# Initial Assessment of Climate Change Impacts to Implementation to 2012 - 2022 Comprehensive Conservation and Management Plan


## Albemarle-Pamlico National Estuary Program

***2019***

Albemarle-Pamlico National Estuary Program
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# Mission

*To identify, restore, and protect the significant resources in the Albemarle-Pamlico estuarine system*.

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## Question 1: *What is a healthy Albemarle-Pamlico estuarine system?*

"Ecosystem health" is a term that is difficult to define. A healthy system has innumerable variables and relationships that can be difficult to describe and study. The meaning of the term differs depending on context. In general terms, a healthy Albemarle-Pamlico Estuarine System might include a thriving natural world, a high quality of life for its people, and a vibrant economy. The air would be safe to breathe and the water would be safe to drink. Farmlands would be fertile and fishing would be bountiful. Outdoor recreation and education opportunities would be readily available. Businesses would be profitable while minimizing negative environmental impacts. While one person might agree that a healthy ecosystem includes all of these factors, others might think this definition is either misguided or woefully incomplete.

Defining the elements of a healthy system is a difficult process. The Albemarle-Pamlico estuarine system encompasses more than 31,000 square miles of land and water. The importance of reaching stakeholder agreement on environmental goals and outcomes to benefit ecosystem health is difficult to overstate. It will always be necessary to consider competing uses and interests when planning for such a large region, and management approaches should consider them fairly. In short, APNEP and its many partners in the region must be able to articulate environmental goals before developing a plan to achieve them.

APNEP and its partners have developed a vision for a healthy Albemarle-Pamlico estuary that accounts for the various interests found within the region. This vision of ecosystem health is communicated through three overarching goals, each of which includes measurable ecosystem outcomes. The CCMP management actions outlined in Question 4 are each predicated on effectively pursuing the goals established by stakeholder representatives.

***Three goals*** have been established that, if fully met, would reflect a healthy Albemarle-Pamlico estuarine system. To assess progress in reaching each goal, a set of ecosystem outcomes has been developed. These ***ecosystem outcomes*** are qualitative statements of what a healthy ecosystem should look like. Each outcome will be supported by a set of measurable **indicators** and associated **ecosystem targets** or benchmarks, which are currently under development. Establishing these indicators and targets is the first action in implementing this CCMP. An example, of these types of indicators is displayed in Table 1 (page 14). These candidate indicators are physical, biological, or chemical conditions that can be measured to provide data about the status of the ecosystem.

As time passes, APNEP will periodically consult with its partners to ensure current outcomes remain meaningful and refine management targets to reflect a balance between competing priorities. Furthermore, as monitoring capabilities improve, APNEP

will work with its representative stakeholders to develop, refine, and agree upon new targets and benchmarks, which are the most precise expression of these ecosystem goals. Ultimately, the development of measurable indicators and benchmarks for the Albemarle-Pamlico estuarine system enables APNEP to determine whether environmental progress has been made, adjust management actions when necessary, and report on the state of the ecosystem to partners, stakeholders, and the general public.

The proposed goals and associated outcomes for the program are:

**Goal 1: A region where human communities are sustained by a functioning ecosystem**

*Ecosystem Outcomes:*

a. *Waters are safe for personal contact.*
b. *Designated surface and ground water supplies are safe for human consumption.*
c. *Surface hydrologic regimes sustain regulated human uses.*
d. *Fish and game are safe for human consumption.*
e. *Opportunities for recreation and access to public lands and waters are protected and enhanced.*

**Goal 2: A region where aquatic, wetland, and upland habitats support viable populations of native species**

*Ecosystem Outcomes:*

a. *The biodiversity, function, and populations of species in aquatic, wetland, and upland communities are protected, restored, or enhanced.*
b. *The extent and quality of upland, freshwater, estuarine, and near-shore marine habitats fully support biodiversity and ecosystem function.*
c. *Non-native invasive species do not significantly impair native species' viability or function, nor impair habitat quality, quantity, and the processes that form and maintain habitats.*

**Goal 3: A region where water quantity and quality maintain ecological integrity**

*Ecosystem Outcomes:*

a. *Appropriate hydrologic regimes support ecological integrity.*
b. *Nutrients and pathogens do not harm species that depend on the waters.*
c. *Toxics in waters and sediments do not harm species that depend on the waters.*
d. *Sediments do not harm species that depend on the waters.*

Table 1. Management goals, ecosystem outcomes, supporting CCMP actions and candidate indicators.

| Goal | Ecosystem Outcome | CCMP Supporting Actions | Candidate Indicator |
|---|---|---|---|
| **1: Human Communities** A region where human communities are sustained by a functioning ecosystem | 1a: Waters are safe for personal contact. | A1.1, 1.2, 2.3, 3.3; B1.2; C1.1,1.2, 1.4; D1.1, 1.2, 2.3,3.1,3.3; E1.1, 1.2, 2.1, 2.2 | Beach action days/closings by water body type (sounds, freshwater river, lake, brackish river) |
| | 1b: Designated surface and ground water supplies are safe for human consumption. | A1.1, 1.2, 2.3, 3.3; B1.2; C1.1,1.2, 1.4; D1.1, 1.2, 2.3,3.1,3.3; E1.1, 1.2 , 2.1, 2.2 | WQ standard violations (surface waters) |
| | | | Drinking water standard violations (aquifers) |
| | 1c: Surface hydrologic regimes sustain regulated human uses. | A 1.1, 1.2, 1.2, 2.3, 3.4; D 1.2, 2.2, 3.2; E1.1, 1.2, 2.1 2.2 | Severity and frequency of droughts |
| | 1d: Fish and game are safe for human consumption. | A1.1, 1.2, 2.3, 3.3; B1.2; C1.1,1.2; D 1.1, 1.2, 2.3,3.1,3.3; E1.1, 1.2, 2.1, 2.2 | Fish consumption advisories |
| | | | Shellfish area closures |
| | 1e: Opportunities for recreation and access to public lands and waters are protected and enhanced. | A 1.1, 1.2, 2.3; D 1.1, 1.2, 1.5, 2.2, 3.3; E1.1, 1.2, 2.1 2.2 | Total distance of land and paddle trails |
| | | | Water access points: number & location |
| **2: Native Species** A region where aquatic, wetland, and upland habitats support viable populations of native species | 2a: The biodiversity, function, and populations of species in aquatic, wetland, and upland communities are protected, restored, or enhanced. | A1.1, 1.2, 2.2, 3.1, 3.4: B 1.3, 2.1, 2.3, 2.4, 2.5, 3.3; C 1.3, 1.4, 2.2, 3.2, 3.3, 4.1, 4.2, 4.3, 4.4; D1.1, 1.2, 1.4, 2.1, 2.2, 3.1, 3.3; E 1.1, 1.2, 2.1, 2.2 | Oyster bed extent |
| | | | River herring abundance |
| | | | King rail, Swainson's warbler population /occurrences |
| | | | Box Turtle population /occurrences |
| | | | Longleaf Pine extent, location |
| | | | Firefly population |
| | 2b: The extent and quality of upland, freshwater, estuarine and near-shore marine habitats fully support biodiversity and ecosystem function. | A 1.1, 1.2, 2.3, 3.1, 3.2, 3.4; B 1.1, 1.2, 1.3, 1.4, 1.5, 2.2, 2.3, 2.4, 2.5, 2.6, 3.1, 3.2, 3.3; C 1.3, 1.4, 1.5, 2.1, 2.2, 3.1, 3.2, 3.3, 4.1, 4.2, 4.3, 4.4, 5.1, 5.2, 5.3; D 1.2, 1.4, 2.2, 3.1, 3.3; E1.1, 1.2, 2.1, 2.2 | SAV extent and composition |
| | | | Quality & extent of anadromous fish spawning/nursery areas |
| | 2c: Non-native invasive species do not significantly impair native species' viability or function, nor impair habitat quality, quantity, and the processes that form and maintain habitats. | A 1.2, 2.1, 2.3; B 2.6; C 3.1; D 1.2, 1.3, 2.2, 3.3; E 1.1, 1.2, 2.1, 2.2 | Hydrilla population status/occurrences |
| | | | Phragmites australis extent (common reed) |
| | | | Kudzu population status/occurrences |
| **3: Water Quantity & Quality** A region where water quantity and quality maintain ecological integrity | 3a: Appropriate hydrologic regimes support ecological integrity. | A 1.2, 2.1, 2.3; B 2.6; C 3.1; D 1.2, 1.3, 2.2, 3.3; E 1.1, 1.2, 2.1, 2.2 | Dissolved oxygen concentration |
| | | | Major river flows |
| | 3b: Nutrients and pathogens do not harm species that depend on the waters. | A 1.1, 1.2, 2.3; B 1.2, 1.3, 1.4, 1.5; C 1.2, 2.1, 2.3, 2.4; D 1.1,1.2, 1.4, 2.1,2.2, 3.3, E1.1, 1.2, 2.1, 2.2 | Amount and extent of impaired waters |
| | | | Chlorophyll-a concentration |
| | 3c: Toxics in waters and sediments do not harm species that depend on the waters. | A 1.1, 1.2, 2.3, 2.4; B 1.1; C 1.2; D 1.2, 3.1, 3.3; E 1.1, 1.2, 2.1, 2.2 | Amount and extent of impaired waters |
| | | | Dissolved metals concentrations |
| | 3d: Sediments do not harm species that depend on the waters. | A 1.1, 1.2, 2.3; B 1.3, 1.4, 1.5, 2.3, 2.6, 3.1, 3.2; C 1.3, 1.5, 2.1, 2.3, 3.1, 3.2; D 1.2, 3.1, 3.3; E 1.1, 1.2, 2.1, 2.2 | Amount and extent of impaired waters |
| | | | Average secchi disk depth |

*This table illustrates the linkage between the CCMP goals and ecosystem outcomes (page 13), the CCMP management actions (found on pages 19 to 53), and example ecosystem indicators by which success can be measu*

For the reader’s convenience, a table of acronyms is provided on page 57

## Question 4: What actions should be taken to move toward healthier Albemarle-Pamlico Sounds by 2022?

The management actions identified in this plan are presented in five general **components** (**Identify, Protect, Restore, Engage, Monitor**), which together address the major challenges to understanding, protecting, and restoring ecosystem health and function while embracing the new systems-based approach to managing the Albemarle-Pamlico region. The five components are based on the APNEP mission statement and the adaptive management cycle (see page 14).

The objectives and actions described here are designed to achieve environmental and ecosystem outcomes at the watershed scale and address the complex connections among both ecological and human aspects of the estuarine ecosystem. These actions also address the major threats to ecosystem health and function.

Each component begins with a ***situation assessment*** and provides a rationale for action followed by a set of broad ***objectives*****.** Objectives are supported by more focused ***actions*****,** which describe the program activities or initiatives that APNEP and its partners will implement to achieve the objective. Actions will be implemented through various steps that will be presented in APNEP's annual work plans.

The proposed five components are:

**A: Identify** the gaps in our knowledge. APNEP will implement a focused scientific program with priorities for monitoring and research to improve understanding of the ecosystem and measure the effectiveness of implementation actions.

**B: Protect** the existing ecosystem processes, structures, and functions that sustain the Albemarle-Pamlico estuarine system. Avoiding problems before they occur is the best and most cost-effective approach to maintaining ecosystem health.

**C: Restore** the ecosystem processes, structures, and functions that sustain the Albemarle-Pamlico estuarine system.

**D: Engage** the public in sustained and coordinated efforts to increase public awareness and encourage individual stewardship. Greater awareness, citizen engagement and planning are critical for maintaining the ecosystem processes, structures, and functions that sustain the Albemarle-Pamlico ecosystem, including its human communities.

**E: Monitor** the ecosystem. Tracking and understanding changes in the ecosystem (outcomes) will require the establishment of a coordinated monitoring strategy to detect, measure, track, and assess changes in the ecosystem.

As part of the planning process, APNEP has coupled its recommended actions with regional partners who will be integral to their implementation. The efforts of many partners are required, which resulted in the unavoidable use of many acronyms in this section. State agencies are noted through the prefixes NC- and VA-, while federal agencies and other organizations are referred to by their most recognizable acronyms. For the reader's convenience, a table of acronyms can be found on page 56.

The reader can also access the document electronically at www.apnep.org, where the full name of any organization can be seen by clicking on its acronym with the cursor.

# Component A: Identify

To **Identify** gaps in the knowledge of the Albemarle-Pamlico estuarine system, APNEP will implement a focused scientific program with priorities for monitoring and research to improve understanding of the ecosystem and measure the effectiveness of implementation actions.

To achieve its mission, APNEP and its partners must continually work to identify and assess trends in the regional ecosystem. This component also requires assessment of planning, management, and policy choices related to the ecosystem to ensure environmental progress. Comprehensive monitoring (Component E) provides the information on which these assessments are based.

**Current situation**

APNEP supported a vast amount of data collection and scientific research during the Albemarle-Pamlico Estuarine Study (APES) phase from the program's inception in 1987 to publication of the original CCMP in 1994. These research efforts greatly improved knowledge of the region's resources. Much of this applied research gave environmental professionals key insights on the state of the estuarine ecosystem. These various studies supported *The Albemarle-Pamlico Estuary Study Status and Trends Report* (1991), which provided an environmental baseline for the implementation of the 1994 CCMP. While APNEP's activities have broadened since the early 1990s, promoting science-based management and policy remains a core principle of the program.

Today, APNEP's mission, structure, and ecosystem-based approach allows for broad-scale inquiries and research designed to support management efforts in the region. APNEP staff members work closely with the Science and Technical Advisory Committee (STAC), partner organizations, and project-specific contractors on diverse research initiatives. This network of professionals allows APNEP to consistently access and apply advanced scientific knowledge in areas of strategic interest to the program. Furthermore, natural resource managers, partner agencies and organizations, and other professionals commonly identify knowledge gaps, which if rectified could result in more robust management of the ecosystem's natural resources.

**Rationale for action**

Priorities for research, management, and policy cannot be developed effectively without a clear understanding of how the ecosystem is changing. Increasing impact to the region's natural resources from population growth and consequent land-use changes, coupled with technological advancements, require stakeholders to demand periodic integrated resource assessments based on high quality scientific information. Information derived in this component will help answer seven policy-based questions for any particular APNEP outcome:

- Magnitude: what is the resource condition?
- Extent: over what geographic area does the resource extend?
- Trend: how has condition and range of the resource changed over time?
- Cause: what stressors are believed to be responsible for changing trends?
- Source: what agents are responsible for stressor intensity?
- Risk: what is the likelihood of stressors causing a loss in human well-being or ecological integrity over the coming decade?
- Solutions: what combination of approaches and tools are deemed the most effective and efficient to reduce impacts from stressors?

These integrated assessments will support APNEP's planning and program processes and other policy and program planning activities, including the North Carolina's Coastal Habitat Protection Plan (CHPP) and North Carolina and Virginia basin-wide planning. To evaluate the success of program efforts guided by this plan, APNEP will provide a reliable environmental baseline of ecosystem condition in its *2012 Albemarle-Pamlico Ecosystem Assessment*.

## OBJECTIVES AND ACTIONS

**Objective A1: Develop and refine a conservation atlas**

To effectively protect and restore the Albemarle-Pamlico estuarine system, the significant resources of the system must be identifiable. With recent advances in mapping and technology, this information is often most effectively conveyed, studied, and applied through the use of functional interactive maps. To achieve its mission, APNEP will work with partners to maintain, develop, and distribute current data and maps related to the significant landscape features, habitats, conditions, changes, and stressors in the region.

**Action A1.1: Facilitate the mapping of significant ecological, bathymetric, geologic, demographic, and cultural features**. In a dynamic natural and social environment, regional mapping efforts develop and maintain the timely information necessary to support environmental decision-making. It further provides one method by which management activities can be evaluated.

**Key Partners**: NC-OCPCA, NC-DMF, SALCC, USFWS, NOAA, NC-DCM, NC-WRC, NC-NHP, VA-NHP

**CCMP Outcomes Supported**: 1a, 1b, 1c, 1d, 1e, 2a, 2b, 2c, 3a, 3b, 3c, 3d

**Outputs:** Maps and GIS data

**Results:** Improved resource management decisions

**Climate Impact:** No anticipated implementation impacts

**Action A1.2: Facilitate the refinement and use of online conservation planning tools.** Providing accessible tools for informed decisions is critical for addressing human and ecosystem needs. Tools such as the North Carolina Conservation Planning Tool, the Green Growth Toolbox, and Strategic Habitat Areas support resource management decisions. Additionally, such tools can assist in addressing the potential impacts associated with a changing climate.

**Key Partners:** NC-OCPCA, NC-WRC, TNC, USFWS, SALCC, NC-DEM, VA-DCR

**CCMP Outcomes Supported:** 1a, 1b, 1c, 1d, 1e, 2a, 2b, 2c, 3a, 3b, 3c, 3d

**Outputs:** Access to mapping, GIS data, conservation planning tools

**Results:** Improved resource management decisions

**Climate Impact:** No anticipated implementation impacts

**Objective A2: Assess the impacts of targeted threats on the ecosystem**

The estuarine ecosystem and its various components are sensitive to both localized and systemic changes. Population growth and associated development, climate change, sea level rise, increasing demand for freshwater, invasive species, and introduced pollutants are among the most significant stressors to the ecosystem. Scientific knowledge of the individual and cumulative impacts of these stressors can be developed further, and research is needed to identify thresholds for ecosystem resilience.

**Action A2.1: Facilitate the development of protocols and conduct rapid assessments to determine presence and potential threat of invasive species**. Aquatic and terrestrial invasive species can cause significant ecological damage. The timely identification and assessment of invasive species threats can ultimately result in cost-effective management if addressed before threshold levels are reached.

**Key Partners:** NC-WRC, NC-DENR, VA-DEQ, VA-DCR, EPA, NOAA, USFWS, NC-DWR, NC-DACS, USDA, NC-EPPC, USGS

**CCMP Outcome Supported:** 2c

**Outputs:** Protocols and assessments

**Results:** Better information on presence and potential threat of invasive species

**Climate Impact:** No anticipated implementation impacts

**Action A2.2: Create and improve projections of land use and climate change related impacts on the regional ecosystem.** Forecasting future potential impacts allows managers to undertake proactive measures and consider environmental management initiatives.

**Key Partners:** EPA, SALCC, NOAA, USFWS, USFS, NC-OCPCA, NC-DEM

**CCMP Outcome Supported:** 2a

**Outputs:** Climate change impact models; land use projections

**Results**: Information to support better resource management decisions

**Climate Impact:** No anticipated implementation impacts

**Action A2.3: Support research on adapting to impacts associated with climate change and sea level rise.** Current research suggests that climate change and associated sea level rise will be a significant stressor in the region for the near future. Science that helps predict impacts at the regional level will help support informed decision-making by those in a position to use it.

**Key Partners:** SALCC, NOAA, EPA, USFWS, USFS, NC-DCM, NC-OCPCA, NC-DEM

**CCMP Outcomes Supported:** 1a, 1b, 1c, 1d, 1e, 2a, 2b, 2c, 3a, 3b, 3c, 3d

**Outputs:** Research activities and reports

**Results:** Information to support better resource management decisions in the face of a changing climate

**Climate Impact:** No anticipated implementation impacts

**Action A2.4: Facilitate risk assessments of targeted personal care and pharmaceutical products in the aquatic system.** Numerous chemical compounds reach our waterways and sounds, including medications and other products with unknown effects on the estuarine ecosystem. APNEP will work with its partners to better understand and address the risks associated with these chemicals. Understanding these risks helps prioritize future research and management efforts.

**Key Partners:** EPA, NOAA, NC-DWQ, NC-DPH, VA-VDH, VA-DEQ

**CCMP Outcomes Supported:** 1b, 3c

**Outputs:** Risk assessments

**Results:** Information to support better resource management decisions regarding risks associated with personal care and pharmaceutical products in the ecosystem.

**Climate Impact:** No anticipated implementation impacts

**Action A2.5: Facilitate risk assessments of heavy metals and other toxic contaminants in sediments.** Toxic materials come from smokestacks, roads, and other sources. While risks of some toxic sources have been well documented (e.g., mercury), the risks of other sources are unknown. Understanding these risks helps prioritize future research and management efforts.

**Key Partners:** EPA, NC-DWQ, NC-DPH, NC-DMF, VA-DEQ
**CCMP Outcome Supported:** 3c
**Outputs:** Risk assessments
**Results:** Information to support better resource management decisions regarding risks associated with heavy metals and other toxic contaminants in sediments.
**Climate Impact:** No anticipated implementation impacts

**Objective A3: Assess current natural resource policy, laws, and regulations according to ecosystem-based management principles**

To ensure wise stewardship of the public's natural and fiscal resources, the rigorous review of various environmental laws, policy choices, and management efforts is necessary. These issues are typically complex and require expertise in many areas, and often-subtle changes in management approaches can result in significant environmental improvements. Considering their complex nature and effects on water quality in the sounds, wetland protection and riparian buffer implementation policies have been identified as two priority areas for study.

**Action A3.1: Assess the effectiveness of policies and regulations to minimize wetland loss.** Wetlands are extremely valuable habitats, providing flood protection and filtering runoff. Policies should support the preservation, maintenance, restoration, and creation of ecologically functional wetlands.

**Key Partners:** Sea Grant, NC-DENR, VA-DEQ, USACE, USFWS, SALCC, EPA, NOAA
**CCMP Outcomes Supported:** 2a, 2b
**Outputs:** Recommendations for improved wetland protection
**Results:** Information to support better resource management decisions
**Climate Impact:** Minimal anticipated implementation impacts

**Action A3.2: Assess the effectiveness of policies and regulations regarding riparian buffers.** Riparian buffers reduce runoff into the estuarine system and provide other ecosystem services; however, buffer requirements differ throughout the region. Further study of the issue can help demonstrate the costs and benefits of buffer rules, allowing for optimal investment in this conservation strategy.

**Key Partners:** NC-DWQ, Sea Grant, VA-DEQ, USACE, USFWS, SALCC, EPA, NOAA, VA-VWWP, NC-DACS

**CCMP Outcomes Supported:** 2b, 3d

**Outputs:** Recommendations for improved riparian protection

**Results:** Information to support better resource management decisions

**Climate Impact:** Minimal anticipated implementation impacts

**Action A3.3: Develop and refine ecological flow requirements for each major river.** Many of the fish, aquatic plants, and other species that live within the estuarine system depend on flowing water to survive. Identifying these ecological flows will help ensure that these species and ecosystems are protected.

**Key Partners:** NC-DWR, USFWS, USGS, NC-WRC, VA-DCR, VA-DEQ, USACE, SALCC

**CCMP Outcomes Supported:** 1c, 2a, 2b, 3a

**Outputs:** Hydrologic models of each river basin within the APNEP region and associated ecological flow requirements to support better resource management decisions

**Results:** Management of river flows that support ecological integrity

**Climate Impact:** Minimal anticipated implementation impacts

# Component B: Protect

**Protect** the intact ecosystem processes, structures, and functions that sustain the Albemarle-Pamlico estuarine system. Preventing problems before they occur is the most cost-effective approach to maintaining environmental health.

**Current situation**

The Albemarle-Pamlico estuarine system has been altered significantly during the past 400 years as nearly undisturbed large ecosystems have made way for human development. While not as urbanized as many other watersheds, land uses like forestry, farming, industry, mining, and development characterize much of the land use in the region. These land use activities have important direct, indirect, and cumulative impacts on aquatic ecosystems. Further, more direct aquatic impacts can be seen through the existence of dams and water-dependent structures found through the region. If not properly managed, these activities and structures can cumulatively damage and destroy the underlying processes that allow for healthy and productive ecosystems. Human population growth and a changing climate will likely magnify these challenges in the future. To maintain the structure and function of the ecosystem, it is imperative to identify and retain the ecosystem's important features.

Current environmental protection measures are often insufficient to sustain ecosystem processes and structure because they were intended to protect individual pieces of the system. Further, these measures are often considered only at the site scale with limited information regarding the larger scale of the ecosystem. Since the 1970s, federal, state, and local governments have employed numerous protective measures, including regulations, land use planning tools, acquisition of property, incentive programs, and education/stewardship programs. These measures are designed to protect the environment and to manage for and minimize the adverse consequences of human population growth and associated land cover change. Despite these efforts, many activities continue to alter and impact habitat across the lands and waters of the watershed, placing our ecosystem at increased risk of degradation.

In contrast to many areas of the country, the region has made significant progress integrating environmental information into its protection efforts. Efforts to address this task include the N.C. Coastal Habitat Protection Plan and associated Strategic Habitat Areas, information and tools produced by the N.C. and Virginia Natural Heritage Programs, Virginia's Healthy Waters Initiative, and watershed planning efforts by the N.C. Division of Water Quality and the N.C. Ecosystem Enhancement Program. These data and tools provide target areas whose protection will provide important ecological or water quality benefits.

Despite these promising inroads, work remains to be done. Current efforts to preserve and restore inland aquatic habitats can be bolstered significantly and addressed more comprehensively. The packaging and delivery of information to resource managers and local governments is of critical importance and can be substantially improved by incorporating advances in mapping technology. Finally, because the estuarine region crosses state boundaries, work must be done to integrate information generated on both sides of the North Carolina-Virginia border.

**Rationale for action**

Protecting high quality ecological areas is less expensive and more effective than attempting to repair or recreate damaged areas. Protection of existing land cover is critical for making improvements in water quality, and the survival of important species will depend on our ability to preserve critical and connected habitats along estuarine, riverine, and upland systems. It is important to look at remaining habitat on a larger scale, determining what areas are most valuable, and make these our highest priority for protection. An array of tools such as purchasing property and conservation easements, incentive programs, and regulations are already available. Adaptive strategies are needed to best match these conservation approaches with the areas that are the most important and most vulnerable.

## OBJECTIVES AND ACTIONS

**Objective B1: Minimize the introduction of additional water pollution sources**

Once the water quality in a system is degraded or impaired, it often becomes difficult to improve or restore. Protection efforts will help prevent further degradation to the many impaired stream segments within the Albemarle-Pamlico watershed. The system also benefits from an array of streams and water bodies that fulfill use requirements or even meet high quality water standards. It is important to protect these streams from being degraded to help maintain the valuable services they provide.

Increased potential for water pollution will occur in the Albemarle-Pamlico region as populations grow and land use practices change. Protection of critical buffer areas, sound planning, the adoption of low impact development, and other best practices will ensure that new impacts to water quality are minimized.

> **Action B1.1: Minimize the introduction of toxics from targeted sources.** APNEP will support the development and implementation of best management practices (BMPs) that curb introduction of toxic materials into the estuarine system. Targeted sources of toxic pollution may include new marinas, boatyards, stormwater discharges, and wastewater treatment facilities.

**Key Partners:** NC-DWQ, VA-DEQ, VA-DCR, EPA, NC-CWMTF, VA-WQIF
**CCMP Outcomes Supported:** 1b, 1d, 2b, 3c
**Outputs:** Pollution control measures, BMPs
**Results:** Reduction in toxics within targeted water bodies
**Climate Impact:** Minimal anticipated implementation impacts

**Action B1.2: Minimize the introduction of pathogens from targeted sources.** The reduction of pathogens entering the estuarine system helps improve ecosystem integrity and resiliency. Aging infrastructure and rising sea levels are two challenges that must be addressed to reduce bacteria, viruses, and other microorganisms from entering public waters through identified sources. To address this action APNEP will work with its partners to support upgrades to wastewater treatment facilities and associated infrastructure that account for future risks.

**Key Partners:** NC-DWQ, VA-DEQ, VA-DCR, NC-DMF, NC-DCM, EPA, NC-CWMTF,VA-WQIF, SRF
**CCMP Outcomes Supported:** 1a, 1b, 1d, 2b, 3b
**Outputs:** Pollution control measures, upgraded infrastructure, BMPs
**Results:** Reduction in pathogens within targeted water bodies
**Climate Impact:** Minimal anticipated implementation impacts

**Action B1.3: Facilitate the protection of natural riparian buffers to reduce runoff.** Riparian buffers trap and filter polluted runoff, preventing sediments, nitrogen, phosphorus, pesticides, and other substances from entering the sounds. APNEP will support the purchase of land or conservation easements to protect buffers. APNEP will promote and endorse policies that encourage leaving riparian zones in a natural state.

**Key Partners:** NC-DWQ, NC-DCM, VA-DCR, NC-WRC, NC-CWMTF, VA-WQIF, VA-VOF, CTNC, NC-EEP, NC-SWC, VA-DSM
**CCMP Outcomes Supported:** 2a, 2b, 3b, 3d
**Outputs:** Protect or restore riparian buffers
**Results:** Improved water quality and habitat availability
**Climate Impact:** Minimal anticipated implementation impacts

**Action B1.4: Facilitate the development of state and local policies that support the use of low impact development (LID) practices to reduce runoff.** Use of LID practices will be encouraged through the development of model codes and governmental incentives for implementation.

**Key Partners:** Sea Grant, VA-DCR, NC-DCM, NC-DWQ, EPA, NOAA, Cooperative Extension, NCCF, NC-WRC, COGs, PDCs, IOG
**CCMP Outcomes Supported:** 2b, 3b, 3d
**Outputs:** Model LID codes, LID projects
**Results:** Improved water quality; sustain manageable rates of stormwater runoff
**Climate Impact:** Minimal anticipated implementation impacts

**Action B1.5: Facilitate the use of best management practices on agricultural and silvicultural lands.** Best management practices include a variety of methods and techniques to reduce pollutant runoff from lands modified by human use. BMPs will be promoted in the APNEP region through educational resources, workshops, and demonstration projects.

**Key Partners:** NC-SWC, VA-DSM, NC-NCFS, VA-VDOF, NC-DWQ, Cooperative Extension, NC-DACS, NRCS
**CCMP Outcomes Supported:** 2b, 3b, 3d
**Outputs:** Increased use of BMPs for agricultural and silvicultural activities
**Results:** Improved water quality and aquatic biodiversity
**Climate Impact:** No anticipated implementation impacts

## Objective B2: Protect and manage areas containing significant natural communities and habitats

The natural communities and habitats of the Albemarle-Pamlico region support a diverse and vibrant collection of species. The services provided by these systems include shelter, food sources, spawning areas, passage or travel, protection, and habitat for threatened and endangered species. Loss or fragmentation of these habitats can have severe and possibly irreversible impacts to the species that rely on them.

**Action B2.1: Facilitate the development and implementation of an integrated freshwater habitat protection strategy.** This protection strategy will complement the Coastal Habitat Protection Plan (CHPP), serving as a guide for inland waters. The plan will be a combined effort between North Carolina and Virginia, and it will include actions that address anadromous fish passage to and from spawning areas.

**Key Partners:** TNC, NC-WRC, VA-DGIF, NC-NHP, VA-NHP, USFWS, SALCC, NC-SWC, VA-DSM, NC-DMF
**CCMP Outcome Supported:** 2a
**Outputs:** Integrated freshwater habitat protection strategy/ partnership

**Results:** Improved management of water quality and ecosystem biodiversity to sustain ecosystem health

**Climate Impact:** No anticipated implementation impacts

**Action B2.2: Develop and implement a submerged aquatic vegetation (SAV) protection strategy.** APNEP will work with its partners in protecting SAV habitats through mapping efforts, examination of permitting requirements, water quality and habitat issues, and education for boaters.

**Key Partners:** NOAA, USFWS, NC-DCM, NC-DMF, NC-WRC, VA-VMRC, VIMS, USACE, SALCC

**CCMP Outcomes Supported:** 2a, 2b

**Outputs*:*** Submerged aquatic vegetation (SAV) protection strategy

**Results:** Improved management of water quality and ecosystem biodiversity

**Climate Impact:** Minimal anticipated implementation impacts

**Action B2.3: Facilitate the development of incentives for protection and management of targeted natural communities and habitats.** APNEP will facilitate the development and use of incentives to implement conservation easements and other conservation tools. An emphasis for protection will be placed on inland and coastal wetlands, primary nurseries, floodplain riparian areas, wetland buffers, and Significant Natural Heritage Areas.

**Key Partners:** NC-OCPCA, NC-WRC, NC-DMF, SALCC, CTNC, TNC, NC-SWC, VA-DSM, USFWS, USDA

**CCMP Outcomes Supported**: 2a, 2b, 3d

**Outputs:** New incentives for land protection

**Results:** Increase in acres of protected lands

**Climate Impact:** No anticipated implementation impacts

**Action B2.4: Facilitate the development of policies to minimize dredge and fill activities in naturalized areas and sensitive habitats.** Policies will address direct as well as indirect dredge activities. Over time, the extensive drainage network in several coastal counties has become naturalized and provides important habitats for fish and wildlife. APNEP will work with its partners to ensure that these habitats are considered in maintenance of the network.

**Key Partners:** NC-DMF, NC-DCM, NC-DWQ, USACE, VA-DEQ, NC-WRC, USFWS, EPA, VIMS

**CCMP Outcomes Supported:** 2a, 2b

**Outputs:** Coordinated policies and regulations regarding dredge and fill activities

**Results:** Improved water quality and ecological integrity

**Climate Impact:** Minimal anticipated implementation impacts

**Action B2.5: Facilitate protection of designated anadromous fish spawning areas and inland primary nursery areas from marina impacts.** Consistent with regulations and best practices, new projects should be directed away from or minimize impacts to specially designated areas vital to fishery resources. Marina development in inland waters, if not carefully considered and implemented, can damage valuable estuarine habitats. This action also supports retrofitting at existing facilities to improve aquatic habitat, as well as support for programs that safely dispose of onboard waste that might be discharged in open waters.

**Key Partners:** NC-DCM, NC-WRC, NC-DMF, NC-DWQ, VA-DEQ, EPA, NOAA, USFWS, VA-DGIF, USACE

**CCMP Outcomes Supported:** 2a, 2b

**Outputs:** Policies and regulations to protect designated anadromous fish spawning areas and inland primary nursery areas from adverse impacts of new marinas

**Results:** Increase in ecological integrity

**Climate Impact:** No anticipated implementation impacts

**Action B2.6: Minimize and rapidly respond to the introduction of invasive species through the development and implementation of integrated prevention and control strategies.** Management strategies include education of the public and actions to prevent introduction of invasive species. Existing populations of invasive species will be managed to prevent further encroachment into natural habitats.

**Key Partners:** NC-WRC, NC-DMF, NC-DWR, VA-DGIF, USFWS, NOAA, USDA, NC-OCPCA, VA-NHP, NC-DACS

**CCMP Outcomes Supported:** 2b, 2c, 3d

**Outputs:** Coordinated invasive species prevention and control strategies

**Results:** Prevention of adverse impacts associated with invasive species

**Climate Impact:** Minimal anticipated implementation impacts

## Objective B3: Utilize natural and constructed "living" shorelines to maintain estuarine and riverine ecosystem processes

The marine and estuarine shorelines of the Albemarle-Pamlico ecosystem are vulnerable to multiple threats, including erosion due to normal wave action and currents, storm surge associated with hurricanes and other strong storms, and sea level rise. As humans have settled in increasing numbers along the coast, they have also played a role in the modification of natural shorelines. While the protection of shorelines is necessary in some cases to protect important resources, there are techniques beyond traditional hardening, including the use of natural and living shorelines, which provide benefits to humans and allow for healthy marine and near-shore communities.

**Action B3.1: Assist local governments in the development of incentives for protecting natural shorelines.** Incentives and techniques will be developed and promoted that encourage the protection of natural shorelines as an alternative to hardened structures such as bulkheads and sea walls.

**Key Partners:** Sea Grant, NC-DCM, NC-DWQ, NC-DMF, VIMS, NC-SWC, NCCF

**CCMP Outcomes Supported:** 2b, 3d

**Outputs:** Incentives for protecting natural shorelines

**Results:** Improved water quality and ecological integrity while reducing shoreline erosion.

**Climate Impact:** No anticipated implementation impacts

**Action B3.2: Develop and distribute educational materials encouraging landowners to protect natural shorelines.** APNEP will work with its partners to continue to develop materials will describe how living shorelines are a viable alternative to hardened structures and explain the benefits natural shorelines provide.

**Key Partners:** NC-NERR, Sea Grant, NCCF, VIMS, NC-DWQ, NC-DMF, NC-SWC

**CCMP Outcomes Supported**: 2b, 3d

**Outputs:** Educational materials

**Results:** Improved water quality and ecological integrity while reducing shoreline erosion.

**Climate Impact:** No anticipated implementation impacts

**Action B3.3: Facilitate the development of requirements for living shoreline stabilization projects that optimally protect estuarine aquatic and shoreline habitats while minimizing regulatory requirements.** Homes, businesses, and towns along the estuarine waterfront often take shoreline stabilization measures to protect their property from erosion. Currently, the permitting process for living shorelines often takes more time and is more expensive than the process for most hardened structures. These regulatory requirements can be a

disincentive for those who might utilize living shoreline stabilization techniques, which can have significant long-term benefits for aquatic habitats. Because all shoreline stabilization techniques can impact water quality and aquatic habitat, APNEP will work with collaborating regulatory partners to develop standards that balance competing environmental considerations in the permitting process.

**Key Partners:** Sea Grant, NC-DCM**,** USACE, USFWS, NC-DWQ, NC-DMF, VIMS, NC-SWC, NCCF

**CCMP Outcomes Supported:** 2a, 2b

**Outputs:** Collaborative recommendations for estuarine shoreline stabilization policies

**Results:** Structures that control erosion with the least impact to natural shoreline function, Improved water quality and ecological integrity.

**Climate Impact:** No anticipated implementation impacts

# Component C: Restore

**Restore** the ecosystem processes, structures, and functions that sustain the Albemarle-Pamlico estuarine system. The restoration component recognizes that some ecosystem function has been lost, and that it must be strategically repaired to meet the demands of human and natural environments. The implementation and maintenance of integrative ecosystem restoration projects will be guided by comprehensive regional ecosystem assessments.

**Current situation**

The protection and restoration components are closely linked, as they both address common ecosystem functions and sources of decline. As mentioned in the preceding section, the Albemarle-Pamlico estuarine system has been modified by the actions of its human inhabitants. Changes to the landscape that accommodate homes, businesses, and infrastructure have increased runoff, which results in more polluted water reaching our rivers and sounds. Permanent vegetation removal, ditching, and the loss of riparian areas have increased erosion and degraded habitat for aquatic and upland species. Dams have blocked the passage of diadromous fish species. These actions have caused flooding, algal blooms, species declines, closed shellfish beds, and other serious impacts to the estuarine environment.

Despite these impacts, the Albemarle-Pamlico region is well positioned to benefit from coordinated and integrated restoration approaches. Urban centers like Raleigh and Durham continue to implement state-of-the-art development and infrastructure projects that advance LID approaches. Farmers and foresters are adopting best management practices that ensure the viability of working lands while improving water quality. Coastal hydrology, oyster reefs, degraded shorelines, and other critical ecosystem components are being restored through innovative projects. These restoration efforts will ultimately result in cleaner water, healthier ecosystems, and associated benefits for the people of the region.

**Rationale for action**

In addition to protecting important parts of the ecosystem from future human impacts, strategic restoration efforts are also needed to reach our ecosystem goals. While protection initiatives are important to preserve key ecosystem functions, environmental improvement in the face of increasing population pressures can only be achieved through targeted restoration efforts.

As in other sections, these restoration actions have been linked to CCMP outcomes through an ecosystem-based management decision-making process. APNEP aims to ensure that projects are selected considering the broader ecosystem, including habitat connectivity and potential effects of climate change. Furthermore, restoration work

should address identified challenges like wetland loss or nutrient pollution. The most desirable restoration efforts will address many of these factors in unison, improving both the quality of the ecosystem and the quality of life for the region's people.

## OBJECTIVES AND ACTIONS

**Objective C1: Restore water quality by eliminating targeted sources of water pollution**

The Albemarle-Pamlico estuarine system contains many streams and bodies of water that are polluted. Where these waters do not meet water quality standards, they are considered to be impaired. Contaminant management strategies will be developed and implemented for all waters not meeting water quality standards. Restoration activities will also improve damaged riparian and estuarine shorelines and reduce unregulated discharges from wastewater treatment facilities. Developments and infrastructure that create large amounts of polluted runoff will be targeted for retrofitting with low impact development practices.

**Action C1.1: Establish contaminant management strategies for waters not meeting water quality standards**. Management strategies for pathogens, toxics, and nutrients will have a more extensive focus than traditional total maximum daily load (TMDL) plans, which primarily manage industrial point sources and municipal stormwater. These strategies will also incorporate agricultural runoff and atmospheric deposition.

**Key Partners:** NC-DWQ, VA-DEQ, NC-CWMTF, EPA, NC-DACS, NC-SWC, VA-DSM

**CCMP Outcomes Supported:** 1a, 1b, 1d

**Outputs:** Coordinated contaminant management strategies

**Results:** Improved water quality and ecological integrity; reduction in impaired waters.

**Climate Impact:** No anticipated implementation impacts

**Action C1.2: Facilitate the implementation of existing contaminant management strategies.** APNEP will work with partners to support full implementation of existing management strategies for pathogens, toxics, and nutrients.

**Key Partners:** NC-DWQ, VA-DEQ, VA-DCR, NC-CWMTF, NC-SWC, EPA

**CCMP Outcomes Supported:** 1a, 1b, 1d, 3b, 3c

**Outputs:** Coordinated implementation of management strategies

**Results:** Improved water quality and ecological integrity

**Climate Impact:** No anticipated implementation impacts

**Action C1.3: Facilitate the restoration of riparian and estuarine shorelines.** Impacted shorelines will be replanted with native vegetation. Where feasible, bulkheads, and riprap structures will be replaced with living shorelines or structures that control erosion with the least impact to natural shoreline function.

**Key Partners:** NC-DCM, NC-WRC, USACE, NC-EEP, NCCF, USFWS, NOAA, TNC, NFWF, NC-CWMTF, CTNC, NRCS, VA-DCR, NC-SWC, VA-DSM, DU, UNC, CSI, Sea Grant

**CCMP Outcomes Supported:** 2a, 2b, 3d

**Outputs:** Voluntary shoreline restoration projects to support natural shoreline ecosystem functions

**Results:** Improved water quality and ecological integrity

**Climate Impact:** Minimal anticipated implementation impacts

**Action C1.4: Reduce unregulated discharge from wastewater treatment systems.** APNEP will work with municipalities in the region whose wastewater infrastructure is in need of repair or upgrade. APNEP will work with its partners to secure funding either directly or through federal and state grants or loans, to work with these communities.

**Key Partners:** NC-DWQ, VA-DEQ, NC-CWMTF, VA-WQIF, SRF, EPA

**CCMP Outcomes Supported**: 1a, 1b, 2a, 2b, 3b

**Outputs:** Wastewater treatment systems upgrade projects

**Results:** Improved water quality and ecological integrity

**Climate Impact:** No anticipated implementation impacts

**Action C1.5: Facilitate voluntary retrofitting of existing development and infrastructure to reduce runoff.** This action targets existing stormwater systems that are to be improved to reduce runoff. Where development or infrastructure has a high percentage of impervious surfaces, implementation of low impact development practices will be encouraged.

**Key Partners**: EPA, NC-DWQ, VA-DCR, NOAA, NC-CWMTF, VA-WQIF, NCCF, Sea Grant, CSI, Cooperative Extension

**CCMP Outcomes Supported:** 2b, 3d

**Outputs:** Stormwater retrofitting projects

**Results:** Improved water quality and ecological integrity

**Climate Impact:** No anticipated implementation impacts

**Objective C2: Restore hydrological processes in rivers and estuaries to support significant natural communities and ecosystem functions**

As human beings developed the Albemarle-Pamlico region, the hydrology of the system was highly altered. An increase in impervious surfaces resulted in increased runoff and higher rates of erosion. Streams were physically altered and diverted, sometimes eliminating habitats or leaving poor conditions for natural growth. Along the shores of the sounds and estuaries, hardening methods, such as bulkheads, have become the standard to prevent loss of coastal acreage.

To improve the hydrology of the Albemarle-Pamlico system, large-scale, coordinated efforts must be initiated. Alternative methods to shoreline armoring, including living shorelines, will be promoted to restore tidal shorelines while providing shallow water habitat and shoreline access to wildlife. Incentives will help increase the implementation of living shorelines. Restoration of streams to provide natural function and flow conditions provides a direct benefit to the ecosystem.

**Action C2.1: Facilitate the development and implementation of coordinated landscape-scale hydrological restoration strategies.** Much of the lowland agricultural areas are characterized by modified drainage networks that incorporate ditches and pumps. A coordinated strategy is the best way to ensure restoration is accomplished at the system scale.

**Key Partners:** SALCC, TNC, NCCF**,** USFWS, EPA, NOAA, USACE, NC-CWMTF, NC-DWQ, NC-DCM, NC-WRC, NC-EEP, Cooperative Extension, NC-DWR, NC-DSWC

**CCMP Outcomes Supported**: 2a, 2b, 3a, 3b, 3d

**Outputs:** Coordinated landscape-scale hydrological restoration strategies

**Results:** Improved water quality and ecological integrity

**Climate Impact:** Minimal anticipated implementation impacts

**Action C2.2: Facilitate the development of incentives to replace hardened estuarine shorelines with living shorelines.** Regulatory and financial incentives will make it easier to construct living shorelines and help motivate landowners to restore shoreline property. Technical assistance

can demonstrate that living shorelines are a viable option for shoreline stabilization.

**Key Partners:** NC-DCM, NC-DMF, USFWS, EPA, NOAA, USACE
**CCMP Outcomes Supported:** 2a, 2b
**Outputs:** Incentives for removing hardened estuarine shorelines
**Results:** Improved water quality and ecological integrity
**Climate Impact:** No anticipated implementation impacts

**Action C2.3: Facilitate the hydrologic restoration of floodplains and streams.** Floodplain restoration will include restoring wetland function and planting riparian vegetation. Removing channelization and improving stream banks will restore streams that have been altered.

**Key Partners:** TNC, NCCF, USFWS, EPA, USACE, NC-WRC, VA-DCR, NOAA, NC-CWMTF, NC-DWQ, NC-DCM, NC-EEP. NC-DSWC, VA-DSWC
**CCMP Outcomes Supported:** 3a, 3b, 3d
**Outputs:** Floodplain restoration projects
**Results:** Improved water quality, hydrology, and ecological integrity
**Climate Impact:** Minimal anticipated implementation impacts

**Objective C3: Facilitate collaborative and integrative restoration programs and projects**

The ecosystem-based management approach taken by APNEP recognizes that species and habitats are linked through complex natural processes. The ecological integrity of the Albemarle-Pamlico ecosystem is dependent on a myriad of ecological, social, and economic factors. Three elements of the ecosystem would especially benefit from the development and implementation of a comprehensive restoration strategy: invasive species, wetlands, and submerged aquatic vegetation. Collaborative restoration strategies should be developed for each of these environmental components to ensure all factors are considered as a management plan is created.

**Action C3.1: Develop and refine integrated invasive species eradication and control strategies.** Invasive species that adversely impact native populations must be systematically removed. A restoration strategy for habitats populated by invasive species will be comprehensive and consider the natural processes of all species within the ecosystem.

**Key Partners:** NC-DWR, NC-DACS, NC-WRC**,** USFWS, NOAA, VA-DGIF, NC-NHP, VA-NHP, USDA, NC-DCM, NC-DMF
**CCMP Outcome Supported**: 2b, 2c, 3d
**Outputs:** Invasive species eradication and control strategies

**Results:** Improved ecological integrity
**Climate Impact:** Minimal anticipated implementation impacts

**Action C3.2: Develop and implement a coordinated wetland restoration strategy.** APNEP will work with its partners to re-establish wetland hydrology and vegetation at sites where wetlands previously existed. Restoration will aim to improve wetlands in urban as well as rural/agricultural areas, and work will be coordinated with ongoing efforts to maximize output.

**Key Partners:** NC-DWQ, NC-DCM, NC-WRC, NC-EEP, NOAA, USFWS, USACE, EPA, TNC, NCCF, SALCC
**CCMP Outcomes Supported:** 2a, 2b, 3d
**Outputs:** Wetland restoration strategy/ partnership
**Results:** Improved water quality and ecological integrity
**Climate Impact:** Minimal anticipated implementation impacts

**Action C3.3: Develop and implement a submerged aquatic vegetation restoration strategy.** In conjunction with strategies to protect SAV (see B2.2), APNEP will work to restore areas capable of supporting SAV. This work will require study of effective restoration techniques, bathymetric mapping, water quality monitoring, and other efforts. APNEP will continue its contributions to the SAV Partnership to develop and promote a SAV restoration strategy.

**Key Partners:** NOAA, USFWS, NC-DCM, NC-DMF, NC-WRC, VA-VMRC, VIMS, USACE
**CCMP Outcomes Supported:**2a, 2b
**Outputs:** SAV restoration strategy
**Results:** Improved water quality and ecological integrity
**Climate Impact:** Minimal anticipated implementation impacts

## Objective C4: Remove in-stream barriers and restore spawning areas for diadromous fish

Humans have modified the rivers and streams of the Albemarle-Pamlico region for centuries to meet needs for water supply, irrigation, flood control, and other infrastructure. These changes come to the detriment of diadromous species, which depend on both rivers and the ocean for their survival. A single impassable barrier between these two environments can prevent miles of otherwise acceptable habitat from being utilized by these species. Barriers will be removed where feasible to facilitate the movement of these species around obstructions and restore degraded habitats.

**Action C4.1: Install fish ladders and eel-ways on existing dams and other permanent barriers.** Fish ladders and eel-ways can preserve passage across dams that are otherwise providing societal benefits like drinking water supplies or electricity. APNEP will support the construction and maintenance of mechanisms for fish and eel passage around in-stream barriers.

**Key Partners:** NC-WRC, VA-DGIF, USACE, NOAA, USFWS, NFWF, SALCC, American Rivers, NC-DMF, NCCF, TNC, NC-DWR
**CCMP Outcomes Supported:** 2a, 2b
**Outputs**: New fish ladders and eel-ways
**Results:** Improved fish populations and ecological integrity
**Climate Impact:** No anticipated implementation impacts

**Action C4.2: Facilitate the removal of dams, culverts, and other in-stream barriers.** Structures that have surpassed their designed lifespan or intended use will be targeted for removal. In-stream barriers scheduled for replacement also present opportunities to implement technologies that improve fish passage.

**Key Partners:** NC-WRC, VA-DGIF, NC-DMF, USACE, NOAA, USFWS, SALCC, NC-SWC, VA-DSM, NFWF, NC-EEP, American Rivers, NC-NCDOT, VA-VDOT, FHA, SEPA, NC-DCM
**CCMP Outcomes Supported:** 2a, 2b
**Outputs**: In-stream barrier removal projects
**Results:** Improved fish populations and ecological integrity
**Climate Impact:** No anticipated implementation impacts

**Action C4.3: Restore degraded anadromous fish spawning habitats.** Anadromous fish spawning habitat is dependent on suitable current velocities, adequate dissolved oxygen levels, and low turbidity. APNEP will work to support suitable hydrologic flows and restore submerged aquatic vegetation in streams and rivers that contain anadromous species.

**Key Partners:** NC-DMF, NC-WRC, VA-DGIF, USACE, NOAA, USFWS, NFWF, NC-DCM, CTNC, NCCF
**CCMP Outcomes Supported:** 2a, 2b
**Outputs**: Habitat restoration projects
**Results:** Improved fish populations and ecological integrity
**Climate Impact:** Minimal anticipated implementation impacts

**Action C4.4: Facilitate research to improve fish passage.** APNEP will provide funding and support for research to improve fish passage. In-stream barriers will be studied to identify structures that may potentially be removed. Mechanisms for conveying anadromous species, such as fish ladders, will be considered and targeted for strategic locations.

**Key Partners:** Sea Grant, NOAA, USFWS, USACE, NC-DMF, NC-WRC, VA-DGIF, VA-VMRC, SALCC

**CCMP Outcomes Supported:** 2a, 2b

**Outputs**: Recommendations for improved fish and eel passage

**Results:** Improved fish populations and ecological integrity

**Climate Impact:** No anticipated implementation impacts

**Objective C5: Restore oyster habitats to improve water quality and other ecosystem functions**

Oysters are an important resource for the Albemarle-Pamlico estuarine system that provide a livelihood to coastal residents and serve an important function by filtering pollutants out of the water. Harvests from the sounds of North Carolina have declined dramatically over the last 100 years, and efforts are under way to restore the extent of oyster habitat in the region.

**Action C5.1: Construct new oyster habitats.** Where conditions are optimal for oyster habitat, APNEP will fund the replanting of cultch material and seed oysters. APNEP will support the development of oyster sanctuaries and shellfish management areas to provide continued propagation of oysters.

**Key Partners:** NC-DMF, NCCF, TNC, NOAA, USACE, NC-DCM, EPA, CSI, IMS, VIMS

**CCMP Outcome Supported:** 2b

**Outputs**: Oyster habitat restoration projects

**Results:** Increased oyster habitats, improved water quality, and ecological integrity

**Climate Impact:** No anticipated implementation impacts

**Action C5.2: Reduce the adverse impacts of harvests to existing oyster habitat.** APNEP will support management efforts to prevent adverse oyster harvest practices. Existing reefs should be carefully managed to prevent further decline of oyster populations, and research

should refine technologies and methods to support improved management of oysters in the future.

**Key Partners**: NC-DMF, NOAA, Sea Grant, CSI, VIMS, IMS
**CCMP Outcome Supported:** 2b
**Outputs**: Recommendations for oyster harvest methods
**Results:** Continued oyster harvests and viable habitats
**Climate Impact:** No anticipated implementation impacts

**Action C5.3: Facilitate research to improve oyster restoration technologies and methods.** APNEP will support the completion and update of shellfish habitat mapping efforts along the North Carolina coast. Research supported by APNEP will study conditions that support reef productivity, change analysis in oyster habitat shifts, and site selection and benefits of oyster sanctuaries.

**Lead Organizations**: APNEP, NC-DMF, Sea Grant
**Key Partners:** NC-DMF, Sea Grant, NCCF, TNC, NOAA, SALCC, IMS, CSI, VIMS
**CCMP Outcome Supported:** 2b
**Outputs**: Recommendations for oyster restoration
**Results:** Increased oyster habitats, improved water quality, and ecological integrity
**Climate Impact:** No anticipated implementation impacts

# Component D: Engage

**Engaging** partners and collaboration are the overarching principles necessary for the achievement of suitable environmental outcomes. To accomplish program goals, APNEP will work closely with its partners to ensure that activities and resources are focused on the most urgent and important problems. Many of the programs and laws now used to regulate or support activities in our watershed were established on a piecemeal basis to address significant individual problems. Improved coordination of planning for land use, water supply, ecosystem protection, transportation, and restoration will enable us to more effectively address problems at an ecosystem scale.

APNEP will engage its partnering organizations and the public to improve awareness and understanding of environmental issues facing the Albemarle-Pamlico region. Furthermore, APNEP will encourage individual and collective stewardship of the region's resources, including support for the planning, policies, and actions required to sustain the Albemarle-Pamlico ecosystem and its human communities.

**Current situation**

Most management efforts in the Albemarle-Pamlico estuarine system were not designed to protect the entire ecosystem. Instead, most programs focus on smaller pieces of the ecosystem (fisheries, soil, water, and others), which can result in a fragmented approach to restoration and protection. For example, many land use and permit decisions are made without full consideration of broad-scale impacts to land, water, species, and human well-being. Furthermore, many decisions do not fully consider land use, climate change, or sea level rise forecasts.

Our review of environmental efforts in the Albemarle-Pamlico estuarine system indicates that many people, organizations, and agencies are working to improve the region. However, regional capacity to work at an ecosystem scale remains low despite decades of work and progress. Fully integrated approaches to restoring and sustaining the Albemarle-Pamlico estuarine system have not yet been realized. The transfer of knowledge and resources to implement strategic actions remains uneven, and coordination of management initiatives can be improved substantially.

**Rationale for action**

APNEP is well positioned to coordinate stewardship, environmental education, and management efforts across state lines, between all levels of government, and with a broad array of stakeholder groups in the region. APNEP's advisory committee structure ensures strong community ties throughout the region, and APNEP's partners consistently undertake engagement activities throughout the region. With its mission to protect the entire estuarine ecosystem, APNEP can identify opportunities to integrate and improve engagement efforts on a regional scale.

## OBJECTIVES AND ACTIONS

**Objective D1: Foster environmental stewardship**

The Albemarle-Pamlico region's inhabitants and visitors recognize the beauty and rich natural resources of the region. Through targeted education and communications efforts, APNEP and its partners will encourage citizens to reduce their environmental impacts and provide meaningful opportunities to restore the ecosystem. APNEP will further work to find areas of mutual benefit between citizens, businesses, and governments related to the protection and restoration of the region's resources.

**Action D1.1: Communicate the importance of stewardship and offer opportunities for volunteerism to further APNEP's mission.** Advocating environmental stewardship and providing citizens with meaningful volunteer options improves the environment while educating the public about the Albemarle-Pamlico estuarine system.

**Key Partners:** NC-DENR, NC-OEEPA, VA-OEE, VA-DCR, VA-DEQ, NCCF, TNC, EPA, NOAA, PfS, IMS, CSI, VIMS, NC-NERR, NC-AQ, VA-AQ

**CCMP Outcomes Supported:** 1a, 1b, 1d, 1e, 2a

**Output:** Workshops and engagement materials on stewardship and volunteer opportunities

**Results:** Increase in voluntary citizen action to protect and restore the Albemarle-Pamlico estuarine system

**Climate Impact:** No anticipated implementation impacts

**Action D1.2: Facilitate efforts to improve collaborations to protect and restore ecosystem processes.** Homeowners, farmers, foresters, and businesses control most land in the Albemarle-Pamlico region. The interest and action of private individuals, supported by government expertise and resources, is critical to protect and restore the estuarine ecosystem.

**Key Partners**: NC-OCPCA, CTNC, NC-DENR, VA-DCR, VA-DEQ, NCCF, TNC

**CCMP Outcomes Supported:** 1a, 1b, 1c, 1d, 1e, 2a, 2b, 2c, 3a, 3b, 3c, 3d

**Outputs:** Workshops and engagement materials on land conservation

**Results:** Increase in protected lands through easements, better management, or other methods

**Climate Impact:** No anticipated implementation impacts

**Action D1.3: Coordinate outreach and engagement efforts regarding the impacts of invasive species.** Effective outreach and engagement is an important part of any integrated invasive species management effort. There are many ways citizens can help limit the spread of invasive species and informed volunteers can report on the presence and spread of these organisms.

**Key Partners:** Sea Grant, Cooperative Extension, NC-DWR, NC-WRC, NC-DACS, VA-VDACS, NC-NHP, VA-NHP, TNC, VA-DGIF, NC-NERR

**CCMP Outcome Supported**: 2c

**Outputs:** Coordinated outreach and engagement programs

**Results:** Reduced introductions of and impacts from invasive species

**Climate Impact:** No anticipated implementation impacts

**Action D1.4: Coordinate outreach efforts regarding the proper application of fertilizers to reduce nutrient runoff.** Perhaps no everyday action affects the estuarine system as does the application of fertilizer, which contributes to eutrophication if improperly applied. The choice of product, as well as the timing, volume, and area of application are important considerations for consumers. A coordinated outreach and engagement program will be an important part of nutrient management efforts. Best practices can help save money while preserving the region's waters.

**Key Partners:** Sea Grant, Cooperative Extension, NC-DWQ, VA-DCR, NC-DACS, VA-DEQ, NC-SWC, VA-DSM

**CCMP Outcomes Supported:** 2a, 2b, 3b

**Outputs:** Coordinated outreach and engagement programs

**Results:** Nutrient reductions in the waters of the Albemarle-Pamlico estuarine system

**Climate Impact:** No anticipated implementation impacts

**Action D1.5: Increase opportunities for public access to waterways, public lands, and trails.** Greenways, parks, piers, and other projects can help protect water quality and provide opportunities for experiencing and learning about the environment. As people seek out these areas for relaxation and recreation, they also support an increasingly valuable ecotourism industry.

**Key Partners:** NC-WRC, USACE, NC-DCM, VA-DCR, NC-PRTF, VA-VOF, CTNC, NC-DPR, NPS, USFWS, USFS, NC-CWMTF, VA-DGIF, PfS, NC-AQ, VA-AQ

**CCMP Outcome Supported:** 1e

**Outputs:** New opportunities for the public to become engaged in experiencing the Albemarle-Pamlico ecosystem

**Results:** Increased awareness and engagement in implementation of the CCMP

**Climate Impact:** No anticipated implementation impacts

**Objective D2: Conduct targeted environmental education efforts regarding sustainable use, habitats, and ecosystem services**

Environmental education is a learning process that increases people's knowledge and awareness about the environment and associated challenges while developing the necessary skills and expertise to address these challenges. Environmental education also fosters attitudes, motivations, and commitments to make informed decisions and take responsible action with respect to the environment. APNEP is committed to educating children and adults about the rich natural resources found throughout the Albemarle-Pamlico ecosystem, with the purpose of increasing knowledge of the ecosystem and equipping the region's citizens with the skills to effectively approach environmental issues.

**Action D2.1: Provide and promote opportunities for outdoor experiences that connect individuals with the Albemarle-Pamlico ecosystem**. A meaningful and educational outdoor experience can change the lens through which a person views the natural world. A person who is connected to the estuarine system is more likely to take the steps necessary to ensure that it thrives. APNEP will continue to work with its partners to provide and promote opportunities for meaningful outdoor experiences.

**Key Partners:** APNEP, NC-DPR, VA-DCR, NC-NERR, NC-WRC, PfS, VA-OEE, NC-OEEPA, USFWS, NPS, NCCF, NC-DOC, VA-DOC, NC-MNS, NC-DACS, NC-AQ, VA-AQ

**CCMP Outcome Supported:** 2a

**Outputs:** Activities for the public to become engaged in experiencing the Albemarle-Pamlico ecosystem

**Results:** Increased awareness and engagement in implementation of the CCMP

**Climate Impact:** No anticipated implementation impacts

**Action D2.2: Provide environmental education training opportunities for educators in the region.** By teaching educators about the Albemarle-Pamlico region and its associated environmental issues and providing them with science-based resources, APNEP and its partners enrich the education of thousands of students annually.

**Key Partners:** NC-NERR, PfS, NCCF, NC-DPR, Sea Grant, NC-MNS, NC-OEEPA, VA-OEE, VIMS, CSI, UNC, NC-AQ, VA-AQ
**CCMP Outcome Supported**: 1c, 1e, 2a, 2b, 2c, 3b
**Outputs:** Workshops and materials for educators
**Results:** Increased awareness and engagement in implementation of the CCMP
**Climate Impact:** No anticipated implementation impacts

**Action D2.3: Increase public understanding of the relationship between ecosystem health and human health advisories relating to water, fish, and game**. Few citizens fully understand the relationships between human activity and health advisories. APNEP will work to help people make these connections, allowing citizens to take concrete steps to address pollution sources.

**Key Partners:** Sea Grant, USFWS, NC-WRC, EPA, NC-DWQ, NC-DMF, VA-VDH, NC-DPH
**CCMP Outcome Supported:** 1a, 1b, 1d
**Outputs:** Outreach and educational materials
**Results:** Improved water quality.
**Climate Impact:** No anticipated implementation impacts

**Objective D3: Provide tools and training to support ecosystem-based management.**

Many decisions that affect the integrity of the estuarine ecosystem are made at the local level with little incentive to consider their broader impacts. Local leaders are tasked with making decisions based on a wide range of political, economic, and social factors. Often environmental considerations represent only part of any given issue. Because local leaders come from all disciplines and face many issues, APNEP recognizes the need to provide local government officials with tailored information necessary for efficient and informed environmental decision-making. APNEP will work with its partners to ensure that local governments have access to quality educational opportunities, mapping resources, and other pertinent information necessary to make informed decisions.

**Action D3.1: Develop and implement a strategy to improve decision-makers' understanding of the costs and benefits of environmental protection, restoration, planning, and monitoring.** While the costs of environmental protection are easy to see on a balance sheet, the benefits can be harder to quantify. APNEP will work with its partners to provide science-based information to government officials regarding the value of ecosystem services and help them incorporate this information into the decision-making process.

**Key Partners:** NC-DCM, NC-DWR, NC-DWQ, IOG, COGs, PDCs, APA, Sea Grant, IOG, NC-NHP

**CCMP Outcomes Supported:** 1a, 1b, 1d, 2a, 2b, 3a, 3c, 3d

**Outputs:** Communication strategy and materials on ecosystem services

**Results:** Informed decisions for environmental management

**Climate Impact:** No anticipated implementation impacts

**Action D3.2: Facilitate the development and implementation of basinwide water management plans to ensure no less than minimum in-stream flows are maintained.** APNEP will work to provide scientific information and engage regional stakeholders to develop and implement water management plans that fully account for both human and ecological demands.

**Key Partners:** NC-DWR, NC-WRC, USFWS, USGS, VA-DEQ, USACE, SALCC, NOAA, EPA

**CCMP Outcomes Supported:** 1c, 3a

**Outputs:** Management plans establishing minimum in-stream flows

**Results:** Science-based management of in-stream flows to support both human and ecological demands

**Climate Impact:** Minimal anticipated implementation impacts

**Action D3.3: Provide assistance to state, regional, and local governments to incorporate climate change and sea level rise considerations into their planning processes.** APNEP and its partners have made significant strides predicting and mapping future climate risks, but much work remains to be done. APNEP will support government partners that choose to integrate climate information into their planning process. Additionally, APNEP will work across sectors to identify and leverage mutually beneficial climate adaptation opportunities.

**Key Partners:** Sea Grant, NC-DCM, NC-OCPCA, NC-DMF, NC-DEM, EPA, SALCC, VA-CZM, USFWS, NC-WRC, NOAA, NC-NCDOT, NC-DHHS, IOG

**CCMP Outcomes Supported**: 1a, 1b, 1c, 1d, 1e, 2a, 2b, 2c, 3a, 3b, 3c, 3d

**Outputs:** State, regional, and local plans that address climate change and sea level rise

**Results:** Improved climate resiliency for human and natural communities in the region.

**Climate Impact:** No anticipated implementation impacts

# Component E: Monitor

**Monitoring** the environment and implementation of management actions undertaken by APNEP and its partners are critical components of adaptive, ecosystem-based management.

First, APNEP and its partners will focus monitoring efforts on various indicators of ecosystem condition. Tracking progress towards the ecosystem outcomes will require the establishment of a coordinated monitoring strategy to detect, measure, track, and assess changes in the ecosystem. Without consistent monitoring, financial and human resources could be wasted on ineffective initiatives. Alternatively, the benefits of highly successful management approaches may not be recognized.

Second, APNEP will work with its partners to monitor the implementation of management actions. If actions are not fully implemented, APNEP will take steps to identify and overcome the barriers to implementation. Alternatively, if barriers to an action's implementation prove difficult to overcome, APNEP will revisit the ecosystem-based management process to determine whether more effective actions exist to achieve environmental outcomes.

This monitoring and reassessment is an essential part of adaptive, ecosystem-based management, as it promotes accountability by evaluating whether or not management actions have resulted in progress toward stated environmental goals. The information obtained from monitoring efforts will be provided in an easily accessible format designed to promote transparency and foster cooperative adaptive management efforts.

**Current situation**

Currently, monitoring infrastructure in the region remains sparse, and an integrated ecological monitoring network does not exist. Until recently, little coordination existed among monitoring efforts by local, state, and federal organizations within the region. Most monitoring and reporting efforts conducted in the region are tied to objectives from specific grant programs or legal mandates.

Recent efforts at the federal and state level to organize monitoring are helpful, but these initiatives do not necessarily provide information at a consistency and scale that is needed to address the problems in the Albemarle-Pamlico ecosystem. Actions in this component will begin to more effectively discern who is monitoring the environment, what is being monitored, whether programs are working, and what might be done differently to support ecosystem-based approaches in the region.

**Rationale for action**

The incorporation of a rigorous and relevant monitoring program is critical to the success of APNEP and its partner organizations. Yet the complexity of ecological systems makes the design, construction, and maintenance of monitoring efforts a challenging task. Despite this fact, the residents of the region deserve accountability and information regarding the state of their environment. A comprehensive and integrated environmental monitoring strategy and its full implementation are necessary to fulfill this obligation.

## OBJECTIVES & ACTIONS

**Objective E1: Develop and maintain an integrated monitoring network to collect information for assessment of ecosystem outcomes and management actions associated with the implementation of the CCMP**

Implementation of CCMP actions should produce positive changes in the ecosystem, and monitoring should be designed to measure these changes. Where possible, monitoring should also detect other environmental trends, helping the program identify and adjust priorities. Measuring progress toward desired outcomes will require the establishment of a coordinated and integrated monitoring strategy. If fully implemented, these monitoring actions will support a systems-level understanding of the region's environment.

**Action E1.1: Facilitate the development and implementation of an integrated monitoring network through the guidance of regional monitoring and assessment teams.** APNEP resource-themed teams (living aquatic, water, wetlands, terrestrial, air, human dimensions) will help assure that the results of environmental management efforts can be measured, and that management initiatives can be tailored based on the results of environmental assessments.

**Key Partners:** NC-DENR, VA-DEQ, VA-DCR, SALCC, EPA, NOAA

**CCMP Outcomes Supported:** 1a, 1b, 1c, 1d, 1e, 2a, 2b, 2c, 3a, 3b, 3c, 3d

**Outputs:** Regional integrated monitoring network

**Results:** Management decisions based on the results of environmental monitoring and assessments

**Climate Impact:** No anticipated implementation impacts

**Action E1.2: Assess the value of information for measuring ecosystem and CCMP implementation outcomes**. APNEP will work with its partners to assess monitoring information to gauge its ability to assist managers in determining environmental progress of the implementation of CCMP actions. Specifically, the costs and resolution of monitoring data will

be assessed, as well as that data's value for supporting adaptive management and other environmental decisions. When needed, APNEP will work to identify new monitoring technologies and revisit established monitoring strategies.

**Key Partners:** EPA, NC-DENR, VA-DEQ, VA-DCR, SALCC, NOAA

**CCMP Outcomes Supported:** 1 a, 1b, 1c, 1d, 1e, 2a, 2b, 2c, 3a, 3b, 3c, 3d

**Outputs:** Assessments of monitoring and CCMP progress

**Results:** Revised monitoring network to support management decisions

**Climate Impact:** No anticipated implementation impacts

**Action E1.3: Facilitate the expansion of volunteer monitoring into a core element of the integrated monitoring network**. The traditional focus of APNEP's Citizen Monitoring Network has been the monitoring of select ecosystem indicators of water quality and citizen engagement. Where feasible, the expansion will incorporate a volunteer monitoring contribution for active ecosystem and management indicators. A rigorous quality assurance protocol will help maximize the utility of volunteer-produced data in APNEP assessments.

**Key Partners:** NC-MNS, NCCF, NOAA, USFWS, NC-DENR, VA-DEQ, VA-DCR

**CCMP Outcomes Supported:** 1a, 1b, 1c, 1d, 1e, 2a, 2b, 2c, 3a, 3b, 3c, 3d

**Outputs:** High-quality volunteer monitoring data for select ecosystem and management indicators

**Results:** More comprehensive and effective monitoring network to support management decisions

**Climate Impact:** No anticipated implementation impacts

## Objective E2: Develop and maintain a comprehensive spatial database for pertinent environmental data and modeling information

Even the most well planned monitoring and modeling efforts will fall short if the information isn't readily available to those who need it. Currently, data from many monitoring or modeling programs remain difficult to access. Other efforts fall short because they are of limited scope or duration, or the results simply don't reach environmental decision-makers. APNEP will work to develop a clearinghouse of all relevant monitoring and modeling efforts from the regional to community scale. The database will be publicly available, easy to navigate, and will contain historical information to assess changes in the regional ecosystem. This database will make environmental information available to

all whom are interested, and it can maximize monitoring resources by avoiding duplication and focusing efforts where needed.

**Action E2.1: Facilitate the design and content acquisition of a regional database based on partners' data and information needs.** A regional database will help ensure that environmental information will be integrated to support regional assessments and environmental decision-making.

**Key Partners:** SALCC, EPA, NC-DENR, VA-DEQ, VA-DCR, NC-WRC, NC-DEM, NOAA

**CCMP Outcomes Supported:** 1a, 1b, 1c, 1d, 1e, 2a, 2b, 2c, 3a, 3b, 3c, 3d

**Outputs:** Regional database that is comprehensive, current, and easily accessible

**Results:** More informed decisions based on current shared data

**Climate Impact:** No anticipated implementation impacts

**Action E2.2: Develop and maintain an online resource that clearly conveys regional information in support of ecosystem-based management.** In addition to creating a regional database, APNEP will work to make its contents easily and readily available for all who wish to use it.

**Key Partners**: SALCC, NC-WRC, NC-OCPCA, NOAA

**CCMP Outcomes Supported**: 1a, 1b, 1c, 1d, 1e, 2a, 2b, 2c, 3a, 3b, 3c, 3d

**Outputs:** Data portal

**Results:** More informed decisions based on current shared data

**Climate Impact:** No anticipated implementation impacts

## Terms and Definitions

The working terms and definitions below are meant to introduce various concepts and to convey the meaning of technical terms in a straightforward, plain language manner. More precise definitions are available by consulting other references or literature sources.

**303(d) list** – A list of the most seriously impaired waters in the region developed to comply with the federal Clean Water Act.

**anadromous** – Aquatic species that must reproduce in rivers but live much of their life in the ocean.

**aquatic system** – The interconnected surface streams, rivers, lakes, sounds, and ocean in the Albemarle-Pamlico watershed.

**bathymetry** – The study of the depth and contours of underwater surface features.

**best management practices (BMP)** – Practices applied in a number of different industries (including agriculture, stormwater management, and energy development, among others) that minimize negative environmental impacts.

**catadromous** – Aquatic species that breed in the ocean and live a majority of their life in fresh and brackish waters.

**conservation atlas** – An integrated collection of maps and geographic information, presented online, that can be used in support of environmental decision-making.

**contaminant management strategy** – The full array of management measures which may be employed to reduce the amount of contaminants that enter the estuarine system.

**designated use** – A categorization of water bodies based on their most appropriate use. Associated with each designated use are various water quality standards which should be met to support that use.

**diadromous** - Migratory aquatic species that depend on both the river and the ocean for parts of their life cycle. This term includes both anadromous and catadromous species.

**ecological flow** – The amount of stream flow necessary to maintain ecological integrity in aquatic river systems. See N.C.G.S. § 143-355(o)(1)(a).

**ecological health** – A synonym for ecological integrity that compares the function of an ecosystem to that of the human body.

**ecological integrity** – The ability of an ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to prevailing ecological conditions and, when subject

to disruption, to recover and continue to provide the natural goods and services that normally accrue from the system.

**ecosystem** – All living organisms in an area and the nonliving physical environment with which they interact.

**ecosystem-based management** – An environmental management approach that recognizes the full array of interactions within an ecosystem, including humans.

**geographical information system** – Mapping software that allows geographically referenced information to be displayed, managed, and analyzed.

**hardened shorelines** – Areas along a waterfront that are stabilized by structures that prevent erosion, including bulkheads and riprap.

**hydrologic processes** – The ways in which water moves through the ecosystem.

**hydrologic regime** – The movement, distribution, and quality of water in the ecosystem.

**impaired waters** – Bodies of water or stream segments in which at least one surface water quality standard is not met for its designated use.

**indicator** – A numerical value derived from actual measurements of a pressure, state or ambient condition, exposure, ecological condition, or measure of human health or well-being over a specified geographic domain, whose trends over time represent or draw attention to underlying trends in the condition of the environment in the Albemarle-Pamlico region.

**living shorelines** – Stabilization techniques to minimize erosion that use natural habitat Reelements to protect shorelines from erosion while also providing critical habitat for estuarine species.

**low-impact Development (LID)** – An approach to land development (or re-development) that works with nature to manage stormwater as close to its source as possible. This practice employs principles such as preserving and recreating natural landscape features, minimizing or eliminating pollutants in storm water through natural processes, and maintaining pre-development hydrologic characteristics, such as flow patterns, surface retention, and recharge rates.

**National Estuary Program** – Established by section 320 of the Clean Water Act, the National Estuary Program is administered by EPA and protects 28 “estuaries of national significance” throughout the United States. The Albemarle-Pamlico estuary was among the first in the nation to become a part of this program.

**pathogens** – Viruses, bacteria, or other microorganisms that cause disease in humans or other plant or animal species.

For the reader’s convenience, a table of acronyms is provided on page 57

**personal care and pharmaceutical products** – Products used for personal health or cosmetic reasons, or used to enhance the growth or health of livestock. Many of these substances are present in small amounts in regional waterbodies and have unique chemical structures. The ecological effects of these substances remain largely unstudied.

**submerged aquatic vegetation** – Rooted vascular plants that live below the water surface in large meadows or small patches in coastal and estuarine waters. Also known as SAV, aquatic grasses, or grass beds, they can be further classified by the range of salinity of the waters in which they are found.

**toxics** – Chemicals that have adverse health or ecological effects when released into the environment.

**watershed** – The area of land where all water that is under it or drains from it goes to the same place. The Albemarle-Pamlico watershed describes the land and rivers that drain into the Albemarle and Pamlico Sounds.

# Acronyms and Abbreviations

APA- American Planning Association
APES- Albemarle-Pamlico Estuarine Study
APNEP- Albemarle-Pamlico National Estuary Program
BMP- best management practices
CAC- APNEP Citizens Advisory Committee
CAMA- Coastal Area Management Act
CCMP- Comprehensive Conservation and Management Plan
CHPP- Coastal Habitat Protection Plan (NC)
COG- Council(s) of Governments
CSI- University of North Carolina Coastal Studies Institute
CTNC- Conservation Trust for North Carolina
DU- Ducks Unlimited
EBM- ecosystem-based management
EPA- United States Environmental Protection Agency
FHA- Federal Highway Administration
GIS- geographic information system
IMS- University of North Carolina Institute of Marine Sciences
IOG- University of North Carolina Institute of Government
LID- low-impact development
MAC- APNEP Management Advisory Committee
NC- North Carolina
NCCF- North Carolina Coastal Federation
NC-AQ- North Carolina Aquariums
NC-CWMTF- Clean Water Management Trust Fund (NC)
NC-DACS- North Carolina Department of Agriculture and Consumer Services
NC-DCM- North Carolina Division of Coastal Management (NC-DENR)
NC-DEM- North Carolina Division of Emergency Management
NC-DENR- North Carolina Department of Environment and Natural Resources
NC-DHHS- North Carolina Department of Health and Human Services
NC-DMF- North Carolina Division of Marine Fisheries (NC-DENR)
NC-DOC- North Carolina Department of Commerce
NC-DPH- North Carolina Division of Public Health
NC-DPR- North Carolina Division of Parks and Recreation (NC-DENR)
NC-DWQ- North Carolina Division of Water Quality (NC-DENR)
NC-DWR- North Carolina Division of Water Resources (NC-DENR)
NC-EEP- North Carolina Ecosystem Enhancement Program (NC-DENR)
NC-EPPC- North Carolina Exotic Pest Plant Council
NC-MNS- North Carolina Museum of Natural Sciences
NC-NCDOT- North Carolina Department of Transportation
NC-NCFS- North Carolina Forest Service
NC-NHP- North Carolina Natural Heritage Program (NC-DENR)
NC-NERR- North Carolina Coastal Reserve and National Estuarine Research Reserve
NC-OCPCA- North Carolina Office of Conservation, Planning, and Community Affairs (NC-DENR)
NC-OEEPA- North Carolina Office of Environmental Education and Public Affairs (NC-DENR)
NC-PRTF- North Carolina Parks and Recreation Trust Fund
NC-SWC- North Carolina Division of Soil and Water Conservation (NC-DACS)
NC-WRC- North Carolina Wildlife Resources Commission
NCSUWQG- North Carolina State University Water Quality Group
NEMO- Non-point Education for Municipal Officials
NFWF- National Fish and Wildlife Foundation
NGO- Non-governmental organization
NMFS- National Marine Fisheries Service
NOAA- National Oceanic and Atmospheric Administration
NRCS- Natural Resources Conservation Service
PCPP- personal care and pharmaceutical products
PDC- Planning District Commission
PfS- Partnership for the Sounds
SAFMC- South Atlantic Fishery Management Council
SALCC- South Atlantic Landscape Conservation Cooperative
SAV- submerged aquatic vegetation
SEPA- Southeast Power Administration
SHA- Strategic Habitat Area
SRF- North Carolina and Virginia State Revolving Funds
STAC- APNEP Science and Technical Advisory Committee
TNC- The Nature Conservancy
UNC- The University of North Carolina at Chapel Hill
USACE- United States Army Corp of Engineers
USDA- United States Department of Agriculture
USFS- United States Forest Service
USFWS- United States Fish and Wildlife Service
USGS- United States Geological Survey
VA – Virginia
VA-AQ- Virginia Aquarium and Marine Science Center
VA-CZM- Virginia Coastal Zone Management Program (VA-DEQ)
VA-DCR- Virginia Department of Conservation and Recreation
VA-DEQ- Virginia Department of Environmental Quality
VA-DGIF- Virginia Department of Game and Inland Fisheries
VA-DSM- Virginia Division of Stormwater Management (VA-DCR)
VA-NHP- Virginia Natural Heritage Program (VA-DCR)
VA-OEE- Virginia Office of Environmental Education (VA-DEQ)
VA-VDACS- Virginia Department of Agriculture and Consumer Services
VA-VDH- Virginia Department of Health
VA-DOC- Virginia Department of Commerce
VA-VDOF- Virginia Department of Forestry
VA-VDOT- Virginia Department of Transportation
VA-VMRC- Virginia Marine Resources Commission
VA-VOF- Virginia Outdoors Fund
VA-VWWP- Virginia Office of Wetlands and Water Protection (VA-DEQ)
VA-WQIF- Virginia Water Quality Improvement Fund
VIMS- Virginia Institute of Marine Science

For the reader's convenience, a table of acronyms is provided on page 57

# Appendix I
# APNEP's Ecosystem-Based Planning Process 2008-2012

**Development of an ecosystem-based CCMP**

Based on seven years of intensive scientific study and the efforts of numerous stakeholders, APNEP's first Comprehensive Conservation and Management Plan (CCMP) was developed in 1994. Most of the 49 management actions in the plan were implemented. Since then many new issues have arisen that were not addressed in the CCMP. Additionally, as developments in natural resource conservation and ecosystem science progressed, the 1994 plan became increasingly dated. APNEP staff began the process of updating the CCMP in 2008 with assistance from its advisory committees and the EPA.

APNEP began the planning process by seeking initial counsel from a broad array of stakeholders. A CCMP steering committee was created to define issues of importance for the region, which began to inform the development of the new plan. After several meetings a core set of issues emerged and draft objectives were developed. However, the objectives appeared disjointed for lack of a comprehensive watershed management approach necessary for protecting and restoring the Albemarle-Pamlico estuarine ecosystem. An overview of national estuary programs (NEPs) and ecosystem-based management (EBM) was presented to the Policy Board in June 2009.

After much consideration program staff, with the assistance of the Science & Technical Advisory Committee (STAC), investigated current practices among our partners pertaining to their use of EBM principles. Following the summer 2009 STAC meeting, staff began to draft a proposal for Policy Board consideration of using EBM as the foundation for the new CCMP. To provide guidance in development of the EBM proposal the staff assembled an EBM Proposal Team. The team included representatives from the Policy Board, STAC, and the U.S. Fish and Wildlife Service. Working together, the Team developed a proposal that was approved by the Policy Board in December 2009.

To provide guidance in plan development, APNEP recruited an EBM Transition Team in early 2010, which included representatives from the N.C. Department of Environment and Natural Resources, the U.S. Fish and Wildlife Service, and APNEP's Policy Board and each of the advisory committees. The team was later expanded to include select faculty from the Virginia Institute of Marine Sciences Center for Coastal Resources Management (CCRM) whose expertise includes EBM theory. The Team implemented the steps necessary for effective ecosystem-based planning and management. During regular intervals, they sought further advice and input from each of APNEP's advisory

committees. Early in the process, staff suggested a CCMP format similar to the *2008 Puget Sound Action Agenda*.

As a first step in developing the new CCMP, the Team crafted desirable ecosystem *goals* and more explicit *outcomes* for each goal. In essence, these goals and outcomes are qualitative statements that define a "healthy" Albemarle-Pamlico ecosystem (CCMP Question 1). The Team selected three ecosystem goals relating to the support of 1) human communities, 2) native species, and 3) clean and available water. These goals were more specifically articulated through the 12 outcomes found in the plan. Efforts to achieve these outcomes may sometimes conflict, particularly when balancing human interests with ecosystem needs. Therefore, the EBM approach will require engagement with various regional interests to develop new ideas and find areas for compromise.

Next, in the absence of a tested quantitative ecosystem model of the Albemarle - Pamlico ecosystem, the Team developed a conceptual (qualitative) ecosystem model. To do this, explicit *factors* were identified. These factors are the various pieces or elements that influence particular ecosystem outcomes. The factors were assigned into biological, chemical, physical, and human categories, and when considered together these factors represent the Team's conceptual understanding of the primary influences on the Albemarle-Pamlico ecosystem. The factors selected vary in scale, and reflect APNEP's traditional focus on a watershed approach to a healthy estuary and clean water. The regular refinement of this model is necessary to ensure an explicit linkage between human activities, management actions, and environmental outcomes are possible.

Third, factors, which had the greatest impact on a particular outcome, were deemed "high-impact" and addressed in the CCMP. Systems approaches dictate that the thorough management of many factors is often required to achieve the desired environmental outcomes presented in the plan. Therefore, for each desired outcome, the Team selected several of the most influential factors for management actions. These factors were considered in terms of both their importance and manageability.

Fourth, management *actions* were drafted for each high-impact factor (CCMP Question 4). Key organizations were identified and consulted regarding implementation of the actions. Over 50 partner plans were investigated to assess potential collaborations in implementing the CCMP. Additional input was requested from many of the partners. In many cases, representatives from these organizations were able to clarify or improve upon APNEP's original suggested actions.

Once management actions were drafted based on the above approach, APNEP staff reconsidered their ongoing management actions that were not elicited as part of the ecosystem-based planning process. In some cases, current management actions had a moderate effect on many ecosystem factors. These cumulatively significant actions were mapped back to the ecosystem factors and incorporated into the plan. Other actions were deemed low-priority and phased out as the new CCMP was adopted.

Finally, actions generated through the aforementioned process were organized into *objectives* and then objectives were aggregated into *components*. Common actions were grouped under thematic objectives. These objectives were further grouped into five components that build upon APNEP's mission: identify, protect, restore, engage, and monitor. This classification of management actions provides clarity for environmental managers and illuminates opportunities for complimentary management initiatives in the region.

As is apparent in the plan, a single action can address many ecosystem outcomes (see Table 1). Furthermore, in this complex ecosystem, each ecosystem outcome is necessarily dependent on many successful management approaches. By tracking management actions and ecosystem outcomes, APNEP hopes to both refine its ecosystem model and determine the relative importance of the many actions in the plan. Unsuccessful or relatively unimportant approaches will be discontinued, and program resources will be rededicated to proven or promising actions.

**Remaining Steps**

The transition to an ecosystem-based management process is difficult, and the road thus far has included a few detours. Nevertheless, this summary provides a condensed version of the steps APNEP took to incorporate ecosystem-based management into its CCMP for the Albemarle-Pamlico region. APNEP will continue to draw upon lessons learned from the planning process in both the development of annual work plans (implementation) and in future iterations of the CCMP.

To fully implement an ecosystem-based management framework, APNEP will need to associate indicators, targets, and benchmarks with both its ecosystem outcomes and its management actions. This work is ongoing. APNEP will continue to update and assess the impacts of CCMP implementation, to incorporate new actions and metrics directly into the plan.

Each of these metrics will need to be monitored, and APNEP is currently developing a monitoring strategy necessary to support its ecosystem-based management approach. Both the implementation of management actions and the resulting ecosystem changes will be tracked by the Albemarle - Pamlico integrated monitoring network. Where actions are not fully implemented, future assessments will note barriers to implementation. Where actions are implemented but environmental improvement is lacking and thus benchmarks are not achieved, APNEP and its partners must reevaluate the ecosystem model underpinning the plan.