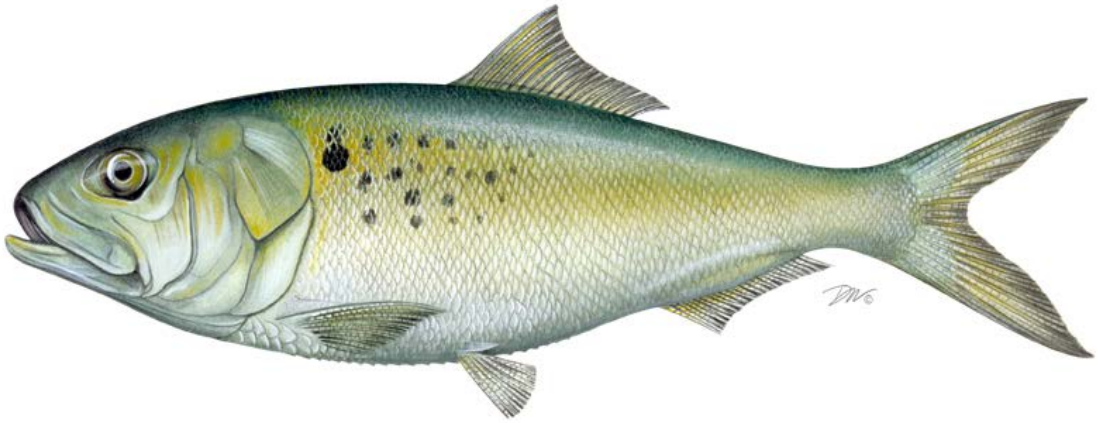
ATLANTIC STATES MARINE FISHERIES COMMISSION

REVIEW OF THE INTERSTATE FISHERY MANAGEMENT PLAN

FOR ATLANTIC MENHADEN
(*Brevoortia tyrannus*)

2020 FISHING YEAR



Prepared by the Plan Review Team

Prepared April 2021

Sustainable and Cooperative Management of Atlantic Coastal Fisheries

REVIEW OF THE ASMFC FISHERY MANAGEMENT PLAN AND STATE COMPLIANCE FOR ATLANTIC MENHADEN *(Brevoortia tyrannus)* FOR THE 2020 FISHERY

Management Summary

Date of FMP:	Original FMP: August 1981
Amendments:	Plan Revision: September 1992 Amendment 1: July 2001 Amendment 2: December 2012 Amendment 3: November 2017
Management Unit:	The range of Atlantic menhaden within U.S. waters of the Northwest Atlantic Ocean, from the estuaries eastward to the offshore boundary of the Exclusive Economic Zone (EEZ).
States With Declared Interest:	Maine – Florida, including Pennsylvania
Additional Jurisdictions:	Potomac River Fisheries Commission, National Marine Fisheries Service, United States Fish and Wildlife Service
Active Boards/Committees:	Atlantic Menhaden Management Board, Advisory Panel, Technical Committee, Stock Assessment Subcommittee, Plan Review Team, Plan Development Team, Ecological Reference Point Workgroup
Stock Status:	Not overfished, and overfishing is not occurring relative to the current single-species reference points (2019 Single-Species Benchmark Stock Assessment)

I. Status of the Fishery Management Plan

Atlantic menhaden management authority is vested in the states because the vast majority of landings come from state waters. All Atlantic coast states and jurisdictions, with the exception of the District of Columbia, have declared interest in the Atlantic menhaden management program.

The first coastwide fishery management plan (FMP) for Atlantic menhaden was passed in 1981. The FMP did not recommend or require specific management actions, but provided a suite of options should they be needed. In 1992, the plan was revised to include a suite of objectives intended to improve data collection and promote awareness of the fishery and its research needs.

Amendment 1, implemented in 2001, provided specific biological, ecological and socioeconomic management objectives. Addenda I and V revised the biological reference points for menhaden and specified that stock assessments are to occur every three years. Although Amendment 1 did not implement any recreational or commercial management measures, Addenda II through IV instituted a harvest cap on the reduction fishery in Chesapeake Bay. Specifically, Addendum II implemented a harvest cap for 2006-2010 fishing seasons; before its first year of implementation, Addendum III revised the cap amount to be the average landings from 2001 to 2005 (or 109,020 mt); and Addendum IV extended the provisions of Addendum III through 2013.

Amendment 2, implemented in 2012, established a 170,800 metric ton (mt) total allowable catch (TAC) for the commercial fishery beginning in 2013. This TAC represented a 20% reduction from average landings between 2009 and 2011. This Amendment alos used the 2009-2011 period to allocate the TAC among jurisdictions. Additionally, the Amendment established timely reporting requirements for commercial landings and required states to be accountable for their respective quotas by paying back any overages the following year. Amendment 2 also included provisions that allowed for the transfer of quota between jurisdictions and a bycatch allowance of 6,000 pounds per day for non-directed fisheries that operate after a jurisdiction's quota has been landed. Addendum 1 to Amendment 2 allows two licensed individuals to harvest up to 12,000 pounds of menhaden bycatch when working from the same vessel using stationary multi-species gear; the intent of this provision is to accommodate cooperative fishing practices that traditionally take place in Chesapeake Bay. The Amendment also reduced the Chesapeake Bay reduction fishery harvest cap by 20% to 87,216 mt.

Amendment 2 also enabled the Board to set aside 1% of the coastwide TAC for episodic events. Episodic events are times and areas where Atlantic menhaden are available in more abundance than they normally occur. Technical Addendum I to Amendment 2 established a mechanism for New England states from Maine to Connecticut[1] to use the set aside, which includes a qualifying definition of episodic events, required effort controls to scale a state's fishery to the set aside amount, and a timely reporting system to monitor the set aside. Any unused set aside quota as of October 31 is redistributed to jurisdictions on November 1 based on the Amendment 2 allocation percentages.

In 2015, the TAC was increased by 10% to 187,880 mt for the 2015 and 2016 fishing years. In 2016, the Board again increased the TAC by 6.45% to 200,000 mt for the 2017 fishing year.

Atlantic menhaden are managed under Amendment 3. Approved in November 2017, the Amendment maintained the management program's single-species biological reference points until the review and adoption of menhaden-specific ecological reference points (ERPs) as part of the 2019 benchmark stock assessment process. In doing so, the Board placed development of menhaden-specific ERPs as its highest priority and supports the efforts of the ERP Workgroup to reach that goal.

[1] At its May 2016 meeting, the Board added New York as an eligible state to harvest under the set aside.

Amendment 3 also changed commercial quota allocations in order to strike an improved balance between gear types and jurisdictions. The Amendment allocated a baseline quota of 0.5% to each jurisdiction, and allocated the rest of the TAC based on average landings between 2009 and 2011. This measure provides fishing opportunities to states that had little quota under Amendment 2, while still recognizing historic landings in the fishery. States also have the option to relinquish all or part of its quota which is then redistributed to the other jurisdictions based on the 2009-2011 landings period. The Amendment also prohibits the rollover of unused quota; maintains the quota transfer process; maintains the bycatch provision (which was rebranded as the 'incidental catch' provision and applicable gear types were defined) and the episodic event set aside program for the states of Maine – New York. Finally, the Amendment reduced the Chesapeake Bay cap to 51,000 mt, recognizing the importance of the Chesapeake Bay as nursery grounds for many species by capping recent reduction landings from the Bay at current levels.

State	Allocations
Maine	0.52%
New Hampshire	0.50%
Massachusetts	1.27%
Rhode Island	0.52%
Connecticut	0.52%
New York	0.69%
New Jersey	10.87%
Pennsylvania	0.50%
Delaware	0.51%
Maryland	1.89%
PRFC	1.07%
Virginia	78.66%
North Carolina	0.96%
South Carolina	0.50%
Georgia	0.50%
Florida	0.52%
Total	100%

In addition to its Amendment 3 deliberations, the Board increased the TAC by 8% to 216,000 mt for the 2018 and 2019 fishing seasons with the expectation that setting of the TAC for subsequent years would be guided by menhaden-specific ERPs. However, the 2019 benchmark stock assessments and peer-review reports would not be available for Board review until February 2020. As a result, in August 2019, the Board maintained the 216,000 mt TAC for 2020.

In October 2019, the Commission found the Commonwealth of Virginia out of compliance with the Interstate FMP for failing to implement and enforce Section 4.3.7 of Amendment 3: Chesapeake Bay Reduction Fishery Cap (cap). Implementation of this measure is necessary to achieve the goals and objectives of Amendment 3 and maintain the Chesapeake Bay marine environment to assure the availability of the ecosystem's resources on a long-term basis. The noncompliance finding was sent to the Secretary of Commerce who concurred with the Commission's finding and declared a moratorium on Atlantic menhaden fisheries in Virginia waters, effective June 17, 2020 if the correct cap was not implemented. In May 2020, ASMFC withdrew the noncompliance finding as the Commonwealth promulgated regulations to implement the 51,000 mt cap. To account for the 2019 overage, the cap for the 2020 fishing year was set at 36,000 mt.

In August 2020, the Board formally approved the use of ERPs to manage Atlantic menhaden, with Atlantic striped bass as the focal species in maintaining their population. Atlantic striped bass was chosen for the ERP definitions because it was the most sensitive predator fish species to Atlantic menhaden harvest, so an ERP target and threshold sustaining striped bass would likely provide sufficient forage for other predators under current ecosystem conditions. For the development of the ERPs, all other focal species in the model (bluefish, weakfish, spiny dogfish, and Atlantic herring) were assumed to be fished at 2017 levels.

In October 2020, the Board approved a TAC for 2021 and 2022 of 194,000 mt, based on the ERPs approved in August. The new TAC represents a 10% reduction from the 2018-2022 TAC level. Based on projections, the TAC is estimated to have a 58.5% and 52.5% probability of exceeding the ERP fishing mortality target in the first and second year, respectively.

II. Status of the Stock

Atlantic menhaden are now managed by menhaden-specific ERPs as indicated above. The ERP target is the maximum fishing mortality rate (*F*) on Atlantic menhaden that sustains Atlantic striped bass at their biomass target when striped bass are fished at their F target , a measure of the intensity with which the population is being fished, is used to evaluate whether the stock is experiencing overfishing. The ERP threshold is the maximum F on Atlantic menhaden that keeps Atlantic striped bass at their biomass threshold when striped bass are fished at their *F* target. Population fecundity, a measure of reproductive capacity, is used to evaluate whether the stock is overfished. According to the latest assessment results, the 2017 estimate of fecundity, was above both the ERP FEC target and threshold, indicating the stock was not overfished.

In February 2020, the Board accepted the results of the Single-Species and Ecological Reference Point (ERP) Benchmark Stock Assessments and Peer Review Reports for management use. These assessments were peer-reviewed and approved by an independent panel of scientific experts through the 69th SouthEast, Data, Assessment and Review (SEDAR) workshop. The single-species assessment acts as a traditional stock assessment using the Beaufort Assessment Model (BAM), a statistical catch-at-age model that estimates population size-at-age and recruitment. According to the model, the stock is not overfished or experiencing overfishing relative to the current single-species reference points. Population fecundity in 2017 is above the single-species threshold and *F* has remained below the single-species overfishing threshold (0.6) since the mid-1970s, and below the single-species overfishing target (0.22) since the mid-1990s. The model also found juvenile abundance was low in 2017, while biomass was relatively high.

The ERP assessment evaluates the health of the stock in an ecosystem context, and indicates the *F* reference points for menhaden should be lower to account for the species' role as a forage fish[2]. The ERP assessment uses the Northwest Atlantic Coastal Shelf Model of Intermediate Complexity for Ecosystems (NWACS-MICE) to develop Atlantic menhaden ERPs.

[2] it should be noted, however, that the conservative TAC the Board has set for recent years is consistent with the ERP *F* target provided in the ERP Assessment

NWACS-MICE is an ecosystem model that focuses on four key predator species (striped bass, bluefish, weakfish, and spiny dogfish) and three key prey species (Atlantic menhaden, Atlantic herring, and bay anchovy). These species were chosen because diet data indicate they are top predators of Atlantic menhaden or are key alternate prey species for those predators.

The ERP assessment indicates the *F* reference points for menhaden should be lower than the single-species reference points, but it also concluded that the final ERP definitions, including the appropriate harvest level for menhaden, depend on the management objectives for the ecosystem (i.e., management objectives for both Atlantic menhaden and its predators). Accordingly, instead of proposing a specific ERP definition, the assessment recommends a combination of the BAM and the NWACS-MICE models as a tool for managers to evaluate trade-offs between menhaden harvest and predator biomass.

III. Status of the Fishery

Commercial

Total commercial Atlantic menhaden landings in 2020, including directed, incidental catch, and episodic event set aside (EESA) landings, are estimated at 184,150 mt (405 million pounds), an approximate 12% decrease relative to 2019 (Table 1). The non-incidental catch fishery landings (directed landings plus landings under the EESA) total for 2020 is estimated at 177,830 mt (392 million pounds) and represents an approximate 82% of the coastwide commercial TAC of 216,000 mt (476.2 million pounds). Landings from the incidental catch fishery are estimated at 6,330 mt (13.95 million pounds) and do not count towards the coastwide TAC.

Reduction Fishery

The 2020 harvest for reduction purposes is estimated at 124,600 mt (274.7 million pounds), a 17% decrease from 2019 and 11% below the previous 5-year average of 140,380 mt (309.4 million pounds) (Table 2; Figure 3). Omega Protein's plant in Reedville, Virginia, is the only active Atlantic menhaden reduction factory on the Atlantic coast. In 2020, the reduction plan was shut down for 3 weeks due to the COVID-19 pandemic. Anecdotal reports indicate that in addition to the pandemic, bad weather may have also contributed to lower harvest.

Bait Fishery

The coastwide bait harvest estimate for 2020, including directed, incidental catch, and EESA landings, is 59,550 mt (131.2 million pounds). This represents a 3% increase relative to 2019 and a 23% increase compared to the previous 5-year average (Table 2; Figure 3). New Jersey (38%), Virginia (25%), Maine (20%), and Massachusetts (7%) landed the four largest shares in 2020.

Incidental Catch and Small Scale Fisheries Landings

Incidental catch landings in 2020 are estimated at 6,330 mt (13.95 million pounds), which is a 30% increase relative to 2019 and the highest level in the time series average (Table 3). Maine, Massachusetts, New York, and New Jersey reported incidental catch landings (88% from purse seines and 8% from gill nets) in 2020 (Table 4). Maine accounted for 97% of total incidental

fishery landings in 2020. Incidental catch trips in 2020 were higher than trips from 2016 through 2019 (Table 4).

Episodic Events Set Aside (EESA) Program
The 2020 EESA quota was 2,160 mt (4.76 million pounds). Maine began harvesting under the EESA program on June 25, with projections indicating that 80% of the EESA quota had been harvested after three days of harvesting. Maine's EESA fishery closed on July 6, although the directed fishery was able to reopen on July 7 through 18th following the state's acquisition of 5.4 million pounds of quota through eight state-to-state transfers. Massachusetts began harvesting under the EESA program on August 17 and landed 361,485 pounds before closing the fishery on August 28. As of October 31, an estimated 2,080 mt (4.5 million pounds) of menhaden were landed under the EESA fishery (Table 5). Approximately 80 mt (176,771 pounds) of remaining EESA quota was reallocated back to the states on November 1 based on the 2009-2011 period (see Table 7).

Chesapeake Bay Reduction Fishery Cap (cap)
Amendment 3 implemented a 51,000 mt harvest cap for the reduction fishery in the Chesapeake Bay. Due to the cap being exceeded in 2019, the cap was reduced to 36,000 mt for 2020 to account for the overage. Reported reduction landings from Chesapeake Bay in 2020 was about 27,700 mt, under the adjusted the cap by approximately 9,000 mt. As a result, the cap for 2021 is set once again at 51,000 mt.

Recreational
Menhaden are important bait in many recreational fisheries; some recreational fishermen use cast nets to capture menhaden or snag them with hook and line for use as bait, both dead and alive. The Marine Recreational Information Program (MRIP) estimate for Atlantic menhaden harvest (A + B1) in 2020 is 2.55 million pounds (PSE of 33.5) which is a 33% increase from 2020 (1.92 million pounds or 1,569 mt). Please note due to COVID-19 pandemic disruptions to the Access Point Angler Intercept Survey and subsequent gaps in catch records, 2020 catch estimates are based in part on imputed data (i.e. proxy or replacement data from 2018 and 2019). For Menhaden in 2020, the contribution of imputed data to total harvest was 26% for harvest in number of fish and 19% for harvest in weight (pounds).

Additionally, it is important to note recreational harvest is not well captured by MRIP because there is not a known, identified direct harvest for menhaden, other than for bait. MRIP intercepts typically capture the landed fish from recreational trips as fishermen come to the dock or beach. However, since menhaden caught by recreational fishermen are often used as bait during their trip, they are typically not part of the catch that is seen by the surveyor completing the intercept.

IV. Status of Research and Monitoring

Commercial fisheries monitoring
Reduction fishery - The NMFS Southeast Fisheries Science Center Beaufort Laboratory in Beaufort, North Carolina, continues to monitor landings and collect biological samples from the

Atlantic menhaden purse-seine reduction fishery. The Beaufort Laboratory processes and ages all reduction samples collected on the East Coast. In addition, the purse-seine reduction fishery continues to provide Captains Daily Fishing Reports (CDFRs) to the Beaufort Laboratory where NMFS personnel enter data into a database for storage and analysis.

Bait fishery - Per Amendment 3, states are required to implement a timely quota monitoring system to maintain menhaden harvest within the TAC and minimize the potential for quota overages. The Standard Atlantic Fisheries Information System (SAFIS) daily electronic dealer reporting system allows near real time data acquisition for federally permitted bait dealers in the Mid-Atlantic and Northeast. Landings by Virginia's purse-seine for-bait vessels (snapper rigs) in Chesapeake Bay are tabulated at season's end using CDFRs maintained on each vessel during the fishing season. A bait-fishery sampling program for size and age composition has also been conducted since 1994. The Beaufort Laboratory, and some states, age the bait samples collected. See *Section VII* for more information on quota monitoring and biological sampling requirements.

Atlantic menhaden research

The following studies relevant to menhaden assessment and management have been published within the last few years:

- Deyle, E., A. M. Schueller, H. Ye, G. M. Pao, and G. Sugihara. 2018. Ecosystem-based forecasts of recruitment in two menhaden species. Fish and Fisheries 19(5): 769-781.
- Liljestrand, E.M., M.J. Wilberg, and A.M. Schueller. 2019. Estimation of movement and mortality of Atlantic menhaden during 1966-1969 using a Bayesian multi-state mark recapture model. Fisheries Research 210: 204-213.
- Liljestrand, E.M., M. J. Wilberg, and A. M. Schueller. 2019. Multi-state dead recovery mark-recovery model performance for estimating movement and mortality rates. Fisheries Research 210: 214-233.
- Lucca, B. M., and J. D. Warren. 2019. Fishery-independent observations of Atlantic menhaden abundance in the coastal waters south of New York. Fisheries Research 218: 229-236.
- Nesslage, G. M., and M. J. Wilberg, M. J. 2019. A performance evaluation of surplus production models with time-varying intrinsic growth in dynamic ecosystems. Canadian Journal of Fisheries and Aquatic Sciences 76(12): 2245-2255.
- Chargaris D., Drew K., Schueller A., Cieri M., J. Brito J., and Buchheister A. 2020. Ecological Reference Points for Atlantic Menhaden Established Using an Ecosystem Model of Intermediate Complexity. Front. Mar. Sci. 7:606417.

Theses and Dissertations of Potential Interest:

- McNamee, J. E. 2018. A multispecies statistical catch-at-age (MSSCAA) model for a Mid-Atlantic species complex. University of Rhode Island.

V. Implementation of FMP Compliance Requirements for 2020

All states are required to submit annual compliance reports by April 1.

Quota Results
Table 7 contains 2020 state-specific quotas and directed harvest. The final quotas for 2020 account for 4.45 million pounds of quota relinquished by Delaware and Georgia, an adjustment of 16 state-to-state transfers (Table 8), and the reallocation of unused EESA quota (176,771 pounds). Quota transfers were generally pursued to ameliorate overages. Based on preliminary 2020 landings and quota transfers through April 2021, no jurisdiction's quota has been adjusted due to quota overage.

The Board set the TAC at 194,400 mt (428.5 million pounds) for 2021 based on the newly adopted ERPs. 1% is set aside for episodic events. States may relinquish all or part of its annual quota by December 1st of the previous year. Delaware relinquished 1.7 million pounds of quota which was redistributed to the states according to procedures outlined in Amendment 3 and is reflected in the 2021 Preliminary Quota (Table 7).

Quota Monitoring
The Board approved timely quota monitoring programs for each state through implementation of Amendment 3. Monitoring programs are intended to minimize the potential for quota overages. Table 6 contains a summary of each state's approved quota monitoring system.

Menhaden purse seine and bait seine vessels (or snapper rigs) are required to submit CDFRs. Maine, New York, and Virginia fulfilled this requirement in 2020. New Jersey did not require purse seine vessels to fill out the specific CDFR but did require monthly trip level reporting on state forms that include complementary data elements to the CDFR. Rhode Island purse seine vessels must call in daily reports to RI DFW and fill out daily trip level logbooks. Massachusetts and Connecticut require trip level reporting for all commercial fishermen. Menhaden purse seine fisheries do not currently operate in all other jurisdictions in the management unit.

Biological Monitoring Requirements
Amendment 3 maintains biological sampling requirements for non *de minimis* states as follows:

- One 10-fish sample (age and length) per 300 mt landed for bait purposes for Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, and Delaware; and
- One 10-fish sample (age and length) per 200 mt landed for bait purposes for Maryland, Potomac River Fisheries Commission, Virginia, and North Carolina

Table 9 provides the number of 10-fish samples required and collected for 2020. These are based on the best available 2020 total bait landings data (including directed, incidental, and EESA landings) provided to the Commission by the states. In 2020, Maine, Massachusetts, and PRFC fell short of the required samples. All three jurisdictions indicated that the COVID-19 pandemic in 2020 prevented them from collecting the full samples. As restrictions remain in place for many states in 2021 in response to the pandemic, there is a strong chance some states will not be able to meet their 2021 sampling requirement. All other jurisdictions met the biological monitoring requirements in 2020.

The PRT continued to discuss whether a sufficient number of age and length samples are being collected from different commercial gear types as well as regions, and whether substituting samples from fishery-independent sources is appropriate for meeting the requirement. The PRT recommends this requirement be evaluated as part of the next management action or during the next benchmark stock assessment.

Adult CPUE Index Requirement
Amendment 3 requires that, at a minimum, each state with a pound net fishery must collect catch and effort data elements for Atlantic menhaden as follows; total pounds landed per day, number of pound nets fished per day. These are harvester trip level ACCSP data requirements. In May of 2013, the Board approved North Carolina's request to omit this information on the basis that it did not have the current reporting structure to require a quantity of gear field by harvesters or dealers. In recent years, NC DMF staff have worked to develop a proxy method to estimate effort but this approach likely would not work for developing an adult CPUE index. The PRT seeks clarification from the Board whether this exemption remains in place for North Carolina. All other states with a pound net fishery met this requirement.

De Minimis Status
To be eligible for *de minimis* status, a state's bait landings must be less than 1% of the total coastwide bait landings for the most recent two years. State(s) with a reduction fishery are not eligible for *de minimis* consideration. If granted *de minimis* status by the Board, states are exempt from implementing biological sampling as well as pound net catch and effort data reporting. The Board also previously approved a *de minimis* exemption for New Hampshire, South Carolina and Georgia from implementation of timely reporting. The states of Pennsylvania, South Carolina, Georgia, and Florida requested and qualify for *de minimis* status for the 2021 fishing season.

VI. Plan Review Team Recommendations and Notable Comments

Management Recommendations
- The PRT recommends that the *de minimis* requests from Pennsylvania, South Carolina, Georgia, and Florida, be approved.
- The PRT recommends that the incidental catch fishery provision issue and biological sampling requirement be readdressed in a future management document.
- The PRT recommends the Board clarify whether North Carolina is exempt from collecting catch and effort data from the pound net fishery.

Notable Comments
Landings data suggest that Atlantic menhaden have become increasingly available to the Gulf of Maine fishery in recent years (2016-2020). In 2020, the state of Maine reported landings in excess of 25 million pounds, marking a 13% increase relative to 2019 landings and a 316% increase relative to 2016. In 2020 Massachusetts reported 8.8 million pounds, marking a 26% increase relative to 2019. While New Hampshire's 2018 and 2020 landings are confidential, in 2019 the states of Maine through Massachusetts accounted for nearly 7% of the coastwide

total landings. Maine has requested additional quota through in-season transfers each year since 2016; both New Hampshire and Massachusetts also received additional quota through transfers in 2020. Both Maine and Massachusetts opted into the EESA fishery in 2020, marking four consecutive years of participation for Maine in the program. Both states also reported incidental catch landings in 2020 as well. Landings in the 2020 incidental catch fishery increased to 13.7 million pounds, a 30% increase from 2019 and a new time series high.

The recent increase in landings is attributed to the status and availability of other bait fish populations in the region (e.g., Atlantic herring). There may be additional social and economic factors that the PRT is unaware of contributing to the change in landings trend.

Similar to last year's report, the PRT highlights how some states manage their quota relative to the incidental catch fishery. The incidental catch provision in Amendment 3 states "after a quota allocation is met for a given jurisdiction, the fishery moves to an incidental catch fishery in which small-scale gears and non-directed gear types may land up to 6,000 pounds of menhaden per trip per day" (12,000 pounds per trip per day for two authorized individuals, working from the same vessel fishing stationary multi-species gear). The amendment does not give guidance for the incidental catch provision if a state subdivides its quota to different gear types or sectors. New Jersey and the Commonwealth of Virginia subdivide their quotas and have done so since the Commission implemented state quotas in 2013. Virginia allocates its annual quota to three sectors: the reduction sector, the purse seine bait sector, and the non-purse seine bait sector. New Jersey allocates the majority of its annual quota to the purse-seine fishery, and the remaining quota is allocated to all other gear types. Once the non-purse seine bait sector or "other gears" fishery has harvested its portion of the state's allocation, that fishery moves into an incidental catch fishery regardless of whether the entire state's quota has been harvested. This has resulted in Virginia and New Jersey reporting incidental catch landings when they have not met their overall quota allocation for a given year. Since the inception of the incidental catch provision, the PRT has reported landings following the closure of Virginia's non-purse seine bait fishery and New Jersey's "other gears" fishery as incidental catch. The PRT requests guidance from the Board if they would like to see this reported differently.

Separately, the PRT notes the overall increase of the incidental catch in recent years relative to the directed fishery landings. While incidental catch does not count towards the annual TAC, in 2020 incidental catch was approximately 10% of bait fishery landings. 2019 and 2020 were the highest levels of incidental catch since the provision was implemented through Amendment 2 in 2013. Given the significant increase of landings in this category, the PRT expressed concern that volume of landings appears to not reflect the original intention of the provision. The PRT recommends this issue be addressed in a future management document.

VII. Literature Cited

Atlantic States Marine Fisheries Commission (ASMFC). 2017. Atlantic Menhaden Stock Assessment Update. Prepared by the ASMFC Atlantic Menhaden Stock Assessment Subcommittee. 180 pp.

Southeast Data, Assessment, and Review (SEDAR). 2015. SEDAR 40 – Atlantic Menhaden Stock Assessment Report. SEDAR, North Charleston SC. 643 pp.

SEDAR. 2020. SEDAR 69 – Atlantic Menhaden Benchmark Stock Assessment Report. SEDAR, North Charleston SC. 691 pp. available online at: http://sedarweb.org/sedar-69

SEDAR. 2020. SEDAR 69 - Atlantic Menhaden Ecological Reference Points Stock Assessment Report. SEDAR, North Charleston SC. 560 pp. available online at: http://sedarweb.org/sedar-69

Table 1. Directed, bycatch, and episodic events set aside landings in 1000s of pounds for 2020 by jurisdiction. NA = not applicable; C = confidential

State	Directed	Incidental Catch	EESA
ME	7,889	10,751	4,398
NH	C	-	NA
MA	8,417	49	361
RI	198	-	NA
CT	112	-	NA
NY	3,766	282	NA
NJ	49,803	20	NA
DE	161	-	NA
MD	2,595	-	NA
PFRC	2,190	-	NA
VA	307,351	-	NA
NC	594	-	NA
SC	-	-	NA
GA	-	-	NA
FL	247	-	NA

Table 2. Atlantic menhaden reduction and bait landings in thousand metric tons, 1986-2020

	Reduction Landings (1000 mt)	Bait Landings (1000 mt)
1986	238	21.6
1987	310	25.5
1988	278	43.8
1989	284	31.5
1990	343	28.1
1991	330	29.7
1992	270	33.8
1993	310	23.4
1994	260	25.6
1995	340	28.4
1996	293	21.7
1997	259	24.2
1998	246	38.4
1999	171	34.8
2000	167	33.5
2001	234	35.3
2002	174	36.2
2003	166	33.2
2004	183	34.0
2005	147	38.4
2006	157	27.2
2007	174	42.1
2008	141	47.6
2009	144	39.2
2010	183	42.7
2011	174	52.6
2012	161	63.7
2013	131	37.0
2014	131	41.6
2015	143	45.8
2016	137	43.1
2017	129	43.8
2018	141	50.2
2019	151	58.1
2020	125	59.6
Avg 2015-2019	140	48.2

Table 3. Incidental fishery landings by state in 1000s of pounds, 2013-2020. Only states that have reported incidental catch landings are listed. Average total incidental catch landings for the time series is 6.9 million pounds.

State	2013	2014	2015	2016	2017	2018	2019	2020
ME		-	-	506	5,374	2,995	10,751	13,605
MA								49
RI	16	99	70	40	136	-	-	-
CT	0	-	10	-	124	-	-	-
NY	0	325	769	281	807	-	-	282
NJ	0	626	241	196	-	204,240	-	20
DE	76	112	92	21	29	-	-	-
MD	2,864	2,201	1,950	996	-	-	-	-
PRFC	1,087	1,112	455	106	670	-	-	-
VA	268	2,232	2,103	326	-	110,281	-	-
FL	65	126	302	111	264	-	-	-
Total	4,377	6,831	5,992	2,581	7,404	3,215	10,751	13,957

Table 4. Total incidental landings (1000s of pounds), number of trips, and number of states reporting landings in the incidental catch fishery, 2013-2020.

Year	Landings (1000s of pounds)	Number of Trips	Number of states landing
2013	4,377	2,783	4
2014	6,831	5,275	8
2015	5,992	4,498	9
2016	2,581	2,222	9
2017	7,404	2,108	7
2018	3,310	1,224	3
2019	10,751	3,113	1
2020	13,957	3,565	4
Total	55,154	24,788	

Table 5. Episodic Events Set-Aside (EESA) fishery quota, landings, and participating states by year. *the 2018 EESA quota was reduced due to an overage in 2017. The 2018 EESA overage was paid back in full by the state of Maine.

Year	States Declared Participation	EESA Quota (MT)	Landed (MT)	% EESA Quota Used
2013		1,708	-	-
2014	RI	1,708	134	7.8%
2015	RI	1,879	854	45.5%
2016	ME, RI, NY	1,879	1,728	92.0%
2017	ME, RI, NY	2,000	2,129	106.5%
2018*	ME	2,031	2,103	103.6%
2019	ME	2,160	1,995	92.4%
2020	ME & MA	2,160	2,080	96.3%

Table 6. State quota reporting timeframes in 2020. The **bold** text indicates which reporting program (dealer or harvesters) the states use to monitor its quotas. Blue text indicates changes from 2019.

State+	Dealer Reporting	Harvester Reporting	Notes
ME	monthly	**monthly/daily**	Harvesters landing greater than 6,000 lbs must report daily during episodic event. **Harvest schedule is Monday, Tuesday, Thursday, and Friday. Change from four consecutive days (M-T) made in 2020**
NH	**weekly**	monthly	Exempt from timely reporting. Implemented weekly, trip level reporting for state dealers.
MA	**weekly**	monthly/daily	Harvesters landing greater than 6,000 lbs must report daily
RI	**twice weekly**	quarterly/daily	Harvesters using purse seines must report daily
CT	**weekly/monthly**	monthly/daily	CT operates as directed fisheries until 90% of the quota is harvested. Then operates at the 6,000 pound bycatch trip limit.
NY	**Weekly**	monthly	Capability to require weekly harvester reporting if needed
NJ	**weekly**	monthly	All menhaden sold or bartered must be done through a licensed dealer
DE	—	**monthly/daily**	Harvesters landing menhaden report daily using IVR
MD	monthly	**monthly/daily**	PN harvest is reported daily, while other harvest is reported monthly.
PRFC	—	**weekly**	Trip level harvester reports submitted weekly. When 70% of quota is estimated to be reached, then pound netters must call in weekly report of daily catch.
VA	—	**monthly/weekly/daily**	Purse seines submit weekly reports until 97% of quota, then daily reports. Monthly for all other gears until 90% of quota, then reporting every 10 days.
NC	**monthly (combined reports)**		Single trip ticket with dealer and harvester information submitted monthly. Larger dealers (>50,000 lbs of landings annually) can report electronically, updated daily.
SC	**monthly (combined reports)**		Exempt from timely reporting. Single trip ticket with dealer and harvester information.
GA	**monthly (combined reports)**		Exempt from timely reporting. Single trip ticket with dealer and harvester information.
FL	**monthly/weekly (combined reports)**		Monthly until 75% fill of quota triggers implementation of weekly.

Table 7. Results of 2020 quota accounting in pounds. The 2020 landings do not include landings from the incidental catch fishery because they do not count towards the TAC. A majority of the 2020 episodic events set aside (EESA) quota was used by Maine (92%) with the remainder used by Massachusetts (8%). The remaining set aside quota (176,771 lbs) redistributed to the states. Massachusetts did exceed its transfer-adjusted quota (2021 quota has been adjusted for overage), but the coastwide TAC was not exceeded in 2020. The 2021 base quotas account for the redistribution of relinquished quota by Delaware (1.7 million pounds). * includes redistributed relinquished quota for that year and any overages from the previous season. ^includes inter-state transfers and transfers to the EESA quota.

State	2020 Base Quota*	Returned Set Aside	Transfers^	Final 2020 Quota	Overages	2021 Base Quota*
ME	2,437,866	32.9	5,450,000	7,888,728		2,194,396
NH	2,357,313	0.1	2,300,000	4,657,315		2,121,582
MA	6,008,565	1,488.4	2,350,000	8,397,582		5,402,667
RI	2,440,542	34.0	-1,800,000	641,433		2,196,815
CT	2,431,491	30.3	-2,000,000	432,285	-	2,188,634
NY	3,256,768	366.7	500,000	3,766,381	-	2,934,618
NJ	51,257,740	19,933.0	0	51,780,273		46,323,661
PA	2,357,183	-	-500,000	1,857,183		2,121,464
DE	2,416,467	-	-100,000	216,467		474,821
MD	8,901,558	2,667.6	-1,350,000	7,621,489		8,037,057
PRFC	5,060,296	1,101.9	0	5,089,181		4,564,863
VA	370,846,528	150,204.8	0	374,784,068		335,206,390
NC	4,507,320	876.4	-1,800,000	2,730,295		4,065,016
SC	2,357,183	-	-1,650,000	707,183		2,121,464
GA	2,357,183	-	0	0		2,121,464
FL	2,442,500	34.8	-1,400,000	1,043,411		2,198,584
TOTAL	471,436,501	176,770.9		471,613,272		424,273,496

Table 8. State-to-state transfers of menhaden commercial quota for the 2020 Fishing year.

Transfers	Transfer Date	ME	NH	MA	RI	CT	NY	NJ	PA	DE	MD	PRFC	VA	NC	SC	GA	FL
1	1-Jul	1,000,000				-1,000,000											
2	7-Jul	1,700,000								-100,000				-600,000			-1,000,000
3	8-Jul			600,000										-600,000			
4	16-Jul		750,000												-750,000		
5	21-Jul			900,000											-900,000		
7	18-Aug	250,000	1,000,000		-250,000	-1,000,000											
8	25-Aug			600,000										-600,000			
9	26-Aug	1,000,000		250,000	-250,000						-1,000,000						
10	27-Aug		350,000								-350,000						
11	25-Sep		400,000														-400,000
12	14-Oct		800,000		-800,000												
13	21-Oct	500,000			-500,000												
14	2-Nov	1,000,000	-1,000,000														
15	20-Nov						500,000		-500,000								
16	13-Apr-21			20,000										-20,000			
Total		5,450,000	2,300,000	2,370,000	-1,800,000	-2,000,000	500,000	0	-500,000	-100,000	-1,350,000	0	0	-1,820,000	-1,650,000	0	-1,400,000

Table 9. Biological monitoring results for the 2020 Atlantic menhaden bait fishery.
*Age samples are still being processed

State	#10-fish samples required	#10-fish samples collected	Age samples collected	Length samples collected	Gear/Comments
ME	38	37	370	370	Two samples tossed due to salting; could not age
NH	6	7	70	70	Purse seine
MA	13	10	104	104	10 purse seine
RI	0	0	0	0	None
CT	1	1	30	30	Gillnet- Lower CT River
NY	7	8	75	75	cast net, seine net
NJ	73	104	*	1040	Purse seine
	2	1	*	10	"Other gear" grouped for confidential reasons
DE	1	1	30	30	Gill net
MD	6	16	293	777	Pound net
PRFC	5	3	45	45	Pound net
VA	5	0	0	0	Pound net
	5	20	200	200	Gill net
	0	2	20	20	Haul seine
NC	3	2	20	252	Gill net
Total	**165**	**212**	**1257**	**3023**	

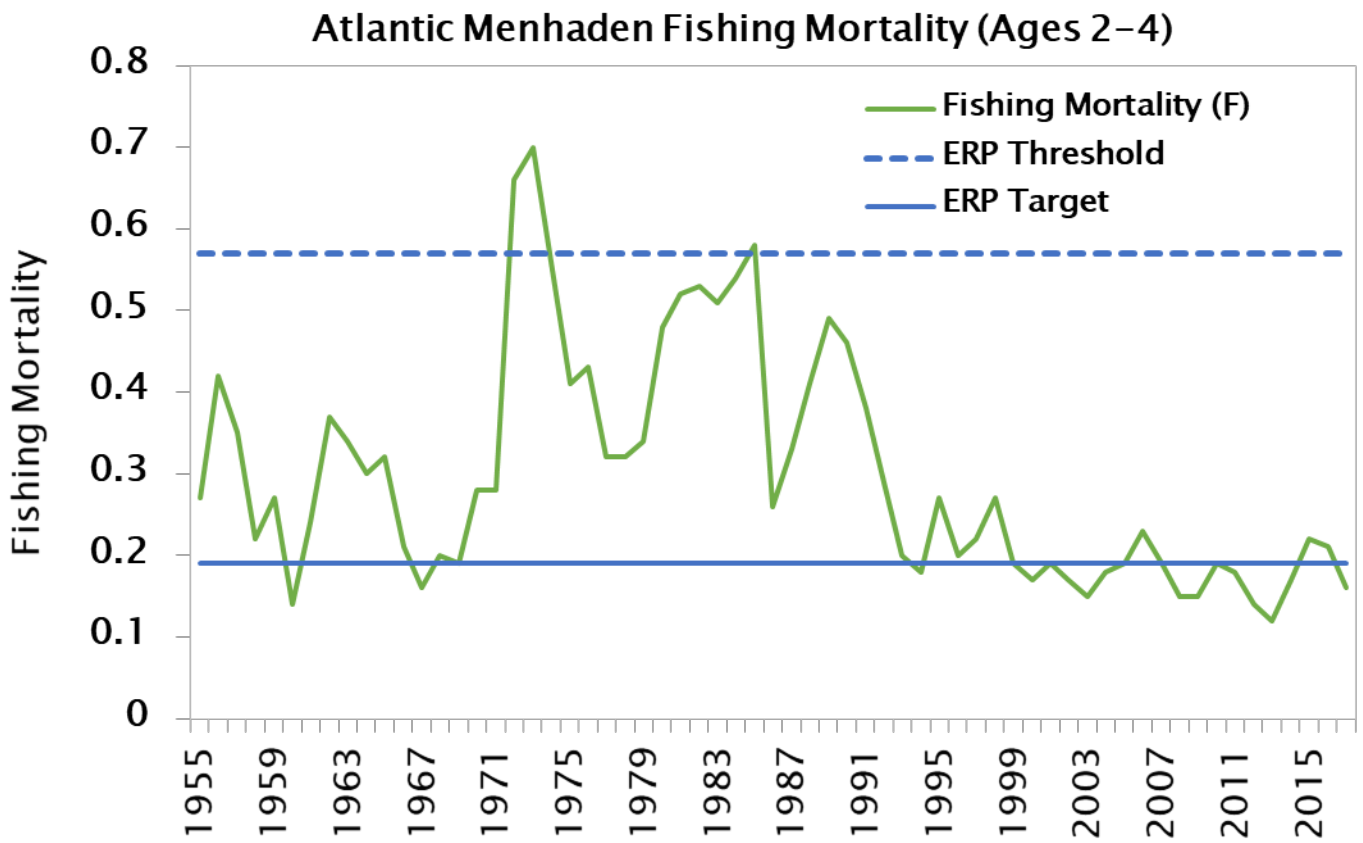


Figure 1. Fishing mortality, 1955-2017. The ERP fishing mortality reference points are F_{target} = 0.19 and $F_{threshold}$ = 0.57. F_{2017} = 0.16. Source: ASMFC 2020.

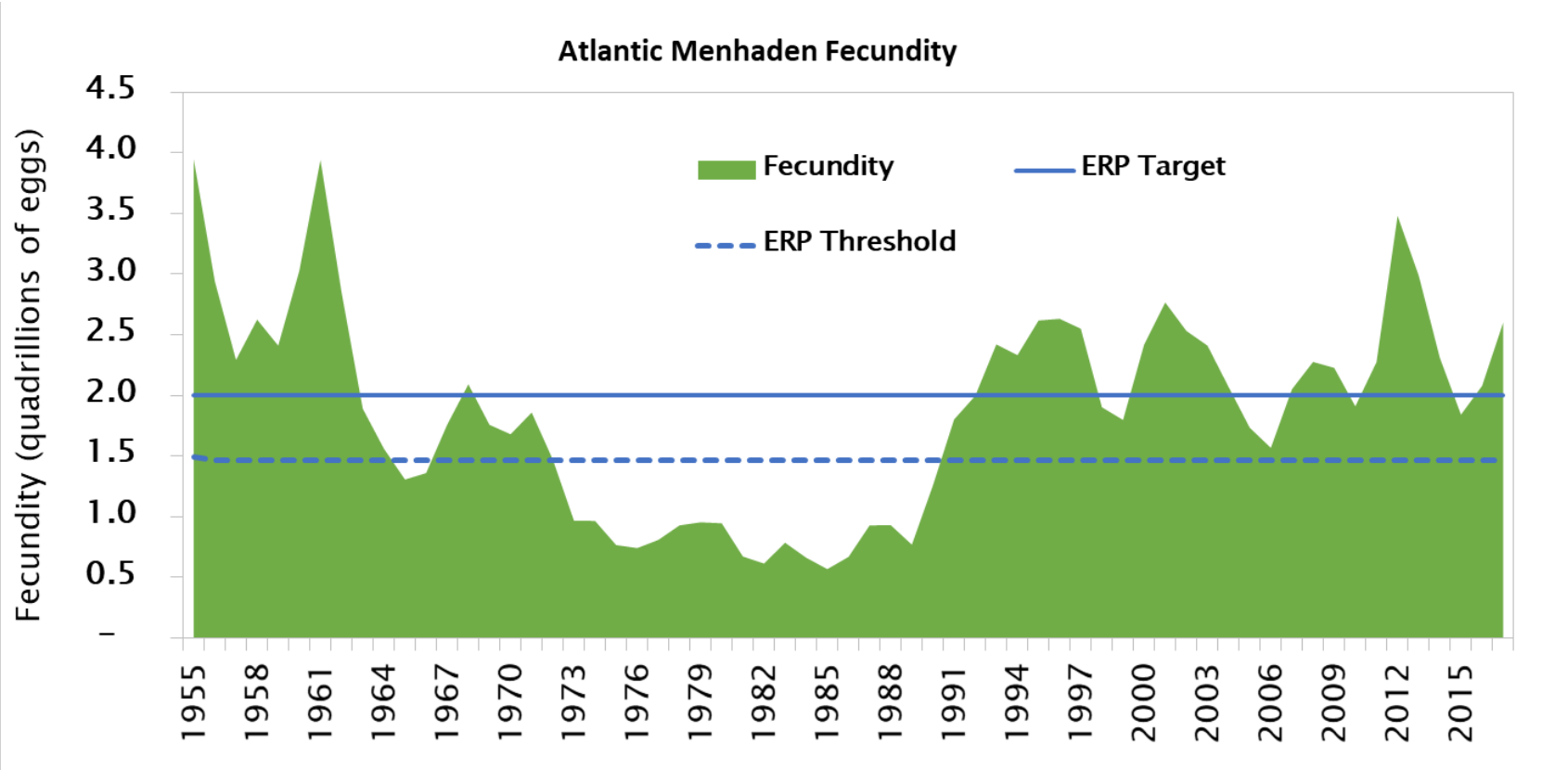


Figure 2. Atlantic menhaden fecundity, 1955-2017. The ERPs for population fecundity are FEC_{target} = 2,003,986 (billions of eggs), and $FEC_{threshold}$ = 1,492,854 (billions of eggs). FEC_{2017} = 2,601,550 billion eggs.

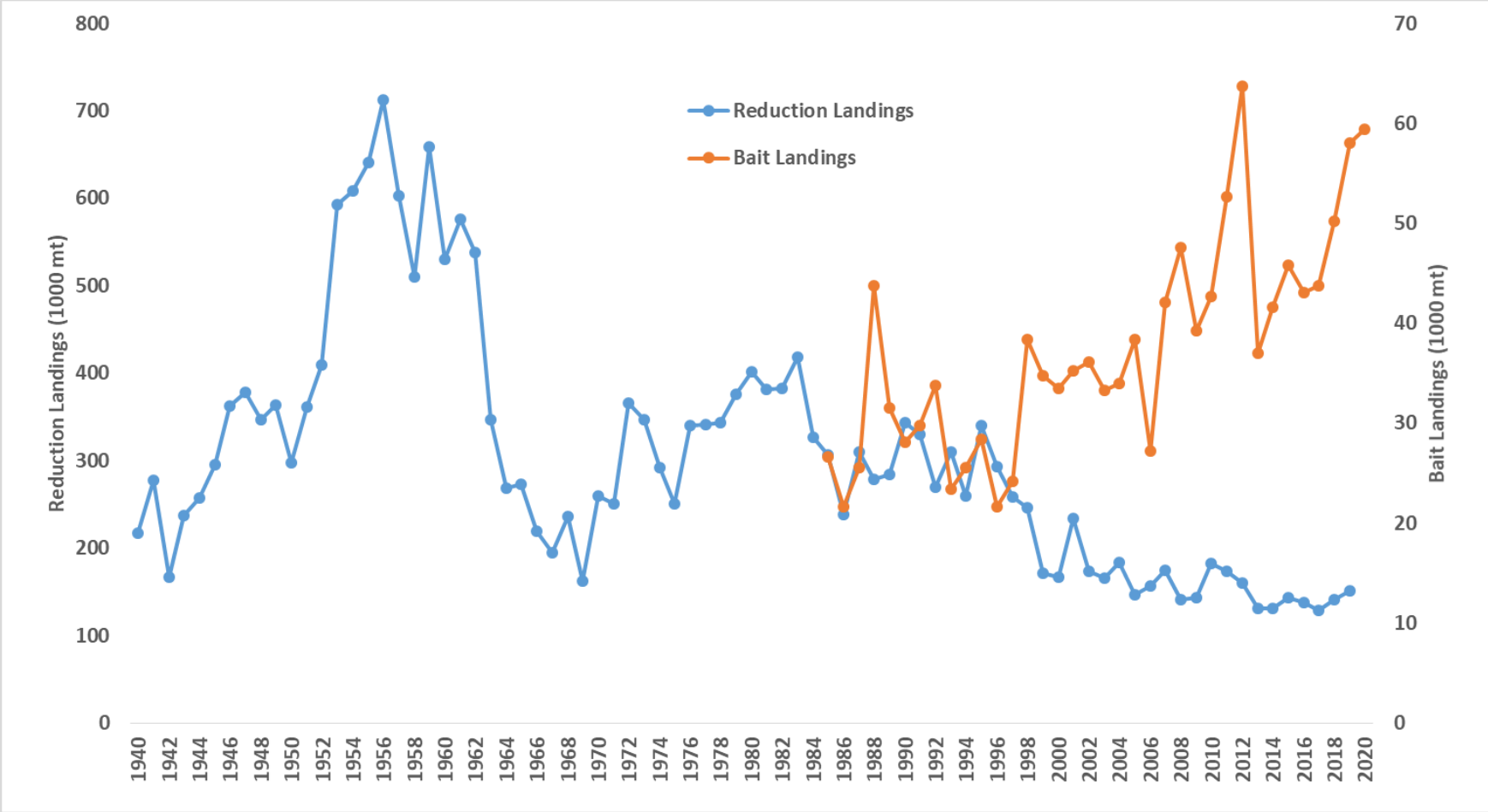


Figure 3. Landings from the reduction purse seine fishery (1940–2020) and bait fishery (1985–2020) for Atlantic menhaden. Note: there are two different scales on the y-axes.

ROY COOPER
Governor

DIONNE DELLI-GATTI
Secretary

JOHN G. BATHERSON
Acting Director

To: Kirby Rootes-Murdy, ASMFC

From: Holly White, NCDMF

CC: Chris Batsavage, Katy West, Charlton Godwin, Amanda Tong

Date: April 23, 2021

Subject: NCDMF Daily Pound Net Landings Proxy for Effort for Atlantic Menhaden

Hi Kirby,

On April 16, 2020 you requested NCDMF provide definitions for the columns "Trips, Nets, ActualPounds" used a proxy to determine the number of pound nets fished per day in the NC Menhaden Workbook. This proxy was developed to meet the requirements of Amendment 3 for mandatory catch and effort data elements for Atlantic menhaden harvested from pound nets. North Carolina does require mandatory reporting of catch but does not require effort data elements. North Carolina calculates effort based on number of pounds nets permitted to fishermen at the time of landings.

The proxy for number of pound nets fished per day has been used to complete Tab 6 of the NC Menhaden Workbook for compliance years 2018, 2019, and 2020. Table 1 provides the non-confidential daily pound net landings using the proxy for number of pound nets fished per day for review by the Plan Review Team. We have also corrected the decimal issue in the "Nets" column. The columns have been reordered for easier understanding. Previously the columns were ordered as "Trips, AcutalPounds, Nets" now ordered as "Trips, Nets, ActualPounds". With these changes, we are providing an updated NC Menhaden Workbook, updated tabs are highlighted in green.

Table 1. NCDMF non-confidential daily pound net landings using proxy for number of pound nets fished per day, 2020.

Year	Month	Day	Gear	Species	Pounds	Participants	Trips	Nets	ActualPounds	CatchperTrip	CatchperNet	CatchperActualPound	Confidential
2020	1	1	Pound Net	Menhaden	133	3	3	3	7	44	44	19	
2020	3	11	Pound Net	Menhaden	765	3	3	10	28	255	80	27	
2020	3	14	Pound Net	Menhaden	861	3	3	10	28	287	90	31	
2020	3	18	Pound Net	Menhaden	300	3	3	10	28	100	31	11	
2020	4	5	Pound Net	Menhaden	520	3	3	10	28	173	54	19	
2020	6	8	Pound Net	Menhaden	842	3	3	5	17	281	168	50	
2020	6	16	Pound Net	Menhaden	560	3	4	8	19	140	70	29	
2020	6	18	Pound Net	Menhaden	5,800	3	3	13	51	1,933	446	114	
2020	6	29	Pound Net	Menhaden	900	3	3	7	14	300	125	62	
2020	7	11	Pound Net	Menhaden	1,490	4	4	8	23	373	187	64	
2020	7	18	Pound Net	Menhaden	1,550	4	5	7	21	310	211	74	

Trips
Number of trips from the Trip Ticket database where date, gear, and waterbody of harvest are specified by dealer during transaction (landing by fisherman). Trips equals the total number of unique trip tickets where gear was a pound net by year/month/day/all waterbodies combined.

Nets
Nets have a singular pound net set permit with unique identifier for a specified location. Nets may have one or multiple 'ActualPounds' fished.

Nets are derived from the Pound Net Permit data and then applied to the Trip Ticket data that is stratified by date and waterbody. Participants with the recorded trip ticket are matched to those participants with a Pound Net Permit. An assumption is made that a Pound Net Permit participant fishes all of his nets every day. In cases where there is trip ticket data for a participant but that participant does not own a valid Pound Net Permit, an average number of nets is then applied to the trip ticket data, again stratified by date and waterbody. In cases where the effort data (nets) is still missing, an average number of nets is applied to those values stratified by date. These values were then all summed up to get the total number of nets fished.

Actual Pounds

Actual Pounds are holding pens, lead(s), one or more enclosures used for harvest of menhaden. Actual pounds was calculated the same way as nets. Instead of using Nets, Actual Pounds derived from the Pound Net Permit data was used.

Atlantic States Marine Fisheries Commission

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MEMORANDUM

TO: Atlantic Menhaden Management Board

FROM: Ecological Reference Point Work Group and Atlantic Menhaden Technical Committee

DATE: April 26, 2021

SUBJECT: Atlantic Menhaden Spatial Model Needs

At the 2021 Winter Meeting, the Atlantic Menhaden Management Board tasked the Ecological Reference Point Work Group (ERP WG) and Atlantic Menhaden Technical Committee (TC) to provide additional detail regarding the research recommendation in the 2019 benchmark stock assessment to "develop a spatially-explicit model." Specifically, the Board requested information on what data would be needed, a timeline for development and implementation, and if it would resolve questions regarding management of menhaden in the Chesapeake Bay.

The ERP WG and TC discussed potential approaches for developing a spatially-explicit model for Atlantic menhaden. These approaches cover a range of spatial complexity, data needs, and timelines, and provide different levels of information to support management. In this memo, the ERP WG and TC provide an initial outline of potential approaches, including the data and modeling development needs, timelines, and expected management information produced, and highlight areas where Board input is needed. The ERP WG and TC stress that the needs and timelines listed here are based on the group's current understanding of what is feasible and may change once model development and data analysis are underway. The approach the group chooses will depend on management goals, as well as data and funding availability.

Attributes	Approach
Coarse spatial scale, minimal additional data requirements	Coastwide Beaufort Assessment Model (BAM) + coastwide Northwest Atlantic Coastal Shelf Model of Intermediate Complexity for Ecosystems (NWACS-MICE) + supplemental Bay information
	Coarse spatial BAM + coastwide NWACS-MICE ERPs
Fine spatial scale, significant additional data requirements	Coarse spatial BAM + coarse spatial NWACS-MICE ERPs
	Detailed spatial BAM + detailed spatial ERPs (NWACS-MICE or alternative detailed spatial multispecies model)

1. Coastwide BAM and NWACS-MICE with supplemental Bay information

These approaches would use the existing BAM plus NWACS-MICE approach to develop coastwide ERPs for Atlantic menhaden to produce a Total Allowable Catch (TAC) that takes into account Atlantic menhaden's role as a forage fish on a coastwide basis, as is done now, but would also provide supplemental information on the Chesapeake Bay.

a. Supplemental Bay Atlantic menhaden abundance information

Approach*:* Supplemental information on absolute Atlantic menhaden abundance in the Chesapeake Bay, such as from an aerial survey, could be used to determine what proportion of the TAC could be taken from the Chesapeake Bay in order to keep exploitation in the Bay at an acceptable level. This simpler, escapement-based approach could be an efficient way to develop information to inform the Chesapeake Bay Cap; however, it would not provide broader spatial information and therefore would not provide advice for regional allocation discussions. In addition, the ERPs developed would be on the coastwide scale, and thus would not include consideration of predator-prey interactions or needs on a finer spatial scale. The ERP WG and TC also noted the uncertainty introduced by combining two different methods of abundance estimation (the BAM and the fishery-independent Bay method), and the lack of information on seasonal migration rates into and out of the Bay.

Data & development needs: This approach would not require additional model development, but would require a significant investment in a robust source of information on absolute abundance in the Chesapeake Bay, which is currently does not exist. It may be possible to use a shorter time series of abundance in this framework than the 10 years that the TC requires for indices of relative abundance within the BAM; however, this will depend on review of the data after collection. An absolute abundance survey would likely require 1-2 years of gear calibration and pilot studies, plus a minimum of 3 years data, in order to evaluate interannual variability and uncertainty in the abundance estimates from the survey, meaning this approach could potentially be taken to peer review within 5-7 years of initiating the survey. However, if interannual variability is high, more years of data would be needed before the approach is ready for management use. Although shorter time series might be sufficient for the initial analysis, the survey would need to be conducted on a regular basis in order to provide management advice in subsequent years.

b. Supplemental Bay multispecies indicators

Approach: Supplemental information such as the state of major predators (striped bass, blue fish, birds) abundance and body fat condition for the Bay could be used as ecosystem indicators to inform management control rules in parallel with the single species BAM and MICE models. Indicators would likely provide qualitative rather than quantitative advice on the Bay cap.

Data & development needs: Ecosystem indicators could be developed from existing datasets, but would require some work to synthesize different data sources and develop a meaningful control rule or traffic light approach to inform management.

2. Coarse spatial model approaches

These approaches would provide information on a coarse spatial scale, e.g., North, Mid, and South Atlantic plus a Chesapeake Bay region. However, it is important to note that, due to data limitations, the Chesapeake Bay region would include the coastal waters of Maryland and Virginia. Additional analysis of the tagging data would be required to determine the significance of including ocean waters and whether or not this information could be used to inform the Bay Cap. Both of these approaches would take approximately 5-7 year to complete, though this could change depending on funding and data availability.

a. Coarse spatial BAM with coastwide NWACS-MICE ERPs

Approach: This approach would refine the BAM to include spatial dynamics at a coarse scale and produce regional estimates of biomass, while the NWACS-MICE model would provide coastwide ERPs. The BAM plus NWACS-MICE would be used to develop a coastwide TAC, as is done now. An escapement-based approach could be used to determine what proportion of the TAC could be taken from each region. Regions would be defined to match management needs and the existing information on migration rates. Again, in the coarse approaches the Chesapeake Bay region would include Maryland and Virginia coastal waters due to its inclusion in the Bay region in the historical tagging study. The coastwide ERPs would not include the ecosystem considerations on a finer spatial scale. Currently, genetic and tagging data indicate Atlantic menhaden comprise a single stock on the Atlantic coast, and the BAM includes some consideration of spatial dynamics with the fleets-as-areas approach. Incorporating spatial structure could provide some improvements to our understanding of the stock, including differences in recruitment and life history characteristics.

Data & development needs: Catch-at-age data are already available on a coarse regional basis. Existing fishery-independent indices could be assigned to or developed at the regional level. The existing information on migration rates between large scale regions is not differentiated by age, and so the model would assume that all ages share the same migration patterns. This would introduce additional uncertainty in the spatial model. Information on the proportion of total recruitment that comes from each region could also be a limitation for this model. This approach could be attempted with the existing datasets, but would require investment of personnel time and effort. This approach would likely be ready for peer review in 5-7 years, but that frame could be longer if existing data are not adequate.

b. Coarse spatial BAM with coarse spatial NWACS-MICE ERPs

Approach: This approach would build on the coarse spatial BAM approach described above, but combine it with a coarse spatial NWACS-MICE. To develop ERPs that take into account spatial dynamics in predator-prey interactions, a spatially-explicit multispecies model is necessary. The most straightforward approach would be to combine a spatially-explicit version of the NWACS-MICE model with a spatially-explicit version of the BAM. Both models would have a similar coarse spatial scale determined by management needs and data availability. Again, note that the Chesapeake Bay region would include Maryland and Virginia coastal waters. This approach could be used to provide advice on both the Chesapeake Bay Cap and broader regional allocation discussions. For example, it would be possible to run scenarios with differing levels of

fishing in the Chesapeake Bay region to estimate specific impacts on predators that use the region.

Data & development needs: A spatially-explicit multispecies model is more data intensive than the spatially-explicit BAM. To develop a coarse NWACS-MICE spatial model, we would need estimates of dispersal rates for all modeled species, information on seasonal spawning, recruitment, and migration patterns, and also information on spatial fishing effort for all fishing fleets in the model. In absence of actual data, expert opinion and rules-of-thumb can be used to parameterize the spatial model. For calibration and validation of the spatial model, we would need reliable species distribution maps that are seasonally resolved, region-specific trends in abundance and catch, fishing effort maps, and region-specific food habit data. The scale of the existing diet data is a weakness in current data availability in developing ERPs that account for finer scale ecosystem dynamics, especially for non-finfish predators. Investment in enhanced diet data collection from new or existing fishery-independent sampling programs at the state or federal level for the species in the NWACS-MICE model would benefit these models. This approach could be attempted with the existing datasets, but would require investment of personnel time and effort. This approach would likely be ready for peer review in 5-7 years; however, that frame could be longer if existing data are not adequate or shorter if resources are made available and more time can be allocated to model development.

3. Complex Spatial Modeling Approaches

These approaches would further refine the spatial scale. If the data were available, these approaches could provide information on the Chesapeake Bay specifically (i.e., not including ocean waters) and other regions beyond the coarse spatial scale. Both of these approaches would likely take at least 10 years, though this could change depending on funding and data availability.

a. Refined spatial BAM with NWACS-MICE ERPs

Approach: This approach would develop a more refined spatial BAM, which would be able to provide information on the Chesapeake Bay specifically (separate from MD and VA ocean waters) and other regions beyond the coarse spatial scale described above. It could be used with a coastwide NWACS-MICE or a refined spatial NWACS-MICE, depending on data availability. Depending on which NWACS-MICE approach was used, this approach would provide information similar to the escapement-based approaches or the coarse NWACS-MICE approach, respectively, but on a more refined spatial scale.

Data & development needs: In order to provide information on a true Chesapeake Bay region, or other regions beyond the coarse spatial scale described above, the BAM would require more fine-scale information on migration rates at age between the regions of interest. This would require a new comprehensive tagging study to provide that information. If complementary data on seasonal spatial distribution maps and trends in abundance and catch were available for the NWACS-MICE model, ERPs could be developed on a similar scale to the BAM's regional structure. If not, coastwide ERPs could be used in conjunction with the more refined BAM model. The refined spatial ERPs require significant investment in movement studies as well as in

diet data and model development. This approach would not be feasible until the necessary movement data are available.

b. Detailed spatial BAM and detailed spatial ERPs

Detailed spatial BAM and detailed spatial ERPs

Approach: The most complex approach would be to develop a fully-realized fine-scale spatial multispecies or ecosystem model for Atlantic menhaden. This could be achieved with NWACS-MICE, or another model such as the multi-species statistical catch-at-age model developed for the 2019 ERP Benchmark Assessment. A fully realized NWACS-MICE or other spatial model would use a much finer spatial resolution (on the order of 10-minute squares) that represented habitat gradients and jurisdictional boundaries. The model could be driven by static and/or spatial-temporal habitat maps, for example from satellite data or oceanographic model. This approach could simulate a broader range of environmental and policy options, such as warming sea temperatures and species range expansion into the northern region. Higher spatial resolution in the model would allow for better representation of spatial fishing effort in and out of the Bay.

Data & development needs: The disadvantage of this approach is that it is far more computationally demanding and requires information on species-habitat interactions that may not be available for some species. Typically, the habitat preference functions are derived from survey data. Assembling habitat maps, combining survey datasets, and estimating species preference functions for the different habitat types adds considerable time to model development. For species/life stages that are not captured in any surveys, expert opinion and online data repositories such as AquaMaps can be used instead. Validating the high-resolution spatial MICE model could be done by comparing region-specific time series (similar to the coarse scale model), comparing predicted and observed species distribution maps, or on a point-by-point basis. Higher resolution movement and diet data would significantly enhance model development and result in more reliable ERP estimates. Spatially-explicit statistical catch-at-age models do exist (i.e., Stock Synthesis and others); however, they do not exist in a multispecies model construct at this point, so would require software development. This approach would not be feasible until the necessary spatial data are available.

Immediate Funding Needs

The ERP WG and the TC indicated that some form of a coarsely structured spatial model was possible to develop for the next benchmark assessment if the Board was willing to accept a longer time frame for the next benchmark (2027-2028 instead of 2025). The approach that the groups pursue will depend on management goals (see 'Management input needs' below), data availability, and development resources. Table 1 provides a comparison of the approaches based on advice provided, data needs, and timeline.

The major areas that would require or benefit from funding to address data or model limitations are summarized below. In addition, the ERP WG and TC noted that timeline for model development could be shortened somewhat with funding for dedicated modelers.

Approach	Major Funding Need
Coastwide model with supplemental Bay information	3-5+ years of reliable absolute abundance estimates for the Chesapeake Bay
Coarse spatial ERPs	Spatially and seasonally explicit diet data and spatial distributions for key predator and prey species; additional model development
Refined spatial ERPs	Spatially- and seasonally-explicit diet data for key predator and prey species; fine-scale information on migration rates between regions by age; additional model development

Management input needs

The TC and ERP WG need guidance from the Board on specific goals and priorities to determine a path forward. The ERP WG and TC pose the following questions to the Board:

- What is the primary goal for spatially-explicit modeling? (e.g., advice on Chesapeake Bay Cap, regional allocation advice, enhance accuracy of coastwide ERPs, something else)
- Are there secondary goals?
- Are the ecosystem management objectives for the Chesapeake Bay the same as those used to develop the coastwide ERPs?
- What tradeoffs is the Board willing to make between the spatial scale/detail of the modeling and the timeline for the next benchmark?
- Would the Board be satisfied with a regional approach that separates MD and VA from the rest of the coast if modeling the Chesapeake Bay separately is not feasible for the next benchmark?

For example, the primary goal could be to provide advice on the Chesapeake Bay Cap by the next benchmark assessment, and the secondary goal could be to provide information to inform regional allocations. In this case, if there were challenges with developing a model to provide regional allocation information in the next benchmark timeframe, the group could switch to an approach that would only provide advice on the Chesapeake Bay Cap. Alternatively, if the Board prioritized regional allocation in addition to the Bay Cap and indicated that they were willing to wait longer for results, the group could delay completion of the benchmark assessment in order to complete that approach.

The TC and ERP WG will need direction from the Board as soon as possible (no later than Annual Meeting) in order to pursue a spatially-explicit modeling as part of the next benchmark stock assessment and follow the current assessment schedule.

Table 1. Comparison of potential approaches for developing a spatially-explicit model for Atlantic menhaden.

Approach	Advice				Data Needs		Timeline***
	Single-spp. CB	Multi-spp. CB	Multi-spp. Regional Allocations	Fine-scale Spatial Dynamics	Possible w/ Existing Data	Addt'l data needs	
Coastwide BAM + NWACS-MICE + supplemental Bay abundance	✓					Absolute abundance estimates in C. Bay	5-7 years
Coastwide BAM + NWACS-MICE + Bay indicators	✓*	✓*			✓		5-7 years
Coarse spatial BAM + coastwide NWACS-MICE ERPs	✓**				✓		5-7 years
Coarse spatial BAM + coarse spatial NWACS-MICE ERPs	✓**	✓**	✓		✓	Better diet data for ERP species	5-7 years.
Refined spatial BAM + NWACS-MICE ERPs	✓	✓	✓			Migration at age data for desired regions, better diet data for ERP species	10+ years
Detailed spatial BAM + detailed spatial ERPs	✓	✓	✓	✓		Finer scale data (all types) for ERP species	10+ years

*: This approach would likely provide qualitative, not quantitative, information on Chesapeake Bay Cap

**: Existing data could provide information on MD and VA separately from the rest of the coast, but not Chesapeake Bay itself.

***: These timelines are preliminary estimates and could be revised once model development is underway.