



# Monterey Bay Aquarium Seafood Watch®

Atlantic Menhaden, Gulf Menhaden

*Brevoortia tyrannus, Brevoortia patronus*

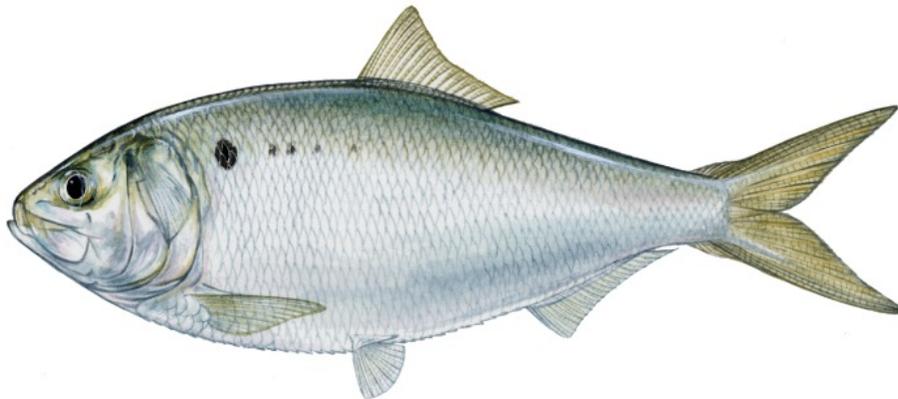


Image @ Diane Rome Peebles

US Atlantic, US Gulf of Mexico

Purse seine

June 4, 2015

Lindsey Feldman, Consulting Researcher

## Disclaimer

Seafood Watch® strives to have all Seafood Reports reviewed for accuracy and completeness by external scientists with expertise in ecology, fisheries science and aquaculture. Scientific review, however, does not constitute an endorsement of the Seafood Watch® program or its recommendations on the part of the reviewing scientists. Seafood Watch® is solely responsible for the conclusions reached in this report.

## **About Seafood Watch®**

Monterey Bay Aquarium's Seafood Watch® program evaluates the ecological sustainability of wild-caught and farmed seafood commonly found in the United States marketplace. Seafood Watch® defines sustainable seafood as originating from sources, whether wild-caught or farmed, which can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems. Seafood Watch® makes its science-based recommendations available to the public in the form of regional pocket guides that can be downloaded from [www.seafoodwatch.org](http://www.seafoodwatch.org). The program's goals are to raise awareness of important ocean conservation issues and empower seafood consumers and businesses to make choices for healthy oceans.

Each sustainability recommendation on the regional pocket guides is supported by a Seafood Report. Each report synthesizes and analyzes the most current ecological, fisheries and ecosystem science on a species, then evaluates this information against the program's conservation ethic to arrive at a recommendation of "Best Choices," "Good Alternatives" or "Avoid." The detailed evaluation methodology is available upon request. In producing the Seafood Reports, Seafood Watch® seeks out research published in academic, peer-reviewed journals whenever possible. Other sources of information include government technical publications, fishery management plans and supporting documents, and other scientific reviews of ecological sustainability. Seafood Watch® Research Analysts also communicate regularly with ecologists, fisheries and aquaculture scientists, and members of industry and conservation organizations when evaluating fisheries and aquaculture practices. Capture fisheries and aquaculture practices are highly dynamic; as the scientific information on each species changes, Seafood Watch®'s sustainability recommendations and the underlying Seafood Reports will be updated to reflect these changes.

Parties interested in capture fisheries, aquaculture practices and the sustainability of ocean ecosystems are welcome to use Seafood Reports in any way they find useful. For more information about Seafood Watch® and Seafood Reports, please contact the Seafood Watch® program at Monterey Bay Aquarium by calling 1-877-229-9990.

## **Guiding Principles**

Seafood Watch defines sustainable seafood as originating from sources, whether fished<sup>1</sup> or farmed, that can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems.

Based on this principle, Seafood Watch had developed four sustainability **criteria** for evaluating wild-catch fisheries for consumers and businesses. These criteria are:

- How does fishing affect the species under assessment?
- How does the fishing affect other, target and non-target species?
- How effective is the fishery's management?
- How does the fishing affect habitats and the stability of the ecosystem?

Each criterion includes:

- Factors to evaluate and score
- Guidelines for integrating these factors to produce a numerical score and **rating**

Once a rating has been assigned to each criterion, we develop an overall recommendation. Criteria ratings and the overall recommendation are color-coded to correspond to the categories on the Seafood Watch pocket guide and the Safina Center's online guide:

**Best Choice/Green:** Are well managed and caught in ways that cause little harm to habitats or other wildlife.

**Good Alternative/Yellow:** Buy, but be aware there are concerns with how they're caught.

**Avoid/Red:** Take a pass on these for now. These items are overfished or caught in ways that harm other marine life or the environment.

---

<sup>1</sup> "Fish" is used throughout this document to refer to finfish, shellfish and other invertebrates.

## **Summary**

This report provides assessment of the purse seine fisheries for menhaden in the U.S. Atlantic Ocean and Gulf of Mexico.

Menhaden have repeatedly been listed as one the nation's most important commercial fisheries. The fishery for Atlantic menhaden (*Brevoortia tyrannus*) constitutes one of the largest fisheries by volume along the East Coast, and Gulf menhaden (*Brevoortia patronus*) ranks second in the U.S. for landings behind Alaskan pollock. Gulf menhaden range from the Yucatan Peninsula in Mexico, across the Gulf of Mexico, to Tampa Bay, Florida, but are most abundant from eastern Texas to western Alabama. Menhaden are targeted using purse seine gear for a reduction fishery that processes the fish into meal and oil, and using pound net gear (and rarely gillnet gear) for a bait fishery that provides bait to a variety of fisheries on the Eastern seaboard and throughout the Gulf of Mexico. There is virtually no bait fishery left in the Gulf and most of the bait sold there is frozen Atlantic Menhaden that is shipped to the region.

The Atlantic menhaden fishery has operated since colonial times, and there are accounts of Native Americans using menhaden as fertilizer. The modern purse seine gear fishery has been in operation since the mid-1800s, and landings peaked in the 1950s for Atlantic menhaden and in the 1980s for Gulf menhaden. Since then, the population has been declining for the Atlantic fishery, which now consists of only 10 purse seine vessels operated by Omega Protein Inc. through their Reedville, VA processing facility. The Gulf fishery has remained stable through the 2000s and consists of 30 vessels that land at 3 facilities in the Gulf of Mexico operated by Omega Protein Inc. and Daybrook Fisheries Inc.

Stock assessments are conducted regularly by the Atlantic States Marine Fisheries Commission (ASMFC) and the Gulf States Marine Fisheries Commission (GSMFC) for Atlantic and Gulf menhaden, respectively. According to the most recent stock assessments (2015 for the Atlantic and 2013 for the Gulf), neither population is overfished, nor is overfishing thought to be occurring. There remains considerable uncertainty in the status of both stocks (the Atlantic menhaden stock was thought to be undergoing overfishing for the past few decades), and the appropriateness of the current reference points is under discussion in both regions.

Relative to menhaden catch, bycatch is minimal in both fisheries. But given the volume of the fishery, bycatch in absolute numbers could still be significant. Few data are available on bycatch species (there is very little observer coverage), and fewer data are made available to the public because of confidentiality issues. In particular, the bycatch of bottlenose dolphins is a concern, especially in the Gulf.

Fisheries managers have been slow to adopt appropriate management measures for Atlantic and Gulf menhaden. This is especially true for Atlantic menhaden: prior to the most recent stock assessment, the stock had been experiencing overfishing for many years, and landings caps and reporting requirements have only recently been implemented. There are no mandatory management measures set by the GSMFC because, unlike the ASMFC, the GSMFC does not have regulatory authority. Instead, states are responsible for implementing any restrictions they deem necessary, and they cooperate regularly with

NOAA and the other state agencies. Gulf menhaden are primarily found in and managed by the following states: Alabama, Mississippi, Louisiana, and Texas. Regulations in those states include gear restrictions, closed areas, and seasons for menhaden fishing, and Texas is the only state with a quota-based management system.

It is also important to have enough fishing controls on menhaden populations because they are considered a species of exceptional importance to both the Mid-Atlantic and Gulf of Mexico ecosystems. Studies have shown menhaden to have significant impacts on phytoplankton and zooplankton populations, and even to have the potential to filter nitrogen out of waters with excess eutrophication—similar to known filter feeders like oysters. Menhaden are also considered a key prey source for striped bass, weakfish, and bluefish, as well as for a variety of piscivorous birds, such as bald eagle, osprey, terns, gannet, loons, great blue heron, double-crested cormorant, brown pelican, and some gulls. The Atlantic menhaden stock assessment did account for the ecosystem role of menhaden when recently implementing mandatory management measures, and they plan to continue to incorporate ecosystem information into the next benchmark stock assessment in any way possible.

### Table of Conservation Concerns and Overall Recommendations

Stock / Fishery	Impacts on the Stock	Impacts on other Spp.	Management	Habitat and Ecosystem	Overall Recommendation
Atlantic menhaden East coast Atlantic - Purse Seine, Unassociated	Green (3.83)	Yellow (2.71)	Yellow (3.00)	Yellow (3.00)	<b>Good Alternative (3.109)</b>
Gulf menhaden Gulf Mgmt. region Gulf of Mexico - Purse Seine, Unassociated	Green (3.83)	Red (2.16)	Yellow (3.00)	Yellow (2.45)	<b>Good Alternative (2.792)</b>

#### Scoring Guide

Scores range from zero to five where zero indicates very poor performance and five indicates the fishing operations have no significant impact.

Final Score = geometric mean of the four Scores (Criterion 1, Criterion 2, Criterion 3, Criterion 4).

- **Best Choice/Green** = Final Score >3.2, **and** no Red Criteria, **and** no Critical scores
- **Good Alternative/Yellow** = Final score >2.2-3.2, **and** neither Harvest Strategy (Factor 3.1) nor Bycatch Management Strategy (Factor 3.2) are Very High Concern<sup>2</sup>, **and** no more than one Red Criterion, **and** no Critical scores
- **Avoid/Red** = Final Score ≤2.2, **or** either Harvest Strategy (Factor 3.1) or Bycatch Management Strategy (Factor 3.2) is Very High Concern **or** two or more Red Criteria, **or** one or more Critical scores.

<sup>2</sup> Because effective management is an essential component of sustainable fisheries, Seafood Watch issues an Avoid recommendation for any fishery scored as a Very High Concern for either factor under Management (Criterion 3).

## **Table of Contents**

About Seafood Watch® .....	2
Guiding Principles .....	3
Summary .....	4
Introduction .....	7
Assessment .....	13
Criterion 1: Stock for which you want a recommendation.....	13
Criterion 2: Impacts on Other Species .....	23
Criterion 3: Management effectiveness .....	30
Criterion 4: Impacts on the habitat and ecosystem.....	45
Acknowledgements.....	51
References .....	52

## **Introduction**

### **Scope of the analysis and ensuing recommendation**

Menhaden has repeatedly been listed as one the nation's most important fish and valuable commercial fisheries. Menhaden are targeted using purse seine gear in the Atlantic and the Gulf of Mexico for a reduction fishery that processes the fish into meal and oil, and using pound net gear (in the Atlantic only) and rarely gillnet gear for a bait fishery that provides bait to variety of fisheries on the Eastern seaboard and throughout the Gulf of Mexico. This assessment focuses on the reduction fisheries using purse seines.

### **Overview of the species and management bodies**

#### **Atlantic menhaden**

Atlantic menhaden are found in inshore waters from Nova Scotia to Florida. Menhaden eggs hatch at sea and larvae are transported into estuaries where they grow into juveniles. Larger individuals migrate north to New England in the summer and move south in the fall, while smaller fish stay in the Mid-Atlantic and migrate south all the way to Florida in the fall months (Judy et al. 1983). They can live 10–12 years and they grow rapidly to full size (NOAA 2014). They are significant prey species for fish and sea birds including striped bass, weakfish, bald eagles, terns, osprey, etc. (Walter et al. 2003).

The Atlantic menhaden fishery has operated since colonial times, and there are accounts of Native Americans using menhaden as fertilizer (Judy et al. 1983) (ASMFC 2012b). The modern purse seine gear fishery has been in operation since the mid-1800s and the fishery expanded such that landings peaked in the 1950s (Maryland Sea Grant 2009). In the 1950s, there were over 20 menhaden factories operational from Florida to Maine (ASMFC 2004). Menhaden began to decline throughout the 1970s and 1980s; by 1993, only three reduction factories remained: two in Reedville, VA, and one in Beaufort, NC. The Reedville plants consolidated in 1997, and the Beaufort factory closed in 2005 (Maryland Sea Grant 2009). The current menhaden reduction fishery consists of 10 purse seine vessels operated by Omega Protein Inc. through their Reedville, VA processing facility (Maryland Sea Grant 2009). From 2008–2012, 91% of Atlantic menhaden were caught using purse seine gear and 3% using pound net gear, while the rest were caught using dip nets and small gillnets.

Atlantic menhaden is managed by the Atlantic States Marine Fisheries Commission (ASMFC). The Atlantic menhaden management board is responsible for carrying out all management actions developed and implemented by the ASMFC at the recommendation of the plan development team (PDT) and plan review team (PRT). The PDT and PRT comprise scientists and managers who provide technical support and guidance to the management board during their decision-making process (ASMFC 2012b). Because there is no Federal Fishery Management Plan (FMP) for Atlantic menhaden, the fishery is managed under the Atlantic Coastal Fishery Conservation and Management Act, which allows the National Marine Fisheries Service (NMFS) a voting seat on the management board and participation on the PDT, PRT, and other committees (ASMFC 2012b). The ASMFC management actions are all recommendations to the states, but it is the responsibility of the states to implement any management

actions approved by the Atlantic menhaden board. States may also choose to implement additional management measures outside the ASMFC regulations (ASMFC 2012b). States are required to submit compliance reports annually to the Atlantic menhaden board for review and are therefore held accountable for self-implementation (ASMFC 2012b).

### **Gulf menhaden**

Gulf menhaden is considered a single stock in the Gulf of Mexico and, although there are other menhaden species caught in the Gulf fishery, *B. patronus* makes up 99% of landings and is therefore considered to be the total population of menhaden in the Gulf of Mexico (SEDAR 2013). As in other estuarine-based fisheries, menhaden spawn offshore in the winter, move to estuarine and inshore waters as juveniles, and migrate back out to near-shore shelf waters in the summer as they mature. There is very little east-to-west migration in the fishery, and fish that move offshore often return to where they matured the previous season (SEDAR 2013). There are reports that Gulf menhaden can live to age 6, but in the last decade, the reduction fishery mostly targets fish aged 2+ years.

The Gulf menhaden fishery consists of a purse seine reduction fishery and a smaller historic bait fishery. Although the Gulf menhaden fishery has been operational since the 1800s, catch data is sparse prior to World War II. In 1948, 103,000 mt were recorded as landed in Florida, Mississippi, Louisiana, and Texas. The fishery developed further and landings increased until their peak in 1984 (982,800 mt). The purse seine fleet in the Gulf peaked at 82 vessels in 1985, was reduced to 58 vessels in 1991, and today operates with only about 30 vessels. There were historically up to 13 facilities that processed menhaden catch into oil and fish meal, but today, there are only three operating in the Gulf of Mexico, owned by two companies, Omega Protein Inc. and Daybrook Fisheries Inc. in Mississippi and Louisiana (SEDAR 2013).

Gulf menhaden is managed by the Gulf States with coordination from the Gulf States Marine Fisheries Commission (GSMFC) under the Interjurisdictional Fisheries Act of 1986, as well as the Gulf States Marine Fisheries Compact and NOAA Fisheries. The GSMFC develops fisheries management plans (FMP) modeled after Federal fisheries managed under the Magnuson-Stevens Act (MSA). The GSMFC requires each plan to be developed by a technical task force comprised of experts from each state. Although the GSMFC does not have regulatory authority over the states (unlike the ASMFC), the states that are part of each task force are responsible for implementation of any management recommendations provided by the FMP (GSMFC 2002). In addition, states may implement their own regulations as they see fit. Gulf menhaden are found in and managed by the following states: Alabama, Mississippi, Louisiana, and Texas. Regulations in those states include gear restrictions, closed areas, and seasons for menhaden fishing (GSMFC 2002).

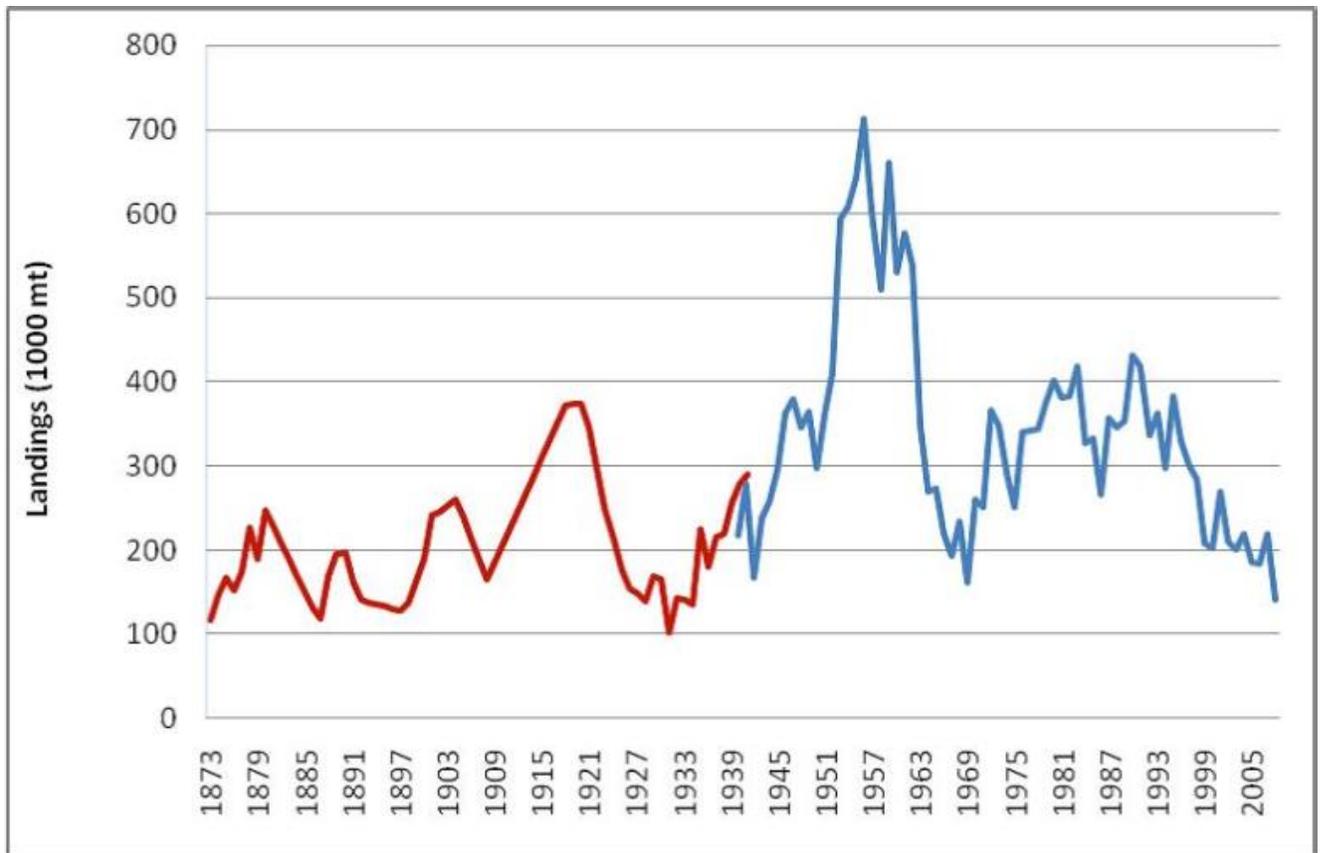


Figure 1: Historical landings of Atlantic menhaden (Maryland Sea Grant 2009).

## Production Statistics

### Atlantic menhaden

Atlantic menhaden landings in the reduction fishery averaged 322,700 mt from 1940–2011, while landings averaged only 164,400 mt from 2002–2011, the lowest amount of landings in recent years (ASMFC 2012b). Bait landings have historically been and continue to be much less than the reduction fishery, but still averaged 40,100 mt from 2002–2011 (20% of total menhaden landings) (ASMFC 2012b). From 2008–2012, 91% of Atlantic menhaden were caught using purse seine gear and 3% using pound net gear, while the rest were caught using dip nets and small gillnets (SEDAR 2015).

### Gulf menhaden

The reduction fishery in the Gulf began after World War II, when fish were recorded as being landed in Florida, Mississippi, Louisiana, and Texas (SEDAR 2013). From the 1940s to the 1980s, landings increased and peaked in 1984 at 982,800 mt. Landings began to decline in the 1990s; this was attributed to plant consolidation, low prices, and bad weather (Hurricane Andrew). The decline continued through the 2000s, and from 2000–2011, landings averaged 490,700 mt annually, a decline of 11% from the previous decade (SEDAR 2013). Though the average was low, year-to-year landings were variable and often

weather-dependent due to tropical weather systems. Landings were 613,300 mt in 2011, but only 468,700 mt in 2004 because of Hurricanes Charley and Ivan. Landings were further reduced in 2005 to 433,800 mt because of Hurricanes Katrina and Wilma, which severely damaged all the menhaden plants and many fishing vessels, and this significantly shortened the fishing season. Landings were also low in 2010 (379,700 mt) due to the Deep Water Horizon Oil Spill in the Gulf of Mexico that forced closures of many menhaden fishing grounds (SEDAR 2013).

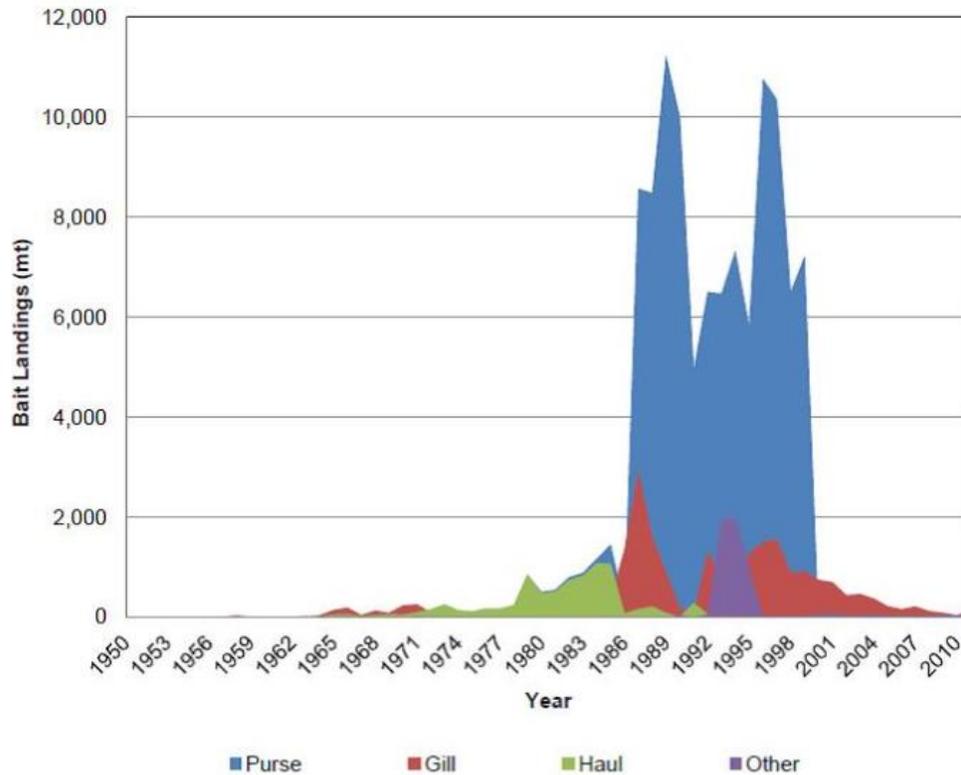


Figure 2. Gulf menhaden bait landings from 2005–2011 from purse seine, gill net, haul seine, and other gears (SEDAR 2013).

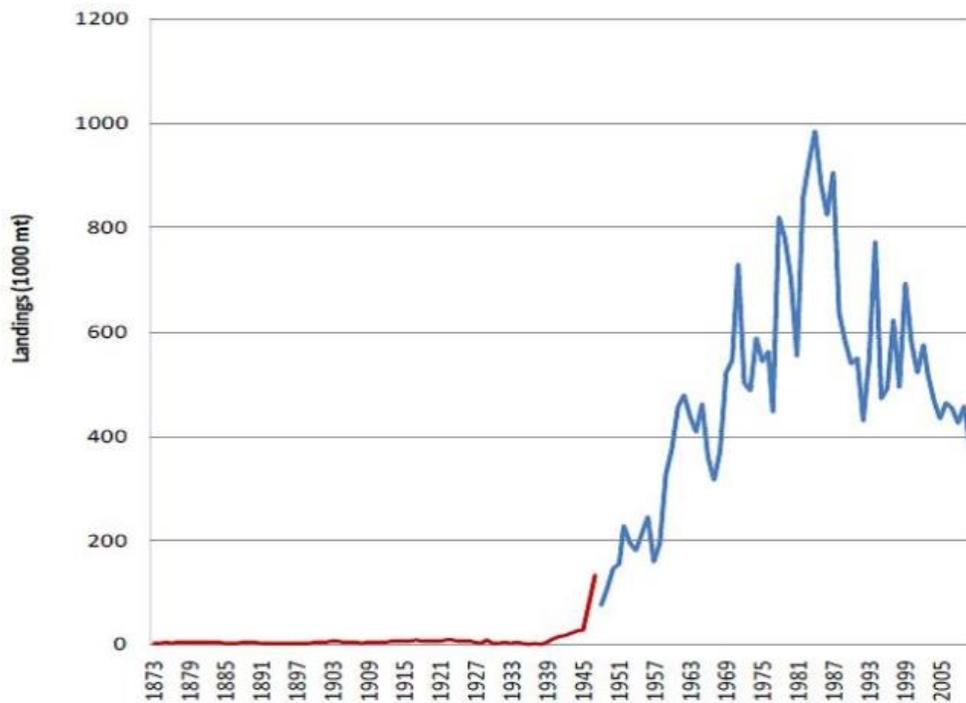


Figure 3. Total Gulf menhaden landings from the reduction fishery and bait fishery from 1873–2010 (SEDAR 2013).

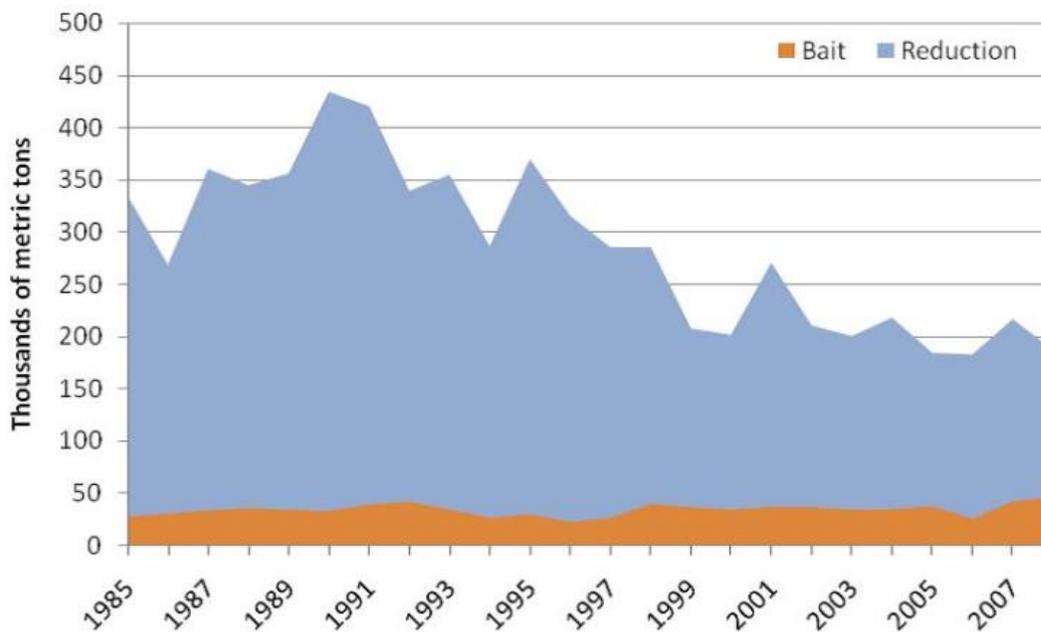


Figure 4. Coast-wide landings of Atlantic menhaden in the reduction and bait fisheries from 1985–2008 in thousands of metric tons (SEDAR 2013).

## **Importance to the U.S./North American market**

Menhaden is a forage fish, and forage fish are known to contribute to approximately 37% of global marine catch of other species (Pikitch et al. 2012). 44,068 mt of menhaden were exported in 2011 as a non-edible fisheries product, with a value of \$49,372, but only 17,840 mt were exported in 2012, for a decreased value of \$19,954 (NOAA 2012). Menhaden oil is exported predominantly to Chile, Denmark, Australia, the Netherlands, and Norway, and in smaller quantities to other countries such as Turkey, the United Kingdom, and Mexico (NOAA 2012).

Upon approval by the U.S. Food and Drug Administration (FDA) in June 1997, the general use of refined menhaden fish oil in foods in the U.S. opened new markets for it as an edible oil for human consumption. Refined menhaden oil is rich in omega-3 fatty acids that research has shown to significantly reduce the incidence of heart disease, diabetes, cancer, immune disorders, inflammation, and macular degeneration (VanderKooy and Smith 2014).

## **Common and market names**

Common names for menhaden include: poggy, sardine, large-scale menhaden, shad, fatback, bugmouth, bunker, and moss bunker (GSMFC 2002).

## **Primary product forms**

The menhaden reduction fishery processes the fish into fish meal, fish oil, and fish solubles. Menhaden oil has been and is used in cooking oils, margarine, dietary supplements, soap, linoleum, waterproof fabrics, and certain types of paint. The meal makes up a large part of poultry and livestock feeds, and is added to pet foods because of its high protein content, and the solubles are added to the meal to create a product called “full meal” (ASMFC 2012b). Menhaden is also used as an important source of bait in the Chesapeake and Gulf of Mexico blue crab fisheries and the Atlantic lobster fishery.

The animal feed industry is the main customer for Gulf menhaden fish meal. In the past two decades, meal has become a more important ingredient in aquaculture feed than its more traditional use in poultry and swine feeds. Aquaculture producers place a higher value on the omega-3 content of the meal. Likewise, most menhaden oil is utilized by the salmon aquaculture industry; the high quality and quantity of omega-3s in menhaden oil have made it a staple in salmon diets in Norway, Canada, the United Kingdom, and Chile. Additionally, the U.S. pet food and cattle industries have realized the benefits of the omega-3s and have become significant consumers of both crude and refined menhaden oil.

A growing market for refined menhaden oil is omega-3s for human consumption. The use of fish oils in omega-3–related supplements, food ingredients, and pharmaceuticals has grown from 2% to 20% of global production over the last decade. Although menhaden oil is currently a small percentage of the overall fish oil market, it is growing and may soon influence global pricing for this commodity (VanderKooy and Smith 2014).

## **Assessment**

This section assesses the sustainability of the fishery(s) relative to the Seafood Watch Criteria for Fisheries, available at <http://www.seafoodwatch.org>.

### **Criterion 1: Stock for which you want a recommendation**

*This criterion evaluates the impact of fishing mortality on the species, given its current abundance. The inherent vulnerability to fishing rating influences how abundance is scored, when abundance is unknown. The final Criterion 1 score is determined by taking the geometric mean of the abundance and fishing mortality scores. The Criterion 1 rating is determined as follows:*

- *Score >3.2=Green or Low Concern*
- *Score >2.2 and <=3.2=Yellow or Moderate Concern*
- *Score <=2.2=Red or High Concern*  
*Rating is Critical if Factor 1.3 (Fishing Mortality) is Critical.*

#### **Criterion 1 Summary**

<b>ATLANTIC MENHADEN</b>				
Region / Method	Inherent Vulnerability	Abundance	Fishing Mortality	Subscore
East coast Atlantic Purse Seine, Unassociated	3.00:Low	4.00:Low Concern	3.67:Low Concern	<b>Green (3.831)</b>

<b>GULF MENHADEN</b>				
Region / Method	Inherent Vulnerability	Abundance	Fishing Mortality	Subscore
Gulf Mgmt. region Gulf of Mexico Purse Seine, Unassociated	3.00:Low	4.00:Low Concern	3.67:Low Concern	<b>Green (3.831)</b>

#### **Criterion 1 Assessment**

##### **ATLANTIC MENHADEN**

##### **Factor 1.1 - Inherent Vulnerability**

###### *Scoring Guidelines*

- *Low—The FishBase vulnerability score for species is 0-35, OR species exhibits life history characteristics that make it resilient to fishing, (e.g., early maturing (*

- *Medium—The FishBase vulnerability score for species is 36-55, OR species exhibits life history characteristics that make it neither particularly vulnerable nor resilient to fishing, (e.g., moderate age at sexual maturity (5-15 years), moderate maximum age (10-25 years), moderate maximum size, and middle of food chain).*
- *High—The FishBase vulnerability score for species is 56-100, OR species exhibits life history characteristics that make it particularly vulnerable to fishing, (e.g., long-lived (>25 years), late maturing (>15 years), low reproduction rate, large body size, and top-predator).*  
*Note: The FishBase vulnerability scores is an index of the inherent vulnerability of marine fishes to fishing based on life history parameters: maximum length, age at first maturity, longevity, growth rate, natural mortality rate, fecundity, spatial behaviors (e.g., schooling, aggregating for breeding, or consistently returning to the same sites for feeding or reproduction) and geographic range.*

#### East coast Atlantic, Purse Seine, Unassociated

##### Low

Atlantic menhaden has low inherent vulnerability, based on a FishBase score of 30 out of 100 (Cheung and Pauly 2005). Atlantic menhaden are found in inshore waters from Nova Scotia to Florida. Menhaden eggs hatch at sea and larvae are transported into estuaries, where they grow into juveniles. Larger individuals migrate north to New England in the summer and move south in the fall, while smaller fish stay in the Mid-Atlantic and migrate south all the way to Florida in the fall months (Judy et al. 1983). They become sexually mature in their second year, but fish at age 3 account for the majority of the stock's egg production. Menhaden recruitment, when young fish successfully make it into the adult population, appears to be controlled by bottom-up processes such as prey and nutrient availability, so it can vary annually (Judy et al. 1983). Natural mortality can be high considering the large number of menhaden predators but, given their full potential, they can live 10–12 years and grow rapidly to full size (NOAA 2014). However, due to fishing pressure, fish older than age 6 have been uncommon since 1965 (ASMFC 2010).

#### Factor 1.2 - Abundance

##### Scoring Guidelines

- *5 (Very Low Concern)—Strong evidence exists that the population is above target abundance level (e.g., biomass at maximum sustainable yield, BMSY) or near virgin biomass.*
- *4 (Low Concern)—Population may be below target abundance level, but it is considered not overfished*
- *3 (Moderate Concern) —Abundance level is unknown and the species has a low or medium inherent vulnerability to fishing.*

- 2 (High Concern)—Population is overfished, depleted, or a species of concern, OR abundance is unknown and the species has a high inherent vulnerability to fishing.
- 1 (Very High Concern)—Population is listed as threatened or endangered.

#### East coast Atlantic, Purse Seine, Unassociated

##### Low Concern

The 2015 benchmark stock assessment found that the Atlantic menhaden stock is not overfished relative to the current biological reference points based on maximum spawning potential (MSP) of the stock (ASMFC 2015). The current stock biomass thresholds are based on fecundity, or the amount of mature egg production. Fecundity levels were higher than expected (FEC = 156,495 billion eggs) and above the stock biomass threshold of population fecundity (FEC<sub>15%</sub> = 50,000 billion eggs) and the target (FEC<sub>30%</sub> = 100,000 billion eggs). More recently, the Technical Committee recommended new reference points based on maximum spawning potential (MSP). The FEC in 2013 (170,536 billion eggs) falls between the threshold (FEC<sub>26%MSP</sub>=86,821 billion eggs) and the target (FEC<sub>57%MSP</sub>=189,270 billion eggs) (ASMFC 2015d). Very low concern is thus precluded by concerns over abundance and recruitment remaining relatively low (see Figures 5 and 6 below) as well as 2013 FEC falling between the target and threshold levels.

##### Rationale:

There were a number of significant changes in the new stock assessment that led to very different results from the 2010 Atlantic menhaden stock assessment. The 2015 assessment used a wider variety of datasets that had not been previously used to estimate maturity at age and relative abundance. Data were collected from state seine and trawl surveys as well as an electrofishing survey in South Carolina, for a total of 16 new surveys that were incorporated into the assessment. The new data found that menhaden abundance had been slowly increasing throughout the 2000s after their historic decline in the 1980s and 1990s. While the 2010 assessment used only a single pound-net survey index to measure adult abundance, the 2015 assessment used multiple trawl surveys from many states and created two indices: one in the North Atlantic and one in the South. Due to an increase in the amount of data and data quality with the new 2015 assessment model, the retrospective inconsistencies that had been in the 2010 assessment were greatly reduced.

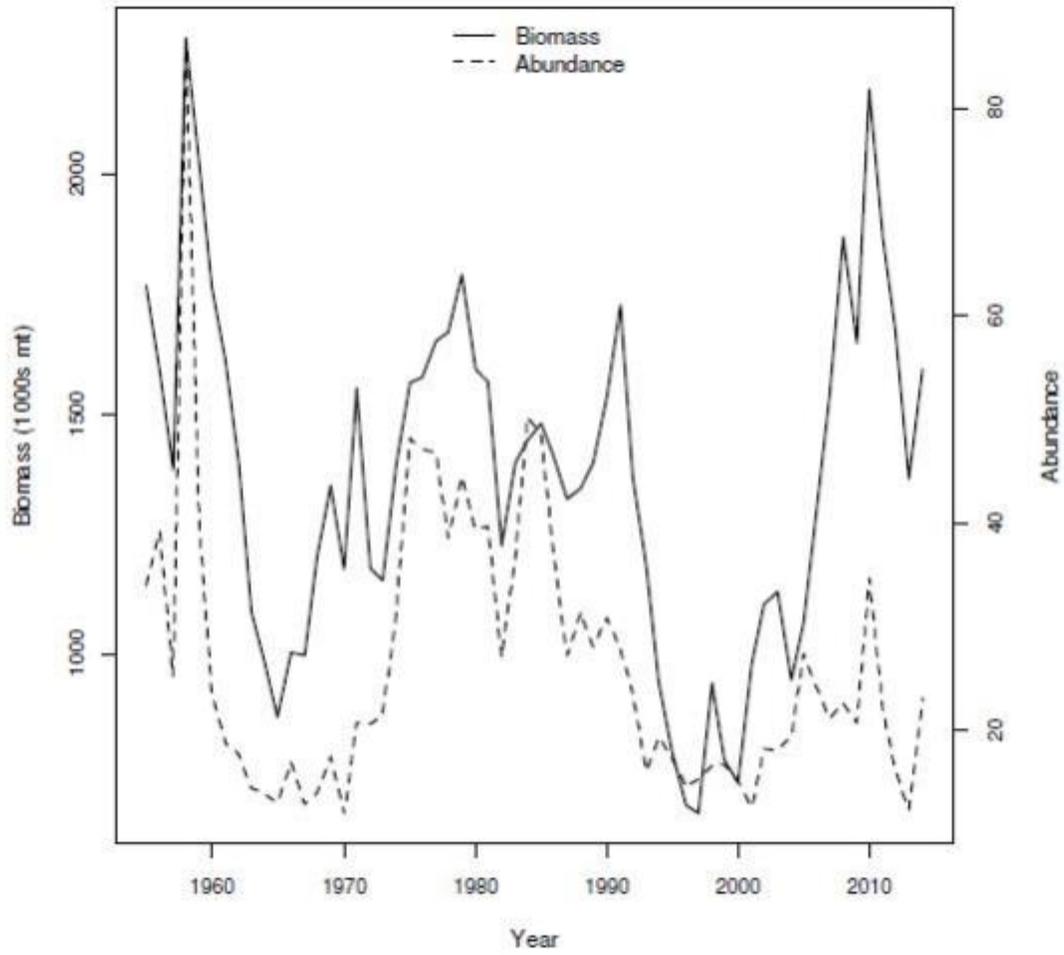


Figure 5. Biomass (1000s mt) and abundance over time for Atlantic menhaden from 1959–2013 (Figure 7.2.3.4 in SEDAR 2015)

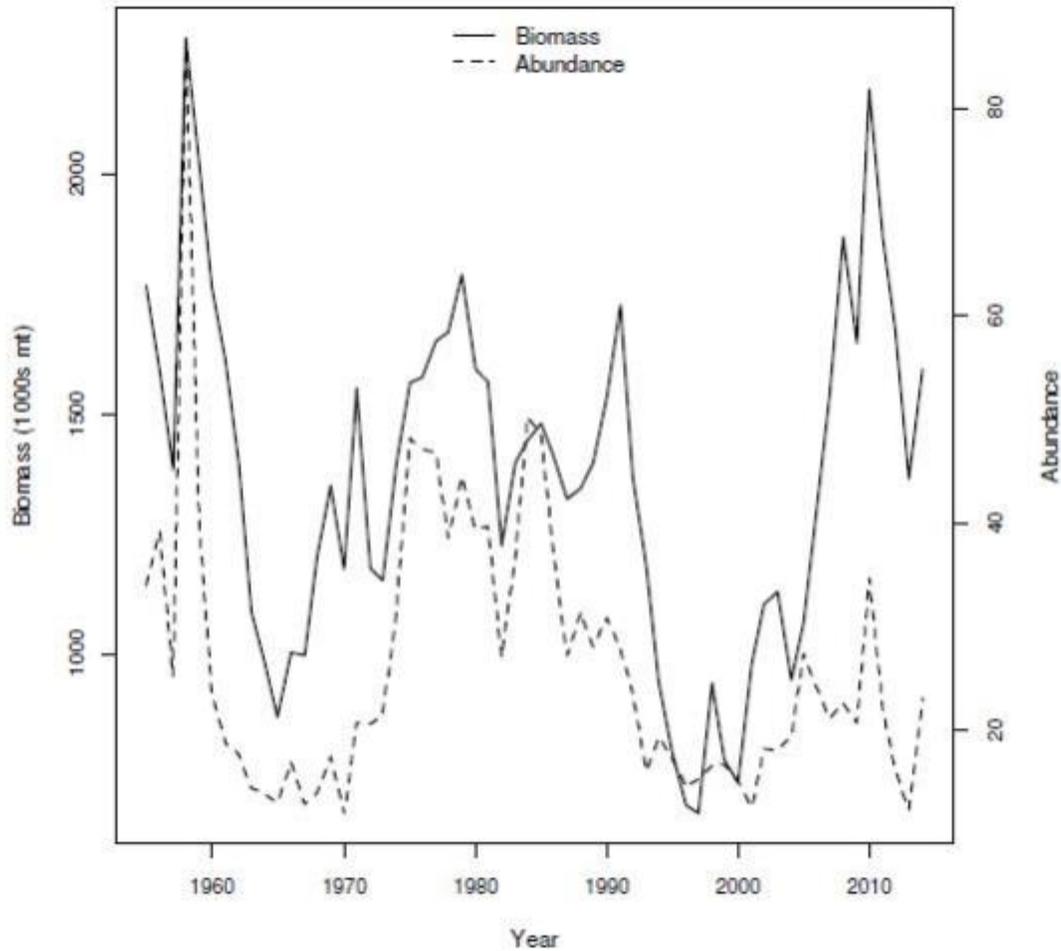


Figure 6. The observed recruitment or YOY index over time for Atlantic menhaden (Figure 5.3.16 in SEDAR 2015).

### Factor 1.3 - Fishing Mortality

#### Scoring Guidelines

- *5 (Very Low Concern)—Highly likely that fishing mortality is below a sustainable level (e.g., below fishing mortality at maximum sustainable yield, FMSY), OR fishery does not target species and its contribution to the mortality of species is negligible ( $\leq 5\%$  of a sustainable level of fishing mortality).*
- *3.67 (Low Concern)—Probable (>50%) chance that fishing mortality is at or below a sustainable level, but some uncertainty exists, OR fishery does not target species and does not adversely affect species, but its contribution to mortality is not negligible, OR fishing mortality is unknown, but the population is healthy and the species has a low susceptibility to the fishery (low chance of being caught).*

- *2.33 (Moderate Concern)—Fishing mortality is fluctuating around sustainable levels, OR fishing mortality is unknown and species has a moderate-high susceptibility to the fishery and, if species is depleted, reasonable management is in place.*
- *1 (High Concern)—Overfishing is occurring, but management is in place to curtail overfishing, OR fishing mortality is unknown, species is depleted, and no management is in place.*
- *0 (Critical)—Overfishing is known to be occurring and no reasonable management is in place to curtail overfishing.*

#### East coast Atlantic, Purse Seine, Unassociated

##### Low Concern

The 2015 benchmark stock assessment found that the Atlantic menhaden stock is not experiencing overfishing relative to the current biological reference points based on maximum spawning potential (MSP) of the stock (ASMFC 2015). Based on new data incorporated into the assessment, fishing mortality rates have been below the current overfishing threshold, except during the 1950s. The 2015 assessment estimated fishing mortality at  $F = 0.27$ , which is below the current threshold of  $F_{15\%} = 2.98$  and the target of  $F = 1.03$ . Based on the new data, fishing mortality rates were the highest in the 1950s for the commercial reduction fishery in the north, and during the 1970s and 1990s for the reduction fishery in the south. The highest fishing mortality for the bait fishery was in the 1950s and 1990s in the north and in the late 1990s and 2000s in the south. The current fishing mortality rates are some of the lowest on record, especially after the coast-wide quota was implemented in Amendment 2 to the Fishery Management Plan.

More recently, the Technical Committee recommended new reference points based on maximum spawning potential (MSP). The  $F$  in 2013 (0.22) falls below the threshold ( $F_{26\%MSP}=1.26$ ) and the target ( $F_{57\%MSP}=0.38$ ) (ASMFC 2015d). The total allowable catch for 2015 and 2016 was increased to 187,880 mt per year, a 10% increase over the 2014 TAC (ASMFC 2015c).

Since overfishing is not occurring, but the cause is still somewhat unknown, fishing mortality is ranked as “low” concern.

##### Rationale:

The Atlantic States Marine Fisheries Commission Atlantic menhaden technical committee recommended that the current biological reference points should be changed due to new information available in the 2015 stock assessment. The new recommended reference points would be  $F_{20\%} = 2.01$  and  $F_{36\%} = 0.82$ . Since the fishing mortality rate in the 2015 assessment is 0.27, overfishing would still not be occurring under these new reference points. As mentioned above, the results of the 2015 stock assessment vary dramatically from the 2010 stock assessment due to the addition of new and higher quality data. In addition, the retrospective inconsistencies that had been a significant concern were greatly reduced with the additional data and the use of a new assessment model.

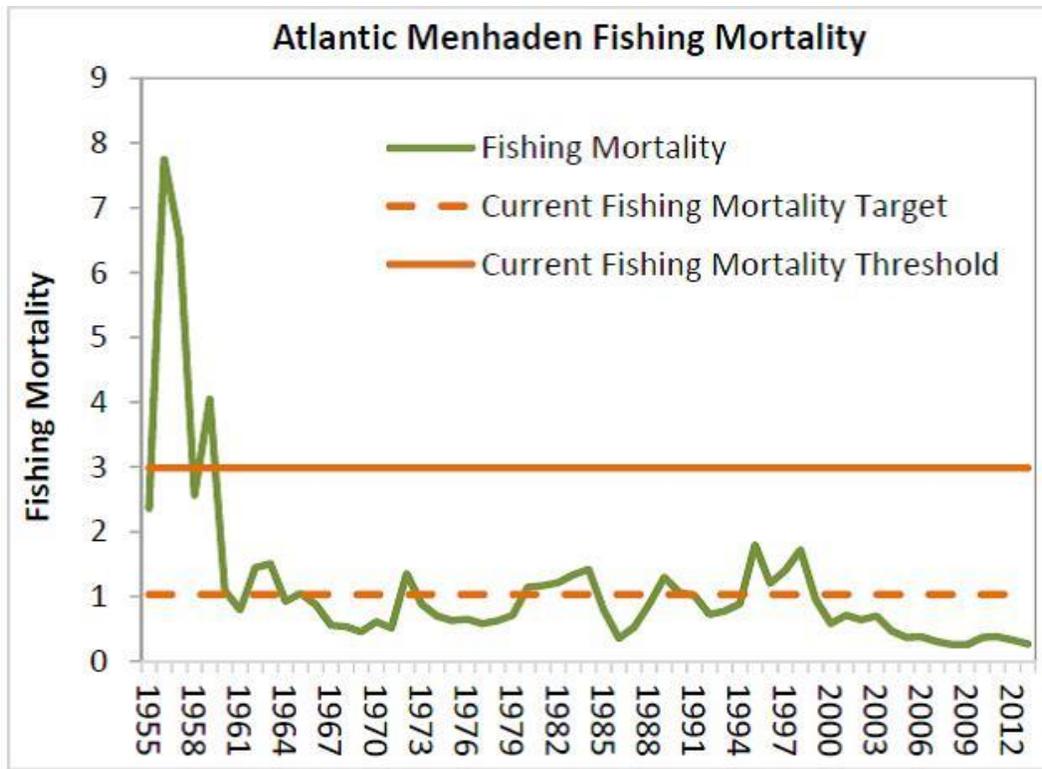


Figure 7. Atlantic menhaden fishing mortality (1955–2013)

## GULF MENHADEN

### Factor 1.1 - Inherent Vulnerability

#### Scoring Guidelines

- *Low*—The FishBase vulnerability score for species is 0-35, OR species exhibits life history characteristics that make it resilient to fishing, (e.g., early maturing (
  - *Medium*—The FishBase vulnerability score for species is 36-55, OR species exhibits life history characteristics that make it neither particularly vulnerable nor resilient to fishing, (e.g., moderate age at sexual maturity (5-15 years), moderate maximum age (10-25 years), moderate maximum size, and middle of food chain).
  - *High*—The FishBase vulnerability score for species is 56-100, OR species exhibits life history characteristics that make it particularly vulnerable to fishing, (e.g., long-lived (>25 years), late maturing (>15 years), low reproduction rate, large body size, and top-predator).
- Note: The FishBase vulnerability scores is an index of the inherent vulnerability of marine fishes to fishing based on life history parameters: maximum length, age at first maturity, longevity, growth rate, natural mortality rate, fecundity, spatial behaviors (e.g., schooling,*

*aggregating for breeding, or consistently returning to the same sites for feeding or reproduction) and geographic range.*

#### Gulf Mgmt. region Gulf of Mexico, Purse Seine, Unassociated

##### Low

Gulf menhaden has low inherent vulnerability, based on a FishBase score of 31 out of 100 (Cheung and Pauly 2005). Like other estuarine-based species, they spawn offshore in the winter, move to estuarine and inshore waters as juveniles, and migrate back out to near-shore shelf waters in the summer as they mature. There is little east-to-west migration in the fishery, and fish that move offshore often return to the areas where they matured the previous season (SEDAR 2013). There are reports that Gulf menhaden can live to age 6 but, in the last decade, the reduction fishery mostly targets younger fish aged 2+ years, and catch of older fish closer to age 6 is minimal. They spawn for the first time at age 1 and then spawn annually, with age 2 fish contributing the majority of stock fecundity by spawning the largest numbers of eggs each year (SEDAR 2013). Fecundity decreases as age increases, as does menhaden catch. This factor is scored as “low” concern.

##### Rationale:

There are additional concerns that were not considered in determining the rating for this section. They include unknown effects of environmental conditions such as the 2010 Deepwater Horizon oil spill in the Gulf of Mexico, the annual hypoxic zone in the Mississippi river delta, and other unknown environmental issues (O’Boyle 2013).

#### Factor 1.2 - Abundance

##### Scoring Guidelines

- *5 (Very Low Concern)—Strong evidence exists that the population is above target abundance level (e.g., biomass at maximum sustainable yield, BMSY) or near virgin biomass.*
- *4 (Low Concern)—Population may be below target abundance level, but it is considered not overfished*
- *3 (Moderate Concern) —Abundance level is unknown and the species has a low or medium inherent vulnerability to fishing.*
- *2 (High Concern)—Population is overfished, depleted, or a species of concern, OR abundance is unknown and the species has a high inherent vulnerability to fishing.*
- *1 (Very High Concern)—Population is listed as threatened or endangered.*

#### Gulf Mgmt. region Gulf of Mexico, Purse Seine, Unassociated

### Low Concern

The most recent stock assessment was conducted in 2013 and the assessment panel did not provide stock biological reference points. Therefore, there are no official reference points to compare the current stock biomass levels to. Managers are currently working on defining reference points in the revision to the Gulf menhaden FMP (SEDAR 2013). Until then, the assessment panel estimated a suite of fecundity-per-recruit estimated benchmarks, which show that the Gulf menhaden stock is not overfished at any potential reference point (SEDAR 2013). The 2011 SSB value was 50,464 mt, which was higher than any of the options in the suite of potential benchmarks ( $SSB_{40\%} = 49,833$  mt,  $SSB_{35\%} = 42,291$  mt,  $SSB_{30\%} = 34,750$  mt). Even though the current SSB could not be compared to any stock targets or threshold levels (because they are not defined), it appears from the suite of potential benchmarks that the stock is not overfished. However, based on the benchmark used, the population may have been overfished in the recent past (SEDAR 2013). This is scored as “low” concern.

### Factor 1.3 - Fishing Mortality

#### Scoring Guidelines

- *5 (Very Low Concern)—Highly likely that fishing mortality is below a sustainable level (e.g., below fishing mortality at maximum sustainable yield, FMSY), OR fishery does not target species and its contribution to the mortality of species is negligible ( $\leq 5\%$  of a sustainable level of fishing mortality).*
- *3.67 (Low Concern)—Probable (>50%) chance that fishing mortality is at or below a sustainable level, but some uncertainty exists, OR fishery does not target species and does not adversely affect species, but its contribution to mortality is not negligible, OR fishing mortality is unknown, but the population is healthy and the species has a low susceptibility to the fishery (low chance of being caught).*
- *2.33 (Moderate Concern)—Fishing mortality is fluctuating around sustainable levels, OR fishing mortality is unknown and species has a moderate-high susceptibility to the fishery and, if species is depleted, reasonable management is in place.*
- *1 (High Concern)—Overfishing is occurring, but management is in place to curtail overfishing, OR fishing mortality is unknown, species is depleted, and no management is in place.*
- *0 (Critical)—Overfishing is known to be occurring and no reasonable management is in place to curtail overfishing.*

#### Gulf Mgmt. region Gulf of Mexico, Purse Seine, Unassociated

### Low Concern

The most recent stock assessment was conducted in 2013 and found that overfishing is not occurring.

However, the assessment panel was not able to define stock biological reference points, and the overfishing definition was based on a suite of fecundity-per-recruit estimated benchmarks (SEDAR 2013). Fishing mortality benchmarks included  $F_{40\%}$ ,  $F_{35\%}$ ,  $F_{30\%}$ , and  $F_{MED}$  (SEDAR 2013). Fishing mortality benchmarks were not determined because Gulf menhaden are short-lived and the stock-recruitment relationship is unknown (SEDAR 2013). The assessment panel discussed using fishing mortality proxies based on per recruit analyses. One such idea was to use  $F_{40\%}$  as a proxy, but studies have shown that it has the potential to lead to low levels of biomass and recruitment. They also considered setting mortality benchmarks based on ecosystem importance, but the data and information are insufficient to incorporate into the assessment at this time (SEDAR 2013). Even though there are no reference points to compare to, estimates of fishing mortality from the assessment model indicate that the stock is not currently experiencing overfishing (SEDAR 2013). This is scored as “low” concern.

## **Criterion 2: Impacts on Other Species**

All main retained and bycatch species in the fishery are evaluated in the same way as the species under assessment were evaluated in Criterion 1. Seafood Watch® defines bycatch as all fisheries-related mortality or injury to species other than the retained catch. Examples include discards, endangered or threatened species catch, and ghost fishing. To determine the final Criterion 2 score, the score for the lowest scoring retained/bycatch species is multiplied by the discard rate score (ranges from 0-1), which evaluates the amount of non-retained catch (discards) and bait use relative to the retained catch. The Criterion 2 rating is determined as follows:

- Score >3.2=Green or Low Concern
  - Score >2.2 and <=3.2=Yellow or Moderate Concern
  - Score <=2.2=Red or High Concern
- Rating is Critical if Factor 2.3 (Fishing Mortality) is Critical.

### **Criterion 2 Summary**

<b>Atlantic menhaden: East coast Atlantic, Purse Seine, Unassociated</b>					
<b>Subscore::</b>	<b>2.709</b>	<b>Discard Rate:</b>	<b>1.00</b>	<b>C2 Rate:</b>	<b>2.709</b>
Species	Inherent Vulnerability	Abundance	Fishing Mortality	Subscore	
<b>BOTTLENOSE DOLPHIN</b>	High	2.00: High Concern	3.67: Low Concern	<b>2.709</b>	
<b>ATLANTIC MENHADEN</b>	Low	4.00: Low Concern	3.67: Low Concern	<b>3.831</b>	

<b>Gulf menhaden: Gulf Mgmt. region Gulf of Mexico, Purse Seine, Unassociated</b>					
<b>Subscore::</b>	<b>2.159</b>	<b>Discard Rate:</b>	<b>1.00</b>	<b>C2 Rate:</b>	<b>2.159</b>
Species	Inherent Vulnerability	Abundance	Fishing Mortality	Subscore	
<b>BOTTLENOSE DOLPHIN</b>	High	2.00: High Concern	2.33: Moderate Concern	<b>2.159</b>	
<b>GULF MENHADEN</b>	Low	4.00: Low Concern	3.67: Low Concern	<b>3.831</b>	
<b>BLACKTIP SHARK</b>	Medium	5.00: Very Low Concern	5.00: Very Low Concern	<b>5.000</b>	

The United Nations Food and Agriculture Organization has listed purse seine fisheries as one of the three fisheries worldwide with lowest bycatch. Observers are not required in the Atlantic or Gulf

menhaden fishery for any reason, so the true nature of bycatch in the fishery is not known. There have been a few research studies (Christmas et al. 1960, Guillory and Hutton 1982, Condrey 1994, DeSilva et al. 2001), numerous onboard observations by the state marine agencies, and an NOAA pilot observer program to explore bycatch by the fishing fleet. But because there are only two processors, the data are confidential under NOAA rules and cannot be released to the public for review (pers. comm., Scott-Denton, 2014) (pers. comm., Shield, 2014). The limited publicly available bycatch research on the menhaden purse seine fishery suggests that bycatch rates are very low. One study found the discard rate to range from 0.002%–0.14% of catch (by counting numbers of fish) (Austin et al. 1994), and another estimated bycatch to be between 1.0% and 2.8% of catch (by weight) (Condrey 1994). Purse seine nets are often set on a school of fish and recorded bycatch is extremely low compared to the volume of menhaden in each haul. Furthermore, although they are not required to, 100% of the menhaden purse seine fleet use a hose cage to prevent large unwanted catch, such as sharks, from entering the pumping system, as well as a large-fish excluder that stops unwanted catch from entering the hold (Simpson 2003). If these non-target species are small, they are removed manually from the pumping operation and discarded; if large, they are encouraged to escape from the net during hardening or pumping, or are allowed to pass over the large-fish excluder if they are pumped and returned to the water.

One study that observed operations in the Gulf of Mexico menhaden purse seine fishery in 1994 and 1995 found a number of large sharks caught incidentally (although sharks only made up 0.03% of total bycatch) (DeSilva et al. 2001). Based on observer data, the authors estimated that 75% of the sharks caught during the study period died; authors extrapolated their data to estimate the total number of sharks killed annually in the fishery at 24,000–26,000 individuals. However, 47% of the sharks observed during the study were from one particular set, which led the authors to believe that sharks are clumped in both space and time and incidental catch levels may not always be so high. In addition, the study was completed in 1994, which is before 100% of the Gulf menhaden fleet had installed bycatch reduction devices (Simpson 2003). The majority (45.3%) of the shark bycatch consisted of blacktip sharks and sandbar sharks (1.8%).

Bottlenose dolphins were included in this report because they are listed as a Category II species for the menhaden fisheries in the NMFS List of Fisheries (79 Federal Register 50, 2014) and because they are depleted under the Marine Mammal Protection Act, although it is unknown how many bottlenose dolphins (if any) have been taken by the fishery.

## **Criterion 2 Assessment**

### **BLACKTIP SHARK**

#### **Factor 2.1 - Inherent Vulnerability**

*Scoring Guidelines (same as Factor 1.1 above)*

### Gulf Mgmt. region Gulf of Mexico, Purse Seine, Unassociated

#### Medium

Blacktip sharks are considered to have a medium vulnerability to fishing based on a FishBase vulnerability score of 55 out of 100 (Cheung and Pauly 2005).

### Factor 2.2 - Abundance

*Scoring Guidelines (same as Factor 1.2 above)*

### Gulf Mgmt. region Gulf of Mexico, Purse Seine, Unassociated

#### Very Low Concern

Blacktip sharks are not overfished and have never been overfished according to the most recent assessment (SEDAR 2012). Because current estimated biomass is far higher than target biomass (Spawning Stock Fecundity;  $SSF_{2010}/SSF_{MSY} = 2.5-2.78$ ), stock status is considered as “very low” concern.

### Factor 2.3 - Fishing Mortality

*Scoring Guidelines (same as Factor 1.3 above)*

### Gulf Mgmt. region Gulf of Mexico, Purse Seine, Unassociated

#### Very Low Concern

Blacktip sharks are not experiencing overfishing and have never been experiencing overfishing according to the most recent Blacktip shark assessment (SEDAR29 2012). A study by (DeSilva et al. 2001) found that there were concerning levels of blacktip shark bycatch in the Gulf menhaden fishery; however, because overall fishing mortality is far lower than target fishing mortality ( $F_{2010}/F_{MSY} = 0.03-0.11$ ), fishing mortality is considered as “very low” concern.

### Factor 2.4 - Discard Rate

### Gulf Mgmt. region Gulf of Mexico, Purse Seine, Unassociated

#### < 20%

The discard rate in the menhaden purse seine fishery ranges from 1.0%–2.8% of menhaden catch, depending on the season and location (Condrey 1994) (Guillory and Hutton 1982) (Christmas et al. 1960). In the 2015 assessment, discards of Atlantic menhaden were believed to be negligible, so they

were ignored in the assessment model (SEDAR 2015). Research suggests that menhaden predators are often concentrated around a particular school of fish and may be absent from another, which can account for the variability in incidental catch based on season and location (DeSilva et al 2001). The results of SEDAR29 (2012) indicate that discard rates in the Gulf menhaden fleet have been declining over the entire data series and were estimated at less than 9,000 animals annually since 2006 (Table 3.5.1A (SEDAR 2012)).

## **BOTTLENOSE DOLPHIN**

### **Factor 2.1 - Inherent Vulnerability**

*Scoring Guidelines (same as Factor 1.1 above)*

**East coast Atlantic, Pound Net**

**East coast Atlantic, Purse Seine, Unassociated**

**Gulf Mgmt. region Gulf of Mexico, Purse Seine, Unassociated**

#### **High**

According to the Seafood Watch criteria, all marine mammals are considered to have a high vulnerability to fishing because they are long-lived, reach sexual maturity late in life, and have low reproductive rates. Bottlenose dolphins are considered to have a high vulnerability to fishing according to the Seafood Watch criteria.

### **Factor 2.2 - Abundance**

*Scoring Guidelines (same as Factor 1.2 above)*

**East coast Atlantic, Pound Net**

**East coast Atlantic, Purse Seine, Unassociated**

#### **High Concern**

The Northern and Southern Migratory Coastal stocks of bottlenose dolphins, which are known to interact with the Mid-Atlantic menhaden purse seine and pound net fisheries, are listed as depleted under the Marine Mammal Protection Act (79 Federal Register 50, 2014). A 2002 survey from Delaware Bay to the Georgia/Florida border counted 185 dolphin groups in the Northern Migratory Coastal stock and 2,114 individuals; during the summer 2,544 individuals were counted. In the summer of 2004, an additional survey counted 3,093 individuals between central Florida and New Jersey. Abundance estimates derived from those surveys estimate the population size of the Northern Migratory Coastal

stock at 9,604 individuals (NMFS 2014). The same surveys in 2002 and 2004 were used to estimate the abundance of the Southern Migratory Coastal stock at 12,482 individuals (NMFS 2014). There are no data to indicate whether the stocks are increasing or declining at this time (NMFS 2014). Since the stock status is unknown for both stocks but the species has high vulnerability (see Factor 2.1) and the stocks have been listed as depleted under the Marine Mammal Protection Act, the abundance factor is ranked as “high” concern.

#### **Gulf Mgmt. region Gulf of Mexico, Purse Seine, Unassociated**

##### **High Concern**

The Gulf of Mexico menhaden fishery is known to interact with the Gulf of Mexico (GMX) bay, sound, and estuarine stock; the Northern GMX Coastal stock; and the Western GMX Coastal stock of bottlenose dolphins. The population sizes of the GMX bay, sound, and estuarine stock, as well as the Western stock, are currently unknown, and there is not enough data to determine whether the population is increasing or decreasing. The GMX bay, sound, and estuarine stock comprises 32 distinct stocks, and the minimum population estimates are unknown for the majority of them (NMFS 2012). The population size of the Northern GMX coastal stock was estimated at 2,473 dolphins from a 2007 aerial survey, and the minimum population estimate derived from this number is 2,004 dolphins. There aren’t enough data to determine if the population size is in good health or not. Since the stock status is unknown for all three stocks but the species has high vulnerability (see Factor 2.1), abundance is ranked as “high” concern.

### **Factor 2.3 - Fishing Mortality**

*Scoring Guidelines (same as Factor 1.3 above)*

#### **East coast Atlantic, Pound Net**

#### **East coast Atlantic, Purse Seine, Unassociated**

##### **Low Concern**

Menhaden are caught throughout the Mid-Atlantic including Virginia and the Chesapeake Bay. The Mid-Atlantic purse seine fishery is listed as a Category II fishery under the NMFS List of Fisheries, with potential bycatch including the Northern and Southern Migratory Coastal stocks of bottlenose dolphins. Because the Northern Migratory and Southern Migratory Coastal stocks occur together in Mid-Atlantic waters, it is difficult to assign all observed mortalities or extrapolated bycatch estimates to a specific stock. In addition, observer coverage is extremely limited in the Atlantic menhaden purse seine fishery, so it is difficult to estimate total mortality specifically in purse seine gear.

Potential Biological Removal (PBR) for the Northern Migratory Coastal stock of bottlenose dolphins is 86

animals, and total estimated mortality is 3.8–5.6 animals a year (the range reflects uncertainty in assigning observed or reported mortalities to a particular stock) (NMFS 2014). Thus, maximum total fishing mortality is around 6% of PBR. PBR for the Southern Migratory Coastal stock is 63 animals, and total estimated fishery mortality is 2.6–16.5 animals (NMFS 2014b). Thus, maximum fishing mortality is 26% of PBR. The major source of mortality appears to be gillnet fisheries (NMFS 2014b) so it is assumed that mortality from the menhaden fisheries is between 1% and 10% of PBR. Because total mortality is <100% of PBR, and mortality from the menhaden fisheries is assumed to be less than 10% of PBR, the fisheries would typically be rated a very low concern for both populations. However, the level of uncertainty in the estimates due to limited observer coverage precludes this score and the fishery is rated a “low” concern.

### **Gulf Mgmt. region Gulf of Mexico, Purse Seine, Unassociated**

#### **Moderate Concern**

The Gulf of Mexico menhaden fishery is known to interact with the Gulf of Mexico (GMX) bay, sound, and estuarine stock, the Northern GMX Coastal stock, and the Western GMX Coastal stock of bottlenose dolphins. PBR for all 32 of the bay, sound, and estuarine stocks is predominantly unknown, but for those stocks that have sufficient data to estimate PBR, it ranges from 1.3–3.9 individuals (NMFS 2012). Based on a review of observer data from 1992–1995, observers recorded nine incidental takes: eight from the Western GMX coastal bottlenose stock (including three mortalities) and one from the Northern GMX coastal stock. All the lethal takes occurred in an area encompassing the Western GMX coastal stock of bottlenose dolphins. Extrapolating the takes from the average observer effort indicated that the annual average mortality and serious injury was 68 animals, exceeding 100% of the Potential Biological Removal (PBR) level for the Western coastal stock (PBR = 29) and thus qualifying this fishery as a Category I fishery on the LOF and as a strategic stock. However, NMFS categorized this fishery as a Category II, pending a revised analysis of stock structure for bottlenose dolphin in the GMX. If all bottlenose stocks in the GMX were grouped together, then PBR would equal 154, putting the fishery in Category II (68 animals/year is 44% of PBR when PBR is 154), and the fishery would not be categorized as a strategic stock. Still, NMFS considers the Gulf stocks to be “strategic” based on the most recent stock assessment report because the stock sizes are currently unknown but, since there is a high probability of them being small, any incidental takes could have a large impact on the population size. In addition, the effects of the Deepwater Horizon oil spill in Louisiana, Mississippi, Alabama and the western Florida panhandle are unknown and may have a large impact on the bottlenose dolphin population size (NMFS 2012). Since incidental takes in the Gulf of Mexico purse seine fishery exceed PBR for the Western stock and are high if the stocks were grouped together, and the impact of fishing mortality is unknown on likely small populations of bottlenose dolphins, fishing mortality is of “moderate” concern for the Gulf of Mexico stocks of bottlenose dolphin.

**Factor 2.4 - Discard Rate****East coast Atlantic, Pound Net****< 20%**

There are no observer data for the pound net fishery, so the discard rate is unknown; however, discard rates in stationary nets are generally less than 1% (Kelleher 2005). In the 2015 assessment, discards of Atlantic menhaden were believed to be negligible and were therefore ignored in the assessment model (SEDAR 2015).

**East coast Atlantic, Purse Seine, Unassociated****Gulf Mgmt. region Gulf of Mexico, Purse Seine, Unassociated****< 20%**

The discard rate in the menhaden purse seine fishery ranges from 1.0%–2.8% of menhaden catch, depending on the season and location (Condrey 1994) (Guillory and Hutton 1982) (Christmas et al. 1960). In the 2015 assessment, discards of Atlantic menhaden were believed to be negligible, so they were ignored in the assessment model (SEDAR 2015). Research suggests that menhaden predators are often concentrated around a particular school of fish and may be absent from another, which can account for the variability in incidental catch based on season and location (DeSilva et al 2001). The results of SEDAR29 (2012) indicate that discard rates in the Gulf menhaden fleet have been declining over the entire data series and were estimated at less than 9,000 animals annually since 2006 (Table 3.5.1A (SEDAR 2012)).

## **Criterion 3: Management effectiveness**

*Management is separated into management of retained species (harvest strategy) and management of non-retained species (bycatch strategy).*

*The final score for this criterion is the geometric mean of the two scores. The Criterion 3 rating is determined as follows:*

- *Score >3.2=Green or Low Concern*
- *Score >2.2 and <=3.2=Yellow or Moderate Concern*
- *Score <=2.2 or either the Harvest Strategy (Factor 3.1) or Bycatch Management Strategy (Factor 3.2) is Very High Concern = Red or High Concern*  
*Rating is Critical if either or both of Harvest Strategy (Factor 3.1) and Bycatch Management Strategy (Factor 3.2) ratings are Critical.*

### **Criterion 3 Summary**

Region / Method	Management of Retained Species	Management of Non-Retained Species	Overall Recommendation
East coast Atlantic Purse Seine, Unassociated	3.000	3.000	Yellow(3.000)
Gulf Mgmt. region Gulf of Mexico Purse Seine, Unassociated	3.000	3.000	Yellow(3.000)

### **Factor 3.1: Harvest Strategy**

#### Scoring Guidelines

*Seven subfactors are evaluated: Management Strategy, Recovery of Species of Concern, Scientific Research/Monitoring, Following of Scientific Advice, Enforcement of Regulations, Management Track Record, and Inclusion of Stakeholders. Each is rated as 'ineffective,' 'moderately effective,' or 'highly effective.'*

- *5 (Very Low Concern)—Rated as 'highly effective' for all seven subfactors considered.*
- *4 (Low Concern)—Management Strategy and Recovery of Species of Concern rated 'highly effective' and all other subfactors rated at least 'moderately effective.'*
- *3 (Moderate Concern)—All subfactors rated at least 'moderately effective.'*
- *2 (High Concern)—At minimum, meets standards for 'moderately effective' for Management Strategy and Recovery of Species of Concern, but at least one other subfactor rated 'ineffective.'*

- 1 (Very High Concern)—Management exists, but Management Strategy and/or Recovery of Species of Concern rated ‘ineffective.’
- 0 (Critical)—No management exists when there is a clear need for management (i.e., fishery catches threatened, endangered, or high concern species), OR there is a high level of illegal, unregulated, and unreported fishing occurring.

### Factor 3.1 Summary

Factor 3.1: Management of fishing impacts on retained species							
Region / Method	Strategy	Recovery	Research	Advice	Enforce	Track	Inclusion
East coast Atlantic Purse Seine, Unassociated	Moderately Effective	Moderately Effective	Highly Effective	Moderately Effective	Moderately Effective	Moderately Effective	Moderately Effective
Gulf Mgmt. region Gulf of Mexico Purse Seine, Unassociated	Moderately Effective	N/A	Moderately Effective				

#### Subfactor 3.1.1 – Management Strategy and Implementation

*Considerations: What type of management measures are in place? Are there appropriate management goals, and is there evidence that management goals are being met? To achieve a highly effective rating, there must be appropriate management goals, and evidence that the measures in place have been successful at maintaining/rebuilding species.*

##### East coast Atlantic, Pound Net

##### East coast Atlantic, Purse Seine, Unassociated

##### **Moderately Effective**

The Atlantic menhaden fishery is managed by the Atlantic States Marine Fisheries Commission (ASMFC) under Amendment 2 to the Fishery Management Plan (FMP), which was approved in December 2012 (ASMFC 2012b). In addition, individual states can and have implemented their own regulatory management such as gear restrictions, seasonal fishing, and restricted areas (see table below) (ASMFC 2012b).

Amendment 2 set fishing mortality reference points for Atlantic menhaden at  $F_{30\%}$  (target) and  $F_{15\%}$  (limit). The target and limit biological reference points are set at the level of egg production expected at the target and limit fishing mortality reference points (i.e., target =  $FEC_{30\%}$  and limit =  $FEC_{15\%}$ ) (ASMFC 2015a). In February 2015, the ASMFC Technical Committee recommended making the reference points more precautionary ( $F_{36\%}$ ,  $F_{20\%}$ ,  $FEC_{36\%}$ ,  $FEC_{20\%}$ ) because these would be a more appropriate measure of

sustainability (ASMFC 2015a). The stock classification (not overfished and overfishing not occurring) would not change if these reference points were adopted.

Amendment 2 also established the first ever coast-wide quota for the Atlantic menhaden fishery. The quota is set on an annual or multiple-year basis, with annual review based on the most recent stock assessment or assessment update (most recent stock assessment was adopted for management in early 2015). The quota beginning in 2013 was 170,800 mt (a 20% reduction from the 2009–2011 average) in response to the fact that overfishing on menhaden was occurring (ASMFC 2012b). The total allowable catch (TAC) for 2015–2016 is set at 187,880 mt, an increase of 10% over 2014 (ASMFC 2015c).

The ASMFC has also moved forward with an amendment to the FMP that will establish ecological-based reference points that reflect Atlantic menhaden's role as a forage species. The amendment will also consider changes to the current state-by-state allocation scheme (ASMFC 2015c).

Management Strategy and Implementation is scored "moderately effective" because it remains unclear how appropriate the TAC is relative to the reference points.

#### **Gulf Mgmt. region Gulf of Mexico, Purse Seine, Unassociated**

##### **Moderately Effective**

The Gulf menhaden fishery is managed by the Gulf states with coordination from the Gulf States Marine Fisheries Commission (GSMFC) under the Interjurisdictional Fisheries Act of 1986, as well as the Gulf States Marine Fisheries Compact and NOAA Fisheries (GSMFC 2013). Membership of the Menhaden Advisory Committee (MAC) is made up of state and federal agency staff as well as representatives from the menhaden reduction fishery operations. Stock assessments are conducted by the GSMFC and NOAA using the Southeast Data, Assessment, and Review (SEDAR) process; the most recent assessment was in 2013, and the previous assessments were in 2011, 2007, 2000, and 1996 (GSMFC 2013). The next benchmark assessment has been requested for 2017 (VanderKooy 2014). The draft fishery management plan (FMP) currently under development will recommend that an assessment update be conducted immediately if fishing mortality is above the set target level for 2 years in a row (VanderKooy 2014). The Gulf menhaden bait fishery is a quota-managed species in Florida and Louisiana, where vessels fishing with purse seines are allowed 1.0 million lbs and 3,000 lbs for commercial bait harvest, respectively by state (GSMFC 2013). Texas is the only state in which the reduction fishery is managed by a quota (currently 31.5 million lbs) (GSMFC 2013). Individual states have other restrictions limiting the fishery, which are predominantly seasonal restrictions on menhaden fishing. In every state, the menhaden reduction fishery opens on the third Monday in April and runs through November 1; Louisiana has the option for an additional bait season that runs from the close of the reduction fishery through December 1 of the same year (LA DMF 2014) (MS DMR 2014) (AL DCNR 2013). Although there are no size or gear restrictions in the Louisiana fishery (LA DMF 2014), the entire Gulf fishing fleet has adopted the Mississippi restrictions, which prohibit purse nets from having mesh size smaller than ½ inch square or 1

inch stretch (MS DMR 2014). Though there are few state-specific regulations, there are some measures that the Gulf menhaden fleet have taken voluntarily, such as not fishing within 1 mile of shore in Texas, and not fishing on weekends or holidays (pers. comm., Steven VanderKooy, 2014). Although the Gulf menhaden fishery is not overfished and overfishing is not occurring, there are numerous uncertainties in the stock assessment and a lack of defined biological reference points. Because the fishery is not managed by a coast-wide quota and has few mandatory management strategies in place, the Gulf menhaden fishery management strategy is ranked “moderately effective.”

### **Subfactor 3.1.2 – Recovery of Species of Concern**

*Considerations: When needed, are recovery strategies/management measures in place to rebuild overfished/threatened/ endangered species or to limit fishery’s impact on these species and what is their likelihood of success? To achieve a rating of Highly Effective, rebuilding strategies that have a high likelihood of success in an appropriate timeframe must be in place when needed, as well as measures to minimize mortality for any overfished/threatened/endangered species.*

#### **East coast Atlantic, Pound Net**

#### **East coast Atlantic, Purse Seine, Unassociated**

##### **Moderately Effective**

The 2015 benchmark stock assessment found that the Atlantic menhaden stock is not overfished or experiencing overfishing (ASMFC 2015). This is a vast improvement over the 2010 Atlantic menhaden benchmark stock assessment, which found that the menhaden population had declined steadily and recruitment was extremely low. Although it was unknown whether the stock was overfished, population levels were so low that the stock was considered depleted. Subsequently, the ASMFC board adopted new reference points that were more conservative than the previous ones. The new reference points took into account the declining population size and the important ecological role of menhaden in the Mid-Atlantic ecosystem (ASMFC 2012b). Addendum V to the FMP states that when overfishing is occurring, the ASMFC board will take the appropriate steps to reduce fishing mortality and institute a rebuilding plan for the species (ASMFC 2012b). Since the 2010 assessment found that overfishing was occurring, Amendment 2 to the Atlantic menhaden FMP implemented an annual quota that was a 20% reduction from an average of catch (2009–2011). Because the stock status of menhaden was unknown in 2010, the ASMFC Atlantic menhaden board used an *ad hoc* approach of setting the quota based on landings and catch data rather than stock status reference points (ASMFC 2012b). Before the implementation of the quota, there was virtually no stock-wide management besides a cap on the Chesapeake Bay fishery (PEW 2012). The 2015 stock assessment found that fecundity (total egg production) was high in 2012 and 2013, which has contributed to the increase in biomass. The assessment is also the result of using new and more accurate data, as well as a new assessment model.

Since the quota has only been in place a short time, it is difficult to say whether it has been effective at lowering fishing mortality or if other factors have led to increases in biomass. Therefore, Recovery of Stocks of Concern has been ranked as “moderately effective.”

#### Gulf Mgmt. region Gulf of Mexico, Purse Seine, Unassociated

**N/A**

The gulf menhaden stock is not overfished and overfishing is not occurring (GSMFC 2013). Therefore, gulf menhaden is not considered a stock of concern. Because this fishery is not targeting any species considered a stock of concern, recovery of stocks of concern is not applicable.

### **Subfactor 3.1.3 – Scientific Research and Monitoring**

*Considerations: How much and what types of data are collected to evaluate the health of the population and the fishery’s impact on the species? To achieve a Highly Effective rating, population assessments must be conducted regularly and they must be robust enough to reliably determine the population status.*

#### East coast Atlantic, Pound Net

#### East coast Atlantic, Purse Seine, Unassociated

**Highly Effective**

Stock assessments are conducted by the ASMFC every few years and are reviewed annually to determine if there are any significant changes to the fishery relative to the reference points and if any new management measures are necessary. The most recent assessment was completed in 2014 and accepted for use in management in early 2015 (ASMFC 2015b).

#### **Rationale:**

The Atlantic menhaden stock assessment uses fishery-dependent and -independent data sources. The 2015 assessment used the following fishery-dependent data sources for the commercial reduction fishery: landings data from the Beaufort Fisheries Inc. menhaden reduction factory until it closed in 2005, and landings data from Omega Protein Inc. in Reedville, VA. Data are also collected via daily fishing reports at landing locations and by daily captain fishing reports (at-sea logbooks) (ASMFC 2015). Catch-at-age information is also collected by full-time NMFS biological samplers that work exclusively at the dock in Reedville, VA. The menhaden dockside sampling program began in 1955 and is one of the longest continuous data sample sets in the country (ASMFC 2015). Commercial bait fishery landings data are collected through a variety of state and federal vessel and dealer reporting methods. Bait landings were previously underreported, but Amendment 2 to the FMP required states to more closely monitor

their own landings, including bait, and to account for any potential overages. They are also required to collect one 10-fish sample (age and length per 300 mt landed for bait; each state in the Chesapeake Bay and South Atlantic is required to collect one 10-fish sample per 200 mt landed for bait). Fishery-independent data includes state seine surveys that capture juvenile menhaden, which are biologically sampled and the catch-at-age information is used in the assessment model (ASMFC 2015). Recreational fishing is monitored through the Marine Recreational Information program, although recreational landings of menhaden are small. There are currently no long-term fisheries-independent population data collected by NMFS, such as the long-term trawl dataset collected for federally managed Northeast fisheries species.

The only fisheries-independent data that are collected are biological samples used for catch-at-age information, and not for determining the population size of the menhaden stock (ASMFC 2012). In the 2015 assessment, data on juvenile menhaden abundance were collected from seine surveys in Connecticut, New York, New Jersey, Virginia, and Maryland; from trawl surveys in Rhode Island, Connecticut, New York, New Jersey, Delaware, Maryland, Virginia, and Georgia; and from an electrofishing survey in South Carolina (ASMFC 2015). There were also two new adult abundance indices developed from state survey data: the southern and northern adult index, which included trawl survey data from the Georgia and the Southeast Area Monitoring and Assessment Program, Connecticut, New Jersey, Delaware, Virginia, the Chesapeake Bay Multispecies Monitoring and Assessment Program, and the Chesapeake Bay Fishery Independent Multispecies Survey (ASMFC 2015). Though the lack of data on population size has hindered the assessment process in the past, reviewers were confident about the amount and quality of data used in the 2015 assessment. The addition of at-sea fisheries observer data through a mandatory observer program would lead to even more data and potentially to assessment accuracy.

#### **Gulf Mgmt. region Gulf of Mexico, Purse Seine, Unassociated**

##### **Moderately Effective**

The Gulf menhaden stock assessment uses fishery-dependent and -independent data sources. The Gulf menhaden fishery has been biologically sampled at the dock by the National Marine Fisheries Service (NMFS) since 1964 (SEDAR 2013). In addition, the Gulf menhaden fishery provides daily logs of fishing activities called the Captain's Daily Fishing Reports (CDFRs) since 1977, similar to the Atlantic menhaden catch sampling program (GSMFC 2013). Fishery-dependent data include daily vessel landings, port-side sampling for catch-at-age information, and CDFRs that itemize catch and fishing locations of purse seine vessels. Fishery-independent data are primarily inshore survey data that are used to compile abundance and recruitment indices for all species and are available for stock assessment analysis (GSMFC 2013). Though there are no directed fishery-independent data sampling procedures to target menhaden specifically in the Gulf states, the existing long-term data (40+ years in most states) provide relative abundance indices across the entire range of the population. However, the use of this data is limited for estimating actual population size or age composition of the near-shore population. Thus the assessment

results rely heavily on abundance and age data derived from the commercial landings data. The lack of high-resolution fishery-independent data on the Gulf menhaden population was a source of uncertainty in the stock assessment model (SEDAR 2013). Due to the lack of a mandatory at-sea observer program, there is also a lack of at-sea fisheries-dependent data, which are often valuable to successful stock assessments (O'Boyle 2013). Additional research was recommended, such as increased at-sea sampling, the development of a coastal juvenile survey, and an aerial survey to monitor abundance (O'Boyle 2013). The stock assessment process is ongoing but slow, and since the Menhaden Advisory Committee (MAC) meets only twice annually, any concerns regarding the stock are slow to be addressed. If there are stock concerns, the MAC requests a stock assessment, and then reviews potential management measures based on that assessment. By the time the stock assessment is complete, the stock may have continued to decline. The Gulf menhaden stock would benefit from a process that allows more rapid management changes in the case of stock status concerns. Scientific research is therefore ranked as “moderately effective” for the Gulf menhaden fishery due to the lack of fisheries-independent data available for use in the stock assessment model and the slow response time in the case of stock status decline.

#### **Subfactor 3.1.4 – Management Record of Following Scientific Advice**

*Considerations: How often (always, sometimes, rarely) do managers of the fishery follow scientific recommendations/advice (e.g. do they set catch limits at recommended levels)? A Highly Effective rating is given if managers nearly always follow scientific advice.*

##### **East coast Atlantic, Pound Net**

##### **East coast Atlantic, Purse Seine, Unassociated**

#### **Moderately Effective**

Although the ASMFC Atlantic menhaden board has always set management measures based on the best scientific advice possible, the stock has been in decline for over a decade and many groups believe that ASMFC should have taken action sooner to reduce menhaden catch (PEW 2012) (Pikitch et al. 2012). Conservation groups, scientists, recreational fishermen, and other concerned parties were calling on the ASMFC for many years to take action to reduce menhaden fishing mortality, even though the 2010 stock assessment did not show that overfishing was occurring (McClenachan et al. 2012). Even though the 2015 stock assessment confidently found that the stock is not overfished and overfishing is not occurring (SEDAR 2015), there are still concerns that the stock assessment is not precautionary enough and does not appropriately account for the large role that menhaden plays in the Mid-Atlantic ecosystem (Pikitch et al. 2012). There is still concern that demand for menhaden by piscivorous birds and fish predators is not adequately taken into account, which can lead to underestimates of natural mortality and, in turn, overestimates of menhaden population levels (Maryland Sea Grant 2009). In the development of the 2015 benchmark stock assessment, the committee prioritized developing ecosystem-based reference points, but there is clearly more work to be done. The concern that the

stock assessment process did not necessarily consider the dynamics, demographics, or depletion of menhaden on local scales, like in the Chesapeake Bay, was addressed in the separation of data into areas, but more work could probably be done on this as well (SEDAR 2015) (Pikitch et al. 2012). Atlantic menhaden management is ranked as “moderately effective” in following scientific advice, due to the delay in implementing reductions in fishing mortality and other management measures, and to the only minor role that ecosystem importance has played in the assessment thus far.

#### **Gulf Mgmt. region Gulf of Mexico, Purse Seine, Unassociated**

##### **Moderately Effective**

Given the lack of biological reference points to date, including the lack of management measures such as catch or size limits, questions have been raised regarding the level of precaution employed by the GSMFC to protect the ecosystem value of menhaden throughout the Gulf of Mexico (PEW 2013). The latest stock assessment (SEDAR 2013) was subjected to independent review, which found that the best available scientific information was being used (O’Boyle 2013). The review also identified shortcomings in the availability of data that, if resolved by managers, would improve the quality and robustness of the assessment (O’Boyle 2013). Revisions to the Gulf Menhaden FMP are underway, including draft biological reference points (pers. comm., Steven VanderKooy, 2014). It is too early to assess whether scientific advice has been followed in the amended FMP.

#### **Subfactor 3.1.5 – Enforcement of Management Regulations**

*Considerations: Do fishermen comply with regulations, and how is this monitored? To achieve a Highly Effective rating, there must be regular enforcement of regulations and verification of compliance.*

#### **East coast Atlantic, Pound Net**

#### **East coast Atlantic, Purse Seine, Unassociated**

##### **Moderately Effective**

Since regulations for the Atlantic menhaden fishery are set on a state-by-state basis, it is up to the states to enforce them. Individual states have their own reporting requirements and reporting systems for state-specific landings (ASMFC 2012b). A report on the states’ compliance with the new management measures found that the first year of the new management measures was a success. Landings were 2.8% below the stock-wide quota and the majority of states were compliant in reporting. The 2013 reduction fishery caught 18% fewer menhaden (131,034 mt) than in 2012. This represents an 18% decrease from the previous 5-year (2008–2012) average of 160,524 mt. Although there were quota overages in New York, Florida, and Rhode Island, quota transfers from states with unused quota allowed

total landings to remain below the coast-wide quota (ASMFC 2014a). Low fishing mortality rates due to the coast-wide quota implementation are likely to have played in factor in the health of the menhaden population (SEDAR 2015).

#### **Gulf Mgmt. region Gulf of Mexico, Purse Seine, Unassociated**

##### **Moderately Effective**

Since regulations for the Gulf menhaden fishery are set on a state-by-state basis, it is up to the states to enforce them. Texas is the only state with a menhaden quota, and vessels are required to submit monthly trip tickets to the state detailing their landings. In addition, the GSMFC has a Law Enforcement Committee that works in conjunction with the Federal NOAA Fisheries Law Enforcement department and meets biannually on the status of fisheries enforcement along the Gulf coast (GSMFC 2002). Additionally, as a part of the Joint Enforcement Agreement Program (JEA), money is allocated to state enforcement agencies for training, while officers are authorized to enforce federal fisheries laws and regulations in both state and federal waters (GSMFC 2014). Like in the Atlantic menhaden fishery, there are no requirements for mandatory vessel monitoring systems (VMS) for the Gulf menhaden fishery. The industry does voluntarily provide catch records in the form of CDFRs and provide opportunity for biological sampling on the vessels and at the docks. The CDFRs have often been provided to the state agencies' enforcement office when there have been questions regarding fish kills that might be attributed to fishing operations; the industry has been quick to clean up spills and has assisted with cleanups even when they are not the party responsible (pers. comm., Steven VanderKooy, 2014).

#### **Subfactor 3.1.6 – Management Track Record**

*Considerations: Does management have a history of successfully maintaining populations at sustainable levels or a history of failing to maintain populations at sustainable levels? A Highly Effective rating is given if measures enacted by management have been shown to result in the long-term maintenance of species overtime.*

#### **East coast Atlantic, Pound Net**

#### **East coast Atlantic, Purse Seine, Unassociated**

##### **Moderately Effective**

Since the 2015 stock assessment found that the Atlantic menhaden stock is not overfished or experiencing overfishing, it appears that the coast-wide quota put in place had some positive effect on the population (SEDAR 2015). Though the stock has been on the decline since the 1990s, a commercial quota on the reduction fishery was implemented for the first time in 2013 (ASMFC 2012b). In 2005 and 2006, Addendums II and III addressed localized menhaden depletion in the Chesapeake Bay by

instituting a cap on the reduction fishery from 2005–2011, but a cap on harvest for the remaining states/regions is relatively new (ASMFC 2012b). Since the coast-wide quota was only recently implemented, it is too early to know whether it was a determining factor in the menhaden stock status, or if that was due to other factors such as updates to the stock assessment and/or high levels of recruitment and fecundity (SEDAR 2015). However, the stock appears to be in better condition than previously thought, so the track record is ranked as “moderately effective.”

#### **Gulf Mgmt. region Gulf of Mexico, Purse Seine, Unassociated**

##### **Moderately Effective**

The Gulf menhaden stock is stable, overfishing is not occurring, and the stock is not overfished. Texas is the only state that has implemented a Gulf menhaden quota, so the only method of assessing the fishery track record is via the status of the stock. There are no catch limits and limited management measures such as seasonal closures and gear limits implemented by individual states, so the track record can be considered “moderately effective.”

#### **Subfactor 3.1.7 – Stakeholder Inclusion**

*Considerations: Are stakeholders involved/included in the decision-making process? Stakeholders are individuals/groups/organizations that have an interest in the fishery or that may be affected by the management of the fishery (e.g., fishermen, conservation groups, etc.). A Highly Effective rating is given if the management process is transparent and includes stakeholder input.*

#### **East coast Atlantic, Pound Net**

#### **East coast Atlantic, Purse Seine, Unassociated**

#### **Gulf Mgmt. region Gulf of Mexico, Purse Seine, Unassociated**

##### **Moderately Effective**

The ASMFC and GSMFC have public meetings where Commission members, Commission staff, and advisory bodies (which include multiple stakeholder groups) discuss menhaden fishery management. The public may attend these meetings and comment on decisions and Commission processes. If they are not available to attend the meetings, members of the public may use an open public comment period to comment on any document before it is finalized. Commission staff actively assist the public in such participation (ASMFC 2014). In addition, individual states may have their own outreach meetings and are required to notify license holders of any management changes such as quota closures, seasonal area closures, or gear changes. The Gulf Menhaden Advisory Committee (MAC) is made up of state and

federal agency staff as well as representatives from the two major menhaden operators. There are currently no outside representatives on the MAC.

## **Bycatch Strategy**

<b>Factor 3.2: Management of fishing impacts on bycatch species</b>						
<b>Region / Method</b>	<b>All Kept</b>	<b>Critical</b>	<b>Strategy</b>	<b>Research</b>	<b>Advice</b>	<b>Enforce</b>
<b>East coast Atlantic Purse Seine, Unassociated</b>	No	No	Moderately Effective	Moderately Effective	Moderately Effective	Moderately Effective
<b>Gulf Mgmt. region Gulf of Mexico Purse Seine, Unassociated</b>	No	No	Moderately Effective	Moderately Effective	Moderately Effective	Moderately Effective

### **Subfactor 3.2.1 – Management Strategy and Implementation**

*Considerations: What type of management strategy/measures are in place to reduce the impacts of the fishery on bycatch species and how successful are these management measures? To achieve a Highly Effective rating, the primary bycatch species must be known and there must be clear goals and measures in place to minimize the impacts on bycatch species (e.g., catch limits, use of proven mitigation measures, etc.).*

#### **East coast Atlantic, Pound Net**

##### **Highly Effective**

Dolphins stranded in the Chesapeake Bay have had entanglement markings that were indicative of pound net gear. Pound nets are made up of three sections: the leader, which is a mesh wall that extends from the seafloor to the surface; the heart that funnels fish to the back of the net; and the pound, where the fish are finally trapped and removed (Silva et al. 2011). Pound net interactions with marine mammals and sea turtles tend to occur in the pound net leader, so in 2004, NOAA prohibited the use of pound net leaders offshore from May 6 through July 15. They also required the use of pound net leaders with a mesh size less than 12 in stretched and prohibited the use of stringers in an inshore area in Virginia waters of the Chesapeake Bay. A study by (Silva et al. 2011) in 2004–2005 found that changing pound net leader configurations leads to lower interactions with sea turtles while maintaining fish catch rates. Based on the results of that study, NOAA required the use of the modified pound net leader offshore to reduce sea turtle mortality in 2006. In 2008, NOAA implemented a pound net inspection program to enforce the pound net regulations (73 FR 68348). Though pound net leader modifications have reduced sea turtle interactions, their effect on bottlenose dolphin interactions is less clear. In a study funded by North Carolina Sea Grant, changing the leader design did reduce the number of bottlenose dolphin interactions with pound nets while maintaining commercial landings (NC Sea Grant 2009). In 2009, the Bottlenose Dolphin Take Reduction Team provided NOAA with a consensus statement recommending that such pound net leader modifications be mandatory to reduce bottlenose

dolphin incidental takes (NMFS 2012). NOAA is currently working on regulations that would implement the pound net leader modifications in order to reduce bottlenose dolphin interactions. A proposed rule is expected in late 2014 (Horstman 2013). Considering the extent to which pound leader modifications have reduced bottlenose dolphin takes in the pound net fishery, management is ranked as “highly effective” at reducing bycatch.

#### East coast Atlantic, Purse Seine, Unassociated

#### Gulf Mgmt. region Gulf of Mexico, Purse Seine, Unassociated

##### **Moderately Effective**

Data on bycatch in the Gulf and Atlantic menhaden fisheries are limited, but the best available data indicate that the quantity of bycatch relative to menhaden catch is quite low in both fisheries. But because the menhaden fisheries are high volume, the absolute quantity of bycatch could still be large (Condrey 1994) (Christmas et al. 1960) (Scott-Denton 2014). Based on numerous published studies of bycatch in the fleet, the majority of fish bycatch includes striped mullet, Atlantic croaker, spot, threadfin shad, gafftopsail catfish, hardhead catfish, sand seatrout, harvestfish, and Atlantic bumper. Condrey (1994) found that Atlantic croaker was the most frequently encountered (30% of the sets), the most abundant (47% of the total number), and the heaviest (25% of the total weight), and nine species accounted for 78% of the cumulative frequency of occurrences.

There are few mandatory management measures regarding catch of incidental species in either menhaden purse seine fishery. There are no bycatch restrictions on the purse net fishery in Florida waters. In Alabama, menhaden purse-seine boats may not possess more than 5% by number of species (excluding game fish) other than menhaden, herrings, and anchovies. In Mississippi, it is unlawful for any boat or vessel carrying or using a purse seine to have any quantity of red drum on board in Mississippi territorial waters. It is unlawful for any person, firm, or corporation using a purse seine or having a purse seine aboard a boat or vessel within Mississippi territorial waters to catch in excess of 5% by weight in any single set of the net or to possess in excess of 10% by weight of the total catch any of the following species: spotted seatrout (*Cynoscion nebulosus*), bluefish (*Pomatomus saltatrix*), Spanish mackerel (*Scomberomorus maculatus*), king mackerel (*Scomberomorus cavalla*), dolphinfish (*Coryphaena hippurus*), pompano (*Trachinotus carolinus*), cobia (*Rachycentron canadum*), or jack crevalle (*Caranx hippos*). In Louisiana waters, anyone legally taking menhaden shall not have in their possession more than 5% by weight of any species of fish other than menhaden and herring-like species. In Texas, purse seines used in taking menhaden may not be used to harvest any other edible products for sale, barter, or exchange. Purse seine catches may not contain more than 5% by volume of other edible products.

In addition, 100% of the vessels in the Gulf menhaden fleet have large grates installed on their pump hoses and over the dewatering screens to avoid large bycatch species and to prevent clogging the pumps and ending up in the fish hold (pers. comm., Steven VanderKooy, 2014). But many species,

including some sharks, get caught in the pump grate and end up dead and discarded overboard (DeSilva et al. 2001). Although the overall ratio of shark bycatch to total catch is very low, the number of sharks caught in menhaden fishing operations is moderate. Blacktip sharks, the most common sharks caught in menhaden nets, are not experiencing overfishing and are not overfished, so the concern is relatively low. Nevertheless, DeSilva et al. (DeSilva et al. 2001) recommended methods for minimizing shark bycatch, such as researching the behavior of sharks relative to menhaden nets, implementing avoidance behaviors when hauling in the purse seines, or requiring vessels to release sharks alive instead of gaffing and releasing the sharks, which often end up dead due to blood loss. None of these suggestions is currently in place.

The main bycatch concern identified in this assessment is bottlenose dolphins (See Criterion 2). Data on incidental take of individual dolphins from each of the various populations are limited, due partly to a paucity of observer coverage and partly to incomplete understanding of population structure of bottlenose dolphins in the Atlantic. The concern is greater in the Gulf of Mexico, where population-level impacts on bottlenose dolphins are unknown. Despite data limitations, there are no precautionary management measures in place to reduce interactions with bottlenose dolphin populations throughout the Gulf.

Overall, purse seine fisheries are considered to be minimal bycatch fisheries and the fishing fleet is taking proactive steps to reduce the little bycatch that does occur. However, few observer data are available and there are concerns with bottlenose dolphin bycatch. Therefore, the bycatch management strategy is ranked as “moderately effective.”

### **Subfactor 3.2.2 – Scientific Research and Monitoring**

*Considerations: Is bycatch in the fishery recorded/documented and is there adequate monitoring of bycatch to measure fishery’s impact on bycatch species? To achieve a Highly Effective rating, assessments must be conducted to determine the impact of the fishery on species of concern, and an adequate bycatch data collection program must be in place to ensure bycatch management goals are being met.*

**East coast Atlantic, Pound Net**

**East coast Atlantic, Purse Seine, Unassociated**

**Gulf Mgmt. region Gulf of Mexico, Purse Seine, Unassociated**

#### **Moderately Effective**

Observer coverage in the menhaden fishery is not mandatory, although there is minimal coverage in the fishery. Due to confidentiality issues, that data cannot be released to the public, but bycatch/discards are reported on logbooks along with catch, and data are available for use in annual scientific

assessments of the species (Shield 2014) (Scott-Denton 2014). There was recently an observer pilot program in the Gulf of Mexico menhaden fishery, but those results also cannot be released to the public (Scott-Denton 2014). Research studies, such as the ones mentioned above, have also contributed to the body of knowledge on bycatch. Assessments monitor bycatch species caught in the fishery, although currently there are no recommendations for specific bycatch reduction measures. The information on bycatch in Atlantic and Gulf menhaden fisheries is lacking and, although some data are collected and pilot programs have focused specifically on this issue, much more research is needed. Therefore, scientific research and monitoring is ranked as “moderately effective.”

### **Subfactor 3.2.3 – Management Record of Following Scientific Advice**

*Considerations: How often (always, sometimes, rarely) do managers of the fishery follow scientific recommendations/advice (e.g., do they set catch limits at recommended levels)? A Highly Effective rating is given if managers nearly always follow scientific advice.*

**East coast Atlantic, Pound Net**

**East coast Atlantic, Purse Seine, Unassociated**

**Gulf Mgmt. region Gulf of Mexico, Purse Seine, Unassociated**

#### **Moderately Effective**

See Subfactor 3.1.4 under Harvest Strategy.

### **Subfactor 3.2.4 – Enforcement of Management Regulations**

*Considerations: Is there a monitoring/enforcement system in place to ensure fishermen follow management regulations and what is the level of fishermen’s compliance with regulations? To achieve a Highly Effective rating, there must be consistent enforcement of regulations and verification of compliance.*

**East coast Atlantic, Pound Net**

#### **Highly Effective**

See Subfactor 3.1.5 under Harvest Strategy.

East coast Atlantic, Purse Seine, Unassociated

Gulf Mgmt. region Gulf of Mexico, Purse Seine, Unassociated

**Moderately Effective**

See Subfactor 3.1.5 under Harvest Strategy.

## **Criterion 4: Impacts on the habitat and ecosystem**

*This Criterion assesses the impact of the fishery on seafloor habitats, and increases that base score if there are measures in place to mitigate any impacts. The fishery's overall impact on the ecosystem and food web and the use of ecosystem-based fisheries management (EBFM) principles is also evaluated. Ecosystem Based Fisheries Management aims to consider the interconnections among species and all natural and human stressors on the environment.*

*The final score is the geometric mean of the impact of fishing gear on habitat score (plus the mitigation of gear impacts score) and the Ecosystem Based Fishery Management score. The Criterion 2 rating is determined as follows:*

- *Score >3.2=Green or Low Concern*
  - *Score >2.2 and <=3.2=Yellow or Moderate Concern*
  - *Score <=2.2=Red or High Concern*
- Rating cannot be Critical for Criterion 4.*

### **Criterion 4 Summary**

<b>Region / Method</b>	<b>Gear Type and Substrate</b>	<b>Mitigation of Gear Impacts</b>	<b>EBFM</b>	<b>Overall Recomm.</b>
<b>East coast Atlantic Purse Seine, Unassociated</b>	3.00:Low Concern	0.00:No Effective Mitigation	3.00:Moderate Concern	<b>Yellow (3.000)</b>
<b>Gulf Mgmt. region Gulf of Mexico Purse Seine, Unassociated</b>	3.00:Low Concern	0.00:No Effective Mitigation	2.00:High Concern	<b>Yellow (2.450)</b>

### **Justification of Ranking**

#### **Factor 4.1 – Impact of Fishing Gear on the Habitat/Substrate**

##### *Scoring Guidelines*

- *5 (None)—Fishing gear does not contact the bottom*
- *4 (Very Low)—Vertical line gear*
- *3 (Low)—Gears that contacts the bottom, but is not dragged along the bottom (e.g. gillnet, bottom longline, trap) and is not fished on sensitive habitats. Bottom seine on resilient mud/sand habitats. Midwater trawl that is known to contact bottom occasionally (*
- *2 (Moderate)—Bottom dragging gears (dredge, trawl) fished on resilient mud/sand habitats. Gillnet, trap, or bottom longline fished on sensitive boulder or coral reef habitat. Bottom seine except on mud/sand*

- *1 (High)—Hydraulic clam dredge. Dredge or trawl gear fished on moderately sensitive habitats (e.g., cobble or boulder)*
- *0 (Very High)—Dredge or trawl fished on biogenic habitat, (e.g., deep-sea corals, eelgrass and maerl)*

*Note: When multiple habitat types are commonly encountered, and/or the habitat classification is uncertain, the score will be based on the most sensitive, plausible habitat type.*

#### East coast Atlantic, Pound Net

##### Very Low Concern

Pound nets are stationary nets anchored on stationary poles. Pound nets in the Chesapeake Bay are usually set and fished between April and November in 12–20 ft depths (Silva et al. 2011). The nets do not have a significant amount of bottom contact and are stationary, so the impact on bottom habitat is assumed to be minimal. However, there has not been any research on how pound nets affect bottom habitat or infauna.

#### East coast Atlantic, Purse Seine, Unassociated

#### Gulf Mgmt. region Gulf of Mexico, Purse Seine, Unassociated

##### Low Concern

Purse seines operate in the water column, so effects on habitat and seafloor are typically minimal (Chuenpagdee et al. 2003). In the case of the menhaden fisheries, contact with the bottom is frequent in the gulf menhaden purse seine fishery, resulting in sediment suspension (Barnette 2001).

## Factor 4.2 – Mitigation of Gear Impacts

### Scoring Guidelines

- *+1 (Strong Mitigation)—Examples include large proportion of habitat protected from fishing (>50%) with gear, fishing intensity low/limited, gear specifically modified to reduce damage to seafloor and modifications shown to be effective at reducing damage, or an effective combination of ‘moderate’ mitigation measures.*
- *+0.5 (Moderate Mitigation)—20% of habitat protected from fishing with gear or other measures in place to limit fishing effort, fishing intensity, and spatial footprint of damage caused from fishing.*

- *+0.25 (Low Mitigation)—A few measures are in place (e.g., vulnerable habitats protected but other habitats not protected); there are some limits on fishing effort/intensity, but not actively being reduced.*
- *0 (No Mitigation)—No effective measures are in place to limit gear impacts on habitats.*

#### East coast Atlantic, Pound Net

##### Minimal Mitigation

Pound net gear makes up a small percentage of overall Atlantic menhaden landings (3.24% on average from 2008–2012) and has little contact with the bottom, so gear impacts on habitat from the menhaden fishery are likely minimal. Fishing effort is managed using a quota-based system that was implemented in 2013 (ASMFC 2012b) on a state-by-state basis, but management measures do not currently include any area or gear restrictions for pound net gear used in the menhaden fishery. The Atlantic menhaden fishery management plan (FMP) also requires that each state implements identification and protection of critical habitat areas for juvenile menhaden and other related species (ASMFC 2012b).

#### East coast Atlantic, Purse Seine, Unassociated

##### Gulf Mgmt. region Gulf of Mexico, Purse Seine, Unassociated

##### No Effective Mitigation

Although there are areas that are closed to menhaden fishing (e.g., <http://www.dem.ri.gov/programs/bnatres/fishwild/anregs/041411mh.pdf>), no specific mitigation is in place to reduce bottom contact of menhaden purse seines.

### Factor 4.3 – Ecosystem-Based Fisheries Management

#### Scoring Guidelines

- *5 (Very Low Concern)—Substantial efforts have been made to protect species' ecological roles and ensure fishing practices do not have negative ecological effects (e.g., large proportion of fishery area is protected with marine reserves, and abundance is maintained at sufficient levels to provide food to predators).*
- *4 (Low Concern)—Studies are underway to assess the ecological role of species and measures are in place to protect the ecological role of any species that plays an exceptionally large role in the ecosystem. Measures are in place to minimize potentially negative ecological effect if hatchery supplementation or fish aggregating devices (FADs) are used.*

- *3 (Moderate Concern)—Fishery does not catch species that play an exceptionally large role in the ecosystem, or if it does, studies are underway to determine how to protect the ecological role of these species, OR negative ecological effects from hatchery supplementation or FADs are possible and management is not place to mitigate these impacts.*
- *2 (High Concern)—Fishery catches species that play an exceptionally large role in the ecosystem and no efforts are being made to incorporate their ecological role into management.*
- *1 (Very High Concern)—Use of hatchery supplementation or fish aggregating devices (FADs) in the fishery is having serious negative ecological or genetic consequences, OR fishery has resulted in trophic cascades or other detrimental impacts to the food web.*

#### East coast Atlantic, Pound Net

#### East coast Atlantic, Purse Seine, Unassociated

##### **Moderate Concern**

The Atlantic Menhaden Management Board adopted new fishing mortality and spawning stock biomass reference points in response to the 2010 Peer Review Panel’s recommendation to provide greater protection for spawning stock biomass or population fecundity relative to the unfished levels. The new reference points are intended to be interim benchmarks while the Commission’s Multispecies Technical Committee develops ecological-based reference points. The ASMFC has committed to an amendment to establish ecological based reference points that reflect Atlantic menhaden’s role as a forage species (ASMFC 2015c), but until those are developed, the interim benchmarks are used (as they were in the 2015 benchmark stock assessment) (SEDAR 2015). Amendment 2 to the Atlantic menhaden FMP implemented a coast-wide quota to reduce fishing mortality and to preserve the important role menhaden play in the Mid-Atlantic ecosystem. Though there was some consideration of the important role of menhaden in the mid-Atlantic ecosystem, the need for ecosystem reference points has still not been fulfilled. In addition, the assessment model was a single-species model and not based on predator-prey relationships as new, ecosystem-based fisheries models have been. Menhaden is an “exceptional species” in terms of its importance to the ecosystem, the fishery lacks policies to protect the ecosystem role of the species, and scientific assessment to account for these species’ ecological roles is underway, so the fishery is rated a “moderate” concern.

##### **Rationale:**

Atlantic menhaden are considered forage fish, which are noted for their functional role in the ecosystem through the transfer of energy to higher trophic levels in marine food webs (Pikitch et al. 2012). Menhaden transfer energy in marine food webs in two ways: as predator and prey.

First, as a predator of zooplankton, phytoplankton, and detritus, menhaden strain their prey through their gill rakers and, due to their large population size, are constantly consuming and redistributing energy throughout oceanic and estuarine ecosystems where they are found (Maryland Sea Grant 2009).

Studies have shown menhaden to have significant impacts on phytoplankton and zooplankton populations (Oviatt et al. 1972), so they are a significant link between primary production and fish that prey on menhaden. Because menhaden are filter feeders and ingest large amounts of phytoplankton, they have the potential to filter nitrogen out of waters with excess eutrophication, like oysters do (Lynch et al. 2010). Recent studies have shown that their nitrogen intake is in part balanced by their nitrogen output, so impacts on nitrogen levels in the ecosystem are likely minimal. But more research is needed in a variety of locations throughout the menhaden range to determine the true nature of nitrogen cycling by localized menhaden populations (Lynch et al. 2010). In addition, the passage of intact cyanobacteria through the gut of menhaden may add to the input of nutrients on the ocean floor (Friendland et al. 2005)

Second, menhaden are considered a key prey source for striped bass, weakfish, and bluefish in the Chesapeake Bay (Walter et al. 2003). Such fish consume small prey such as bay anchovy when they are juvenile, but menhaden are the next predatory step as such fish grow larger (Walter et al. 2003). Therefore, menhaden can be a critical component of the successful growth of many different fish species. Menhaden make up the majority of striped bass diets when available, although studies have shown that, with declines in menhaden populations, striped bass have switched to other food sources (Overton et al. 2008). Menhaden are also a major food source for a variety of piscivorous birds, such as bald eagle, osprey, terns, gannet, loons, great blue heron, double-crested cormorant, brown pelican, and some gulls in the Chesapeake Bay watershed (Viverette et al. 2007). Atlantic menhaden were thought to be locally depleted in the Chesapeake Bay area (ASMFC 2012b). Such depletion can have significant negative impacts on species that rely on menhaden and (Daunt et al. 2008) intense fishing effort has led to concerns by recreational fishermen, managers, and the public that the decline of menhaden populations has led to a substantial loss of their ecosystem services as prey and filterers (Maryland Sea Grant 2009). A cap on the Chesapeake Bay fishery in 2005 aimed to reduce fishing mortality and to ensure that the important role of menhaden in the Bay remained intact.

### **Gulf Mgmt. region Gulf of Mexico, Purse Seine, Unassociated**

#### **High Concern**

Gulf menhaden are forage fish, which are noted for their functional role in the ecosystem through the transfer of energy to higher trophic levels in marine food webs (Pikitch et al. 2012). The Gulf menhaden assessment panel considered the important role that menhaden plays in the Gulf of Mexico ecosystem, but was unable to incorporate ecosystem-based reference points into the most recent assessment because there are virtually no data on predation rates and prey preference in the higher trophic fishes. The next benchmark stock assessment is expected in 2017 and will aim to use a more ecosystem-based approach to analyzing the fishery—provided that additional predator/prey data are available to populate the data-hungry ecosystem models (pers. comm., Steven VanderKooy, 2014). Because menhaden is an “exceptional species” in terms of its importance to the ecosystem and there are no explicit efforts yet to incorporate ecological roles into management, the fishery is rated a “high”

concern.

**Rationale:**

Menhaden, like other members of the clupeid family (sardines and herrings), are an important food fish for many other marine animals, including fish, mammals, and birds. Numerous studies have shown that recreational and commercial finfish such as spotted sea trout and red drum consume shrimp, anchovies, mullet, croaker, and numerous other species, including Gulf menhaden. King mackerel, Spanish mackerel, dorado, crevalle jack, tarpon, and bonito also rely on Gulf menhaden as prey (Geers et al. 2014). Marine mammals and sea birds, most notably the osprey but also the brown pelican, use menhaden as forage (Geers et al. 2014). During SEDAR32A (SEDAR 2013), the assessment panel discussed factors necessary to adequately account for the ecosystem value of Gulf menhaden in defining fishery reference points, and concluded that data and techniques are insufficient at present to incorporate them into the assessment; data are lacking that specifically address the value of menhaden in the ecosystem as prey biomass for other stocks (e.g., piscivorous, avian, and mammalian predators). Nonetheless, the panel had some recommendations regarding future efforts, including the need to develop procedures to establish assessment benchmarks (e.g.,  $F_{MSY}$  or proxies) that account for the multiple priorities of ecosystem management, and the need to initiate food habits of major predator species in the northern Gulf to determine the importance of menhaden in the diets of fish, seabirds, and marine mammals.

## **Acknowledgements**

*Scientific review does not constitute an endorsement of the Seafood Watch® program, or its seafood recommendations, on the part of the reviewing scientists. Seafood Watch® is solely responsible for the conclusions reached in this report.*

Seafood Watch® would like to thank three anonymous reviewers for graciously reviewing this report for scientific accuracy.

## **References**

79 Federal Register 50, 2014. List of Fisheries for 2014. Final rule. Federal Register 50 (April 14, 2014), pp. 14418-14438. <https://www.federalregister.gov/articles/2014/03/14/2014-05576/list-of-fisheries-for-2014>

Alabama Department of Conservation and Natural Resources 2013. Alabama Department of Conservation and Natural Resources Administrative Code. Chapter 220-3; Marine Resources Division.

Atlantic States Marine Fisheries Commission (ASMFC) 2015a. 2015 Atlantic Menhaden Stock Assessment Report, in Atlantic Menhaden Management Board meeting February 3 2015. <http://www.asmfc.org/files/Meetings/Winter2015/AtlanticMenhadenBoard.pdf>

Atlantic States Marine Fisheries Commission (ASMFC) 2015b. Atlantic Menhaden Benchmark Assessment Finds Resource Not Overfished and Overfishing Not Occurring. News Release February 4 2015. <http://www.asmfc.org/uploads/file/54d27ef5pr02AtlanticMenhadenBenchmarkAssmt.pdf>

Atlantic States Marine Fisheries Commission (ASMFC) 2015c. ASMFC Atlantic Menhaden Board Sets 2015 and 2016 TAC at 187,880 MT Initiates Amendment to Establish Ecological Reference Points. News release May 6 2015. [http://asmfc.org/uploads/file/554a42c4pr15AtlMenhadenTAC\\_AmendmentInitiation.pdf](http://asmfc.org/uploads/file/554a42c4pr15AtlMenhadenTAC_AmendmentInitiation.pdf)

Atlantic States Marine Fisheries Commission (ASMFC) 2015d. Recommended Biological Reference Points and Projection Runs. Memo from the Technical Committee to the Atlantic Menhaden Management Board, April 22, 2015.

Atlantic States Marine Fisheries Commission (ASMFC). 2015. ASMFC Stock Assessment Overview. February 2015.

Atlantic States Marine Fisheries Commission (ASMFC) 2014. Fisheries Management: Program Overview. <http://www.asmfc.org/fisheries-management/program-overview>

Atlantic States Marine Fisheries Commission (ASMFC)2014a. 2014 Review of the Fishery Management Plan and State Compliance for the 2013 Atlantic Menhaden (*Brevoortia tyrannus*) Fishery. Prepared by the Atlantic Menhaden Plan Review Team. May 2014.

Atlantic States Marine Fisheries Commission (ASMFC) 2013. Atlantic States Marine Fisheries Commission News Release: ASMFC Begins Preparations for Atlantic Menhaden Benchmark Stock Assessment.

Atlantic States Marine Fisheries Commission (ASMFC) 2012a. 2012 Atlantic menhaden stock assessment update. A publication of the Atlantic States Marine Fisheries Commission pursuant to National Oceanic and Atmospheric Administration Award No. NA05NMF4741025

Atlantic States Marine Fisheries Commission (ASMFC) 2012b. Amendment 2 to the Atlantic Menhaden Fishery Management Plan. A publication of the Atlantic States Marine Fisheries Commission pursuant to U.S. Department of Commerce, National Oceanic and Atmospheric Administration Award No. NA10NMF4740016

Atlantic States Marine Fisheries Commission (ASMFC). 2004. Addendum I to Amendment 1 to Interstate Fishery Management Plan for Atlantic Menhaden. ASMFC, Fisheries Management Report No. 37a, Washington, D.C.

Austin, Herb, James Kirkley, and Jon Lucy. 1994. Bycatch and the Fishery for Atlantic Menhaden (*Brevoortia tyrannus*) in the Mid-Atlantic Bight: An Assessment of the Nature and Extent of Bycatch. Virginia Sea Grant Marine Resource Advisory No. 53 VSG 94-06.

Barnette, M.C. 2001. A review of the fishing gear utilized within the Southeast Region and their potential impacts on essential fish habitat. NOAA Technical Memorandum NMFS-SEFSC-449. Available at [http://ocean.floridamarine.org/efh\\_coral/pdfs/Barnette\\_gear.pdf](http://ocean.floridamarine.org/efh_coral/pdfs/Barnette_gear.pdf)

Cheung, W.W.L., T.J. Pitcher and D. Pauly, 2005. A fuzzy logic expert system to estimate intrinsic extinction vulnerabilities of marine fishes to fishing. *Biol. Conserv.* 124:97-111.

Christmas, J.Y., G. Gunter, and E.C. Whatley 1960. Fishes taken in the menhaden fishery of Alabama, Mississippi, and eastern Louisiana. U.S. Department of Interior, Fish and Wildlife Service SSRF-339. 10 pp.

Chuenpagdee, R., Morgan, L.E. Maxwell, S.M., Norse, E.A., and Pauly, D. 2003. Shifting gears: assessing collateral impacts of fishing methods in U.S. waters. *Frontiers in Ecology and the Environment* 1(10): 517-524.

Condrey, R. 1994. Bycatch in the U.S. Gulf of Mexico Menhaden Fishery: Results of Onboard Sampling in the 1992 Fishing Season. Louisiana State University. Baton Rouge, LA.

Daunt, F., Sarah Wanless, Simon P.R. Greenstreet, Henrik Jensen, Keith C. Hamer, and Michael P. Harris. 2008. The impact of the sandeel fishery closure on seabird food consumption, distribution, and productivity in the northwestern North Sea. *Canadian Journal of Fisheries and Aquatic Sciences*, 65(3), 362–381

DeSilva, J. A., R. E. Condrey, and B. A. Thompson. 2001. Profile of shark bycatch in the U.S. Gulf of Mexico menhaden fishery. *North American Journal of Fisheries Management* 21:111-124.

Friedland, K, D. W. Ahrenholz, and L.W. Haas. 2005. Viable gut passage of cyanobacteria through the filter-feeding fish, Atlantic menhaden, *Brevoortia tyrannus*. *Journal of Plankton Research*: 25(7): 715-718.

Geers, T.M., E.K. Pikitch, and M.G. Frist. 2014. An original model of the northern Gulf of Mexico using Ecopath with Ecosim and its implications for the effects of fishing on ecosystem structure and maturity. Deep-Sea Research II. In press.

GSMFC 2014. Gulf States Marine Fisheries Commission: Fisheries Enforcement.

Gulf States Marine Fisheries Commission (GSMFC) 2002. The Menhaden Fishery of the Gulf of Mexico, United States: A Regional Management Plan. Edited by Steven J. VanderKooy and Joseph W. Smith. No. 99

Guillory, V. and G. Hutton. 1982. A survey of bycatch in the Louisiana gulf menhaden fishery. Proceedings of the Southeastern Association of Fish and Wildlife Agencies 36: 213-223.

Judy, M.H., and R.M. Lewis. 1983. Distribution of eggs and larvae of Atlantic menhaden, *Brevoortia tyrannus*, along the Atlantic coast of the United States. U.S. NMFS. Spec. Sci. Rep. Fish. 774, 23 p.

Kelleher, K. 2005. Discards in the World's Marine Fisheries: An Update. Food and Agriculture Organization of the United States (FAO) Fisheries Technical Paper 470. Available at: <http://www.fao.org/docrep/008/y5936e/y5936e00.htm>

LA DMF 2014. Louisiana Department of Wildlife and Fisheries Commercial Fishing Regulations for 2014.

Lynch, Patrick D., Mark J. Brush, Elizabeth D. Condon, and Robert J. Latour. 2010. Net removal of nitrogen through ingestion of phytoplankton by Atlantic menhaden *Brevoortia tyrannus* in Chesapeake Bay. Marine Ecology Progress Series. 401: 195-209.

Maryland Sea Grant 2009. Ecosystem Based Fisheries Management For Chesapeake Bay: Menhaden Background and Issue Briefs. 2009. EBFM Menhaden Species Team. Publication Number UM-SG--TS-2009---08.

McClenachan, L. et al. 2012. Letter from 94 concerned scientists to the Atlantic States Marine Fisheries Commission on the passage of Amendment 2 to the Atlantic menhaden FMP. November 16, 2012.

MS DMR 2014. Mississippi Department of Marine Resources Guide to Mississippi Saltwater Fishing; Rules and Regulations, 2013-2014.

Neer, JA and Cortes, E. 2005. Estimation of large coastal shark complex, blacktip, and sandbar shark bycatch in the Gulf of Mexico menhaden fishery. LCS05/06-DW-34

NMFS 2014. Bottlenose Dolphin (*Tursiops truncatus truncatus*): Western North Atlantic Northern Migratory Coastal Stock Marine Mammal Stock Assessment Reports (SARs) by Species/Stock. <http://www.nmfs.noaa.gov/pr/sars/species.htm>

NMFS 2014. Bottlenose Dolphin (*Tursiops truncatus truncatus*): Western North Atlantic Southern Migratory Coastal Stock Marine Mammal Stock Assessment Reports (SARs) by Species/Stock. <http://www.nmfs.noaa.gov/pr/sars/species.htm>

- NMFS 2013. 2013-2014 Bottlenose Dolphin Unusual Mortality Event in the Mid-Atlantic. NOAA Fisheries Protected Species Division.
- NOAA 2014. NOAA Chesapeake Bay Office: Menhaden Facts. <http://chesapeakebay.noaa.gov/fish-facts/menhaden>
- NOAA 2012. Imports and Exports of Fishery Products Annual Summary 2012. Current Fishery Statistics No. 2012-2. <http://www.st.nmfs.noaa.gov/st1/trade/documents/TRADE2012.pdf>
- O'Boyle, R. 2013. Gulf of Mexico Menhaden (*Brevoortia patronus*) Review of 2013 SEDAR 32 (2013) Stock Assessment.
- Overton, A. S., C. S. Manooch, and J. W. Smith. 2008. Interactions between adult migratory striped bass (*Morone saxatilis*) and their prey during winter off the Virginia and North Carolina Atlantic coast from 1994 through 2007. *Fishery Bulletin* 106:174-182.
- Oviatt C.A., Gall A.L., Nixon S.W. 1972. Environmental effects of Atlantic menhaden on surrounding waters. *Chesapeake Science* 13:321–323
- PEW 2013. The PEW Charitable Trusts: Results of Southeast Data, Assessment and Review 32A (SEDAR 32A) FOR Gulf Menhaden (*Brevoortia patronus*) and the Establishment of Appropriate Biological Reference Points and Management Goals. Letter to the Gulf States Marine Fisheries Commission dated October 10, 2013.
- PEW 2012. Comment letter on Draft Amendment 2 to the Atlantic Menhaden FMP. November 16, 2012
- Pikitch, E., Boersma, P.D., Boyd, I.L., Conover, D.O., Cury, P., Essington, T., Heppell, S.S., Houde, E.D., Mangel, M., Pauly, D., Plagányi, É., Sainsbury, K., and Steneck, R.S. 2012. Little Fish, Big Impact: Managing a Crucial Link in Ocean Food Webs. Lenfest Ocean Program. Washington, DC. 108 pp.
- Scott-Denton, Elizabeth. NMFS Southeast Region Observer Program. Gulf menhaden pilot observer program. Personal communication on March 31, 2014.
- SEDAR. 2015. SEDAR 40 – Atlantic Menhaden Stock Assessment Report. SEDAR, North Charleston SC. 643 pp. available online at: [http://www.sefsc.noaa.gov/sedar/Sedar\\_Workshops.jsp?WorkshopNum=40](http://www.sefsc.noaa.gov/sedar/Sedar_Workshops.jsp?WorkshopNum=40).
- SEDAR. 2013. SEDAR 32A - Gulf of Mexico menhaden Stock Assessment Report. SEDAR, North Charleston SC. 422 pp. available online at: [http://www.sefsc.noaa.gov/sedar/Sedar\\_Workshops.jsp?WorkshopNum=32A](http://www.sefsc.noaa.gov/sedar/Sedar_Workshops.jsp?WorkshopNum=32A)
- SEDAR 2012. SEDAR 29. HMS Gulf of Mexico Blacktip Shark Stock Assessment Report. SEDAR, North Charleston SC. 197 pp.
- SEDAR 2011. HMFS Sandbar Shark Stock Assessment Report. SEDAR, North Charleston, SC. 18 pp.
- Seafood Watch Criteria Document. 2014

Shield, Gina. NMFS Northeast Region Observer Program. Atlantic menhaden data request. Personal communication on February 8, 2014.

Silva, R.D., J.T. Dealteris, and H.O. Milliken. 2011. Evaluation of a pound net leader designed to reduce sea turtle bycatch. *Marine Fisheries Review*. 73(3): 36.

Simpson, Larry. 2003. Letter to NOAA Fisheries Southeast Fisheries Science Center regarding bycatch in the menhaden fishery. Cosigned by members of the GSMFC.

VanderKooy 2014. Personal communication. April 2, 2014.

VanderKooy, S.J., and J.W. Smith (editors). 2014. *The Menhaden Fishery of the Gulf of Mexico, United States: A Regional Management Plan. 2014 Revision*. Gulf States Marine Fisheries Commission. Ocean Springs, MS. Pub No. XXX. 224 p.

Viverette, C. A., G. C. Garman, S. P. McInnich, A. C. Markham, B. D. Watts, and S. A. Macko. 2007. Finfish-waterbird trophic interactions in tidal freshwater tributaries of the Chesapeake Bay. *Waterbirds* 30 (Special Publication):50-62.

Walter, J. F., A. S. Overton, K. H. Ferry, and M. E. Mather. 2003. Atlantic coast feeding habits of striped bass: a synthesis supporting a coast-wide understanding of trophic biology. *Fisheries Management and Ecology*, 10:349-360.