RESEARCH TO IMPROVE MANAGEMENT OF ATLANTIC MENHADEN IN CHESAPEAKE BAY

From both an economic and ecological standpoint, Atlantic menhaden are one of the most important fish species in Chesapeake Bay. Concerns over localized depletion and a need for improved understanding of the ecological role of menhaden in Chesapeake Bay led the Atlantic States Marine Fisheries Commission to identify research needed to improve menhaden fisheries management. This newsletter provides the status of some of the resulting projects.

WHY THE CONCERN OVER MENHADEN?

Atlantic menhaden (*Brevoortia tyrannus*) live in coastal Atlantic regions, and are an ecologically important filter-feeding fish that provide a direct food link between plankton and top predators, such as striped bass and bluefish. While the spawning stock biomass along the Atlantic coast has remained at healthy levels over the past two decades, the number of young of the year (less than one year old) in Chesapeake Bay since 1995 has been less than10% of 1975 to 1985 levels (Figure 1). Recent levels are similar to equally low recruitment recorded in the 1960s.

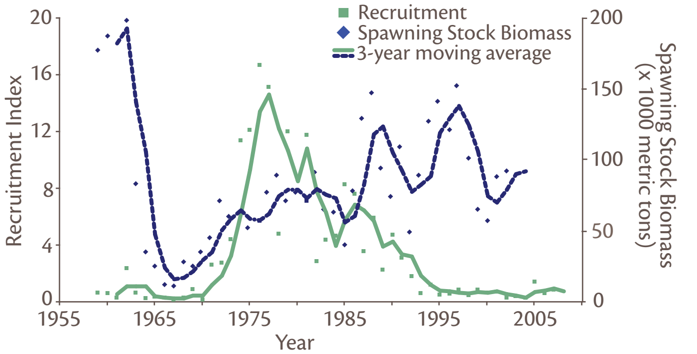


Figure 1. Menhaden spawning stock biomass for the Atlantic Coast region and the Chesapeake Bay recruitment index. Data: MD DNR.

In recent years, it has been suggested that menhaden biomass has declined within Chesapeake Bay and that this has led to poor condition and sick striped bass. However, before this hypothesis can be resolved, some key questions need to be answered, including whether localized depletion in the Bay exists, and whether there are any relationships between striped bass condition and menhaden biomass and recruitment. Based on these unanswered questions, in 2006, the Atlantic States Marine Fisheries Commission (ASMFC) identified a series of research and monitoring priorities. The information in this newsletter represents only a portion of this recent research and is not comprehensive, but is a short summary of some key preliminary findings. Numerous reports and peer-reviewed publications are available online (www.asmfc.org).

Atlantic menhaden, B. tyrannus.

RESEARCH ENCOMPASSES DIFFERENT STAGES OF LIFE CYCLE

Atlantic menhaden spawn along the continental shelf during fall through winter (Figure 2). The larvae are transported to estuaries, such as Chesapeake Bay, where they enter brackish to freshwater regions, which they use as a nursery area. Here, they grow into juveniles. Juveniles grow rapidly from late spring to early fall, then migrate out of the estuaries in late fall. Adult menhaden are common throughout the Bay from spring to fall, but migrate to coastal waters off the Carolinas during the winter.

Basic aspects of the menhaden life cycle are relatively well understood; however, scientists acknowledge that there are many unknown details, and resolving some of these unknowns could lead to improved population assessment and therefore, improved management. As such, current research aims to answer questions related to the following aspects of the life cycle: larval development, variability, and transport into Chesapeake Bay; population spatial structure and abundance; factors affecting growth rates and size; and, predator-prey relationships.

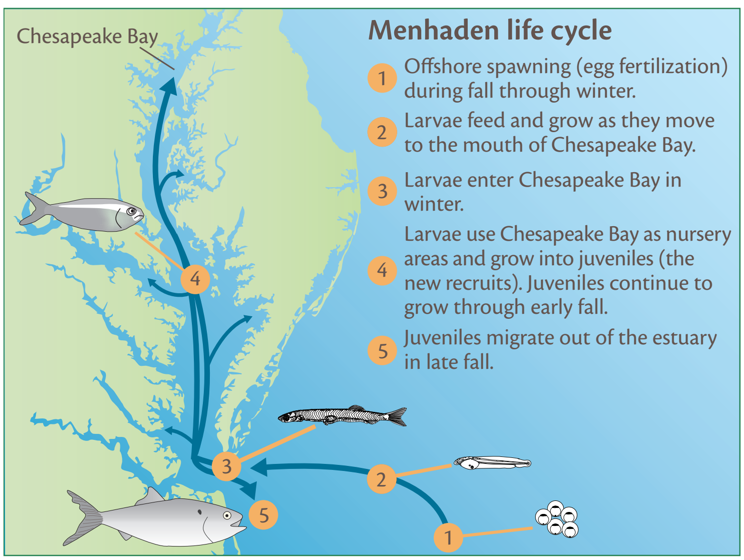
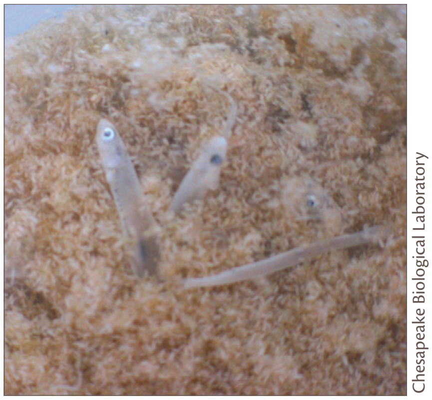


Figure 2: The major stages of the Atlantic menhaden life cycle in the Chesapeake Bay region.

LARVAE ENTER CHESAPEAKE BAY FROM INSHORE ATLANTIC

Mature adult menhaden spawn mostly in the mid-Atlantic Ocean during late fall to early winter. A survey during 2005–06 showed menhaden eggs hatching between October and December, with a peak in hatching in mid-November (Figure 3). Soon after hatching, the larvae enter Chesapeake Bay, a journey likely controlled by currents and tidal exchange. They actively feed and grow during this transport. The 2005–06 survey showed larvae growing at a rate between 0.45 to 0.55 mm (0.018 to 0.022 in) per day, and by the time they reached the mouth of the Bay, they were between 22 to 32 mm (0.87 to 1.26 in) in length and 30 to 60 days old. Distribution and occurrence of larvae at the Bay mouth was patchy, likely due to hydrographic conditions, such as flow rates and direction.

The number of menhaden larvae entering the Bay varies substantially from year to year, with low numbers between 2005 and 2007, and a larger number in the 2007–08 survey (Figure 3). The size and frequency of larvae entering Chesapeake Bay in 2005–06 indicates there may be at least two groups entering the Bay, perhaps originating from the Mid- and South Atlantic Bights, respectively.



Contents of a net tow at the mouth of Chesapeake Bay, showing menhaden larvae.

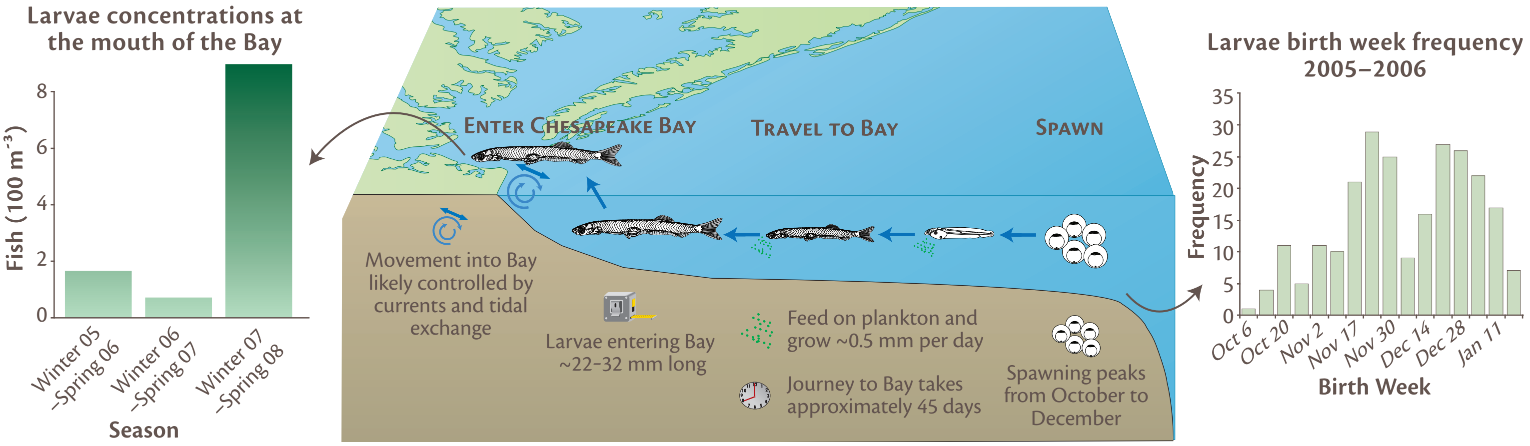


Figure 3: A summary of research results on the transport and growth of larvae into Chesapeake Bay. Data: Chesapeake Biological Laboratory, UMCES.

USING REMOTE SENSING TO DETERMINE MENHADEN DISTRIBUTION AND ABUNDANCE

Researchers are investigating methods to accurately determine menhaden abundance and spatial distribution in Chesapeake Bay. Current population estimates are for the entire Atlantic Coast region (Figure 1) and may not be ideal for managing menhaden within Chesapeake Bay. An aerial remote-sensing technique based on Light Detection and Ranging (LIDAR) has been tested. LIDAR detects objects by sending frequent laser pulses toward the water and measuring the reflected signal (Figure 4). LIDAR is mounted in a plane and flown at low altitudes over the Bay while a laser scans the water. A school of menhaden is detected when the laser signal is reflected back from the surface/subsurface.

To test the accuracy of the method, estimates of menhaden school size were compared to estimates based on purse seine fishing and video techniques. In each case, estimates were well correlated, demonstrating that LIDAR is capable of detecting schooling menhaden. However, the ability to accurately detect schools depends on water clarity, school depth, and size. The results of this study indicate that although LIDAR can measure length and width of schools, it has difficulty measuring depth or thickness due to the densely packed nature of menhaden schools. However, as a result of this study, it was determined that high-definition video may have the potential for surveying menhaden in the Bay.

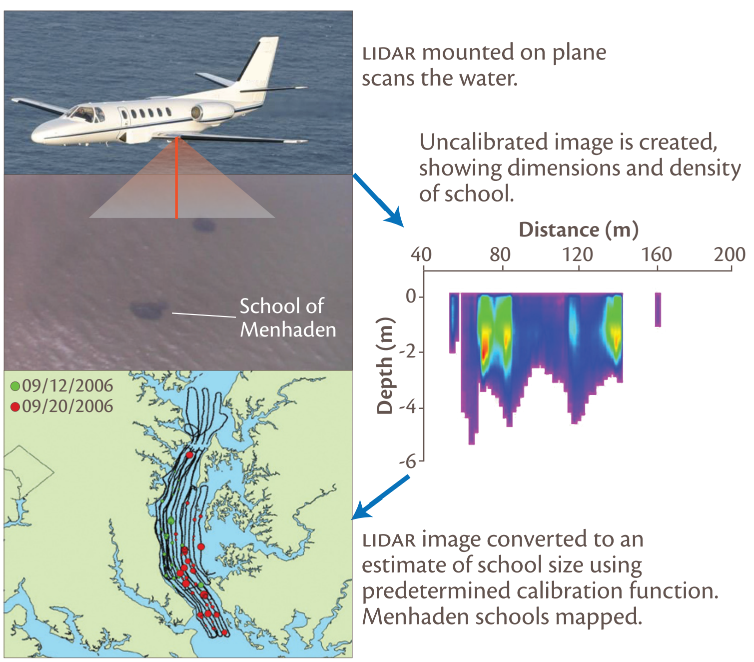
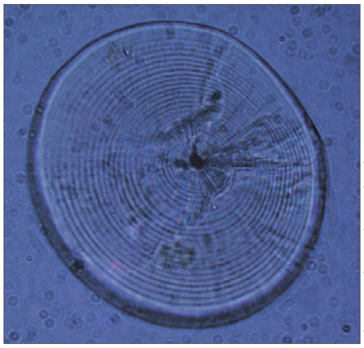


Figure 4: Aircraft-mounted LIDAR detecting schools of menhaden in Chesapeake Bay. Data: Maryland Department of Natural Resources.

SPATIAL STRUCTURE OF MENHADEN POPULATION

Understanding population structure and dynamics within the Bay is also essential for effective management, as it helps determine if the species should be managed as a single coast-wide population or as separate populations (Figure 5). As a first step to addressing these issues, researchers are testing hypotheses regarding the degree of juvenile residency and contribution of different regions to coast-wide populations by using markers that identify and distinguish between potential nursery areas. Early results from this research suggest little exchange between juveniles from the upper, mid, and lower regions of the Bay. Research now needs to determine if a relationship between juvenile and adult population residency exists. If fine-scale structure (i.e., little exchange between regions of the Bay) also occurs in the adult population, there is a chance local depletion could occur. However, the fine-scale structure may offer improved resiliency toward interannual variability in production, as one location can offset variability at other locations.



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A larval menhaden otolith (bone-like structure found in the inner ear). Otoliths are being used as a natural marker of nursery origin.

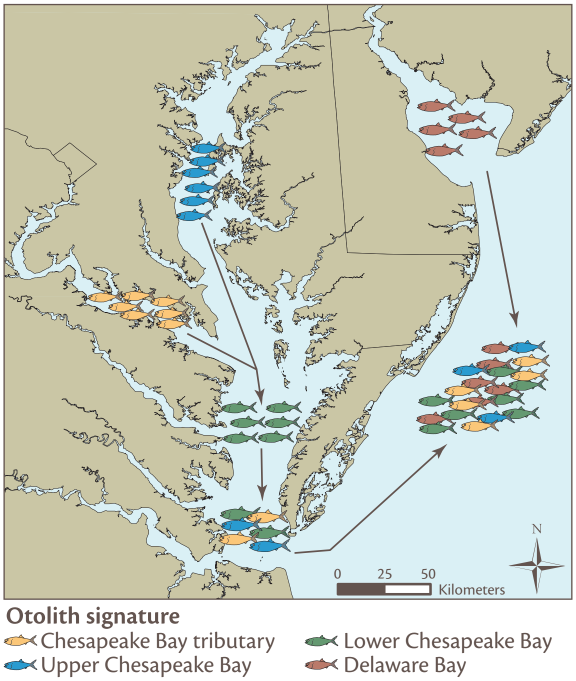

Figure 5: Early results indicate a within-Bay population structure, with natural markers distinguishing between upper, mid, and lower Bay juveniles. Data: Old Dominion University.

RECRUITMENT AND GROWTH RELATED TO FOOD

Menhaden feed on a combination of zooplankton, phytoplankton, and detritus. Recent research has shown the effect of water temperature and food source (phytoplankton) on menhaden recruitment and potential growth rate. Menhaden recruitment in the Bay correlates with chlorophyll *a* (a measure of phytoplankton biomass; Figure 6), which means there may also be a similar relationship with zooplankton since they feed upon phytoplankton. Chlorophyll *a* concentrations in the Bay vary from year to year and month to month in response to factors such as nutrient availability and water temperature. The variability in recruitment observed over 25 years may in part be related to variations in food supply.

Growth rate models that incorporate factors such as water temperature and chlorophyll *a* concentration illustrate how growth changes between seasons and regions of the Bay (Figure 7). Maximum growth rate potential occurs from June to August. Growth rates are also greater in the upper region of the Bay, where chlorophyll *a* concentrations tend to be higher. The relationships developed may enable improvement of spatially explicit growth rate models. Increased growth rate potential in the upper Bay corresponds to other data that shows larger-sized menhaden in the upper Bay.

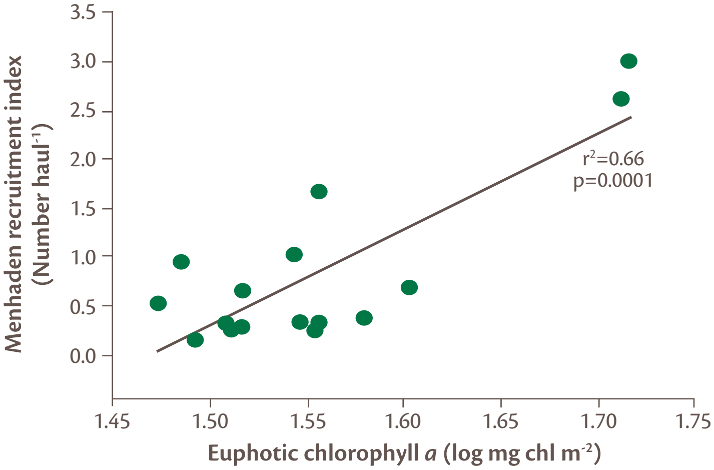

Figure 6: Menhaden recruitment and growth are related to the amount of chlorophyll a *in the water column, 1989–2004.*
Data: Chesapeake Biological Laboratory, UMCES.

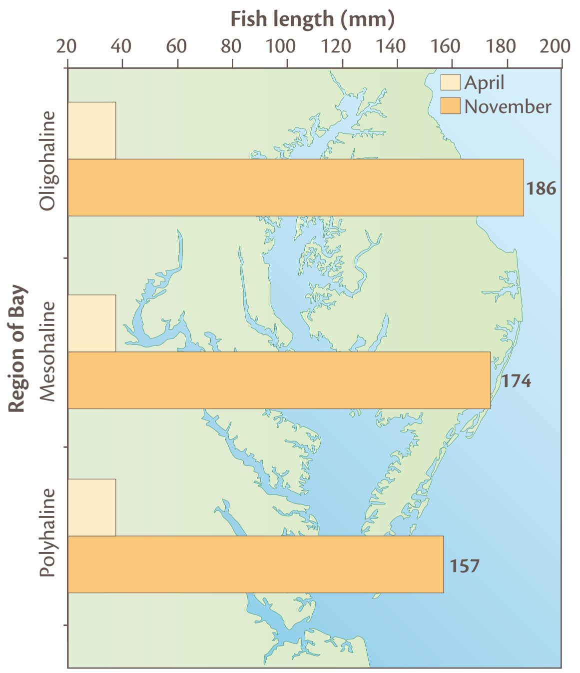

Figure 7: These values are the mean fish size (mm) for model runs conducted for the years 1989–2005 for specific regions of the Bay.
Data: Chesapeake Biological Laboratory, UMCES.

MENHADEN REMOVAL BY PREDATORS

Defining the amount of menhaden removed by predators such as striped bass is not a simple task. Scientists must account for variables such as location, age of predator, and assumptions in the methods and models applied to the data. Bay-wide predation estimates currently used by the ASMFC for management decisions, such as setting the harvest cap, are based on a 5-year, scientifically designed monitoring and research program headed by the Virginia Institute of Marine Science. This method differs from others because it accounts for the effect of schooling behavior and is for the entire Chesapeake Bay. Other methods are only for specific regions of the Bay, and may not take into account that fish within a school have similar feeding behavior and therefore gut contents. Based on the current ASMFC-accepted methods, menhaden are estimated to account for approximately 8% of striped bass diet (Figure 8). Using this same model, during the 2002 to 2006 period, finfish predation of menhaden is estimated to be between 3,200 to 14,000 metric tons, or 3 to 12.8% of the applicable harvest cap (Figure 9).

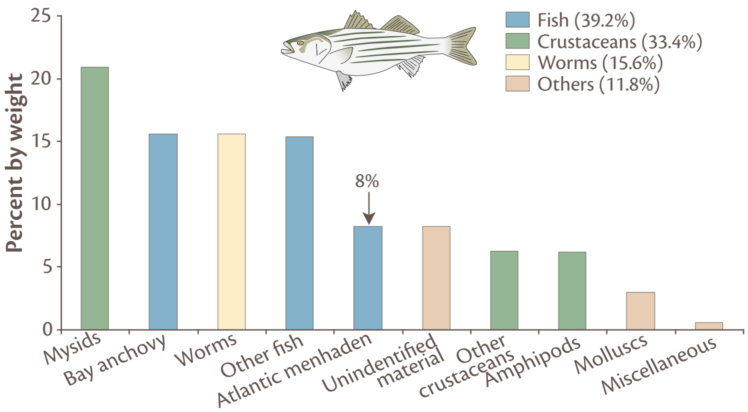

Figure 8: Results of a Bay-wide survey of striped bass gut content, including totals based on type of prey.
Data: ChesMMAP, Virginia Institute of Marine Science.

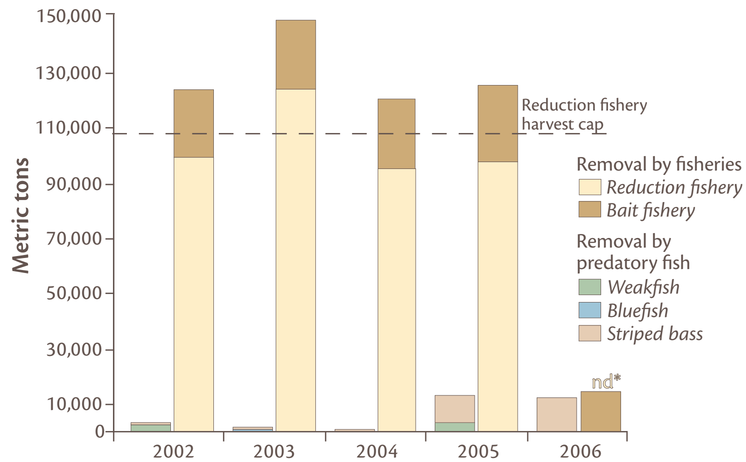

Figure 9: A comparison of the amount of menhaden removed by fisheries (reduction and bait) and predator fish, such as striped bass and weakfish in Chesapeake Bay. Fish predation data based on a model output. Data: ChesMMAP, VIMS, and NOAA.

Waterbirds, such as osprey and cormorants, also rely on menhaden as food. The proportion of menhaden removed by birds is still being determined. However, with the population of waterbirds increasing in recent decades, demand for suitable prey is increasing. A comparison of two studies conducted in Mobjack Bay, Virginia, showed that the amount of menhaden in ospreys' diet decreased from 74.7% in 1986 to 28% in 2007. The cause of such markedly different diets still needs to be determined.

RECOMMENDATIONS FOR FUTURE RESEARCH

Larval exchange and recruitment

- Determine the varying effects of climate and hydrography on recruitment. Climate effects on recruitment are poorly understood, but may be a cause of variability both interannually and in driving decadal or longer-term changes in recruitment.

Abundance and population structure

- Improve methods (e.g., adult monitoring programs) to provide accurate annual estimates of distribution and abundance.
- Initiate random sampling of adult menhaden from the coast-wide stock to continue development of otolith chemistry analyses of regional contribution.
- Develop a coast-wide aerial survey of menhaden abundance via a collaboration between the menhaden industry and the ASMFC Menhaden Technical Committee. Potential frameworks and budgets for survey have been explored.

Growth and biological energy paths (bioenergetics)

- Determine the Bay's carrying capacity for menhaden production. Continued research using bioenergetics modeling is required.
- Quantify relationships between habitat-specific production and key biotic and abiotic factors.

Removal by predators

- Continue to improve estimates of menhaden as a source of food to higher trophic level species such as striped bass.
- Investigate if/why the diet of menhaden predators has changed and broaden to include higher reliance on other species.
- Investigate health effects of diet composition on striped bass.

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We would like to thank the following for thier contributions:
Larval transport, and growth and recruitment:
- Ed Houde, Chesapeake Bay Laboratory, UMCES
- Carlos Lozano, CBL, UMCES
- Eric Annis, Hood University

Measuring abundance using LIDAR:
- Alexei Sharov, Maryland Dept Natural Resources
- James Churnside, NOAA Env. Tech. Lab

Measuring spatial structure:
- Cynthia Jones, Old Dominion University

Menhaden removal by predators:
- Chris Bonzek, Virginia Institute of Marine Science
- Rob Latour, VIMS
- Joseph W. Smith (harvest data), NOAA