COASTAL HABITAT PROTECTION PLAN 2021

CHAPTER 3. CLIMATE CHANGE AND RESILIENCY

Climate change will affect all coastal habitats and species in North Carolina. On October 29, 2018 in the wake of Hurricane Florence, North Carolina's Governor Roy Cooper signed Executive Order 80 – N.C.'s Commitment to Address Climate Change and Transition to a Clean Energy Economy (EO80) directing all cabinet agencies to integrate climate adaptation and resiliency planning into their policies, programs, and operations. As part of this executive order, the Climate Change Interagency Council was created including members from all of the cabinet agencies. The Department of Environmental Quality (DEQ) was tasked to serve as the lead agency the with Department Secretary serving as Council chair.

Department of Environmental Quality staff from all divisions were active on the Council and associated working groups. These working groups, along with staff from the National Oceanic and Atmospheric Administration's (NOAA) National Centers for Environmental Information (NCEI), North Carolina State University's (NCSU) Institute for Climate Studies (NCICS), Duke University's Nicholas School of the Environment, and numerous other academics and stakeholders, developed a state-specific North Carolina Climate Science Report (NCCSR), assessed hazards and risks associated with climate change, and compiled a Natural Working Lands (NWL) Report. All of these efforts were incorporated into the North Carolina Risk Assessment and Resiliency Plan (NCRARP) with goals and recommendations to increase carbon sequestration and resiliency of coastal habitats and communities. The 2016 CHPP provided valuable information during this process and many of the goals and recommendations from the 2016 CHPP were aligned in the NCRARP and NWL report (NCDEQ 2016). Likewise, aspects of the NCCSR, NCRARP, and the NWL report will be integrated into this CHPP update wherever possible (citations – NCCSR unpub, NCRARP unpub., NWL unpub.).

The foundation for addressing climate change related issues is the North Carolina Climate Science Report, which is a scientific assessment of historical climate trends and potential future climate change specific to North Carolina under increased greenhouse gas concentrations. For the NCCSR, statements about future changes refer to projections through the end of this century, and the following definitions apply:

Virtually Certain = 99-100% probability of outcome
Very Likely = 90-100% probability of outcome
Likely = 66-100% probability of outcome

The scientific understanding of the climate system strongly supports the conclusion that large changes in North Carolina's climate, much larger than at any time in the state's history, are ***very likely*** by the end of this century under both the lower and higher greenhouse gas concentration scenarios.

North Carolina's annual average temperature has increased by about 1.0°F since 1895, somewhat less than the global average. The most recent 10 years (2009–2018), however, represent the warmest 10-year period on record in North Carolina, averaging about 0.6°F warmer than the warmest decade in the 20th century (1930–1939). Recently released data for 2019 indicate that 2019 was the warmest year on record for North Carolina. Although regional changes in temperature can vary from global changes, it is ***very likely*** that North Carolina temperatures will also increase substantially in all seasons. It is also ***very likely*** that the number of warm and very warm nights will increase, and the summer heat index values will increase due to increases in absolute humidity. Just as the number of hot and very hot days is ***likely***

to increase, the number of cold days will ***likely*** decrease. Along the northeastern coast of North Carolina sea level has risen about twice as fast as along the southeastern coast, averaging 1.8 inches per decade since 1978 at Duck, NC, and 0.9 inches per decade since 1935 at Wilmington, NC (Figure 3.1). It is ***virtually certain*** that sea level along the North Carolina coast will continue to rise due to expansion of ocean water from warming and melting of ice on land, such as the Greenland and Antarctic ice sheets (NCCSR unpub).

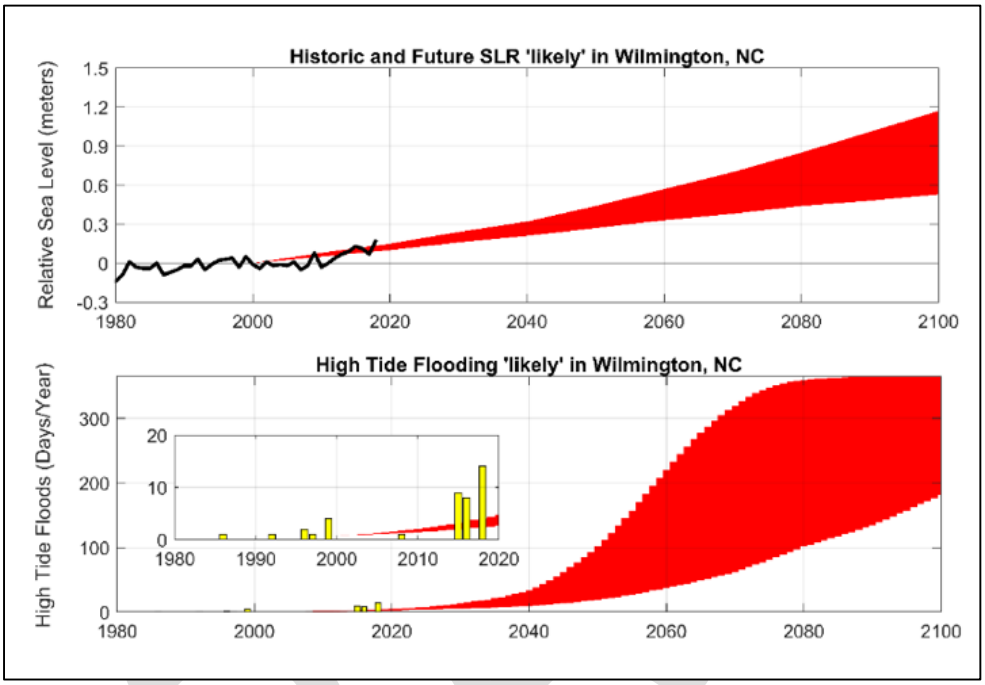

Figure 3.1. Historic and future relative sea level rise (SLR) and high tide flood events in Wilmington, NC from the North Carolina Climate Science Report (NCCSR). Likely = 66-100% probability of outcome. (NCCSR unpub)

In North Carolina, hurricanes have some of the most important impacts on the state, often catastrophic (storm surge, wind, and flooding damage), but sometimes beneficial (rainfall recharging soil moisture and groundwater aquifers). The intensity of the strongest hurricanes is ***likely*** to increase with warming temperature that could result in stronger hurricanes impacting North Carolina. Heavy precipitation accompanying hurricanes that pass near or over North Carolina is ***very likely*** to increase, which would in turn increase the potential for freshwater flooding. These events could have major ramifications on the hydrology, carbon and nutrient loads, and habitat and water quality in the state. However, there is low confidence concerning future changes in the number of hurricanes making landfall in North Carolina. Additionally, it is ***likely*** that the frequency of severe thunderstorms and the annual total precipitation in North Carolina will increase. It is ***very likely*** that extreme precipitation frequency and intensity in North Carolina will increase due to increases in atmospheric water vapor content. So, it is ***virtually certain*** that rising sea level and increasing intensity of coastal storms, especially hurricanes, will lead to increases in storm surge flooding in coastal North Carolina (NCCSR unpub).

The repeated impacts and compounding losses from the effects of climate change, such as stronger hurricanes, more severe storms, sea level rise, and associated flooding events can be catastrophic not only to the coastal communities, but to the coastal habitats and the ecosystem services they support. While we cannot completely eliminate the risk and hazards associated with climate change and natural disasters, we can begin to lessen their affects by increasing coastal resilience. Coastal resilience can be

broken down into two parts that are intertwined: 1) community resiliency – the ability of a community to withstand, respond to, and recover from a disruption, and 2) ecosystem resiliency – the ability of the natural environment to withstand, respond to, and recover from a disruption, such as hurricanes, tropical storms, and flooding. A resilient ecosystem is able to bounce back from distributions over time while resistant ecosystems may withstand a disturbance or two but over time the ecosystem function is lost and unable to recover (Figure 3.2).

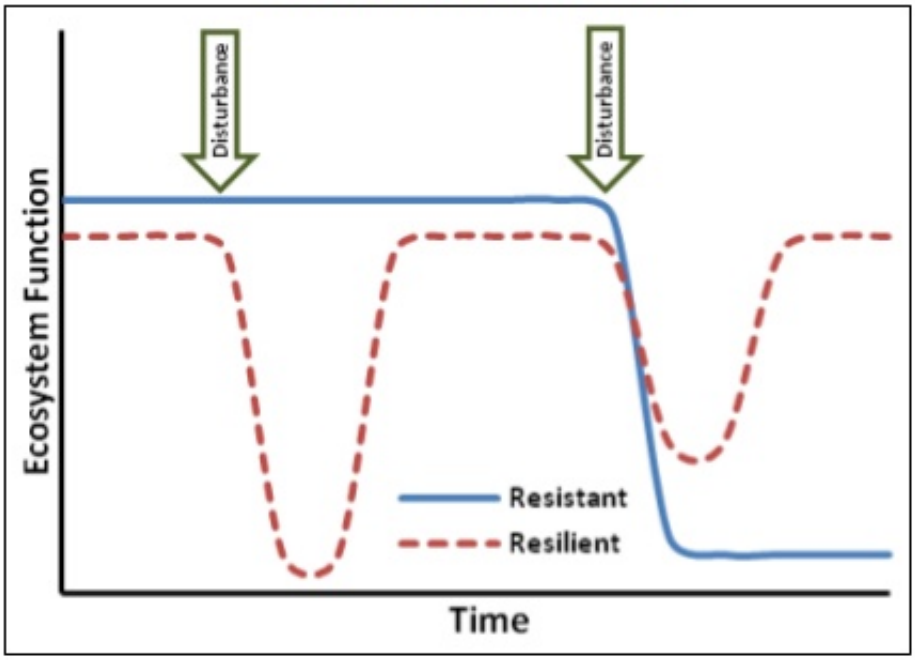

Figure 3.2. Illustration of the response of ecosystem function of resistant and resilient ecosystems after multiple disturbances.

Almost all of North Carolina's coastal habitats and the species that use them will be impacted by the effects of climate change, and actions should be taken to make them more resilient to these disturbances ensuring coastal habitats and their valuable ecosystem services continue to persist. Changes to environmental variables, such as increased water temperatures due to warmer air temperatures and salinity due to increased freshwater runoff or breached inlets from hurricanes, will impact the distribution, range, and abundance of coastal habitats and the finfish, invertebrates, and other species that use them for nursery, forage, and refuge. Impacts can be minimized and coastal resilience can be increased by conserving, protecting, and restoring coastal habitats that provide valuable ecosystem services and using natural and nature based infrastructure wherever possible.

Wetland loss due to sea level rise and continued coastal development will outpace the rate of wetland migration inland in many areas. Loss of wetlands will result in habitat losses that will impact the species that use them and degrade water quality due to the reduction in buffering capacity of nutrient rich stormwater runoff. The 2021 CHPP priority habitat issue, **Wetland Protection and Enhancement, with Focus on Nature-Based Methods,** will provide more information on shoreline erosion, wetland loss, and potential mitigating techniques to ensure wetlands have mechanisms for increased adaptive capacity and resiliency. Extreme precipitation events result in flooding which leads to high loads of organic matter and organic nitrogen and phosphorus, fueling phytoplankton production and resulting in algal blooms and associated hypoxia. Runoff from agricultural fields and urban development also add to the contamination of floodwaters into the watershed. These impacts to water quality could have major

detrimental effects on coastal habitats in North Carolina.

Submerged aquatic vegetation (SAV), also known as seagrass or underwater grass, is a critical coastal habitat for many important aquatic species, and is also highly responsive to degraded water quality including changes in salinity, water temperature, and water clarity, making SAV an ideal indicator species for water quality and climate change impacts. The expected changes to water conditions due to climate change are likely to result in varying distribution and reduced abundance of SAV. The impairment of water quality is one of the most widespread threats to SAV ecosystems, with global losses estimated at over 29% during the last century (Waycott et al. 2009). Along the Atlantic seaboard, SAV has already experienced significant declines directly or indirectly attributed to the stressors associated with degraded water quality. What distinguishes North Carolina from other coastal seagrass systems on the Atlantic seaboard is the overlapping distribution of temperate and tropical seagrasses in the higher salinity waters: eel grass (*Zostera marina*), a temperate grass at the southernmost extent of its range, and shoal grass (*Halodule wrightii*), a tropical grass at the northern most extent of its range. It has been suggested that under the current emissions scenario, it is very likely that eelgrass will be extirpated in North Carolina and the Chesapeake Bay with the new southern range as far north as Long Island Sound by 2100 (Wilson and Lotze 2019).

The effects of the climate-change-driven shift in distribution of SAV species will affect the aquatic organisms of the coast of North Carolina that use the SAV as nursery areas, refuge from predation, and foraging for food. It has also been indicated that there is a potential for increased Harmful Algal Bloom (HAB) occurrence due to increased nutrient loading in the water and increasing water temperature attributed to changing climate (Paerl 2019). In addition to causing detrimental impacts to water quality, fish, and habitats, particularly submerged aquatic vegetation (SAV) and shell bottom, HABs are unsightly, malodorous, and potentially hazardous to humans and pets if exposed to contaminated waters or consumed shellfish that have taken up the algae toxins. The 2021 CHPP priority habitat issue, **Protecting SAV with a Focus on Water Quality**, will go into further details about the issues facing SAV in North Carolina.

Shell bottom, composed of living or dead shellfish including oysters, clams, and scallops, serves as both an important commercial and recreational fishery resource and an essential coastal habitat. Increased precipitation from hurricanes and storm events coupled with wetland loss will increase the amount of nutrient rich and polluted stormwater runoff entering the estuaries. This can lead to hypoxic (low oxygen) conditions, resulting in mass mortality of shellfish and finfish. Smaller storm events can result in the closure of shellfish growing areas and recreational swimming advisories, all of which have economic impacts to the resource and the use of the public trust waters of North Carolina. As sea level continues to rise, intertidal oysters will become inundated and have to adapt to the subtidal environment. Additionally, increased water temperatures could result in more occurrences of illness from shellfish consumption, which is a significant public health issue and can also disrupt shellfish markets. The acidification of ocean waters, a consequence of excess carbon dioxide in the atmosphere, will also cause oysters and other shellfish to be unable to grow their shells. The loss of shell bottom habitat will not only affect these important fisheries, but the marine organisms that rely on them for habitat. As shell bottom and other coastal habitats are lost or shift in distribution and abundance due to climate change and anthropogenic impacts, they will need to be mapped and monitored to assess these changes and habitat conditions to ensure they persist. This will be discussed in more detail in the 2021 CHPP priority habitat issue, **Habitat Monitoring to Assess Status and Regulatory Effectiveness**.

The predicted impacts of climate change will have direct impacts on the finfish and invertebrate populations off North Carolina's coast. In recent years, it has been predicted that hundreds of finfish and invertebrate species will be forced to move northward by climate change (Morley et al. 2018). The range

of valuable fisheries species in North Carolina, including black sea bass (*Centropristis striata*) and summer flounder (*Paralichthys dentatus*), have already been seen shifting northward while other species such as white shrimp (*Litopenaeus setiferus)* are having greater biomass following warm winters (Morley et al 2017). Other species, such as spot *(Leiostomus xanthurus*) are shifting their migration route to occur further offshore or deeper in the water column, affecting catchability (SAFMC 2018). Environmental changes are affecting how species use certain estuaries and habitat types, such as bull sharks (*Carcharhinus leucas*) using North Carolina's estuary as a nursery area when it has historically only been used as foraging grounds for adults (Bangley et al. 2018). Some species like Cobia (*Rachycentron canadum*) may be able to withstand the environmental fluctuations due to climate change that occur in coastal habitats and the broad environmental conditions their prey items can tolerate (Crear et al. 2020). Under some future climate change scenarios, spotted seatrout (*Cynoscion nebulosus*) have been shown to increase range due to increased habitat suitability. However, under the same scenarios, their prey species show significant decreases which could result in a food-limited population (Kearney et al. 2015).

In addition to shifts in coastal habitat availability and species distribution, economic impacts and regulatory issues due to impacts from climate change will need to be addressed. North Carolina already exhibits one of the greatest northward shifts in commercial fishing effort, with average vessel landings occurring 24km further north each year (Bradford et al. 2019). As finfish move north, the commercial fishermen follow, resulting in North Carolina fishermen landing more finfish in North Carolina ports that were caught outside of state waters. This can cause confounding regulatory issues when trying to determine the new or expanded ranges and distributions of the finfish species. The management of commercially and recreationally important finfish and shellfish species and the coastal habitat they call home is vital to ensuring the sustainability of these species.

Since its inception, the CHPP has focused on identifying threats and recommending management actions to protect and restore habitats critical to North Carolina's coastal fishery resources. The 2016 CHPP included priority habitat issues focused on oyster restoration, living shorelines, sedimentation, and developing metrics to assess habitat trends along with implementation actions such as improving water quality by reducing stormwater runoff. These issues and actions are not only beneficial to the fishery habitats, but also increase coastal community and ecosystem resilience to climate change stressors. The CHPP has and will continue to highlight the importance of conserving, protecting, and restoring coastal habitats and the ecosystem services they provide, and will integrate climate adaptation and resiliency planning wherever possible. Recommendations and implementation actions from CHPP will continue to support and align with the recommendations of the NWL report and the NCRARP (Table 3.1) (NWL unpub and NCRARP unpub). With more interest and urgency sparked by the storm events of the last several years and Governor Cooper's EO80, the CHPP will play an even more important role in ensuring the future of coastal fishery habitats for the benefit and resiliency of all North Carolinians.

Table 3.1. List of summarized coastal habitats recommendations from the North Carolina Natural Working Lands report which were also included in the North Carolina Risk Assessment and Resiliency Plan (NCRARP).

Natural Working Lands Report - Coastal Habitats Recommendation Summaries	
Action	**Recommended Strategies**
Protect	**Provide incentives to stakeholders for coastal habitat protection**. Protecting coastal habitats, such as natural shorelines, coastal wetlands, oyster beds, and submerged aquatic vegetation (SAV), through landowner incentives will provide benefits to community and ecosystem resilience and increase carbon sequestration. Providing these

Natural Working Lands Report - Coastal Habitats Recommendation Summaries	
Action	**Recommended Strategies**
	incentives can ensure protection of coastal habitats and the ecosystem services they provide. This protection will result in increased hazard mitigation and decrease costs required to repair assets and property and restore coastal habitats after major storm events.
	Facilitate salt marsh migration through protection of migration corridors. There is significant need for the state to facilitate conservation of migration corridors (natural areas without barriers such as development) for salt marsh and other coastal habitats. Ensuring these migration spaces remain undeveloped is key to facilitating marsh migration with sea-level rise, and therefore preserving the coastal protection, ecological functions, and carbon benefits of North Carolina's marshes. Minimizing risk and expenses of hazard damage by ensuring protection and migration of salt marsh and other coastal habitats will increase ecosystem and community resilience.
Restore	**Prioritize climate change and sea-level rise in coastal habitat restoration planning**. Climate change and sea-level rise considerations need to be incorporated into planning processes for coastal habitat restoration by the state, federal, and local governments. Currently, federal habitat restoration programs consider the impacts of climate change and sea level rise (SLR), and North Carolina should also require these impacts be considered when planning habitat restoration projects. Improved restoration planning will allow for more targeted and cost-effective efforts that will increase coastal resilience and carbon sequestration.

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