



A tray holds the remnants of some of the more unique organisms found in the stomach contents of fish collected by the Chesapeake Bay Multispecies Monitoring and Assessment Program and the Northeast Area Monitoring and Assessment Program. Stomach contents can include mysid shrimp, worms, bivalves, bay anchovy and menhaden. (Photo by Will Parson/Chesapeake Bay Program)

I. Introduction

Forage species are an important component of the food web linking primary production to predator species in the Bay. Many of those predatory and prey fish and shellfish are commercially and recreationally valuable to people. This Outcome acknowledges the connections among different species in the Bay food web and strives to use our understanding of those connections to assess forage needs of predators. It is a step toward multi-species ecosystem management.

II. Goal, Outcome and Baseline

This management strategy identifies approaches for achieving the following goal and outcome:



Sustainable Fisheries Goal

Protect, restore and enhance finfish, shellfish and other living resources, their habitats and ecological relationships to sustain all fisheries and provide for a balanced ecosystem in the watershed and Bay.

Forage Fish Outcome

Continually improve the partnership’s capacity to understand the role of forage fish populations in the Chesapeake Bay. By 2016, develop a strategy for assessing the forage fish base available as food for predatory species in the Chesapeake Bay.

Baseline and Current Condition

Most forage species are not directly managed, but support valuable managed predator species. The forage species and predator species that are managed in the Chesapeake Bay are managed by the Maryland Department of Natural Resources (MD DNR), Potomac River Fisheries Commission (PRFC), District Department of the Environment (DDOE), and the Virginia Marine Resources Commission (VMRC). Management of migratory finfish species among Chesapeake Bay jurisdictions and other Atlantic states is coordinated through the Atlantic States Marine Fisheries Commission (ASMFC).

Analyses have shown that a diversity of forage species are important to predators, including invertebrates. Therefore, for the purposes of this strategy, the workgroup interprets “forage fish” broadly to mean all forage species, not just finfish.

There is broad agreement that maintaining a “balanced” forage base in the Chesapeake Bay is a desirable goal but “balanced” has yet to be defined or quantified. In basic terms, a “balanced” system would have enough forage to support the growth and productivity of predator populations and fisheries. This would depend on what type and how many predators are wanted based on fishery management objectives and then quantifying the relationships between priority predators and prey.

The development of indicators would help quantify these relationships and provide insight into the status of forage in the Bay. Indicators are tools used to synthesize complex relationships and other factors to help guide management. Indicators based on forage and predator abundance, forage consumption, and predator health can provide managers with information to judge balance.

III. Participating Partners

The following partners have participated in the development of this strategy. A work plan to accompany this management strategy will be completed in conjunction with this document. It will identify specific partner commitments for implementing the strategy.

Chesapeake Bay Watershed Agreement Signatories

- State of Maryland
- Commonwealth of Virginia
- District of Columbia
- Commonwealth of Pennsylvania
- Chesapeake Bay Commission
- National Oceanic and Atmospheric Administration (NOAA)

Other Key Participants

The forage species and predator species that are managed in the Chesapeake Bay are managed by the Maryland Department of Natural Resources (MD DNR), Potomac River Fisheries Commission (PRFC), District Department of the Environment (DDOE), and the Virginia Marine Resources Commission

(VMRC). Management of migratory finfish species among Chesapeake Bay jurisdictions and other Atlantic states is coordinated through the Atlantic States Marine Fisheries Commission (ASMFC).

Key partners, including academic institutions, nonprofits and federal agencies, provide research and funding to support understanding of the forage base in the Chesapeake Bay.

Stakeholder Engagement

The commercial fishing industry and recreational fishermen are important partners in efforts to better understand forage species and associated predator-prey relationships. Both fishing sectors are subject to harvest regulations related to forage species and their predators. Each management jurisdiction and ASMFC currently engages commercial and recreational fishermen on issues related to single-species management through established stakeholder committees, advisory groups and public meetings. Moving forward, this stakeholder engagement needs to include an ecosystem perspective and specific discussion on predator-prey relationships. Given fishing is not the only factor affecting forage (habitat loss, water quality, and others affect forage abundance and productivity) it will be critical to work across the other Chesapeake Bay Program Goal Implementations Team to ensure engagement includes federal, state, local and non-government agencies that can influence factors affecting forage not associated with fishing.

IV. Factors Influencing Success

Forage species are diverse and live in many different habitats in the Chesapeake Bay. Most are short-lived and experience large swings in abundance annually, seasonally, and spatially. They are subject to environmental variability and other factors that control their populations and reproductive success. Resource managers need to understand the factors that control forage abundance to manage responsibly. The following are factors that influence forage species abundance and that influence the partnership's ability to attain the outcome of assessing the forage base.

Factors Affecting Forage Abundance (in priority order based on a survey of this strategy drafting team)

- Habitat (amount and quality)
- Predation
- Water quality
- Land use and watershed development
- Fishing and catch removals
- Climate change
- Food for forage species

Habitat

Most habitats of the Bay and its tributaries are home to forage species. Loss and modification of habitats—for example hardening of shorelines and other shoreline modifications—limit productive habitat for production of forage. In addition, dams that limit access to upriver spawning areas of anadromous fishes (e.g., shad and herring) can limit their reproductive success.

Predation

Forage species support production of managed and unmanaged predators. Predators limit forage abundance and, in turn, forage availability limits abundance and production of predators.

Water Quality

Water quality is closely linked to land use and watershed development. Runoff, nutrient loading, sediment loads and other sources of contaminants can reduce the productive capacity of living resources in the Bay. Excess nutrients lead to hypoxia in a large portion of the Bay each summer and limit production of benthic organisms that are key prey of managed fish species (e.g., Atlantic croaker, spot).

Land Use and Watershed Development; Shoreline and Upland Development

Watershed and human activities such as poor agricultural practices, increases in impervious surfaces, contaminated runoff, shoreline hardening and development degrade water quality and affect forage species habitats and health.

Fishing Removals

Most forage taxa in the Chesapeake Bay are not exploited in fisheries. However, several species that are exploited (e.g., spot, weakfish, Atlantic croaker, Atlantic menhaden, flounder, blue crab, razor clams) are recognized as important forage, especially at juvenile stages. We must consider both the ecological and commercial value of these species when drafting management policies.

Climate Change

Ongoing climate change is expected to lead to significant changes to the Chesapeake Bay ecosystem. Shifts in distribution and changes in levels of relative abundance of dominant forage species and their predators can be expected.

Food for Forage Species

Diverse foods (living and non-living) are eaten by small forage species including phytoplankton, zooplankton, microbenthos, macrobenthos and detritus. The abundance and availability of these foods for forage species are affected by various physical and biological factors.

Factors Affecting Forage Assessment

The ability to assess the status of the forage base in the Bay will depend largely on currently available funding and staffing to carry out monitoring and analysis. Below are factors that should be considered:

- *Scientific and Technical Understanding of forage in shallow water habitats:* Jurisdictions and research institutions are limited in the number of monitoring and survey programs they can support. Determining presence, abundance, and diversity of forage species in shallow water estuarine habitats will aid in development of an indicator.
- *Data availability and analysis costs:* Data may be unavailable or insufficient to answer some questions. Time and expertise are needed to analyze data once it has been collected. Baywide or coastwide data integration and comparisons may be needed. The Forage Action Team will address this in future work plans as an indicator becomes developed and standardized.
- *Partner coordination:* Coordinated support and participation across Bay jurisdictions, ASMFC, research institutions, and other fisheries organizations will facilitate better understanding and management of the forage base in the Bay. Collaboration in selection of species to include in an indicator will ensure the resulting indicator is widely accepted and used, and will provide managers with relevant information.

- *Public, Nongovernmental Organization, and Government Agency Engagement:* Communicating forage research to various agencies and organizations will allow for engagement and coordination. Ensuring usability and wide distribution of results from forage sampling pilot and shoreline study can facilitate management decision-making.

V. Current Efforts and Gaps

Current Efforts:

- **Scientific and Technical Advisory Committee (STAC) Forage Workshop (2014):** STAC held a workshop “Assessing the Chesapeake Forage Base: Existing Data and Research Priorities” in November 2014. This workshop aimed to define the forage base in the Chesapeake Bay and put 5 forward actionable recommendations to better understand and quantify the forage base and their availability to predators. Preliminary workshop outcomes include an initial list of forage species based on diet analysis of key predators and input from workshop participants. The species list follows *in no prescribed order*:

Table 1: The most important forage groups of the Chesapeake Bay as determined by data analysis and expert consultation provided at the STAC Forage Workshop, November 12-13, 2014. The first column includes key forage taxa important to a wide variety of predators. The second column includes groups recognized as important forage in the Chesapeake system, but were not identified as top contributors to diets of predatory fishes, based on data analysis conducted for the workshop. Note: This table represents an initial assessment and may be refined as the Management Strategy is implemented.

Key Forage Groups	Additional Important Forage Groups (alphabetical)
Bay Anchovy	American Shad & River Herrings
Polychaetes	Atlantic Rock Crab
Mysids	Atlantic Silverside
Amphipods and Isopods	Blackcheek Tonguefish
Mantis Shrimp	Blue Crab
Spot	Flounders
Weakfish	Gizzard Shad
Sand Shrimp	Kingfish
Atlantic Croaker	Lady Crab
Razor Clams	Macoma Clams
Atlantic Menhaden	Mud Crab
	Mummichog & Killifishes
	Small Bivalves*

*other than *Macoma* spp. or Razor clams

- **Fisheries Ecosystem Planning for Chesapeake Bay (FEP) (2006):** The FEP provides guidance for ecosystem-based fisheries management in the Bay and coastal region, including a compilation of existing information on the structure and function of the ecosystem such as key habitats and species interactions. The FEP is designed to increase awareness of how management decisions can affect the ecosystem, and to facilitate use of ecosystem-based principles, goals and policies in fisheries management. It provides a framework for refining single-species management and makes recommendations for incremental steps toward ecosystem-based fisheries management.

These recommendations fit well with this management strategy and include conducting studies to quantify major predator-prey interactions, obtaining food habits data for predator species and applying integrated indicators that include information on fish stocks, their habitats and interacting species.

- **Maryland Sea Grant Single Species Briefs (2009):** Maryland Sea Grant facilitated the development of “single species briefs” for alosines, blue crab, striped bass and menhaden. These reports identify the critical ecosystem stressors for the species. This information could serve as a foundation to inform the development of indicators and reference points to help managers.
- **Monitoring:** Some predators and forage species are monitored by benthic and fisheries surveys conducted in all jurisdictions by management entities, academic institutions and citizen monitoring programs. A small-scale, citizen science forage sampling effort began in 2017 that may be expanded to provide more data on shallow-water habitats that are not monitored with existing surveys.
- **Indicator Development:** Specific efforts are currently underway by MD DNR, the ASMFC, and the University of Maryland Center for Environmental Science (UMCES) to develop indicators to evaluate the status of forage:
 - MD DNR is using resident striped bass as an indicator species for forage in the Maryland portion of the Chesapeake Bay. MD DNR has been developing an approach that combines available information on striped bass nutritional status, diet, relative prey abundance and prey-predator ratios to evaluate foraging success of striped bass in Maryland’s portion of Chesapeake Bay as part of a Federal Aid to Sportfishing Grant. The major forage being analyzed are Atlantic menhaden, bay anchovy, spot, white perch and blue crab. Data for this indicator approach come from existing monitoring programs, including striped bass diet and nutritional status data from the Chesapeake Bay Ecological Foundation’s Predator/Prey Monitoring Program.
 - ASMFC is working to identify potential options for ecological reference points for menhaden that would account for their role as a forage fish in the Atlantic coast ecosystem. Various options for these reference points are currently being considered and reviewed, including ecosystem indicators (environmental, forage abundance indices, prey to predator ratios), nutritional reference points using the nutritional status of predatory species as well as various modelling approaches.
 - Research conducted by the UMCES-Chesapeake Biological Lab to develop a suite of forage indicators for dominant prey species, specifically for many of the priority species identified by the STAC Forage Workshop, will help to inform future indicator development. Two projects funded by the EPA Chesapeake Bay Program through the Chesapeake Bay Trust provided members of the Forage Action Team with a firm starting point to develop species-based indicators. Staff are now working to apply abundance data to a framework discussed in May 2018.
- **Fish Habitat WIP Fact Sheets:** Watershed Implementation Plans are developed by Bay jurisdictions to help determine how they will meet their pollution reduction goals. The Sustainable Fisheries GIT recommended inclusion of fish habitat considerations in Best Management Practices for WIPs, providing multiple ecosystem benefits.

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- Forage Presentations: The Fish GIT and the Forage Action Team regularly schedule forage research presentations to inform partners of relevant forage studies, such as research funded by the NOAA Chesapeake Bay Office on the connections between forage and habitat.

Gaps:

- Information on benthic species in shallow, estuarine habitats. A data review should be conducted to determine what areas are and are not being sampled.
- An indicator or suite of indicators that can be utilized by managers.
- Trends of some forage species, especially small invertebrates and zooplankton.
- Definition of “balanced” state and natural variability for forage species (species abundance, habitat, water quality).
- Economic data on the value of these species.
- Need to synthesize and present recent studies into formats that can engage a variety of audiences and educate stakeholders on the importance of forage.

Actions, Tools and Support to Empower Local Government and Others

Indicators of forage health will help local governments better understand the factors affecting the forage base and better identify management actions (e.g., local planning to protect habitats) to reduce impacts to forage base.

VI. Management Approaches

The identified partners in this strategy will work together to carry out the following actions and strategies to achieve the forage outcome. These approaches seek to address the factors affecting our ability to meet the outcome and the gaps identified above.

It is important to understand relationships between forage abundance and predator demand and to determine what levels of forage are critical or limiting (targets and thresholds) to support predators. The question of how much forage is required to support production of managed (fish) and unmanaged (birds, fish, turtles, mammals, shellfish, etc.) predators is key to understanding and working toward a balanced system with adequate forage to support predator populations.

The following steps will be taken:

1. Identify and prioritize forage species.
 - Explain their role both as an economic value to humans and as a food source for commercially/recreationally valuable predator species. The STAC workshop initiated this by developing a list of key forage species. The management agencies should work to refine this list to species of major concern to them.
2. Evaluate and communicate status of priority forage species.
 - Guidance documents, such as those listed in the above “Current Efforts” section, exist for indicators of forage supply and demand in Chesapeake Bay. Important forage species and species groups have been defined; a suite of potentially useful metrics and indicators to assess forage has been identified; research gaps identified.
 - In addition, the STAC workshop participants agreed that enough data exist to perform a preliminary analysis of the predominant and most important forage to support predatory

demand in the Chesapeake system. It is important to use the best available data, both from current monitoring programs and from historical data sets.

3. Inform management decisions to better address sustainability of the forage base.
 - Develop indicators based on forage management objectives and priority factors affecting forage base.
 - Use indicators to identify and promote actions to manage fisheries and protect habitats that support forage. Protecting habitats will require working across multiple Goal Teams (Sustainable Fisheries, Habitat, Water Quality, and Citizen Stewardship).
4. Maximize the efficiency of monitoring programs and build on existing efforts
 - Map areas and habitats important for the production and maintenance of forage, with special emphasis on shoreline habitat, land use change and developments in the tributaries throughout the watershed.
 - Consider options to improve phytoplankton and zooplankton monitoring Baywide.

Approaches Targeted to Local Participation

Indicators of forage health will help local governments better understand the factors affecting the forage base and better identify management actions (e.g., local planning to protect habitats to reduce impacts to forage base. It will be important to include local constituents and organizations in the development and evaluation of potential indicators. Targeted efforts will likely focus on commercial and recreational fishing organizations and stakeholders.

Cross-Outcome Collaboration and Multiple Benefits

- Water quality
- Fish habitat
- Fish passage
- Land use
- Blue crab
- Oyster restoration

VII. Monitoring Progress

- Use forage indicators to identify forage and predator status, data gaps, and monitoring needs.
- Enhance plankton/zooplankton monitoring to understand the condition of key forage species that rely on plankton as their food source.

VIII. Assessing Progress

- Track development of indicators that allow assessment of current and future Bay condition of the forage base.

IX. Adaptively Manage

The partnership will use the following approaches to ensure adaptive management:

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- Update forage indicators as new data and research findings become available. Through continued, adaptive re-evaluation of indicator performance and through improvement of indicators and benchmarks, scientists and managers can refine the forage thresholds, adopt appropriate actions, and in turn, improve management of the species in managed fisheries that depend on forage.

Lessons Learned

We are making great strides in increasing our understanding of forage. After going through the adaptive management process, the Fisheries GIT learned that the main factors and gaps affecting accomplishment of the Forage outcome include gathering more monitoring data and evaluating habitat impacts on forage species.

The 2014 Scientific and Technical Advisory Committee Forage Workshop, where experts worked to develop a system-wide scientific synthesis of forage in the Chesapeake Bay and develop actionable recommendations for management, along with several studies conducted by The University of Maryland Center for Environmental Science, highlighted the existing gaps in knowledge affecting the Forage outcome. A GIT funded study determining shoreline development threshold will aid in filling some of those gaps.

A citizen science forage sampling pilot began in 2017, carried out by volunteers from four Riverkeeper associations. Depending on the ability to secure funding for 2018, this study may contribute important data regarding forage associations with structured habitat, including natural (e.g., *Spartina* marsh, *Phragmites* marsh, submerged aquatic vegetation, woody debris, oyster reef) and man-made (e.g., riprap, bulkhead, living shoreline projects, artificial reef) habitats. In addition to this opportunity to work with citizen scientists, collaboration with recreational fishing groups may be explored.

X. Biennial Work Plan

A biennial work plan is developed in conjunction with each management strategy. It includes the following information:

- Each key action
- Timeline for the action
- Expected outcome
- Partners responsible for each action
- Estimated resources