The status and trends of North Carolina coastal ecosystems: ecosystem indicator metrics and a statewide coastal ecosystem report card

Executive summary

An understanding of the status of NC's coastal habitats is needed to assess and address the drivers of long-term habitat change and the cascading effects on the fish, shellfish, and crustaceans dependent on them. Since acquiring substantial resources remains a barrier to establishing comprehensive long-term monitoring for a suite of indicators for each habitat, DEQ must explore alternative approaches such as an ecosystem level evaluation. This chapter identifies ecosystem report cards as a stakeholder driven assessment and communication tool to evaluate the ecological, social, and/or economic aspects of North Carolina's coastal ecosystems. DEQ will co-design a framework for the report card with a stakeholder workgroup, and scientists and managers will select metrics to best reflect the ecosystems and distill trends into easy-to-understand grades (A, B, C, D, F). The completed ecosystem report card will provide a simple, accessible way for the public and decision makers to understand the current ecosystem status and how it has changed over time.

Introduction

An understanding of the status of NC's coastal habitats is needed to assess and address the drivers of long-term habitat change and the cascading effects on the fish, shellfish, and crustaceans dependent on them. To accomplish this goal, long-term monitoring of each coastal habitat (water column, shell bottom, SAV, wetlands, soft bottom, and hard bottom) needs to occur at appropriate spatial scales and regular intervals.

While there is a range of active long-term programs to monitor fish and water quality, programs that monitor habitat area and function are limited or absent due to the lack of funding for long-term data collection not directly related to agency regulatory compliance. The 2021 CHPP Amendment called to expand mapping and monitoring programs across all habitats to enable formal assessment of ecological indicators (2021 CHPP Recommended Action 8.6), but limited progress has been made to expand in coverage or frequency, let alone establish new monitoring.

Current habitat and water quality monitoring programs

The following sections describe the status of active long-term monitoring programs for coastal water quality and habitats in North Carolina. For historical mapping and monitoring information, please see *Chapter 8. Coastal habitat mapping and monitoring to assess status and trends* in the 2021 CHPP. Complete descriptions, distribution, ecological function, and threats of the six coastal habitats can be found in the 2016 CHPP source document.

Water column

The water column habitat includes all water covering a submerged surface and is the medium that connects all aquatic habitats and associated fauna. The water quality describes the condition of water based on the physical, chemical, and biological characteristics, usually with respect to its suitability for a particular purpose such as drinking, recreation, or supporting aquatic life. While there are multiple programs that measure water quality data in the state, there is not sufficient spatial or temporal coverage within CHPP boundaries.

The NC Ambient Monitoring System (AMS), conducted by NC Division of Water Resources across the entire state, is the most comprehensive long-term, continuous water quality monitoring program along NC's coast. There are 149 active monitoring stations within the CHPP boundaries. However, stations are concentrated mostly in riverine and upper estuarine waters, with some large spatial gaps existing along the coast (2021 CHPP Chapter 8). Water temperature, specific conductance, pH, turbidity, total suspended solids (TSS), dissolved oxygen (DO), and fecal coliform are monitored monthly at each site. Some sites receive specific additional measurements based on stream classification, discharge types, and historical/suspected issues, which can include salinity, water clarity, flow, nutrients (NH_3, NO_2+NO_3, TKN, TP), fluoride, sulfate, total hardness, color, oil and grease, and chlorophyll a. The 2021 CHPP (Recommended Action 8.3) called for DWR to evaluate and prioritize estuarine ambient monitoring system sites by 2023, but there was no capacity to address gaps in the spatial, habitat, or parameter coverage.

DEQ also tracks the occurrence of fish kills and algal blooms. Algal blooms occur when specific environmental conditions in the water column are met (e.g., increased nutrient concentrations, high water temperature, prolonged solar radiation, stagnant water flows). Algae rapidly grow or "bloom" and some can contain toxic compounds for fauna and humans. Additionally, as they decompose, large areas of low dissolved oxygen or high pH can occur. In addition to public health concerns, if fish cannot seek refuge from hypoxic events, large schools can die and result in a fish kill. Outreach to the public occurs each year as algal blooms and fish kills are reported to DEQ. DWR staff investigates some public sightings, but not all events are formally investigated.

Since 1925, the DMF Shellfish Sanitation Program has collected water quality data to assess suitability for harvesting shellfish in 968 shellfish growing areas. A detailed shoreline survey is conducted every three years to identify confirmed and potential pollution sources to determine their potential impact on shellfish growing waters and public health. These detailed surveys involve visits to properties throughout each Growing Area watershed, where potential sources of pollution such as marinas, on-site wastewater systems, agricultural areas, wastewater treatment plants, and stormwater drainage systems are all evaluated for their potential impacts on surrounding water quality. Fecal coliform bacteria, an indicator for human or animal waste, is measured a minimum of six times a year and used with the identified potential pollution sources to classify if the area is open to shellfish harvest. The salinity, temperature, tide, and weather conditions are also measured at sampling stations.

The Recreational Water Quality Program is another DMF program that has tested water quality since 1997 to protect public health by notifying the public when bacteriological standards for safe bodily contact are exceeded. The program tests water at 204 swimming sites during the April through September swimming season, with additional sites tested by NGOs (e.g., Sound Rivers weekly Swim Guide). This program measures Enterococcus bacteria, an indicator organism found in the intestines of mammals, and standard water quality parameters. The salinity, temperature, tide, and weather conditions are also measured at sampling stations.

All DMF independent sampling programs collect abiotic water quality parameters such as temperature, salinity, DO, depth, and Secchi depth, which have been used to look at long-term trends interpolated across waterbodies. For instance, the 2021 CHPP presented interpolated salinity maps that were created using DMF, AMS, and NC Wildlife Resources Commission measurements for different river flow regimes, and Secchi depths from DMF independent sampling programs were used to develop the proposed water clarity standard (Hall 2022).

Few continuous water quality monitoring stations are active in North Carolina. The National Parks Service runs a water quality station for the Cape Hatteras National Seashore in Ocracoke. NC Division of Coastal Management's (NC DCM) Coastal Reserve and National Estuarine Research Reserve (NC CR & NERR) have a limited number of water quality stations at three reserve sites as part of the NERRS System Wide Monitoring Program (Zeke's Island and Masonboro Island Reserves) as well as a partnership with the National Parks Service (Rachel Carson Reserve and Shackleford Banks). These stations collect continuous temperature, salinity, dissolved oxygen, turbidity, and pH; monthly chlorophyll a and nutrient concentrations are also sampled.

DMF deploys a coastwide array of temperature loggers at 52 stations to collect continuous water temperature data to monitor cold stun events for Spotted Seatrout management (NCDMF 2025b). DMF previously used water quality sondes that record additional continuous parameters, including DO, for River Herring management and to assist with site selection and monitoring of oyster sanctuaries and artificial reefs. However, they required extensive maintenance and were discontinued in 2021 due to insufficient staff time and funds.

Shell bottom

Shell bottom habitat includes areas that have surface shell concentrations of living or dead oysters (*Crassostrea virginica*), hard clams (*Merceneria merceneria*), or other shellfish in estuarine waters. Oyster reefs are vital to the estuarine ecosystem, providing structured habitat for fish and invertebrates to forage and seek refuge, in addition to enhancing sediment stabilization, shoreline protection, and nutrient cycling. Historical loss of shell bottom habitat has occurred in NC due to habitat destruction, overfishing, disease, and deteriorating water quality (NCDMF 2025a; Lenihan and Peterson 1998; Powers et al. 2009).

In addition to being a structured habitat, North Carolina has regulated the oyster fishery as far back as 1872. Under the Fisheries Reform Act of 1997, the DMF has been developing and reviewing fishery management plans for oysters since 2001, with the most recent amendment to the Eastern Oyster Fishery Management Plan adopted in 2025 (NCDMF 2025a). DMF monitors commercial landings from wild harvest as well as landings from private aquaculture, but there are insufficient data to conduct a traditional stock assessment. DMF partnered with researchers at North Carolina State University and The Nature Conservancy to design a statistically robust fishery-independent population survey for oysters in North Carolina; however, DMF currently lacks sufficient resources to implement the program.

DMF monitoring of oyster habitat occurs through SCUBA surveys (Program 612) and tong surveys (Program 628), spanning artificially enhanced habitats (sanctuaries and cultch reefs) and natural oyster beds. These surveys aim to evaluate reef performance and quantify the contribution to the state's oyster fishery and benthic habitat. Generally, oyster sanctuaries are evaluated annually for oyster density and population demographics via quadrat extraction and subsequent oyster measurements. Cultch sites are sampled annually for three years, post-construction, using a tong survey (formerly a mechanical dredge) to track oyster density and population demographics. While cultch planting has been occurring since 1915, formal record keeping of geospatial data began in 1981 with limited resolution. Furthermore, long-term monitoring on cultch sites beyond three years post-construction is not conducted due to funding and logistical constraints. Both sanctuary and cultch reefs are also evaluated opportunistically via side scan sonar and multi-beam bathymetry to provide a metric of material persistence and reef rugosity through time.

A pre-season and mid-season survey occurs to assess oyster condition in DMF's efforts to manage the mechanical (dredge) wild oyster fishery. With the adoption of Amendment 5 to the Eastern Oyster FMP in 2025, this survey was redesigned and replaced the oyster dredge as sampling gear to a hydraulic tong to improve standardization and cohesion with existing oyster surveying programs. Under the new survey, historical cultch sites are surveyed as well as areas open to mechanical harvest identified by stakeholders. Ten locations in each of the four management areas will be sampled for oyster metrics before the start of the mechanical harvest season as well as before the mid-season point to determine the length of the area's mechanical harvest season.

Additionally, two Deepwater Oyster Recovery Areas (DORAs) were established at the mouth of the Pamlico and Neuse Rivers as part of Amendment 5 to the Eastern Oyster FMP to prohibit mechanical harvest of deep-water reefs, which are vulnerable to hypoxia events. Monitoring is underway and includes side-scan sonar and multi-beam bathymetric surveying to assess the reef footprint as well as SCUBA surveys to assess oyster density and population structure throughout the course of five years prior to the next fishery management plan review.

Intertidal reefs, which occur in high salinity regions, are currently monitored with a remote sensing pilot program. The Remote Sensing Estuarine Bottom Habitat Mapping Program (DMF Program 636), pairs remote sensing in conjunction with ground truthing to produce high resolution maps of intertidal oyster habitat. Fifteen 100-acre sentinel sites were selected to develop best practices for drone monitoring and ground truth sampling methods which tentatively will be visited every three years.

Submerged aquatic vegetation

Submerged aquatic vegetation (SAV) is habitat dominated by one or more species of underwater vascular plants. SAV is recognized as essential fish habitat because of five integrated features – primary production, structural complexity, modification of energy regimes, sediment and shoreline stabilization, and nutrient cycling. There are two distinctive groups of SAV ecosystems in NC distributed according to estuarine salinity. One group, referred to as low salinity SAV, or underwater grasses, thrives in fresh and low salinity riverine waters (≤10 ppt), and includes species such as Redhead grass (*Potamogeton perfoliatus*), Wild celery (*Vallisneria americana*), and Sago pondweed (*Stuckenia pectinate*). The second group, referred to as high salinity SAV, or seagrass, occurs in moderate to high (>10 ppt) salinity estuarine waters of the bays, sounds, and tidal creeks, and includes three species: temperate eelgrass (*Zostera marina*), tropical shoal grass (*Halodule wrightii*), and cosmopolitan widgeon grass (*Ruppia maritima*).

DMF and APNEP have collaborated on statewide SAV monitoring projects since 2006. In 2021, APNEP adopted a robust three-tiered monitoring plan for the Albemarle Pamlico Estuary System region to support their Comprehensive Conservation and Management Plan (APNEP 2025). Tier 1 monitoring characterizes the distribution and extent of SAV using remote sensing and has been conducted intermittently since 2006. Tier 2 monitoring captures the spatial-temporal variation in seagrass population structure and abundance to describe the ecological condition over time. Some Tier 2 data have been collected since 2006, but with the adoption of the 2021 SAV monitoring plan, sampling now includes a wider scope of SAV and environmental data. Tier 3 monitoring is conducted more frequently, and at a smaller spatial scale, to address the drivers and outcomes of patterns observed in Tier 1 and 2 monitoring.

Monitoring in the APES region has found that high-salinity SAV meadow area has continually declined and shifted towards more patchy and fragmented meadows (Field et al. 2026). The 2021 CHPP aimed to develop and implement a full-scale assessment program to conduct coastwide SAV mapping and monitoring at regular intervals (≤ 5 years). Some SAV mapping and monitoring has been conducted outside of the APES region, but it does not occur on a regular basis.

Wetland

The CHPP uses a simplified Cowardin System to classify wetlands in NC, which splits wetlands into two broad classes: palustrine and estuarine (Cowardin et al. 1979). Palustrine wetlands include all non-tidal wetlands that are dominated by trees, shrubs, or emergent vegetation, as well as any tidal wetlands where ocean-derived salinities are less than 0.5 parts per thousand (ppt). Wetlands with ocean-derived salinities greater than 0.5 ppt are categorized as estuarine wetlands, which can be further divided by vegetation type into forested, scrub/shrub, and emergent estuarine wetlands.

Wetland maps are fundamental to wetland inventories, which are critical to management, restoration, protection, and informed development. The two primary wetland mapping sources that provide coastwide wetland distribution data include the National Wetland Inventory (NWI) and DCM's Wetland Inventory. NWI produces wetland and deepwater habitat maps throughout the United States using aerial imagery and is the most extensive inventory of wetlands in the United States. The accuracy of imagery interpretation that informs NWI maps is dependent on the quality of the imagery, availability of ground truthing data, and repeatability by photointerpretation analysts. DCM created a coastwide wetland inventory in the mid-1990's using NWI data, landcover classification from satellite imagery (Landsat data), and county-level soils data. The resolution and accuracy of these efforts, along with older imagery, limit the modern applications of DCM's wetland inventory.

NOAA Coastal Change Analysis Program (C-CAP) data has been used to measure wetland area over five-year periods since 1996 at 30m x 30m resolution. NOAA C-CAP now can generate spatially robust, high resolution (1m x 1m pixel) land cover inventories and map products. In 2024, the DMF, DCM, DWR and APNEP combined monetary resources with South Carolina agencies to fund an update to C-CAP land classification for the states using 2020-2021 imagery at one meter resolution. These maps are expected to be available in early 2027 and will enable North Carolina to better identify and quantify wetland change (2021 CHPP action 5.1).

The Wetland Program Plan (NC WPP) is developed by NC DWR with a stakeholder group on five-year cycles to guide actions to research and protect wetlands. It emphasizes the need for systematic monitoring to track wetland health and called for standardized wetland mapping methods for the state. The plan is currently being updated and will be finalized in 2026.

Long-term monitoring of elevation change using surface elevation tables (SET), which are portable mechanical instruments that provide high-resolution measurements of elevation change within wetland sediments. North Carolina Surface Elevation Table Community of Practice is a voluntary partnership of stakeholders who have SETs in North Carolina coastal wetlands or use SET data (North Carolina SET Community of Practice 2024). There are currently over 130 SETs throughout coastal NC generating information on the degree to which coastal marshes are keeping up with sea level rise. This partnership has provided on the ground validation of wetland vulnerability modeling at greater scales (e.g., remotely sensed unvegetated-vegetated ratios) and found the majority of marshes monitored by SETs are not keeping up with sea level rise (North Carolina SET Community of Practice 2024).

There are also numerous short term data sources from DEQ programs, universities, and NGOs conducting research on coastal wetlands. However, the inconsistent sampling methodologies in these studies have impeded efforts to combine data to generate a meaningful picture of habitat condition at broader spatial or temporal scales. The Division of Mitigation Services (DMS) also compiles monitoring reports for compensatory mitigation projects, and the Wildlife Resource Commission (WRC) has conducted monitoring to assess abundances of select fauna of interest.

Expanded long-term funding opportunities should also be explored. Wetland monitoring conducted by DWR has been funded primarily by the EPAs Wetland Program Development Grants that typically focus on short-term monitoring projects. To provide a spatially robust inventory of the condition of the state's wetland resources over ecologically meaningful temporal scales, there is a need to move away from a dependence on external grant funding, which can be intermittent and variable in their research objectives, to recurring funding for standardized wetland monitoring that is critical to generating the data needed for science driven management.

Hard-bottom

Natural hard bottom habitat includes exposed areas of rock or consolidated sediments, distinguished from surrounding unconsolidated sediments, which may or may not be characterized by a thin veneer of live or dead biota (Street et al. 2005). Hard bottom is the primary structured habitat for offshore marine organisms on the continental shelf of NC. The hard structure provides a foundation for sessile invertebrates and algae, and the structural complexity provides a refuge and foraging habitat for mobile fauna, including both juvenile and adult life stages of economically important fish.

There is limited information on the distribution of productive live hard bottom off the NC Coast (Riggs et al. 1996; Moser and Taylor 1995; Udouj 2007). The majority is limited to specific areas of the continental shelf. Ninety percent of known hard bottom is found south of Cape Hatteras in the ocean rather than estuarine systems(Moser and Taylor 1995). Sampling methods and classification can be subjective, making it difficult to determine the distribution (Conery et al. 2022). The ephemeral nature also makes it particularly difficult to quantify because it can become periodically buried with sand (Riggs et al. 1996).

The NC DMF Artificial Reef Program maintains 43 oceanic artificial reefs to provide public recreational opportunities for fishing and diving, while adding structured hard-bottom habitat to primarily soft-bottom systems. The constructed reefs are monitored annually using SCUBA surveys for material stability, environmental parameters, and fauna communities. Hydrographic mapping surveys are also conducted on established artificial reefs periodically according to programmatic need.

The 2021 CHPP Amendment called for DMF to develop a monitoring strategy to map natural hard bottom reefs in NC state waters and monitor the condition of both natural and artificial reefs (2021 CHPP Recommended Action 8.5). Although DMF has established workflows to conduct monitoring, the scale of operations necessary to provide consistent mapping requires significant resources, including long-term funding for survey staff, boats, and equipment. Furthermore, other programmatic needs (oyster sanctuary, cultch planting, artificial reefs) limit existing available resources for devoting survey efforts towards hard-bottom mapping. The division will continue to periodically review the feasibility of adding new monitoring of hard-bottom habitat to its existing efforts.

Applying ecosystem-based management tools to understand coastal habitat status and trends

Coastal landscapes are made up of a mosaic of habitat components, including the ones above, that are affected by humans who live there. The CHPP has recognized the need to incorporate ecosystem-based management (EBM) into coastal resource conservation strategies in North Carolina. This approach incorporates the entire ecosystem, including humans, into resource management decisions, and is guided by adaptive management. Both the 2016 CHPP and 2021 CHPP amendment outlined management actions to develop indicator metrics for monitoring the status and trends of each individual habitat and establish thresholds to initiate pre-determined management actions. Since substantial resources are needed to establish comprehensive long-term monitoring for a suite of indicators for each habitat, DEQ must explore alternative approaches such as an ecosystem level evaluation.

Ecosystem assessments are used to provide the necessary science to carry out ecosystem-based management. An Integrated Ecosystem Assessment (IEA) is a formal synthesis and quantitative analysis of natural and socio-economic factors relative to specific management objectives (Levin et al. 2014). The framework as described by Levin et al. (2009) is used by NOAA to support adaptive Ecosystem Based Management. This framework was supported by the CHPP since 2016 and was recommended by the NC Policy Collaboratory as a model of a qualitative indicator-based evaluation of the estuarine and coastal ecosystems in its report (NC Collaboratory 2026).

This process relies on clearly defined management objectives that are co-designed with stakeholders. Scientists, managers, and stakeholders establish the vision and determine which ecosystem components, threats, and spatial scale are relevant to the management objectives. Examples of objectives include seafood production, commercial profits, recreational opportunities, ecosystem stability, social and cultural values, and protected species (Northeast Fisheries Science Center (U.S.) 2026). Conceptual modeling is conducted to describe and define the ecological system of interest including important connections and cascading effects of changes in components.

Ecosystem assessments use monitoring data as environmental indicators to characterize the aspects of the ecosystem that are relevant to the established management goals. Indicators are most effective when they are directly observable, scientifically rigorous, supported by a historical time series, cost effective to measure, understandable to the public, and sensitive to change in the ecosystem or management actions (Levin et al. 2014). In the assessment process, potential indicators are inventoried and then are evaluated to determine if they are an appropriate metric. In North Carolina, the Albemarle Pamlico National Estuary Program conducted an ecosystem assessment in 2012 (Carpenter and Dubbs 2012). In the development they defined and evaluated indicators for a comprehensive ecosystem assessment of the APES region that describes the status of the system and identifies threats to prioritize addressing through management. The range of data sources on coastal habitats and water quality discussed above in the *Current habitat and water quality monitoring programs* section serve as likely candidates to use as ecosystem indicators, along with additional data collected by external partners.

To track progress towards EBM goals, indicator variables need to have science-based reference levels to measure ecosystem state and determine the magnitude of ecosystem pressures. Indicators then need an established target level to identify quantitatively if the desired ecosystem status is reached. Targets as well as established thresholds can also be used to trigger management actions.

Once indicator data is compiled, the ecosystem is assessed using the status of the selected indicators. NOAA's IEA programs teams produce Ecosystem Status Reports for management regions that describe the status and trend of each indicator that was selected for specific management needs. Ecosystem status reports have been produced for each fishery management council region in the United States; however, the South Atlantic has only had one ecosystem status report (Craig et al. 2021), while other regions have annual ecosystem assessments with communication tools for outreach with the public.

Even though ecosystems assessments are co-designed with stakeholders, they are long technical reports, which can be hard for decision makers to interpret and apply to management strategies. While the ecosystem status reports synthesize ecosystem information, "state of the ecosystem" reports are commonly produced in some regions (e.g. the 2025 New England State of the Ecosystem report), putting decisions into a broader context.

Ecosystem report cards are another stakeholder driven assessment and communication tool used to compare ecological, social, and/or economic information (Vargas-Nguyen et al. 2020; Costanzo et al. 2017). Report card developers set evaluation goals and criteria to calculate a number or letter grade, like a school report card, to determine the status of the ecosystem. Report cards distill complex data from multiple sources into a format that is easily accessible to wide audiences. By incorporating a range of stakeholders in the development process, the report card helps create a shared vision for the future of the ecosystem. This information is then used to educate the public about the habitat condition, inform protection and restoration efforts, and evaluate the effectiveness of management strategies to achieve the overarching CHPP goal of the long-term enhancement of fisheries associated with coastal habitats.

Report cards can be flexible in that managers can choose indicators from the data that are available, and report cards can be easily updated if new data streams become available. The University of Maryland's Integration & Application Network (UMCES IAN) has developed a process for creating ecosystem report cards since 2006 and has refined its processes for stakeholder facilitation and index analysis (Costanzo et al. 2017). One example produced by UMCES IAN, the Coastal Georgia Ecosystem Report Card, evaluates the health of Georgia's ecosystems and uses twelve indicators to examine human health, fisheries, and wildlife annually (2014-2024). The evolution of the coastal Georgia ecosystem report cards, which updated indices based on relevance and importance, is an example of how this approach can be refined as more data or an improved understanding of the ecosystem is available. Another example, the Chesapeake Bay ecosystem report card, implements an especially data rich reporting effort (Logan et al. 2020) that produces a static report card publication as well as an interactive counterpart through Eco Health Report Cards, which allows users to explore data time series at various spatial scales.

Using a state report card for a coastwide ecosystem assessment

An ecosystem report card would provide the foundation to work toward ecosystem-based management in North Carolina and meet CHPP goals of understanding the status and trends of the state's coastal habitats (2021 CHPP recommended actions 8.1 and 8.2). DMF will begin with internal scoping discussions to establish broader ecosystem-scale fishery management objectives based on relevant legislation, regulatory requirements, established management practices, and the agency's mission and strategic guidance. This process will help determine the conceptual scope of the report card and ensure that the development and final products can be integrated into decision-making.

As a collaborative process, development will require stakeholder engagement. To ensure that the final product has been co-designed and fosters stakeholder buy-in, DEQ will conduct a stakeholder mapping exercise at the start of development to identify the breadth of stakeholders (both in role and spatial variation) in the state. These stakeholders will be invited to participate in a workshop which will be held to identify both local values and challenges to meet ecosystems objectives. This process helps ensure that the final product has concurrence, relevance, and meets the values of stakeholders. The stakeholder workshop output will be a conceptual framework and a short list of potential indicators and thresholds associated with the values and identified threats.

Although stakeholder driven, the foundation of an ecosystem report card is a thorough ecosystem assessment. Sourced from stakeholders and experts, data inputs will include the indicators that were identified in the stakeholder workshops. The NC Collaboratory's Legislative Study of Coastal and Marine Fisheries Report has already analyzed 170 potential indicators to understand how ecosystems are changing over time, the drivers of change, and the status of current monitoring (NC Collaboratory 2026). Indicators that meet the spatial and temporal resolution requirements can be included in the report card.

Once the conceptual framework and potential indicators are established by the stakeholder workgroup, scientists and managers will evaluate those indicators to determine which indicators best reflect the ecosystems and develop thresholds that will be transformed into easy-to-understand grades (A, B, C, D, F).

The report card will be drafted to include information capturing the existing health of the state's coastal ecosystems, distilling the key messages into an image-rich format easily accessible to a wide audience. A second stakeholder meeting will be held to discuss report card draft results, conclusions, and recommendations. Relevant feedback will then be taken into consideration for the final version. The complete methodology will be documented to ensure that the report card is scientifically defensible and can be updated regularly between each CHPP cycle.

The completed ecosystem report card will offer several benefits to DEQ and stakeholders. The report card will provide a simple, accessible way for the public to understand the overall status of coastal ecosystems and how that has changed over time. The report card will also serve as an additional tool for decision makers when considering environmental and fishery management options. This tool will also aid in facilitating discussions for building capacity and enhancing resolution and frequency of monitoring ecosystems.

Improving the use of ecosystem data in fishery management

In addition to providing tools for the public, the ecosystem assessment and report card development processes will help enhance the use of ecosystem data in DMF's fishery management. Integrating ecosystem data into fishery management decision-making will require a division-wide effort that can be initiated across DMF's programs. Beginning with the ecosystem data assembled as input for the ecosystem report card, a working group should be established to discuss how to accomplish integrating ecosystem data into development of FMP strategies.

One approach to better incorporating ecosystem data into fishery management could be emphasizing fish habitat use and life history bottlenecks during each fishery management plan cycle. Like the process of defining the ecosystem for an assessment, this approach would identify a conceptual map of a species' life cycle along with indicators and thresholds that would support management decisions. This process would also help identify specific research gaps and data needs to support incorporation of ecosystem data into a fishery stock assessment.

Once ecosystem assessments are conducted at regular intervals, DMF could also begin to apply risk assessments into the fishery management process. Risk assessments evaluate the impacts that natural disturbances and human activities would have on the ecosystem status. The goal of risk assessment is to qualitatively or quantitatively determine the likelihood that an ecosystem indicator will reach or remain above reference points (e.g., an established baseline level) that indicate an undesirable status. At a basic level, the sensitivity of an indicator to a stressor and the exposure to that stressor is calculated or mapped into high, medium, or low risk categories. More comprehensive risk assessments can be used to evaluate the cumulative effects of multiple stressors on many ecosystem components. Improved understanding of the risks to fisheries associated with the status of ecosystem indicators can inform decision-making in fishery management when traditional management tools (i.e. stock assessments) are unavailable, or when fishery decision-makers want to base decisions on a broader range of information.

Recommended actions

1. Establish internal working group to establish goals of an ecosystem assessment and state ecosystem report card.
2. Conduct workshops with stakeholders, scientists and managers to select ecosystem indicators and establish appropriate thresholds.
3. Calculate scores and create a state report card that is easily accessible to a wide audience.
4. Communicate status and trends of coastal ecosystems to stakeholders, decisionmakers, and the public.

Literature cited

APNEP. 2025. Albemarle-Pamlico National Estuary Partnership Comprehensive Conservation and Management Plan 2025-2030. Raleigh, NC. 83 pages.

Carpenter, Dean E., and Lindsay Dubbs. 2012. *2012 Albemarle-Pamlico Ecosystem Assessment*. https://apnep.nc.gov/documents/files/publications/2012-ecosystem-assessment/open.

Conery, Ian, John P. Walsh, David Mallinson, and David R. Corbett. 2022. “Marine Geology and Sand Resources of the Southern North Carolina Inner Shelf.” *Marine Georesources & Geotechnology* 40 (9): 1084–107. 158808588. https://doi.org/10.1080/1064119X.2021.1967531.

Costanzo, Simon, Bill Dennison, Alexandra Fries, et al. 2017. *Practitioner’s Guide to Developing River Basin Report Cards*. https://ian.umces.edu/site/assets/files/11191/practitioners-guide-to-developing-river-basin-report-cards.pdf.

Cowardin, Lewis M., Virginia Carter, Francis C. Golet, and Edward T. LaRoe. 1979. *Classification of Wetlands and Deepwater Habitats of the United States*. Fish and Wildlife Service, U.S. Department of the Interior.

Craig, J. K., G. T. Kellison, S. M. Binion-Rock, S. D. Regan, M. Karnauskas, and S. K. Lee. 2021. *Ecosystem Status Report for the U.S. South Atlantic Region*. https://doi.org/10.25923/qmgr-pr03.

Field, Don, Jud Kenworthy, Dean Carpenter, and Tim Ellis. 2026. *Metric Report: Extent and Distribution of Submerged Aquatic Vegetation, High-Salinity Estuarine Waters (2nd Edition)*. Albemarle-Pamlico National Estuary Partnership. https://apnep.nc.gov/metric-report-extent-submerged-aquatic-vegetation-high-salinity-estuarine-waters-phase-ii/open.

Hall, Nathan S. 2022. *Evaluation of Water Clarity Metrics for Protection of Submerged Aquatic Vegetation in the Albemarle-Pamlico Estuarine System*. Final Report for a Contract Between the UNC Institute of Marine Sciences and the Albemarle-Pamlico National Estuary Partnership.

Lenihan, Hunter S., and Charles H. Peterson. 1998. “HOW HABITAT DEGRADATION THROUGH FISHERY DISTURBANCE ENHANCES IMPACTS OF HYPOXIA ON OYSTER REEFS.” *Ecological Applications* 8 (1): 13.

Levin, Phillip S., Christopher R. Kelble, Rebecca L. Shuford, et al. 2014. “Guidance for Implementation of Integrated Ecosystem Assessments: A US Perspective.” *ICES Journal of Marine Science* 71 (5): 1198–204. https://doi.org/10.1093/icesjms/fst112.

Logan, Murray, Ziyuan Hu, Richard Brinkman, Song Sun, Xiaoxia Sun, and Britta Schaffelke. 2020. “Ecosystem Health Report Cards: An Overview of Frameworks and Analytical Methodologies.” *Ecological Indicators* 113 (June): 105834. https://doi.org/10.1016/j.ecolind.2019.105834.

Moser, ML, and TB Taylor. 1995. *Hard Bottom Habitat in North Carolina State Waters: A Survey of Available Data,*. Final Report of the Center for Marine Science Research to the North Carolina Division of Coastal Management, Ocean Resources Taskforce.

NC Collaboratory. 2026. *The Status of North Carolina's Marine Fisheries and Coastal Habitats – with Recommendations to Enhance Marine Public Trust Resources and Management Outcomes*. NC Policy Collaboratory.

NCDMF. 2025a. *North Carolina Eastern Oyster FIshery Management Plan Amendment 5*. North Carolina Division of Marine Fisheries. https://www.deq.nc.gov/marine-fisheries/fisheries-management/oyster/oyster-fmp-amendment-5/open.

NCDMF. 2025b. *North Carolina Spotted Seatrout Fishery Management Plan, Amendment 1*. North Carolina Division of Marine Fisheries. https://www.deq.nc.gov/marine-fisheries/fisheries-management/spotted-seatrout/spotted-seatrout-amendment-1/open.

North Carolina SET Community of Practice. 2024. *Surface Elevation Trends in North Carolina's Coastal Wetlands*. https://iris.fws.gov/APPS/ServCat/DownloadFile/248442.

Northeast Fisheries Science Center (U.S.). 2026. *State of the Ecosystem 2026: New England*. https://doi.org/10.25923/509j-tr77.

Powers, Sp, Ch Peterson, Jh Grabowski, and Hs Lenihan. 2009. "Success of Constructed Oyster Reefs in No-Harvest Sanctuaries: Implications for Restoration." *Marine Ecology Progress Series* 389 (September): 159–70. https://doi.org/10.3354/meps08164.

Riggs, Stanley R., Stephen W. Snyder, Albert C. Hine, and David L. Mearns. 1996. "Hardbottom Morphology and Relationship to the Geologic Framework; Mid-Atlantic Continental Shelf." *Journal of Sedimentary Research* 66 (4): 830–46. https://doi.org/10.1306/D4268419-2B26-11D7-8648000102C1865D.

Street, Michael W., Anne S. Deaton, William Chappell, and Peter D. Mooreside. 2005. *North Carolina Habitat Protection Plan*. North Carolina Department of Environment and Natural Resources, Division of Marine Fisheries. https://files.nc.gov/ncdeq/Marine-Fisheries/public-info-education/habitat/completed-chpp/Complete-CHPP-2005.pdf.

Udouj, J. 2007. *Final Report Deepwater Habitat Mapping Project Phase III: Partnership with the FWC Florida Fish and Wildlife Research Institute in the Recovery, Interpretation, Integration and Distribution of Bottom Habitat Information for the South Atlantic Bight (200-2,000 m)*. SAFMC.

Vargas-Nguyen, Vanessa, R. Heath Kelsey, Harald Jordahl, et al. 2020. "Using Socioenvironmental Report Cards as a Tool for Transdisciplinary Collaboration." *Integrated Environmental Assessment and Management* 16 (4): 494–507. https://doi.org/10.1002/ieam.4243.