeholders should be involved in these processes in addition to non-profits, academic institutions, local residents, and other interested parties. Information sharing efforts should focus on both within state and between state efforts. After developing a common understanding of issues, CCAT will have established a baseline from which several different courses of action at the state, federal or regional levels will be possible.

Building upon the notion of common understanding and knowledge sharing, more intense involvement includes informing consistent state policy. States might work together to analyze and understand the different types of strategies (e.g. (1) reactive and anticipatory adaptation, (2) autonomous and planned adaptation, and (3) substitutes and complements)

[32] http://water.epa.gov/type/oceb/nep/index.cfm#tabs-2
[33] http://www2.epa.gov/cre

and connect these types of strategies with other environmental and economic policy issues (Fankhauser & Tol, 1999). Coordination of state policy issues could include using similar measures for climate projections, coordinating projects and investments to prevent negative effects in neighboring states, or other strategies.

At the federal level, programs like EPA's Climate Ready Estuaries program assesses climate change vulnerabilities in coastal areas and shares the lessons learned with other coastal managers (Camacho, 2011). Advocating for federal policies requires a level of common understanding, but does not necessarily require full coordination of activities on behalf of the states. Thus, state coordination is not always a necessary condition for federal advocacy. In such cases, working with an agency that has already implemented programs may reduce cost constraints and enhance the potential to implement strategies through pre-existing mechanisms.

Regional action will require the most amount of coordination and action. In an analysis of 40 climate change action plans, Tang et al (2010) illustrates that plans have a high level of 'awareness', moderate 'analysis capabilities' for climate change, and relatively limited 'action approaches' for climate change mitigation. The authors recommend that, since local jurisdictions may not yet feel climate change mitigation is their responsibility, state guidance provides the essential motivation for localities to undertake adaptation projects. In a similar way, regional action by MARCO constituents may provide motivation for states to act together. Examples of regional action include the Chesapeake Bay Agreement where the Governors of Maryland, Virginia and Pennsylvania, the Mayor of the District of Columbia, and the EPA Administrator committed their states and the District of Columbia to prepare plans for protecting and improving water quality and living resources in the Chesapeake Bay. Regional coalitions must demonstrate clear benefits to cooperation, and often govern issues that are definitively trans-boundary in nature (e.g. water quality).

There are several measures that the research team suggests will be able to be undertaken based on the review. These recommendations are examples based on projects that stakeholders have accomplished or are currently undertaking in the United States. However, the recommendations are illustrative of the types of projects that could be undertaken by the CCAT. The CCAT should review the suggestions and modify each as it sees fit. In addition, CCAT may wish to use this list to evaluate, rank and invest in projects using a method that they determine is fit for incorporating other considerations by the management board and stakeholders.

Common Understanding recommendations center on MARCO's role as a convener and forum for discussion and coordination among the Mid-Atlantic States. This function plays a critical role for setting the baseline understanding from which each of the states could determine the most fruitful and agreed upon way to investigate moving forward for action through federal, state or local measures. Coordination of state policies focus on opportunities for state coastal zone management organizations to adapt similar definitions or approaches to projects. This would ensure that projects conducted in one state would not harm the other and would allow the comparison of the projects throughout the region, in coordination with other regional wildlife asset data sets. Advocating for federal policy suggests that there may be cases where the states may see fit to come together and work with the federal government to offer recommendations for programmatic changes that would enable regional actions or coordinated

actions on behalf of the states. For example, if the states were able to agree upon certain definitions than federal agencies could potentially adopt those definitions in their programs. Accordingly, federal actions may be necessary to allow states to coordinate and collaborate on, for example, grant proposals. Advocating for true regional action requires the agreement of two or more states, a common baseline, and appropriate federal coordination. As such, this action is the most far off. Yet, the establishment of regional fisheries management, programs, bay coalitions and other marine governance structures offer an opportunity for stakeholders to extend their authorities in certain occasions.

The North Atlantic Landscape Conservation Cooperative and MARCO are collaborating to address shared priorities in the Mid-Atlantic region. More specifically, the collaboration seeks to synthesize information on the value and functions of beaches, marshes, and shorelines to make information more accessible and applicable for coastal decision makers. Figure 7 displays how the current 2015 NALCC grant opportunity would fit within the proposed planning framework for MARCO CCAT. Depending on the nature of the proposals, project outcomes will help CCAT to pursue initiatives related to informing state policy and implementation related to near shore habitat and/or beaches. Within the proposed planning framework, the subsequent projects would advance the nature of the CCAT work into other categories and demonstrate progression toward investigating regional initiatives, where possible.

Figure 7: Current NALCC Grant Objectives Projected in MARCO CCAT Strategic Planning Framework

Strategies/Assets	Beaches	Near Shore Habitat	Marine Terminals	Offshore Habitat
Common Understanding				
Inform state policy				
Advocate for federal policies				
Regional Action				

The following table outlines the four assets that coincided with MARCO's mission priorities list (beaches, near shore habitat, marine terminals, and offshore habitat) with the four levels of increasing climate change adaptation strategies (common understanding, inform consistent state policy, advocating for federal policies, and regional action). Recommendations were developed using the adaptation clearing house of the Georgetown climate center and literature review from the broader research team to find evidence of areas that have been addressed or are under investigation by other states.

Table 11: Example Recommendations for Adaptation Efforts and Initiatives Conforming to the Adaptation Strategy Framework by Asset Area

Strategic Area	Beaches	Near Shore Habitat	Marine Terminals	Offshore Habitat

Common Understanding
 	
Host conferences or provide other forums (e.g. webinars, blogs, web-based catalogues, etc.) for sharing best practices
	• Management of beaches and dune systems, and regulating upland development to ensure that coastal development does not harm the beach or dune system.
	• Assess public access to beaches. The New York–New Jersey Harbor & Estuary Program will expand a vulnerability assessment protocol piloted by N.J. Sea Grant and others to identify public access points that are vulnerable to climate change impacts
		• Incorporation of nature-based and living shoreline approaches into state and federal projects, including leading practices for project funding and engineering training. For implemented projects, understand how agencies intend to monitor the efficacy of these approaches over time.
		• Account for future sea-level rise in coastal land use and state capital investment decisions.
		• Regional coastal resilience framework to help local governments manage development and reduce impacts on estuaries and coasts.
		• Modifications to acquisition guidelines to account for future changes in sea level and to ensure that states are conserving a diversity of coastal ecosystems.
		• Combine funding to develop sea-level rise and wetlands maps for the region that could inform implementation of the Federal Flood Risk Management Standard.
			• Port authorities to share the lessons learned through FHWA pilot projects and their own resilience and adaptation efforts.
			• Review recommendations from the Transportation Research Board (TRB) to develop a decision making framework for transportation providers based on assessments of hazards, assets, and consequences.
				• Discuss a baseline of understanding related to changes in ocean chemistry and the resulting effects on marine life, people, and the local, regional, and national economies. Partners could include:
				  • NOAA OA program
				  • National Science Foundation OA program
				  • Woods Hole Oceanographic Institution

Strategic Area	Beaches	Near Shore Habitat	Marine Terminals	Offshore Habitat
Inform state policy **Review state policies for areas of consistency and identify the observed or perceived effects of any inconsistencies from the regional perspective related to adaptation impacts.**	• Policies on sediment management and beneficial reuse of dredge materials • Setback requirements, dune management requirements, and state armoring policies to identify any potential effects discrepancies could have on neighboring states, embayments, estuaries, species, or sedimentation processes. • Beach restoration and maintenance provisions • Rolling easement provisions (currently used in Maine, Texas, South Carolina, and Rhode Island)	• Management of development and protection of barrier islands. • Use of nonstructural or "hybrid" approaches to shoreline stabilization, including preservation of wetlands and natural shoreline features • Collaborative development of consistent design guidelines for living shoreline and coastal restoration projects, especially where habitat and natural features cross state boundaries (e.g. preserved lands) • Guidance for incorporating climate change considerations into state Wildlife Action Plans, and reconciling management of species, particularly for migratory species of regional significance.	• Review consistency of sustainability and resilience policies implemented by regional port authorities • Collaborate to encourage adaptation planning for state port facilities.	• Review consistency of fisheries management plans and USACE permitting to ensure preservation of offshore habitats in the face of climate change.

Strategic Area	Beaches	Near Shore Habitat	Marine Terminals	Offshore Habitat
Advocate for federal policies	• Work with EPA to understand opportunities for water quality monitoring and notification processes to assist in climate adaptation data gathering and monitoring. • Work with USACE to understand opportunities to enhance policies for the beneficial reuse of fill, and examine reforms to requirements for dredge material disposal.[34] • Build on state coastal management programs consistency reviews to evaluate federal activities	• Work with Climate Ready Estuaries to review assessments of climate change vulnerabilities in coastal areas, stakeholder engagement materials and program results. • Investigate development of regional permitting for living shoreline and wetland restoration projects with USACE • Work with federal agencies to investigate costs to implement living shoreline projects and the benefits of flood risk reduction and ecosystem services to inform federal benefit-cost analyses (e.g., Hazard Mitigation Grant Program funds) • States with shared estuaries could work with the National Estuary Program to investigate alternatives for a Special Area Management Plan (SAMPs) to develop adaptive management strategies. • Coordinate to inform the Federal Flood Risk Management Standard, reviewing to analyze if federal agencies are adhering to the focus on nature-based approaches	• Review USACE strategy for reusing dredge spoils, particularly because of current harbor deepening projects in support of larger vessels. • Work with USDOT or MARAD to fund pilot projects to support adaptation planning for port facilities and marine terminals, similar to the FHWA and FTA adaptation pilot projects • Convene agencies that supply key data to ports, including NOAA, FEMA, U.S. DOT and the USACE, to discuss how new or existing data products could incorporate climate change forecasts	• Work with the ASMFC to enhance fisheries management plans and designations of essential fish habitat consider the long-term effects of climate change on offshore habitats. • Investigate potential for OA data gathering policies under EPA Clean Water Act requirements for monitoring and regulating pH in coastal waters.

[34] U.S. Army Corps of Engineers, NORTH-ATLANTIC COAST COMPREHENSIVE STUDY, *Institutional and Other Barriers Report* at 15 (Jan. 2015), http://www.nad.usace.army.mil/Portals/40/docs/NACCS/NACCS%20IOB%20Report.pdf.

Strategic Area	Beaches	Near Shore Habitat	Marine Terminals	Offshore Habitat
Regional Action	• Investigate regional sediment management plans to study sediment transport in the region, and to manage dredge placement activities for the region's beaches, bays, and estuaries. • Study the economic benefits of regional beach assets and the economic consequence of coastal erosion from sea-level rise on state and local economies and tourism. MARCO could study the costs to maintain these beach and barrier island systems over time as sea levels rise.	• Collaborate with a consortium of regional estuary programs to share leading practices and encourage consistency for measures to protect and improve water quality and living resources in Mid-Atlantic estuaries. • Collectively investigate and define regional guidelines for nature-based approaches to responding to threats from sea-level rise.	• Review and partner with port authorities to develop regional guidelines for incorporating climate change for into port master plans and amendments • Coordinate to fund research analyzing the economic consequences to the states, the region, and the nation of potential climate change impacts on port facilities, marine terminals and supporting infrastructure for the MARCO states	• Collaborate with regional ocean observation organizations to gather, analyze, and disseminate ocean acidification information in an effort to better inform stakeholders of the issue and solicit critical data and information needed for future policy inputs and monitoring.

10. Conclusion

With assistance from the research team, MARCO CCAT analyzed a series of 25 group-defined asset types based on MARCO's mission priorities, geographic scope of governance, potential transboundary impacts, and potential implementation capabilities. The CCAT collectively identified the following focus areas to recommend to the Management Board (MB) as priorities for further MARCO initiatives:

1. Beaches, including public access, habitat, tourism, local economies, dunes, availability of appropriate resources for beach management and associated tradeoffs
2. Near shore habitat, including estuarine, tidal wetlands, SAV, and aquaculture
3. Offshore habitat, including deep water and coral habitat, and ocean habitat
4. Marine terminals, including supporting built infrastructure

In concert with the discussion of the regional asset priorities, the CCAT also discussed strategies MARCO could take to advance climate change adaptation among the five states related to each asset type. The CCAT agreed on four (4) viable categories of potential actions, based on the resources required and the level of coordination needed between each of the states:

- Increase common understanding, including having states help each other to understand gaps in current knowledge
- Inform consistent state policy by sharing best practices across the states
- Advocating for and influencing federal policies
- Opportunities for true regional action

The CCAT recommends that its efforts be focused on initiatives to develop and share information that can establish a common understanding of vulnerabilities and the successes and barriers related to implementing adaptation measures. MARCO can enable these efforts by hosting in-person and virtual forums or other types of information gathering and knowledge sharing initiatives. In addition, MARCO may examine existing regional data collection and modeling systems to identify opportunities to improve physical and biological modeling that can serve as a resource for understanding climate change effects and prioritizing management options. Based on common information and common understanding, MARCO can determine what additional information is needed to meet unaddressed regional needs for the priority focus areas, and to develop shared understanding of vulnerabilities and resources among the states. MARCO can the decide how to pursue shared priorities using policy coordination among states, federal advocacy, and/or regional body coordination to facilitate resilient asset adaptation. Whether or not those actions proceed in a continuum (i.e. from state advocacy to federal coordination to the formation of any regional initiative) and which adaptation opportunities are pursued can be determined based on the current stakeholder environment at that time.

The findings and recommendations herein are a first step in setting forth a framework to guide strategic investments in targeted assets that represent asset classes that are particularly important for maintaining the health of the regional ecology and economy of the Mid-Atlantic Ocean. Though the collective decision-making process has resulted in the CCAT recommendation to focus on the four asset types above, there is considerable overlap between the four suggested priority asset types and the other 21 asset types that are each vulnerable to climate change. There are systemic considerations for investigating adaptation and resilience of

each individual asset and the CCAT should view the current priorities flexibly to allow strategic opportunities that could encompass other assets. For example, marine terminals are dependent on the road, rail and utility infrastructure that support their operation. Thus, opportunities to study supporting infrastructure should be carefully considered, provided the main objective is to enhance the resilience of marine terminals as an outcome. The CCAT team should reassess their strategic direction on an annual basis, reviewing the projects completed with reference to the framework to determine further efforts and advance goals that move from understanding to action at the appropriate level of governance.

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