Submerged Aquatic Vegetation Protection and Restoration

Executive Summary

North Carolina's coastal waters have historically supported nearly 200,000 acres of submerged aquatic vegetation (SAV), which provides critical spawning, foraging, and nursery habitat for most of North Carolina's fisheries, and provides additional ecosystem services including carbon sequestration, nutrient filtering, and sediment stabilization. However, degraded water clarity, sea level rise, and rising temperatures represent growing threats to SAV across the state, with rates of habitat loss currently exceeding 1% per year, plus increasing conversion of continuous meadows to patchy SAV beds. The 2021 CHPP set a statewide goal of ensuring a SAV extent of 191,155 acres and recommended new and updated water quality standards to ensure adequate light penetration to allow SAV to regrow in areas where poor water clarity has led to its loss. To ensure progress on slowing the rate of SAV loss across the coast, this CHPP highlights the need to continue to advance a water clarity standard to protect SAV, outlines an approach for a habitat-based rulemaking framework for the MFC to implement additional SAV protections, and summarizes the regulatory framework and ecological and practical concerns for future seed- and transplant-based SAV restoration projects.

Part 1: Background and water quality improvements to protect and restore SAV

Introduction

North Carolina (NC) is home to one of the most productive and biodiverse submerged aquatic vegetation (SAV) resources on the Atlantic seaboard, including the largest polyhaline and mesohaline seagrass meadows in the temperate western Atlantic (Thayer et al. 1984; NCDEQ 2016). SAV habitat is the foundation for ecological services that directly benefit the coastal ecosystems of North Carolina, including primary and secondary fisheries production, habitat for fish, wildlife and waterfowl, sediment and shoreline stabilization, wave energy attenuation, water purification, and carbon sequestration (Mtwana Nordlund et al. 2016). All these services are important to ecosystem health and provide increased community and ecosystem resilience (NCDEQ 2020). Resource valuation studies indicate that the monetary value of the ecosystem services provided makes SAV habitat protection and restoration a priority conservation and management issue (Costanza et al. 1997; Barbier et al. 2011; Sutherland et al. 2021). In addition to its contributions to coastal resilience and economic production, SAV also provides cultural value and contributes to human wellbeing for local coastal communities and residents globally, making it an integral part of coastal socio-ecological systems (Cullen-Unsworth et al. 2013).

Submerged aquatic vegetation includes marine, estuarine, riverine and lacustrine vascular plants that are rooted in unconsolidated sediment. Because SAVs are rooted in anaerobic sediments, they need to produce a large amount of oxygen to aerate the roots and therefore have the highest light requirements of all aquatic plants (Stevenson 1988; NCDEQ 2016). SAV can become stressed by eutrophication and other environmental conditions that impair water transparency and/or diminish the oxygen content of water and sediments. The plant's response to these factors makes them a sensitive bio-indicator of environmental health (Dennison et al. 1993; Biber et al. 2008). There are two distinct groups of SAV habitats in NC distributed according to water salinity. One group thrives in fresh and low salinity riverine waters (<10 ppt), referred to as low salinity SAV. The second group occurs in the moderate to high (>10 ppt) salinity estuarine waters of the bays, sounds, and tidal creeks, referred to as high salinity SAV or seagrasses.

These groups are distinguished by different species composition and environmental requirements, and they have characteristics similar to SAV communities found in many other estuaries in the US (Table 1) (Stevenson 1988; Orth et al. 2017). Low salinity SAV includes southern naiad (*Najas guadalupensis*), coontail (*Ceratophyllum demersum*), horned pondweed (*Zannichellia palustris*), naiads (*Najas* spp.), redhead grass (*Potamogeton perfoliatus*), sago pondweed (*Stuckenia pectinata*), slender pondweed (*Potamogeton pusillus*), water stargrass (*Heteranthera dubia*), water starwort (*Callitriche heterophylla*), waterweeds (*Elodea* spp.), wild celery (*Vallisneria americana*), and two non-native species, Eurasian milfoil (*Myriophyllum spicatum*) and hydrilla (*Hydrilla verticillata*). High salinity SAV includes eelgrass (*Zostera marina*), shoal grass (*Halodule wrightii*), and Widgeon grass (Ruppia maritima), a eurytolerant species that grows best in moderate salinity areas.

Table 1. Average environmental requirements at locations where submerged aquatic vegetation (SAV) occurred in coastal NC, 1988-1991 (Thayer et al. 1994).

	Environmental parameter					
	Salinity (ppt)		Secchi depth m (ft)		Water depth m (ft)	
SAV species	Range	Average	Range	Average	Range	Average
HIGH SALINITY (<10-30 ppt)						
Eel grass (*Zostera marina*)	10 ≥ 36	26	0.3 - 2.0 (1.0 - 6.6)	1.0 (3.3)	0.4 - 1.7 (1.3 - 5.6)	1.2 (3.9)
Shoal grass (*Halodule wrightii*))	8 ≥ 36	25	0.4 - 2.0 (1.3 - 6.6)	1.0 (3.3)	0.1 - 2.1 (0.3 - 6.9)	0.8 (2.6)
Widgeon grass (*Ruppia maritima*)	0 - 36	15	0.2 - 1.8 (0.7 - 5.9)	0.7 (2.3)	0.1 - 2.5 (0.3 - 8.2)	0.8 (2.6)
FRESHWATER-LOW SALINITY (0-≥10 ppt)						
Redhead grass (*Potamogeton perfoliatus*)	0 - 20	1	0.4 - 1.4 (1.3 - 4.6)	0.9 (3.0)	0.4 - 2.4 (1.3 - 7.9)	0.9 (3.0)
Wild celery (*Vallisneria Americana)*	0 - 10	2	0.2 - 2.0 (0.7 - 6.6)	0.6 (2.0)	0.2 - 2.3 (0.7 - 7.6)	1.0 (3.3)
Eurasian watermilfoil (*Myriophyllum spicatum*)	0 - 10	2	0.2 - 1.4 (0.7 - 4.6)	0.6 (2.0)	0.5 - 2.4 (1.6 - 7.9)	1.1 (3.6)
Bushy pondweed (*Najas guadalupensis)*	0 - 10	1	0.2 - 2.0 (0.7 - 6.6)	0.7 (2.3)	0.5 - 1.7 (1.6 - 5.6)	1.0 (3.3)
Sago pondweed (*Stuckenia pectinate*)	0 - 9	2	0.2 - 0.4 (0.7 - 1.3)	0.3 (1.0)	0.6 - 0.9 (2.0 - 3.0)	0.8 (2.6)

High Salinity SAV Extent and Distribution

SAV mapping was conducted by DMF and partners in 2021 from Bogue Inlet south to Carolina Beach, and that survey is now included in the statewide SAV "mosaic" dataset, which includes all available aerial surveys from 1981 to 2021. Additional mapping of SAV beds from Bogue Inlet north to Roanoke Island that occurred from 2021-2025 will be available in the near future. However, the bigger-picture trends in SAV habitat are expected to be generally comparable to those previously reported, with rates of loss of SAV extent on the order of approximately 1% per year over a 30-40 year timespan, though with spatial variability in rates of loss. While extensive new mapping is currently unavailable, APNEP released a 2nd edition metric report on the *Extent and Distribution of Submerged Aquatic Vegetation in High Salinity Estuarine Waters* (Field et al. 2026), which analyzed the changes in high-salinity SAV meadows documented across three survey periods occurring in 2006-2007, 2013, and 2020.

In North Carolina, high salinity SAV is predominantly eelgrass (*Zostera marina*) and shoal grass (*Halodule wrightii*) with widgeon grass (*Ruppia maritima*) having a relatively lower (< 10%) abundance (Bartenfelder et al. 2022). In North Carolina, seasonal temperature variability exposes the temperate seagrass *Zostera marina* and the tropical seagrass *Halodule wrightii* to periods of both favorable and stressful thermal conditions (Thayer et al., 1984; Short et al., 2016; Bartenfelder et al., 2022). During summer, water temperatures exceed the thermal optimum of *Z. marina* (≥ 25°C up to three months), increasing respiratory demand and light requirements, resulting in seasonal declines in abundance (Zimmerman et al., 1989; Biber et al., 2008; Bartenfelder et al., 2022). Additionally, warming water temperatures in the region have extended the duration of *Z. marina*'s stressful season from 84 to 156 days between 1962 and 2019 (Bartenfelder et al., 2022). Although warmer water temperatures could increase habitat suitability for the tropical species *H. wrightii* to expand (Hyndes et al., 2016; Pinsky et al., 2020), the species has not increased in abundance or colonized areas of *Z. marina* loss, specifically at the meadow deep edge (Field et al. 2021; Bartenfelder et al., 2022). The lack of expansion is likely a result of annual winter water temperatures consistently occurring below the thermal optimum of *H. wrightii* (≤ 20°C up to three months), reducing metabolic performance required to sustain photosynthesis and limiting annual growth (Stevenson et al., 2025; Wheeler et al. 2025; Lytle et al. 2026). Together, these patterns indicate that both species are constrained by opposing thermal stressors that impact their life cycles. These contrasting thermal sensitivities highlight uncertainty in how seagrass meadow composition and structure will respond to continued climate change trajectories (Chefaoui et al., 2018; Kunkel et al., 2020; Pinskey et al., 2020).

APNEP conducted aerial surveys to map high-salinity SAV distribution along the coast from Roanoke Island south through Bogue Sound. Seagrass extent was mapped as continuous (>70% cover) or patchy (>10% and <70% cover), with a minimum mapping unit of approximately 0.2 ha and rasterized 2 m pixel size. Comparison of seagrass extent was limited to areas with interpretable imagery in subsequent surveys (e.g. areas uninterpretable in 2020 were removed from maps from 2007-2007 and 2013 for comparison), so figures do not represent all seagrass mapped. Across the survey range, of the originally mapped high salinity SAV extent of 99,398 acres in 2006 – 2007 (Figure 1) declined to 83,269 acres in 2020, representing a loss of 16,129 acres over the 14-year period, or a loss of 16.2%, or 1.16% per year (Figure 2) The extent of continuous meadows decreased by approximately 50%, from 44,978 to 20,804 acres, while patchy seagrass meadow extent increased approximately 15%, from 54,420 to 62,465 acres, indicating that not only is seagrass extent in North Carolina declining, but seagrass cover is also shifting toward more patchy and fragmented meadows.

The APNEP aerial survey data are divided into three regional zones: 1) the "North Zone" from the U.S. Highway 64 Bridge at Roanoke Island to Hatteras Inlet, 2) the "Central Zone" from Hatteras Inlet to Barden Inlet near Cape Lookout, and 3) the "South Zone" from Barden Inlet to Bogue Inlet (Figure 1). Spatial patterns of seagrass change over the 14-year period varied by region (Figure 2). In the Northern Zone, which contains the largest seagrass extent, most losses occurred along the outer western edges of patchy beds on the back-barrier shelf. In the Central Zone, much of the change reflected a transition from continuous to patchy meadows along the deep-water edge of the back-barrier shelf and on flood tidal shoals around Hatteras and Ocracoke Inlets. In contrast, the Southern Zone exhibited both gains and losses, with substantial seagrass expansion in western Bogue Sound and declines in the eastern portion of the zone. Northern and Central Zones surveyed lost seagrass extent, with regional rates of loss reaching as much as 3.08% per year in subareas from Drum Inlet to Hatteras Inlet. The APNEP report notes that the Chesapeake Bay and Indian River Lagoon both experienced substantially larger losses of seagrass over the same time period, but the seagrass loss reported in NC is on par with globally reported rates of seagrass declines (Dunic et al. 2021).

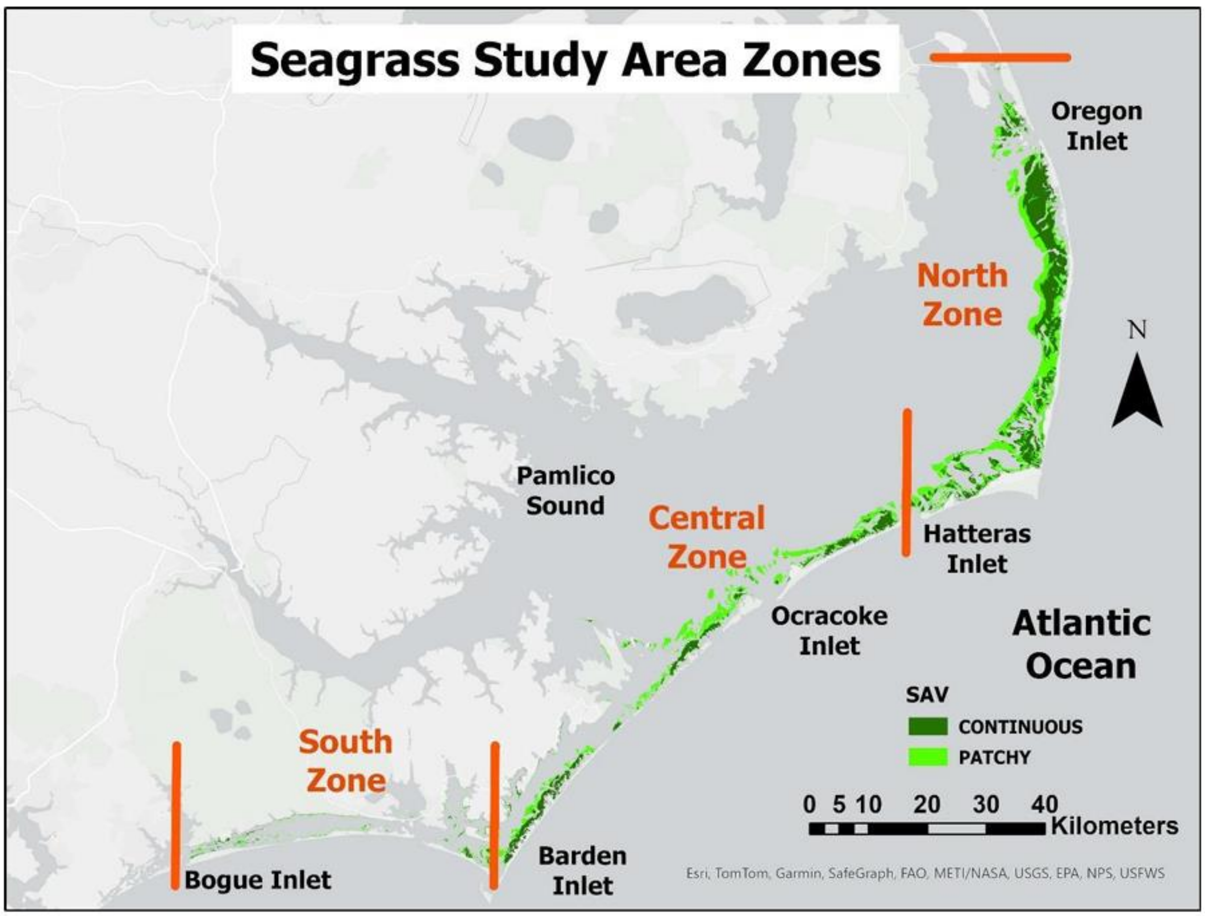

Figure 1. The three regional zones for the high salinity aerial surveys: 1) the “North Zone” from the U.S. Highway 64 Bridge at Roanoke Island to Hatteras Inlet, 2) the “Central Zone” from Hatteras Inlet to Barden Inlet near Cape Lookout and, 3) the “South Zone” from

Barden Inlet to Bogue Inlet. The high salinity SAV mapped in the figure is from interpretation of the 2006/2007 imagery (Field et al. 2026).

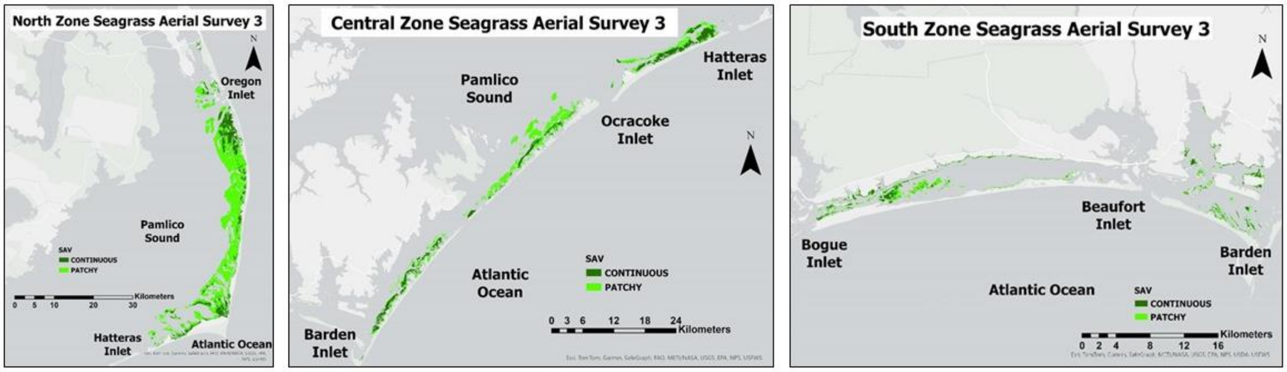

Figure 2. The three zones for the high salinity monitoring from Survey 3 (2020) imagery interpretation. Colors demote the SAV location and spatial cover classes (continuous and patchy). Modified from Field et al. 2026.

The APNEP mapping analysis highlights that a common area of loss was at the deeper-water edge of the seagrass meadows, which are generally also exposed to the largest fetch and wave energy. Seagrass growing at the deep edge of the beds is likely growing at or near the threshold of light limitation, so loss in this area can also be driven by sea level rise and poor water clarity. Increasing water temperatures also exacerbate the impacts of light limitation, especially for eelgrass, which is already growing near its thermal tolerance in North Carolina and has experienced documented long-term declines in Back Sound (Bartenfelder et al 2022 MEPS). Flood tidal deltas at Hatteras and Ocracoke Inlets experienced large losses of seagrass extent, associated with the widening of both inlets, shifting of sand shoals, and notably Hurricane Dorian in 2019, which produced a large storm surge in north Core Sound and southeastern Pamlico Sound.

The reported reductions in seagrass habitat over the past 14 years reflect the multi-decadal patterns of loss noted in previous CHPPs, and this ongoing pattern emphasizes the need for management action to protect North Carolina's remaining SAV habitat and restore the meadows that have been lost. It is important to manage the threats within the domain of existing management paradigms, including sediment and nutrient loading, water quality, and land use, but given the threats posed by climate change, new approaches will need to be developed to mitigate the impacts of increased storminess, rising temperatures, and sea level rise. While the 2021 CHPP set a statewide SAV acreage goal of 191,155 acres, of which 149,427 acres is high-salinity SAV, based on seagrass extent mapped from 1981-

2015. The APNEP report recommends an interim target for high salinity SAV extent of 109,167 acres, representing the seagrass extent mapped in 2006-2007, as such a target may be more immediately achievable. Finally, while over 16,000 acres of seagrass meadows were lost between 2006 and 2020, at least some of that lost acreage remains viable seagrass habitat that can be repopulated as long as management practices preserve the environmental conditions that sustain persistent seagrass meadows and promote their reestablishment.

Low Salinity Extent and Distribution

The Currituck Sound and Back Bay, Albemarle Sound, and Tar-Pamlico and Neuse Rivers regions are home to North Carolina's low salinity SAV. The known historical extent of low salinity SAV mapped in NC, from 1981 – 2015 is 39,066 acres or 20.4% of the state's total SAV extent (NCDEQ 2021). Mapping and monitoring low salinity SAV is more difficult due to low water clarity compared to the areas of the estuary where high salinity SAV grows. Despite low water clarity and limited availability of historical baseline data of low salinity SAV habitat, fluctuations in SAV abundance have been observed through hydroacoustic surveys and other sentinel site observations (Speight 2020; APNEP 2020). Comparing alongshore hydroacoustic surveys conducted 2014-2017 to the historical extent of SAV (from the 1981-2015 SAV mosaic dataset, though the earliest surveys contained in that dataset for the low salinity regions date to 1990), approximately 33 percent of the linear extent of low-salinity SAV was estimated to have been lost (APNEP 2020).

The 2026 amendment to the CHPP proposes three strategies going forward to support SAV protection:

1. Completion of the recommendation from the 2021 CHPP amendment for the EMC to be presented with a water quality standard for light penetration, along with continuation of the other recommended actions to improve water quality for SAV.
2. Outlining the permitting process for active SAV restoration where conditions may be supportive of long-term reestablishment through seeding or transplantation.
3. A plan for developing comprehensive management options for SAV protection from physical disturbance under the authority of the MFC, in accordance with the MFC's request during implementation of Amendment 2 to the Shrimp Fishery Management Plan.

Continued work on water quality improvements to protect and restore SAV

Chapter 4 of the 2021 CHPP amendment (NCDEQ 2021) explored the declines in SAV statewide and illustrated the connections to decreased water clarity, in addition to describing the component factors driving this reduction, with a focus on chlorophyll (driven by nutrient input), but also including turbidity and chromophoric dissolved organic matter (CDOM) (Hall, 2022). The 2021 CHPP amendment recommended 13 actions under the theme of *Protection and Restoration of Submerged Aquatic Vegetation (SAV) through Water Quality Improvements*, with a heavy emphasis on establishing water clarity solutions through new and/or improved water quality standards. As underwater plants, SAV species require waters to be clear enough for sunlight to penetrate the water column during the growing season, and light availability typically limits the depth at which SAV can grow. Required light conditions vary by species; low salinity SAV species have slightly lower light requirements of > 9 percent of surface incident light required at the leaf and >13 percent of surface incident light required through the surface, compared to >15 percent and >22 percent, respectively, for species found in moderate to high salinity areas (Kemp et al. 2004; Funderburk et al. 1991; USEPA 2003). These biological light requirements, along with modeling by Hall (2022), formed the basis of the 2021 CHPP Amendment's recommendation for a light penetration (clarity) standard to protect and restore SAV. A study conducted in 2022 (Lytle et al. 2026) evaluated light availability relative to the 2021 CHPP amendment recommendation of a 22% surface irradiance threshold for high-salinity SAV up to depths of 1.7 m. During a three-week study conducted in a seagrass meadow in Back Sound between August and September, observed light availability was 14 percent surface irradiance at 1.0 m depth, with an estimated 9.8 percent surface irradiance reaching 1.7 m, substantially below the recommended threshold. These data highlight the need to continue to characterize the light conditions currently experienced by SAV habitats across North Carolina to inform efforts to improve water clarity for SAV restoration.

Efforts to reduce algal blooms and chlorophyll a impairments in North Carolina's estuaries have been ongoing for over 20 years, to mixed results. The NC Division of Water Resources' Nonpoint Source Planning Branch's draft *20-Year Neuse and Tar-Pamlico Nutrient Management Strategy Retrospective* (NCDWR 2023) provides an overview of the history and progress of nutrient management in the two primary watersheds that impact the Pamlico Sound estuary, including a large portion of the state's SAV habitat, from the early 2000s to the early 2020s. Among the preliminary findings are that (a) progress on nutrient reduction has been mostly limited to point source improvements, and that the increase in organic nitrogen loads has offset the nitrogen loading reductions achieved from point sources; (b) loading from developed lands has approximately doubled, while loading from cropland has not substantially decreased; and (c) agricultural lands dominate nutrient loading in high precipitation years, while urban areas dominate in low precipitation years, indicating that both agricultural and urban sources must both continue to be addressed to protect downstream environments.

The impacts of climate change threaten to exacerbate water clarity issues as rainfall patterns change. According to North Carolina's 2020 Climate Science Report (Kunkel et al. 2020), the intensity of the strongest hurricanes is likely to increase with warming temperatures, which will result in increased heavy precipitation from hurricanes impacting NC. Additionally, it is likely that the frequency of severe thunderstorms and the annual total precipitation in NC will increase. The expected increase in heavy precipitation events will lead to increased runoff from both agricultural and developed lands, which will result in an increase in nutrients, sediments, and other pollutants carried to North Carolina's estuaries. Paerl et al. (2019) analyzed rainfall records from coastal NC going back to 1898, and their findings suggest that this increase in precipitation and pollutant delivery to estuaries has already begun. Specifically, they found "a period of unprecedentedly high precipitation since the late-1990's, and a trend toward increasingly high precipitation associated with tropical cyclones over the last 120 years," and that those changes represent "a recent regime shift with major ramifications for hydrology, carbon and nutrient cycling, [and] water and habitat quality." As the magnitude and frequency of rainfall and storm events increase, it will be even more important for state agencies to implement policies that encourage the use of agriculture, forestry, and urban stormwater best management practices (BMPs) and explore complementary regulatory updates to reduce the amount of runoff reaching North Carolina's estuaries. Each edition of the CHPP has emphasized the need for increased use of BMPs, along with other actions to improve water quality, and increased implementation will be necessary to mitigate the impacts from anticipated climatic changes.

The 2021 CHPP amendment recommended 3 incrementally progressive regulatory solutions to be brought to the EMC: (1) a clarity standard to protect SAV, (2) an update to the existing chlorophyll standard to address deficiencies in the standard and its assessment, and (3) nitrogen and phosphorus standards. While not accomplished in the ambitious timeframes initially proposed, the 2021 CHPP recommendations for water quality improvements to protect and restore SAV habitat remain DEQ's top priorities to advance SAV protection and restoration coastwide.

Since the 2021 CHPP amendment's passage, the Scientific Advisory Council (SAC) to the Nutrient Criteria Development Plan (NCDP) made a recommendation for a clarity standard that included the photosynthetically active radiation (PAR) extinction coefficients (K_dPAR) recommended in the 2021 CHPP amendment of 1.36 m^{-1} for low-salinity SAV (allowing for 13% of incident light to reach 1.5 m depth) and 0.89 m^{-1} for high-salinity SAV (allowing for 22% of incident light to reach 1.7 m depth), applied across a growing season of March through October to areas that are currently or have historically been vegetated by one or more of the 14 species identified in the MFC definition of SAV habitat (15A NCAC 03I .0101(4)(i)(i)). The NCDP SAC reviewed presentations on chlorophyll in their final few meetings, however the SAC's appointment concluded without action on either updates to the chlorophyll standard or new nitrogen and phosphorus standards.

Following the conclusion of the SAC's appointment, DWR NCDP staff developed the SAC's recommendation into a draft water clarity standard, which was presented to the Criteria Implementation Committee (CIC). CIC member feedback was solicited as a group and in one-on-one meetings, and NCDP staff have been developing a regulatory impact analysis (commonly referred to as a fiscal note) in accordance with NCGS § 150B-21.4 to identify, describe, and quantify the expected effects of the proposed standard to the extent possible. Upon completion of the fiscal note, DWR staff will complete the rulemaking package and present the draft standard to the EMC, with a vote on the standard anticipated in 2027.

While passage of a water clarity standard protective of SAV would mark a comprehensive approach to reversing the decline of North Carolina's SAV habitat, the earliest initiation of restoration activities in clarity-impaired waterbodies will likely take at least 8-10 years after passage of the standard, accounting for standard implementation, monitoring and assessment, development of restoration plans, and on-the-ground restoration projects.

In public meetings since passage of the 2021 CHPP amendment, commercial and recreational fishing stakeholders have made clear their frustration with continued declines in water quality and the impacts of those declines on fish and fish habitats. Accordingly, this CHPP amendment recommends continuing to prioritize progress on the recommended actions from the 2021 CHPP amendment to improve water quality for SAV, specifically that DMF, DWR, and partners should continue to collaborate in facilitating the adoption of a water clarity standard to protect SAV. Additionally, in acknowledgment of the long timeframe anticipated to achieve comprehensive water clarity solutions for SAV, this CHPP amendment provides guidance for further SAV protection and restoration measures that, while less wide-ranging, still represent meaningful steps that can be taken to slow the rate of coastwide SAV loss. Specifically, this CHPP amendment explores the range of SAV protections that may be available under the authority granted to the Marine Fisheries Commission, and this amendment also lays out the permitting framework, best practices, and next steps for active restoration of SAV habitat across North Carolina's coast. The approaches present additional tools for DEQ and partner organizations to work with while long-term solutions to the threats to SAV from water quality degradation are simultaneously addressed.

Recommended Action

DMF, DWR, and partners should continue to prioritize progress on the recommended actions from the 2021 CHPP amendment to improve water quality for SAV, especially by collaborating to facilitate the passage and implementation of a water clarity standard to protect SAV.

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Part 2: Submerged Aquatic Vegetation Restoration

This paper synthesizes the state of active submerged aquatic vegetation (SAV) restoration as it bears on management decisions in North Carolina, summarizes the regulatory framework currently governing active SAV restoration in state waters, and notes practical and ecological concerns to address before attempting or permitting active SAV restoration. While this issue paper does not attempt to summarize restoration methods (e.g., transplant unit design, anchoring techniques, or seed handling), researchers and practitioners are directed to the manuals cited below and others.

Background

North Carolina estuaries support SAV across a wide salinity range, broadly grouped into high-salinity communities of polyhaline and mesohaline waters (dominated by eelgrass *Zostera marina*, shoal grass *Halodule wrightii*, and widgeon grass *Ruppia maritima*) and low-salinity communities of the oligohaline and tidal freshwater rivers and sounds (dominated by wild celery *Vallisneria americana*, sago pondweed *Stuckenia pectinata*, pondweeds *Potamogeton* spp., and other freshwater taxa) along with the invasive hydrilla *Hydrilla verticillata*, which is widespread and in many areas the dominant low-salinity SAV by biomass. The two groups differ in species composition, dominant stressors, bed dynamics, and climate vulnerability. The presence of hydrilla complicates restoration planning in low-salinity systems both because of its competitive effects on native species and because of the herbicide treatments used to control it. Active restoration considerations, including donor sourcing and species suitability under changing conditions, may differ substantially between groups, and project planning should be informed by the ecological and management context of the relevant salinity zone.

Where water quality or physical impacts to SAV habitat have been mitigated but natural revegetation has not occurred, active placement of transplants or seeds can help overcome source and dispersal limitations that may prevent recovery. Active restoration is therefore distinct from the stressor-reduction actions (e.g., water clarity needs) addressed in Part 1 of this issue paper. Active restoration is most appropriate as a follow-up measure once underlying stressors have been removed or reduced, not as a mitigation for them. However, there may be localized areas where stressors are not as prevalent and active restoration can be considered despite water clarity measures not met within the broader geography.

In addition to benefits to fish and wildlife that depend on the habitat, SAV restoration presents an opportunity to restore lost blue carbon stocks. North Carolina's Coastal Habitat Greenhouse Gas Inventory (NC Coastal Habitat GHG Workgroup 2023) uses a single carbon sequestration rate for both patchy and continuous high-salinity seagrass meadows (-0.17 t C $acre^{-1}$ yr^{-1}; IPCC 2014), indicating that, based on North Carolina's 2021 mapped seagrass extent, statewide carbon sequestration in seagrass soils totaled 14.69 kt C yr^{-1}, or 55.14 kt CO_2eq yr^{-1}, though uncertainty in that estimate is poorly constrained. Key et al. (2026) found that continuous seagrass beds have higher carbon concentrations stored in their soils than discontinuous (patchy) seagrass beds (1.5-2.0% vs. 0.64-1.0% organic matter), and those sediments are more resistant to erosion and are better preserved by storm burial than discontinuous seagrass beds. These findings would suggest that restoration of lost seagrass beds, or of continuous beds that have become patchy, would increase both carbon sequestration rates and long-term storage of soil carbon in high-salinity seagrass habitats.

Under changing climate conditions, restoration planning may also need to account for shifting species suitability and consider the role of assisted migration. For example, eelgrass, which is near its southern thermal limit in North Carolina, is increasingly vulnerable to warming temperatures, whereas shoal grass is more heat-tolerant and may expand northerly under future conditions (Bartenfelder et al. 2022). In such cases, restoration efforts that incorporate climate-adapted species or genotypes may improve long-term persistence (e.g., Hoegh-Guldberg et al. 2008; van Katwijk et al. 2021).

A growing body of literature exists to inform SAV restoration practice. Guidance for U.S. seagrass restoration was set out in Fonseca et al. (1998), and the Chesapeake Bay SAV Restoration Manual (Jasinski et al. 2021) provides region-specific protocols developed in the most directly analogous Atlantic Coast system. More recently, Unsworth et al. (2025) discuss ten guiding principles for seagrass restoration, beginning with the principle that *protection* of extant meadows is more effective than replanting and that restoration is not a substitute for reducing the stressors that caused decline. The single most consistent finding across syntheses of seagrass restoration is that restoration is unlikely to succeed where the impacts that caused loss have not been mitigated, particularly when those impacts originate from degraded water quality. Van Katwijk et al. (2016), in a global meta-analysis of 1,786 restoration trials, found that sites previously impacted by reduced water quality (principally eutrophication) and by construction activities had poorer restoration outcomes than sites impacted by dredging, localized direct impacts, or natural causes. Persistent water-quality stressors are therefore a strong reason to postpone active restoration regardless of the techniques used.

Several factors are positively associated with restoration success. Van Katwijk et al. (2016) identified that larger planting efforts (number of plants or seeds), proximity to existing donor beds, and use of effective anchoring techniques are among the strongest factors for survival and population growth. Proximity to donor beds is generally interpreted as an indicator that the receiving environment is suitable for seagrass growth, but it may also reflect benefits from locally adapted genotypes and from shorter handling time between collection and planting. Recent work also points to potential benefits from microbial inoculation (Sun et al. 2024). However, with these successes the drawbacks must also be considered. The high salinity SAV species *Zostera marina* exhibits a mixed annual life-history strategy in which aboveground shoots senesce during summer and plants re-established each year from the seed bank that was established the year prior (Jarvis et al. 2012). *Z.marina's* dependence on annual seed recruitment makes seed production and seed bank persistence critical to the North Carolina population resilience. Consequently, restoration efforts that rely on harvested seeds must ensure seed collection does not deplete the limited seed reserves required for natural annual recovery of the species.

Van Katwijk et al. (2016) concluded that larger trials succeed more often than smaller ones, suggesting that plantings must reach a sufficient density and spatial footprint to overcome negative factors (e.g., sediment resuspension, grazing, hydrodynamic stress) and persist. In a synthesis of 82 eelgrass restoration projects conducted along the U.S. West Coast between 1989 and 2020 reinforce these conclusions (Ward and Beheshti 2023). Project failure rates were 32–60% depending on how success was defined, and the authors attributed the regional failure rate in part to the small scale at which most West Coast restoration has been conducted (a total of only ~85.5 ha across all 82 projects). Practitioners most often attributed failure due to environmental conditions such as algal blooms, sedimentation, and light limitation. This is consistent with Van Katwijk et al. (2016) finding that water quality and other persistent stressors are dominant causes of restoration failure. Ward and Beheshti (2023) also showed a substantial documentation gap (only 6 of 82 projects were peer-reviewed; few projects monitored ecosystem functions or maintained co-monitored reference sites. North Carolina will need to develop a standardized and well-documented monitoring approach for restoration sites. This approach will need to be accessible to practitioners and contain information that reports restoration sites, restoration efforts implemented, and restoration progress (success or failure) to inform future restoration decisions.

The contrast between eelgrass improvements or declines in Chesapeake Bay and the adjacent Virginia coastal bays on the Eastern Shore is an illustration of how stressor context determines restoration outcomes. Orth et al. (2009) reported that eelgrass beds in Chesapeake Bay, which had begun to recover from earlier diebacks, declined over the period 2000–2009. This was attributed to declining water quality as the main stressor as there was bay-wide dieback in 2005 associated with very high summer water temperatures and poor water clarity. Over the same period, eelgrass abundance increased substantially in the Virginia coastal bays on the Eastern Shore, where a large-scale seed-based restoration program initiated in 2001 was able to take advantage of better water clarity and produced expanding, self-sustaining beds. This shows that the same general restoration approaches, in the same region, can produce different outcomes depending on whether the underlying water quality and thermal regime supported eelgrass. Numerous transplant projects in Chesapeake Bay over this same period failed to persist beyond one to two years (Orth et al. (2009), reinforcing the conclusion that active restoration in waters that have not recovered the conditions supporting natural revegetation should be treated as experimental rather than as a reliable management tool.

Criteria for successful SAV restoration

Active SAV restoration in North Carolina is most likely to succeed under the following circumstances. These are offered as decision criteria for evaluating proposed restoration projects; however, site-specific judgment by qualified practitioners and resource managers is essential.

1. Stressors have been mitigated or reduced enough for successful restoration. The causes of historical SAV loss at the site, whether they are degraded water clarity, nutrient enrichment, persistent physical disturbance (e.g., shellfish operations), or other stressors, have been reduced to the point where conditions fall within the target species' water quality conditions that support SAV growth. Where stressors persist, restoration should generally be deferred until conditions improve. However, smaller localized areas with adequate conditions may persist within the larger area in question.

2. Water quality conditions support SAV growth. Light availability, salinity, temperature, and dissolved-oxygen conditions at the proposed site are within the documented ranges for the target species and life stage to accommodate survival and growth.

3. Physical site conditions are appropriate. Sediment composition, depth, and current and wave energy are consistent with conditions at nearby reference beds and within the species' tolerance thresholds. Sites with persistent high energy disturbance or unsuitable sediments are unlikely to support persistent SAV regardless of planting effort.

4. Natural revegetation has not occurred despite suitable conditions. Measurements of adequate conditions for growth and evidence that a site has remained unvegetated over a period long enough to indicate that natural recolonization is constrained by seed or propagule limitation, dispersal limitation, or density-dependence rather than by a current stressor that planting cannot overcome.

5. Donor material and type can be sourced appropriately. Donor beds within a reasonable proximity to the restoration site are healthy and large enough to supply the needed material without compromising the donor population. Genetic and disease considerations should be addressed in donor selection (see below). The use of propagules (shoots) or seeds will need to be determined.

6. Climate-adapted species and genotype selection are considered. Where projected changes in temperature, salinity, or other conditions may push current SAV species or genotypes outside their tolerance ranges, restoration planning should consider whether the historically dominant species remains the most appropriate target, and whether donor genotypes from populations adapted to warmer or more variable conditions should be incorporated. Decisions about climate-adapted sourcing carry their own risks and should be made with input from genetic and ecological expertise.

7. Grazing pressure can be limited. Grazing and foraging from waterfowl, fish, and other wildlife (e.g., turtles, rays) can quickly cause disturbance and in some cases cause complete restoration failure, especially in small-scale experimental planting areas. Where this is a concern, there may be options such as temporary grazer exclosures (e.g., fencing) that could be placed around individual plants, groups, or the entire restoration site.

8. Project scale is commensurate with the goal. Project design includes sufficient planting effort (i.e., number of plants or seeds, spatial footprint, and density) to exceed plausible thresholds for establishment and to allow the planting to generate the self-reinforcing conditions (e.g., sediment stabilization, light improvement, energy attenuation) that support persistence. Small pilot plantings have value for testing site suitability and providing source material to an area but should not be expected to produce self-sustaining meadows on their own.

9. Monitoring duration is sufficient to evaluate persistence. A monitoring commitment of at least five years is in place, with the recognition that short-term (one- to two-year) survival is a weak predictor of long-term outcome. Many seagrass restoration projects globally have shown initial survival followed by failure within the first few years; therefore, persistence, not initial establishment, should be the success criterion.

10. Active restoration will not be impacted by herbicidal treatment for invasive species. Broad-scale usage of herbicidal treatments to exterminate an invasive species (e.g., hydrilla) can harm active restoration areas of native SAV. Planning and coordination with appropriate agencies should occur to minimize impacts (see Recommendation # 7).

11. Additional criteria as needed. For example, projects should be aligned with regional restoration priorities, presence of compatible adjacent habitats, and minimized conflicts with existing uses. These and other criteria as they arise will also be relevant for evaluating specific projects.

Current regulations pertaining to active SAV restoration

The regulatory framework governing active SAV restoration in North Carolina state waters is summarized below. In brief, the current framework allows for on-land culture and collection of SAV but provide limited mechanisms for in-water restoration efforts.

1. In-water leases for marine plants are not currently available. North Carolina General Statutes Chapter 113, Article 16, authorizes the Secretary to issue bottom and water-column leases for the cultivation of shellfish (N.C.G.S. §§ 113-202, 113-202.1, 113-202.2). The statutory authority is specific to shellfish and does not extend to marine plants. There is no analogous lease authority for SAV in current statute, and creating one would require legislative action. As a result, researchers and practitioners seeking to conduct active SAV restoration cannot obtain an in-water lease providing exclusive use, or a defined management footprint for the planted area.

2. Limited in-water protections for restored SAV sites. Once SAV has been re-established, it is generally afforded the same protections as naturally occurring SAV through existing rules governing impacts to SAV habitat. SAV is designated as Essential Fish Habitat (and as Habitat Area of Particular Concern in the South Atlantic) under the Magnuson-Stevens Act, triggering NOAA Fisheries consultation on federal actions that may adversely affect SAV. SAV is also protected through USACE Nationwide Permit conditions, and restrictions on shellfish lease siting in mapped SAV areas. The NCDMF Director may, by proclamation, designate a temporary research sanctuary that restrict fishing and equipment use for a SAV restoration project, renewable on an annual basis (15A NCAC 03I .0109). Beyond these mechanisms, NCDMF does not currently have a discrete tool for designating, managing, or providing long-term legal protection to a restoration site.

3. Land-based SAV culture. Collection, culture, and planting of SAV that involves land-based culture can be permitted under NCDMF's existing aquaculture authorities. Under 15A NCAC 03O .0503(a), it is unlawful to conduct aquaculture operations using marine and estuarine resources without an Aquaculture Operation Permit (AOP), and it is unlawful to take marine or estuarine resources from coastal fishing waters for aquaculture purposes without an Aquaculture Collection Permit (ACP). Both permits are issued by the NCDMF Fisheries Director and renewed annually. Holders of an ACP must submit an annual report stating the amount and disposition of resources collected, including any additional reporting required by other state or federal agencies. SAV falls within the scope of these authorities. N.C.G.S. § 113-129 defines "marine and estuarine resources" to include all uncultivated or undomesticated plant and animal life inhabiting or dependent upon coastal fishing waters, which encompasses SAV. The Marine Aquaculture Article (N.C.G.S. § 113-217) defines "marine aquatic species" to include aquatic plants found in coastal fishing waters. Through the conditions attached to AOPs and ACPs, NCDMF may regulate the amount of material collected, the location and timing of collection, and the methods used. These conditions are set on a permit-by-permit basis under the NCDMF Director's authority, providing flexibility but not a uniform standard for SAV.

4. Activities exempt from NCDMF permitting. Harvest and transplanting of SAV that does not involve land-based storage or culture is unlikely to trigger AOP or ACP requirements as currently written. For example, direct collection from a donor bed and immediate planting at a restoration site is exempt from permitting. The AOP requirement applies to "aquaculture operations," and the ACP requirement applies to take "for aquaculture purposes" (15A NCAC 03O .0503(a)(1) – (2)). Under the statutory definition, aquaculture involves the propagation and rearing of aquatic species in controlled or selected environments. Neither clearly applies to direct bed-to-bed transplantation.

5. Permitting requirements from other agencies. Individual SAV restoration projects may also involve other state and federal agencies, including the U.S. Army Corps of Engineers (USACE), the Division of Water Resources (DWR) for Section 401 Water Quality Certification, and the Division of Coastal Management (DCM) for Coastal Area Management Act (CAMA) major or minor permits and Dredge and Fill permits. Additional permitting requirements for transplanting SAV and protective structures are generally not anticipated to be burdensome, but consultation with agency staff through DEQ's Division of Environmental Assistance and Customer Service (DEACS) is highly recommended to confirm, as permitting requirements vary on a case-by-case basis.

Recommendations for policy and regulatory updates

The current regulatory landscape provides only partial coverage of active SAV restoration. Land-based operations can be permitted, but in-water collection and transplanting are largely unregulated, and there is no mechanism for in-water lease or for restoration-specific in-water protection. The recommendations below are offered for consideration during the 2026 CHPP amendment process.

Recommendation 1: Develop SAV considerations for AOP and ACP conditions. Authority to attach permit conditions to AOPs and ACPs already exists under 15A NCAC 03O .0502 and N.C.G.S. § 113-169.1 (also, N.C.G.S. § 113-134, N.C.G.S. § 113-169.1, N.C.G.S. § 113-182, N.C.G.S. § 143B-289.52, and 15A NCAC 03O .0500). NCDMF could work with partners to develop a set of standard considerations for permit reviewers to ensure best practices when an AOP or ACP involves SAV. This could address allowable donor sources, take limits, seasonal restrictions on collection, disease and biosecurity screening, genetic considerations, and reporting requirements. Given that North Carolina is in the process of developing restoration best practices and evaluating long-term management needs, priority should be placed on conserving in-state donor material to support restoration and resilience of North Carolina's own SAV resource, and consideration should be given for limiting the collection of North Carolina SAV seeds or plants for restoration projects outside the state.

Recommendation 2: Address potential donor bed impacts. Harvest from a donor bed can be a source of impact in seagrass restoration van Katwijk et al. 2021. Even when transplant material is taken at modest intensities, the spatial and temporal patterns of harvest may affect donor bed density, structure, and recovery. NCDMF should consider requiring donor bed monitoring and reporting as a condition of permits authorizing SAV collection and should establish standardized criteria for evaluating donor bed suitability and post-harvest recovery. North Carolina donor bed monitoring protocols should be developed.

Recommendation 3: Address transplant sourcing. Transplant sourcing decisions affect the probability of restoration success and the broader management risks of the project. Four considerations are particularly relevant. First, disease and pathogen transmission risk increases with movement of plant material between water bodies where donor screening or quarantine in land-based culture may be appropriate. Second, there can be genetic differentiation among populations (Olsen et al. 2004). Locally sourced material is more likely to carry adaptations to local conditions, but genetically diverse populations may also be more resilient to environmental variability. For example, Campanella et al. (2010) documented genetic population structure along the U.S. Atlantic Coast and found that the Chesapeake Bay may be the best donor source for eelgrass for restoration. Third, sourcing should avoid moving material from areas where non-target species (including invasive species) may be inadvertently translocated and (or) have a mechanism for identifying non-target species prior to restoration activities. Fourth, physical proximity of donor to recipient site is among the more reliable predictors of restoration success (Van Katwijk et al. (2016)) and reduces handling time. Standard considerations attached to AOP/ACP conditions for SAV operations (Recommendation 1) should address each of these factors.

Recommendation 4: Address protection of restored SAV sites. As noted above, the only restoration-specific protection currently available is the temporary research sanctuary mechanism, which is time-limited and tied to a research purpose. Regulators may wish to consider a long-term protective designation. Because no current statute authorizes a marine plant lease, this would likely require either a statutory amendment extending lease authority to marine plants, or creation of a new designation under existing rule authority (e.g., extended-duration research areas or restoration-specific management zones).

Recommendation 5: Develop guidance for climate-adapted restoration decisions. North Carolina sits at a biogeographic transition where projected warming may affect species and genotype suitability for SAV restoration. NCDMF, in coordination with research partners (e.g., APNEP, NC Sea Grant, university research programs), should develop guidance on when and how to consider assisted migration or sourcing of climate-adapted genotypes as alternative restoration tools. Such guidance should address the trade-offs between local adaptation and projected conditions and should be developed in coordination with the AOP/ACP considerations identified in Recommendations 1 and 3.

Recommendation 6: Coordinate active restoration with aquatic weed control activities. Invasive species control under the Aquatic Weed Control Act of 1991 (N.C.G.S. § 113A-220 et seq.) is administered by NCDEQ with interagency advisory input through the North Carolina Aquatic Weed Control Council. Herbicide treatments (e.g., fluridone) intended for hydrilla in low-salinity systems can impact native SAV beds. NCDMF, which holds a seat on the Aquatic Weed Control Council (15A NCAC 01T .0107), should use that role to develop a coordination protocol with the Council and treatment agencies that identifies active native SAV restoration sites in advance of herbicide treatment planning to allow for buffer zones, treatment timing adjustments, or use of more selective methods where feasible. Also, where treatment is planned in waters that support native SAV, schedule treatment to allow harvest of native SAV material in advance of herbicide application for land-based culture under existing AOP/ACP authorities (Recommendation 1). This would allow for replanting into the treated area once herbicide residues have cleared and site conditions support re-establishment. Coordinated native restoration during herbicidal treatments requires planning across multiple seasons and species-specific consideration of holding feasibility, replanting timing, and post-treatment monitoring.

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Part 3: MFC Authority for Submerged Aquatic Vegetation Protections

Background

Impacts from physical disturbance remain a major consideration for the protection of high and low salinity SAV. Protections of SAV in North Carolina from physical disturbance include both state and federal policies that are wide-ranging, though room for improvement remains. The Albemarle-Pamlico National Estuary Partnership (APNEP) published a summary and assessment of the policies, permitting, and management of SAV in North Carolina (Ragain, in preparation). The report summarizes the various state and federal protections currently protecting SAV, ongoing threats to SAV conservation, and recommendations to address gaps in SAV policy and protection. The federal regulations covered are characterized by federal designations under the Magnusen-Stevens Act - SAV is designated as Essential Fish Habitat (EFH), and further as Habitat Areas of Particular Concern (HAPC) - which allow for federal protection. State regulations are characterized by state law and rules developed by the MFC, CRC, and EMC that aim to protect SAV by addressing specific impacts.

Recommendations made in the APNEP report fall into categories of regulatory, non-regulatory, and research suggestions. The regulatory recommendations include additional policy or rule recommendations addressing impacts from mariculture, development, boating, and water quality. The non-regulatory recommendations include outreach and education and further work from state agencies on mariculture, fisheries, development, and boating. The research suggestions cover directions for state agencies and university researchers to further explore impacts from water quality, fisheries, and boating, and to continue or expand monitoring. Among these, some specific examples of areas to improve included reducing the impacts on SAV from shellfish aquaculture operations, further research trawling impacts to SAV, and improving the compensatory mitigation for permitted SAV impacts.

MFC directive to develop additional SAV protections

Amendment 2 to the N.C. Shrimp Fishery Management Plan (FMP), adopted by the North Carolina Marine Fisheries Commission (MFC) in February 2022, was developed to further reduce bycatch of non-target species and minimize ecosystem impacts. The MFC's management strategy included adaptive management for future action to address issues related to SAV identified through North Carolina Division of Marine Fisheries (DMF) collaboration with the Coastal Habitat Protection Plan (CHPP) support staff, the Habitat and Water Quality (HWQ) Advisory Committee (AC), and stakeholder groups (NCDMF, 2022).

In February 2024, the DMF proposed additional SAV protections to the MFC in the Shrimp FMP Amendment 2 Revision. In response, the MFC passed a motion to refer the issue paper to the Northern and Southern Regional and Shellfish/Crustacean ACs for input. The response from shrimp fishery participants and the ACs to the MFC was against SAV-centered place-based management. While the ACs acknowledged the need to protect SAV, they cited that shrimp trawling was not the primary threat to SAV and further noted the need to address poor water quality as well as other bottom disturbing activities (e.g., propeller scarring, anchoring). The HWQ AC further recommended that a monitoring program be established to measure the status of SAV habitat in North Carolina (NCDMF, 2022). This led the DMF to recommend a broader approach to SAV protections. At its May 2024 business meeting, the MFC unanimously passed the following motion on the Shrimp FMP Amendment 2 Revision (emphasis added):

"to accept the Division of Marine Fisheries (DMF) recommendation that it is <u>advantageous to examine issues and develop management actions related to the broader conservation of Submerged Aquatic Vegetation (SAV) habitat conservation</u>. Therefore, action to address SAV protection under the Shrimp FMP Amendment 2 has concluded. The Marine Fisheries Commission (MFC) requests the DMF work with the MFC's Habitat and Water Quality Advisory Committee to <u>examine and develop more comprehensive options to protect identified SAV habitat related to all activities under the authority of the MFC</u>, consistent with the N.C. Coastal Habitat Protection Plan."

Following this action, DMF and partners have evaluated the MFC's authority for physical protections, historical management actions, and the basis for further actions to strengthen protections from physical impacts to SAV. This evaluation was undertaken in the context of the Shrimp FMP and Bay Scallop FMP, as well as other aspects of marine and estuarine fisheries resources that are under the MFC's authority.

Evaluation of MFC authority for physical protections

MFC statutory authority

This evaluation began with a broad review of the statutory authority of the MFC. N.C.G.S. § 113-132, gives the MFC authority over the conservation and regulation of marine and estuarine resources.

Marine and estuarine resources are defined by N.C.G.S. § 113-129 (11) as:

"All fish, except inland game fish, found in the Atlantic Ocean and in coastal fishing waters; all fisheries based upon such fish; all uncultivated or undomesticated plant and animal life, other than wildlife resources, inhabiting or dependent upon coastal fishing waters; and the entire ecology supporting such fish, fisheries, and plant and animal life."

The inclusion of the phrase "entire ecology" in this statute provides an expansive basis of authority over all organisms and the environment supporting the plant and animal life in the State waters of the Atlantic Ocean and coastal fishing waters.

The MFC's authority over marine and estuarine resources is subject to specific grants of authority to other state agencies, which are summarized below. Even accounting for those exceptions, the MFC retains broad jurisdiction over the conservation and regulation of marine and estuarine resources, including the entire ecology of coastal fishing waters. For areas outside its jurisdiction, the MFC is able to coordinate and collaborate with the respective commissions and agencies on reducing impacts to marine and estuarine resources.

Regarding the MFC's jurisdiction, there are three primary laws that delegate authority to the MFC to implement its powers and duties. First, N.C.G.S. § 113-134 grants explicit rulemaking authority to the MFC. The implementation of this authority includes adopting rules to define and designate specific areas that are subject to certain restrictions for the protection of resources that in some instances are referenced in other Commissions' rules.

Second, in addition to the broad authority over marine and estuarine resources, N.C.G.S. § 113-182 authorizes the MFC to regulate marine and estuarine fishing and fisheries related to these resources. This includes the power to authorize, license, regulate, prohibit, prescribe, or restrict all forms of marine and estuarine resources with respect to gear and activities.

Finally, the MFC has the power and duty to establish standards and adopt rules for the management, protection, preservation, and enhancement of marine and estuarine resources within its jurisdiction, per N.C.G.S. § 143B-289.52. This statute further elaborates on these duties and powers through: specific powers and rulemaking authority regarding commercial and recreational fisheries and mariculture in subsection (a); rulemaking authority for specific sections and statues of Chapter 113 in subsection (b); and management and potential restriction of fish take, equipment and vessel usage, and possession and movement of marine and estuarine resources as needed to carry out its duties in subsection (c). The remainder of the statute sets requirements for the MFC's administrative powers and duties pertaining to the powers and duties of subsections (a), (b), and (c).

As mentioned above, the MFC's authority over marine and estuarine resources is subject to specific grants of authority to other state agencies, including the Department of Agriculture and Consumer Services, the Pesticide Board, the Commission of Public Health, the Environmental Management Commission (EMC), other DEQ divisions regulating air or water, and the Coastal Resources Commission. The MFC's authority is also subject to the concurrent jurisdiction of the Wildlife Resources Commission (WRC) for instances of overlap between the MFC and the WRC. The delineation of the respective authorities of these agencies highlights not only the distinct ways that each agency can affect coastal habitat, but also the need for agencies to collaborate to develop holistic solutions.

The jurisdiction of the Department of Agriculture and Consumer Services is defined in N.C.G.S. 143A Article 7 and the authorities outlined in N.C.G.S. Chapter 106. The authorities in these statutes, as it pertains to coastal habitat impacts, includes regulatory authority over agricultural runoff, insecticides, forestry, and other impacts. As a result, the MFC authority does not include regulating impacts from or connected to agriculture or forestry but could, knowing the boundaries, coordinate with the Department of Agriculture and Consumer Services on overlapping issues.

The jurisdiction of the Pesticide Board is defined in N.C.G.S. 143 Article 52. Within this Article, N.C.G.S. § 143-437 grants the Pesticide Board the powers and duties to "carry out a program of planning, environmental and biological monitoring, and of investigation into long-range needs and problems concerning pesticides." The authority prescribed in these statutes means that the MFC cannot regulate or directly monitor impacts on marine and estuarine resources from pesticides but could coordinate ongoing DMF monitoring with monitoring from the Pesticide Board to enable concurrent evaluation and future regulatory coordination.

The authority of the Commission for Public Health is defined in N.C.G.S. § 130A-29. This statute grants express rulemaking authority to implement public health programs related to sewage, sanitation, and biological agents, among others. These instances of effects are, therefore, outside of the authority of the MFC, though, impacts within the existing regulations of the Commission of Public Health are potentially less likely to impact marine and estuarine resources without also impacting public health.

The authority of the EMC is defined in N.C.G.S. 143 Article 21. Among the duties outlined in this Article, the EMC has authority over administering the federally mandated National Pollutant Discharge Elimination System (NPDES) permit and certifications pursuant to section 401 of the Clean Water Act, 33 U.S.C. § 1341(a)(1), and impacts from non-discharge related effects, animal feeding operations, and impacts to air quality. While these impacts are, as a result, not under the authority of the MFC, the CHPP implementation by the EMC can still address them. This delineation of authority also encompasses the other listed DEQ Divisions, namely, DWR and the Division of Air Quality (DAQ).

Lastly, among this list is the Coastal Resources Commission (CRC), whose authority is defined in N.C.G.S. 113A Article 7, or the Coastal Area Management Act (CAMA). This Article gives the CRC and DCM authority over development impacts to coastal wetlands and waters. As a result, the MFC has no direct authority over impacts from coastal development, though, the CRC's rules rely on the MFC's definitions of certain marine and estuarine resources and protected areas (e.g., SAV, nursery areas, anadromous fish spawning areas). DMF also reviews potential impacts from CAMA permit applications utilizing the applicable CRC and MFC rules to determine and address impacts on marine and estuarine resources. Additionally, the CHPP implementation by the CRC can also address coastal development impacts.

Supporting statutory authority

The statutory authority outlined above is further supported by additional general statutes that provide clarification of the delineation of authority and provide management tools for the MFC to fulfill its powers and duties.

N.C.G.S. § 113-134.1 clarifies the geographic extent of the MFC's authority by directing the MFC to exercise its regulatory authority over marine and estuarine resources in the Atlantic Ocean to the extent of state jurisdiction of ocean waters (three nautical miles). This statute also grants enforcement authority of these regulations to marine fisheries inspectors in these waters.

A vital tool of the MFC to be able to responsibly manage marine and estuarine resources is proclamation authority, authorized by N.C.G.S. § 113-221.1. This statute enables the MFC to delegate authority to the Fisheries Director to issue proclamations that suspend or implement rules (in whole or in part) of the MFC that may be affected by variable conditions. Of the three commissions charged with reviewing and revising CHPPs, only the MFC has proclamation authority. The MFC's delegation of proclamation authority to the Fisheries Director through adoption of a rule (e.g., 15A NCAC 03K .0201), is described in more detail in the MFC Rules and Historical Management Actions and Basis for Additional Action sections below.

CHPP and FMP statutory authority

The MFC has two statutorily authorized tools that are required to address marine and estuarine resource and habitat management issues: FMPs and CHPPs.

N.C.G.S. § 113-182.1 sets the requirements for management of commercially or recreationally significant species or fisheries that comprise state marine or estuarine resources through FMPs. Each FMP shall contain, among other items, "fishery habitat and water quality considerations consistent with Coastal Habitat Protection Plans" that have been adopted. Additionally, this statute states in subsection (f) that the MFC "shall adopt rules to implement Fishery Management Plans."

The requirements for management of critical fisheries habitats through CHPPs is set forth in N.C.G.S. § 143B 279.8, which states that the CHPPs shall "describe and classify biological systems in the habitats" among other requirements. The 2005 CHPP (Street et al., 2005) further classified the state's coastal waters into six basic fish habitat types: water column, shell bottom, SAV, soft bottom, hard bottom, and wetlands. This statute also sets forth in subsection (c) that the MFC "shall adopt rules to implement Coastal Habitat Protection Plans." The MFC has adopted numerous rules to implement North Carolina's 13 FMPs since the FRA was enacted in 1997 but has not yet exercised its authority to adopt rules to implement the CHPP.

MFC rules for habitats

The MFC has several rules in place to protect habitat, but they have been promulgated from the primary perspective of protection of FMP-covered species, such as shrimp, bay scallops, or juvenile finfish, for example. In other words, the currency used to date has not been "habitat," but the MFC has the authority to do so as explained in the first part of this examination.

The first instance of habitat-related MFC rules, is 15A NCAC Subchapter 03I, Rule .0101, which defines important fish habitat areas, including primary and secondary nursery areas, strategic habitat areas, and SAV habitat. Not only do these definitions play a role in the MFC's rules and management through FMPs, they also are referenced in the EMC and CRC rules. These definitions, therefore, are pivotal to the protection of these habitat types from fisheries, water quality, and coastal development impacts.

Subchapter 03K contains three instances of gear restrictions designed to protect SAV. These rules prohibit the use of certain rakes for clamming in established SAV beds or in areas of *Spartina alterniflora* (15A NCAC 03K .0102(2)); the use of mechanical methods for oystering or clamming in established SAV beds or in areas of *Spartina alterniflora* (03K

.0108(b)(1)); and the taking of clams by hand tongs in established SAV beds or in areas of *Spartina alterniflora* (03K .0304(a)).

Subchapter 03N establishes and provides protections for nursery areas and anadromous fish spawning areas. Rule 03N .0103 clarifies the specific bounds of a particular nursery area in relation to specific coordinates, inland-coastal boundary lines, or headwaters of the named waterbody. Rule 03N .0104 then provides protection for primary nursery areas through prohibition of the use of trawl nets, long haul seines, swipe nets, dredges, or mechanical methods used to take clams or oysters. Rule 03N .0105 provides protections for permanent and special secondary nursery areas through prohibition of trawls nets, and it allows for the fisheries director to open special secondary nursery areas to shrimp and crab trawling with certain restrictions by proclamation. Primary nursery areas as defined and designated in MFC rules, along with definitions of SAV and shellfish producing habitat, are also cited in CRC[1] and EMC[2] rules for further protections within the respective Commissions' jurisdictions. The protections found in these Commissions' rules include protections for these MFC defined resources from specific activities and through elevating surface water classifications to further protected levels, respectively.

Subchapter 03R designates the geographic locations of primary nursery areas (.0103), permanent secondary nursery areas (.0104), special secondary nursery areas (.0105), and anadromous fish spawning areas (.0115), among other areas of gear-based management. The designation, through MFC rule, of these areas began with primary nursery areas in 1977, continued with permanent and special secondary nursery areas in 1986, and finally with anadromous fish spawning areas in 2007, with a handful of amendments in the last 20 years.

Although not in and of itself a protection of habitat, the MFC's delegation of proclamation authority creates a useful tool for habitat protection and management. 15A NCAC 03H .0103 sets forth the scope of the Fisheries Director's to implement management through proclamations. It outlines the variable conditions through which the Fisheries Director can issue a proclamation if a specific variable condition is not set forth in a rule of the MFC delegating proclamation authority. This rule also makes it unlawful to violate a proclamation, which creates an important tool for enforcement.

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[1] References to MFC definitions and designations of primary nursery areas and the MFC definition of SAV within CRC Rules can be noted in 15A NCAC 07H .0208, .0209, and .1505.

[2] References to MFC definitions SAV and shellfish producing habitat within EMC Rules can be noted in the surface water classification of outstanding resource waters (ORW) in 15A NCAC 02B .0225 that provide set protections from activities within the EMC's jurisdiction based on the classification.

Historical management actions and basis for additional action

The MFC's management of impacts to the CHPP-defined habitats has occurred through species- or gear-based management actions taken through species-specific FMPs or the defined fish habitat areas, outlined above, in subchapters 03N and 03R. However, the MFC has authority to proceed with adopting rules for habitat-based management actions consistent with the CHPP.

Management actions, which can include habitat protection and habitat management, are implemented through permanent rulemaking, which can include the use of proclamations. Permanent rulemaking follows the formal process set forth in the Administrative Procedure Act, N.C.G.S. Chapter 150B. It may take up to two to three years if legislative review is required to complete this process for a rule to go into effect. In contrast, the use of proclamations allows for more responsive management, given that the variable conditions and specific restrictions have previously been set in rule through the formal rulemaking process and must be met prior to issuance. However, this requirement means that as part of the delegation of MFC rulemaking authority to the Fisheries Director, the MFC must first undergo permanent rulemaking for a specific static rule to prescribe the applicable restrictions for which the proclamation authority can be used.

Recent developments have highlighted the difficulty in achieving comprehensive protections for habitats in the MFC's implementation of protections and restrictions for habitat management. One such development is an increasing interest in SAV restoration projects across the east coast. While there is not currently a method by which public trust waters can be leased for the growout and harvest of SAV, SAV seeds can be harvested with proper permitting and replanted in restoration project areas. The success rate of such replanting is not yet well understood in North Carolina; however, the potential development of viable replanting methods could lead to much greater management needs to regulate SAV seed harvest. The existing permit does not limit the amount, season, or methodology used to harvest SAV. Unchecked, an increase in SAV harvest combined with seasonal variation among SAV beds and unknown long-term impacts from harvest activities (e.g., water quality and physical destruction), could further exacerbate SAV loss in key historical SAV areas. Additionally, outside of the currency the MFC has historically used for management—gear- and species-driven rule restrictions and protections—outlined above, the MFC has no existing rules to broadly address protections for SAV or other habitats at large that are under its authority. An additional habitat currency would enable SAV management that could benefit all estuarine fisheries in NC outside of the individual species FMP process.

Another example comes from the designation of Deep-Water Oyster Recovery Areas (DORAs) in the Eastern Oyster FMP Amendment 5, adopted by the MFC in 2025 (NCDMF, 2025). As a management strategy, designation of DORAs recognized the habitat value of deep-water oyster reefs. Mechanical oyster dredging in DORAs is prohibited, as these natural reefs are particularly susceptible to mortality from water quality impacts. The Director has proclamation authority as set forth in 15A NCAC 03K .0201(b); however, the management options apply only to the taking of oysters. This does not prevent impacts from other bottom disturbing gears (fishing and non-fishing) that can contribute to the degradation of these reefs. This concern is especially prevalent for reefs that may be identified to have little to no living oyster presence but still have a shell matrix capable of recovery. Further protections of these vacant shell bottom reefs could encourage recovery with no expense to the oyster fishery. Additionally, a habitat-based management approach could allow for coordinated FMP and non-FMP management to benefit the oyster stock from multiple avenues.

Need for habitat-based rulemaking

This analysis of MFC authority, as it pertains to direct SAV protections outside of species-specific FMPs or defined fish habitat areas, has highlighted the applicability and need to develop a rule framework to enable habitat-based management of all habitat types under the MFC's jurisdiction. Rulemaking specific to these habitats would be consistent with the statutorily defined authority of and existing rules adopted by the MFC.

Additionally, developing rules specific to these habitats would enable the MFC to address direct impacts to each type and provide management solutions for needs outside of or broader than an individual FMP. As expressed above in the SAV considerations in the Shrimp and Bay Scallop FMPs and the shell bottom considerations in the Eastern Oyster FMP, management specific to each habitat type could address impacts beyond the restrictions currently provided in each species-based rule (15A NCAC 03L .0101, 03K .0501, and 03K .0201, respectively).

Conclusion

The authority of the MFC within the context of the CHPP, as outlined above, is sufficiently broad to encompass regulating individual impacts to marine and estuarine resources, aside from the jurisdictional boundaries with other agencies and commissions. The definition of marine and estuarine resources also confirms that the MFC's authority encompasses both biotic and abiotic factors that the habitat types fall under. This authority given over the “conservation and regulation of marine and estuarine resources,” per N.C.G.S. § 113-132(a), along with the requirement of each CHPP to “recommend actions to protect and restore the habitats,” per N.C.G.S. § 143B-279.8(a)(4), implies the statutory responsibility of the MFC to act to protect and conserve the CHPP-defined habitats.

As a result of this analysis, this CHPP amendment recommends the initiation of the formal MFC rulemaking process to develop a CHPP habitat-based rule framework following the adoption of the CHPP amendment. This rulemaking process, consistent with the Administrative Procedure Act, would include significant coordination between and input from the MFC, DMF, regulated stakeholders, and the general public.

Recommended Action

DMF will initiate formal rulemaking to develop a CHPP habitat-based rule framework through development of a rulemaking issue paper beginning in 2027. This issue paper will address the need for rules specific to each habitat type, including consideration of regulatory needs for SAV harvest and transplanting for restoration projects, considerations regarding gear and activity impacts in DORAs, and parameters for establishing criteria for habitat-based management. The public, stakeholder, and advisory committee comments related to the rulemaking issue paper will be brought to the Habitat and Water Quality Advisory Committee to evaluate and develop proposed management options for the rule frameworks regarding SAV and the other habitats within the MFC’s jurisdiction.

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