PROTECTION OF CRITICAL SEA GRASS HABITAT THROUGH SHRIMP TRAWL AREA CLOSURES

March 25, 2024

ISSUE

Providing additional protection for critical sea grass habitat through shrimp trawl area closures.

II. ORIGINATION

The North Carolina Shrimp Fishery Management Plan (FMP) Amendment 2 and the North Carolina Marine Fisheries Commission (NCMFC).

III. BACKGROUND

In February 2022, the NCMFC adopted the Shrimp Fishery Management Plan Amendment 2. With the adoption of Amendment 2 several management strategies were implemented to further reduce bycatch of non-target species and minimize ecosystem impacts (NCDMF 2022). The commission's management strategy included adaptive management for future action to address issues related to submerged aquatic vegetation (SAV) identified through Department collaboration with the Coastal Habitat Protection Plan (CHPP) support staff, the Habitat and Water Quality Advisory Committee (AC), and stakeholder groups. Adaptive management combines management and monitoring, with the aim of improving decision-making over time as more information becomes available. Adaptive management uses an iterative learning process to improve management outcomes, allows flexibility in decision making, and incorporates new information to accommodate alternative and/or additional actions (Holling 1978; Allan and Stankey 2009; Smith et al. 2013). In the context of North Carolina FMPs, adaptive management is an optional management framework that allows for specific management changes to be implemented between FMP reviews under specified conditions to accomplish the goal and objectives of the plan.

This issue paper uses the adaptive management strategy adopted in Amendment 2 to further protect SAV habitat in North Carolina, by identifying unprotected SAV habitat using updated imagery and providing additional protection through shrimp trawl area closures. As new imagery becomes available, shrimp trawl lines may be created or adjusted to encompass additional SAV habitat via revision of existing proclamations (NCMFC Rule 15A NCAC 03L .0101) or suspending of rules via proclamation (NCMFC Rule 15A NCAC 03I .0102). The Atlantic State Marine Fisheries Commission (ASMFC) SAV policy encourages state agencies to implement regular statewide SAV monitoring programs every five years to identify changes in SAV health and abundance (Havel and ASMFC 2018). Additionally, the South Atlantic Fishery Management Council (SAFMC) strongly recommends that a comprehensive adaptive management strategy be developed as a long-term protection strategy (SAMFC 2014). The 2021 Amendment to the CHPP recommends coast-wide monitoring occur every five years to evaluate the success of management actions and determine contributing relationships between changes in SAV species extent, distribution, and composition (Field et al 2020; NCDEQ 2021). The Albemarle-Pamlico National Estuary Partnership coordinates annual aerial and ground-based monitoring statewide on a rotating schedule during the spring and fall each year.

North Carolina is home to the largest documented polyhaline and mesohaline (brackish) SAV ecosystem on the Atlantic seaboard of North America (Bartenfelder et al. 2022). NCMFC Rule 15A NCAC 03I .0101 (4)(i) defines SAV as fish habitat dominated by one or more species of underwater vascular plants and occurs in subtidal and intertidal zones. SAV habitat provides refuge, forage, corridor, spawning, and nursery areas for many organisms including flounder (*Paralichthys* spp.), red drum (*Sciaenops ocellatus*), spotted seatrout (*Cynoscion nebulosus*), snapper, grouper, bay scallops (*Argopecten irradians*), blue crab (*Callinectes sapidus*), and penaeid shrimp (NCDMF 2021). Fish and invertebrate use of SAV differs spatially and temporally due to distribution ranges, time of recruitment, and life histories as well as seasonal abundance patterns of SAV (Micheli and Peterson 1999; Minello 1999; NOAA 2001; NCDEQ 2016). The SAFMC designated SAV as Essential Fish Habitat (EFH) for shrimp, snapper and grouper species, and spiny lobster (*Panulirus argus*), and Essential Fish Habitat Areas of Particular Concern for shrimp and snapper and grouper species (SAFMC 2021). The Mid-Atlantic Fishery Management Council designated SAV as Habitat Areas of Particular Concerns for summer flounder (*P. dentatus*; MAFMC 2016).

Field sampling of Strategic Habitat Areas (SHAs) in regions 3 and 4 (Core Sound through Brunswick County) found that SHAs had a greater abundance of SAV dependent species [Penaeid shrimp, southern flounder (*P. lethostigma*), red drum, silver perch (*Bidyanus bidyanus*), blue crab, etc.], as well as SAV (NCDMF 2023), supporting the critical importance of SAV for fishery species (Deaton et al. 2023). SAV also provides other important ecosystem functions such as increasing structural complexity, sediment and shoreline stabilization, improving water quality, primary productivity, nutrient cycling, and carbon sequestration. Beyond its ecological value, SAV provides significant market and nonmarket value to the state of North Carolina (Sutherland et al. 2021). In the Albemarle-Pamlico estuary alone, a five percent decadal loss in SAV is estimated to account for $8.6 million in losses a year in commercial fishing, recreational fishing, property value, and carbon sequestration. For a complete review of habitat requirements, species composition, ecological and biological functions, fish use, and status of SAV habitat see the North Carolina CHPP source document (NCDEQ 2016) and the 2021 Amendment (NCDEQ 2021).

In North Carolina, beds of SAV occur in subtidal and intertidal areas of sheltered estuarine and riverine waters where there is suitable sediment, adequate light reaching the bottom, and moderate to negligible current disturbance (Ferguson and Wood 1990, 1994; Thayer et al. 1984). SAV habitat is primarily located in shallow subtidal water (<6 feet) and individual species vary in their occurrence as salinity, depth, and water clarity change (NCDEQ 2016, 2021). The distribution, abundance, and density of SAV varies seasonally and annually (Dawes et al. 1995; Fonseca et al. 1998; SAFMC 1998; Thayer et al. 1984). Therefore, historical as well as current occurrences need to be considered to determine locations of viable seagrass habitat (SAFMC 1998).

Since the 1980s various mapping and monitoring projects have been conducted by several universities and state and federal agencies to document the extent of SAV in North Carolina (NCDMF 2021). More recently, aerial survey and ground-based monitoring data were collected in the high salinity waters from Manteo to Wrightsville Beach from 2020 to 2021. These maps were merged with previous data to comprise the historical or maximum known extent of SAV along North Carolina's coast (commonly referred to as the SAV mosaic). The 2021 Amendment to the CHPP divides the mosaic into nine SAV regions to best represent regional variability of

waterbodies (Figure 1). For a complete review of coastal habitat mapping and SAV monitoring, see Amendment 1 to the CHPP (NCDEQ 2021).

While there are several major threats to SAV (i.e., eutrophication, sedimentation, pollution, coastal development, climate change, etc.), impacts from mobile bottom disturbing fishing gears is of particular concern. It has been well documented that bottom disturbing gears such as trawls can significantly reduce habitat complexity and community composition from the physical disruption of the habitat to the removal of species (Dorsey and Pederson 1998; Auster 1998; NCDMF 1999; SAFMC 2014; Hiddink et al. 2017; Sciberras et al. 2018; Barnette 2001; NRC 2002; NCDEQ 2016, 2021). Otter trawls, the primary fishing gear used to harvest shrimp in NC, are conical nets pulled behind vessels along the benthos (Stewart and Dietz 2021; NCDMF 2022). Shearing or cutting of SAV leaves, flowers, or seeds, and uprooting of the plant may occur from the sweep of the net or the digging of the trawl doors into the sediment (ASMFC 2000). Skimmer trawls, another common gear used to harvest shrimp in North Carolina, uses metal skids to keep frames with attached nets off the bottom as they are fished. However, damage to the bottom can still occur if the gear is improperly tuned or designed (Hein and Meier 1995). Additionally, skimmer trawls are effectively fished in shallow waters, raising concerns with propeller scarring. Both gears increase turbidity, which can slow the growth of primary (algae and plants) and secondary producers (organisms that consume other organisms), limit nutrient regeneration, and disrupt the feeding relationships of all organisms within the ecosystem (the food web). For a comprehensive review of the impact of trawling in North Carolina waters, see NCDMF (1999, 2014, 2022), and NCDEQ (2016, 2021).

IV. AUTHORITY

North Carolina General Statutes
§ 113134 RULES
§ 113-173 RECREATIONAL COMMERCIAL GEAR LICENSE
§ 113182 REGULATION OF FISHING AND FISHERIES
§ 113-182.1 FISHERY MANAGEMENT PLANS
§ 113-221.1 PROCLAMATIONS; EMERGENCY REVIEW
§ 143B-289.52 MARINE FISHERIES COMMISSION – POWERS AND DUTIES

North Carolina Marine Fisheries Commission Rules
15A NCAC 03H .0103 PROCLAMATIONS, GENERAL
15A NCAC 03J .0104 TRAWL NETS
15A NCAC 03L .0101 SHRIMP HARVEST RESTRICTIONS
15A NCAC 03L .0103 PROHIBITED NETS, MESH LENGTHS AND AREAS

V. DISCUSSION

Specific habitat protections for SAV have been implemented as part of FMPs for shrimp (NCDMF 2006, 2015, 2022), bay scallop (NCDMF 2007, 2015), hard clam (NCDMF 2008, 2017), and blue crab (NCDMF 1998; 2020). In addition, the 2006 Shrimp FMP included consideration of a strategy to expand areas where dredging and trawling is prohibited to allow some recovery of SAV and shell bottom where those habitats historically occurred (NCDMF 2006). Trawling was prohibited

in the Albemarle and Currituck sounds due to user conflicts, but the prohibition also provided ancillary protections for SAV habitat (NCMFC Rule 15A NCAC 03J .0104). Trawling and dredging is prohibited in SAV beds on the eastern side of Pamlico, Core, and Back sounds through a trawl net prohibited area designation (NCMFC Rule 15A NCAC 03R .0106). SAV beds north of the Intracoastal Waterway (IWW) and on the western end of Bogue Sound are protected via proclamation (NCDMF 2007). With the adoption of Amendment 2 to the Shrimp FMP, trawling in Bogue Sound was further restricted to the IWW only to protect SAV habitat while continuing to allow shrimp trawling. SAV in the New River is also protected within no trawl areas below the Highway 172 Bridge. Crab Spawning Sanctuaries (NCMFC Rule 15A NCAC 03L .0205) and inlet trawling restrictions (NCMFC Rule 15A NCAC 03J .0401) provide a "no trawl corridor" around inlets that protect crabs and allows migration of sub-adult fish to the ocean. All trawling was permanently prohibited in Crab Spawning Sanctuaries with the adoption of Amendment 2 to the Shrimp FMP; prior to its adoption, trawling was limited to November through February. See Shrimp Fishery Management FMP Amendment 2 (NCDMF 2022) for additional area restrictions that prohibit trawls in North Carolina's coastal and estuarine waters.

Because the current understanding of SAV distribution is based on historic mapping efforts (1981-2021), maps may not represent the actual, real-time extent of SAV for a given year but represent potential SAV habitat. Unsworth et al. (2018) notes seagrass conservation targets should incorporate future potential distribution of seagrasses and account for physiological responses to shifting environmental conditions that may result in species range-changes, localized invasions and extinctions, and shifts in structure and function of SAV habitat. Therefore, any shrimp trawl closures implemented to protect SAV must be broad enough to capture potential SAV habitat distribution.

One method to promote protection and recovery of SAV habitat is the creation of management buffers around important habitats. The overall goal of a buffer is to achieve sustainable use of natural resources that benefit both local communities and resources, while limiting the impact of destructive activities that take place outside of a protected area (Sanderson and Bird 1998; Martino 2011; Ebregt and Greve 2000). Terrestrial buffers are used by the North Carolina Environmental Management and Coastal Resources commissions to protect wetlands and water quality (NCDEQ 2016). In the marine environment, buffers have been used in conjunction with Marine Protected Areas (MPA) to protect important marine and coastal ecosystems as well as create migration corridors. Increasing connectivity between SAV habitats and other essential fish habitats can further reduce habitat fragmentation (edge effect) which can negatively impact community structure and nursery value (Benitez-Malvido and Arroyo-Rodriguez 2008). As a part of the Hard Clam FMP, adaptive management is used to modify mechanical clam harvest areas (MCHAs) to allow a buffer between dredged areas and SAV and oyster beds (NCDMF 2008, 2017). Similar buffers between open shrimp trawl areas and the maximum known extent of SAV habitat should be established as a means of protecting SAV habitat. More expansive closures are needed to reduce the impact of turbidity and sedimentation associated with bottom disturbing gear. Excessive sedimentation from bottom disturbing fishing gear and propeller wash can bury SAV. Increased turbidity further reduces water clarity, SAV growth, productivity, and survival (NCDEQ 2016). Furthermore, buffers that are expanded to make use of existing navigation aids, landmarks, or management boundaries accomplish the goal of increased buffers while also helping to promote compliance and simplify enforcement.

The 2021 Amendment to the CHPP cites the need to further protect and restore SAV as new mapping data become available (NCDEQ 2021). At the time of the amendment, the maximum extent of SAV along North Carolina's coast was 191,155 acres (1981-2015). With the additional mapping data from 2020 to 2021, the maximum known extent of SAV habitat is approximately 196,190 acres (Table 2; Figure 1). While closing areas of critical SAV habitat allows for calculation of how much additional habitat will be protected from direct physical disturbance from shrimp trawls, overall and additional benefits to SAV are difficult to quantify. In the absence of shrimp trawls, SAV growth may continue to be impaired by poor water quality, climate change, disease, or other natural disturbances. It's important to note that while broad scale closures are often better for conservation and biodiversity (Ebregt and Greve 2000), their creation may prevent trawling in productive areas with no SAV and disproportionately impact some user groups (i.e., small vessels, Recreational Commercial Gear License holders). The division does not have shrimp trawl effort data specific for each SAV region; thus, the precise economic impacts to the shrimp trawl fishery cannot be estimated but effort was made to balance SAV habitat protection and impacts to fishermen when determining closure boundaries.

VI. MANAGEMENT OPTIONS AND IMPACTS

(+ Potential positive impact of action)
(- Potential negative impact of action)

SAV Region 1 – Currituck Sound and Back Bay

Region 1 extends from Back Bay south to Point Harbor and encompasses all of Currituck Sound. Based on the most recent SAV mosaic (1981-2021), there are 21,613 acres of known SAV habitat in this region (Table 2; Figure 1). Shrimp trawling is prohibited throughout Currituck Sound [NCMFC Rule 15A NCAC 03J .0104(b)(3)]; no additional shrimp trawl closures are needed to protect SAV habitat in this region.

SAV Region 2 – Albemarle / Roanoke Sound

Region 2 extends from the Albemarle Sound to the Melvin R. Daniels Bridge (HWY 64) in the Roanoke Sound and includes the Alligator River and portions of the Croatan Sound (Figure 1). There are 12,872 acres of known SAV habitat in this region of which 42.1% is unprotected (Table 2). Shrimp trawling is prohibited in the Albemarle Sound, and throughout much of Roanoke Sound [NCMFC Rule 15A NCAC 03J .0104(b)(3)]. Special secondary nursery areas (SSNA) are designated in Kitty Hawk/ Buzzards, and Shallowbag bays. While these SSNAs have not opened since 2017, establishing shrimp trawl prohibited areas will provide permanent protection to known SAV habitat within these SSNAs.

Shallow water and other impediments limit trawling in this region; however, there is a considerable amount of unprotected SAV habitat in waters surrounding Colington and Roanoke islands. Creating a new no shrimp trawl line from Weir Point to the Manns Harbor Bridge will protect SAV habitat along the western shoreline of Roanoke Island and increase connectivity (Figure 2). Further restricting trawling to the Roanoke Sound Channel will increase connectivity between SAV habitats and create clear boundaries for enforcement (Figure 2). Allowing trawling within 100 feet on either side of the channel will allow trawlers space to safely maneuver their vessels and reduce user group conflict. While broad shrimp trawl closures may further limit small

commercial and recreational vessels, they provide the greatest protection to SAV habitat. Complementary closures in Region 5 (Roanoke Sound to Ocracoke Inlet) should be considered in conjunction with closures in Region 2 to create a continuous closed area of SAV habitats across these regions (Figure 5).

1. Prohibit shrimp trawling along the western shoreline of Roanoke Island from Weir Point to the Manns Harbor Bridge.
   + Decrease damage to SAV from shrimp trawls and allow potential for SAV recovery in formerly occupied areas
   + Creates continuous closed areas between SAV habitats among regions
   - Decreases some traditional shrimp trawling areas
   - SAV mapping reflects maximum known extent, so creation of broad no shrimp trawl areas may prevent shrimp trawling in areas that currently do not have SAV

2. Limit shrimp trawling to main channel only (100 ft either side) of the Roanoke Sound Channel.
   + Decrease damage to SAV from shrimp trawls and allow potential for SAV recovery in formerly occupied areas
   + Creates continuous closed areas between SAV habitats among regions
   + Provides access to fishermen and has minimal impact to soft bottom habitats that are dredged for navigation
   - Decreases some traditional shrimp trawling areas
   - Modification of existing closure lines could cause confusion
   - SAV mapping reflects maximum known extent, so creation of broad no shrimp trawl areas may prevent shrimp trawling in areas that currently do not have SAV

SAV Region 3 – Tar-Pamlico and Neuse rivers

Region 3 stretches across three counties (Beaufort, Pamlico, and Carteret) and encompasses the Pungo, Tar-Pamlico, Neuse, and Bay rivers and their tributaries (Figures 1 and 3). There are 4,581 acres of known SAV habitat within this region, of which 11.6% is unprotected (Table 2). In the Pungo River, shrimp trawling is prohibited upstream of a line from Currituck Point running southwesterly to Wades Point [NCMFC Rule 15A NCAC 03R .0114(A)]. All waters upstream of a line running from the entrance of Goose Creek northeasterly to Wades Point are closed to trawling in the Tar-Pamlico River [NCMFC Rule 15A NCAC 03R .0114(B)]. In the Neuse River, shrimp trawling is prohibited upstream of a line running northerly from Cherry Point to Wilkinson Point [NCMFC Rule 15A NCAC 03R .0114(C)]. Most of the tributaries and bays in this region are designated as primary and secondary nursery areas; however, trawling is allowed in Bay River as well as parts of Goose Creek, Clubfoot Creek, Adams Creek, South River, and Turnagain Bay.

Shrimp trawling is prohibited in designated pot areas in the Pamlico, Bay, and Neuse rivers from June 1 to November 30 in less than six feet of water [NCMFC Rules 15A NCAC 03J .0104(b)(6), 03J .0301(a)(2), and 03R .0107(a)(5)(6)(7)(8)]. Establishing permanent shrimp trawl closures in select designated pot areas where SAV is known to occur will provide permanent protection to SAV habitat and further reduce conflict between shrimp trawls and crab pots. Permanent shrimp trawl closures are recommended for designated pot areas in Vandemere Creek, Shell Bay, White Perch Bay, Bonner Bay, Fisherman's Bay, Turnagain Bay, and South River (Figure 3).

3. Prohibit shrimp trawling year-round in designated pot areas in Vandemere Creek, Shell Bay, White Perch Bay, Bonner Bay, Fisherman's Bay, Turnagain Bay, and South River.
   + Decrease damage to SAV from shrimp trawls and allow for SAV recovery in formerly occupied areas
   + Provides additional protection to critical shell bottom habitat
   + Minimal impact to fishermen since areas are not used extensively
   + Reduce gear conflicts between trawls and crab pots
   - Decreases some traditional shrimp trawling areas
   - SAV mapping reflects maximum known extent, so creation of broad no shrimp trawl areas may prevent shrimp trawling in areas that currently do not have SAV

<u>SAV Region 4 – Pamlico Sound</u>

Region 4 encompasses most of Pamlico Sound, spanning from the Manns Harbor Bridge (HWY 64) to the mouth of Neuse River and Cedar Island (Figures 1 and 4). The eastern side of Pamlico Sound (Outer Banks) is in SAV Region 5 and connected to SAV Regions 2, 3, and 6. There are 712 acres of known SAV habitat in Region 4, of which 68.8% is unprotected (Table 2). Stumpy Point Bay is closed to trawling from Drain Point to a line running westerly to Kazer Point [NCMFC Rule 15A NCAC 03R .0106(2)]. Most of the feeder creeks and bays along the Hyde County shoreline are classified as Primary Nursey Areas (PNA) and Secondary Nursery Areas (SNA). It is unlawful to use trawl nets in PNAs and SNAs (NCMFC Rule 15A NCAC 03N .0104 and .0105). Trawling is also prohibited in three military danger zones and restricted areas located near the mouths of Long Shoal and Bay rivers as well as Piney Island.

SAV habitat has been documented along the northwestern shoreline of Dare County from Manns Harbor to Callaghan Creek and from Long Wretch Creek to Stumpy Point (Figure 4). Establishing straight-line closures along the shoreline would protect known SAV habitat, simplify enforcement, and have minimal impact to fishermen in the Croatan Sound (Figure 4). Expanding the Stumpy Point shrimp trawl closure to include the area from Drain Point to Sandy Point will further protect SAV habitat south of Wild Boar Point. Additional closures in Sandy, Parched Corn, Berrys, East Bluff, and West Bluff bays as well as the mouths of Burrus, Middletown, Back, Brooks, and Middle creeks should also be considered (Figure 4). Establishing prescribed area closures along the western Hyde County shoreline will further protect SAV habitat and simplify enforcement (Figure 4).

4. Create and expand existing closures along the western shoreline of Dare and Hyde counties to include the bays and tributaries from Manns Harbor to West Bluff Bay.
   + Decrease damage to SAV from shrimp trawls and allow for SAV recovery in formerly occupied areas
   + Minimal impact to fishermen since areas are not used extensively
   + Reduce gear conflicts between trawls and crab pots
   - Decreases some traditional shrimp trawling areas
   - SAV mapping reflects maximum known extent, so creation of broad no shrimp trawl areas may prevent shrimp trawling in areas that currently do not have SAV

SAV Region 5 – Roanoke Sound to Ocracoke Inlet

Region 5 extends from the Manns Harbor Bridge (HWY 64) south to Ocracoke Inlet and includes portions of the Roanoke and Pamlico sounds (Figures 1 and 5). There are 103,856 acres of known SAV habitat within this region; the largest acreage of SAV habitat in North Carolina (Table 2). Much of the eastern side of the Pamlico Sound is closed to trawling to protect SAV habitat (15A NCAC 03R .0106 (1)). Shrimp trawling is prohibited in the Wanchese Marshes Seed Oyster Management Area [NCMFC Rule 15A NCAC 03R .0116(2)]. Oregon, Hatteras, and Ocracoke inlets are designated as crab spawning sanctuaries. Amendment 2 to the Shrimp FMP permanently closed all crab spawning sanctuaries to trawling (NCDMF 2022; Proclamation SH-1-2023).

Because of their proximity and connection, shrimp trawl closures in SAV regions 2 and 5 should complement each other to increase connectivity as well as simplify enforcement and compliance. Therefore, shrimp trawling should be further restricted to within 100 feet on either side of the channel running from the southeastern shore of Wanchese to the Bodie Island marshes (Figure 5). Along the western shore of Roanoke Island, shrimp trawl closures should extend south of the Manns Harbor Bridge to the Wanchese Seed Oyster Management Area at Cedar Bush Bay to align with proposed closures in Region 2 (Figure 5). To protect the remaining SAV habitat along the western shoreline of the Outer Banks, the existing trawl net prohibited area should be extended to the west behind Salvo and Buxton Harbor (Figure 5).

5. Limit shrimp trawling to main channel only (100 ft either side) of the southeastern shore of Wanchese to the Bodie Island marshes.
   + Decrease damage to SAV from shrimp trawls and allow for SAV recovery in formerly occupied areas
   + Creates continuous closed areas between SAV habitats among regions
   + Provides access to fishermen and has minimal impact to soft bottom habitats that are dredged for navigation
   - Decreases some traditional shrimp trawling areas
   - SAV mapping reflects maximum known extent, so creation of broad no shrimp trawl areas may prevent shrimp trawling in areas that currently do not have SAV

6. Prohibit trawling along the western shore of Roanoke Island from the Manns Harbor Bridge to northern most tip of the Wanchese Seed Oyster Management Area.
   + Decrease damage to SAV from shrimp trawls and allow for SAV recovery in formerly occupied areas
   + Creates continuous closed areas between SAV habitats among regions
   + Provides access to fishermen and has minimal impact to soft bottom habitats that are dredged for navigation
   - Decreases some traditional shrimp trawling areas
   - Modification of existing closure lines could cause confusion
   - SAV mapping reflects maximum known extent, so creation of broad no shrimp trawl areas may prevent shrimp trawling in areas that currently do not have SAV

7. Modify the existing trawl net prohibited area along the Outer Banks to include portions of the western shoreline behind Salvo and Buxton Harbor.

+ Decrease damage to SAV from shrimp trawls and allow for SAV recovery in formerly occupied areas
+ Creates continuous closed areas between SAV habitats among regions
+ Minimal impact to fishermen since areas are not used extensively
- Modification of existing closure lines could cause confusion
- SAV mapping reflects maximum known extent, so creation of broad no shrimp trawl areas may prevent shrimp trawling in areas that currently do not have SAV

SAV Region 6 – Core Sound

Region 6 contains the second largest known SAV habitat within the state; however, the vast majority of SAV in this region is unprotected (Figures 1 and 6). There are 37,645 acres of known SAV and SAV habitat, of which 35.5% is unprotected (Table 2). The area on the eastern side of Core Sound is designated as a no trawl area by NCMFC Rule 15A NCAC 03R .0106 (1) and is in place to protect SAV but can be opened to peeler crab trawling by proclamation [NCMFC Rule 15A NCAC 03J .0104 (4)]. On the mainland side of Core Sound, Jarrett Bay, Brett Bay, Nelson Bay, Thorofare-Barry Bay, and Cedar Island Bay are designated as SSNAs; however, they have not opened since 2018 (Proclamation SH-6-2018). Prior to the adoption of Amendment 2 to the Shrimp FMP, West Bay was managed in conjunction with SSNAs, last opening in 2017 (NCDMF 2022). SSNA openings based on division sampling were eliminated as a part of Amendment 2; thus, openings in West Bay no longer occur. All other tributaries and bays in Core Sound are designated as PNAs. Ophelia and Drum inlets are designated as crab spawning sanctuaries and are closed to trawling.

Limiting shrimp trawling to the MCHA in Core Sound (Figure 6) will increase connectivity between SAV habitats among regions as well as simplify enforcement and compliance.

8. Prohibit trawling in Core Sound, and its tributaries except for the MCHA.
    + Decrease damage to SAV habitat from shrimp trawls
    + Creates continuous closed areas between SAV habitats among regions
    + Provides access to resource and has minimal impact to soft bottom habitats that are impacted by other fisheries and or dredged for navigation
    - Decreases some traditional shrimp trawling areas
    - SAV mapping reflects maximum known extent, so creation of broad no shrimp trawl areas may prevent shrimp trawling in areas that currently do not have SAV
    - Modification of existing closure lines could cause confusion

SAV Region 7 – Back Sound to Sanders Island

Region 7 stretches across Carteret and Onslow counites and comprises 12,265 acres of known SAV habitat, of which 45.4% is unprotected (Table 2; Figures 1 and 7). Amendment 2 to the Shrimp FMP prohibited trawling in Bogue Sound except for the IWW and permanently closed crab spawning sanctuaries located at Barden, Beaufort, and Bogue inlets to trawling. The North River SSNA may be open to trawling at the Director's discretion; however, it has not opened since 2000 (Proclamation SH-14-2000). The bays and tributaries that surround the North River, Newport River, White Oak River, Bear Creek, and Queens Creek are designated as either PNAs or SNAs, and are closed to trawling.

Due to the patchy distribution of SAV in this region, it is difficult to designate areas where trawling could occur without overlapping SAV habitat. Broader shrimp trawl closures providing a buffer between open areas and SAV habitat should be considered, particularly along the shoreline of the Straits and Back Sound (Figure 7). Further limiting trawling to the North River MCHA will protect SAV along the shoreline and continue to allow shrimp trawling and have minimal impact to soft bottom habitats that are impacted by other fisheries or dredged for navigation (Figure 7). Additional shrimp trawl closures are recommended along the eastern shoreline of Newport River off Russells and Wading creeks. While SAV is less extensive in the White Oak River, additional shrimp trawl closures below the Highway 24 Bridge should be considered (Figure 7). Further limiting trawling to the IWW from Cedar Point to Sanders Island will provide additional protection to SAV habitat and increase connectivity among regions (Figure 7).

9. Prohibit shrimp trawling in the Straits, Back Sound, and their tributaries.
   + Decrease damage to SAV from shrimp trawls and allow for SAV recovery in formerly occupied areas
   + Creates continuous closed areas between regions and SAV habitats
   + Provides additional protection to critical shell bottom habitat
   + Minimal impact to fishermen since areas are not used extensively
   - Decreases some traditional shrimp trawling areas
   - Modification of existing closure lines could cause confusion
   - SAV mapping reflects maximum known extent, so creation of broad no shrimp trawl areas may prevent shrimp trawling in areas that currently do not have SAV

10. Modify existing or create new shrimp trawl closure lines in the North and Newport rivers.
   + Decrease damage to SAV from shrimp trawls and allow for SAV recovery in formerly occupied areas
   + Creates continuous closed areas between regions and SAV habitats
   + Provides access to resource and has minimal impact to soft bottom habitats that are impacted by other fisheries and or dredged for navigation
   - Decreases some traditional shrimp trawling areas
   - SAV mapping reflects maximum known extent, so creation of broad no shrimp trawl areas may prevent shrimp trawling in areas that currently do not have SAV
   - Modification of existing closure lines could cause confusion

11. Limit shrimp trawling to IWW from Cedar Point to Sanders Island.
   + Decrease damage to SAV from shrimp trawls and allow for SAV recovery in formerly occupied areas
   + Creates continuous closed areas between regions and SAV habitats
   + Provides access to resource and has minimal impact to soft bottom habitats that are dredged for navigation
   - Decreases some traditional shrimp trawling areas
   - Modification of existing closure lines could cause confusion
   - SAV mapping reflects maximum known extent, so creation of broad no shrimp trawl areas may prevent shrimp trawling in areas that currently do not have SAV

SAV Region 8 – Brown's Inlet to Snow's Cut

Region 8 extends from Brown's Inlet to Carolina Beach (Snow's Cut) and encompasses the New River and Topsail, Stump, and Middle Sounds (Figures 1 and 8). Within this region there are 2,646 acres of known SAV habitat, of which 17.9% is unprotected (Table 2). The majority of SAV habitat in the region is in the New River and along the IWW (Stump and Topsail sounds) and is largely protected under existing rules and proclamations. In the New River, trawling is prohibited in all tributary creeks downstream of the closure line at Grey and Wards Point and in the military restricted zone that extends from the western shoreline of the river below Grey Point to the northeastern shoreline of Stones Bay. The waters upstream of the Highway 172 bridge are designated as SSNA and can be opened to the use of skimmer trawls only from September 1 to November 30. Below the Highway 172 Bridge, trawling is prohibited in all bays and tributary creeks and additional areas were closed to match the MCHA in 2017 to protect SAV (Proclamation SH-2-2017).

Trawling is restricted to the main channel throughout the IWW (Figure 8). The area from Marker #105 to the Wrightsville Beach drawbridge was closed to trawling following the adoption of the 2006 Shrimp FMP. Within the waters from Rich Inlet to Carolina Beach, the division maintains six shellfish management areas (SMA) as well as an oyster sanctuary at the mouth of Hewlett's Creek, all of which are closed to trawling. The remainder of the feeder creeks and bays along the IWW are classified as PNAs or SNAs and are closed to trawling. Trawling is further prohibited in the crab spawning sanctuaries located at Browns, New, Topsail, Rich, Masonboro, and Carolina Beach inlets.

The current no shrimp trawl lines in the New River MCHA could be modified to fully encompass documented SAV habitat at Hall Point (Figure 8). While depth limits effort in these areas, the existing lines could be refined via revision of existing proclamations. Above the Highway 172 Bridge, the creation of new shrimp trawl closure lines would be needed to protect SAV habitat at the mouths of Stones and Everett creeks as well as Pollocks Point. Establishing straight-line closures using channel markers and landmarks would simplify enforcement and compliance. Additional closures could be implemented to protect SAV Habitat between Wards and Lowes points (Figure 8). Additional closures are recommended in Chadwick Bay to protect SAV along the shoreline from Fullard Creek to Swan Point. There would be minimal to no impact to fishermen, as Chadwick Bay is a SSNA and last opened in 2012. The proposed closures would also protect several clutch planting sites off of Roses Point. Outside of the New River, no additional shrimp trawl closures are needed along the IWW.

12. Modify existing or create new shrimp trawl closure lines in the New River.
    + Decrease damage to SAV from shrimp trawls and allow for SAV recovery in formerly occupied areas
    + Minimal impact to fishermen since areas are not used extensively
    + Identifying clear boundaries could prevent damage gear and habitat
    - Decreases some traditional shrimp trawling areas
    - Modification of existing closure lines could cause confusion
    - SAV mapping reflects maximum known extent, so creation of broad no shrimp trawl areas may prevent shrimp trawling in areas that currently do not have SAV

SAV Region 9 – Cape Fear River to NC-SC Stateline

Region 9 spans across New Hanover and Brunswick counties and encompasses the Cape Fear River and the IWW to the NC-SC Stateline (Figure 1). Below Snow's Cut, trawling is allowed in the main river channel and behind many of the spoil islands. The areas known as the "Dow Chemical Bay" and "Radar Bay" are closed to trawling. Trawling, and all other boating activity, is prohibited in the military restricted area at the Sunny Point Military Ocean Terminal. Trawling in the SSNA behind Kure Beach was prohibited following rule changes implemented in the May 2021 Revision to Amendment 1 that re-designated it as a permanent SNA (NCDMF 2021). The bays south of the Fort Fisher Ferry Terminal (First Bay or "the Basin", Second Bay, Buzzard's Bay) and behind Bald Head Island (Cape and Bay creeks) were designated as Trawl Net Prohibited areas with the implementation of the 2006 Shrimp FMP (NCDMF 2006). Trawling is further prohibited in the crab spawning sanctuary at the Cape Fear River Inlet.

Trawling in Brunswick County is primarily limited to the main channel of the IWW. Most of the shoreline bordering the IWW is designated as nursery areas and are closed to trawling. With the adoption of Amendment 1, shrimp trawling was prohibited in the IWW from the Sunset Beach Bridge to the South Carolina line, including the Shallotte River, Eastern Channel, and lower Calabash River to protect small shrimp and reduce bycatch. Following rule changes implemented in the May 2021 Revision to Amendment 1, the Lockwood Folly River and Saucepan Creek SSNAs were re-designated as permanent SNAs (NCDMF 2021). With the adoption of Amendment 2, the Carolina Boat Basin was closed to trawling (NCDMF 2022). The remainder of the feeder creeks and bays along the IWW are classified as PNAs or SNAs and are closed to trawling. Trawling is prohibited in crab spawning sanctuaries located at Shallotte River Inlet, Lockwood Folly Inlet, and Tubbs Inlet.

Elevated tidal heights in the southern portion of the state increase turbidity and light attenuation, limiting SAV growth in the region. No additional shrimp trawl closures are recommended in Region 9 due to the absence of documented SAV habitat.

VII. RECOMMENDATIONS

NCDMF: Implement shrimp trawl closures specified in this paper to further protect SAV and SAV habitat from physical damage, turbidity, and sedimentation.

The 2021 Amendment to the CHPP cites the need to further protect and restore SAV as new mapping data become available (NCDEQ 2021). The 2022 Shrimp FMP Amendment 2 adopted a strategy to provide recommendations for future action through adaptive management to address SAV issues identified through collaboration of the Division, CHPP support staff, Habitat and Water Quality AC, and stakeholder groups. In support of the CHPP, NCDMF recommends creating management buffers to protect SAV habitat from physical disturbance, turbidity, and sedimentation by implementing broad, region specific shrimp trawl closures. Specifically, the NCDMF recommends management options 1-12. The division also recommends that issue paper be referred to the regional and Shellfish/Crustation ACs for further input before making final recommendations to the MFC.

Habitat and Water Quality AC: Endorse the division's recommendations to protect existing and prospective SAV habitat. In portions of proposed closure areas where SAV cannot be supported, the division should work with stakeholders to maximize SAV protection while reducing impact on stakeholder to maximize SAV protection while reducing impact on stakeholder use. A commitment should be made to quantify the status of SAV habitat in NC and a monitoring program to measure progress of these programs.

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August 1, 2023
November 8, 2023
November 28, 2023
December 20, 2023
January 31, 2024
March 25, 2024

Tables

Table 1. Data sources, mapping years, methodology, and extent of each individual submerged aquatic vegetation (SAV) mapping event used to create the North Carolina SAV Mosaic, 1981 to 2021.

Data Source	Mapping Year(s)	Methodology	Mapping Extent
Carraway & Priddy (1983)	1981	Maps of SAV were created from aerial natural color photography accompanied by ground truth data for verification including location and density.	1981 (May): Bogue, Back and Core sounds
Ferguson & Wood (1994)	1983, 1985, 1990, 1992	SAV was delineated and mapped from natural color aerial photography with a minimum mapping unit of 20m. Accompanying field inventories were conducted within study regions to verify SAV signatures and species distribution and composition.	1983 (Spring): Outer Banks from Ocracoke Inlet to Oregon Inlet 1985 (Spring): Core Sound 1988 (Spring): Core Sound, and behind Cape Hatteras from Hatteras to Avon 1990 (Fall): Currituck, Albemarle, Roanoke, and Croatan sounds, and Oregon Inlet to south of Pea Island 1991 (Fall): Pamlico River Estuary, Neuse River Estuary, western Pamlico Sound and Albemarle 1992 (Fall): Pamlico River, parts of eastern and western Pamlico Sound, and Albemarle Sound (Perquimans River)
Division Water Quality (now Water Resources)	1998	Maps from aerial photography.	Neuse River and tributaries
Elizabeth City State University	2002-2003, 2006	Maps from color aerial photography, accompanied by field survey point data to aid in photo interpretation were produced by the ECSU Remote Sensing Program. SAV polygons were generated using “heads up” digitizing on the computer monitor.	2002 (October): Northern shoreline of Albemarle Sound and tributaries from Big Flatty Creek to Edenton Bay 2003 (October): Back Bay, Currituck Sound, and Kitty Hawk Bay 2006: Western Albemarle Sound
North Carolina State University	2005	Aerial photography from July 2005 accompanied by ground truth data.	2005 (July): Southern shore of Albemarle Sound including Bull Bay to northern Croatan Sound
Division Water Quality Rapid Response Team (NCDEQ 2005, 2007)	2005-2007	Maps from interpolated transect data SAV was observed and collected using a garden rake from boat, traveling along the shoreline.	2005 and 2006 (June-September): field surveys were conducted for the major tributaries of Neuse and Pamlico rivers 2007 (May-August): field surveys were conducted in the Neuse and Pamlico rivers and tributaries
Marine Corps Air Station Cherry Point (MCAS Cherry Point 2007)	2007	Field survey’s consisting of visual observations and underwater cameras in ≤ 6 ft depth of water. Aerial survey using hyperspectral imagery, collected on May 14, 2007, was analyzed in ENVI software using the Spectral Angle Mapper Classification method to identify SAV.	May 14, 2007: imagery data of Piney Island was collected 2007 (June-July): field surveys for Piney Island and Brant Island Shoal

Table 1 (continued).

Data Source	Mapping Year(s)	Methodology	Mapping Extent
Albemarle Pamlico National Estuarine Partnership & SAV Partners (APNEP 2019, 2019b)	2006-2008	SAV was mapped along the coast of NC and northward into Back Bay, VA by manually digitizing visible SAV from remotely sensed imagery. Digitizing scale was typically set at 1:1,500 with a minimum mapping unit set at 15 m.	This extent encompasses the coastal zone that lies within the APNEP regional boundary (Bogue Inlet north to Back Bay), as well as that which is outside of that boundary (Bogue Inlet south to Masonboro Inlet). 2006 (May-June): Bogue, Back, and Core sounds 2007 (September): Pamlico and Pungo rivers 2007 (October): coast wide except Bogue, Back and Core sounds 2008 (May-June): Bogue, Back, and Core sounds
	2012-2014	SAV was mapped along the coast of NC by manually digitizing visible SAV from remotely sensed imagery. Digitizing scale was typically set between 1:2,000 and 1:3,000 with a minimum mapping unit set at 15m.	This extent encompasses the high-salinity coastal zone that lies within the APNEP regional boundary (Hwy. 64 Bridge of Roanoke Sound south to Bogue Inlet). 2013 (May): Bogue, Back, and North Pamlico sounds
NCDMF & APNEP (NCDEQ 2015)	2015	SAV was mapped along the Southern coast of NC by manually digitizing visible SAV from remotely sensed imagery.	This extent encompasses the high-salinity coastal zone of Onslow Bay that lies south of the APNEP regional boundary. Imagery collected May 24, 2015
APNEP SAV Partners (APNEP 2022)	2019-2020	SAV was mapped along the coast of NC by manually digitizing visible SAV from remotely sensed imagery. Digitizing scale was typically set between 1:1,500 and 1:3,000 with a minimum mapping unit set at 15 m.	This extent encompasses the high-salinity coastal zone that lies within the APNEP regional boundary (Hwy. 64 Bridge of Roanoke Sound south to Bogue Inlet), except for mainland Core Sound and multiple areas in Pamlico and Roanoke Sounds (see source metadata for detailed description). All SAV was digitized from 2020 (May-June) imagery – 2019 imagery was uninterpretable for SAV.
NCDMF & APNEP (APNEP 2022b)	2021	SAV was mapped along the Southern coast of NC by manually digitizing visible SAV from remotely sensed imagery. Digitizing scale was typically between 1:1,500 and 1:2,000 with a minimum mapping unit set at 15 m.	This extent encompasses the high-salinity coastal zone of Onslow Bay that lies south of Bogue Sound and terminating near Mason's Inlet (Onslow, Pender, and New Hanover counties). 2021 (May): Bear Inlet south to Mason's Inlet

Table 2. The known historic extent of mapped submerged aquatic vegetation (SAV) in North Carolina, 1981-2021.

			Historic Extent SAV Habitat 1981-2015		Historic Extent SAV Habitat 1981-2021		Unprotected SAV Habitat 1981-2021	
SAV Region	Salinity Zone	SAV Region Name	Acres	Percent (%)	Acres	Percent (%)	Acres	Percent (%)
1	Low	Currituck Sound & Back Bay	21,613	11.3	21,613	11.3	81	0.4
2	Low	Albemarle Sound	12,872	6.7	12,872	6.7	5,422	42.1
3	Low	Tar-Pamlico & Neuse rivers	4,581	2.4	4,581	2.4	530	11.6
4	High	Pamlico Sound	712	0.4	712	0.4	490	68.8
5	High	Roanoke Sound to Ocracoke Inlet	101,739	53.2	103,856	53.2	19,693	19.0
6	High	Core Sound	36,862	19.3	37,645	19.3	13,095	34.8
7	High	Back Sound to Sanders Island	10,826	5.7	12,265	5.7	4,916	40.1
8	High	Brown’s Inlet to Snow's Cut	1,950	1.0	2,646	1	348	13.2
9	High/Low	Cape Fear River to SC line	0	0.0	0	0	0	0.0
Total			191, 155		196,190		44,576	

Figures

Figure 1. Historic extent of submerged aquatic vegetation (SAV) habitat mapped in North Carolina, 1981 to 2021.

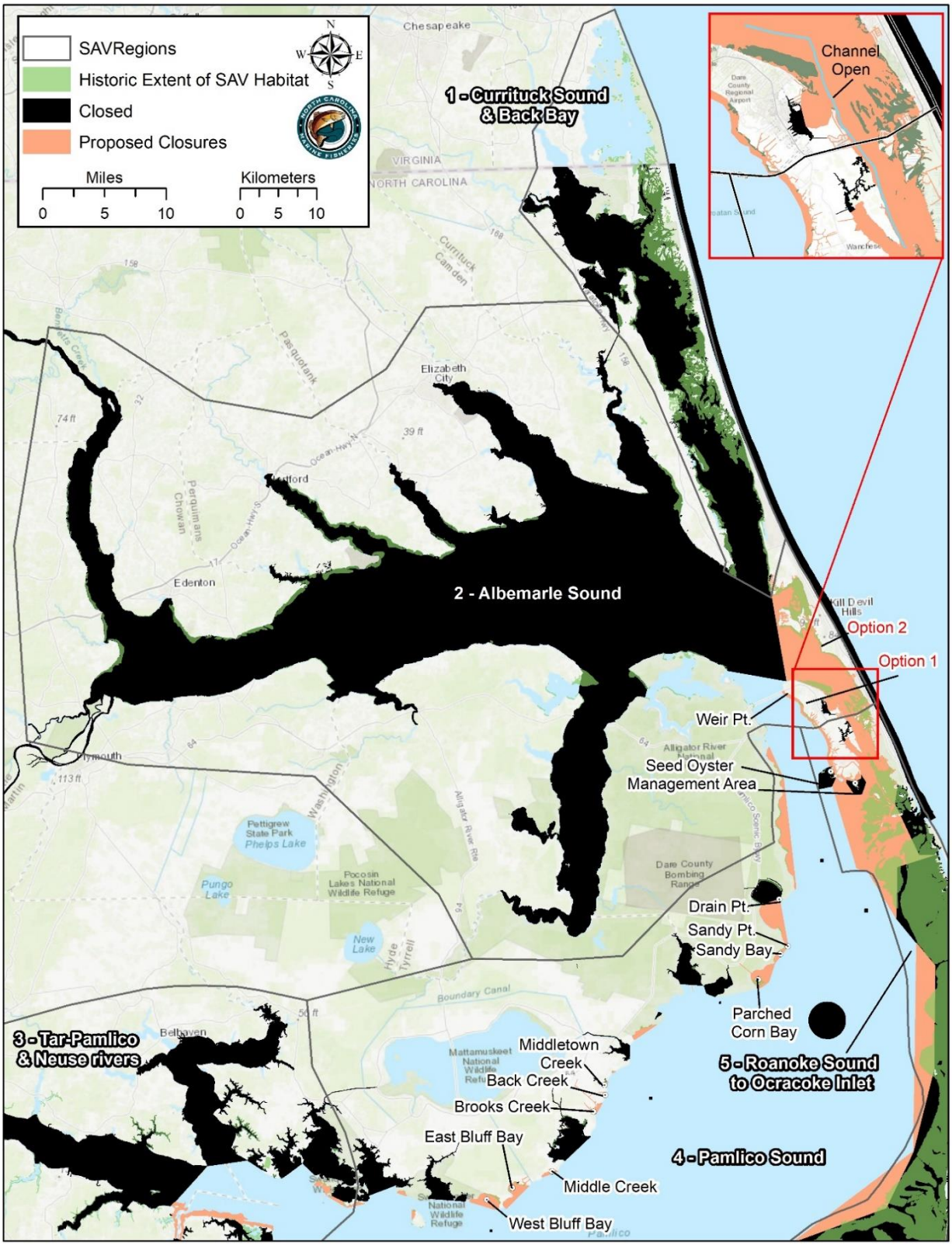

Figure 2. Proposed shrimp trawl closures in the Roanoke Sound (SAV Region 2) to protect submerged aquatic vegetation (SAV).

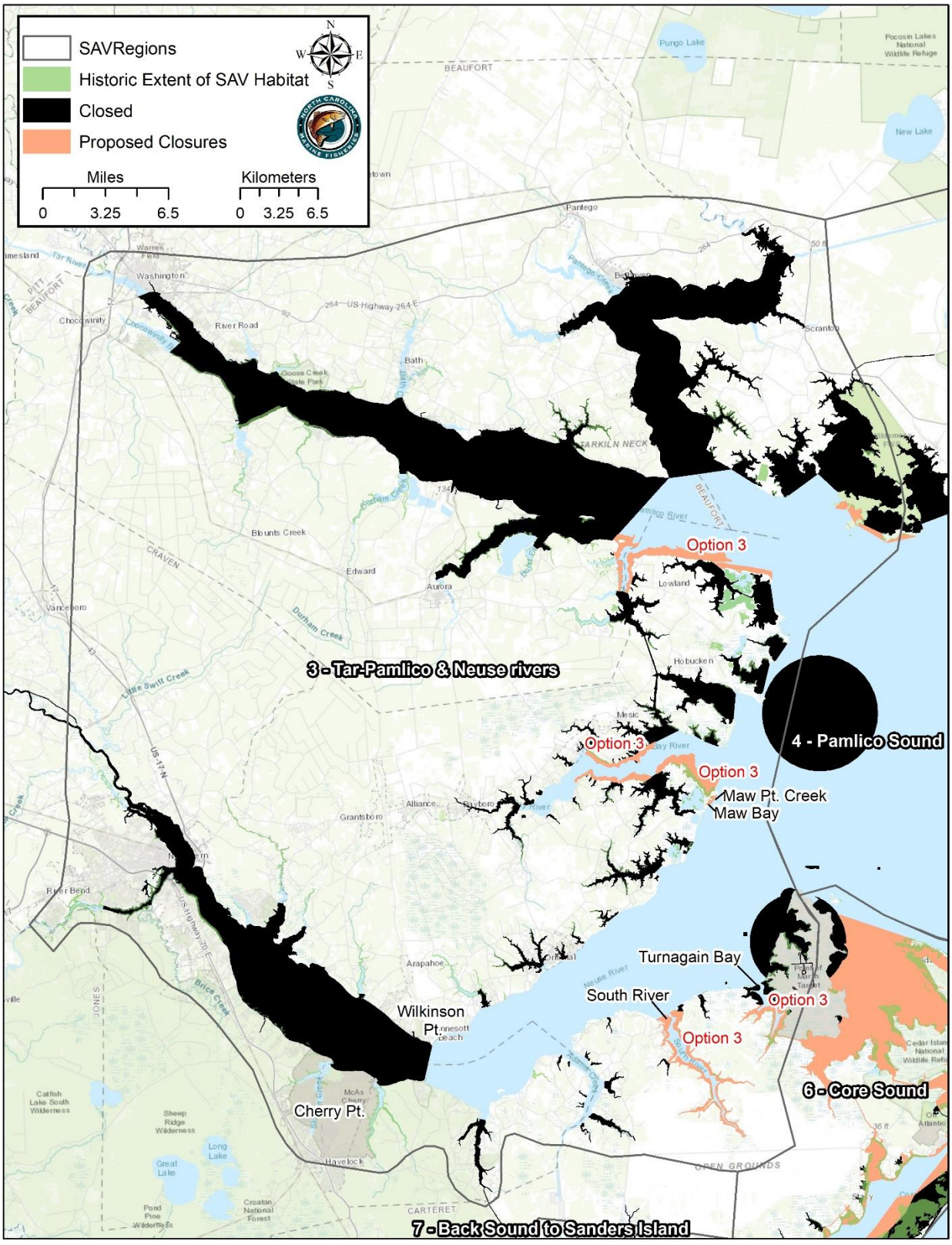

Figure 3. Proposed shrimp trawl closures in the Tar-Pamlico and Neuse rivers (SAV Region 3) to protect submerged aquatic vegetation (SAV).

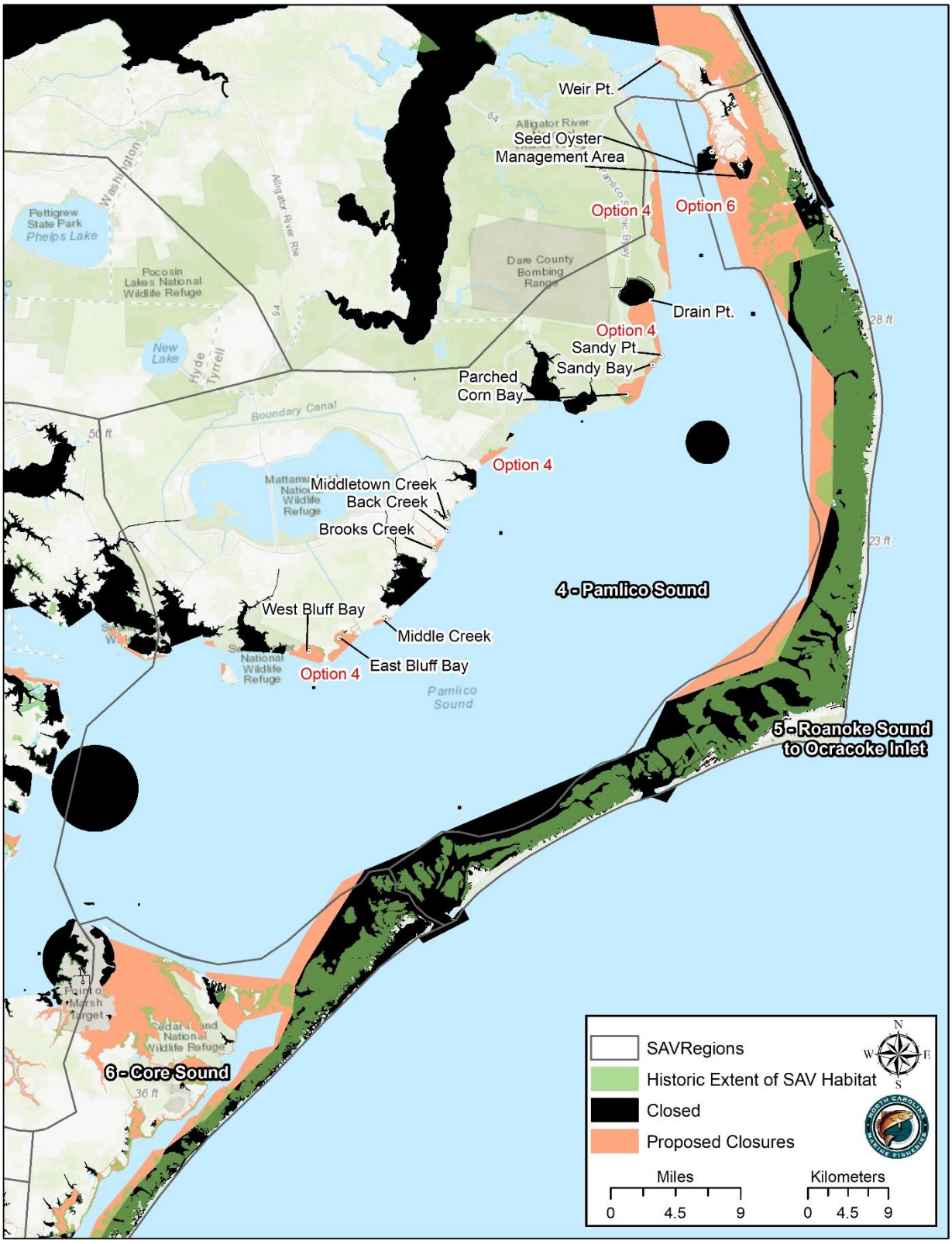

Figure 4. Proposed shrimp trawl closures in the Pamlico Sound (SAV Region 4) to protect submerged aquatic vegetation (SAV).

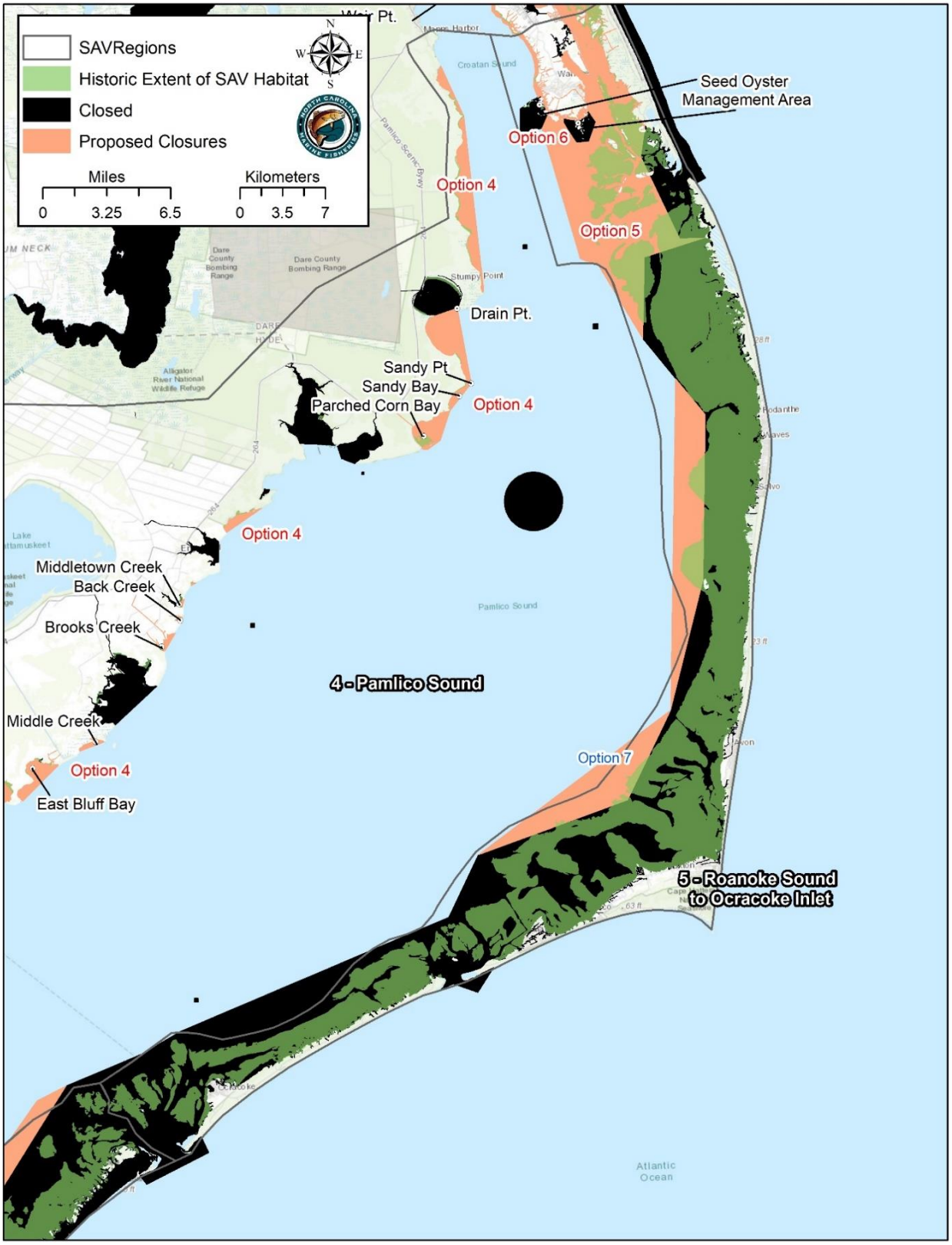

Figure 5. Proposed shrimp trawl closures from Roanoke Sound to Ocracoke Inlet (SAV Region 5) to protect submerged aquatic vegetation (SAV).

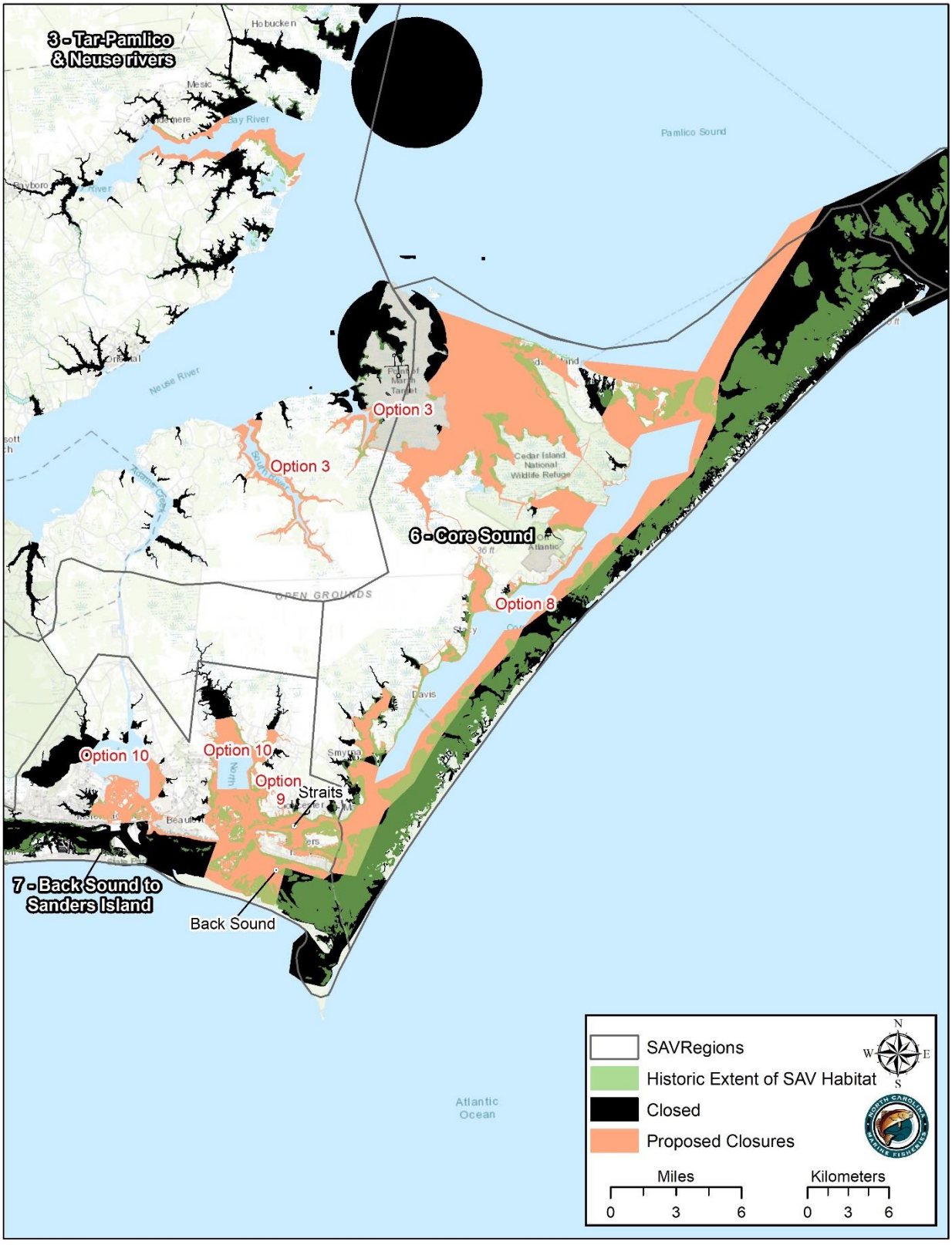

Figure 6. Proposed shrimp trawl closures in the Core Sound (SAV Region 6) to protect submerged aquatic vegetation (SAV).

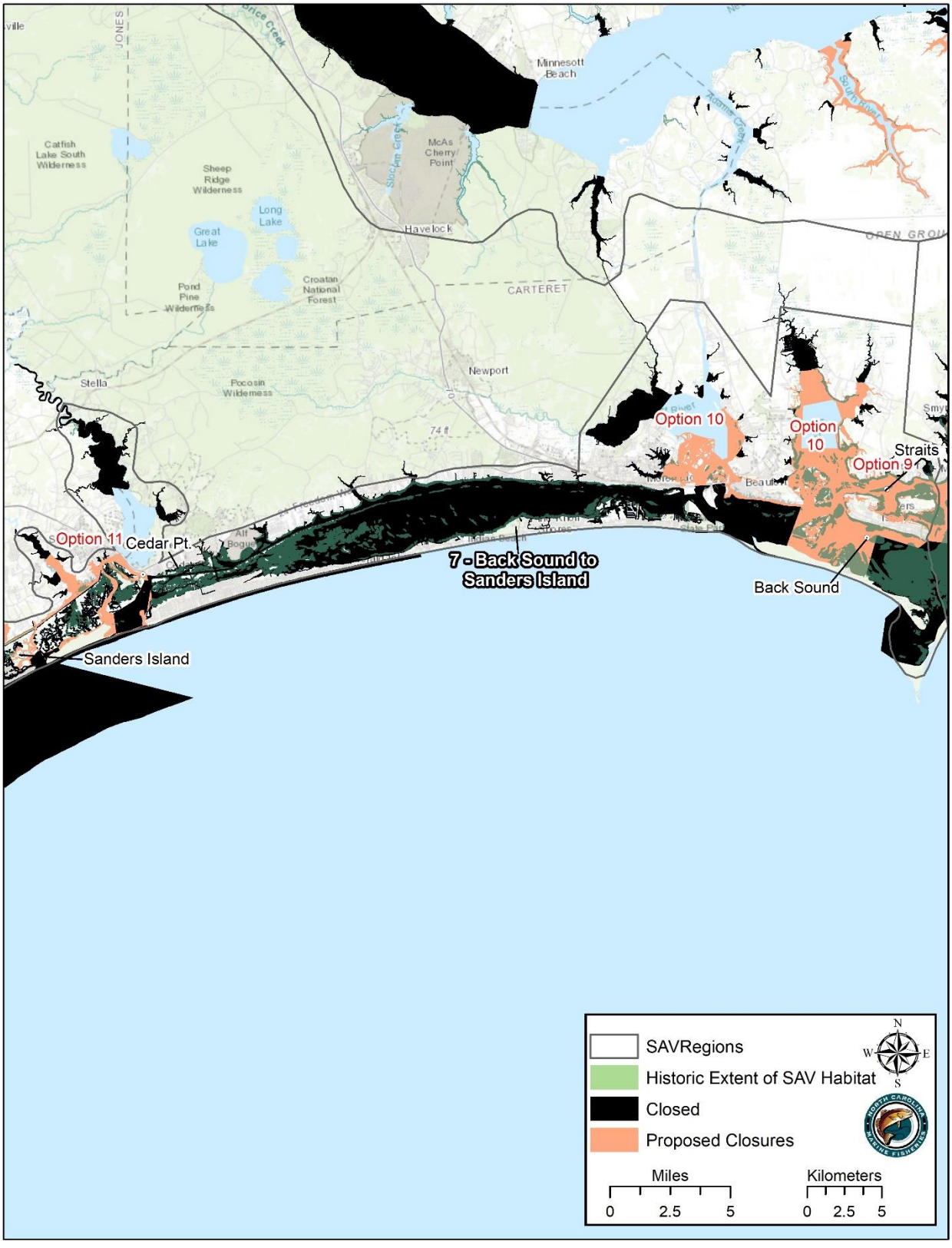

Figure 7. Proposed shrimp trawl closures from Back Sound to Sanders Island (SAV Region 7) to protect submerged aquatic vegetation (SAV).

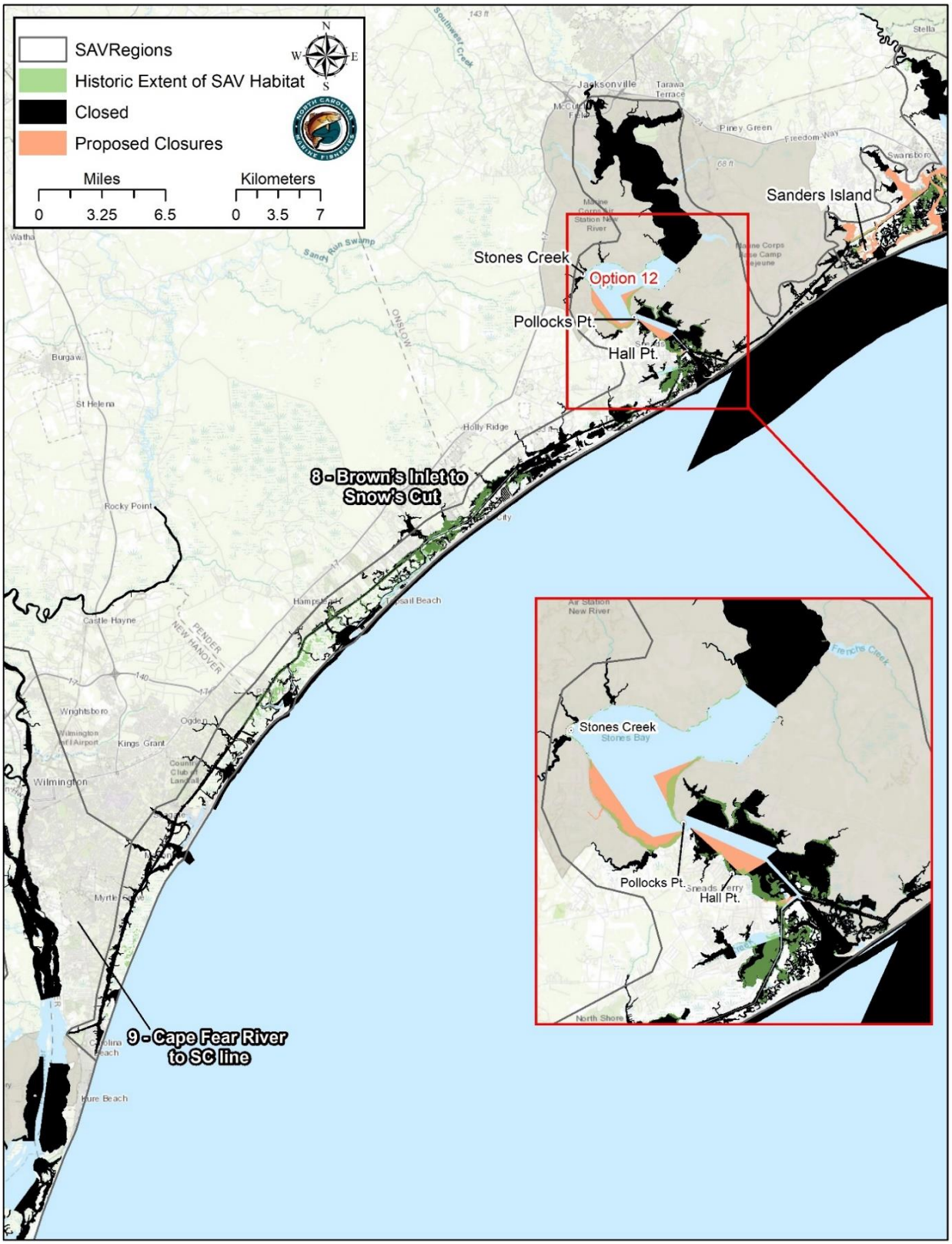

Figure 8. Proposed shrimp trawl closures from Brown's Inlet to Snow's Cut (SAV Region 8) to protect submerged aquatic vegetation (SAV).